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YWLH59

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EXTERNAL REFERENCE / VERSION

Report

Report on Stress Analysis of VVPSS Relief Lines

This document is a detail report on stress analysis calculations of Relief Lines of Vacuum Vessel Pressure Suppression System (VVPSS). It describes the inputs, the criteria & methodology used and the results of stress analysis.

Approval Process			
	Name	*Action*	*Affiliation*
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Change Log			
Report on Stress Analysis of VVPSS Relief Lines (YWLH59)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v0.0	In Work	07 Feb 2020	
v1.0	Revision Required	12 Feb 2020	FIRST VERSION
v1.1	Revision Required	06 May 2020	Addressed comments from reviewers
v1.2	Approved	16 Jun 2020	- Two new supports added and configuration of one support changed to reduce the support loads and enable qualification of EPs. - Addressed reviewer's comments on version 1.1.

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Revision Sheet

Reviewer: Christophe Seropian

V1.1: Recommended

V1.0: Comments

Sr. No.	Comment	Reply
1	Could you indicate to which document you refers for fire analysis? Fire + SL2 is a cat. IV.	Fire + SL2 is indeed Cat IV. Corrected the TYPO in para 7.6
2	For the load 22, could you confirm 11 bars? I have in mind 15 bars g.	Confirm 11 bars (g) based on 'Loads Case Specification VVPSS -RL (UXX829 v2.5)'
3	For the VV dust explosion; did you consider the dynamic effect? The temperature of 115 C refers to temperature in material or gas temperature?	VVPSS relief lines have been checked for integrity at 30 bar static pressure. Postulated dust explosion pressure is only 5 bar. 115 C refers to the temperature of pipe material in this report
4	Load 23: could you clarify why you consider this scenario?	Event considered as per Loads Case Specification VVPSS -RL (UXX829 v2.5)
5	What is planned to solve the issue on the bellows?	Two options possible. Details given in para 11.3.

Reviewer: Pascal De boe

V1.1: Comments

Sr. No.	Comment	Reply
1	May I ask you to add a table with the node numbers and the blocked directions for each supports and penetrations? Not easy to understand who is who without opening CAESAR	Added table 11.8. This table shall be used along with figure 11.1

V1.0: Comments

Sr. No.	Comment	Reply
1	Could you please confirm that equilibrating reaction force (PxA) due to pressure at the bellows have been considered? I suggest to add a subsection to document it.	It is confirmed that these forces have been considered in the analysis. Added explanation in para 5.1.3
2	I have heard that the drain tank room shall withstand the 2.0 bar absolute pressure from a ex-vessel coolant event. Is this case well considered with a equilibrating reaction force (PxA)?	This event has been considered under LS-23 (LOCA PC III + ICE II). Equilibrating reaction force due to bellows has been considered for this event.
3	It looks that there is an internal (guide) support at the penetrations to DTR room. If I'm correct, please provide and document the reaction loads.	Incorporated in Appendix A & B
4	I recommend to document explicitly the interface loads between the piping and the valves, rupture disk, special Y tee, etc ... for future validation	Incorporated in Appendix C & D
5	I recommend to document explicitly the nozzle interface loads for future validation	Incorporated in Appendix C & D

Reviewer: Christopher Hall

V1.0: Comments

Sr. No.	Comment	Reply
1	Several minor corrections and typographic errors identified as comments on the attached pdf.	Incorporated.
2	Section 8.4 - The pressure wave due to NRV closure will travel back inside the VST sparger and be reflected only when it meets the closed cap of the steam sparger, Please include this extra length of pipe when determining the times for wave reflection (NRV closure and Surge cases).	Incorporated. Revised para 8.4
3	The design of the pipe support at Node 760 is such that a vertical displacement of up to 2 mm will be applied to the pipe by the support. Please include this pipe displacement at the next revision.	Confirm no adverse effect of this minor displacement on the pipes
4	The relief pipe will be installed progressively - a captive portion install prior to first plasma and the remainder around 5 years later. A hydraulic test of the captive portion will be undertaken following installation. Please include this scenario in the assessment to ensure the installed supports are adequate.	Included in Section 13.0.

Reviewer: Anatoly Zhirnov

V1.0: Comments

Sr. No.	Comment	Reply
1	Please add item with verification of the model	Caesar model re-checked and verified.
2	Please describe how WYe piece is presented in this model? Rigid component?	Wye piece has been modeled as rigid component.
3	Which source is used? Please give reference.	Not applicable in the revised version
4	Need to clarify an integrity for the piping fittings.	Refer para 9.1 for pressure loads. For other loads, SIFs are used for fittings as per ASME B31.3.
5	What about temperature? Is margin assessed relatively ultimate stress at accidental temperature or not? Please clarify.	Comment incorporated. Ultimate tensile strength at 250 oC is used now instead of UTS at room temperature.
6	Need to add Appendix with interface loads for Wye piece	Added Appendix C & D
7	Need to add Appendix with interface piping loads for the following: - VVPSS boxes - VSTs	Added Appendix C & D
8	Loads on the sliding and fixing supports of R/BV assemblies shall be presented for the future analysis of the assemblies. Thermal displacements for nodes of the sliding supports shall be presented as well.	Loads on sliding and fixed supports included in Appendix A and B. Displacements for all nodes added as an attachment on IDM.

9	Please add node numbers for the RD/BV assemblies fixing and sliding supports	Added

Reviewer: Bingchen Wang

V1.0: Comments

Sr. No.	Comment	Reply
1	I would suggest if you could add the pages at the center bottom?	Added
2	For the displacement here, as with the pipe insulation of 50mm on each pipe the clearance is very critical, I would suggest if you could add the displacement result and check it.	Displacements for all nodes added as an attachment on IDM.
3	I would suggest if you could add the description how the seismic load is considered and combined in each load cases, the direction, the combination method,	Description added in para 8.6.1
4	as a "hot" model is required by the HIT context, can you extract one for the purpose of clash checking in DTR, The output should be a txt format file from CAESAR II result, and it will be used for HIT to rebuilt the model in ENOVIA, I would suggest add it as attachment on IDM	Text file will be attached on IDM
5	Load Case 3 is for Lifting and Maintenance. as we do not have the lifting plan. so this analysis is not included. and for Load case 4 has it been analyzed with compression loads for the maintenance condition defined in the piping spec or not? if this will be done later, I would suggest to add the pending issues or TBD?	LS-3 (Lifting & handling load case) is not included in this report. LS-4 is enveloped by other operating conditions which are more severe.
6	for the load on the supports: 1. for each sliding support, how the friction load is considered? what is the friction coefficient used? 2. can you add the summarized table? just show the minimum and maximum value for each service lever (A, C, D)for each support. 3. I would suggest if you could add the interface loads separately for the VVPSS boxes and two VSTs as appendixes? 4. I would suggest if you could add the description of the loads local coordinates, how is it defined?	1. Sliding friction has been assumed for all supports. Coefficient of friction is assumed as 0.3. Refer para 5.2. 2. Added in appendices A & B. 3. Added in appendix C & D 4. Local coordinate system described in para 11.3

Reviewer: Stefan Nicolici

V1.1: Comments

Sr. No.	Comment	Reply
1	Since (1) a simplified procedure has been adopted to evaluate the water hammer forces which is more applicable to standard cases - steady state flow interrupted by a valve (which is not your case - liquid front filling a pipe) and (2) the velocities used for your evaluations are coming from steady state hydraulic simulations as per [7], I would also recommend to use a	It is confirmed from Author of Ref [7] that the velocities estimated in Ref [7] includes the transient behavior during the accident event. Author of Ref [7] is also the reviewer of this report.

	hydraulic dynamic amplification factor for the water hammer pressures.	
2	I believe Caesar II is not performing any buckling checks when the pipe is subjected to an external pressure higher than the internal one. If so, some additional verifications should be performed using another tool (like Ansys) or analytical approaches.	Buckling due to external pressure is considered in para 9.1. Added para 11.2 for consideration of column bucking and local shell buckling.

V1.0: Comments

Sr. No.	Comment	Reply
1	The 3DXML file should be attached to the report in IDM	Attached
2	Has the elbows flexibility been modified to account for the closeness of rigid elements, such as flanges, valves, etc? Caesar manual recommends that if such elements are within two diameters than the elbow should be considered flanged.	Comment incorporated (ref para 5.1.2)
3	Is the tank rigid enough to support this assumption? If the VST deforms during the seismic event than the additional displacements are not captured. A pipe element with the dimensions of the VSTs could have been used.	The structural analysis reports of VSTs shows that minimum frequency of the VSTs is 28.2 Hz. Thus, the tanks are quite rigid and hence have been modelled as rigid elements. Design FRS for this system shows that 28.2 Hz lies in almost flat regime of the spectra i.e. the response in this region is insensitive to the frequency (almost close to ZPA). Thus, the modelling of VSTs as rigid is reasonable. Ref: CS-2016034-02 - Structural Analyses Report for SLT&LLT1 (UNSMJ6 v1.3) CS-2016035-02 - Structural Analyses Report for LLT2&LLT3 (UNSR2F v1.3)
4	Do you consider also the nozzle flexibility in your analysis? Caesar allows you to include it if necessary.	Nozzle flexibility has been ignored at the moment to obtain conservatively the maximum nozzle loads. If there is an issue in qualifying the equipment for these nozzle loads, these can be reduced by considering the flexibility of the nozzles. Also, it may be noted shells of vessels are quite thick (64 mm) and due to this nozzle flexibility will be quite low.
5	How are these one directional axial restraints considered in the dynamic analysis? They are non-linear and for modal it is necessary to linearize them.	Modal analysis has been performed with and without restraint and conservative results have been used.
6	Is this the final design of these supports? If yes, the flexibility of the support should be evaluated and included in the piping analysis if necessary. An alternative would be to evaluate the support displacements when loaded with the seismic piping reactions and show that they are below 1.5-2 mm.	Support design is under progress. The loads from piping analysis will be used to design the supports. Suggestion is accepted. Supports will be designed rigid enough so that displacements do not exceed 1.5-2 mm
7	Do you think it is worth checking the thermal load cases presented in Figure 2.2 and 2.3 from UXX829 v2.3 (only one train of the RD and BV open at a time)?	This requirement has been already implemented in the analysis. Only one train has been considered open as mentioned in the Load Specifications

8	The methodology used here to evaluate the water hammer loads should be proved to be conservative. The hydraulic transient should be modeled with an appropriate software to capture the pressure wave propagation inside the pipe. Checking reference [7] it seems that no such dynamic water-hammer analysis has been performed. Therefore, the velocities used here could be unrealistic.	The pressure time histories shown in figure 8-8 to 8-10 of this report have been calculated without the use of any software but are based on the clear fundamentals of water hammer wave propagation. This is required to estimate conservatively the first hand water hammer loads for piping stress analysis in Caesar. Reference [7] gives the details about the velocity of travelling water surge due to deflagration and detonation. The water surge velocity when it reaches the NRV have been used to calculate water hammer loads during deflagration and detonation events.
9	The SLS specifies that a detailed fatigue evaluation shall be performed in accordance with EN 13480-3.	Incorporated as section 12.0
10	Please note that Reference [10] states that the elastic-follow up should be also checked, otherwise the 6.0Sh limit cannot be used	This stress limit is applicable only for Service Level D loads. The maximum stress is 197.8 N/mm^2 stresses which is about 27 % of the allowable 6.0Sh limit. It is confirmed from stress distribution that this is a balanced system as the stress gradually reaches the maximum values. So strains are expected to be well distributed. Moreover the stress value is also lower than 3.0Sh applicable for unbalanced system.

1.0 OBJECTIVE

This document is a detail report on stress analysis calculations of Relief Lines of Vacuum Vessel Pressure Suppression System (VVPSS). It describes the inputs, the criteria & methodology used and the results of stress analysis. Interface loads on pipe supports and nozzles are compiled in the annexures.

2.0 SCOPE

This stress analysis report addresses the following relief lines:

a) DN 300 Relief line starting from VVPSS Box (in NB Cell) up to Small LOCA Tank (in Drain Tank Room).
b) DN 500 Relief line starting from VVPSS Box (in NB Cell) up to three Large LOCA Tanks (in Drain Tank Room). Each of the three Large LOCA Tanks is connected by independent DN 300 branch from the main DN 500 header.
c) DN 200 line with assembly of isolation valves which connects downstream of the bleed valve assembly to DN500 relief line at downstream the rupture disk assembly.

Figure 4-1 shows the above-mentioned relief lines.

DN 150 HMS line (SLT by-pass line) is connected to DN 300 relief line at downstream of bleed valve assembly. The present stress analysis includes the coupling effect of HMS line on DN 300 relief line. However, the qualification of HMS line itself is not within the scope of this report.

The piping stress analysis is based on the loadings generated on the relief lines due to operating conditions defined in the '*Load Specifications of VVPSS-RL*' [1]. The focus of this report is mainly on the description of the stress analysis procedure and reporting its results with reference to loads defined in [1]. Please refer [1] for the justification of the operating conditions from safety perspective.

3.0 ABBREVIATIONS

Table 3-1 shows the list of abbreviations. For a complete list of ITER abbreviations, please refer [3].

Table 3-1: Abbreviations

ASME	American Society of Mechanical Engineers
BL	Bleed Valve
BDBA	Beyond Design Basis Accident
DTR	Drain Tank Room
ESP	Equipment manufactured in compliance with Directive 2014/68.
ESPN	Equipment manufactured in compliance French order dated December 30, 2015 related to the manufacture of Nuclear Pressure Equipment (NPE) modified by French order 03/09/2018
FRS	Floor Response Spectra
HMS	Hydrogen Mitigation System

ICE	Ingress of Coolant Event
LLT	Large LOCA Tank
LOCA	Loss of Coolant Accident
LOVA	Loss of Vacuum Accident
NRV	Non-Return Valve
PED	Pressure Equipment Directive (Directive 2014/68/UE)
RD	Rupture Discs
RH	Remote Handling
RL	Relief Line
RPrS	Preliminary Safety Report (Rapport Préliminaire de Sûreté)
SC	Seismic Class
SIC	Safety Importance Class (-1)
SL-1	Seismic Level 1 – Defined by ITER for investment protection
SL-2	Seismic Level 2 – equivalent to Safe Shutdown Earthquake
SL-3	SL-3 or SND Seismic Noyau Dur
SLT	Small LOCA Tank
SMHV	Séismes Maximaux Historiquement Vraisemblables = Maximum Historically Probable Earthquake
SRSS	Square Root of Sum of Square
ST-VS	Suppression Tank – Venting System
VST	Vapour Suppression Tank
VV	Vacuum Vessel
VVPSS	Vacuum Vessel Pressure Suppression System

4.0 GENERAL DESCRIPTION

Vacuum Vessel Pressure Suppression System (VVPSS) is a Safety Important Class 1 (SIC-1) system of ITER. It has been assigned Quality Class 1 (QC-1) requirements [1].
The functions of VVPSS are [2]:

a) To protect Vacuum Vessel (VV) against overpressure in case of an in-vessel LOCA.
b) To provide dynamic confinement and maintain the VV below the atmospheric pressure in case of a loss of vacuum accident (LOVA) caused due to connection of VV volume with the port cell volume. This is required to avoid contamination of port cells.

The brief description of some of the VVPSS components related to stress analysis of relief line is given below and shown in
Figure 4-1 and **Figure 4-2**. Detail descriptions and functions of VVPSS components can be referred in higher MQP level documents.

a) Vapour Suppression Tanks (VSTs)
The main function of the vapour suppression tanks is to condense the steam released in the Vacuum Vessel following LOCA. There are four VSTs belonging to VVPSS and all of them are located in the Drain Tank Room (DTR). One VST is dedicated to condense the steam carried by DN 300 relief line and it called as Small LOCA Tank (SLT). Three VSTs are dedicated to condense the steam carried by DN 500 relief line. These are called as large LOCA tanks (LLTs)
b) DN 300 Relief Line
DN 300 relief line connects the Vacuum Vessel volume to Small LOCA Tank through the Bleed Valve assembly. It manages small leaks. Bleed Valve assembly consists of two sets of redundant bleed valves. The bleed valves open at pre-set pressure and plays a safety role for small accidents.
c) DN 500 Relief Line
DN 500 relief line connects the Vacuum Vessel volume to three Large LOCA tanks through Rupture Disk assembly. It manages large leaks. Rupture disk assembly consists of two sets of redundant rupture disks, which open at pre-set pressure. DN 500 relief line is connected to each of the three LLTs through DN 300 branches.
d) Suppression Tank Venting System (ST-VS)
Provides a venting function to remove the non-condensable gases accumulating in the VSTs and to maintain a pressure cascade in case of LOVA.
e) HMS line
DN 150 HMS line with assembly of isolation valves connects DN 300 relief line to HMS. It is connected to DN 300 relief line at the downstream of the bleed valve assembly.
f) DN 200 Line
DN 200 line with assembly of isolation valves connects the DN 300 relief line at downstream of the bleed valve assembly to the DN500 relief line at downstream of the rupture disk assembly. It is operated to maintain dynamic confinement for some LOCA+LOVA events.

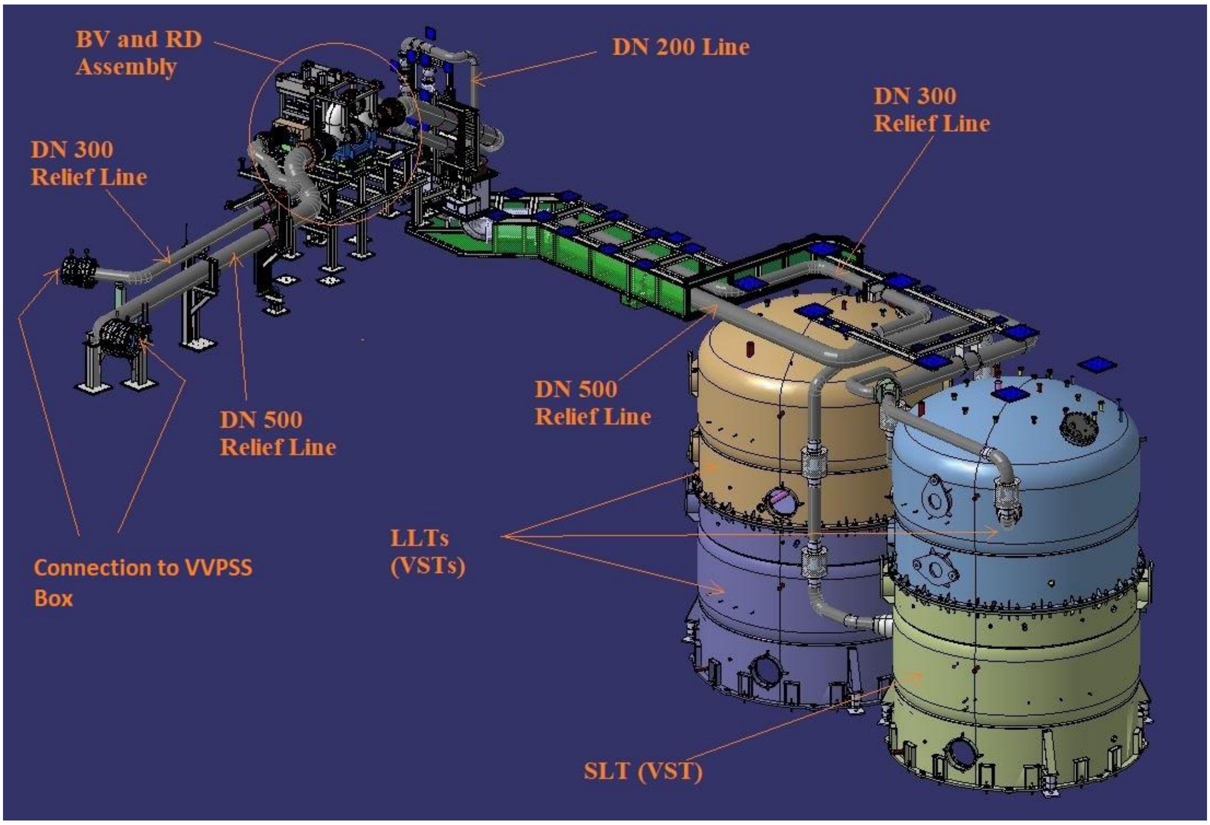


Figure 4-1: General Arrangement of the VVPSS Relief Lines

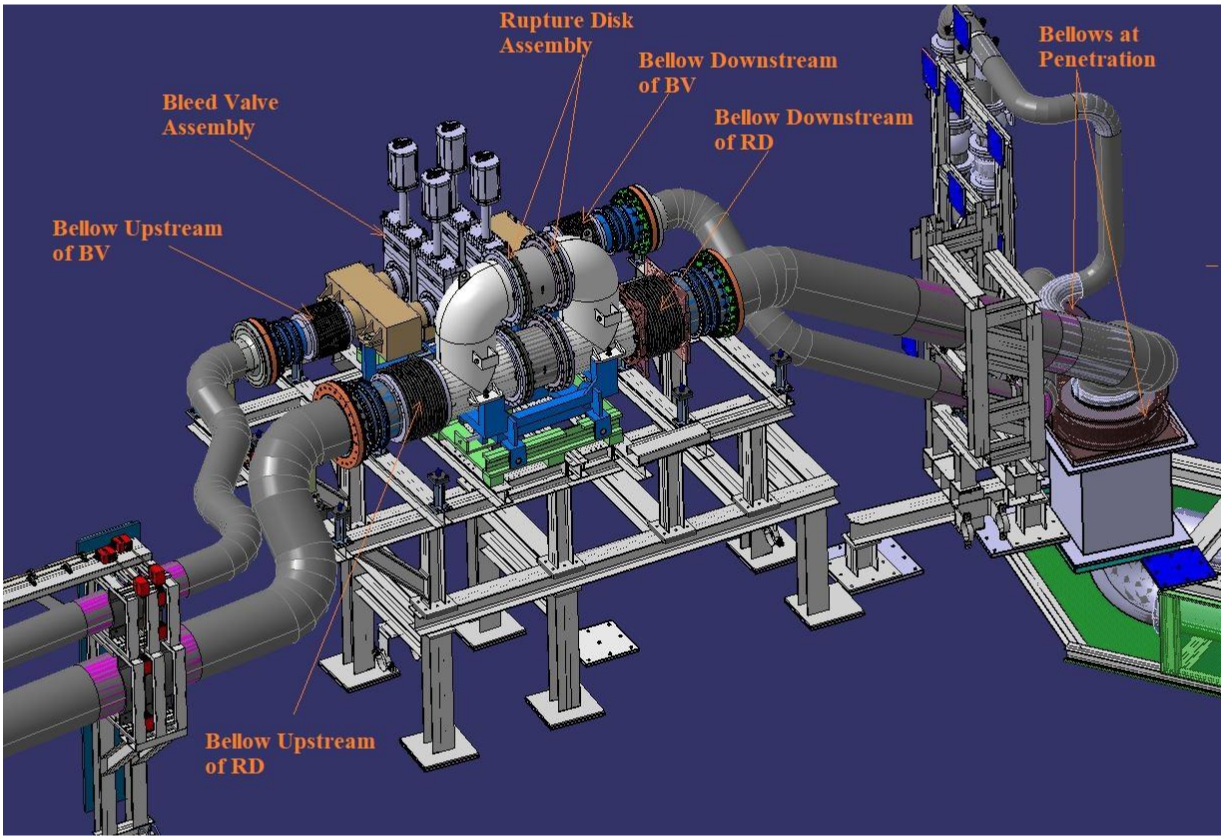


Figure 4-2: General Arrangement of the Bleed Valve and Rupture Disk Assemblies

5.0 CAESAR MODEL

The stress analysis of VVPSS relief lines has been performed using Caesar II software. Piping stress analysis using Caesar is based on finite element analysis, wherein each element is a mathematical representation of actual piping geometry with respect to its stiffness, boundary conditions and the loadings.

Figure 5-1 shows the Caesar model of VVPSS relief lines. Relief lines and their components have been modelled in Caesar based on the geometry defined in 3DXML file [4]. Standard elements of Caesar have been used to model pipes, elbows, bellows and rigid elements (valves & flanges). Appropriate boundary conditions have been used to simulate actual degrees of freedom for the piping nodes representing pipe supports and nozzle connections. Following paragraphs describe the Caesar model and associated inputs in detail.

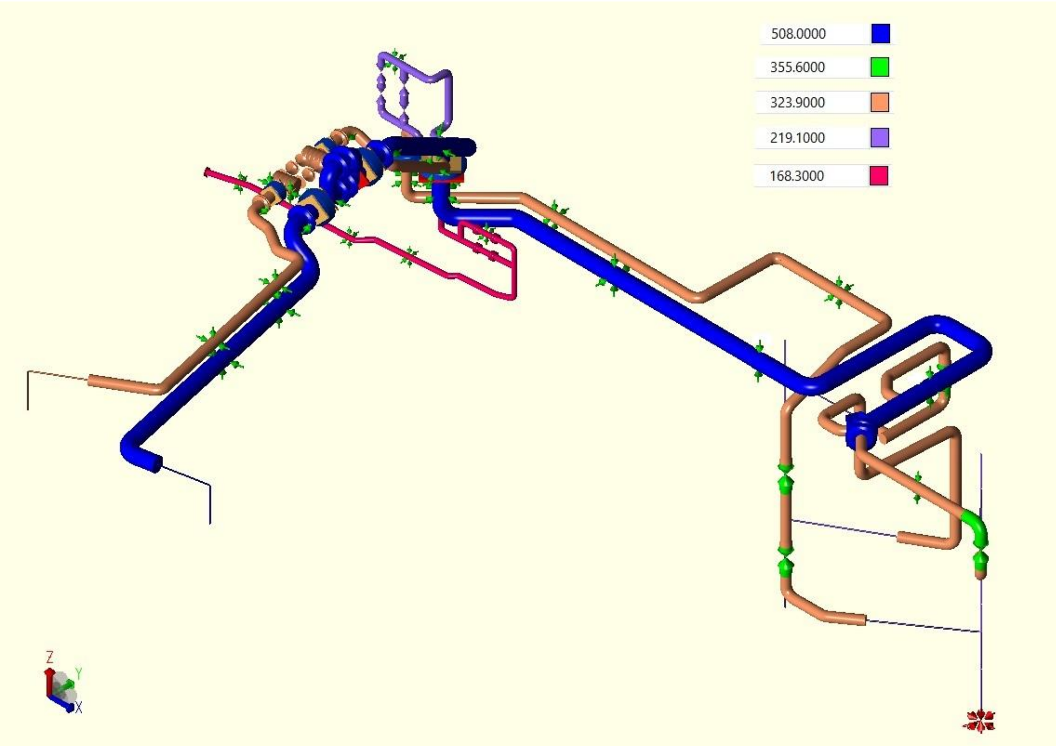


Figure 5-1: Caesar Model with Pipe Sizes

5.1 Piping Components

5.1.1 Pipes

Straight pipe lengths of relief lines have been modelled with standard pipe element of Caesar. This element has 6 degrees of freedom at each node. The loads that can be applied on pipe element include forces and moments at nodes, internal pressure and temperature of the pipe wall. In addition to this, it is possible to include self-weight of pipe material, weight of insulation and weight of fluid contents.

Pipe sizes used for analysis are given in **Table 5-1**. These are based on actual measurements in [4] and the process flow diagram extracted from [1] and shown in **Figure 5-2**.

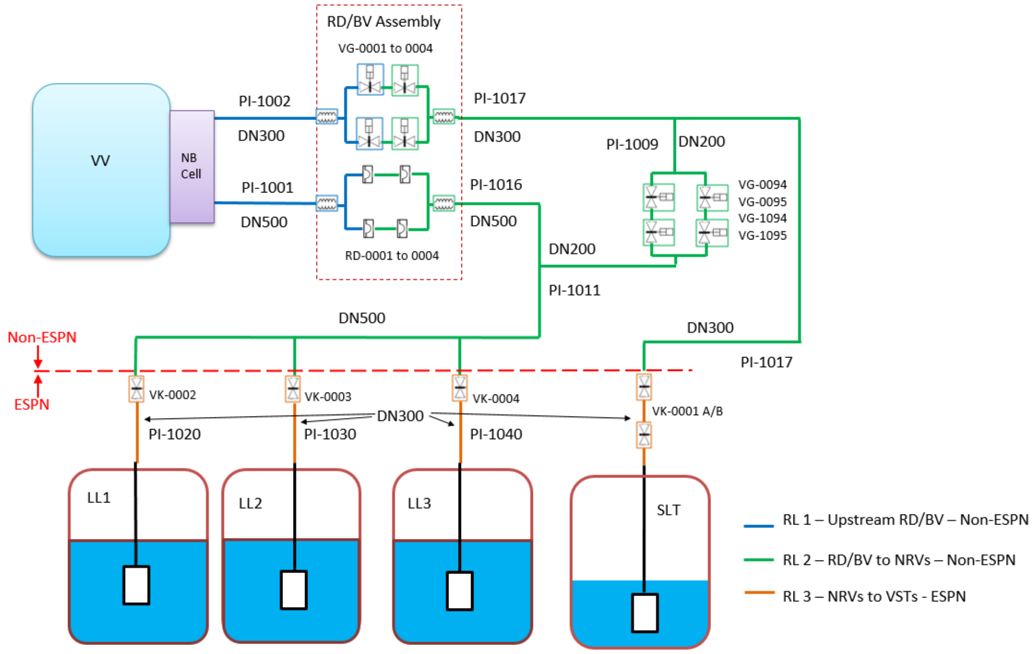


Figure 5-2: Process Flow Diagram of the VVPSS Relief Line from [1]

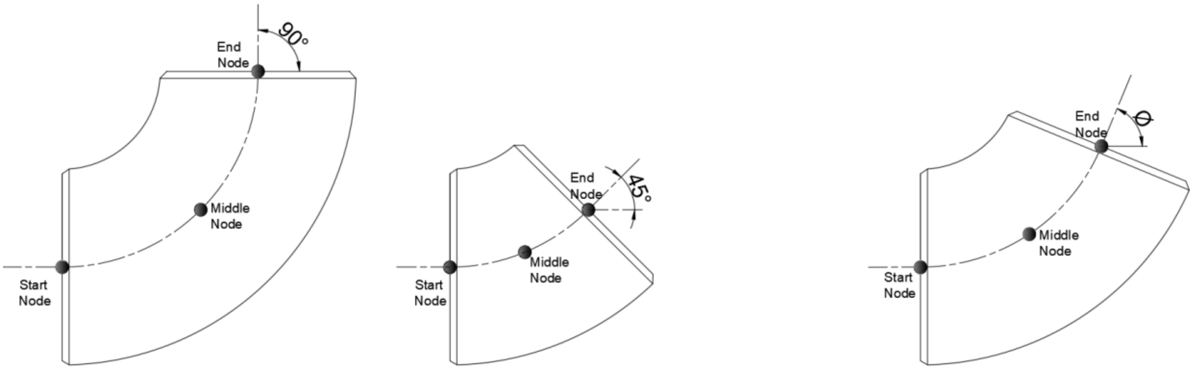
Table 5-1: Line Numbers and Pipe Sizes

Sr. No	Line No.	Pipe Size	OD (mm)	Thickness (mm)
1	PI-1001; PI-1016	DN 500; 80S	508	12.70
2	PI-1002; PI-1017	DN 300; 80S	323.9	12.70
3	PI-1020; PI-1030; PI-1040	DN 300; 80S	323.9	12.70
4	PI-1020; PI-1030; PI-1040 (At NRVs)	DN 350; 80S	355.6	12.70
5	PI-1009	DN 200; 80S	219.1	12.70
6	HMS Line	DN 150; 80S	168.3	10.97

5.1.2 Elbows

Elbows of relief lines have been modelled using a standard ‘Bend’ element of Caesar. **Figure 5-3** shows the various types of elbows used in VVPSS. It includes standard elbows (45^{O} & 90^{O}) as well as some non-standard elbows. **Table 5-2** gives the list of end nodes representing elbows of relief line.

Three nodes (start, middle and end) have been defined for each elbow in the model for the stress analysis. All the elbows are butt-welded elbows, but the elbows, which are within the distance of 2 times the pipe diameter from rigid elements (flange, valve or Y piece) have been modelled as single flanged elbows to take into account their reduced flexibility. Thus elbows at nodes 150, 200, 350, 500, 1050, 1100, 1150, 1400, 3350, 3660, 3800, 3850, 4400, 4700 and 4850 have been modelled as single flanged elbows for mathematical representation only.



Standard Elbows (90º and 45º) **Non-Standard Elbows**

Figure 5-3: Elbows

Table 5-2: Elbows of VVPSS

Bend Node	Bend Angle (φ)	Bend Radius
50	90	SR
100	88.098	SR
150	90	SR
200	30	SR
300	76.503	SR
350	67.382	SR
500	89.5	SR
550	45	SR
650	90.007	SR
700	90	SR
750	90	SR
1050	44.905	SR
1100	89.098	SR
1150	89.703	SR
1400	45	SR
1450	90	SR
1500	89.992	SR
1550	89.995	SR
1580	90	SR
1600	90.096	SR
1700	45	SR
1720	45	SR
1750	90	SR
1790	90	SR
170	90	R=275 mm
180	90	R=275 mm

Bend Node	Bend Angle (φ)	Bend Type
3100	70.153	SR
3200	92.325	SR
3250	45	SR
3300	45	SR
3350	90	SR
3660	90	SR
3670	70.033	SR
3690	65.965	SR
3800	82.871	SR
3850	89.388	SR
3900	45.062	SR
4100	90	SR
4150	90	SR
4200	90	SR
4250	20	SR
4300	69.353	SR
4400	90	SR
4450	34.999	SR
4600	75.788	SR
4700	90	SR
4850	90	SR
4950	90	SR
5000	90	SR
5050	90	SR
5100	95.692	SR

*SR = short radius elbow

5.1.3 Bellows

Bellows have been used in VVPSS due to system's functional requirements. Bellows at the upstream and downstream of bleed valves and rupture disks have been incorporated due to remote handling requirements. Bellows at the penetrations have been used to isolate the areas (DTR and NB cell). These bellows have been pre-selected based on pressure ratings (refer **Table 5-3**) and hence are the input for the stress analysis.

Bellows being flexible elements, have the capability to absorb large displacements and relieve the piping of displacement stresses (secondary stresses) such as those arising due to thermal loads.

It may be noted that bellow design and manufacturing is an art mastered by manufacturers through years of practice and experiments. Each manufacturer adopts its own unique bellow shape, material, fabrication method, testing scope and qualification procedure to produce safe bellows for applications within their published limitations. The role of piping engineer is to ensure that the bellow characteristics (specifically spring rates and pressure thrust forces) are included in the piping analysis and to ensure that the resultant bellow deformations from relative piping movements are within the manufacturer's limitations.

Another criterion to be considered when using bellows is their stability, which depend on the eccentricity generated due to end rotations. Here again, role of piping engineer is to ensure that the end rotation limits prescribed by the manufacturer are not exceeded. Beyond that, we rely on the manufacturer to ensure stability of bellows.

Witzenmann bellows have been selected for VVPSS relief lines [1]. **Table 5-3** shows the manufacturers specification for bellows.

Table 5-3: VVPSS Bellow Specifications

Sr. No.	Bellow	Selected type
1	Penetration of DN 500 Pipe Internal Bellow External Bellow	 ARN 02.0700.080.0 ARN 02.0800.084.0
2	Penetration of DN 300 Pipe Inner Bellow Outer Bellow	 ARN 02.0500.068.0 ARN 02.0600.076.0
3	DN 300 Pipe (Near Bleed Valves) Inner Bellow Outer Bellow	 ARN 06.0300.165.0 ARN 02.0400.210.0*
4	DN 500 Pipe (Near Rupture Disks) Inner Bellow Outer Bellow	 ARN 06.0500.215.0 ARN 02.0600.228.0

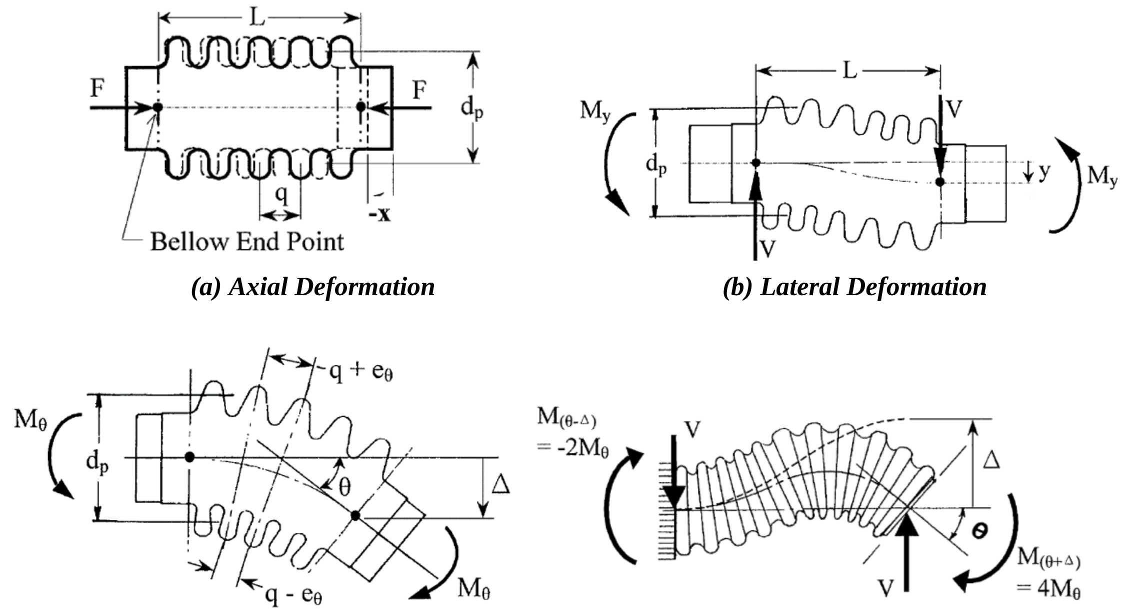
(** ARN 02.0400.210.0 bellow has been considered for analysis instead of ARN 02.0350.210.0 mentioned in v2.3 of [1] as DN 350 bellow is dimensionally incompatible as outer bellow*)

All the bellows have been incorporated in Caesar model using 'Expansion Joint' element of Caesar. Each bellow element has axial, two lateral, two rotational and torsional stiffness. The stiffness (spring rates) values are provided by the manufacturer in the catalogue.

Only the axial and lateral stiffness values provided by the manufacturer have been used for the stress analysis. **Rotational (bending) stiffness provided by the manufacturer has not been**

used in the analysis. This is due to fact that rotational stiffness provided by the manufacturer is based on pure rotation only. In actual condition, lateral deflection also causes rotation as bellow ends are fixed to the straight pipe. Thus, combined effect of pure rotation and rotation due to lateral deflection needs to be considered in the analysis. Caesar has the capability to incorporate this combined effect if the option is activated.

The general theory of expansion joints (bellows) is explained below briefly. Various modes of deformation of bellows are shown in **Figure 5-4.**



(a) Axial Deformation *(b) Lateral Deformation*

(c) Pure Rotation *(d) Rotation with effect of lateral deflection*

Figure 5-4: Bellow Deformation Modes

Axial Stiffness (K_X)

Axial stiffness is the basic stiffness of the bellow. It depends on basic property of bellow, called as working spring rate of single convolution (f_w) expressed in N/mm.

The axial force (F) is related to axial displacement (x) by: $F = (K_x).x$ where K_x is the axial stiffness in N/mm.

K_x is given by $K_x = f_w/N$ where N are number of convolutions of bellows.

All other stiffness values can be expressed in terms of axial stiffness based on bellow flexible length (L) and bellow pitch or effective diameter (d_p).

Axial stiffness values provided in the manufacturer's catalogue have been used for analysis.

Lateral Siffness (K_L)

The lateral force (V) is related to lateral displacement (y) by: $V = (K_L).y$ where K_L is the lateral stiffness in N/mm.

K_L is related to K_x by:

$$K_L = \frac{3}{2}\left(\frac{d_p}{L}\right)^2 K_x$$

The lateral stiffness values supplied by the manufacturer is well aligned with the theory and hence have been used.

Rotation Stiffness Rate (K_R)

The rotational moment (M_θ) associated with free rotation (θ *radians*) is given by: $M_\theta = (K_R).\theta$ where K_R is rotational stiffness (N.mm/rad)

The rotational stiffness (K_R) is related to K_x by:

$$K_R = \frac{d_p^2}{8} K_x$$

Manufacturer's catalogue provides this value of rotational stiffness (K_R). However, as discussed before, the combined effect of pure rotation and rotation due to lateral displacement needs to be considered in the analysis. Thus, the rotational stiffness value supplied by the manufacturer has not been considered for the analysis. Instead, option has been activated in Caesar to consider overall rotational stiffness, which is internally calculated by Caesar. The pure rotation of bellow is shown in **Figure 5-4**c and the rotation of effect with lateral deflection is shown **Figure 5-4**d.

As mentioned earlier, each bellow has been modelled in Caesar using 'Expansion Joint' element. The properties used for these elements are based on manufacturer's catalogue [12] and these are listed in tables from **Table 5-4** to **Table 5-9**.

The details of Caesar model node numbers are shown in figures from **Figure 5-5** to **Figure 5-10**.

Application of Pressure Thrust Force

CAESAR has an inbuilt capability to apply the pressure thrust force generated due the expansion joint, if the value of effective ID is specified in the input. Internally calculated thrust force equal to the pressure multiplied by the effective area of the bellows is applied automatically at the two nodes that define the expansion joint.

Hence, pressure thrust forces for various load cases have not been applied externally.

Although in practical sense, pressure thrust force acts on the next elbow after the expansion joint, application of the thrust force at the bellow node does not create major difference in stress analysis results.

a) NB Cell to DTR Penetration of DN 500 Pipe

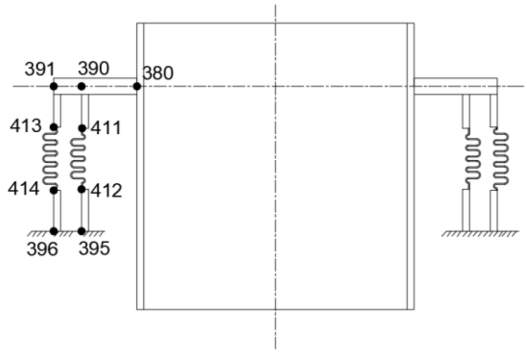


Figure 5-5: Node Numbering of Bellow at penetration of DN 500 Pipe

Table 5-4: Properties of Bellow at penetration of DN 500 Pipe

Bellow	Total Length	Length flexible	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 02.0700.080.0	340	112	197	12990	4312	740.96	40	2	6
Outer Bellow ARN 02.0800.084.0	348	116	197	15687	5575	842.51	42	1.95	5.5

b) NB Cell to DTR Penetration of DN 300 Pipe

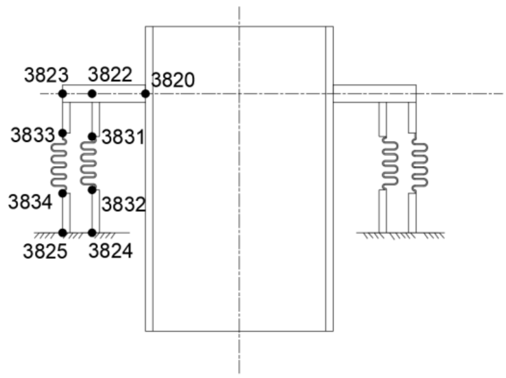


Figure 5-6: Node numbers of bellows at penetration of DN 300 Pipe

Table 5-5: Properties of bellows at penetration of DN 300 Pipe

Bellow	Total Length	Length flexible	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 02.0500.068.0	320	92	210	10641	2244	534.28	34	1.95	7
Outer Bellow ARN 02.0600.076.0	332	104	205	11569	3192	637.51	38	2.05	6.5

c) Bellows at upstream of Bleed Valves

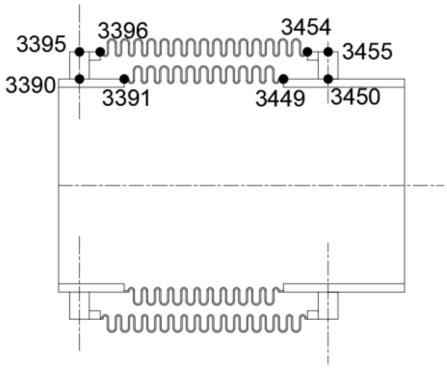


Figure 5-7: Node numbers of bellows at upstream bleed valves

Table 5-6: Properties of bellows at upstream of bleed Valves

Bellow	Length Total	Length flexible	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 06.0300.165.0	426	242	182	564	927	343.6	82.5	19	22
Outer Bellow ARN 02.0400.195.0	499	315	62	173	1439	428.04	97.5	24	19.5

d) Bellows at downstream of Bleed Valves

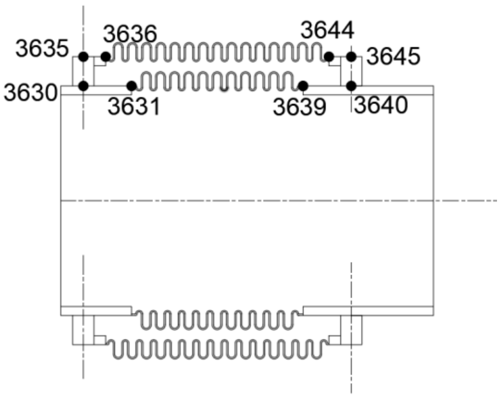


Figure 5-8: Node numbers of bellows at downstream of bleed valves

Table 5-7: Properties of bellows at downstream of bleed valves

Bellow	Length Total	Length flexible mm	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 06.0300.165.0	426	242	182	564	927	343.6	82.5	19	22
Outer Bellow ARN 02.0400.195.0	499	315	62	173	1439	428.04	97.5	24	19.5

e) Bellows at upstream of Rupture Disks

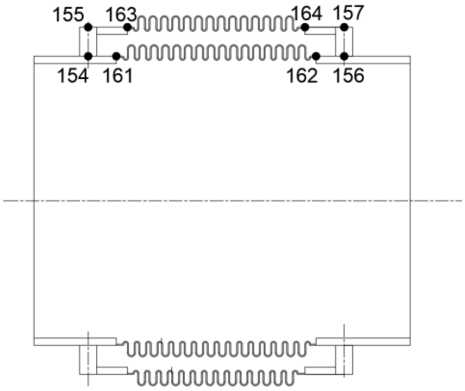


Figure 5-9: Node numbers of bellows at upstream rupture disks

Table 5-8: Properties of bellows at upstream rupture disks

Bellow	Length	Length flexible	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 06.0500.215.0	579	351	209	737	2248	534.99	107.5	23.5	17.5
Outer Bellow ARN 02.0600.228.0	540	312	68	431	3192	637.51	114	18.5	16

f) Bellows at downstream of Rupture Disks

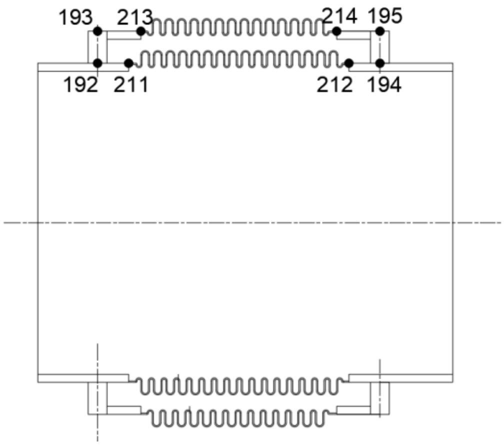


Figure 5-10: Node numbers of bellows at downstream rupture disks

Table 5-9: Properties of bellows at downstream rupture disks

Bellow	Length	Length flexible	Axial Stiffness (N/mm)	Lateral Stiffness (N/mm)	Effective Area (cm^2)	Effective Diameter (mm)	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (degrees)
Inner Bellow ARN 06.0500.215.0	579	351	209	737	2248	534.99	107.5	23.5	17.5
Outer Bellow ARN 02.0600.228.0	540	312	68	431	3192	637.51	114	18.5	16

5.1.4 Valves and Flanges

Valves and flanges have been modelled as rigid elements. Their weights as mentioned in **Table 5-10** have been considered for the stress analysis.

Table 5-10: Weights of Valves and Flanges

Sr. No.	Component	Elements	Weight
1	DN 200 Valves VG-0094, 0095, 1094, 1095	4760-4780; 4720-4740; 4820-4840; 4670-4690	350 kg
2	DN 300 Bleed Valves VG-0001, 0002, 0003, 0004	3500-3510; 3520-3530; 3570-3575; 3580-3585	340 kg
3	VK-0001 A/B, VK-0002, 0003, 0004	4330-4340; 4370-4380; 1765-1775; 1530-1535; 1110-1120	320 kg
4	DN 500 Rupture Disks RD-0001, 0002, 0003, 0004	171-174; 178-181; 173-172; 175-177	350 kg
5	Y piece	800-1350-1000	265 kg
6	DN 300 Flange Assembly	3360-3370; 3370-3380; 3646-3650; 3650-3655	65 kg
7	DN 500 Flange Assembly	151-152; 152-153; 197-196; 196-201	130 kg
8	Rectangular box near BVs		155 kg

5.2 Support Boundary Conditions

Appropriate boundary conditions have been applied to the nodes in the Caesar model representing nozzles and supports. These are described in detail in following paragraphs

a) Nozzles of VSTs.

Nozzles at VSTs are the anchor points for the piping stress analysis. Nozzles are associated with anchor motions (thermal and seismic). Each VST has been modelled as vertical rigid link at the centre line of VST as shown in **Figure 5-11**. The bottom node of rigid link represents the tank base anchor and hence all 6 degrees of freedom have been fixed at this node. The vertical rigid link is connected to the nozzle point by horizontal rigid link representing the radius of the tank.

To calculate the thermal anchor motion, tanks have been conservatively assigned the temperature of RL-3 portion of the relief line. Thus, for a given operating condition, thermal anchor motions are automatically calculated and taken into account for the expansion stresses of the pipe.

Displacements due to seismic anchor motions are applied at the fixed anchor point representing the tank base.

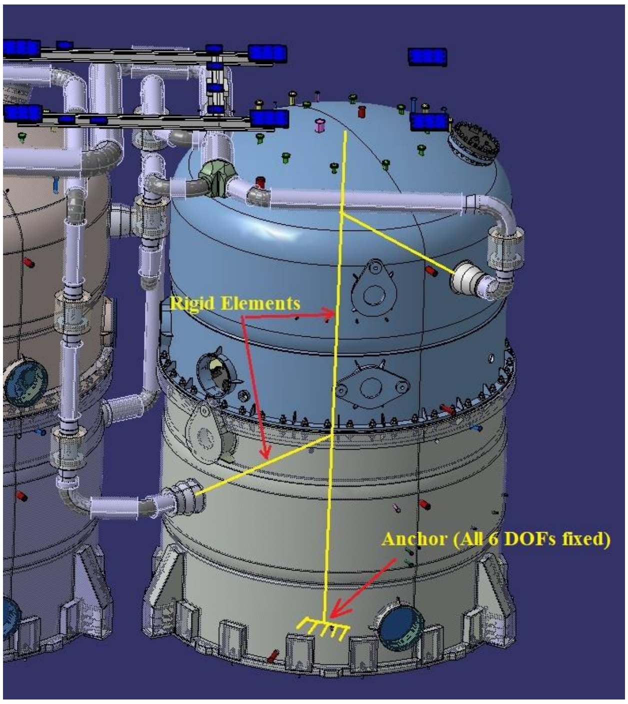


Figure 5-11: Boundary Conditions at the nozzle of VSTs

b) Connection to VVPSS Box

At the interface between the Vacuum Vessel and the VVPSS system, each relief line will be connected to a separate interface box called as VVPSS Box. As described for VSTs, each VVPSS box has been also modelled in Caesar through rigid elements. The rigid element representing VVPSS box have been anchored at the bottom node, which represents fixation of frame of box trolley. The rigid elements have been conservatively assigned temperature corresponding to RL-1 section of the relief line. This takes into account thermal anchor motion of the nozzle connections of the relief lines. The seismic anchor motions are applied through the fixation point of VVPSS box.

The current design of the VVPSS Box interface with VV will not provide any impact from VV ports to VVPSS relief piping system.

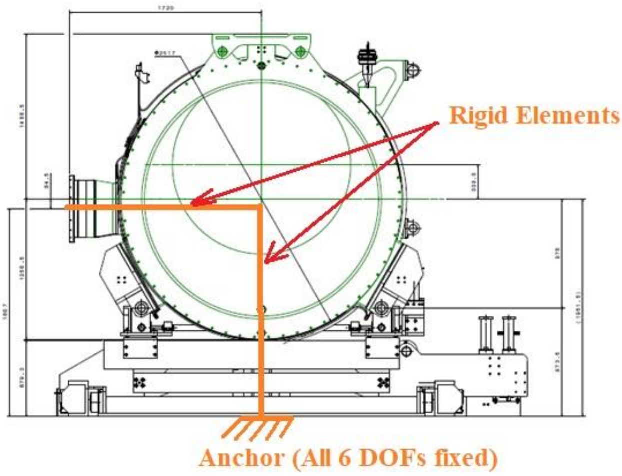


Figure 5-12: Boundary Conditions at the nozzles of VVPSS box.

c) ***Supports upstream of Bleed Valves / Rupture Disks***

Figure 5-13, shows the supports at upstream of bleed valves and rupture disks. In the stress analysis, these supports have been assumes as ***lateral restraint*** (bidirectional) ***plus vertical restraint*** (bidirectional) as indicated in this figure. (Vertical restraint is perpendicular to the pipe axis and not to the floor).
Final configuration of primary supports shall be adopted in accordance with the assumed boundary conditions.

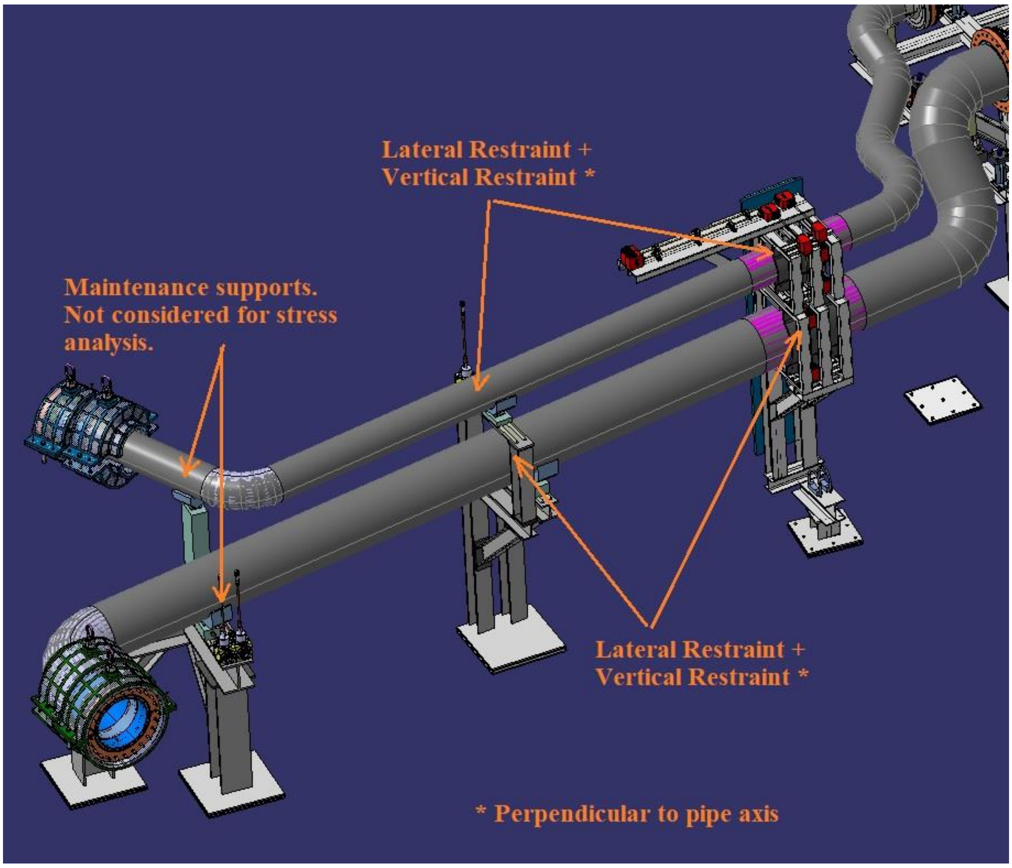


Figure 5-13: Boundary Conditions at supports upstream of BVs/RDs

d) Supports around BVs and RDs

Boundary conditions assumed for the supports around the rupture disks and bleed valves are shown in **Figure 5-14**. These are described below.

1) One directional ***axial restraints*** have been assumed at the four locations at flanges of the BV/RD assembly. These restraints permit the pipe movement only in one direction towards the bellows. Pipes are not permitted to move in the opposite direction.
2) At the boxes upstream of Bleed Valves, supports have ***vertical restraint*** (bidirectional) plus the ***lateral restraint*** (bidirectional). Gap of 2 mm has been assumed for lateral restraint. This gap is required to accommodate the thermal expansion of box itself along its longitudinal direction.
3) At the boxes downstream of Bleed Valves, supports assumed are ***axial restraint*** (bidirectional) ***plus vertical restraint*** (bidirectional) ***plus the lateral restraint*** (bidirectional). Gap of 2 mm has been assumed for the lateral restraint. This gap is required to accommodate the thermal expansion of the box itself.

4) At the upstream of Rupture Disks, supports have ***vertical restraint*** (bidirectional) plus ***lateral restraint*** (bidirectional).
5) At the downstream of Rupture Disks, ***anchor supports*** have been assumed i.e. all six DOFs have been fixed.

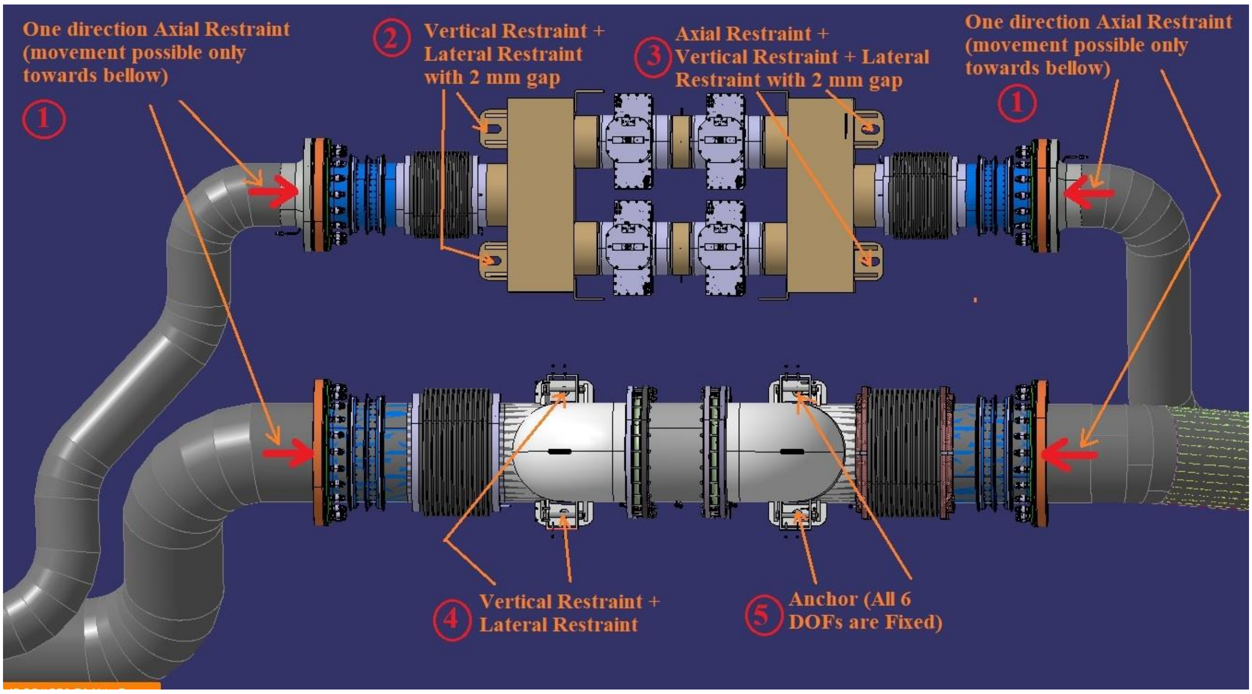


Figure 5-14: Boundary Conditions around BVs/RDs

e) Supports between Bleed Valves/Rupture Disks and DTR penetration

Figure 5-15 shows the supports between BVs/RDs and DTR penetration. These supports have been considered as ***lateral restraint*** (bidirectional) ***plus vertical restraint*** (bidirectional) in the stress analysis as indicated in this figure. (The vertical restraint is perpendicular to the pipe axis and not to the floor).

Final configuration of primary supports shall be adopted in accordance with the assumed boundary conditions.

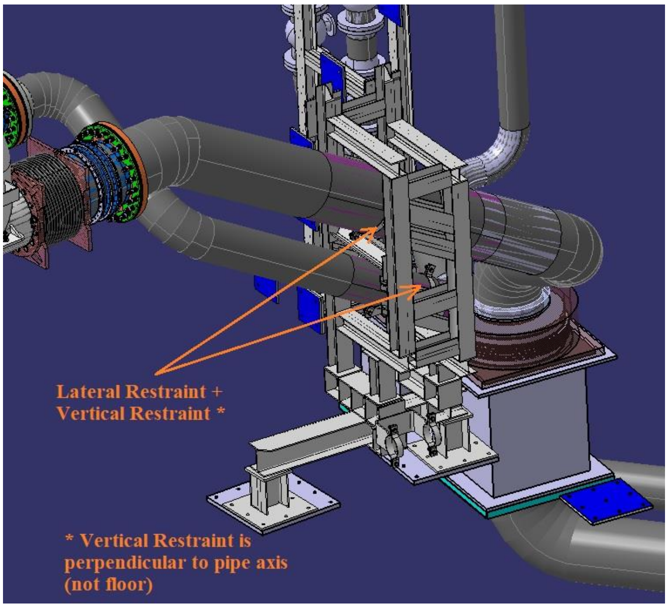


Figure 5-15: Boundary Conditions between BVs/RDs and DTR penetration

f) Supports between DTR penetration and VSTs

Boundary conditions assumed for the supports between DTR penetration and VSTs are shown in **Figure 5-16**. These are described below.

1) Three supports marked as '1' have been assumed as ***lateral restraint*** (bidirectional) ***plus vertical restraint*** (bidirectional).
2) Support marked as '2' has been assumed as ***vertical restraint*** (bidirectional).
3) Support marked as '3', is the new support introduced compared to the input 3DXML. The boundary conditions for this support has been assumed as ***vertical restraint*** (bidirectional).
4) Support marked as '4', is the new support introduced compared to the input 3DXML. The boundary conditions for this support has been assumed as ***vertical restraint*** (bidirectional).

The final configuration of primary support at this location shall be adopted as per the assumed boundary conditions.

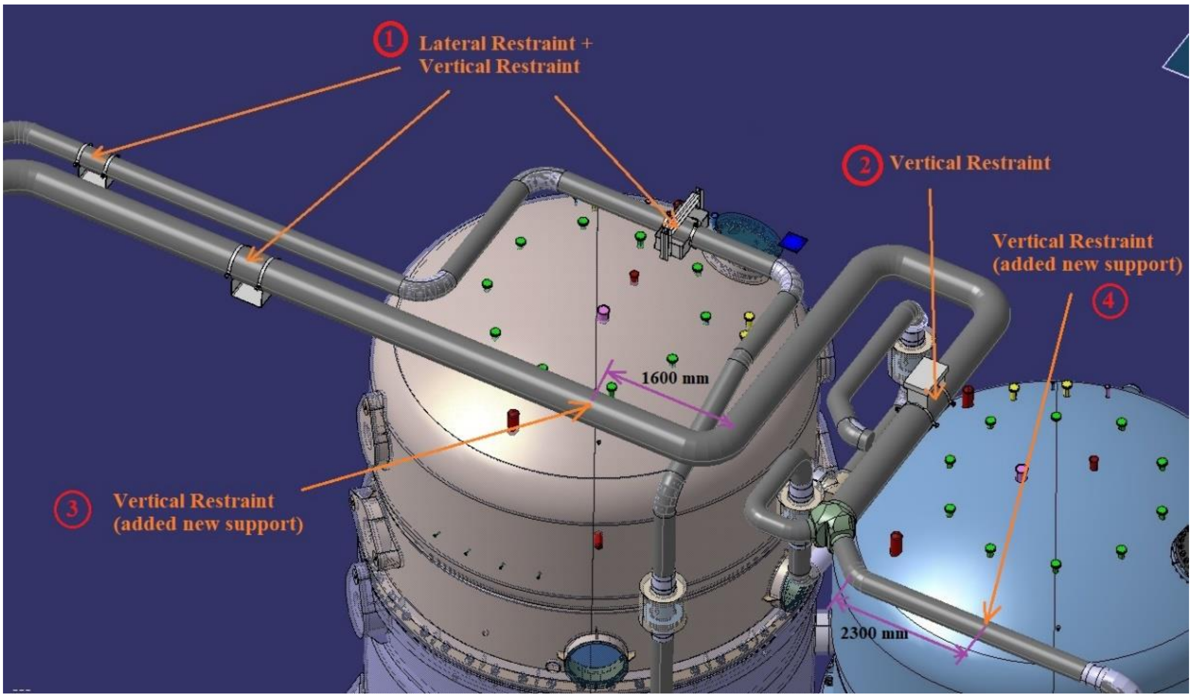


Figure 5-16: Boundary Conditions between floor penetrations and VSTs

g) Supports on DN 200 line

One support has been considered for analysis of DN 200 line as shown in **Figure 5-17**. The boundary conditions assumed at this support are ***lateral restraint*** (bidirectional) ***plus vertical restraint*** (bidirectional).

The final configuration of primary support at this location shall be adopted as per the assumed boundary conditions.

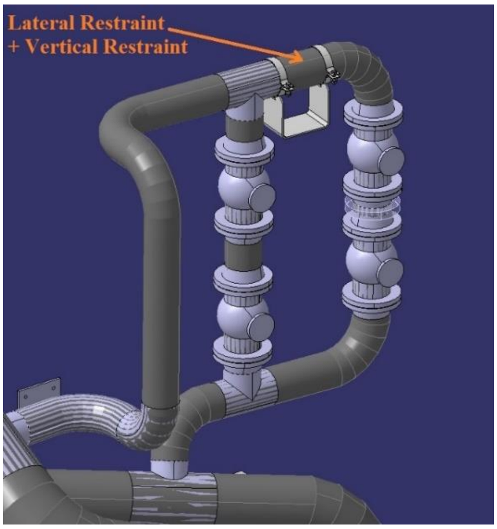


Figure 5-17: Support on Bypass line

Sliding Friction

Inclusion of sliding friction at supports usually affects the distribution of the loads among pipe supports. Stress analysis has been carried for two cases, without sliding friction and with sliding friction at supports. Support loads have been reported for both the cases.
When sliding friction is considered, coefficient of friction has been assumed as 0.3

6.0 MATERIAL

The material of construction of VVPSS relief pipes is ASTM A312 TP 304/304L [1]. It is a Dual Certified Material. Grade TP 304 has higher strength than grade TP 304L. Hence, for stress analysis, properties of grade TP 304 have been used.

The allowable stress values used for piping stress analysis are based on ASME B31.3 Appendix A-1 [5]. These are listed in **Table 6-1**.

Table 6-1: Material Properties [5]

Material	Min. Tensile Strength, MPa	Min. Yield Strength, MPa	Basic Allowable Stress, S, MPa at Metal Temperature,							
			< 40 °C	100 °C	125 °C	150 °C	200 °C	250 °C	300 °C	325 °C
ASTM A312 TP 304	517	207	138	138	138	138	129	122	116	113

7.0 OPERATING CONDITIONS (including accidental events)

Relief lines are subjected to various operating conditions. The term operating condition used here includes normal operation and accidental event conditions. These operating conditions are defined in [1]. For a particular operating condition, applicable loading may or may not be uniform across entire length of the relief line. It depends on whether bleed valves, rupture disks and NRVs are open or close during that operating condition. Due to this, relief lines are divided into following three sub-parts.
RL-1: From Vacuum Vessel to Bleed Valve / Rupture Disk.
RL-2: From Bleed Valve / Rupture Disk to NRVs.
RL-3: From NRVs to VSTs.
The three sub-parts of relief lines are shown in **Figure 7-1**

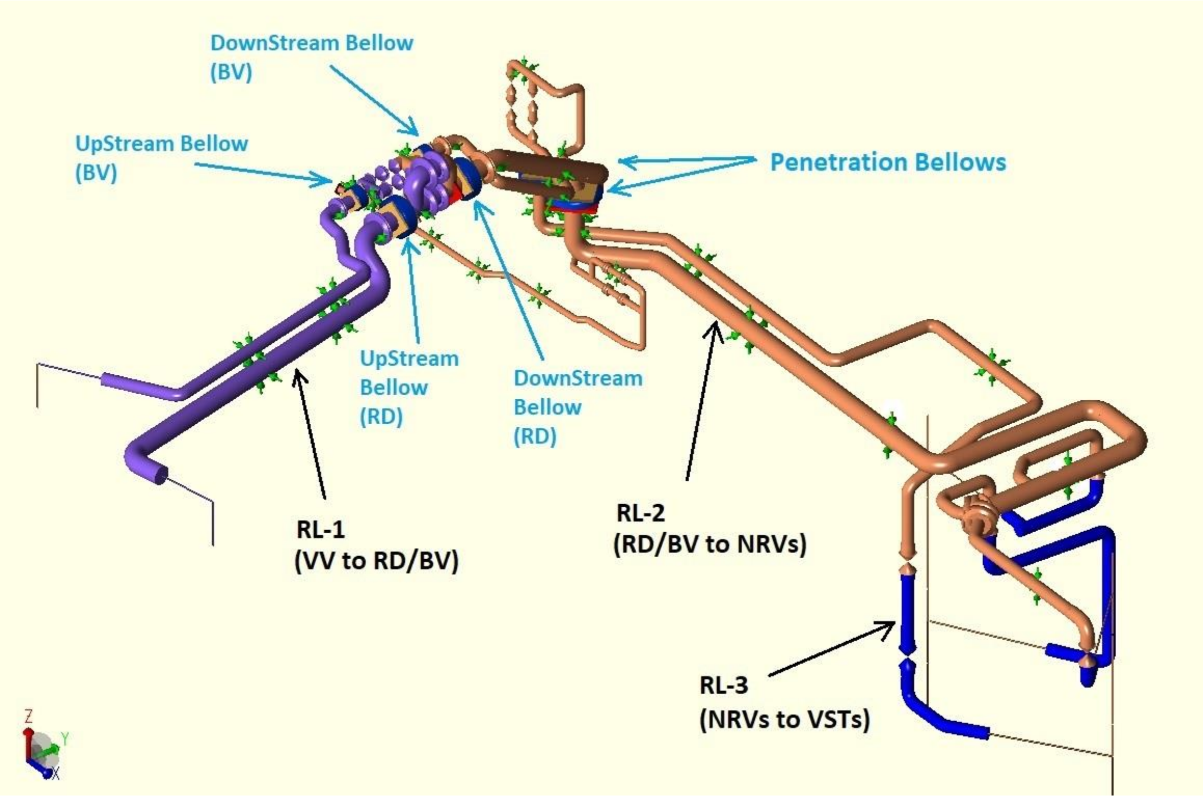


Figure 7-1: RL-1, RL-2 and RL-3 parts of relief lines

Each operating condition has loads in the form of pressure, temperature and mechanical loads. In addition, each operating condition has load category and service level associated with it. Following paragraphs describe the operating conditions considered for stress analysis of relief lines.

7.1 Normal Operation Condition

During normal operation condition, bleed valves and rupture disks are closed. Upstream of bleed valves and rupture disks forms the pressure boundary of vacuum vessel. Temperature of RL-1 will be at 115 ^{o}C whereas temperature of remaining parts of relief lines will be 35 ^{o}C. The internal pressure of entire relief lines will be 0 bar (a). The loads during normal operation condition are summarized in **Table 7-1**.

Table 7-1: Loads during Normal Operation Condition

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P1	-1	-1	-1
Temperature (^{o}C)	T1	115	35	35
Mechanical	W	Dead Weight		

The load category and service level assigned to normal operation condition are:

	Load Spec. No.	*Load Category*	*Service Level*
Normal Operation	*1*	*I*	*A*

Seismic events combined with Normal Operation Condition
Two levels of seismic events (SMHV and SL-2) have been considered in combination with normal operation condition. The load categories and service levels assigned for these events are:

	Load Spec. No.	*Load Category*	*Service Level*
Normal Operation + SMHV	*10*	*III*	*A*
Normal Operation + SL-2	*13*	*IV*	*C*

7.2 Baking Condition

Like normal operation condition, bleed valves and rupture disks are closed for baking condition as well. Upstream of bleed valves and rupture disks forms the pressure boundary of vacuum vessel. Temperature of RL-1 will be 200 ^{o}C whereas temperature of remaining relief lines will be 35 ^{o}C. The loads during baking operation condition are summarized in **Table 7-2**.

Table 7-2: Loads during Baking Condition

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P1	-1	-1	-1
Temperature (^{o}C)	T2	200	35	35
Mechanical	W	Dead Weight		

The load category and service level assigned to baking condition are:

	Load Spec. No.	*Load Category*	*Service Level*
Baking Condition	*5*	*I*	*A*

Seismic events combined with Baking Condition
Three levels of seismic events (SL-1, SMHV and SL-2) have been considered in combination with baking condition. The load categories and service levels assigned for these events are:

	Load Spec. No.	*Load Category*	*Service Level*
Baking Condition + SL-1	*6*	*I*	*A*
Baking Condition + SMHV	*11*	*III*	*A*
Baking Condition + SL-2	*15*	*IV*	*C*

7.3 VVICE II and VVICE III

Vacuum Vessel Ingress of Coolant Events (VVICE) are LOCA events. VVICE II and VVICE III are category II and category III events respectively. VVICE III is more severe than VVICE II.

VVICE II is initiated by a failure of 1 to 10 first wall-cooling pipes, resulting in water ingress into VV, which causes plasma disruption. The BVs on DN 300 relief lines opens and the small steam generation is managed by the operation of small LOCA tank (SLT). The internal pressure assigned to this event is 1.5 bar (a) for entire DN 300 relief line. The maximum temperature expected for DN 300 relief line during this event is 250 ^{o}C.

VVICE III event is the worst conditions corresponding to the discharge from multiple coolant channels affecting one PHTS loop of first wall cooling system or 1-2 coolant channels of the divertor and other in-vessel components. This event will result in bursting of Rupture Disks. The internal pressure assigned to this event is 1.5 bar (a) for entire DN 500 relief line. The maximum temperature expected for DN 500 relief line during this event is 250 ^{o}C.

The loads during VVICE II and VVICE III are summarized in **Table 7-3**

Table 7-3: Loads during VVICE II and VVICE III

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P2	0.5	0.5	0.5
Temperature (^{o}C)	T3	250	250	250
Mechanical	W	Dead Weight		

The load category and service level assigned to VVICE II and VVICE III are:

	Load Spec. No.	*Load Category*	*Service Level*
VVICE II	*7*	*II*	*A*
VVICE III	*8*	*III*	*A*

7.4 LOCA VV-PHTS

This is the event wherein Vacuum Vessel PHTS LOCA occurs in the DTR or NB Cell. During this event, relief lines will be subjected to external pressure of up to 2 bar (a). The maximum temperature of relief can reach 145 ^{o}C.

The loads during LOCA VV-PHTS event are summarized in **Table 7-4**

Table 7-4: Loads during LOCA VV PHTS

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P3	-2	-2	-2
Temperature (^{o}C)	T4	145	145	145
Mechanical	W	Dead Weight		

The load category and service level assigned to LOCA VV PHTS event are:

	Load Spec. No.	*Load Category*	*Service Level*
LOCA VV-PHTS	*9*	*III*	*A*

7.5 VVICE IV and VVICE V

Vacuum Vessel Ingress of Coolant Events (VVICE) are LOCA events. VVICE IV and VVICE V are category IV and category V events respectively. VVICE V is more severe than VVICE IV.

VVICE IV event is considered the worst vacuum vessel ingress of coolant event corresponding to a multiple (>100) break of FW cooling tubes with total break of 0.02 m^2, resulting in three FW/BLK cooling loops spilling inside the VV. An internal pressure of 2 bar (a) could be experienced by the relief line. The maximum temperature expected in the relief lines during this event is 250 ^{o}C.

VVICE V event corresponds to a break size the same as ICE IV, but is coincident with the failure of the VV PHTS isolation valves, which extends the duration of the event and the quantity of water drained into the VV. The ICE V can lead to a saturation of the condensation capacity within the VSTs. In this event, pressure would build until 1.8 bar (a), at which point emergency relief valves located on each VST open to release the pressure to the DTR. An internal pressure of 2 bar (a) within the relief lines has been assumed. The maximum temperature expected in the relief lines during this event is 250 ^{o}C.

The loads during VVICE IV and VVICE V are summarized in **Table 7-5**.

Table 7-5: Loads during VVICE IV and VVICE V

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P4	1	1	1
Temperature (^{o}C)	T3	250	250	250
Mechanical	W	Dead Weight		

The load category and service level assigned to VVICE IV and VVICE V event are:

	Load Spec. No.	Load Category	Service Level
VVICE IV	*12*	*IV*	*C*
VVICE V	*14*	*V*	*C*

Seismic events combined with VVICE V

SL-3 earthquake has been considered in combination with VVICE V event. The load categories and service levels assigned for this combination are:

	Load Spec. No.	Load Category	Service Level
VVICE V + SL-3	*19*	*V*	*C*

7.6 FIRE

Based on fire event analysis, the maximum temperature rise expected in the relief lines is 302 ^{o}C for RL-1 part and 252 ^{o}C for remaining portion. The internal pressure is considered as 0 bar (a)

The loads during Fire event are summarized in **Table 7-6**

Table 7-6: Loads during Fire Event

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P1	-1	-1	-1
Temperature (^{o}C)	T5	302	252	252
Mechanical	W	Dead Weight		

Seismic events combined with Fire event

SL-2 earthquake has been considered in combination with Fire event. The load category and service level assigned for this combination are:

	Load Spec. No.	Load Category	Service Level
FIRE + SL-2	*16*	*IV*	*C*

7.7 LOVA +VVICE

During combine Ingress of Coolant Event (ICE) and Loss of Vacuum Event (LOVA), a significant amount of non-condensable gases including hydrogen is accumulated in the free volume of VSTs (primarily in the SLT but also possible in 3 LLTS). As per the procedure of VVPSS, the controlled combustion of hydrogen is carried out to mitigate the risk of hydrogen explosion. This is called as Deflagration. During Deflagration, sudden pressure rise occurs in the free volume of VSTs. This pressure rise will push back the water stored in VSTs to the relief lines. To prevent water from flowing back to Vacuum Vessel, NRVs have been incorporated in the relief lines, which operates and closes immediately. Sudden closing of NRVs will create a pressure rise in relief lines at NRV. The pressure wave will travel back and forth in the relief line section between NRVs and VSTs creating water hammer loads. The deflagration event in VSTs and closure (functioning) of NRVs is a category II event.

The deflagration event described above is the controlled combustion of hydrogen in VSTs. In the worst case, there is possibility of hydrogen explosion in VSTs. This is called Detonation event. During detonation, pressurise in VSTs will be more than that of deflagration event. Thus, water will be pushed back in relief lines with higher velocity. Closure of NRVs will prevent the water transfer in the vacuum vessel, but due to its sudden closure, water hammer effect will occur in the relief line between NRVs and VSTs. The water hammer pressure waves will be of higher magnitude due to detonation compared to deflagration. The detonation event in the VSTs and closure (functioning) of NRVs is a category IV event.

The possibility of failure of NRVs to operate and close during deflagration and detonation are also considered as accidental event VVPSS. Each of these cases is a category V event. If the NRVs fails to operate, water will flow through relief lines in the form of surge. The surge flow is a transient flow causing impulse on each bend at different instants of time and causing unbalanced load on the piping. Velocities and pressure will be higher for detonation than deflagration and hence surge loads will be of higher magnitude in detonation case than deflagration case.

The loads due to events described are summarized in the following paragraphs.

7.7.1 H_2 **Deflagration** *and NRV operates*

During hydrogen deflagration and proper function of NRVs, pressure rise to 5 bar (a) is limited to RL-3 portion of relief lines. The pressure in RL-1 and RL-2 is 1.5 bar (a). The temperature of 250 ^{o}C is assigned to entire relief lines. The loads during this event are summarized in **Table 7-7.**

Table 7-7: Loads during H_2 deflagration + NRV operational

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P10 (P7 used)	0.5	0.5	4
Temperature (^{o}C)	T3	250	250	250
Mechanical	W+F1	Dead Weight (W) + Water Hammer (F1)		

The load category and service level assigned for this event are:

	Load Spec. No.	*Load Category*	*Service Level*
LOVA + VVICE + H2 Deflagration and NRV operates	*17*	*II*	*A*

7.7.2 H_2 Detonation and NRV operates

During hydrogen detonation and proper function of NRV, pressure rise to 12 bar (a) is limited to RL-3 portion of relief lines. The pressure in RL-1 and RL-2 is 2 bar (a). The temperature of 250 C is assigned to entire relief lines. The loads during this event are summarized in **Table 7-8**.

Table 7-8: Loads during H_2 detonation + NRV operational

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P5	1	1	11
Temperature (^{o}C)	T3	250	250	250
Mechanical	W+F2	Dead Weight (W) + Water Hammer (F2)		

The load category and service level assigned for this event are:

	Load Spec. No.	*Load Category*	*Service Level*
LOVA + VVICE + H2 Detonation and NRV operates	*18*	*IV*	*D*

7.7.3 H_2 Deflagration and NRV fails to close

During hydrogen deflagration and failure of NRVs to close, the surge of water flow will travel from VSTs to up to the vacuum vessel. However, the pressure will fall down as the flow travels towards the vacuum vessel. Thus, different values of pressure have been defined for RL-1, RL-2 and RL-3. These are listed in **Table 7-9**. The temperature has been defined as 250 °C for the entire relief line. Surge impulse loads will act on each bend.

Table 7-9: Loads during H_2 deflagration and NRV fails to close

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P7	1	2	4
Temperature (°C)	T3	250	250	250
Mechanical	WW + F3	Dead Weight (WW) + F3 (Impulse Loads)		

The load category and service level assigned for this event are:

	Load Spec. No.	*Load Category*	*Service Level*
LOVA + VVICE + H2 Deflagration and NRV fails to close	*21*	*V*	*D*

7.7.4 H_2 Detonation and NRV fails to close

During hydrogen detonation and failure of NRVs to close, the surge of water flow will travel from VSTs to up to the vacuum vessel. However, the pressure will fall down as the flow travels towards the VV. Thus, different values of pressure have been defined for RL-1, RL-2 and RL-3. These are listed in **Table 7-9**. The temperature has been defined as 250 °C for the entire relief line. Surge impulse loads will act on each bend.

Table 7-10: Loads during H_2 detonation and NRV fails to close

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P8	1	4	11
Temperature (°C)	T3	250	250	250
Mechanical	W + F4	Dead Weight + F4 (Impulse Loads)		

The load category and service level assigned for this event are:

	Load Spec. No.	*Load Category*	*Service Level*
LOVA + VVICE + H2 Detonation and NRV fails to close	*22*	*V*	*Ultimate failure*

7.8 VV Dust Explosion (L20)

This accident is considered because of VV LOVA, which leads to the mobilisation of hydrogen isotopes and deflagration, which then triggers a dust explosion. The pressure generated by such an event in relief lines is 6 bar (a). The pressure and temperature defined for this event are listed in **Table 7-11**.

Table 7-11: Loads during VV Dust Explosion

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P6	5	5	5
Temperature (°C)	T1	115	35	35
Mechanical	W	Dead Weight		

The load category and service level assigned for this event are:

	Load Spec. No.	Load Category	Service Level
VV Dust Explosion	*20*	*V*	*A*

7.9 LOCA PC III + ICE II

This event represents combination of two events, LOCA in Port Cell and ICE II. The external pressure of relief lines will be 2 bar (a) whereas internal pressure will be 1.5 bar (a). Applicable temperature for entire relief lines is 250 °C.

The loads defined for this event are listed in **Table 7-12**

Table 7-12: Loads during LOCA PC III + ICE II

Load	Assigned Designation	Relief Line		
		VV to RD/BV (RL-1)	RD/BV to NRVs (RL-2)	NRVs to VSTs (RL-3)
Internal Pressure (bars g)	P9	- 0.5	-0.5	-0.5
Temperature (°C)	T3	250	250	250
Mechanical	W	Dead Weight		

The load category and service level assigned for this event are:

	Load Spec. No.	Load Category	Service Level
LOCA PC III+ICE II	*23*	*IV*	*D*

7.10 Integrity at 30 bar pressure

Load specification mentions about the requirement of a special check of relief lines integrity at pressure of 30 bar at a temperature of 120 ^{o}C.

The loads defined for this check are listed in **Table 7-13**.

Table 7-13: Loads for integrity check at 30 bar

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P10	29.0	29.0	29.0
Temperature (^{o}C)	T6	120	120	120
Mechanical	W	Dead Weight		

The load category and service level assigned for this check are:

	Load Spec. No.	*Load Category*	*Service Level*
Integrity at 30 bar	--	*IV*	*D*

7.11 Normal Operation + SL-3

This event represents combination of SL-3 level earthquake with normal operation loads. It addresses the load specification requirement '*SL-3 seismic event will be assessed against Service Level B*'.

The loads defined for this check are listed in **Table 7-14**.

Table 7-14: Loads for Normal Operation + SL-3

Load	**Assigned Designation**	**Relief Line**		
		VV to RD/BV (RL-1)	**RD/BV to NRVs (RL-2)**	**NRVs to VSTs (RL-3)**
Internal Pressure (bars g)	P1	-1	-1	-1
Temperature (^{o}C)	T1	115	35	35
Mechanical	W	Dead Weight		

The load category and service level assigned for this check are:

	Load Spec. No.	*Load Category*	*Service Level*
NO+SL-3	--	*V*	*B*

8.0 SINGLE LOAD CASES

8.1 Dead Weight

Designation: W or WW

Dead Weight includes:

a) Weight of pipes
Density of pipe material is 8027.1 kg/m3 [4].

b) Weight of piping components
Weight of various rigid components such as flanges and valves as defined in **Table 5-10**.

c) Weight of insulation
Insulation thickness is 50 mm and insulation density is 320 kg/m^3 [1]

d) Weight of fluid contents
During most of the operating conditions, fluid will be steam or mixture of steam and air. For few operating conditions such as hydrostatic testing and surge flow during deflagration/detonation, fluid will be water. Total dead weight is designated as W if it includes weight of steam and WW it includes water.
Density of steam = 0.84 kg/m^3 (specific volume of superheated steam at 1 bar (gauge) and 250 C is 1.19096 m^3/kg)
Density of water = 1000 kg/m^3

8.2 Pressure

Designation: P1 to P10

As mention in paragraph 7.0, piping will be subjected to various operating conditions. Each operating condition has a different pressure. The applicable pressures for various operating conditions have been described in subparagraphs of 7.0. These have been tabulated together in **Table 8-1**. This table includes additional columns to show the pressures applicable to internal and external bellows during each operating event.

8.3 Temperature

Designation: T1 to T6

As mention in paragraph 7.0, piping will be subjected to various operating conditions. Each operating condition has a different temperature. The applicable temperatures for various operating conditions have been described in subparagraphs of 7.0. These have been tabulated together in **Table 8-2**. This table includes additional columns to show the temperatures applicable to internal and external bellows.

Table 8-1: Pressure Load Cases

Pressure	**Event**	**Pipes**			**Bellows**			
		VV to RD/BV (RL-1) (bars) gauge	**RD/BV to NRVs (RL-2)** (bars) gauge	**NRVs to VSTs (RL-3)** (bars) gauge	**RD/BV Internal Bellows** (bars) gauge	**RD/BV External Bellows** (bars) gauge	**Penetration Internal Bellow** (bars) gauge	**Penetration External Bellow** (bars) gauge
HP	Hydrostatic test	0 (NA)	25.7	25.7	0 (NA)	0 (NA)	0 (NA)	0 (NA)
P1	a) NO b) Baking c) Fire	-1	-1	-1	0	-1	1	-1
P2	a) VVICE II b) VVICE III	0.5	0.5	0.5	1.5	-1	1	-1
P3	a) LOCA VV-PHTS	-2	-2	-2	0	-2	2	-2
P4	a) VVICE IV b) VVICE V	1	1	1	2	-1	1	-1
Note 1	a) LOVA+VVICE+FA (NRV operates)	0.5	0.5	4	1.5	-1	1	-1
P5	a) LOVA+VVICE+ Explosion+FD (NRV operates)	1	1	11	2	-1	1	-1
P6	a)VV Dust Explosion	5	5	5	6	-1	1	-1
P7	a) LOVA+VVICE+FA (NRV doesn’t operate)	1	2	4	2(Upstream)& 3(Downstream)	-1	1	-1
P8	a) LOVA+VVICE+ Explosion+FD (NRV doesn’t operate)	1	4	11	2(Upstream& 5(Downstream)	-1	1	-1
P9	a) LOCA PCIII+ICEII	-0.5	-0.5	-0.5	1.5	-2	2	-2
P10	Integrity at 30 bar	29.0	29.0	29.0	30.0	-1	1	-1

Note 1: P7 used conservatively

Note 2: Ambient temperature has been assumed as 20 ^{o}C for all the conditions.

Table 8-2: Temperature Load Cases

Temperature	Event	Pipe			Bellows			
		VV to RD/BV (RL-1) (ºC)	RD/BV to NRVs (RL-2) (ºC)	NRVs to VSTs (RL-3) (ºC)	RD/BV Internal Bellows (ºC)	RD/BV External Bellows (ºC)	Penetration Internal Bellow (ºC)	Penetration External Bellow (ºC)
T1	a) NO b) VV Dust Explosion	115	35	35	115(upstream) 35(downstream)	20	20	20
T2	a) Baking	200	35	35	200(upstream) 35(downstream)	20	20	20
T3	a) VVICE II b) VVICE III c) VVICE IV d) VVICE V e) LOVA+VVICE+FA, f) LOVA+VVICE+Explosion+FD, g) LOCA PC III+ICE II	250	250	250	250	20	20	20
T4	a) LOCA VV-PHTS	145	145	145	145	20	20	20
T5	a) FIRE	302	252	252	302(upstream) 252(downstream)	302(upstream) 252(downstream)	252	252
T6	Integrity at 30 bar	120	120	120	120	20	20	20

8.4 Hydrodynamic Impulse Loads

Designation: F3 (Deflagration) and F4 (Detonation)

Hydrodynamic impulse loads arise due to event of LOVA + VVICE described in paragraph 7.7. These loads occur if NRVs fail to operate (close) during controlled combustion/deflagration of hydrogen in VSTs (refer para 7.7.3) and explosion/detonation of hydrogen in VSTs (refer para 7.7.4).

During deflagration, pressure in the VSTs will rise due to controlled combustion of hydrogen. Pressure in VSTs will also rise during detonation event. These pressure rises will be sudden and will push the water back in the relief lines. The NRVs are provided in the relief lines to prevent the water flow being transmitted to the vacuum vessel. However, if the NRVs fail to operate, surge of water flow will travel from VSTs to the vacuum vessel. This is a transient phenomenon. The flow will reach the bends at different time instants sequentially starting from the VST to the vacuum vessel. The force acting at each bend is called as impulse force or end force. The impulse or end force is the combination ($\rho AV^2 + PA$). This force acts at the change of directions of the piping. The term ρAV^2 is the momentum force and PA is the pressure force.

The impulse load acting on bends at different time instants creates the unbalanced loads. This is explained in ***Figure 8-1***. Let us say, flow reaches at node n in time t_n and reaches node n+1 later at time $t_{n+\Delta t}$ i.e. after time interval Δt. During this time interval (Δt), unbalanced force will act on the pipe leg. The piping needs to be analysed for these hydrodynamic forces.

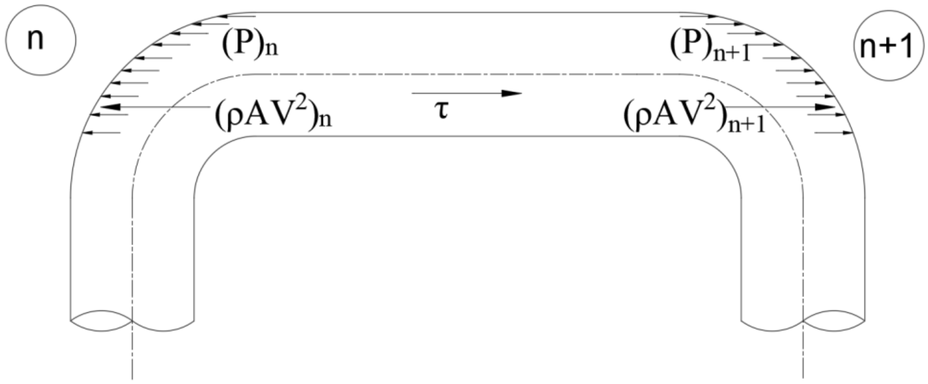


Figure 8-1: Impulse loads acting on a pipe leg [6]

The unbalance force acting along the pipe axis is important rather than the individual forces at each bend. Assuming the flow direction is from n to n+1, the unbalanced force is given by [6]:

$$F = (PA)_n + (\rho AV^2)_n - (PA)_{n+1} - (\rho AV^2)_{n+1} - F_\tau$$

The unbalance force will exist only during the transient condition. In steady state condition, the forces will balance each other, and F = 0.

This unbalance load acting on each pipe leg is a dynamic load and thus the response of the piping system to these loads will involve inertial and damping effects of the system. The equilibrium equation for such dynamic loads is given by:

$$M_p\ddot{x} + C\dot{x} + Kx = F(t)$$

Where, M_p is the pipe leg mass, C is the damping coefficient and K is the stiffness. $F(t)$ represents the force time history. For multi-degree of freedom system, these are actually matrices and vectors corresponding to the degrees of freedom.

One method of calculating system response is by performing equivalent static analysis with applying unbalance force multiplied by DLF (Dynamic load factor) at each leg simultaneously. To get more realistic system response, Time History analysis has been performed. This analysis involves application of the force time history at each change of direction n, n+1, n+2, etc. Caesar II calculates the dynamic response resulting due to unbalance force acting at each instant. There is no need to apply DLFs in this case as systems dynamic response is taken into account in the time history analysis.

The results of thermo-hydraulic analysis during deflagration and detonation events in Small LOCA Tank (SLT) have been provided in [7]. It provides pressure, velocity and mass flow rate of the travelling water surge at various locations in DN 300 relief line due to deflagration / detonation in the SLT. It also provides the time instants at which the surge arrives at these locations of DN 300 relief line. Thus, [7] provides the basic data required to calculate the force time history at each node of DN 300 relief line. **Table 8-3** shows this data for deflagration and **Table 8-6** show this data for detonation. **Figure 8-2** is taken from [7]. It shown the junctions of DN 300 relief line in the fathom model used for thermo-hydraulic analysis.

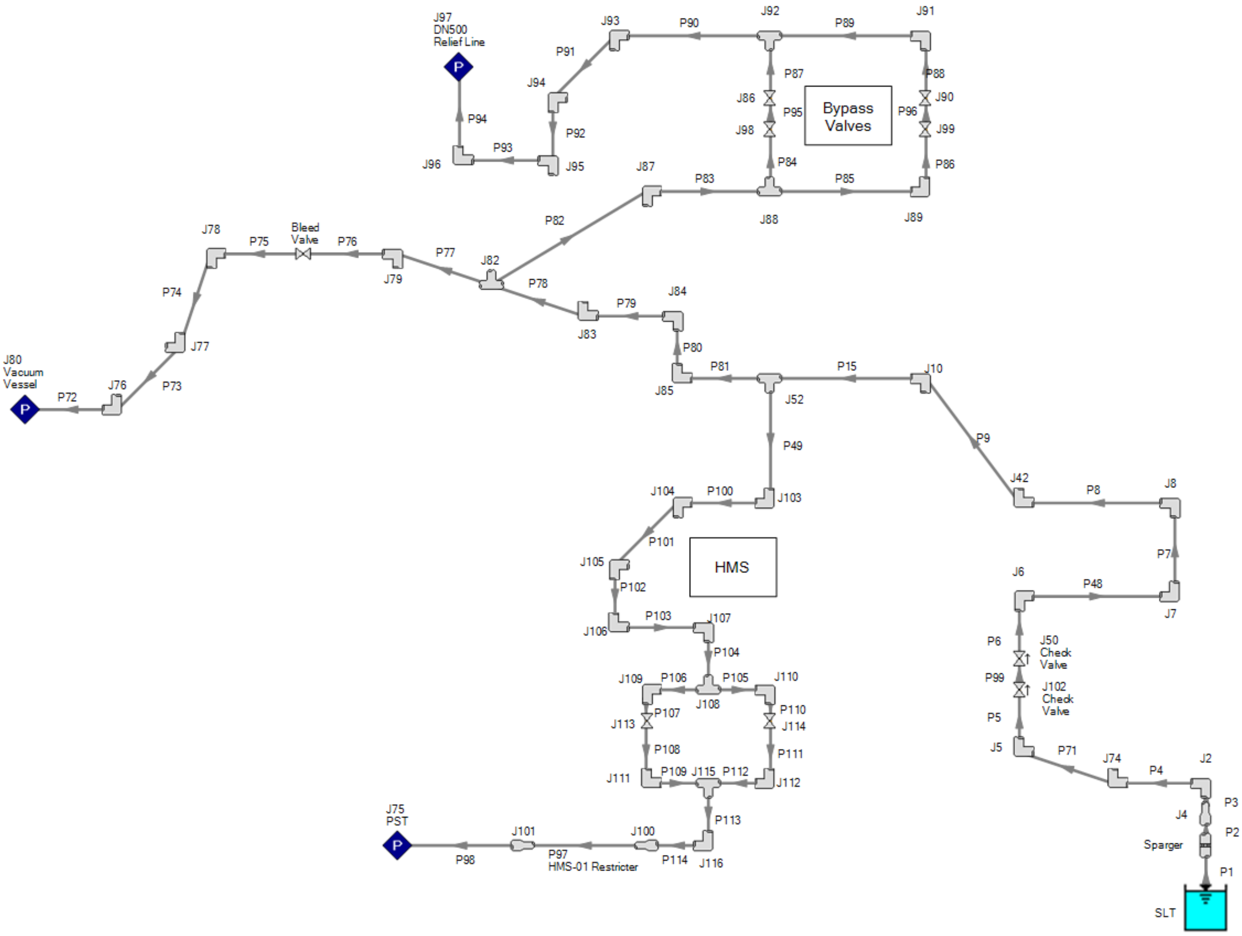


Figure 8-2: Fathom Model [7]

The DN 300 relief line nodes in the Caesar model needs to be correlated with junctions of fathom model. **Figure 8-3** shows the correlation.

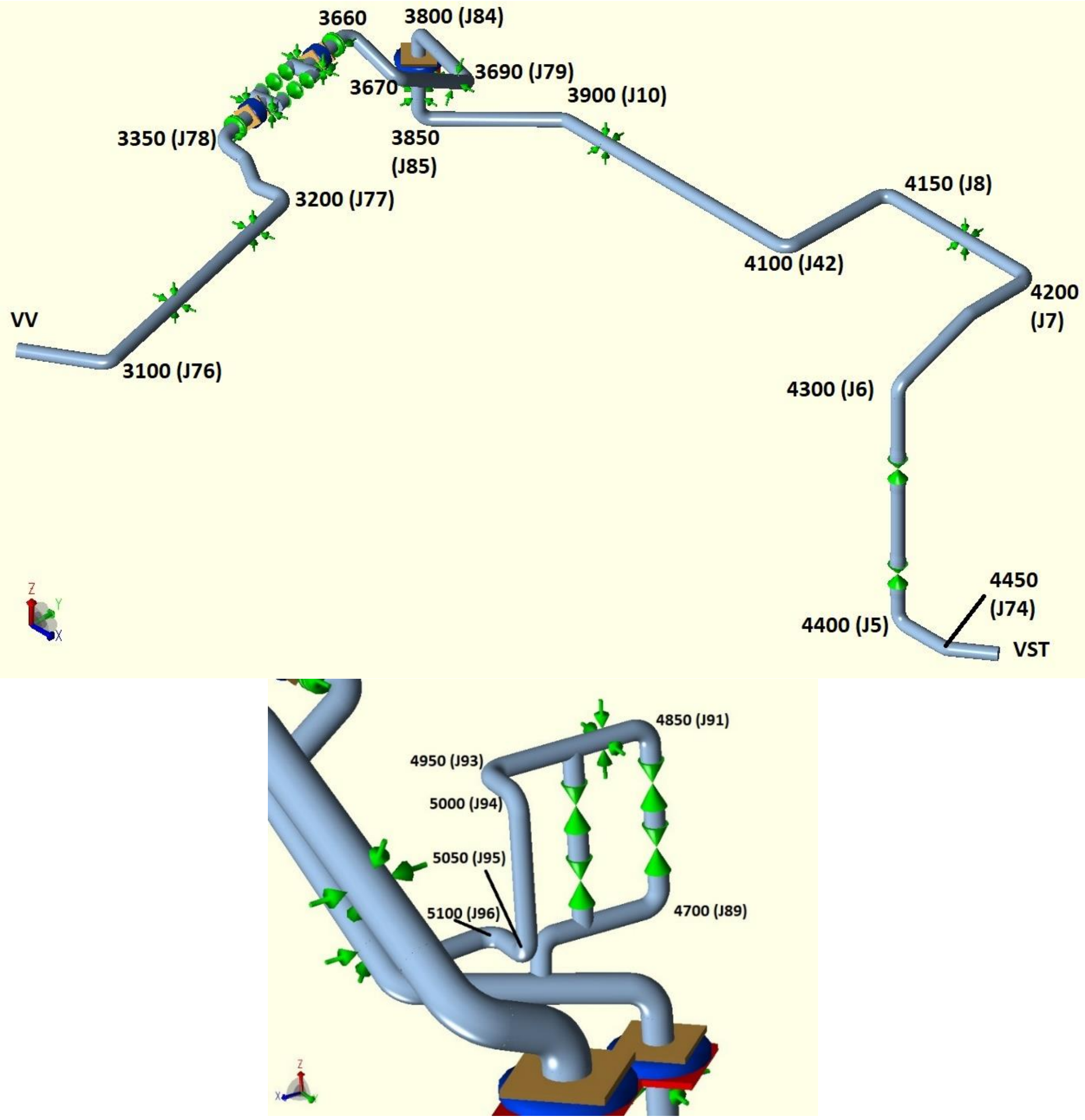


Figure 8-3: Relation between nodes of Caesar Model and Fathom Model

As mentioned earlier, time history analysis has been performed in Caesar to calculate the response of the system due to dynamic unbalanced forces acting at each instant of the time. Time history analysis required input of force v/s time at each bend node of the relief line. The time history profile assumed for this analysis is shown in **Figure 8-4**.

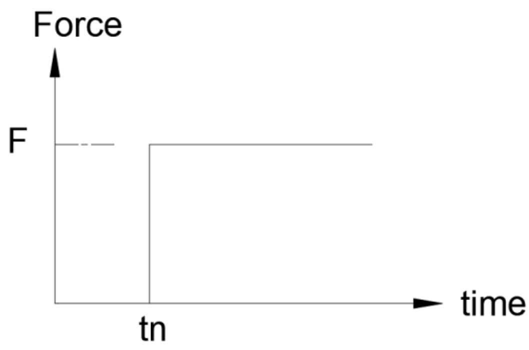


Figure 8-4: Time history profile assumed

The time of arrival (t_n) at each node are listed in **Table 8-3** for deflagration and **Table 8-6** for detonation event.

The impulse loads ($F=F_1=F_2$) acting on a pipe bend can be calculated as shown in **Figure 8-5** and by formula:

$$F = (\dot{m}V + PA)(1 - \cos\theta)$$

$\dot{m}$ is mass flow rate (kg/s) at the node.
V is the velocity (m/s) of water surge at the node.
P is the pressure (N/m^2) of surge at the node.
A is cross section area (m^2) of pipe bend.

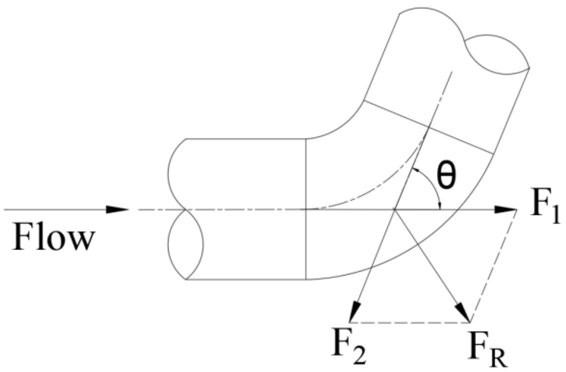


Figure 8-5: Hydrodynamic forces acting at a bend

Based on this principle, the hydrodynamic impulse loads calculated at each bend for deflagration case are listed in **Table 8-4** and for detonation case are listed in **Table 8-7**.

8.4.1 Deflagration

Table 8-3 shows the arrival time, mass flow rate and absolute pressure at various nodes of DN 300 relief line during deflagration event.

Table 8-3: Arrival time, pressure and mass flow rates for deflagration

Caesar Node	Fathom Junction	Flow arrival time (s)	Mass Flow Rate (kg/s)	Pressure Absolute (bars)
4450	J74	0.321	1428	4.211
4400	J5	0.395	1361	4.153
4300	J6	1.089	688	1.912
4200	J7	1.59	619.8	1.787
4150	J8	2.116	619.8	1.67
4100	J42	2.467	619.8	1.568
3900	J10	3.282	619.8	1.427
3850	J85	3.737	619.8	1.308
3800	J84	4.062	545.4	1.003
3690	J79	5.101	345.8	1.003
3670		5.471(1)	345.8 (1)	1.003(1)
3660		5.841(1)	345.8 (1)	1.003(1)
3350	J78	6.209	345.8	1.003(2)
3200	J77	6.525	345.8	1.003(2)
3100	J76	8.544	345.8	1.003(2)
4700	J89	4.725	187.3	0.408(2)
4850	J91	4.854	187.3	0.408(2)
4950	J93	4.849	187.3	0.408(2)
5000	J94	4.987	187.3	0.408(2)
5050	J95	5.012	187.3	0.408(2)
5100	J96	5.038	187.3	0.408(2)

(1) Nodes 3670 and 3660 are not modelled in Fathom. So arrival time has been assumed based on equal intervals between arrival at J79 and J78. Mass flow rates and pressures have been conservatively assumed to be same as J79

(2) The pressure and velocity data is not listed in output report specifically for these junctions. So conservative assumptions are made based on the output data for other pipes/ nodes.

The forces acting on various bends of DN 300 relief line have been calculated and tabulated in **Table 8-4**.

Table 8-4: Forces acting on the bends due to deflagration

Node No	Angle	F = F_1 = F_2 (N)
4450	35	10393.7
4400	90	54505.5
4300	69.35	12869.1
4200	90	17451.6
4150	90	16632.8
4100	90	15919.0
3900	45	4373.6
3850	90	13994.1
3800	90	10853.2
3690	65.965	5073.1
3670	70.033	5636.5
3660	90	8559.3
3350	90	8559.3
3200	90	8559.3
3100	90	8559.3
4700	90	2290.5
4850	90	2290.5
4950	90	2290.5
5000	90	2290.5
5050	90	2290.5
5100	90	2290.5

The X, Y and Z components of the resultant force (F_R) on each bend are given in **Table 8-5**.

Table 8-5: Components of resultant deflagration forces along global axis

Node	Components of Resultant F_R		
	FX (N)	FY (N)	FZ (N)
4450	1881.3	-5966.0	-20.8
4400	-54505.5	0.0	-54505.5
4300	12869.1	0.0	12727.5
4200	17451.6	17451.6	0.0
4150	-16649.4	16632.8	0.0
4100	15934.9	-15919.0	15.9
3900	-1285.8	3096.5	-4.4
3850	-9879.8	-9907.8	-13840.2
3800	-10115.2	3690.1	9507.4
3690	4444.1	2658.3	-1907.5
3670	5101.0	-3979.3	-22.5
3660	-8833.2	7061.4	4313.9
3350	-6453.7	-9911.6	2593.5
3200	6770.4	10322.5	325.3
3100	8944.4	-4065.6	-445.1
4700	2290.5	0.0	-2290.5
4850	-2290.5	0.0	-2290.5
4950	-2290.5	-2290.5	0.0
5000	0.0	-2290.5	2290.5
5050	0.0	2290.5	2290.5
5100	-2279.1	2063.7	36.6

8.4.2 Detonation

Table 8-6 shows the arrival time, mass flow rate and absolute pressure at various nodes of DN 300 relief line during detonation event.

Table 8-6: Arrival time, pressure and mass flow rates for detonation

Caesar Node	Fathom Junction	Flow arrival time (s)	Mass Flow Rate (kg/s)	Pressure Absolute (bars)
4450	J74	0.198	2307	4.31
4400	J5	0.243	2303	4.269
4300	J6	0.647	1186	2.503
4200	J7	0.937	1070.6	2.416
4150	J8	1.242	1070.6	2.334
4100	J42	1.445	1070.6	2.262
3900	J10	1.916	1070.6	2.163
3850	J85	2.178	1070.6	2.07
3800	J84	2.364	952.3	1.799
3690	J79	3.116	399.8	1.552
3670		3.436(1)	399.8 (1)	1.592(1)
3660		3.756(1)	399.8 (1)	1.592(1)
3350	J78	4.075	399.8	1.592(2)
3200	J77	4.348	399.8	1.592(2)
3100	J76	6.095	399.8	1.592(2)
4700	J89	2.717	342.1	0.903(2)
4850	J91	2.788	342.1	0.903(2)
4950	J93	2.785	342.1	0.903(2)
5000	J94	2.861	342.1	0.903(2)
5050	J95	2.875	342.1	0.903(2)
5100	J96	2.889	342.1	0.903(2)

The forces acting on various bends of DN 300 relief line have been calculated and tabulated in **Table 8-7**.

Table 8-7: Forces acting on the bend due to detonation

Node No	Angle	$F = F_1 = F_2$ (N)
4450	35	18672.1
4400	90	102695.6
4300	69.35	23845.5
4200	90	31670.9
4150	90	31097.1
4100	90	30593.2
3900	45	8757.6
3850	90	29099.7
3800	90	24274.2
3690	65.965	7823.2
3670	70.033	8691.9
3660	90	13199.1
3350	90	13199.1
3200	90	13199.1
3100	90	13199.1
4700	90	6294.1
4850	90	6294.1
4950	90	6294.1
5000	90	6294.1
5050	90	6294.1
5100	90	6294.1

The X, Y and Z components of the resultant force (F_R) on each bend are given in **Table 8-8**.

Table 8-8: Components of resultant detonation forces along global axis

Node	Components of Resultant		
	FX (N)	FY (N)	FZ (N)
4450	3379.6	-10717.8	-37.3
4400	-102695.6	0.0	-102695.6
4300	23845.5	0.0	23583.2
4200	31670.9	31670.9	0.0
4150	-31128.2	31097.1	0.0
4100	30623.8	-30593.2	30.6
3900	-2574.7	6200.4	-8.8
3850	-20544.4	-20602.6	-28779.6
3800	-22623.6	8253.2	21264.2
3690	6853.1	4099.3	-2941.5
3670	7866.2	-6136.5	-34.8
3660	-13621.5	10889.3	6652.3
3350	-9952.1	-15284.6	3999.3
3200	10440.5	15918.1	501.6
3100	13793.1	-6269.6	-686.4
4700	6294.1	0.0	-6294.1
4850	-6294.1	0.0	-6294.1
4950	-6294.1	-6294.1	0.0
5000	0.0	-6294.1	6294.1
5050	0.0	6294.1	6294.1
5100	-6262.6	5670.9	100.7

Recommendation

The hydrodynamic impulse loads due to surge flow have been calculated only for DN 300 relief line. DN 300 relief line is connected to the Small LOCA Tank (SLT). Currently the thermal hydraulic data (pressure, velocity, mass flow rate, etc.) required for this analysis is available only for DN 300 relief line. Refer [7].

The stress analysis can be extended to include hydrodynamic loads due to surge flow in DN 500 relief line if it is established in future that deflagration and detonation events are prominent in the Large LOCA Tanks (LLTs) as well.

8.5 Water Hammer Loads

Designation: F1 (Deflagration) and F2 (Detonation)

Water hammer loads arise due to event of LOVA + VVICE described in paragraph 7.7.

During deflagration, pressure in the VSTs will rise due to controlled combustion of hydrogen. Pressure in VSTs will also rise during detonation event. The pressure rise in VSTs due to detonation will be of higher than the pressure rise due to deflagration. In both the cases, the pressure rise will be sudden and this will push the water back in the relief lines. The non-return valves (NRVs) are provided in the relief lines to prevent the flow being transmitted to the vacuum vessel.

The quick closure of non-return valve will cause the reduction of velocity from maximum to zero during the short time. The time taken for reduction of velocity from maximum to zero will be equal to the time taken for closure of valve. The reduction of velocity will cause rise in the pressure at NRV. The schematic of pressure rise due to velocity reduction at the NRV is shown in **Figure 8-6**. This pressure rise at NRVs will cause a pressure wave travelling upstream along the pipe at sonic velocity, thus leading to water hammer effect between NRV and VST. The unbalanced forces generated due to travelling pressure waves needs to be considered in the piping analysis. These are dynamic forces and stress analysis needs to include the inertial and damping characteristics of the piping system.

The water hammer analysis procedure adopted in this stress analysis is based on [6] and [8].

For a small reduction of velocity (ΔV_i), the increase of pressure is given by Joukowsky equation,

$$\Delta P_i = \rho . a . \Delta V_i$$

ρ is density of water (kg/m^3)
a is sonic velocity in water (m/s)

The total pressure rise at the time when valve is fully closed is given by:

$$\Delta P_T = \rho . a . V_o$$

V_o is the initial velocity of water.

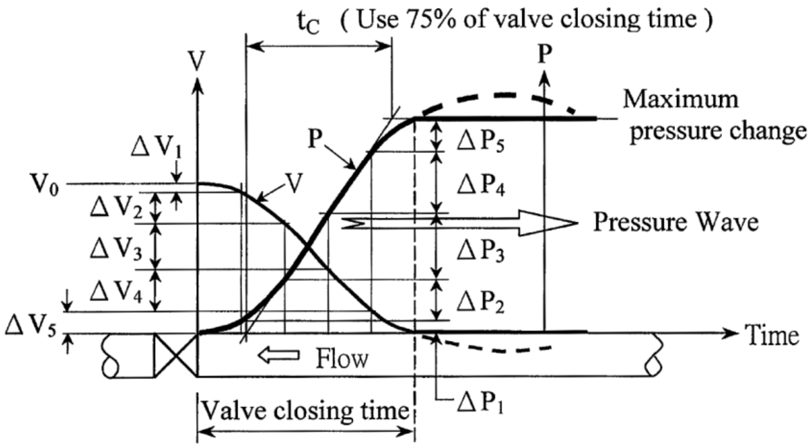


Figure 8-6: Water Hammer pressure rise

As shown in the above figure, the pressure rise can be assumed to be linear in a time *tc*. Time *tc* is taken as 75 % of the valve closure time reported by the manufacturer.

The NRV valve specifications are still not finalized. In order to evaluate the water hammer loads, a reasonable valve closure time of 0.5 seconds has been assumed. The value of *tc* is thus 0.375 seconds (75 % of 0.5 seconds).

The sonic velocity in water is given by:

$$a = \sqrt{\frac{1}{\rho(\frac{1}{K} + \frac{Dc_1}{Et})}}$$

K= Bulk Modulus of Water = 319000 psi = 21.99 x 10^8 N/m^2
D = pipe diameter (m)
c_1 = constant depending on pipe restraints.
E = Young's modulus of pipe material = 200 GPa
t = pipe thickness.

Sonic velocity can be calculated conservatively as,

$$a = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{21.99 \times 10^8}{1000}} = 1484\ m/s$$

8.5.1 Deflagration

During the deflagration event, the velocity of water at the valve and at the instant the valve starts to close is 17.49 m/s. [7]

The total pressure rise at the time valve is fully closed is given by

$$\Delta P_T = (\rho.a.V) = 1000\ \times 1484 \times 17.49 = 25.95 \times 10^6 N/m^2$$

V=17.49 m/s
a = 1484 m/s
A = π/4 x $(330.2)^2$ = 85633.56 mm^2 = 85.633 x 10^{-3} m^2

However, the pressure rise of 25.95 x 10^6 N/m^2 calculated above is only possible if the generated pressure wave is not countered by the reflected water hammer pressure wave within 0.375 s. For the DN300 relief line, the generated pressure wave will travel towards the tank with velocity sonic velocity (*a*), it will be reflected at tank reservoir, and it will again travel back and reach NRV before 0.375 seconds. Thus actual pressure rise will be much lower than at 25.95 x 10^6 N/m^2. It is calculated below.

Actually, pressure wave will travel back and forth many times with diminishing magnitude. In practical calculations, only the first complete reflection is considered. The reflections after first one are ignored because they are much smaller forces.

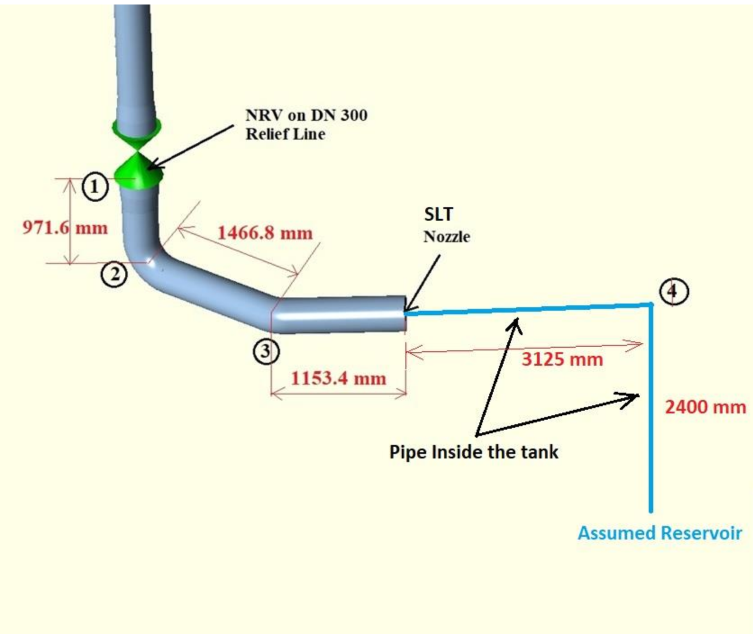


Figure 8-7: DN 300 Relief Line between SLT and NRV

Figure 8-7 shows the segments 1-2, 2-3 and 3-4 of the DN300 relief line. Pressure time histories have been calculated at points 1, 2, 3 and 4 to calculate the unbalanced load due to water hammer on each of these 3 segments of DN 300 relief line.

The pressure time histories shown below represent pressure rise above 5 bar (a).

Figure 8-8 shows the pressure time history at point 1. As the valve starts to close, pressure starts rising. The generated pressure wave travels towards the reservoir. It travels a distance of 18.23 m with a speed of 1484 m/s and thus reaches point 1 in time 12.28 milliseconds with opposite magnitude. The resultant pressure time history at point 1 is shown in red colour.
Thus, the actual net pressure rise at point 1 is 0.85 N/mm^2.

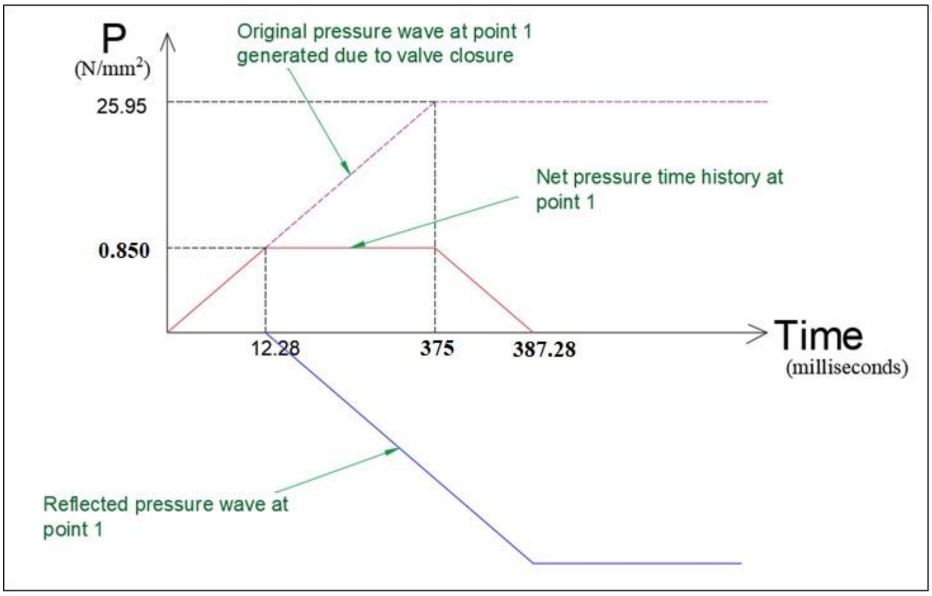


Figure 8-8: Pressure Time History at point 1

Figure 8-9 shows the pressure time history at point 2. Original pressure wave reaches point 2 after it travels distance 971.58 mm. The time at which original pressure wave reaches point 2 is 0.65 milliseconds. The reflected pressure wave reaches point 2 after 10.97 milliseconds i.e. at 11.62 milliseconds. The resultant pressure time history at point 2 is shown in red colour. Thus, the actual net pressure rise at point 2 is 0.759 N/mm^2.

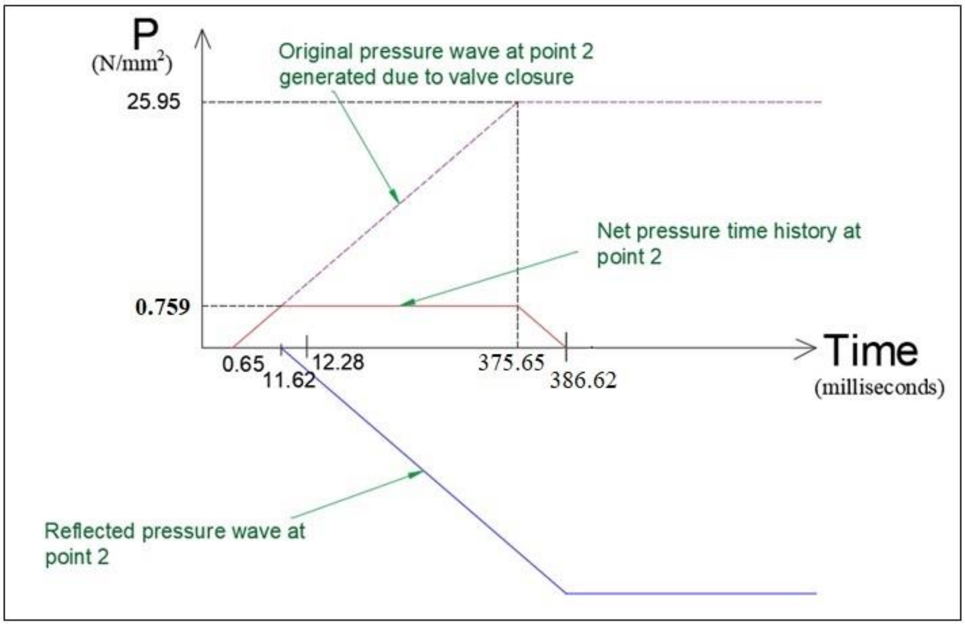


Figure 8-9: Pressure Time History at point 2

Figure 8-10 shows the pressure time history at point 3. Original pressure wave will reach point 3 after it travels distance 2438.37 mm. The time at which it reaches point 3 is 1.65 milliseconds. The reflected pressure wave reaches point 3 after 9.0 milliseconds i.e at 10.65 milliseconds. The resultant time history is shown in red colour.
Thus, the actual net pressure rise at point 3 is 0.623 N/mm^2.

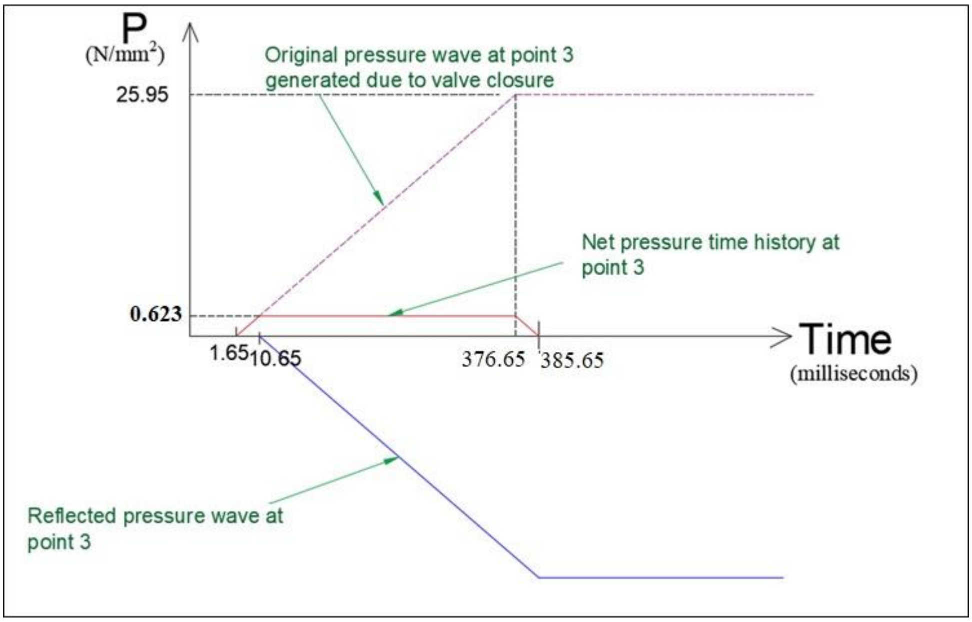


Figure 8-10: Pressure Time History at point 3

Figure 8-11 shows the pressure time history at point 4. Original pressure wave will reach point after it travels distance 6716.8 mm. The time at which it reaches point 4 is 4.53 milliseconds.

The reflected pressure wave reaches point 4 after 3.23 milliseconds i.e at 7.77 milliseconds. The resultant time history is shown in red colour.
Thus, the actual net pressure rise at point 3 is 0.224 N/mm^2.

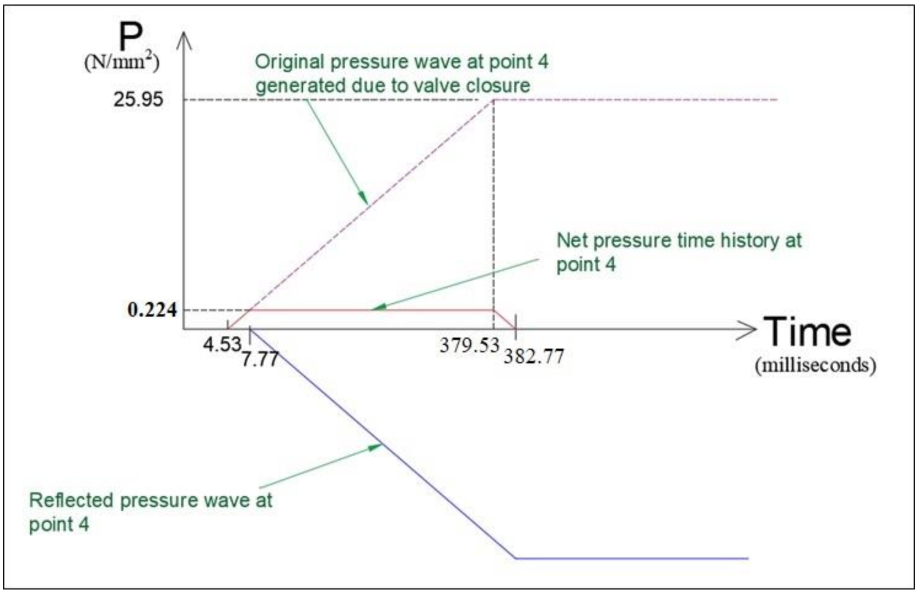


Figure 8-11: Pressure Time History at point 4

In water hammer analysis, often ignore the momentum flux change due to flow velocity is ignored. The piping shaking force is established mainly on the pressure changes. The unbalanced force on each leg at any instant is due to different pressure acting at its ends due to travelling pressure wave. The maximum unbalanced force can be calculated for each segment 1-2, 2-3 and 3-4 based on the resultant pressure time at nodes 1, 2 and 3.

Unbalanced load on each segment is a dynamic load varying with time. It is possible to do time history analysis or instead an equivalent static analysis by applying all the unbalanced loads simultaneously and after multiplying them with the dynamic amplification factors. In the present stress analysis, equivalent static analysis approach has been adopted.

The unbalance loads on each segment are calculated below:

a) Unbalanced force on leg 1-2

$f_{1\text{-}2}$ = (Pressure x Area)$_1$ - (Pressure x Area)$_2$
= [0.85 x π/4 x (330.2)^2] - [0.759 x π/4 x (298.5)^2]
= 19674 N

$F_{1\text{-}2}$ = $f_{1\text{-}2}$ x (DAF) = 19674 x 2 = 39348 N

b) Unbalanced force on leg 2-3

$f_{2\text{-}3}$ = (Pressure x Area)$_2$ - (Pressure x Area)$_3$
= [0.759 x π/4 x (298.5)^2] - [0.623 x π/4 x (298.5)^2]
= 9518 N

$F_{2\text{-}3}$ = $f_{2\text{-}3}$ x (DAF) = 9518 x 2 = 19036 N

c) Unbalanced force on leg 3-4

f_{3-4} = (Pressure x Area)$_3$ - (Pressure x Area)$_4$
= [0.623 x π/4 x $(298.5)^2$] - [0.224 x π/4 x $(298.5)^2$]
= 27923 N

F_{3-4} = f_{3-4} x (DAF) = 27923 x 2 = 55846 N

8.5.2 Detonation

During detonation, the velocity at NRV at the instant of valve closure is 28.48 m/s. The increase of forces during detonation compared to deflagration will be by the factor of increase in velocity. This factor is 1.63 (as the ratio of velocity = 28.48/17.49)

Thus, the unbalanced forces on the segments of DN 300 relief line due to detonation are as follows.

a) F_{1-2} = 39348 x 1.63 = 64138 N
b) F_{2-3} = 19036 x 1.63 = 31029 N
c) F_{3-4} = 55846 x 1.63 = 91029 N

Recommendation

The water hammer loads have been calculated only for DN 300 relief line. DN 300 relief line is connected to the Small LOCA Tank (SLT). Currently the basic thermal hydraulic data (pressure, velocity, mass flow rate, etc.) required to evaluate the water hammer loads is available only for DN 300 relief line. Refer [7].
The stress analysis can be extended to include water hammer loads due to closure of NRVs in DN 500 relief line, if it is established in future that deflagration and detonation events are prominent in the Large LOCA Tanks (LLTs) as well.

8.6 Seismic Loads

Seismic loads applicable for VVPSS have been mentioned in [1]. Accordingly, following four level of earthquakes have been considered for the analysis.

a) SL-1: It is a category II event with a return period of about 100 years.
b) SMHV: It is a category III event and is the most penalising earthquakes liable to occur over a period of about 1000 years.
c) SL-2: It is a category IV event and corresponds to the seismic level required by French nuclear practice.
d) SL-3: According to stress test methodology for HCC on ITER plant, a seismic event of magnitude 1.5 times the SL-2 have been defined as SL-3.

The loads generated due to each earthquake on VVPSS relief lines are divided into 2 types, inertial loads and seismic anchor motions.

8.6.1 Inertial loads

These are the loads due to dynamic response of the system due to its inertia after considering the structural damping effects.

To evaluate inertial loads for each earthquake level, response spectrum analysis has been carried out. Frequencies, mode shapes and mass participation factors required for response spectrum analysis have been calculated by modal analysis. 10%-Group Method had been used for modal combination and SRSS method has been used for spatial combination.

The damping assumed for each level of earthquake are:
SL-1: 3%
SMHV and SL-2: 4%
SL-3: 5 %
The floor response spectra for,
SL-1 earthquake are shown in **Figure 8-12** and **Figure 8-13**,
SMHV earthquake are shown in **Figure 8-14** and **Figure 8-15**,
SL-2 earthquake are shown in **Figure 8-16** and **Figure 8-17**, and
SL-3 earthquake are shown in **Figure 8-18** and **Figure 8-19**.

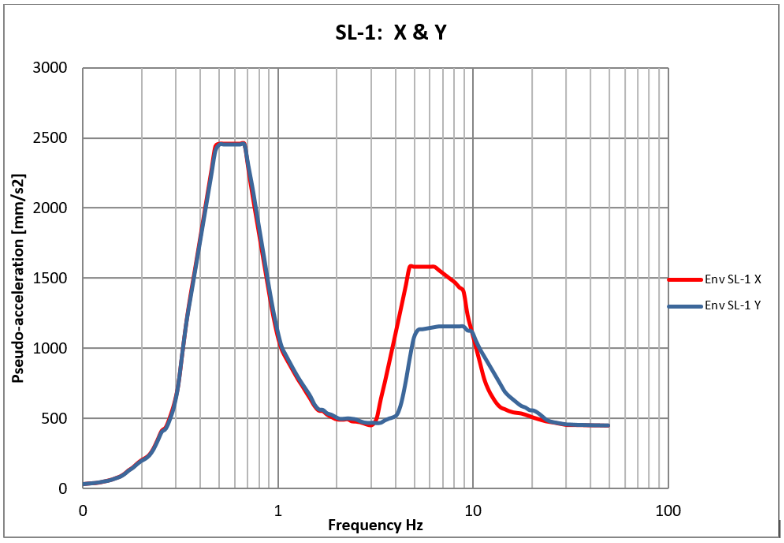


Figure 8-12: FRS SL-1 Horizontal (X& Y) Directions

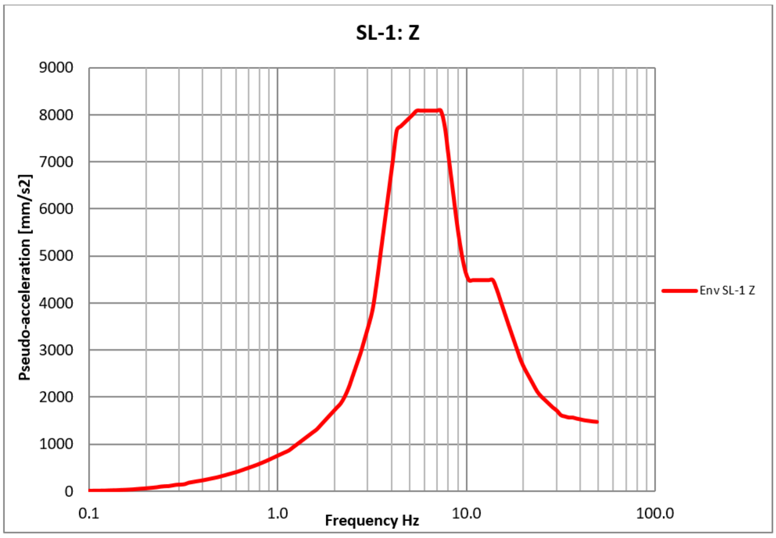


Figure 8-13: FRS SL-1 Vertical (Z) Direction

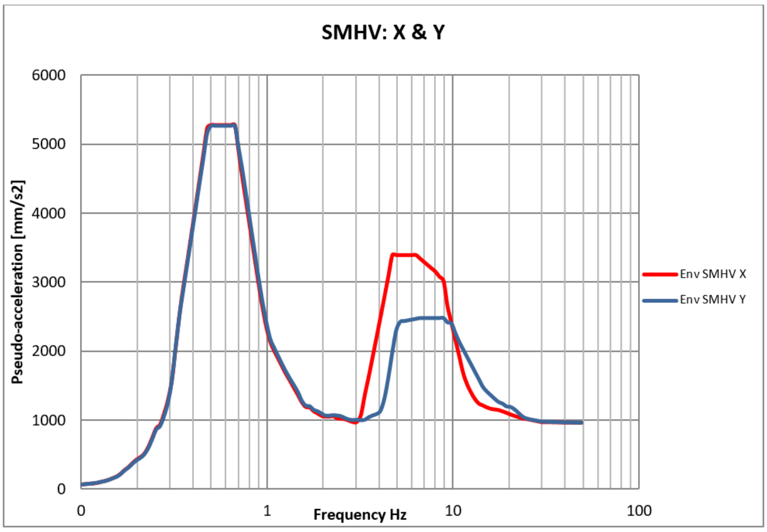


Figure 8-14: FRS SMHV Horizontal (X& Y) Directions

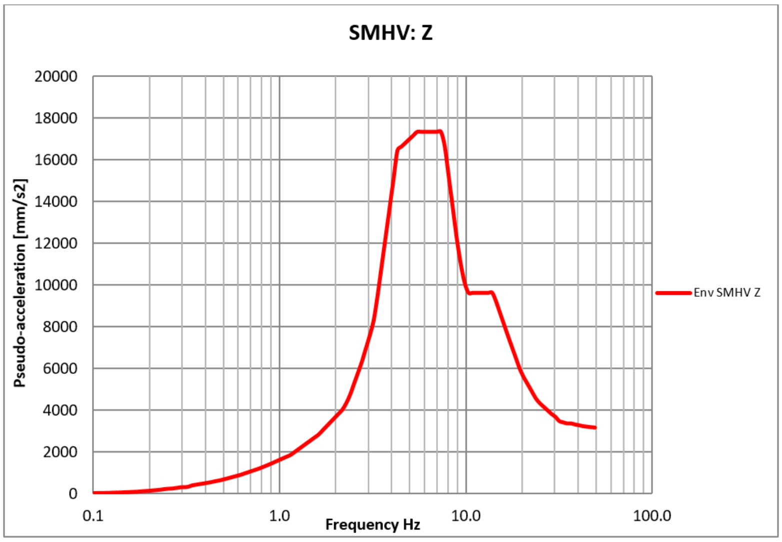


Figure 8-15: FRS SMHV Vertical (Z) Direction

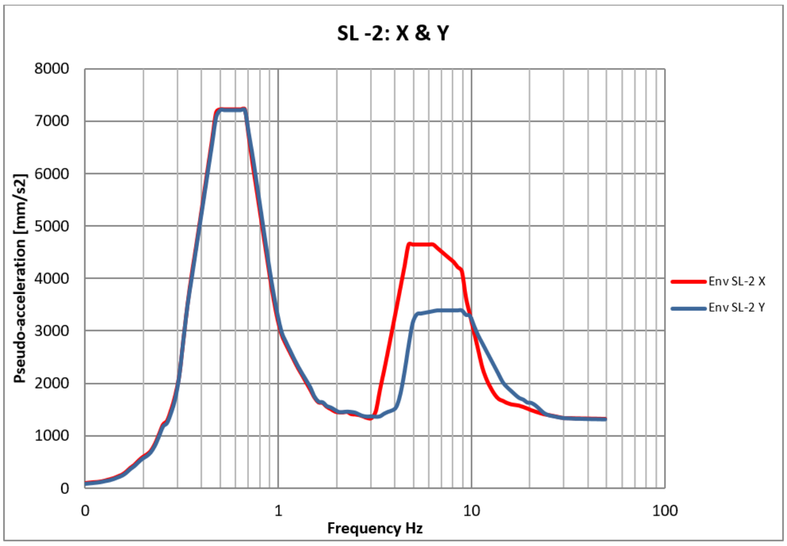


Figure 8-16: FRS SL-2 Horizontal (X& Y) Directions

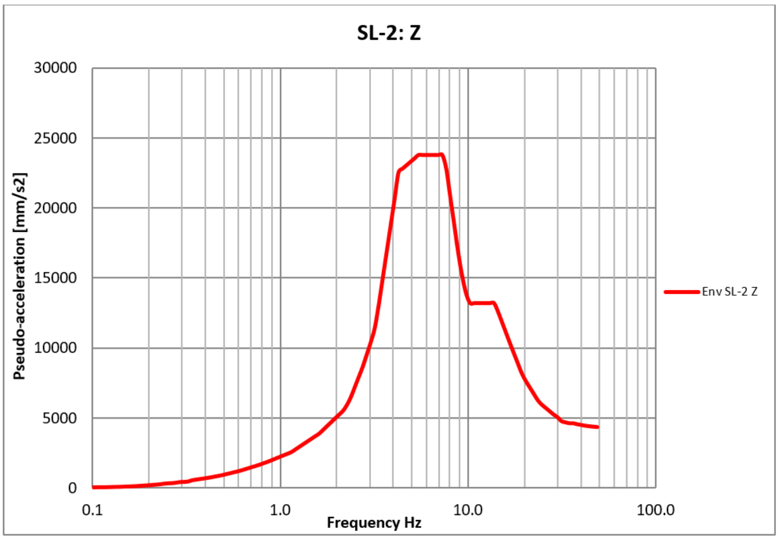


Figure 8-17: FRS SL-2 Vertical (Z) Direction

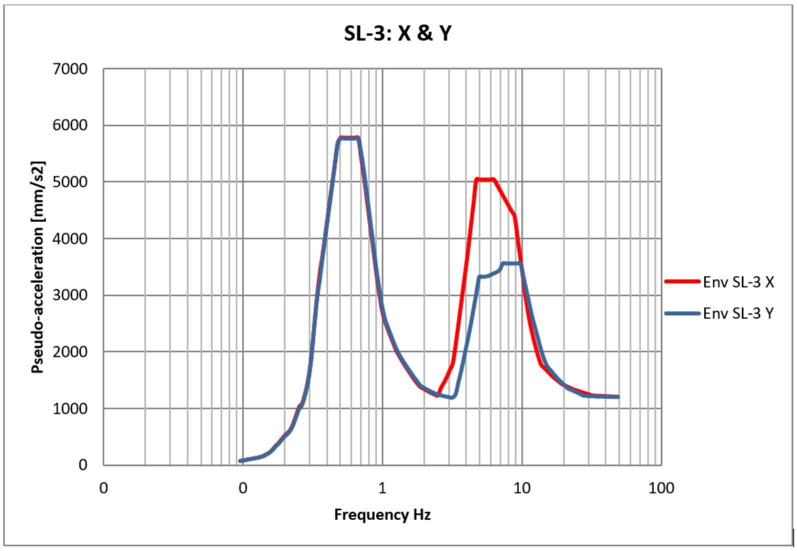


Figure 8-18: FRS SL-3 Horizontal (X& Y) Directions

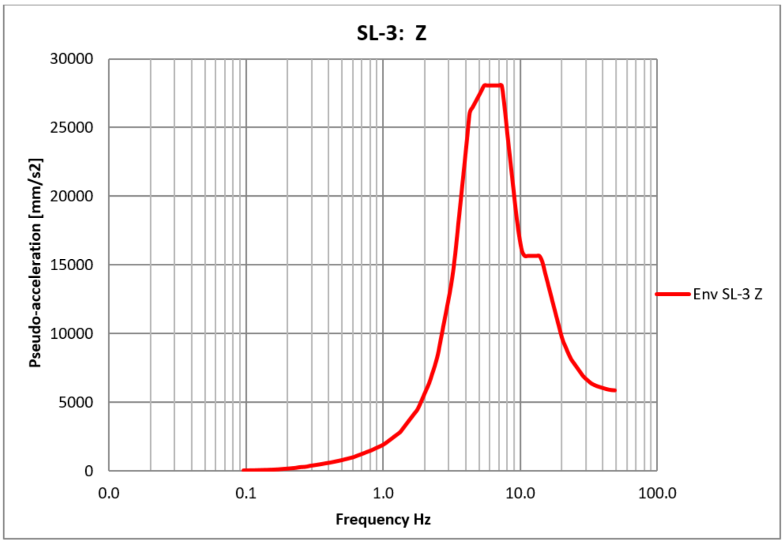


Figure 8-19: FRS SL-3 Vertical (Z) Direction

8.6.2 Seismic Anchor Motions

The response on the system due to relative displacements of anchors during each earthquake have been considered in the analysis.
The relative displacements for SL-2 level earthquake between various floors are listed in [9]. The maximum relative displacement for the VVPSS system between level B2 and L1 for SL-2 are 0.686 mm, 1.120 mm and 0.267 mm for X, Y and Z directions respectively. The relative displacements for other levels of earthquake are derived from SL-2 level and listed in **Table 8-9**.

Table 8-9: Seismic Anchor Motions for various seismic levels

EQ level	**UX**	**UY**	**UZ**
SL-2	0.686 mm	1.120 mm	0.267 mm
SMHV = 0.73 x SL-2	0.501 mm	0.818 mm	0.195 mm
SL-1 = 0.34 x SL-2	0.233 mm	0.381 mm	0.091 mm
SL-3 = SL-2 x 1.5	1.029 mm	1.680 mm	0.401 mm

9.0 CRITERIA FOR STRESS ANALYSIS

As described in paragraph 7.0, VVPSS relief lines are subjected to various operating conditions (including accidental events). Each operating condition is associated with the load category (I to V) defined based on frequency of occurrence of the load. Each operating condition also has associated to it a service level (A, B, C or D) which defines the acceptance level of damage (allowable stress level) in the component.

An operating condition has loads in the form of pressure, temperature and mechanical loads. They give rise to either primary or secondary stresses. The design code for VVPSS relief lines has been defined as ASME B31.3. Hence, the treatment of stresses due to each operating condition will be based on ASME B31.3 code qualification criteria. ASME B31.3 code does not provide allowable stress limits based on service levels. It provides allowable stress limits for normal operation and occasional loads. Service Levels A and B have been assigned B31.3 allowable stress limits of normal operation. Allowable stress limits for service level C and D have been defined based on '*Allowable values and limits in service level C and D for ITER mechanical components (3G3SYJ v3.1)*' [10].

9.1 Pressure loads

<u>Internal Pressure</u>

Pressure gives rise to primary stresses in the piping. The minimum thickness (t_m) to be provided to the straight pipe is based on the design pressure and given by following formula [5].

$$t_m = t + c$$

$$t = \frac{PD}{2(SEW + PY)}$$

c is the sum of the mechanical allowances (thread or groove depth) plus corrosion and erosion allowances
D is the outside diameter of pipe
E is the quality factor from Table A-1A or A-1B of [5]
P is the internal design gauge pressure
S is the basic allowable stress value from Table A-1 of [5]
t is the pressure design thickness
t_m is the minimum required thickness, including mechanical, corrosion, and erosion allowances
W is the weld joint strength reduction factor taken as 1.0
Y is a coefficient equal to 0.4

For VVPSS relief lines, this step has been completed by the process engineering. Pipe thicknesses have been finalized as mentioned in **Table 5-1**.

The scope of this report is to check if the limits are satisfied for pressures corresponding to various service levels. Thus, for a given thickness, allowable pressure can be calculated by:

$$P_a = \frac{2SEWt}{D - 2Yt}$$

where t is the nominal thickness minus corrosion allowance and manufacturing tolerances. The corrosion allowance has been assumed as zero for VVPSS relief lines.
Thus, the allowable pressure for various pipe sizes for service level A and B are shown in **Table 9-1**

Table 9-1: Allowable internal pressures for various pipe sizes for service level A and B

Sr. No	Pipe Size	OD (mm)	Nominal Thickness (mm)	Thickness T (mm)	Allowable Pressure (Pa) bars
1	DN 500; 80S	508	12.70	11.11	54.3
2	DN 300; 80S	323.9	12.70	11.11	86.1
4	DN 350; 80S	355.6	12.70	11.11	78.2
5	DN 200; 80S	219.1	12.70	11.11	128.9
6	DN 150; 80S	168.3	10.97	9.59	145.8

The limits for safe pressure for various service levels C and D are shown in **Table 9-2**.

Table 9-2: Allowable internal pressure for service level C and D

Sr. No.	Service Level	Maximum permissible pressure
1	C	1.5 Pa
2	D	2 Pa

Components in accordance with the standards for which pressure ratings are provided in the standard, such as ASME B16.5 for flanges, are considered suitable by ASME B31.3 for the pressure rating specified in the standard. For the components as per listed standards (such as ASME B16.9, B16.11, B16.28), pressure temperature ratings are based on straight seamless pipe. As per ASME B31.3, such components are rated considering 87.5% of the nominal thickness of seamless pipe, made of a material having the same allowable stress as the component. Thus, the pressure design calculations are usually performed for the straight pipe and matching fittings are selected from the standards approved by ASME B31.3.

External Pressure

Allowable external pressure has been calculated based on buckling criteria of ASME BPV Code Section VIII, Division 1 and charts of ASME BPV Code Section II, Part D Subpart 3.

DN 500 relief line has maximum diameter to thickness ratio and longest span. Hence, allowable external pressure has been calculated below for DN 500 relief line.

L = 7600; L/Do = 7600/508 = 14.96; Do/t = 508/12.7 = 40
Factor A = 0.0007 [16][17]
Factor B = 5000 psi
Allowable external pressure is given by:

$$P_a = \frac{4B}{3(D_o/t)}$$

$$P_a = 166.6\,psi = 11.4\,bar$$

9.2 Pressure plus Mechanical loads

Mechanical loads generate forces and moments in the piping. In combination with the pressure loads, mechanical loads generate primary stresses on the piping referred as sustained stresses. The equation for the stress due to sustained loads, such as pressure and weight, S_L, is provided in equation:

$$S_L = \sqrt{(|S_a| + S_b)^2 + (2S_t)^2}$$

The equation for the stress due to sustained longitudinal force, S_a, is

$$S_a = \frac{I_a F_a}{A_p}$$

A_p is cross-sectional area of the pipe, considering nominal pipe dimensions less allowances
F_a is the longitudinal force due to sustained loads, e.g. pressure and weight
I_a is sustained longitudinal force index. In the absence of more applicable data, I_a is taken as 1.0.

The equation for the stress due to sustained bending moments, S_b, is provided by equation:

$$S_b = \frac{\sqrt{(I_i M_i)^2 + (I_o M_o)^2}}{Z}$$

Where,
I_i is sustained in-plane moment index. In the absence of more applicable data, *Ii* is taken as the greater of $0.75i_i$ or 1.0.
I_o is sustained out-plane moment index. In the absence of more applicable data, I_o is taken as the greater of $0.75i_o$ or 1.0.
i_i *and* i_o are stress intensification factors
M_i is in-plane moment due to sustained loads, e.g. pressure and weight.
M_o is out-plane moment due to sustained loads, e.g. pressure and weight.
Z is the sustained section modulus calculated using nominal pipe dimensions less allowances.

The equation for the stress due to sustained torsional moment, S_t, is given by equation:

$$S_t = \frac{I_t M_t}{2Z}$$

M_t is torsional moment due to sustained loads, e.g. pressure and weight.
I_t is sustained torsional moment index. In the absence of more applicable data, I_t is taken as 1.0.

Limits
As per ASME B31.3, the sum of the longitudinal stresses due to sustained loads, S_L, such as pressure and weight in any component in a piping system shall not exceed S_h, where S_h is taken from Table A-1 at the metal temperature of the operating condition being considered. This limit is applicable for Service level A.

For operating conditions other than service level A, the sum of the longitudinal stresses, S_L, due to sustained loads and the stresses produced by the occasional loads corresponding to the service level shall be within the allowable stress limits mentioned in **Table 9-3**.

Table 9-3: Allowable stress for sustained + occasional loads

Sr. No.	Service Level	Stress	Allowable Stress
1	A	S_L	$1.0\ S_h$
2	B	$S_L + S_{OCC}$	$1.0\ S_h$
3	C	$S_L + S_{OCC}$	$1.5\ S_h$
4	D	$S_L + S_{OCC}$	$2.0\ S_h$

The longitudinal stress during hydrostatic test shall not exceed the yield strength at the test temperature.

9.3 Temperature loads

Temperature gives rise to displacement stresses in the piping. These are secondary stresses, which are associated with fatigue failure.

Displacement stress range S_E is calculated by equation:

$$S_E = \sqrt{(|S_a| + S_b)^2 + (2S_t)^2}$$

Where,
S_a is axial stress range due to displacement strains (= $i_a\ F_a/A_p$)
i_a is axial stress intensification factor. In the absence of more applicable data, i_a = 1.0 for elbows and bends, $i_a = i_o$ for other components
A_p is cross-sectional area of pipe based on nominal thickness and outside diameter.

The equation for the bending stress range, S_b, due to range of bending moments, is provided by equation:

$$S_b = \frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z}$$

where
i_i is in-plane stress intensification factor from Appendix D of [5]
i_o is out-plane stress intensification factor from Appendix D of [5]
M_i is in-plane bending moment range
M_o is out-plane bending moment range
Z is section modulus of pipe

The equation for the torsional stress range is:

$$S_t = \frac{i_t M_t}{2Z}$$

M_t is torsional moment range.
i_t is torsional stress intensification factor. In the absence of more applicable data $i_t = 1.0$

Limits

The allowable displacement stress range S_A is given by:

$$S_A = f(1.25S_c + 0.25S_h)$$

When S_h is greater than S_L, the difference between them may be added to the term $0.25S_h$. In that case, the allowable stress range is calculated by:

$$S_A = f[1.25(S_c + S_h) - S_L].$$

f is the stress range factor given by $f = 6.0 \times (N)^{-0.2}$, where N is the equivalent number of full displacement cycles during the expected service life of the piping system.

S_c is basic allowable stress at minimum metal temperature expected during the displacement cycle under analysis
S_h is basic allowable stress at maximum metal temperature expected during the displacement cycle under analysis.

When the computed stress range varies, whether from thermal expansion or other conditions, S_E is defined as the greatest computed displacement stress range. The value of N in such cases can be calculated by eq.

$$N = N_E + \sum (r_i^5 N_i) \;\; for\ i = 1,2, \ldots ..n$$

where
N_E = number of cycles of maximum computed displacement stress range, S_E
N_i = number of cycles associated with displacement stress range, S_i
r_i = S_i/S_E
S_i = any computed displacement stress range smaller than S_E

The allowable stress limits for expansion / displacement loads are given in **Table 9-4**.

Table 9-4: Allowable stress for expansion / displacement loads

Sr. No.	Service Level	Expansion/Displacement Stress	Allowable stress
1	A and B	S_E	S_A
2	C	*Amplitude of membrane stress due axial force*	$0.7\ S_h$
		Range of membrane plus bending (S_E)	$4.2\ S_h$
3	D	*Amplitude of membrane stress due axial force*	$1.0\ S_h$
		Range of membrane plus bending (S_E)	$6.0\ S_h$

Note: Seismic loads consists of two parts, inertial loads and seismic anchor motion. Inertial loads are considered as primary stresses and hence the allowable limit for the stresses calculated due to them will be as per **Table 9-3**. The stresses generated due to seismic anchor motions are secondary stresses and the allowable limits for stresses due to them will be as per **Table 9-4**.

9.4 Displacements

Along with the stresses, the important criteria for qualifying the piping system is the displacements, particularly, the displacements in the bellow. Bellows absorb large thermal displacements and hence relieve the piping of thermal stresses to a big extent. The permitted displacements in the bellow are based on fatigue life determined by the manufacturer based on factory testing or analysis.

Piping engineer cannot determine the stresses in the bellow. The role of the piping engineer to ensure that the bellow characteristics (specifically spring rates and pressure thrust forces) are included in the piping analysis and to ensure that the resultant bellow deformations from relative piping movements are within the manufacturer's limitations.

The permitted displacements in each bellow used in VVPSS have been mentioned in **Table 5-4** to **Table 5-9**. The permitted displacement values mentioned in these tables are for fatigue life of 1000 years.

1) Check for total axial deformation in the bellow.
   Bellows will be checked for total axial displacement. The total axial displacement included axial displacement from pure axial loads plus axial displacement due to bending deformation plus axial displacement due to the lateral deformation.
   The total axial displacement (x_a) is given by:
   $$x_T = x_a + x_l + x_\theta$$
   x_a is axial displacement due to axial load.
   x_l is axial displacement due to lateral deformation.
   x_θ is axial displacement due to lateral deformation.

2) Check for cumulative effect of axial, bending and lateral deformation in the bellow.
   The cumulative effect of axial, lateral and bending deformation in the bellow is checked by equation:
   $$\frac{x_a}{(x_a)_{allow}} + \frac{y}{(y)_{allow}} + \frac{\theta}{(\theta)_{allow}} \leq 1.0$$

10.0 LOAD COMBINATIONS FOR STRESS ANALYSIS

Various operating conditions experienced by the VVPSS relief lines have been mentioned in para 7.0. All the single load cases arising due to operating conditions have been defined in para 8.0. Piping stress analysis requires load combinations to fulfil the criteria defined in para 9.0.

The load combinations required for evaluating the sustained stresses or sustained plus occasional stresses are shown in **Table 10-1**. Operating load combinations shown in this table are required to evaluate the displacements of relief lines and the support loads.

Table 10-2 shows the thermal expansion load combinations. These are required to check the secondary stresses due to thermal expansion.

As discussed before, seismic anchor motions (SAMs) produce secondary stresses. Stresses due to SAMs needs to be included in thermal expansion cases. The operating load cases with SAMs are shown in **Table 10-3**. The expansion load combination with seismic anchor motions are shown in **Table 10-4**.

Table 10-5 shows two load combinations. One load combination is the operating load combination for seismic events. This load combination is useful to calculate total support loads due to seismic events. The other load combination is for calculation inertial stress due to seismic events.

Table 10-1: Sustained and Operating Load Combinations

Load Spec. No. (i)	Event (ii)	Load case No. (Caesar) (iii)	Caesar Load Combination (iv)	Load case type (v)	Caesar Output Significance (vi)	Pressure (g) (bars) (vii)			Temperature (ºC) (viii)			Service Level (ix)
2	Hydrostatic Test	L1	WW+HP	Test	Primary Stress	0	25.7	25.7	20	20	20	Test
1	DW+NO	L2	W+P1+T1	Operating	Displ./Forces	-1	-1	-1	115	35	35	A
		L3	W+P1	Sustained	Primary Stress							
5	DW+T Baking	L4	W+P1+T2	Operating	Displ./Forces	-1	-1	-1	200	35	35	A
		L5	W+P1	Sustained	Primary Stress							
7	DW+VVICE II	L6	W+P2+T3	Operating	Displ./Forces	0.5	0.5	0.5	250	250	250	A
		L7	W+P2	Sustained	Primary Stress							
8	DW+VVICE III	L8	W+P2+T3	Operating	Displ./Forces	0.5	0.5	0.5	250	250	250	A
		L9	W+P2	Sustained	Primary Stress							
9	DW+LOCA VV-PHTS	L10	W+P3+T4	Operating	Displ./Forces	-2	-2	-2	145	145	145	A
		L11	W+P3	Sustained	Primary Stress							
12	DW+VVICE IV	L12	W+P4+T3	Operating	Displ./Forces	1	1	1	250	250	250	C
		L13	W+P4	Sustained	Primary Stress							
14	DW+VVICE V	L14	W+P4+T3	Operating	Displ./Forces	1	1	1	250	250	250	C
		L15	W+P4	Sustained	Primary Stress							
16	DW+FIRE	L16	W+P1+T5	Operating	Displ./Forces	-1	-1	-1	302	252	252	C
		L17	W+P1	Sustained	Primary Stress							
17	DW+LOVA+ VVICE+FA	L18	W+P7+T3+F1	Operating	Displ./Forces	0.5 (1)*	0.5 (2)*	4 (4)*	250	250	250	A
		L19	W+P7+F1	Sustained	Primary Stress							
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L20	W+P5+T3+F2	Operating	Displ./Forces	1	1	11	250	250	250	D
		L21	W+P5+F2	Sustained	Primary Stress							
20	DW+VV Dust Explosion	L22	W+P6+T1	Operating	Displ./Forces	5	5	5	115	35	35	A
		L23	W+P6	Sustained	Primary Stress							
21	DW+LOVA+VVICE +FA	L24	WW+P7+T3+ F3	Operating	Displ./Forces	1	2	4	250	250	250	D
		L25	WW+P7+F3	Sustained	Primary Stress							
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L26	WW+P8+T3+ F4	Operating	Displ./Forces	1	4	11	250	250	250	Ultimate Failure σ_u
		L27	WW+P8+F4	Sustained	Primary Stress							
23	DW+LOCA PC III+ICE II	L28	W+P9+T3	Operating	Displ./Forces	-0.5	-0.5	-0.5	250	250	250	D
		L29	W+P9	Sustained	Primary Stress							

--	Integrity at 30 bar	L60	W+P10+T6	Operating	Displ./Forces	29.0	29.0	29.0	120	120	120	D
		L61	W+P10	Sustained	Primary Stress							

Table 10-2: Thermal Expansion Load Combinations

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Load case type	Caesar Output Significance	Service Level
1	DW+NO	L37	(W+P1+T1)-(W+P1) *L2-L3*	Expansion	Secondary Stress	A
5	DW+T Baking	L38	(W+P1+T2)-(W+P1) *L4-L5*	Expansion	Secondary Stress	A
7	DW+VVICE II	L39	(W+P2+T3)-(W+P2) *L6-L7*	Expansion	Secondary Stress	A
8	DW+VVICE III	L40	(W+P2+T3) – (W+P2) *L8-L9*	Expansion	Secondary Stress	A
9	DW+LOCA VV-PHTS	L41	(W+P3+T4)-(W+P3) *L10-L11*	Expansion	Secondary Stress	A
12	DW+VVICE IV	L42	(W+P4+T3)-(W+P4) *L12-L13*	Expansion	Secondary Stress	C
14	DW+VVICE V	L43	(W+P4+T3)-(W+P4) *L14-L15*	Expansion	Secondary Stress	C
16	DW+FIRE	L44	(W+P1+T5)-(W+P1) *L16-L17*	Expansion	Secondary Stress	C
17	DW+LOVA+VVICE +FA	L45	(W+P2+T3+F1)-(W+P2+F1) *L18-L19*	Expansion	Secondary Stress	A
18	DW+LOVA+VVICE +Explosion in VSTs+FD	L46	(W+P5+T3+F2)-(W+P5+F2) *L20-L21*	Expansion	Secondary Stress	D
20	DW+VV Dust Explosion	L47	(W+P6+T1)-(W+P6) *L22-L23*	Expansion	Secondary Stress	A
21	DW+LOVA+VVICE +FA	L48	(W+P7+T3+F3)-(W+P7+F3) *L24-L25*	Expansion	Secondary Stress	D
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L49	(W+P8+T3+F4)-(W+P8+F4) *L26-L27*	Expansion	Secondary Stress	Ultimate failure
23	DW+LOCA PC III+ICE II	L50	(W+P9+T3)-(W+P9) *L28-L29*	Expansion	Secondary Stress	D

Table 10-3: Operating Load Combination with SAMs

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Load case type	Caesar Output Significance	Pressure (g) (bars)			Temperature (ºC)			Service Level
6	DW + T Baking + SAM_{SL-1}	L30	W+P1+T2+0.34D1	Operating	Displ/Force	-1	-1	-1	200	35	35	A
10	DW + NO + SAM_{SMHV}	L31	W+P1+T1+0.73D1	Operating	Displ/Force	-1	-1	-1	115	35	35	A
11	DW + T Baking + SAM_{SMHV}	L32	W+P1+T2+0.73D1	Operating	Displ/Force	-1	-1	-1	200	35	35	A
13	DW + NO + SAM_{SL-2}	L33	W+P1+T1+D1	Operating	Displ/Force	-1	-1	-1	115	35	35	C
15	DW + T Baking + SAM_{SL-2}	L34	W+P1+T2+D1	Operating	Displ/Force	-1	-1	-1	200	35	35	C
16	DW + FIRE + SAM_{SL-2}	L35	W+P1+T5+D1	Operating	Displ/Force	-1	-1	-1	302	252	252	C
19	DW + VVICE V + SAM_{SL-3}	L36	W+P4+T3+1.5D1	Operating	Displ/Force	1	1	1	250	250	250	C
--	DW + NO + SAM_{SL-3}	L62	W+P1+T1+1.5D1	Operating	Displ/Force	-1	-1	-1	115	35	35	B

Table 10-4: Expansion Load Combination with SAMs

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Load case type	Caesar Output Significance	Service Level
6	DW + T Baking + SAM_{SL-1}	L51	(W+P1+T2+0.34D1)-(W+P1) *L30-L5*	Expansion	Secondary Stress	A
10	DW + NO + SAM_{SMHV}	L52	(W+P1+T1+0.73D1)-(W+P1) L31-L3	Expansion	Secondary Stress	A
11	DW + T baking + SAM_{SMHV}	L53	(W+P1+T2+0.73D1)-(W+P1) L32-L5	Expansion	Secondary Stress	A
13	DW + NO + SAM_{SL-2}	L54	(W+P1+T1+D1)-(W+P1) L33-L3	Expansion	Secondary Stress	C
15	DW + T baking + SAM_{SL-2}	L55	(W+P1+T2+D1)-(W+P1) L34-L5	Expansion	Secondary Stress	C
16	DW + FIRE + SAM_{SL-2}	L56	(W+P1+T5+D1)-(W+P1) L35-L17	Expansion	Secondary Stress	C
19	DW + VVICE V + SL-3	L57	(W+P4+T3+1.5D1)-(W+P4) L36-L15	Expansion	Secondary Stress	C
--	DW + NO + SAM_{SL-3}	L63	(W+P1+T1+1.5D1)-(W+P1) L62-L3	Expansion	Secondary Stress	B

Table 10-5: Seismic operating load combinations and load combination for inertial stresses due to earthquake

Load case no. (LS)	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	**Load case type**	**Caesar Output Significance**	Service Level
6	DW+T baking + SL-1	S8	W+P1+T2+0.34D1+SL-1 *(L30+SL-1)*	Operating	Displ./Forces	A
		S1	W+P1+SL-1 *(L5+SL-1)*	Sustained with Inertial Seismic	Primary Stress	
10	DW+NO+SMHV	S9	W+P1+T1+0.73D1+SMHV *(L31+SMHV)*	Operating	Displ./Forces	A
		S2	W+P1+SMHV *(L3+SMHV)*	Sustained with Inertial Seismic	Primary Stress	
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV *(L32+SMHV)*	Operating	Displ./Forces	A
		S3	W+P1+SMHV *(L5+SMHV)*	Sustained with Inertial Seismic	Primary Stress	
13	DW+ NO+SL-2	S11	W+P1+T1+D1+SL-2 *(L33+SL-2)*	Operating	Displ./Forces	C
		S4	W+P1+SL-2 *(L3+SL-2)*	Sustained with Inertial Seismic	Primary Stress	
15	DW+T baking + SL-2	S12	W+P1+T2+D1+SL-2 *(L34+SL-2)*	Operating	Displ./Forces	C
		S5	W+P1+SL-2 *(L5+SL-2)*	Sustained with Inertial Seismic	Primary Stress	
16	DW+FIRE+SL-2	S13	W+P1+T5+D1+SL-2 *(L35+SL-2)*	Operating	Displ./Forces	C
		S6	W+P1+SL-2 *(L17+SL-2)*	Sustained with Inertial Seismic	Primary Stress	
19	DW+VVICE V+SL-3	S14	W+P4+T3+1.5D1+SL-3 *(L36+SL-3)*	Operating	Displ./Forces	C
		S7	W+P4+SL-3 *(L15+SL-3)*	Sustained with Inertial Seismic	Primary Stress	
--	DW+NO+SL-3	S16	W+P1+T1+1.5D1+SL-3 *(L62+SL-3)*	Operating	Displ./Forces	B
		S15	W+P1+SL-3 *(L3+SL-3)*	Sustained with Inertial Seismic	Primary Stress	

11.0 RESULTS

11.1 Stresses

As per the criteria mentioned in para 9.1, the maximum pressure during each operating condition should be lower than the allowable pressures defined in para 9.1.

This check has been performed and the results are shown in **Table 11-1** which concludes that the maximum pressure in each operating condition is lower than corresponding the allowable limit.

Table 11-1: Check of maximum pressure against allowable

Load Spec No.	Event	Pressure	Service Level	Pressure ($P_{int} – P_{ext}$) bar (g)	Allowable Pressure ($P_{int} – P_{ext}$) bar (g)	
					Maximum	Minimum
1	DW+NO	P1	A	-1	54.3	-11.4
5	DW+T Baking	P1	A	-1	54.3	-11.4
7	DW+VVICE II	P2	A	0.5	54.3	-11.4
8	DW+VVICE III	P2	A	0.5	54.3	-11.4
9	DW+LOCA VV-PHTS	P3	A	-2	54.3	-11.4
12	DW+VVICE IV	P4	C	1	81.8	-11.4
14	DW+VVICE V	P4	C	1	81.8	-11.4
16	DW+FIRE	P1	C	-1	81.8	-11.4
17	DW+LOVA+ VVICE+FA	P7	A	4	54.3	-11.4
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	P5	D	11	108.6	-11.4
20	DW+VV Dust Explosion	P6	A	5	54.3	-11.4
21	DW+LOVA+VVICE+ FA	P7	D	4	108.6	-11.4
22	DW+LOVA+VVICE+ Explosion in VSTs+FD	P8	Ultimate Failure	11	108.6	-11.4
23	DW+LOCA PC III+ICE II	P9	D	-0.5	108.6	-11.4
--	Integrity at 30 bar*	P10	D	29.0	108.6	-11.4

Note: Integrity at 30 bar has been checked only for pipes and not for bellows. Integrity of bellows at 30 bar and service level D needs to be checked from the bellow manufacturer.

As per the criteria mentioned in paragraph 9.2, the maximum sustained stress and sustained plus occasional stress shall be lower than the allowable limits defined in **Table 9-3**.

This check has been performed and the results are shown in **Table 11-2**. It can be seen from the results that the sustained and sustained plus occasional stresses are within the allowable limits.

Table 11-2: Check of Sustained and Sustained plus Occasional stresses

Load Spec. no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level	Maximum Sustained Stress S_L+S_{OCC} (N/mm^2)	Allowable Stress S_h (N/mm^2)	Stress Ratio (S_L+S_{OCC}) / S_h
2	Hydrostatic Test	L1	WW+HP	Test	54.5	206.8	**0.26**
1	DW+NO	L3	W+P1	A	40.0	137.9	**0.29**
5	DW+T Baking	L5	W+P1	A	40.0	129.0	**0.31**
7	DW+VVICE II	L7	W+P2	A	31.5	122.0	**0.25**
8	DW+VVICE III	L9	W+P2	A	31.5	122.0	**0.25**
9	DW+LOCA VV-PHTS	L11	W+P3	A	77.2	137.9	**0.56**
12	DW+VVICE IV	L13	W+P4	C	31.7	122 x 1.5	**0.17**
14	DW+VVICE V	L15	W+P4	C	31.7	122 x 1.5	**0.17**
16	DW+FIRE	L17	W+P1	C	40	116 x 1.5	**0.23**
17	DW+LOVA+ VVICE+FA	L19	W+P7+F1	A	47.5	122.0	**0.39**
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L21	W+P5+F2	D	98.8	122 x 2	**0.41**
20	DW+VV Dust Explosion	L23	W+P6	A	33.9	137.9	**0.24**
21	DW+LOVA+VVICE+ FA	L25	WW+P7+F3	D	189.7	122 x 2	**0.77**
22	DW+LOVA+VVICE+ Explosion in VSTs+FD	L27	WW+P8+F4	Ultimate Failure	317.4	456.0	**0.69**
23	DW+LOCA PC III+ICE II	L29	W+P9	D	41.2	122 x 2	**0.17**
--	Integrity at 30 bar	L61	W+P6	D	46.4	137.9 x 2	**0.17**

Note: The service level for load specification no. 22 has been specified as 'Ultimate failure'. The allowable stress for ultimate failure has been assumed as equal to the ultimate tensile strength (UTS) of the material at 250^{O}C, which is 456 N/mm^2 as per ASME Section II Part D.

As mentioned in paragraph 9.3, the secondary stresses due to thermal expansion and thermal anchor motions shall be maintained within the limits defined by **Table 9-4**. This check has been performed and the results are shown in **Table 11-3**. It can be seen that the thermal expansion stresses are within the allowable limits.

Table 11-4 shows the results for secondary stresses for seismic load cases after including seismic anchor motions. The stresses in this case are also within the allowable limits.

Table 11-3: Stresses due to Thermal Expansion

Load case no. (LS)	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	**Load case type**	**Service Level**	**Stress Sa (N/mm^2)**	**Allowable Stress (N/mm^2)**	**Stress Ratio**
1	DW+NO	L37	(W+P1+T1)-(W+P1) *L2-L3*	Expansion	A	48.5	S_A=206.8	**0.23**
5	DW+T Baking	L38	(W+P1+T2)-(W+P1) *L4-L5*	Expansion	A	103.2	S_A=204.6	**0.50**
7	DW+VVICE II	L39	(W+P2+T3)-(W+P2) *L6-L7*	Expansion	A	170.6	S_A=202.9	**0.84**
8	DW+VVICE III	L40	(W+P2+T3) – (W+P2) *L8-L9*	Expansion	A	170.6	S_A=202.9	**0.84**
9	DW+LOCA VV-PHTS	L41	(W+P3+T4)-(W+P3) *L10-L11*	Expansion	A	88.6	S_A=206.8	**0.43**
12	DW+VVICE IV	L42	(W+P4+T3)-(W+P4) *L12-L13*	Expansion	C	170.7	4.2 Sh = 512.4	**0.33**
14	DW+VVICE V	L43	(W+P4+T3)-(W+P4) *L14-L15*	Expansion	C	170.7	4.2 Sh = 512.4	**0.33**
16	DW+FIRE	L44	(W+P1+T5)-(W+P1) *L16-L17*	Expansion	C	174.8	4.2 Sh = 487.2	**0.36**
17	DW+LOVA+VVICE +FA	L45	(W+P2+T3+F1)-(W+P2+F1) *L18-L19*	Expansion	A	169.0	S_A=202.9	**0.83**
18	DW+LOVA+VVICE +Explosion in VSTs+FD	L46	(W+P5+T3+F2)-(W+P5+F2) *L20-L21*	Expansion	D	168.1	6.0 Sh = 732	**0.23**
20	DW+VV Dust Explosion	L47	(W+P6+T1)-(W+P6) *L22-L23*	Expansion	A	158.8	S_A=206.8	**0.76**
21	DW+LOVA+VVICE +FA	L48	(W+P7+T3+F3)-(W+P7+F3) *L24-L25*	Expansion	D	172.7	6.0 Sh = 732	**0.24**
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L49	(W+P8+T3+F4)-(W+P8+F4) *L26-L27*	Expansion	Ult. failure	169.6	6.0 Sh = 732	**0.23**
23	DW+LOCA PC III+ICE II	L50	(W+P9+T3)-(W+P9) *L28-L29*	Expansion	D	170.4	6.0 Sh = 732	**0.23**

Table 11-4: Stresses due to Thermal Expansion + SAMs

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Load case type	Service Level	Stress Sa (N/mm^2)	Allowable Stress (N/mm^2)	Stress Ratio
6	DW + T Baking + SAM_{SL-1}	L51	(W+P1+T2+0.34D1)-(W+P1) *L30-L5*	Expansion	A	103.2	204.6	**0.50**
10	DW + NO + SAM_{SMHV}	L52	(W+P1+T1+0.73D1)-(W+P1) L31-L3	Expansion	A	48.5	206.8	**0.23**
11	DW + T baking + SAM_{SMHV}	L53	(W+P1+T2+0.73D1)-(W+P1) L32-L5	Expansion	A	103.2	204.6	**0.50**
13	DW + NO + SAM_{SL-2}	L54	(W+P1+T1+D1)-(W+P1) L33-L3	Expansion	C	48.5	4.2 Sh = 512.4	**0.09**
15	DW + T baking + SAM_{SL-2}	L55	(W+P1+T2+D1)-(W+P1) L34-L5	Expansion	C	103.2	4.2 Sh = 512.4	**0.20**
16	DW + FIRE + SAM_{SL-2}	L56	(W+P1+T5+D1)-(W+P1) L35-L17	Expansion	C	174.8	4.2 Sh = 512.4	**0.34**
19	DW + VVICE V + SAM_{SL-3}	L57	(W+P4+T3+1.5D1)-(W+P4) L36-L15	Expansion	C	172.8	4.2 Sh = 512.4	**0.34**
--	DW + NO + SAM_{SL-3}	L63	(W+P1+T1+1.5D1)-(W+P1) L62-L3	Expansion	B	48.5	206.8	**0.23**

The results for sustained plus occasional stresses for load cases involving seismic loads are shown in **Table 11-5**. It is observed from this table that maximum stress due to seismic inertial loads are within the allowable limits defined by **Table 9-3**.

Table 11-5: Stresses due to Seismic Inertial Loads

Load Spec. No.	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	**Service Level**	**S_L+S_{OCC} (N/mm^2)**	**Allowable Stress (N/mm^2)**	**Stress Ratio**
6	DW+T baking + SL-1	S1	W+P1+SL-1 *(L5+SL-1)*	A	50.9	122.0	**0.42**
10	DW+NO+SMHV	S2	W+P1+SMHV *(L3+SMHV)*	A	72.7	122.0	**0.59**
11	DW+ T baking + SMHV	S3	W+P1+SMHV *(L5+SMHV)*	A	72.7	122.0	**0.59**
13	DW+ NO+SL-2	S4	W+P1+SL-2 *(L3+SL-2)*	C	87.7	122.0x1.5	**0.48**
15	DW+T baking + SL-2	S5	W+P1+SL-2 *(L5+SL-2)*	C	87.7	122.0x1.5	**0.48**
16	DW+FIRE+SL-2	S6	W+P1+SL-2 *(L17+SL-2)*	C	87.7	122.0x1.5	**0.48**
19	DW+VVICE V+SL-3	S7	W+P4+SL-3 *(L15+SL-3)*	C	97.5	122.0 x1.5	**0.53**
-	DW+NO+SL-3	S15	W+P1+SL-3	B	97.7	122.0	**0.80**

11.2 Check for Buckling

The check for buckling of pipes due to axial (longitudinal) compression stress generated by external pressure in combination with other sustained loads in service level A and B has been made and the results are given below. Buckling due to compressive hoop stresses generated by external pressure is covered by the allowable external pressure calculated in para 9.1.

11.2.1 Column Buckling

Since ASME B31.3 does not provide specific rules for column buckling due to sustained compressive axial stresses, reference is made to EN 13480-3. EN13480-3 under para C.2.2 provides guidance to control the axial compression stress under the context of thrust force due expansion joint. The philosophy is based on Euler's criteria for elastic buckling with factor of safety 3 and is applied here.

The permitted axial force (F_x) for a pipe of length (L) is given by [13]:

$$F_x = \frac{\pi^2 EI}{(\beta L)^2 S}$$

E is the modulus if elasticity, I is moment of inertia of pipe, L is length of pipe, β is the guiding factor (assumed equal to 1.0) and S is factor of safety (equal to 3).

Table 11-6 below shows the comparison between maximum sustained axial compressive stress in DN 300 and DN 500 relief line due to service level A & B loads and respective allowable stresses.

Table 11-6: Check for Column Buckling due to Sustained Axial Compressive Stress (SL-A & B)

Sr. No.	Pipe Size	Maximum span (L) (mm)	Permitted Axial Compressive Stress (F_x/A) (N/mm^2)	Maximum Axial Compressive Stress due to external pressure & axial force (N/mm^2)
1	DN 300	6184	16.33	5.19
2	DN 500	5988	42.12	1.94

11.2.2 Local Pipe Shell Buckling

Local pipe shell buckling due to total sustained axial compression stress due to pressure, axial force and bending moments has been checked as per the procedure of ASME BPV Code Section VIII Division 1.

Table 11-7 shows the comparison between maximum total sustained axial compressive stress in DN 300 and DN 500 relief line due to service level A & B loads and respective allowable stresses (Factor B).

Table 11-7: Check for local pipe shell buckling due to combined sustained Axial Compressive Stress (SL-A & B)

Sr. No.	Pipe Size	Factor A	Factor B (Permitted Axial Compression Stress)		Maximum Total Axial Compressive Stress due to external pressure, axial force and bending moment (N/mm^2)
			(psi)	(N/mm2)	
1	DN 300	0.01	10000	68.9	46.67
2	DN 500	0.006	9500	65.5	29.55

11.3 Loads on Supports

Support loads in global coordinate system are listed in:
Appendix A: Assuming no sliding friction at supports.
Appendix B: Assuming sliding friction at supports.

The node numbers representing supports are shown in **Figure 11-1**.

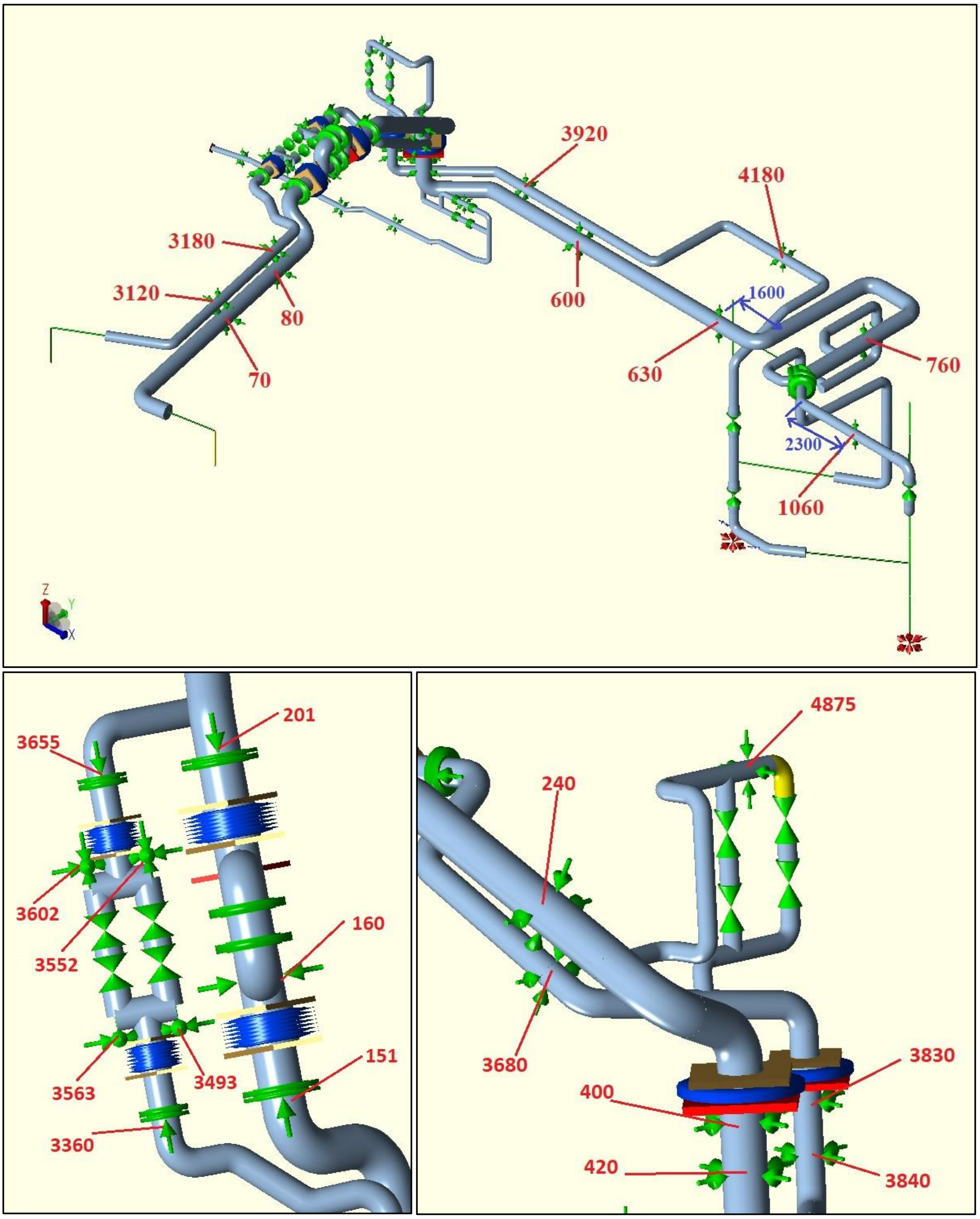


Figure 11-1: Nodes representing supports

The boundary conditions for supports are listed in

Table 11-8.

Table 11-8: Support Boundary Conditions

Node No.	Support Type
70	Rigid GUI; Rigid Z
80	Rigid GUI; Rigid Z
151	Rigid +LIM
160	Rigid GUI; Rigid Z
190	Rigid ANC
201	Rigid -LIM
240	Rigid GUI; Rigid Z
396	Rigid ANC
400	Rigid GUI; Rigid GUI
420	Rigid GUI; Rigid GUI
600	Rigid GUI; Rigid Z
630	Rigid Z
760	Rigid Z
1060	Rigid Z
3120	Rigid GUI; Rigid Z
3180	Rigid GUI; Rigid Z
3360	Rigid +LIM
3493	Rigid GUI with 2 mm gap; Rigid Z
3552	Rigid GUI with 2 mm gap; Rigid LIM; Rigid Z
3563	Rigid GUI with 2 mm gap; Rigid Z
3602	Rigid GUI with 2 mm gap; Rigid LIM; Rigid Z
3655	Rigid -LIM
3680	Rigid GUI; Rigid Z
3825	Rigid ANC
3830	Rigid GUI; Rigid GUI
3840	Rigid GUI; Rigid GUI
3920	Rigid GUI; Rigid Z
4180	Rigid GUI; Rigid Z
4875	Rigid GUI; Rigid Z

11.4 Loads on Nozzles and Y piece

Nozzle loads are listed in:
Appendix C: Assuming no sliding friction at supports.
Appendix D: Assuming sliding friction at supports.

Local coordinate systems applicable for nozzles are shown in **Figure 11-2**.
Blue: local x-axis (axial)
Green: local y-axis (lateral)
Red: local z-axis (vertical)

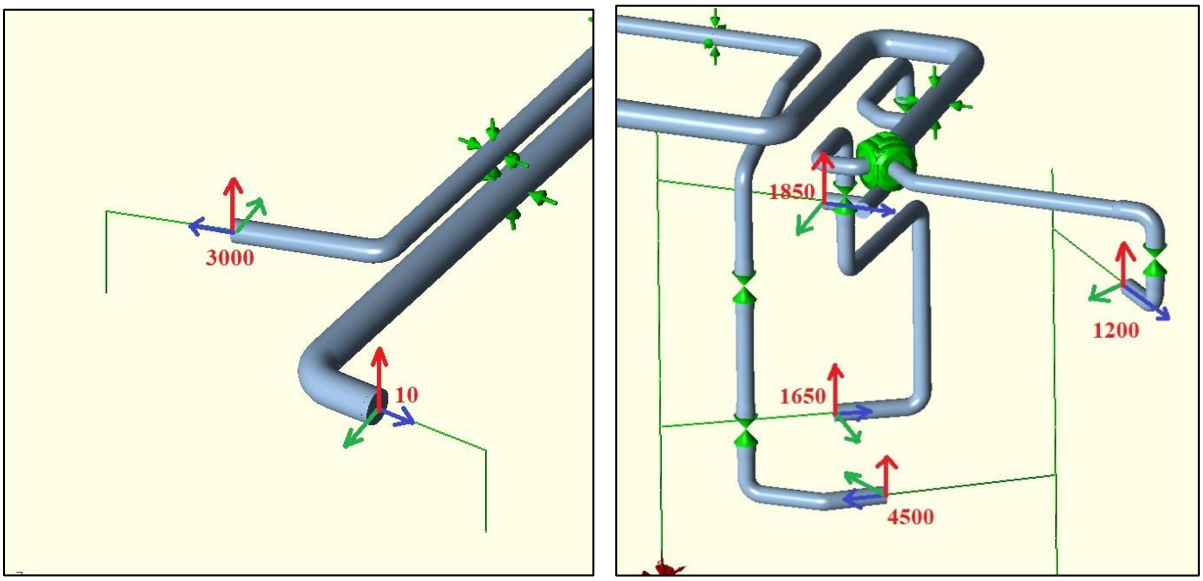


Figure 11-2: Local Coordinate System for Nozzle loads

Local coordinate system for loads on Y piece are shown in **Figure 11-3**

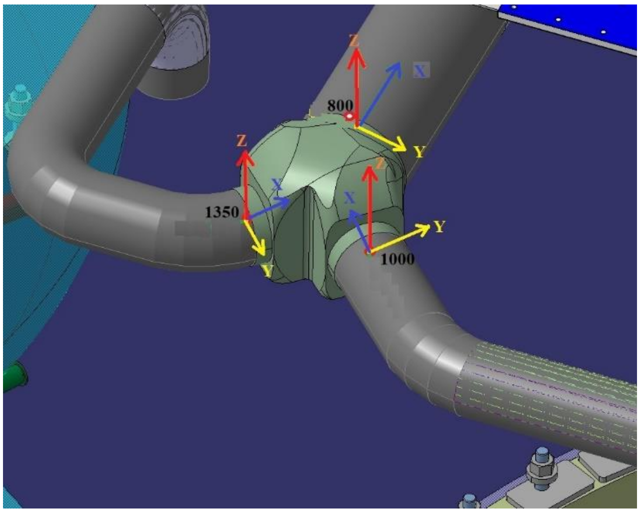


Figure 11-3: Local Coordinate System for loads on Y piece

11.5 Displacements

11.5.1 Maximum sag due to Sustained Loads

Maximum sag in the relief line due to sustained loads (W+P) is 8.3 mm at the location shown in **Figure 11-4**.

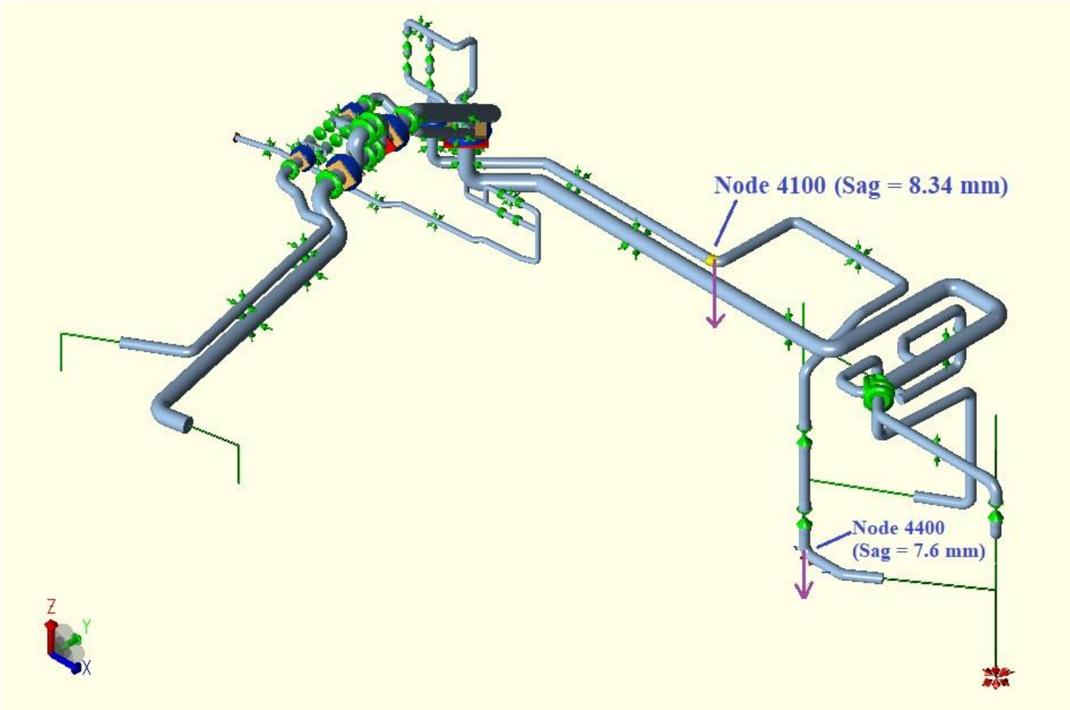


Figure 11-4: Maximum sag due to sustained loads

11.5.2 Maximum displacements

Maximum displacements for each service level and for all the nodes are provided as an attachment on IDM. These displacements shall be used to check clashes of relief lines with the surrounding components in the 3D model.

This section reports only the maximum displacement at key locations marked in **Figure 11-5** for Service Level A loads. **Table 11-9** lists absolute (without sign +/-) maximum displacements due to Service Level A loads.

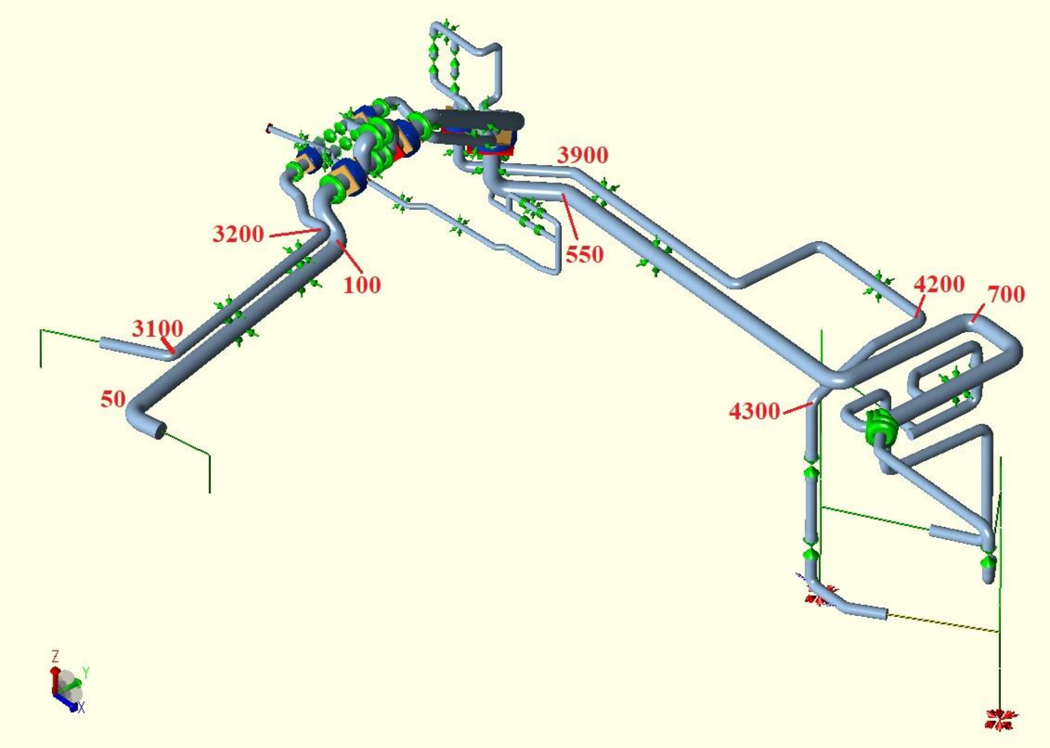


Figure 11-5: Key location for displacements

Table 11-9: Maximum displacements due to Service Level A loads

Node	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
50	11.0	1.4	4.5	0.1	0.1	0.2
100	9.6	37.1	3.4	0.4	0.1	0.4
150	13.5	38.2	7.2	0.3	0.1	0.4
200	3.0	14.6	8.8	0.2	0.2	0.0
550	7.7	6.0	10.8	0.1	0.2	0.1
700	47.0	8.3	5.0	0.1	0.2	0.2
1750	39.1	10.0	16.3	0.2	0.2	0.2
3100	10.2	11.2	3.4	0.1	0.0	0.3
3200	6.7	35.2	1.7	0.0	0.1	0.4
3670	8.4	17.4	13.0	0.3	0.3	0.2
3900	16.5	3.3	5.7	0.2	0.3	0.2
4100	42.9	12.5	16.8	0.4	0.1	0.1
4200	55.0	6.6	6.8	0.7	0.1	0.3
4250	49.9	11.3	26.9	0.7	0.2	0.4

11.5.3 Check for Bellow Displacements

The displacements in the bellow have been checked for Service Level A operating conditions as per the criteria mentioned in paragraph 9.4.

The results are tabulated below from **Table 11-10** to **Table 11-15**

It can be seen from these results that few bellows do no satisfy the acceptable deformation criteria specified by the manufacturer for minimum 1000 fatigue cycles.
The results for the bellows, which do not satisfy the criteria for permitted displacement for 1000 fatigue cycles, are shown in ***Bold Italics***. These bellows needs further assessment with two options described below.

Option 1
It may be noted from [1] that the maximum number of displacement cycles expected in VVPSS system are much less than 1000. Thus, it needs to be investigated with the bellow manufacturer if the values of permitted displacements in the bellow can be increased for low number of cyclic operation of bellows.

Option 2
The other possibility, which can be explored for such bellows, is the cold spring during installation. Bellows can deform in compression as well as tension from its neutral position. The permitted displacement values listed in **Table 5-4** to **Table 5-9** are only in one direction. This aspect can also be studied.

Bellows at NB Cell to DTR penetration of DN 500 relief line

Table 11-10: Check for deformations in bellows at NB Cell to DTR penetration of DN 500 relief line

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 40 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =40 mm)*	*(Allow =2 mm)*	*(Allow =6 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	5.50	3.10	0.13	**8.73**	5.50	0.16	0.02	**0.22**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	3.31	1.85	0.16	**5.33**	3.31	0.09	0.02	**0.13**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	12.61	3.01	0.21	**15.84**	12.62	0.15	0.03	**0.40**
20	DW+VV Dust Explosion	L22	W+P6+T1	2.14	0.18	0.03	**2.35**	2.13	0.01	0.001	**0.06**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 42 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =42 mm)*	*(Allow =1.95 mm)*	*(Allow =5.5 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	5.50	3.45	0.15	**9.10**	5.50	0.16	0.02	**0.22**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	3.31	2.02	0.18	**5.51**	3.31	0.09	0.02	**0.13**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	12.62	3.28	0.02	**16.10**	12.62	0.15	0.03	**0.38**
20	DW+VV Dust Explosion	L22	W+P6+T1	2.14	0.21	0.03	**2.37**	2.14	0.01	0.01	**0.06**

Bellows at NB Cell to DTR penetration of DN 300 relief line

Table 11-11: Check for deformations in bellows at NB Cell to DTR penetration of DN 300 relief line

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 34 mm) Due to: Axial (i)	Lateral (ii)	Bend. (iii)	**Total (i)+(ii)+(iii)**	Axial (mm) *(Allow =34 mm)*	Lateral (mm) *(Allow =1.95 mm)*	Bend. (deg) *(Allow =7.0 deg)*	**Combined Ratio** ***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	3.18	2.66	0.12	**5.96**	3.18	0.15	0.03	**0.18**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	6.41	1.82	0.17	**8.4**	6.41	0.10	0.04	**0.25**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	17.30	7.69	0.53	**25.52**	17.23	0.44	0.11	**0.75**
20	DW+VV Dust Explosion	L22	W+P6+T1	2.33	0.87	0.07	**3.27**	2.33	0.05	0.01	**0.10**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 38 mm) Due to: Axial (i)	Lateral (ii)	Bend. (iii)	**Total (i)+(ii)+(iii)**	Axial (mm) *(Allow =38 mm)*	Lateral (mm) *(Allow =2.05 mm)*	Bend. (deg) *(Allow =6.5 deg)*	**Combined Ratio** ***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	3.18	2.93	0.14	**6.25**	3.18	0.16	0.03	**0.17**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	6.42	1.85	0.21	**8.47**	6.41	0.10	0.04	**0.22**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	17.30	7.90	0.63	**25.84**	17.30	0.43	0.11	**0.68**
20	DW+VV Dust Explosion	L22	W+P6+T1	2.33	0.89	0.08	**3.30**	2.33	0.05	0.01	**0.09**

Bellows upstream of Bleed Valves

Table 11-12: Check for deformations in bellows upstream of Bleed Valves

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 82.5 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**	*(Allow =82.5 mm)*	*(Allow =19.0 mm)*	*(Allow =22 deg)*	***(Allow =1.0)***
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**				
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	41.50	69.18	0.68	***111.37***	41.50	16.24	0.23	***1.37***
9	DW+LOCA VV-PHTS	L10	W+P3+T4	44.02	45.45	1.15	***90.62***	44.02	10.67	0.38	***1.11***
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	46.06	48.53	0.14	***94.74***	46.06	11.39	0.05	***1.16***
20	DW+VV Dust Explosion	L22	W+P6+T1	2.34	68.81	0.94	**69.10**	2.34	15.45	0.31	**0.86**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 97.5 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**	*(Allow =97.5 mm)*	*(Allow =24.0 mm)*	*(Allow =19.5 deg)*	***(Allow =1.0)***
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**				
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	41.07	65.0	0.84	***106.91***	41.07	15.94	0.23	***1.10***
9	DW+LOCA VV-PHTS	L10	W+P3+T4	43.75	44.49	1.44	**89.67**	43.75	10.91	0.38	**0.92**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	45.52	46.57	0.18	**92.27**	45.52	11.42	0.05	**0.95**
20	DW+VV Dust Explosion	L22	W+P6+T1	2.14	63.81	1.17	**67.12**	2.14	15.65	0.31	**0.69**

Bellows downstream of Bleed Valves

Table 11-13: Check for deformations in bellows downstream of Bleed Valves

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 82.5 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =82.5 mm)*	*(Allow =19.0 mm)*	*(Allow =22 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	13.89	74.31	0.92	***89.12***	13.89	17.45	0.31	***1.10***
9	DW+LOCA VV-PHTS	L10	W+P3+T4	32.54	35.88	1.42	**69.84**	32.54	8.52	0.47	**0.86**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	12.08	97.38	0.28	***109.74***	12.08	22.86	0.09	***1.35***
20	DW+VV Dust Explosion	L22	W+P6+T1	0.12	6.52	0.05	**6.69**	0.12	1.53	0.02	**0.08**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 97.5 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =97.5 mm)*	*(Allow =24.0 mm)*	*(Allow =19.5 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	13.90	70.36	1.15	**85.41**	13.90	17.26	0.31	**0.88**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	32.26	33.42	1.76	**67.44**	32.26	8.20	0.47	**0.70**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	11.54	93.18	0.35	***105.07***	11.54	22.86	0.09	***1.08***
20	DW+VV Dust Explosion	L22	W+P6+T1	0.09	6.22	0.06	**6.37**	0.09	1.53	0.02	**0.07**

Bellows upstream of Rupture Disks

Table 11-14: Check for deformations in bellows upstream of Rupture Disks

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 107.5 mm) Due to: Axial (i)	Lateral (ii)	Bend. (iii)	**Total** **(i)+(ii)+(iii)**	Axial (mm) *(Allow =107.5mm)*	Lateral (mm) *(Allow =23.5 mm)*	Bend. (deg) *(Allow =17.5 deg)*	**Combined Ratio** ***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	37.47	70.70	1.04	***<u>109.21</u>***	37.47	15.46	0.22	***<u>1.02</u>***
9	DW+LOCA VV-PHTS	L10	W+P3+T4	34.80	40.78	1.66	**77.24**	34.80	8.92	0.36	**0.72**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	46.81	40.02	0.16	**86.99**	46.81	8.75	0.03	**0.81**
20	DW+VV Dust Explosion	L22	W+P6+T1	3.90	96.70	2.37	**102.97**	3.90	21.15	0.51	**0.97**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 114.0 mm) Due to: Axial (i)	Lateral (ii)	Bend. (iii)	**Total** **(i)+(ii)+(iii)**	Axial (mm) *(Allow =114.0mm)*	Lateral (mm) *(Allow =18.5 mm)*	Bend. (deg) *(Allow =16.0 deg)*	**Combined Ratio** ***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	37.21	94.43	1.24	***<u>132.88</u>***	37.21	15.41	0.22	***<u>1.17</u>***
9	DW+LOCA VV-PHTS	L10	W+P3+T4	34.60	53.95	1.98	**90.52**	34.60	8.80	0.36	**0.80**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	46.42	53.61	0.19	**100.22**	46.42	8.75	0.03	**0.88**
20	DW+VV Dust Explosion	L22	W+P6+T1	3.76	128.6	2.82	***<u>135.16</u>***	3.75	20.98	0.51	***<u>1.20</u>***

Bellows downstream of Rupture Disks

Table 11-15: Check for deformations in bellows downstream of Rupture Disks

Inner Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 107.5 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =107.5mm)*	*(Allow =23.5 mm)*	*(Allow =17.5 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	7.99	29.85	0.77	**38.61**	7.99	6.53	0.17	**0.36**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	19.31	16.94	0.95	**37.19**	19.30	3.70	0.20	**0.35**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	12.11	50.11	0.39	**62.61**	12.11	10.96	0.08	**0.58**
20	DW+VV Dust Explosion	L22	W+P6+T1	0.21	3.14	0.12	**3.47**	0.21	0.69	0.03	**0.03**

Outer Bellow

Load Spec. No.	Event	Caesar Load Case No.	Load Combination	Axial (mm) (Allowable = 114.0 mm)				Axial (mm)	Lateral (mm)	Bend. (deg)	**Combined Ratio**
				Due to:			**Total**				
				Axial (i)	Lateral (ii)	Bend. (iii)	**(i)+(ii)+(iii)**	*(Allow =114.0mm)*	*(Allow =18.5 mm)*	*(Allow =16.0 deg)*	***(Allow =1.0)***
11	DW+ T baking + SMHV	S10	W+P1+T2+0.73D1+SMHV	7.96	40.29	0.92	**49.17**	7.96	6.57	0.16	**0.44**
9	DW+LOCA VV-PHTS	L10	W+P3+T4	19.10	23.09	1.13	**43.32**	19.10	3.77	0.20	**0.38**
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	11.72	67.32	0.47	**79.50**	11.72	10.98	0.08	**0.70**
20	DW+VV Dust Explosion	L22	W+P6+T1	0.19	4.27	0.14	**4.59**	0.19	0.70	0.03	**0.04**

12.0 FATIGUE ANALYSIS AS PER EN 13480-3/EN 13445-3

Load Specifications [1] requires fatigue analysis as per EN 13480-3 / EN 13445-3. This section of report demonstrates the fulfilment of this criterion.

12.1 Fatigue due to Displacement Stress Range

Fatigue analysis criterion for displacement stress range of EN 13480-3 (section 12.0) is similar to ASME B31.3. The terminologies used in ASME B31.3 has been retained below.

It has been shown in para 11.1 of this report that the maximum displacement stress ranges for various operating conditions are lower than allowable displacement stress range, S_A = 202.9 N/mm^2. This value of allowable stress value is based on 7000 operating cycles, since the value of stress range factor (*f*) used is 1.0.

Maximum displacement stress ranges obtained by stress analysis for various operating conditions in Service level A and B, are reproduced below in **Table 12-1**. This table also shows the number of operation cycles for each event during design life of relief lines

As expected, maximum displacement stress range (S_E = 170.6 N/mm^2) occurs for LS-7 (event VVICE II), as it corresponds to maximum operating temperature of 250 ^{o}C. The number of cycles corresponding to maximum displacement stress range are, N_E = 15.

All other cycles corresponding to lower stress range (e.g. 300 for LS-1, 500 for LS-5, etc.) are converted to equivalent number of cycles.

The total equivalent displacement cycles are given by:

$$N = N_E + \sum (r_i^5 N_i) \ \ for\ i = 1,2, \ldots..n$$

where
N_E = number of cycles of maximum computed displacement stress range, S_E
N_i = number of cycles associated with displacement stress range, S_i
r_i = S_i/S_E
S_i = any computed displacement stress range smaller than S_E
S_E = Maximum displacement stress range smaller than S_E = 170.6 N/mm^2

The objective of this section is to demonstrate that the total equivalent number of cycles for SL-A and SL-B operating events are less than 7000.

It is obvious that this criterion is fulfilled by the VVPSS relief lines as the sum of the individual cycles are already lower than 7000. As illustrated in **Table 12-1** below, the total equivalent cycles are only 64.

Table 12-1: Calculation of Equivalent Displacement Cycles

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level	Displ. Stress Range Si (N/mm^2)	No of cycles	Equivalent no. of cycles $r_i^5 N_i$
1	DW+NO	L37	(W+P1+T1)-(W+P1) *L2-L3*	A	48.5	300	0.56
5	DW+T Baking	L38	(W+P1+T2)-(W+P1) *L4-L5*	A	103.2	500	40.50
7	DW+VVICE II	L39	(W+P2+T3)-(W+P2) *L6-L7*	A	170.6	15	15.00
8	DW+VVICE III	L40	(W+P2+T3) – (W+P2) *L8-L9*	A	170.6	01	1.00
9	DW+LOCA VV-PHTS	L41	(W+P3+T4)-(W+P3) *L10-L11*	A	88.6	01	0.04
17	DW+LOVA+ VVICE+FA	L45	(W+P2+T3+F1)-(W+P2+F1) *L18-L19*	A	169.0	01	0.95
20	DW+VV Dust Explosion	L47	(W+P6+T1)-(W+P6) *L22-L23*	A	158.8	01	0.70
6	DW + T Baking + SAM_{SL-1}	L51	(W+P1+T2+0.34D1)-(W+P1) *L30-L5*	A	103.2	50	4.05
10	DW + NO + SAM_{SMHV}	L52	(W+P1+T1+0.73D1)-(W+P1) L31-L3	A	48.5	50	0.09
11	DW + T baking + SAM_{SMHV}	L53	(W+P1+T2+0.73D1)-(W+P1) L32-L5	A	103.2	10	0.81
--	DW + NO + SAM_{SL-3}	L63	(W+P1+T1+1.5D1)-(W+P1) L62-L3	B	48.5	01	0.00
				Total		930 cycles	64 cycles

12.2 Fatigue due to Cycling of Pressure and Moments

Section 10.3 of EN 13480-3 provides requirements to perform fatigue design of piping for pressure cycling. These requirements are in addition to fatigue check due to displacement stresses alone dealt by section 12 of EN13480-3.

Section 10.3 of EN 13480-3 considers stress variation due to pressure alone. When fatigue due to variation in forces and moments is to be included, reference is made to EN 13445-3 (*refer note 1 clause 12.4 of EN 13480-3*).

Pseudo elastic stress range $(\Delta\sigma)_P$ due to pressure variation is given by:

$$(\Delta\sigma)_P = \frac{\Delta P}{P_{max}} \eta f$$

ΔP = Pmax – Pmin
η = stress factor (considered 1.3 for weld class K2)
f = nominal design stress (122 N/mm^2)

$(\Delta\sigma)_P$ obtained by above equation gives stress variation due to pressure alone. However, it is permitted to add stress variation due to external moments to get the total stress variation. (*refer clause 17.1.2 of EN 13443-3*)

Fatigue chart of EN 13443-3 provides curves for welded joints, in which notch effect is included. Thus, the structural stress (instead of peak stress) is to be used in these fatigue curves.

Stress ranges due to thermal expansion and earthquake loads are obtained from Caesar analysis (refer **Table 11-3** & **Table 11-5**). These stresses have SIFs of ASME B31.3 included in them. Since the SIFs of ASME B31.3 are also based with respect to fatigue testing of welded joint, these stresses have been added to stress range due to pressure variation. Thus, the total stress range $(\Delta\sigma)_T$ is given by: $(\Delta\sigma)_T = (\Delta\sigma)_P + (\Delta\sigma)_M$

Table 12-2 below shows the total stress range $(\Delta\sigma)_T$ obtained for various operating conditions.

Table 12-2: Fatigue check due to cycling of pressure and moments

Load Spec No.	Event	Service Level	No of Cycles	Range of Pressure bar (g) ΔP	Stress Range due to Pressure cycling $(\Delta\sigma)_P$ (N/mm^2)	Thermal Expansion $(\Delta\sigma)_{M1}$ (N/mm^2)	SL1/ SMHV $(\Delta\sigma)_{M2}$ (N/mm^2)	Total Stress Range $(\Delta\sigma)_T$ N/mm^2
1	DW+NO	A	300	- 1	- 4.91	- 48.5	-	53.4
5	DW+T Baking	A	500	- 1	- 4.91	-103.2	-	108.1
7	DW+VVICE II	A	15	- 0.5	- 2.45	-170.6	-	173.1
8	DW+VVICE III	A	01	- 0.5	- 2.45	-170.6	-	173.1
9	DW+LOCA VV-PHTS	A	01	- 2	- 9.82	- 88.6	-	98.4
6	DW+T baking + SL-1	A	50	- 1	- 4.91	-103.2	± 50.9	159.0
10	DW+NO+SMHV	A	50	- 1	- 4.91	-48.5	± 72.7	126.1
11	DW+ T baking + SMHV	A	10	- 1	- 4.91	-103.2	± 72.7	180.8
17	DW+LOVA+VVICE+ FA	A	01	4	19.62	169.0	-	188.6
20	DW+VV Dust Explosion	A	01	5	24.55	158.8	-	183.4

a) Elastic Shakedown $(\Delta\sigma)_T < 3f$

To ensure validity of stresses calculated by elastic analysis in the fatigue analysis it is necessary that $(\Delta\sigma)_T < 3f$ (*para 17.6.1.3 of EN 13443-3*).
For VVPSS relief lines this criterion is satisfied as max $(\Delta\sigma)_T$ is 188.6 N/mm^2 which is less than $3f$ i.e. 366 N/mm^2.

b) Allowable number of cycles

The stress range to be used in the fatigue curve for estimating the allowable number of cycles is:

$$(\Delta\sigma)_T^* = \frac{(\Delta\sigma)_T}{C_e C_T}$$

C_e is thickness correction factor (1.0 for thickness of 12.7 mm) [15]
C_T is the temperature correction factor (0.96) [15]
The allowable no. of cycles are derived from fatigue chart or from equation below.

$$N_{all} = \left(\frac{B}{\Delta\sigma_T^*}\right)^m$$

m = constant (3 for welded joints)

B = 6300 N/mm^2 (for weld class K2)

For LS-17,

- $(\Delta\sigma)_T^* = \frac{188.6}{1.0 \times 0.96} = 196.5\ N/mm^2$
- $N_{all} = \left(\frac{6300}{196.5}\right)^3 = 32955\ cycles$

It is seen that allowable cycles for LS-17 (which has maximum stress range) are 32955. Even the total cycles of operation including all other events of SL A and SL B are less than 32955.

Thus criteria for cumulative fatigue damage,

$$\frac{n_1}{N_1} + \frac{n_1}{N_1} + \cdots \quad \frac{n_n}{N_N} \leq 1.0$$

is satisfied for VVPSS relief lines.

12.3 Fatigue due to Thermal Gradients

EN13480-3 provides a guidance to avoid thermal gradients and there by large thermal stresses in the piping. When thermal gradients cannot be avoided, fatigue evaluation of thermal stresses due to gradients is required. Heat transfer analysis is required to know if significant thermal gradients (temperature variation) across thickness of the pipes exist for any operating condition. The objective of this section of the report is to ensure that margin is available for stresses due thermal gradients if these need to be accommodated in the future.

As an example, let us assume that the temperature gradient range T(y) exists across the thickness of the pipe when system goes to the condition LOVA + VVICE and consider the condition LS-17 from **Table 12-2**.

17	DW+LOVA+VVICE+ FA	A	01	4	19.62	169.0	-	188.6

Maximum thermal stress range is given,

$$(\Delta\sigma)_{th} = \frac{E\alpha}{(1-\vartheta)}(T_{inside} - T_{mean})$$

E = Young's modulus (2 x 10^5)
α = coefficient of thermal expansion (17.0 x 10^{-6} mm/mmC)

As shown in **Figure 12-1**, temperature profile consists of average temperature (T), linearly varying temperature (ΔT_1) and peak temperature (ΔT_2).

$$(\Delta\sigma)_{th} = \frac{E\alpha}{(1-\vartheta)}(T_i - T) = \frac{E\alpha}{(1-\vartheta)}\left(\frac{\Delta T_1}{2} + \Delta T_2\right) = \frac{E\alpha}{(1-\vartheta)}\frac{\Delta T_1}{2} + \frac{E\alpha}{(1-\vartheta)}\Delta T_2$$

(Limited by 3f or 2Sy)

(Limited based on fatigue life)

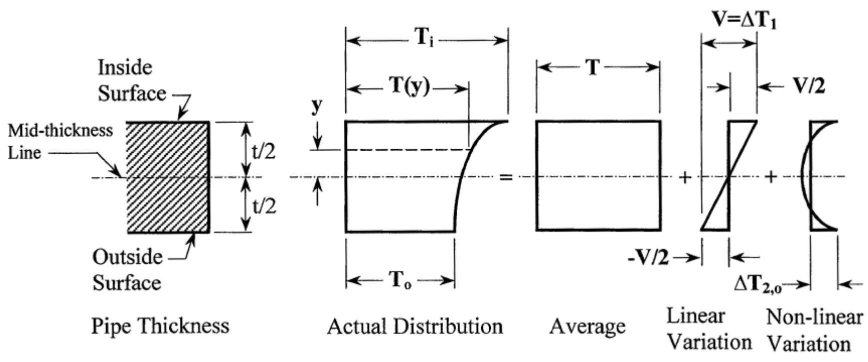


Figure 12-1: Temperature distribution across the wall thickness

Limits

1) Linearly varying temperature (ΔT_1) needs to be controlled to ensure that the total stress (including pressure, moments and thermal) is below 3f or 2Sy.

As seen in **Table 12-2**, for LS-17, the total stress range due to variation in pressure and moments is 188.6 N/mm^2. Thus, margin of (3*f* – 188.6 = 366 – 188.6 = 177.4) N/mm^2 exists for thermal stress.

Considering LS-11,

$$\frac{E\alpha}{(1-\vartheta)}\frac{\Delta T_1}{2} < 177.6$$

$$\Delta T_1 < 73^{o}C$$

Limit of 73 ^{o}C on ΔT_1 is to ensure the gross elastic behavior during thermal cycling. If it is found through steady or transient heat transfer analysis in future that ΔT_1 exceeds 73 ^{o}C, it can be accommodated by elastic plastic analysis.

2) Local stress due to (ΔT_2) will influence the fatigue life.

E.g.

If ΔT_2 = 10 ^{o}C, fatigue life will be 3101 cycles

If ΔT_2 = 20 ^{o}C, fatigue life will be 2226 cycles

This demonstrates that enough margin is available to accommodate the thermal stresses due to temperature gradients if these are found significant in future studies.

13.0 LOAD CASE FOR CAPTIVE PART & ITS RESULTS

Only part of the VVPSS relief lines will be installed initially, known as 'Captive Part'. Separate analysis of the Captive part of relief lines has been carried out. **Figure 13-1** shows the Caesar model of Captive Part.
Few temporary supports needs to be installed for captive lines to avoid otherwise large static deflections (sag) if they are free. Temporary support arrangement is shown in **Table 13-1**.

Table 13-1: Temporary support arrangement for Captive Relief Lines

Support No.	Type*	Remark
600	Vertical Restraint + Lateral Restraint + Axial Restraint	Configuration of existing support modified temporarily
630	Vertical Restraint	Existing support
760	Vertical Restraint	Existing support
3920	Vertical Restraint + Lateral Restraint + Axial Restraint	Configuration of existing support modified
4180	Vertical Restraint + Lateral Restraint	Existing support
525	Vertical Restraint + Lateral Restraint	Temporary support (Anywhere along L1)
1060	Vertical Restraint + Lateral Restraint	Configuration of existing support modified
1475	Vertical Restraint + Lateral Restraint	Temporary support (Anywhere along L2)
1735	Vertical Restraint + Lateral Restraint	Temporary support (Anywhere along L3)
4275	Vertical Restraint + Lateral Restraint	Temporary support (Anywhere along L4)

All supports are bi-directional (acing in plus and minus direction)

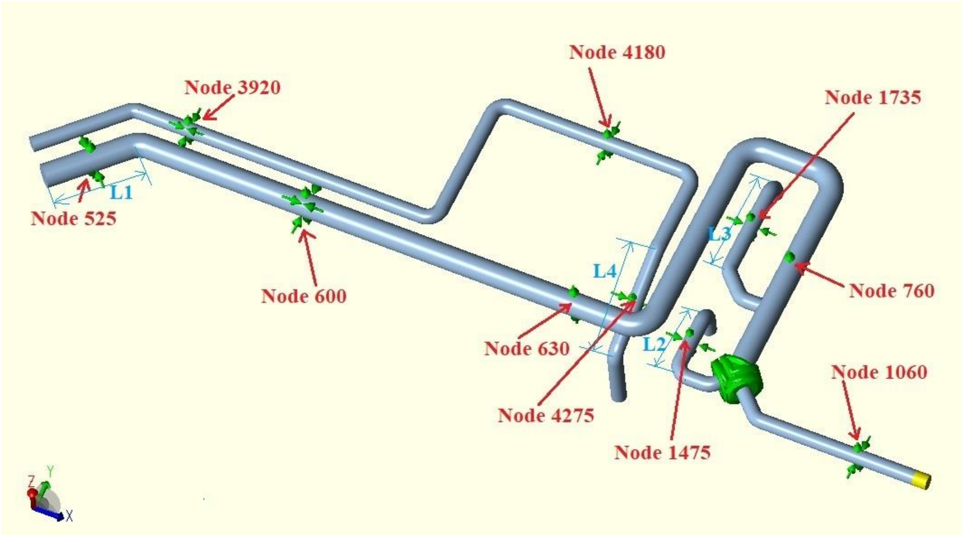


Figure 13-1: Captive Part of Relief Line

Stresses in the captive relief lines are shown in **Table 13-2**.
Maximum deflections are shown in **Figure 13-2**.

Table 13-2: Stresses in Captive Relief Lines

Sr. No.	Load Case	Pressure (g) (bars)	Temperature (º C)	Maximum Stress (N/mm^2)	Allowable Stress (N/mm^2)
1	WW+HP	25.7	20	52.1	206.8
2	W+P1	1.0	35	26.9	137.9
3	W+P1+SL-1	1.0	35	51.0	137.9
4	W+P1+SMHV	1.0	35	78.6	137.9

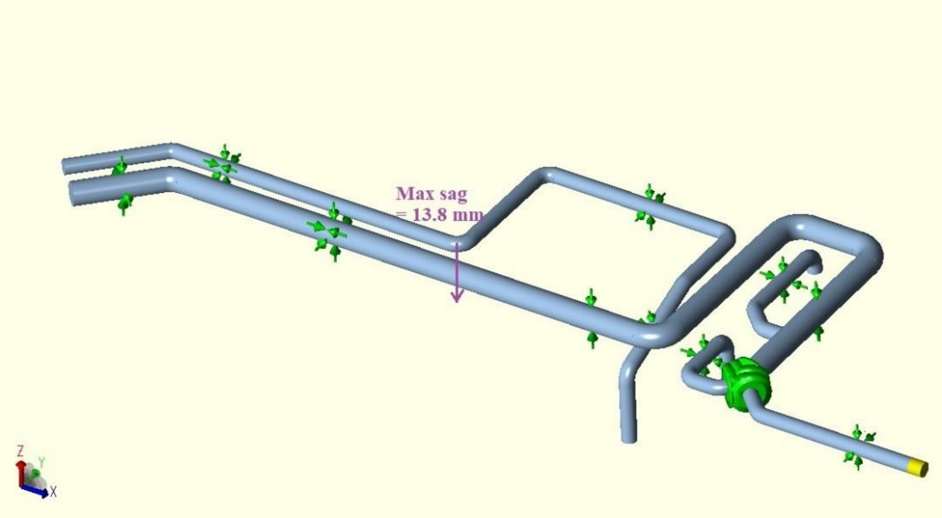


Figure 13-2: Deflections in captive relief lines

14.0 REQUIREMENTS AND RECOMMENDATIONS

REQUIREMENTS

1) It has been found that the deformations in some of the bellows are more than the allowable deformation limits prescribed by the bellow manufacturer for 1000 cyclic operations (refer para 11.5.3). It is required to consult the bellow manufacturer to study the possibility of extending the allowable deformation limits for low number of operating cycles expected in VVPSS. The other option is to study the feasibility of cold spring during installation of bellows.
2) Following changes in the supports have been made in the supports compared to the input 3DXML.
   a) Support at node 4180 shall be shifted by 50 mm with respect to its position in 3DXML

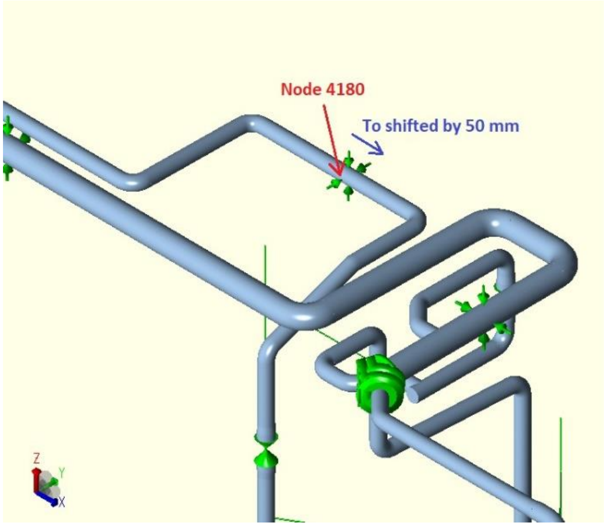


Figure 14-1: Shifting of support at node 4180

   b) New supports have been introduced at node 630 and node 1060 as shown in **Figure 14-2**. The boundary conditions for these supports have been assumed as vertical bi-directional restraints.

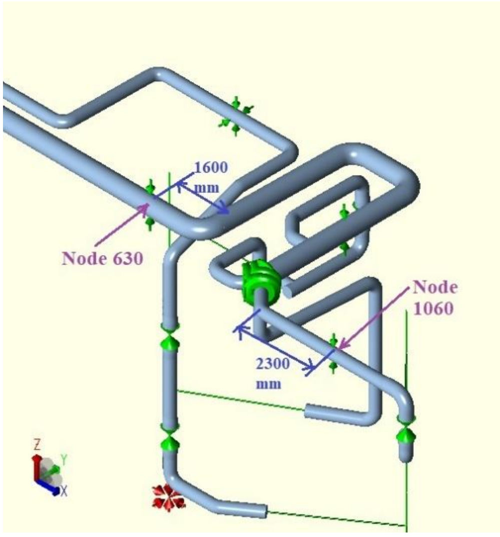


Figure 14-2: New supports at node 630 and node 1060

RECOMMENDATIONS

Water hammer analysis and surge flow analysis has been performed for DN 300 relief line due to event of hydrogen deflagration and detonation in SLT. Water hammer loads are highly dependent on the non-return valve (NRV) closure time. For the stress analysis, it has been assume that NRV closure time is 0.5 seconds. If during procurement stage, the actual valve closure time is less than 0.5 seconds, the water hammer loads needs to be revised. Water hammer and surge flow analysis can be further extended in future if it is found by process engineering that deflagration and detonation events are prominent in LLTs as well.

15.0 CONCLUSION

The stress analysis of the VVPSS Relief Lines has been performed for the operating conditions defined in the VVPSS load specification. It is concluded that for the analysed load combinations, the stresses in the Relief Pipelines are below the allowable stress limits.

16.0 REFERENCES

[1] Loads Case Specification VVPSS -RL (UXX829 v2.5).

[2] New VVPSS design proposal - Description (PX64Q7 v2.3)

[3] ITER Abbreviations (2MU6W5 v1.17)

[4] 3D VVPSS Model (3dxml) received through email dated 29/10/2019.

[5] ASME B31.3 - 2012.

[6] ASME Press, ‘Pipe Stress Engineering’ by L. C. Peng & T. L. Peng.

[7] Small LOCA Tank Reverse Flow Modelling (YK6RCP v2.0).

[8] John Parmakian, 1955, Water Hammer Analysis, Dover Publications, New York.

[9] Seismic Relative Displacements between the Building Floors (KWXL6B v1.0)

[10] Allowable values and limits in service level C and D for ITER mechanical components (3G3SYJ v3.1)

[11] ASME B16.9-2001 Factory-Made Wrought Butt Welding Fittings.

[12] Bellow Catalogue by Bellow Manufacturer Witzenmann.

[13] EN13480-3 (2017) Metallic industrial piping - Part 3: Design and calculation.

[14] EN 12952-3 (2001) Water tube boilers and auxiliary installations.

[15] EN 13445-3 Unfired Pressure Vessels –Part 3: Design

[16] ASME BPV Code Section VIII, Division 1

[17] ASME BPV Code Section II, Part D Subpart 3.

A. APPENDIX: Loads on Supports *(without sliding friction)*

I) Service Level A

<u>Part 1 of 2:</u> Static Load Cases

Load Spec. No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
2	Hydrostatic Test	L1	WW+HP	Test
1	DW+NO	L2	W+P1+T1	A
		L3	W+P1	
5	DW+T Baking	L4	W+P1+T2	A
		L5	W+P1	
7	DW+VVICE II	L6	W+P2+T3	A
		L7	W+P2	
8	DW+VVICE III	L8	W+P2+T3	A
		L9	W+P2	
9	DW+LOCA VV-PHTS	L10	W+P3+T4	A
		L11	W+P3	
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	A
		L19	W+P7+F1	
20	DW+VV Dust Explosion	L22	W+P6+T1	A
		L23	W+P6	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	1(HYD)	-1112	278	-9229	0	0	0
	2(OPE)	-35084	-7346	16648	0	0	0
	3(SUS)	-4075	-857	1999	0	0	0
	4(OPE)	-65826	-13780	31179	0	0	0
	5(SUS)	-4075	-857	1999	0	0	0
	6(OPE)	-80860	-16635	32717	0	0	0
	7(SUS)	-442	200	-5377	0	0	0
	8(OPE)	-80860	-16635	32717	0	0	0
	9(SUS)	-442	200	-5377	0	0	0
	10(OPE)	-49004	-10537	28530	0	0	0
	11(SUS)	-7515	-1857	8981	0	0	0
	18(OPE)	-79649	-16283	30258	0	0	0
	19(SUS)	-374	220	-5516	0	0	0
	22(OPE)	-20551	-3120	-12854	0	0	0
	23(SUS)	-373	220	-5513	0	0	0
	MAX	-80860/L6	-16635/L6	32717/L6			
80		Rigid GUI; Rigid Z					
	1(HYD)	1155	1390	-22497	0	0	0
	2(OPE)	21944	5455	-26863	0	0	0
	3(SUS)	1226	1082	-16352	0	0	0

	4(OPE)	42481	9790	-37284	0	0	0
	5(SUS)	1226	1082	-16352	0	0	0
	6(OPE)	54411	12130	-39911	0	0	0
	7(SUS)	644	765	-12349	0	0	0
	8(OPE)	54411	12130	-39911	0	0	0
	9(SUS)	644	765	-12349	0	0	0
	10(OPE)	29522	7238	-34204	0	0	0
	11(SUS)	1778	1382	-20142	0	0	0
	18(OPE)	54217	12024	-38577	0	0	0
	19(SUS)	633	759	-12274	0	0	0
	22(OPE)	19612	4187	-10850	0	0	0
	23(SUS)	633	759	-12280	0	0	0
	MAX	54411/L6	12130/L6	-39911/L6			
151	Rigid +LIM						
	1(HYD)	0	0	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	1943	-10421	0	0	0	0
	22(OPE)	0	0	0	0	0	0
	23(SUS)	18419	-98797	0	0	0	0
	MAX	18419/L23	-98797/L23				
160	Rigid GUI; Rigid Z						
	1(HYD)	-798	-149	-19412	0	0	0
	2(OPE)	3000	559	-26095	0	0	0
	3(SUS)	6471	1206	-18736	0	0	0
	4(OPE)	-429	-80	-35206	0	0	0
	5(SUS)	6471	1206	-18736	0	0	0
	6(OPE)	-9989	-1862	-92095	0	0	0
	7(SUS)	-855	-159	-12876	0	0	0
	8(OPE)	-9989	-1862	-92095	0	0	0
	9(SUS)	-855	-159	-12876	0	0	0
	10(OPE)	8665	1615	-20250	0	0	0
	11(SUS)	13406	2499	-24284	0	0	0
	18(OPE)	-12431	-2318	-90142	0	0	0
	19(SUS)	-994	-185	-12989	0	0	0
	22(OPE)	-26304	-4904	-2655	0	0	0

	23(SUS)	-995	-185	-14881	0	0	0
	MAX	-26304/L22	-4904/L22	-92095/L6			
190		Rigid ANC					
	1(HYD)	1490	452	-16426	-1022	-2038	-795
	2(OPE)	-948	5322	-2651	-12274	-4040	-844
	3(SUS)	-878	691	-12501	-79	-1281	-1193
	4(OPE)	-686	10307	8616	-26679	-7074	-722
	5(SUS)	-878	691	-12501	-79	-1281	-1193
	6(OPE)	-3590	7458	82025	-98491	-23188	3385
	7(SUS)	1701	342	-12171	-455	-1371	-829
	8(OPE)	-3590	7458	82025	-98491	-23188	3385
	9(SUS)	1701	342	-12171	-455	-1371	-829
	10(OPE)	-5122	3753	-13103	599	-2890	237
	11(SUS)	-2491	578	-14795	-781	-1484	-1942
	18(OPE)	1065	-13214	86942	-95949	-23068	3526
	19(SUS)	5862	-21773	-11956	-736	-1412	-817
	22(OPE)	9746	2825	-4805	-15696	-4552	518
	23(SUS)	1747	319	-10075	-2980	-1837	-819
	MAX	9746/L22	-21773/L19	86942/L18	-98491/L6	-23188/L6	3526/L18
201		Rigid -LIM					
	1(HYD)	-3828	20532	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	-4846	25990	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	-4846	25990	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	-11082	59440	0	0	0	0
	22(OPE)	-22221	119188	0	0	0	0
	23(SUS)	-23434	125695	0	0	0	0
	MAX	-23434/L23	125695/L23				
240		Rigid GUI; Rigid Z					
	1(HYD)	1072	-21582	-37799	0	0	0
	2(OPE)	-3307	-20738	-35499	0	0	0
	3(SUS)	-4440	-20972	-35691	0	0	0
	4(OPE)	-3289	-20737	-35500	0	0	0
	5(SUS)	-4440	-20972	-35691	0	0	0
	6(OPE)	23678	-9149	-20431	0	0	0

	7(SUS)	-1038	-20051	-34732	0	0	0
	8(OPE)	23678	-9149	-20431	0	0	0
	9(SUS)	-1038	-20051	-34732	0	0	0
	10(OPE)	-1906	-30679	-53080	0	0	0
	11(SUS)	-11884	-32753	-54801	0	0	0
	18(OPE)	32408	-1385	-8562	0	0	0
	19(SUS)	-932	-20251	-35099	0	0	0
	22(OPE)	1725	-18316	-32234	0	0	0
	23(SUS)	-909	-20206	-35025	0	0	0
	MAX	32408/L18	-32753/L11	-54801/L11			
396		Rigid ANC					
	1(HYD)	-477	211	-1966	-29	-66	438
	2(OPE)	-306	-943	12207	129	-43	-9
	3(SUS)	-194	-894	12236	122	-28	4
	4(OPE)	-305	-942	12207	129	-43	-9
	5(SUS)	-194	-894	12236	122	-28	4
	6(OPE)	-2951	849	9693	-116	-403	394
	7(SUS)	-346	-166	11654	23	-48	148
	8(OPE)	-2951	849	9693	-116	-403	394
	9(SUS)	-346	-166	11654	23	-48	148
	10(OPE)	-839	-3180	25600	435	-117	-555
	11(SUS)	163	-2739	25860	374	20	-446
	18(OPE)	-3766	3452	7649	-472	-514	982
	19(SUS)	-333	-163	11652	22	-47	128
	22(OPE)	-611	269	11246	-37	-84	247
	23(SUS)	-336	-166	11653	23	-47	144
	MAX	-3766/L18	3452/L18	25860/L11	-472/L18	-514/L18	982/L18
400		Rigid GUI; Rigid GUI					
	1(HYD)	-17671	17435	0	0	0	0
	2(OPE)	-6615	-26258	0	0	0	0
	3(SUS)	-2162	-23635	0	0	0	0
	4(OPE)	-6594	-26231	0	0	0	0
	5(SUS)	-2162	-23635	0	0	0	0
	6(OPE)	-124446	8427	0	0	0	0
	7(SUS)	-12192	-2041	0	0	0	0
	8(OPE)	-124446	8427	0	0	0	0
	9(SUS)	-12192	-2041	0	0	0	0
	10(OPE)	-18863	-105720	0	0	0	0
	11(SUS)	21008	-82125	0	0	0	0
	18(OPE)	-169728	86371	0	0	0	0
	19(SUS)	-11985	-1909	0	0	0	0
	22(OPE)	-25065	9836	0	0	0	0
	23(SUS)	-11839	-2067	0	0	0	0
	MAX	-169728/L18	-105720/L10				

420	Rigid GUI; Rigid GUI						
	1(HYD)	22290	-17301	0	0	0	0
	2(OPE)	14367	17491	0	0	0	0
	3(SUS)	11837	14807	0	0	0	0
	4(OPE)	14347	17469	0	0	0	0
	5(SUS)	11837	14807	0	0	0	0
	6(OPE)	89732	1580	0	0	0	0
	7(SUS)	19580	-1945	0	0	0	0
	8(OPE)	89732	1580	0	0	0	0
	9(SUS)	19580	-1945	0	0	0	0
	10(OPE)	22339	82787	0	0	0	0
	11(SUS)	-365	58692	0	0	0	0
	18(OPE)	124199	-58500	0	0	0	0
	19(SUS)	19811	-2105	0	0	0	0
	22(OPE)	28434	-10427	0	0	0	0
	23(SUS)	19334	-1940	0	0	0	0
	MAX	124199/L18	82787/L10				
600	Rigid GUI; Rigid Z						
	1(HYD)	-305	1684	-28345	0	0	0
	2(OPE)	-157	534	-14613	0	0	0
	3(SUS)	-144	614	-13441	0	0	0
	4(OPE)	-157	533	-14612	0	0	0
	5(SUS)	-144	614	-13441	0	0	0
	6(OPE)	-502	868	-46749	0	0	0
	7(SUS)	-184	1003	-17166	0	0	0
	8(OPE)	-502	868	-46749	0	0	0
	9(SUS)	-184	1003	-17166	0	0	0
	10(OPE)	-187	-1257	-17447	0	0	0
	11(SUS)	-75	-556	-6995	0	0	0
	18(OPE)	-643	2606	-59826	0	0	0
	19(SUS)	-185	1114	-17170	0	0	0
	22(OPE)	-223	1223	-20758	0	0	0
	23(SUS)	-184	993	-17168	0	0	0
	MAX	-643/L18	2606/L18	-59826/L18			
630	Rigid Z						
	1(HYD)	-225	0	-20939	0	0	0
	2(OPE)	-132	0	-12248	0	0	0
	3(SUS)	-136	0	-12689	0	0	0
	4(OPE)	-132	0	-12248	0	0	0
	5(SUS)	-136	0	-12689	0	0	0
	6(OPE)	-4	0	-368	0	0	0
	7(SUS)	-122	0	-11361	0	0	0
	8(OPE)	-4	0	-368	0	0	0
	9(SUS)	-122	0	-11361	0	0	0
	10(OPE)	-119	0	-11107	0	0	0

	11(SUS)	-162	0	-15048	0	0	0
	18(OPE)	47	0	4420	0	0	0
	19(SUS)	-121	0	-11266	0	0	0
	22(OPE)	-108	0	-10051	0	0	0
	23(SUS)	-122	0	-11362	0	0	0
	MAX	-225/L1		-20939/L1			
760		Rigid Z					
	1(HYD)	0	537	-53096	0	0	0
	2(OPE)	0	301	-29736	0	0	0
	3(SUS)	0	327	-32361	0	0	0
	4(OPE)	0	301	-29736	0	0	0
	5(SUS)	0	327	-32361	0	0	0
	6(OPE)	0	-139	13733	0	0	0
	7(SUS)	0	325	-32150	0	0	0
	8(OPE)	0	-139	13733	0	0	0
	9(SUS)	0	325	-32150	0	0	0
	10(OPE)	0	94	-9291	0	0	0
	11(SUS)	0	331	-32705	0	0	0
	18(OPE)	0	-144	14181	0	0	0
	19(SUS)	0	328	-32437	0	0	0
	22(OPE)	0	297	-29389	0	0	0
	23(SUS)	0	325	-32150	0	0	0
	MAX		537/L1	-53096/L1			
1060		Rigid Z					
	1(HYD)	-151	0	-15382	0	0	0
	2(OPE)	-94	0	-9644	0	0	0
	3(SUS)	-123	0	-12558	0	0	0
	4(OPE)	-94	0	-9643	0	0	0
	5(SUS)	-123	0	-12558	0	0	0
	6(OPE)	363	0	37132	0	0	0
	7(SUS)	-125	0	-12743	0	0	0
	8(OPE)	363	0	37132	0	0	0
	9(SUS)	-125	0	-12743	0	0	0
	10(OPE)	135	0	13768	0	0	0
	11(SUS)	-120	0	-12222	0	0	0
	18(OPE)	355	0	36259	0	0	0
	19(SUS)	-127	0	-12952	0	0	0
	22(OPE)	-97	0	-9951	0	0	0
	23(SUS)	-125	0	-12743	0	0	0
	MAX	363/L6		37132/L6			
3120		Rigid GUI; Rigid Z					
	1(HYD)	528	279	-3414	0	0	0
	2(OPE)	19451	3306	6186	0	0	0
	3(SUS)	-9720	-1730	-1622	0	0	0
	4(OPE)	48318	8288	13930	0	0	0

	5(SUS)	-9720	-1730	-1622	0	0	0
	6(OPE)	75802	13214	17854	0	0	0
	7(SUS)	-220	83	-2350	0	0	0
	8(OPE)	75802	13214	17854	0	0	0
	9(SUS)	-220	83	-2350	0	0	0
	10(OPE)	20578	3338	9555	0	0	0
	11(SUS)	-18858	-3476	-872	0	0	0
	18(OPE)	78756	13779	17613	0	0	0
	19(SUS)	368	195	-2376	0	0	0
	22(OPE)	44544	8097	4217	0	0	0
	23(SUS)	368	195	-2376	0	0	0
	MAX	78756/L18	13779/L18	17854/L6			
3180		Rigid GUI; Rigid Z					
	1(HYD)	-442	456	-10172	0	0	0
	2(OPE)	-8855	-1049	-11437	0	0	0
	3(SUS)	586	515	-7655	0	0	0
	4(OPE)	-18221	-2599	-15189	0	0	0
	5(SUS)	586	515	-7655	0	0	0
	6(OPE)	-23637	-3518	-16945	0	0	0
	7(SUS)	164	410	-7159	0	0	0
	8(OPE)	-23637	-3518	-16945	0	0	0
	9(SUS)	164	410	-7159	0	0	0
	10(OPE)	-12730	-1679	-13195	0	0	0
	11(SUS)	-138	406	-8150	0	0	0
	18(OPE)	-23422	-3486	-16785	0	0	0
	19(SUS)	-319	318	-7136	0	0	0
	22(OPE)	-8941	-1135	-10112	0	0	0
	23(SUS)	-311	320	-7136	0	0	0
	MAX	-23637/L6	-3518/L6	-16945/L6			
3360		Rigid +LIM					
	1(HYD)	4	-24	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	766	-4111	0	0	0	0
	22(OPE)	3294	-17665	0	0	0	0
	23(SUS)	7562	-40558	0	0	0	0
	MAX	7562/L23	-40558/L23				

3493		Rigid GUI w/gap; Rigid Z					
	1(HYD)	0	0	-5088	0	0	0
	2(OPE)	5136	957	-3962	0	0	0
	3(SUS)	4160	776	-4476	0	0	0
	4(OPE)	3122	582	-3491	0	0	0
	5(SUS)	4160	776	-4476	0	0	0
	6(OPE)	0	0	-2537	0	0	0
	7(SUS)	0	0	-4485	0	0	0
	8(OPE)	0	0	-2537	0	0	0
	9(SUS)	0	0	-4485	0	0	0
	10(OPE)	7266	1355	-3409	0	0	0
	11(SUS)	8733	1628	-4393	0	0	0
	18(OPE)	0	0	-2637	0	0	0
	19(SUS)	0	0	-4463	0	0	0
	22(OPE)	0	0	-3717	0	0	0
	23(SUS)	0	0	-4466	0	0	0
	MAX	8733/L11	1628/L11	-5088/L1			
3552		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	1(HYD)	-40	214	-5655	0	0	0
	2(OPE)	1042	-5587	-6944	0	0	0
	3(SUS)	2841	651	-7471	0	0	0
	4(OPE)	933	-5002	-6946	0	0	0
	5(SUS)	2841	651	-7471	0	0	0
	6(OPE)	2646	-14194	4609	0	0	0
	7(SUS)	10	-53	-4968	0	0	0
	8(OPE)	2646	-14194	4609	0	0	0
	9(SUS)	10	-53	-4968	0	0	0
	10(OPE)	818	3342	-5347	0	0	0
	11(SUS)	6545	1282	-10078	0	0	0
	18(OPE)	4158	-22303	7471	0	0	0
	19(SUS)	802	-4304	-4743	0	0	0
	22(OPE)	367	-1969	-4049	0	0	0
	23(SUS)	-43	228	-4715	0	0	0
	MAX	6545/L11	-22303/L18	-10078/L11			
3563		Rigid GUI w/gap; Rigid Z					
	1(HYD)	0	0	-8588	0	0	0
	2(OPE)	0	0	-6938	0	0	0
	3(SUS)	815	152	-7218	0	0	0
	4(OPE)	0	0	-6571	0	0	0
	5(SUS)	815	152	-7218	0	0	0
	6(OPE)	0	0	-7591	0	0	0
	7(SUS)	0	0	-6947	0	0	0
	8(OPE)	0	0	-7591	0	0	0
	9(SUS)	0	0	-6947	0	0	0

	10(OPE)	0	0	-7874	0	0	0
	11(SUS)	1991	371	-7569	0	0	0
	18(OPE)	0	0	-7765	0	0	0
	19(SUS)	0	0	-6987	0	0	0
	22(OPE)	-11569	-2157	-5650	0	0	0
	23(SUS)	0	0	-6990	0	0	0
	MAX	-11569/L22	-2157/L22	-8588/L1			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	1(HYD)	80	-428	-7825	0	0	0
	2(OPE)	-1725	9252	-8511	0	0	0
	3(SUS)	47	-253	-8325	0	0	0
	4(OPE)	-2365	12685	-8641	0	0	0
	5(SUS)	47	-253	-8325	0	0	0
	6(OPE)	-20960	17380	-8068	0	0	0
	7(SUS)	6	-34	-6480	0	0	0
	8(OPE)	-20960	17380	-8068	0	0	0
	9(SUS)	6	-34	-6480	0	0	0
	10(OPE)	35	-187	-11135	0	0	0
	11(SUS)	68	-363	-10435	0	0	0
	18(OPE)	-26489	17106	-6312	0	0	0
	19(SUS)	897	-4809	-6418	0	0	0
	22(OPE)	-461	2473	-6551	0	0	0
	23(SUS)	43	-229	-6393	0	0	0
	MAX	-26489/L18	17380/L6	-11135/L10			
3655		Rigid -LIM					
	1(HYD)	0	0	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	-2334	12519	0	0	0	0
	22(OPE)	-7248	38874	0	0	0	0
	23(SUS)	-7427	39836	0	0	0	0
	MAX	-7427/L23	39836/L23				
3680		Rigid GUI; Rigid Z					
	1(HYD)	3341	-3412	-6274	0	0	0
	2(OPE)	-6704	-5066	-8019	0	0	0

3(SUS)	-9322	-4748	-7179	0	0	0
4(OPE)	-7353	-5108	-8021	0	0	0
5(SUS)	-9322	-4748	-7179	0	0	0
6(OPE)	58150	-8114	-20499	0	0	0
7(SUS)	309	-1863	-3257	0	0	0
8(OPE)	58150	-8114	-20499	0	0	0
9(SUS)	309	-1863	-3257	0	0	0
10(OPE)	2654	-9186	-16188	0	0	0
11(SUS)	-25331	-6659	-8706	0	0	0
18(OPE)	73308	-6356	-19143	0	0	0
19(SUS)	669	-1488	-2648	0	0	0
22(OPE)	3834	-2080	-4024	0	0	0
23(SUS)	330	-1612	-2825	0	0	0
MAX	73308/L18	-9186/L10	-20499/L6			
3825	Rigid ANC					
1(HYD)	-912	283	-1140	-35	-112	141
2(OPE)	-457	-1017	8620	125	-58	-297
3(SUS)	-35	-1137	8915	140	-5	-115
4(OPE)	-400	-1022	8625	126	-51	-288
5(SUS)	-35	-1137	8915	140	-5	-115
6(OPE)	-9399	2508	3005	-309	-1159	-3040
7(SUS)	-819	197	8640	-24	-101	95
8(OPE)	-9399	2508	3005	-309	-1159	-3040
9(SUS)	-819	197	8640	-24	-101	95
10(OPE)	-3159	-1450	15955	179	-392	-2032
11(SUS)	1010	-2562	18616	316	122	-346
18(OPE)	-10869	4002	2237	-493	-1339	-2598
19(SUS)	-854	289	8634	-36	-105	239
22(OPE)	-1347	548	8216	-67	-166	-10
23(SUS)	-809	302	8637	-37	-100	118
MAX	-10869/L18	4002/L18	18616/L11	-493/L18	-1339/L18	-3040/L6
3830	Rigid GUI; Rigid GUI					
1(HYD)	-9232	-7183	0	0	0	0
2(OPE)	-909	-27067	0	0	0	0
3(SUS)	10261	-29180	0	0	0	0
4(OPE)	181	-27130	0	0	0	0
5(SUS)	10261	-29180	0	0	0	0
6(OPE)	-228028	30436	0	0	0	0
7(SUS)	-8864	-7419	0	0	0	0
8(OPE)	-228028	30436	0	0	0	0
9(SUS)	-8864	-7419	0	0	0	0
10(OPE)	-71663	-34378	0	0	0	0
11(SUS)	35778	-53687	0	0	0	0
18(OPE)	-266277	55179	0	0	0	0

	19(SUS)	-14458	-3255	0	0	0	0
	22(OPE)	-22989	-1925	0	0	0	0
	23(SUS)	-8983	-5620	0	0	0	0
	MAX	-266277/L18	55179/L18				
3840		Rigid GUI; Rigid GUI					
	1(HYD)	3149	7341	0	0	0	0
	2(OPE)	7631	20420	0	0	0	0
	3(SUS)	-3605	22305	0	0	0	0
	4(OPE)	6955	20442	0	0	0	0
	5(SUS)	-3605	22305	0	0	0	0
	6(OPE)	214631	-27078	0	0	0	0
	7(SUS)	4758	6123	0	0	0	0
	8(OPE)	214631	-27078	0	0	0	0
	9(SUS)	4758	6123	0	0	0	0
	10(OPE)	90621	22745	0	0	0	0
	11(SUS)	-14429	39718	0	0	0	0
	18(OPE)	238132	-43039	0	0	0	0
	19(SUS)	11700	5362	0	0	0	0
	22(OPE)	17182	1675	0	0	0	0
	23(SUS)	4546	4758	0	0	0	0
	MAX	238132/L18	-43039/L18				
3920		Rigid GUI; Rigid Z					
	1(HYD)	-170	3973	-16354	0	0	0
	2(OPE)	-127	2633	-12226	0	0	0
	3(SUS)	-120	2660	-11485	0	0	0
	4(OPE)	-127	2646	-12218	0	0	0
	5(SUS)	-120	2660	-11485	0	0	0
	6(OPE)	-271	2799	-25976	0	0	0
	7(SUS)	-126	3077	-12068	0	0	0
	8(OPE)	-271	2799	-25976	0	0	0
	9(SUS)	-126	3077	-12068	0	0	0
	10(OPE)	-185	1904	-17720	0	0	0
	11(SUS)	-115	2231	-11055	0	0	0
	18(OPE)	-289	-679	-27764	0	0	0
	19(SUS)	-128	-1107	-12263	0	0	0
	22(OPE)	-136	3212	-13080	0	0	0
	23(SUS)	-126	3115	-12076	0	0	0
	MAX	-289/L18	3973/L1	-27764/L18			
4180		Rigid GUI; Rigid Z					
	1(HYD)	-181	-2809	-16899	0	0	0
	2(OPE)	-116	-1374	-10827	0	0	0
	3(SUS)	-129	-2112	-11998	0	0	0
	4(OPE)	-116	-1375	-10829	0	0	0
	5(SUS)	-129	-2112	-11998	0	0	0
	6(OPE)	92	10615	8594	0	0	0

	7(SUS)	-128	-2149	-11884	0	0	0
	8(OPE)	92	10615	8594	0	0	0
	9(SUS)	-128	-2149	-11884	0	0	0
	10(OPE)	-17	4529	-1614	0	0	0
	11(SUS)	-130	-2070	-12076	0	0	0
	18(OPE)	147	14821	13679	0	0	0
	19(SUS)	-77	2108	-7129	0	0	0
	22(OPE)	-114	-1423	-10659	0	0	0
	23(SUS)	-128	-2153	-11884	0	0	0
	MAX	-181/L1	14821/L18	-16899/L1			
4875		Rigid GUI; Rigid Z					
	1(HYD)	0	-220	-27854	0	0	0
	2(OPE)	0	-1985	-24384	0	0	0
	3(SUS)	0	-1914	-25263	0	0	0
	4(OPE)	0	-1989	-24372	0	0	0
	5(SUS)	0	-1914	-25263	0	0	0
	6(OPE)	0	1269	-19364	0	0	0
	7(SUS)	0	-210	-31493	0	0	0
	8(OPE)	0	1269	-19364	0	0	0
	9(SUS)	0	-210	-31493	0	0	0
	10(OPE)	0	-5538	-17156	0	0	0
	11(SUS)	0	-4932	-24913	0	0	0
	18(OPE)	0	5601	-28672	0	0	0
	19(SUS)	0	-196	-32064	0	0	0
	22(OPE)	0	501	-32139	0	0	0
	23(SUS)	0	-158	-31920	0	0	0
	MAX		5601/L18	-32139/L22			

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
6	DW+T baking + SL-1	S8 S1	W+P1+T2+0.34D1+SL-1 *(L30+SL-1)* W+P1+SL-1 *(L5+SL-1)*	A
10	DW+NO+SMHV	S9 S2	W+P1+T1+0.73D1+SMHV *(L31+SMHV)* W+P1+SMHV *(L3+SMHV)*	A
11	DW+ T baking + SMHV	S10 S3	W+P1+T2+0.73D1+SMHV *(L32+SMHV)* W+P1+SMHV *(L5+SMHV)*	A

S8

(SUS)COMBINATION # 8

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.	)-------		-----Moments(N.m.	)-----		
70	67013	12367	0	0	0	0	Rigid GUI
70	303	1644	32501	0	0	0	Rigid Z
80	44541	8219	0	0	0	0	Rigid GUI
80	368	1997	39482	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	1110	207	0	0	0	0	Rigid GUI
160	0	0	37095	0	0	0	Rigid Z
190	1322	11388	10865	27417	7540	902	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	8278	901	0	0	0	0	Rigid GUI
240	2402	22054	38875	0	0	0	Rigid Z
396	539	1430	12717	195	74	361	Rigid ANC
400	0	41621	0	0	0	0	Rigid GUI
400	18665	0	0	0	0	0	Rigid GUI
420	0	31136	0	0	0	0	Rigid GUI
420	29772	0	0	0	0	0	Rigid GUI
600	0	5232	0	0	0	0	Rigid GUI
600	202	0	18798	0	0	0	Rigid Z
630	158	0	14751	0	0	0	Rigid Z
760	0	368	36376	0	0	0	Rigid Z
1060	153	0	15706	0	0	0	Rigid Z
3120	48963	9146	0	0	0	0	Rigid GUI
3120	143	768	15029	0	0	0	Rigid Z
3180	18751	3502	0	0	0	0	Rigid GUI
3180	160	861	16838	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	4321	805	0	0	0	0	Rigid GUI w/gap
3493	0	0	4293	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	1492	8006	0	0	0	0	Rigid LIM
3552	0	0	8022	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	7855	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	2848	15280	0	0	0	0	Rigid LIM
3602	0	0	9724	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	12506	803	0	0	0	0	Rigid GUI
3680	388	6047	10506	0	0	0	Rigid Z
3825	829	1497	8910	184	103	463	Rigid ANC
3830	0	36959	0	0	0	0	Rigid GUI
3830	9195	0	0	0	0	0	Rigid GUI
3840	0	29739	0	0	0	0	Rigid GUI
3840	17197	0	0	0	0	0	Rigid GUI
3920	0	5716	0	0	0	0	Rigid GUI
3920	159	0	15259	0	0	0	Rigid Z
4180	0	4076	0	0	0	0	Rigid GUI
4180	143	0	13369	0	0	0	Rigid Z

4875	0	4017	0	0	0	0	Rigid GUI
4875	0	0	29274	0	0	0	Rigid Z

S9

(SUS)COMBINATION # 9

NODE	------Forces(N.)------- FX	FY	FZ	-----Moments(N.m.)----- MX	MY	MZ	
70	37162	6858	0	0	0	0	Rigid GUI
70	182	986	19487	0	0	0	Rigid Z
80	25871	4774	0	0	0	0	Rigid GUI
80	295	1598	31583	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	4462	832	0	0	0	0	Rigid GUI
160	0	0	30153	0	0	0	Rigid Z
190	2314	7643	7438	13860	5041	1232	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	11503	1252	0	0	0	0	Rigid GUI
240	2641	24251	42746	0	0	0	Rigid Z
396	809	1990	13303	272	111	765	Rigid ANC
400	0	59302	0	0	0	0	Rigid GUI
400	32533	0	0	0	0	0	Rigid GUI
420	0	46835	0	0	0	0	Rigid GUI
420	47486	0	0	0	0	0	Rigid GUI
600	0	10625	0	0	0	0	Rigid GUI
600	253	0	23601	0	0	0	Rigid Z
630	189	0	17623	0	0	0	Rigid Z
760	0	445	43993	0	0	0	Rigid Z
1060	221	0	22661	0	0	0	Rigid Z
3120	21063	3934	0	0	0	0	Rigid GUI
3120	81	437	8547	0	0	0	Rigid Z
3180	10196	1904	0	0	0	0	Rigid GUI
3180	143	766	14978	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	7710	1437	0	0	0	0	Rigid GUI w/gap
3493	0	0	5685	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2244	12037	0	0	0	0	Rigid LIM
3552	0	0	9256	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	9696	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	2763	14824	0	0	0	0	Rigid LIM
3602	0	0	10838	0	0	0	Rigid Z
3630	2325	13759	2015	322	482	183	Rigid ANC
3640	2277	13706	1745	401	388	193	Rigid ANC
3655	0	0	0	0	0	0	Rigid -LIM
3680	17430	1119	0	0	0	0	Rigid GUI
3680	493	7688	13356	0	0	0	Rigid Z
3825	1378	2036	9233	250	170	674	Rigid ANC
3830	0	48171	0	0	0	0	Rigid GUI
3830	20362	0	0	0	0	0	Rigid GUI
3840	0	40382	0	0	0	0	Rigid GUI
3840	29622	0	0	0	0	0	Rigid GUI
3920	0	9226	0	0	0	0	Rigid GUI
3920	195	0	18755	0	0	0	Rigid Z
4180	0	7172	0	0	0	0	Rigid GUI
4180	174	0	16281	0	0	0	Rigid Z
4875	0	6340	0	0	0	0	Rigid GUI
4875	0	0	34910	0	0	0	Rigid Z

S10

(SUS)COMBINATION # 10

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.	)-------		-----Moments(N.m.		)-----	
70	68041	12556	0	0	0	0	Rigid GUI
70	317	1721	34018	0	0	0	Rigid Z
80	46505	8582	0	0	0	0	Rigid GUI
80	392	2125	42004	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	1892	352	0	0	0	0	Rigid GUI
160	0	0	39263	0	0	0	Rigid Z
190	2052	12629	13445	28265	8075	1110	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	11485	1251	0	0	0	0	Rigid GUI
240	2641	24251	42747	0	0	0	Rigid Z
396	808	1989	13303	272	111	765	Rigid ANC
400	0	59275	0	0	0	0	Rigid GUI
400	32512	0	0	0	0	0	Rigid GUI
420	0	46813	0	0	0	0	Rigid GUI
420	47466	0	0	0	0	0	Rigid GUI
600	0	10624	0	0	0	0	Rigid GUI
600	253	0	23601	0	0	0	Rigid Z
630	189	0	17623	0	0	0	Rigid Z
760	0	445	43993	0	0	0	Rigid Z
1060	221	0	22661	0	0	0	Rigid Z
3120	49857	9313	0	0	0	0	Rigid GUI
3120	155	833	16291	0	0	0	Rigid Z
3180	19526	3647	0	0	0	0	Rigid GUI
3180	178	958	18730	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5696	1062	0	0	0	0	Rigid GUI w/gap
3493	0	0	5213	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2135	11452	0	0	0	0	Rigid LIM
3552	0	0	9258	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	9329	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3403	18257	0	0	0	0	Rigid LIM
3602	0	0	10968	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	18078	1161	0	0	0	0	Rigid GUI
3680	493	7689	13357	0	0	0	Rigid Z
3825	1321	2042	9237	251	163	665	Rigid ANC
3830	0	48235	0	0	0	0	Rigid GUI
3830	19536	0	0	0	0	0	Rigid GUI
3840	0	40404	0	0	0	0	Rigid GUI
3840	28946	0	0	0	0	0	Rigid GUI
3920	0	9239	0	0	0	0	Rigid GUI
3920	195	0	18747	0	0	0	Rigid Z
4180	0	7174	0	0	0	0	Rigid GUI
4180	174	0	16283	0	0	0	Rigid Z
4875	0	6344	0	0	0	0	Rigid GUI
4875	0	0	34898	0	0	0	Rigid Z

S1

(SUS)COMBINATION # 1

NODE	------Forces(N.) FX	FY	------- FZ	-----Moments(N.m. MX	MY	)----- MZ	
70	4990	920	0	0	0	0	Rigid GUI
70	31	168	3321	0	0	0	Rigid Z
80	3091	570	0	0	0	0	Rigid GUI
80	173	938	18550	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	7152	1333	0	0	0	0	Rigid GUI
160	0	0	20626	0	0	0	Rigid Z
190	1511	1773	14740	822	1753	1375	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	9408	1024	0	0	0	0	Rigid GUI
240	2412	22150	39044	0	0	0	Rigid Z
396	430	1384	12746	189	59	343	Rigid ANC
400	0	39175	0	0	0	0	Rigid GUI
400	14210	0	0	0	0	0	Rigid GUI
420	0	28703	0	0	0	0	Rigid GUI
420	27080	0	0	0	0	0	Rigid GUI
600	0	5099	0	0	0	0	Rigid GUI
600	189	0	17633	0	0	0	Rigid Z
630	163	0	15176	0	0	0	Rigid Z
760	0	396	39198	0	0	0	Rigid Z
1060	182	0	18673	0	0	0	Rigid Z
3120	10483	1958	0	0	0	0	Rigid GUI
3120	26	139	2722	0	0	0	Rigid Z
3180	1334	249	0	0	0	0	Rigid GUI
3180	88	476	9304	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5359	999	0	0	0	0	Rigid GUI w/gap
3493	0	0	5278	0	0	0	Rigid Z
3552	2863	533	0	0	0	0	Rigid GUI w/gap
3552	582	3122	0	0	0	0	Rigid LIM
3552	0	0	8547	0	0	0	Rigid Z
3563	815	152	0	0	0	0	Rigid GUI w/gap
3563	0	0	8503	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	531	2849	0	0	0	0	Rigid LIM
3602	0	0	9408	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	14453	928	0	0	0	0	Rigid GUI
3680	357	5563	9664	0	0	0	Rigid Z
3825	464	1611	9200	198	58	292	Rigid ANC
3830	0	38992	0	0	0	0	Rigid GUI
3830	19298	0	0	0	0	0	Rigid GUI
3840	0	31561	0	0	0	0	Rigid GUI
3840	13824	0	0	0	0	0	Rigid GUI
3920	0	5781	0	0	0	0	Rigid GUI
3920	151	0	14499	0	0	0	Rigid Z
4180	0	4896	0	0	0	0	Rigid GUI
4180	156	0	14609	0	0	0	Rigid Z
4875	0	3943	0	0	0	0	Rigid GUI
4875	0	0	30179	0	0	0	Rigid Z

S2, S3

(SUS)COMBINATION # 2

NODE	------Forces(N.)------- FX	FY	FZ	-----Moments(N.m.)----- MX	MY	MZ	
70	6017	1110	0	0	0	0	Rigid GUI
70	45	244	4838	0	0	0	Rigid Z
80	5055	933	0	0	0	0	Rigid GUI
80	196	1066	21072	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	7934	1479	0	0	0	0	Rigid GUI
160	0	0	22794	0	0	0	Rigid Z
190	2238	3015	17309	1674	2295	1585	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	12578	1370	0	0	0	0	Rigid GUI
240	2650	24332	42890	0	0	0	Rigid Z
396	701	1946	13332	266	96	733	Rigid ANC
400	0	57001	0	0	0	0	Rigid GUI
400	28031	0	0	0	0	0	Rigid GUI
420	0	44644	0	0	0	0	Rigid GUI
420	44566	0	0	0	0	0	Rigid GUI
600	0	10244	0	0	0	0	Rigid GUI
600	241	0	22442	0	0	0	Rigid Z
630	193	0	18029	0	0	0	Rigid Z
760	0	476	47040	0	0	0	Rigid Z
1060	251	0	25688	0	0	0	Rigid Z
3120	11376	2125	0	0	0	0	Rigid GUI
3120	38	203	3984	0	0	0	Rigid Z
3180	2109	394	0	0	0	0	Rigid GUI
3180	106	572	11196	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	6735	1255	0	0	0	0	Rigid GUI w/gap
3493	0	0	6198	0	0	0	Rigid Z
3552	2863	533	0	0	0	0	Rigid GUI w/gap
3552	1225	6570	0	0	0	0	Rigid LIM
3552	0	0	9781	0	0	0	Rigid Z
3563	815	152	0	0	0	0	Rigid GUI w/gap
3563	0	0	9977	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1086	5828	0	0	0	0	Rigid LIM
3602	0	0	10652	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	20036	1286	0	0	0	0	Rigid GUI
3680	462	7204	12515	0	0	0	Rigid Z
3825	956	2156	9527	265	118	495	Rigid ANC
3830	0	50249	0	0	0	0	Rigid GUI
3830	29665	0	0	0	0	0	Rigid GUI
3840	0	42179	0	0	0	0	Rigid GUI
3840	25546	0	0	0	0	0	Rigid GUI
3920	0	9361	0	0	0	0	Rigid GUI
3920	187	0	17957	0	0	0	Rigid Z
4180	0	8089	0	0	0	0	Rigid GUI
4180	188	0	17604	0	0	0	Rigid Z
4875	0	6270	0	0	0	0	Rigid GUI
4875	0	0	35819	0	0	0	Rigid Z

II) Service Level B

Part 1 of 1: Dynamic Load Cases

Load case no. (LS)	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	Service Level
--	DW+NO+SL-3	S16 S15	W+P1+T1+1.5D1+SL-3 *(L62+SL-3)* W+P1+SL-3 *(L3+SL-3)*	B

S16

NODE	Forces (N.) FX	FY	FZ	Moments (N.m.) MX	MY	MZ	
70	38332	7074	0	0	0	0	Rigid GUI
70	203	1100	21746	0	0	0	Rigid Z
80	28202	5204	0	0	0	0	Rigid GUI
80	325	1765	34890	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	5248	978	0	0	0	0	Rigid GUI
160	0	0	33520	0	0	0	Rigid Z
190	2862	8361	11162	14806	5524	1461	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	15277	1664	0	0	0	0	Rigid GUI
240	2939	26982	47560	0	0	0	Rigid Z
396	1127	2636	13988	360	154	1230	Rigid ANC
400	0	79624	0	0	0	0	Rigid GUI
400	48978	0	0	0	0	0	Rigid GUI
420	0	64542	0	0	0	0	Rigid GUI
420	68409	0	0	0	0	0	Rigid GUI
600	0	16401	0	0	0	0	Rigid GUI
600	315	0	29344	0	0	0	Rigid Z
630	234	0	21777	0	0	0	Rigid Z
760	0	535	52912	0	0	0	Rigid Z
1060	300	0	30661	0	0	0	Rigid Z
3120	22030	4115	0	0	0	0	Rigid GUI
3120	97	522	10220	0	0	0	Rigid Z
3180	10962	2047	0	0	0	0	Rigid GUI
3180	165	886	17334	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	9001	1678	0	0	0	0	Rigid GUI w/gap
3493	0	0	7155	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2958	15869	0	0	0	0	Rigid LIM
3552	0	0	11019	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	11645	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3358	18012	0	0	0	0	Rigid LIM
3602	0	0	12621	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	24079	1546	0	0	0	0	Rigid GUI
3680	624	9718	16883	0	0	0	Rigid Z
3825	1998	2691	9616	331	247	904	Rigid ANC
3830	0	61642	0	0	0	0	Rigid GUI
3830	33218	0	0	0	0	0	Rigid GUI
3840	0	53042	0	0	0	0	Rigid GUI
3840	43591	0	0	0	0	0	Rigid GUI
3920	0	13188	0	0	0	0	Rigid GUI
3920	239	0	22959	0	0	0	Rigid Z
4180	0	10564	0	0	0	0	Rigid GUI
4180	212	0	19787	0	0	0	Rigid Z
4875	0	9123	0	0	0	0	Rigid GUI
4875	0	0	42716	0	0	0	Rigid Z

S15

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	7187	1326	0	0	0	0	Rigid GUI
70	66	359	7097	0	0	0	Rigid Z
80	7386	1363	0	0	0	0	Rigid GUI
80	227	1233	24379	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	8720	1625	0	0	0	0	Rigid GUI
160	0	0	26161	0	0	0	Rigid Z
190	2780	3736	21055	2631	2792	1817	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	16280	1773	0	0	0	0	Rigid GUI
240	2944	27035	47653	0	0	0	Rigid Z
396	1024	2597	14017	355	140	1170	Rigid ANC
400	0	77663	0	0	0	0	Rigid GUI
400	44424	0	0	0	0	0	Rigid GUI
420	0	62873	0	0	0	0	Rigid GUI
420	65078	0	0	0	0	0	Rigid GUI
600	0	15534	0	0	0	0	Rigid GUI
600	303	0	28196	0	0	0	Rigid Z
630	237	0	22146	0	0	0	Rigid Z
760	0	570	56405	0	0	0	Rigid Z
1060	330	0	33808	0	0	0	Rigid Z
3120	12343	2305	0	0	0	0	Rigid GUI
3120	54	289	5657	0	0	0	Rigid Z
3180	2875	537	0	0	0	0	Rigid GUI
3180	129	693	13551	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	8028	1496	0	0	0	0	Rigid GUI w/gap
3493	0	0	7669	0	0	0	Rigid Z
3552	2863	533	0	0	0	0	Rigid GUI w/gap
3552	1940	10407	0	0	0	0	Rigid LIM
3552	0	0	11544	0	0	0	Rigid Z
3563	815	152	0	0	0	0	Rigid GUI w/gap
3563	0	0	11926	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1682	9021	0	0	0	0	Rigid LIM
3602	0	0	12435	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	26707	1715	0	0	0	0	Rigid GUI
3680	593	9234	16042	0	0	0	Rigid Z
3825	1576	2811	9909	346	195	729	Rigid ANC
3830	0	63683	0	0	0	0	Rigid GUI
3830	42470	0	0	0	0	0	Rigid GUI
3840	0	54746	0	0	0	0	Rigid GUI
3840	39462	0	0	0	0	0	Rigid GUI
3920	0	13438	0	0	0	0	Rigid GUI
3920	230	0	22098	0	0	0	Rigid Z
4180	0	11669	0	0	0	0	Rigid GUI
4180	228	0	21270	0	0	0	Rigid Z
4875	0	9054	0	0	0	0	Rigid GUI
4875	0	0	43655	0	0	0	Rigid Z

III) Service Level C

Part 1 of 2: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
12	DW+VVICE IV	L12	W+P4+T3	C
		L13	W+P4	
14	DW+VVICE V	L14	W+P4+T3	C
		L15	W+P4	
16	DW+FIRE	L16	W+P1+T5	C
		L17	W+P1	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	12(OPE)	-79649	-16283	30258	0	0	0
	13(SUS)	-374	220	-5516	0	0	0
	14(OPE)	-79649	-16283	30258	0	0	0
	15(SUS)	-374	220	-5516	0	0	0
	16(OPE)	-104567	-21882	49377	0	0	0
	17(SUS)	-4075	-857	1999	0	0	0
	MAX	-104567/L16	-21882/L16	49377/L16			
80		Rigid GUI; Rigid Z					
	12(OPE)	54217	12024	-38577	0	0	0
	13(SUS)	633	759	-12274	0	0	0
	14(OPE)	54217	12024	-38577	0	0	0
	15(SUS)	633	759	-12274	0	0	0
	16(OPE)	68412	15263	-50413	0	0	0
	17(SUS)	1226	1082	-16352	0	0	0
	MAX	68412/L16	15263/L16	-50413/L16			
151		Rigid +LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	1943	-10421	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	1943	-10421	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	1943/L13	-10421/L13				
160		Rigid GUI; Rigid Z					
	12(OPE)	-12431	-2318	-90142	0	0	0

	13(SUS)	-994	-185	-12989	0	0	0
	14(OPE)	-12431	-2318	-90142	0	0	0
	15(SUS)	-994	-185	-12989	0	0	0
	16(OPE)	-4959	-925	-16583	0	0	0
	17(SUS)	6471	1206	-18736	0	0	0
	MAX	-12431/L12	-2318/L12	-90142/L12			
190		Rigid ANC					
	12(OPE)	-2804	7750	83401	-97913	-23185	3505
	13(SUS)	1746	325	-11970	-742	-1420	-819
	14(OPE)	-2804	7750	83401	-97913	-23185	3505
	15(SUS)	1746	325	-11970	-742	-1420	-819
	16(OPE)	-5865	9989	-2128	-6464	-5934	3154
	17(SUS)	-878	691	-12501	-79	-1281	-1193
	MAX	-5865/L16	9989/L16	83401/L12	-97913/L12	-23185/L12	3505/L12
201		Rigid -LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	-6956	37309	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	-6956	37309	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	-6956/L13	37309/L13				
240		Rigid GUI; Rigid Z					
	12(OPE)	26592	-6549	-16454	0	0	0
	13(SUS)	-909	-20206	-35025	0	0	0
	14(OPE)	26592	-6549	-16454	0	0	0
	15(SUS)	-909	-20206	-35025	0	0	0
	16(OPE)	15093	-16814	-32153	0	0	0
	17(SUS)	-4440	-20972	-35691	0	0	0
	MAX	26592/L12	-20972/L17	-35691/L17			
396		Rigid ANC					
	12(OPE)	-3223	1715	9013	-234	-440	595
	13(SUS)	-336	-166	11653	23	-47	144
	14(OPE)	-3223	1715	9013	-234	-440	595
	15(SUS)	-336	-166	11653	23	-47	144
	16(OPE)	-2146	-1766	11503	242	-294	-213
	17(SUS)	-194	-894	12236	122	-28	4
	MAX	-3223/L12	-1766/L16	12236/L17	242/L16	-440/L12	595/L12
400		Rigid GUI; Rigid GUI					
	12(OPE)	-139475	34327	0	0	0	0

	13(SUS)	-11839	-2067	0	0	0	0
	14(OPE)	-139475	34327	0	0	0	0
	15(SUS)	-11839	-2067	0	0	0	0
	16(OPE)	-79768	-69957	0	0	0	0
	17(SUS)	-2162	-23635	0	0	0	0
	MAX	-139475/L12	-69957/L16				
420		Rigid GUI; Rigid GUI					
	12(OPE)	101050	-18370	0	0	0	0
	13(SUS)	19334	-1940	0	0	0	0
	14(OPE)	101050	-18370	0	0	0	0
	15(SUS)	19334	-1940	0	0	0	0
	16(OPE)	55854	62088	0	0	0	0
	17(SUS)	11837	14807	0	0	0	0
	MAX	101050/L12	62088/L16				
600		Rigid GUI; Rigid Z					
	12(OPE)	-549	1407	-51103	0	0	0
	13(SUS)	-184	993	-17168	0	0	0
	14(OPE)	-549	1407	-51103	0	0	0
	15(SUS)	-184	993	-17168	0	0	0
	16(OPE)	-363	-766	-33774	0	0	0
	17(SUS)	-144	614	-13441	0	0	0
	MAX	-549/L12	1407/L12	-51103/L12			
630		Rigid Z					
	12(OPE)	13	0	1195	0	0	0
	13(SUS)	-122	0	-11362	0	0	0
	14(OPE)	13	0	1195	0	0	0
	15(SUS)	-122	0	-11362	0	0	0
	16(OPE)	-54	0	-5021	0	0	0
	17(SUS)	-136	0	-12689	0	0	0
	MAX	-136/L17		-12689/L17			
760		Rigid Z					
	12(OPE)	0	-141	13978	0	0	0
	13(SUS)	0	325	-32150	0	0	0
	14(OPE)	0	-141	13978	0	0	0
	15(SUS)	0	325	-32150	0	0	0
	16(OPE)	0	-136	13422	0	0	0
	17(SUS)	0	327	-32361	0	0	0
	MAX		327/L17	-32361/L17			
1060		Rigid Z					
	12(OPE)	361	0	36911	0	0	0
	13(SUS)	-125	0	-12743	0	0	0
	14(OPE)	361	0	36911	0	0	0
	15(SUS)	-125	0	-12743	0	0	0

	16(OPE)	375	0	38276	0	0	0
	17(SUS)	-123	0	-12558	0	0	0
	MAX	375/L16		38276/L16			
3120		Rigid GUI; Rigid Z					
	12(OPE)	78756	13779	17613	0	0	0
	13(SUS)	368	195	-2376	0	0	0
	14(OPE)	78756	13779	17613	0	0	0
	15(SUS)	368	195	-2376	0	0	0
	16(OPE)	85807	14777	23643	0	0	0
	17(SUS)	-9720	-1730	-1622	0	0	0
	MAX	85807/L16	14777/L16	23643/L16			
3180		Rigid GUI; Rigid Z					
	12(OPE)	-23421	-3486	-16785	0	0	0
	13(SUS)	-311	320	-7136	0	0	0
	14(OPE)	-23421	-3486	-16785	0	0	0
	15(SUS)	-311	320	-7136	0	0	0
	16(OPE)	-30327	-4613	-19878	0	0	0
	17(SUS)	586	515	-7655	0	0	0
	MAX	-30327/L16	-4613/L16	-19878/L16			
3360		Rigid +LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	765	-4103	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	765	-4103	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	765/L13	-4103/L13				
3493		Rigid GUI w/gap; Rigid Z					
	12(OPE)	0	0	-2544	0	0	0
	13(SUS)	0	0	-4466	0	0	0
	14(OPE)	0	0	-2544	0	0	0
	15(SUS)	0	0	-4466	0	0	0
	16(OPE)	0	0	-2224	0	0	0
	17(SUS)	4160	776	-4476	0	0	0
	MAX	4160/L17	776/L17	-4476/L17			
3552		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	12(OPE)	3630	-19471	5547	0	0	0
	13(SUS)	-43	229	-4715	0	0	0
	14(OPE)	3630	-19471	5547	0	0	0
	15(SUS)	-43	229	-4715	0	0	0
	16(OPE)	-4957	26586	1832	0	0	0
	17(SUS)	2841	651	-7471	0	0	0

	MAX	-4957/L16	26586/L16	-7471/L17			
3563		Rigid GUI w/gap; Rigid Z					
	12(OPE)	0	0	-7500	0	0	0
	13(SUS)	0	0	-6990	0	0	0
	14(OPE)	0	0	-7500	0	0	0
	15(SUS)	0	0	-6990	0	0	0
	16(OPE)	-9886	-1843	-7619	0	0	0
	17(SUS)	815	152	-7218	0	0	0
	MAX	-9886/L16	-1843/L16	-7619/L16			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	12(OPE)	-24941	22215	-7472	0	0	0
	13(SUS)	43	-229	-6393	0	0	0
	14(OPE)	-24941	22215	-7472	0	0	0
	15(SUS)	43	-229	-6393	0	0	0
	16(OPE)	3350	-17968	-9859	0	0	0
	17(SUS)	47	-253	-8325	0	0	0
	MAX	-24941/L12	22215/L12	-9859/L16			
3655		Rigid -LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	-630	3381	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	-630	3381	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	-630/L13	3381/L13				
3680		Rigid GUI; Rigid Z					
	12(OPE)	63078	-7571	-20108	0	0	0
	13(SUS)	330	-1612	-2825	0	0	0
	14(OPE)	63078	-7571	-20108	0	0	0
	15(SUS)	330	-1612	-2825	0	0	0
	16(OPE)	44257	-9768	-21817	0	0	0
	17(SUS)	-9322	-4748	-7179	0	0	0
	MAX	63078/L12	-9768/L16	-21817/L16			
3825		Rigid ANC					
	12(OPE)	-9873	3009	2751	-371	-1217	-2933
	13(SUS)	-809	302	8637	-37	-100	118
	14(OPE)	-9873	3009	2751	-371	-1217	-2933
	15(SUS)	-809	302	8637	-37	-100	118
	16(OPE)	-8077	1026	3492	-126	-997	-3398
	17(SUS)	-35	-1137	8915	140	-5	-115

	MAX	-9873/L12	3009/L12	8915/L17	-371/L12	-1217/L12	-3398/L16
3830		Rigid GUI; Rigid GUI					
	12(OPE)	-238929	37882	0	0	0	0
	13(SUS)	-8983	-5620	0	0	0	0
	14(OPE)	-238929	37882	0	0	0	0
	15(SUS)	-8983	-5620	0	0	0	0
	16(OPE)	-197726	8534	0	0	0	0
	17(SUS)	10261	-29180	0	0	0	0
	MAX	-238929/L12	37882/L12				
3840		Rigid GUI; Rigid GUI					
	12(OPE)	220068	-32590	0	0	0	0
	13(SUS)	4546	4758	0	0	0	0
	14(OPE)	220068	-32590	0	0	0	0
	15(SUS)	4546	4758	0	0	0	0
	16(OPE)	200487	-10883	0	0	0	0
	17(SUS)	-3605	22305	0	0	0	0
	MAX	220068/L12	-32590/L12				
3920		Rigid GUI; Rigid Z					
	12(OPE)	-276	3046	-26509	0	0	0
	13(SUS)	-126	3115	-12076	0	0	0
	14(OPE)	-276	3046	-26509	0	0	0
	15(SUS)	-126	3115	-12076	0	0	0
	16(OPE)	-255	2038	-24480	0	0	0
	17(SUS)	-120	2660	-11485	0	0	0
	MAX	-276/L12	3115/L13	-26509/L12			
4180		Rigid GUI; Rigid Z					
	12(OPE)	93	10597	8704	0	0	0
	13(SUS)	-128	-2153	-11884	0	0	0
	14(OPE)	93	10597	8704	0	0	0
	15(SUS)	-128	-2153	-11884	0	0	0
	16(OPE)	91	10792	8452	0	0	0
	17(SUS)	-129	-2112	-11998	0	0	0
	MAX	-129/L17	10792/L16	-11998/L17			
4875		Rigid GUI; Rigid Z					
	12(OPE)	0	2724	-22414	0	0	0
	13(SUS)	0	-158	-31920	0	0	0
	14(OPE)	0	2724	-22414	0	0	0
	15(SUS)	0	-158	-31920	0	0	0
	16(OPE)	0	-3125	-9875	0	0	0
	17(SUS)	0	-1914	-25263	0	0	0
	MAX		-3125/L16	-31920/L13			

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
13	DW+ NO+SL-2	S11 S4	W+P1+T1+D1+SL-2 *(L33+SL-2)* W+P1+SL-2 *(L3+SL-2)*	C
15	DW+T baking + SL-2	S12 S5	W+P1+T2+D1+SL-2 *(L34+SL-2)* W+P1+SL-2 *(L5+SL-2)*	C
16	DW+FIRE+SL-2	S13 S6	W+P1+T5+D1+SL-2 *(L35+SL-2)* W+P1+SL-2 *(L17+SL-2)*	C
19	DW+VVICE V+SL-3	S14 S7	W+P4+T3+1.5D1+SL-3 *(L36+SL-3)* W+P4+SL-3 *(L15+SL-3)*	C

S11

(SUS)COMBINATION # 11

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.	)-------		-----Moments(N.m.		)-----	
70	37874	6989	0	0	0	0	Rigid GUI
70	191	1039	20537	0	0	0	Rigid Z
80	27231	5025	0	0	0	0	Rigid GUI
80	311	1686	33329	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	5004	932	0	0	0	0	Rigid GUI
160	0	0	31654	0	0	0	Rigid Z
190	2820	8502	9209	14446	5411	1376	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	13723	1494	0	0	0	0	Rigid GUI
240	2807	25771	45426	0	0	0	Rigid Z
396	995	2377	13709	325	136	1044	Rigid ANC
400	0	71524	0	0	0	0	Rigid GUI
400	42120	0	0	0	0	0	Rigid GUI
420	0	57688	0	0	0	0	Rigid GUI
420	59735	0	0	0	0	0	Rigid GUI
600	0	14357	0	0	0	0	Rigid GUI
600	289	0	26926	0	0	0	Rigid Z
630	210	0	19611	0	0	0	Rigid Z
760	0	498	49266	0	0	0	Rigid Z
1060	268	0	27476	0	0	0	Rigid Z
3120	21682	4050	0	0	0	0	Rigid GUI
3120	90	482	9421	0	0	0	Rigid Z
3180	10732	2004	0	0	0	0	Rigid GUI
3180	155	833	16288	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	8662	1615	0	0	0	0	Rigid GUI w/gap
3493	0	0	6322	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2689	14422	0	0	0	0	Rigid LIM
3552	0	0	10111	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	10716	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3148	16885	0	0	0	0	Rigid LIM
3602	0	0	11699	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	21287	1367	0	0	0	0	Rigid GUI
3680	566	8824	15330	0	0	0	Rigid Z
3825	1719	2413	9460	297	212	814	Rigid ANC
3830	0	55977	0	0	0	0	Rigid GUI
3830	27557	0	0	0	0	0	Rigid GUI
3840	0	47766	0	0	0	0	Rigid GUI
3840	37756	0	0	0	0	0	Rigid GUI
3920	0	11664	0	0	0	0	Rigid GUI

3920	220	0	21171	0	0	0	Rigid Z
4180	0	9317	0	0	0	0	Rigid GUI
4180	196	0	18298	0	0	0	Rigid Z
4875	0	7951	0	0	0	0	Rigid GUI
4875	0	0	38803	0	0	0	Rigid Z

S12

(SUS)COMBINATION # 12

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	68753	12688	0	0	0	0	Rigid GUI
70	327	1774	35068	0	0	0	Rigid Z
80	47865	8833	0	0	0	0	Rigid GUI
80	408	2213	43750	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	2433	453	0	0	0	0	Rigid GUI
160	0	0	40764	0	0	0	Rigid Z
190	2558	13488	15232	28852	8446	1253	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	13705	1492	0	0	0	0	Rigid GUI
240	2807	25772	45428	0	0	0	Rigid Z
396	994	2377	13709	325	136	1045	Rigid ANC
400	0	71497	0	0	0	0	Rigid GUI
400	42099	0	0	0	0	0	Rigid GUI
420	0	57666	0	0	0	0	Rigid GUI
420	59716	0	0	0	0	0	Rigid GUI
600	0	14356	0	0	0	0	Rigid GUI
600	289	0	26925	0	0	0	Rigid Z
630	210	0	19612	0	0	0	Rigid Z
760	0	498	49266	0	0	0	Rigid Z
1060	268	0	27476	0	0	0	Rigid Z
3120	50475	9428	0	0	0	0	Rigid GUI
3120	164	878	17165	0	0	0	Rigid Z
3180	20062	3747	0	0	0	0	Rigid GUI
3180	191	1025	20040	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	6649	1239	0	0	0	0	Rigid GUI w/gap
3493	0	0	5851	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2579	13837	0	0	0	0	Rigid LIM
3552	0	0	10113	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	10350	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3788	20318	0	0	0	0	Rigid LIM
3602	0	0	11829	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	21936	1408	0	0	0	0	Rigid GUI
3680	566	8825	15331	0	0	0	Rigid Z
3825	1662	2419	9464	298	205	805	Rigid ANC
3830	0	56040	0	0	0	0	Rigid GUI
3830	26694	0	0	0	0	0	Rigid GUI
3840	0	47788	0	0	0	0	Rigid GUI
3840	37080	0	0	0	0	0	Rigid GUI
3920	0	11677	0	0	0	0	Rigid GUI
3920	220	0	21162	0	0	0	Rigid Z
4180	0	9319	0	0	0	0	Rigid GUI
4180	196	0	18301	0	0	0	Rigid Z
4875	0	7955	0	0	0	0	Rigid GUI
4875	0	0	38792	0	0	0	Rigid Z

S13

(SUS)COMBINATION # 13

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	107663	19868	0	0	0	0	Rigid GUI
70	497	2695	53266	0	0	0	Rigid Z
80	73919	13641	0	0	0	0	Rigid GUI
80	531	2878	56879	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	6963	1298	0	0	0	0	Rigid GUI
160	0	0	22142	0	0	0	Rigid Z
190	7737	13170	8685	8637	7305	3696	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	21139	2302	0	0	0	0	Rigid GUI
240	2600	23873	42081	0	0	0	Rigid Z
396	2835	3200	13006	438	387	1248	Rigid ANC
400	0	115223	0	0	0	0	Rigid GUI
400	115273	0	0	0	0	0	Rigid GUI
420	0	102285	0	0	0	0	Rigid GUI
420	101222	0	0	0	0	0	Rigid GUI
600	0	13327	0	0	0	0	Rigid GUI
600	495	0	46087	0	0	0	Rigid Z
630	133	0	12384	0	0	0	Rigid Z
760	0	345	34110	0	0	0	Rigid Z
1060	552	0	56418	0	0	0	Rigid Z
3120	87871	16414	0	0	0	0	Rigid GUI
3120	256	1375	26878	0	0	0	Rigid Z
3180	32123	6000	0	0	0	0	Rigid GUI
3180	236	1265	24729	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	3528	657	0	0	0	0	Rigid GUI w/gap
3493	0	0	4584	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	6606	35432	0	0	0	0	Rigid LIM
3552	0	0	4997	0	0	0	Rigid Z
3563	9887	1843	0	0	0	0	Rigid GUI w/gap
3563	0	0	11398	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	4775	25611	0	0	0	0	Rigid LIM
3602	0	0	13048	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	57792	3712	0	0	0	0	Rigid GUI
3680	1076	16767	29128	0	0	0	Rigid Z
3825	9340	2421	4331	298	1152	3915	Rigid ANC
3830	0	37347	0	0	0	0	Rigid GUI
3830	224373	0	0	0	0	0	Rigid GUI
3840	0	37986	0	0	0	0	Rigid GUI
3840	230612	0	0	0	0	0	Rigid GUI
3920	0	11069	0	0	0	0	Rigid GUI
3920	348	0	33425	0	0	0	Rigid Z
4180	0	19223	0	0	0	0	Rigid GUI
4180	175	0	16339	0	0	0	Rigid Z
4875	0	9091	0	0	0	0	Rigid GUI
4875	0	0	24295	0	0	0	Rigid Z

S14

(SUS)COMBINATION # 14

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	83025	15322	0	0	0	0	Rigid GUI
70	330	1789	35356	0	0	0	Rigid Z
80	60584	11180	0	0	0	0	Rigid GUI
80	435	2358	46604	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	14680	2736	0	0	0	0	Rigid GUI
160	0	0	97567	0	0	0	Rigid Z
190	4718	10790	92000	100445	24668	4136	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	35068	3819	0	0	0	0	Rigid GUI
240	1762	16177	28514	0	0	0	Rigid Z
396	4044	3428	10794	468	552	1706	Rigid ANC
400	0	89017	0	0	0	0	Rigid GUI
400	181838	0	0	0	0	0	Rigid GUI
420	0	67450	0	0	0	0	Rigid GUI
420	155092	0	0	0	0	0	Rigid GUI
600	0	17273	0	0	0	0	Rigid GUI
600	707	0	65834	0	0	0	Rigid Z
630	113	0	10579	0	0	0	Rigid Z
760	0	393	38890	0	0	0	Rigid Z
1060	571	0	58394	0	0	0	Rigid Z
3120	81227	15172	0	0	0	0	Rigid GUI
3120	206	1107	21647	0	0	0	Rigid Z
3180	25476	4758	0	0	0	0	Rigid GUI
3180	216	1160	22681	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	3868	721	0	0	0	0	Rigid GUI w/gap
3493	0	0	5737	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	5548	29760	0	0	0	0	Rigid LIM
3552	0	0	9619	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	12207	0	0	0	Rigid Z
3602	20103	3748	0	0	0	0	Rigid GUI w/gap
3602	6475	34730	0	0	0	0	Rigid LIM
3602	0	0	11583	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	79495	5106	0	0	0	0	Rigid GUI
3680	1071	16677	28972	0	0	0	Rigid Z
3825	11415	4682	3746	576	1406	3541	Rigid ANC
3830	0	72312	0	0	0	0	Rigid GUI
3830	271238	0	0	0	0	0	Rigid GUI
3840	0	64849	0	0	0	0	Rigid GUI
3840	256028	0	0	0	0	0	Rigid GUI
3920	0	13601	0	0	0	0	Rigid GUI
3920	388	0	37242	0	0	0	Rigid Z
4180	0	20520	0	0	0	0	Rigid GUI
4180	196	0	18288	0	0	0	Rigid Z
4875	0	9865	0	0	0	0	Rigid GUI
4875	0	0	40746	0	0	0	Rigid Z

S4, S5, S6

(SUS)COMBINATION # 4

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	6729	1241	0	0	0	0	Rigid GUI
70	55	298	5888	0	0	0	Rigid Z
80	6415	1183	0	0	0	0	Rigid GUI
80	213	1154	22818	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	8475	1580	0	0	0	0	Rigid GUI
160	0	0	24295	0	0	0	Rigid Z
190	2742	3875	19087	2264	2671	1730	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	14773	1609	0	0	0	0	Rigid GUI
240	2815	25843	45553	0	0	0	Rigid Z
396	889	2335	13738	319	122	1003	Rigid ANC
400	0	69342	0	0	0	0	Rigid GUI
400	37600	0	0	0	0	0	Rigid GUI
420	0	55680	0	0	0	0	Rigid GUI
420	56672	0	0	0	0	0	Rigid GUI
600	0	13806	0	0	0	0	Rigid GUI
600	276	0	25771	0	0	0	Rigid Z
630	214	0	20005	0	0	0	Rigid Z
760	0	531	52470	0	0	0	Rigid Z
1060	298	0	30545	0	0	0	Rigid Z
3120	11995	2240	0	0	0	0	Rigid GUI
3120	46	248	4857	0	0	0	Rigid Z
3180	2645	494	0	0	0	0	Rigid GUI
3180	119	639	12506	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	7688	1433	0	0	0	0	Rigid GUI w/gap
3493	0	0	6836	0	0	0	Rigid Z
3552	2863	533	0	0	0	0	Rigid GUI w/gap
3552	1670	8958	0	0	0	0	Rigid LIM
3552	0	0	10636	0	0	0	Rigid Z
3563	815	152	0	0	0	0	Rigid GUI w/gap
3563	0	0	10997	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1471	7891	0	0	0	0	Rigid LIM
3602	0	0	11513	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	23901	1535	0	0	0	0	Rigid GUI
3680	535	8340	14489	0	0	0	Rigid Z
3825	1297	2533	9753	312	160	636	Rigid ANC
3830	0	58041	0	0	0	0	Rigid GUI
3830	36842	0	0	0	0	0	Rigid GUI
3840	0	49530	0	0	0	0	Rigid GUI
3840	33661	0	0	0	0	0	Rigid GUI
3920	0	11840	0	0	0	0	Rigid GUI
3920	212	0	20350	0	0	0	Rigid Z
4180	0	10300	0	0	0	0	Rigid GUI
4180	211	0	19677	0	0	0	Rigid Z
4875	0	7882	0	0	0	0	Rigid GUI
4875	0	0	39723	0	0	0	Rigid Z

S7

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	3415	630	0	0	0	0	Rigid GUI
70	99	537	10614	0	0	0	Rigid Z
80	6754	1246	0	0	0	0	Rigid GUI
80	189	1027	20301	0	0	0	Rigid Z
151	1942	10420	0	0	0	0	Rigid +LIM
160	3242	604	0	0	0	0	Rigid GUI
160	0	0	20414	0	0	0	Rigid Z
190	3648	3369	20525	3294	2931	1443	Rigid ANC
201	6955	37309	0	0	0	0	Rigid -LIM
240	12709	1384	0	0	0	0	Rigid GUI
240	2903	26657	46988	0	0	0	Rigid Z
396	1165	1869	13435	255	159	1310	Rigid ANC
400	0	56095	0	0	0	0	Rigid GUI
400	54101	0	0	0	0	0	Rigid GUI
420	0	50006	0	0	0	0	Rigid GUI
420	72575	0	0	0	0	0	Rigid GUI
600	0	15914	0	0	0	0	Rigid GUI
600	343	0	31923	0	0	0	Rigid Z
630	223	0	20819	0	0	0	Rigid Z
760	0	568	56194	0	0	0	Rigid Z
1060	332	0	33993	0	0	0	Rigid Z
3120	3030	566	0	0	0	0	Rigid GUI
3120	61	327	6410	0	0	0	Rigid Z
3180	2458	459	0	0	0	0	Rigid GUI
3180	124	666	13032	0	0	0	Rigid Z
3360	765	4103	0	0	0	0	Rigid +LIM
3493	3868	721	0	0	0	0	Rigid GUI w/gap
3493	0	0	7659	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	1961	10519	0	0	0	0	Rigid LIM
3552	0	0	8788	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	11698	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1677	8997	0	0	0	0	Rigid LIM
3602	0	0	10503	0	0	0	Rigid Z
3655	630	3381	0	0	0	0	Rigid -LIM
3680	17345	1114	0	0	0	0	Rigid GUI
3680	432	6729	11689	0	0	0	Rigid Z
3825	2350	1975	9631	243	289	733	Rigid ANC
3830	0	40123	0	0	0	0	Rigid GUI
3830	41192	0	0	0	0	0	Rigid GUI
3840	0	37199	0	0	0	0	Rigid GUI
3840	40403	0	0	0	0	0	Rigid GUI
3920	0	13893	0	0	0	0	Rigid GUI
3920	236	0	22689	0	0	0	Rigid Z
4180	0	11709	0	0	0	0	Rigid GUI
4180	227	0	21156	0	0	0	Rigid Z
4875	0	7297	0	0	0	0	Rigid GUI
4875	0	0	50312	0	0	0	Rigid Z

IV) Service Level D

Part 1 of 3: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L20	W+P5+T3+F2	D
		L21	W+P5+F2	
23	DW+LOCA PC III+ICE II	L28	W+P9+T3	D
		L29	W+P9	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	20(OPE)	-79649	-16283	30258	0	0	0
	21(SUS)	-374	220	-5516	0	0	0
	28(OPE)	-84300	-17635	39699	0	0	0
	29(SUS)	-3882	-800	1605	0	0	0
	MAX	-84300/L28	-17635/L28	39699/L28			
80		Rigid GUI; Rigid Z					
	20(OPE)	54217	12024	-38577	0	0	0
	21(SUS)	633	759	-12274	0	0	0
	28(OPE)	54963	12430	-43701	0	0	0
	29(SUS)	1195	1065	-16139	0	0	0
	MAX	54963/L28	12430/L28	-43701/L28			
151		Rigid +LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	1943	-10421	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	1943/L21	-10421/L21				
160		Rigid GUI; Rigid Z					
	20(OPE)	-12431	-2318	-90142	0	0	0
	21(SUS)	-994	-185	-12989	0	0	0
	28(OPE)	-3054	-569	-97642	0	0	0
	29(SUS)	6080	1134	-18424	0	0	0
	MAX	-12431/L20	-2318/L20	-97642/L28			
190		Rigid ANC					

	20(OPE)	-2810	7752	83433	-97897	-23172	3508
	21(SUS)	1740	324	-11948	-732	-1407	-815
	28(OPE)	-5204	7345	79731	-99192	-23392	2636
	29(SUS)	-97	1266	-11253	628	-1489	-1582
	MAX	-5204/L28	7752/L20	83433/L20	-99192/L28	-23392/L28	3508/L20
201	Rigid -LIM						
	20(OPE)	0	0	0	0	0	0
	21(SUS)	-6966	37366	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	-747	4007	0	0	0	0
	MAX	-6966/L21	37366/L21				
240	Rigid GUI; Rigid Z						
	20(OPE)	26571	-6610	-16556	0	0	0
	21(SUS)	-947	-20279	-35146	0	0	0
	28(OPE)	16234	-20930	-39541	0	0	0
	29(SUS)	-3973	-26012	-44559	0	0	0
	MAX	26571/L20	-26012/L29	-44559/L29			
396	Rigid ANC						
	20(OPE)	-3220	1724	9008	-235	-440	570
	21(SUS)	-332	-161	11652	22	-46	118
	28(OPE)	-2593	-995	23317	137	-356	-56
	29(SUS)	-551	-431	24044	58	-77	87
	MAX	-3220/L20	1724/L20	24044/L29	-235/L20	-440/L20	570/L20
400	Rigid GUI; Rigid GUI						
	20(OPE)	-139790	34723	0	0	0	0
	21(SUS)	-12076	-1809	0	0	0	0
	28(OPE)	-101276	-50064	0	0	0	0
	29(SUS)	-18687	-13087	0	0	0	0
	MAX	-139790/L20	-50064/L28				
420	Rigid GUI; Rigid GUI						
	20(OPE)	101886	-18745	0	0	0	0
	21(SUS)	20111	-2209	0	0	0	0
	28(OPE)	77530	45466	0	0	0	0
	29(SUS)	29557	5497	0	0	0	0
	MAX	101886/L20	45466/L28				
600	Rigid GUI; Rigid Z						
	20(OPE)	-549	1606	-51129	0	0	0

	21(SUS)	-185	1190	-17171	0	0	0
	28(OPE)	-433	-302	-40303	0	0	0
	29(SUS)	-200	871	-18617	0	0	0
	MAX	-549/L20	1606/L20	-51129/L20			
630		Rigid Z					
	20(OPE)	15	0	1359	0	0	0
	21(SUS)	-120	0	-11206	0	0	0
	28(OPE)	-29	0	-2727	0	0	0
	29(SUS)	-117	0	-10878	0	0	0
	MAX	-120/L21		-11206/L21			
760		Rigid Z					
	20(OPE)	0	-137	13512	0	0	0
	21(SUS)	0	330	-32618	0	0	0
	28(OPE)	0	-136	13390	0	0	0
	29(SUS)	0	324	-32052	0	0	0
	MAX		330/L21	-32618/L21			
1060		Rigid Z					
	20(OPE)	358	0	36569	0	0	0
	21(SUS)	-128	0	-13084	0	0	0
	28(OPE)	367	0	37468	0	0	0
	29(SUS)	-125	0	-12811	0	0	0
	MAX	367/L28		37468/L28			
3120		Rigid GUI; Rigid Z					
	20(OPE)	78756	13779	17613	0	0	0
	21(SUS)	368	195	-2375	0	0	0
	28(OPE)	66632	11462	18605	0	0	0
	29(SUS)	-10025	-1788	-1597	0	0	0
	MAX	78756/L20	13779/L20	18605/L28			
3180		Rigid GUI; Rigid Z					
	20(OPE)	-23421	-3486	-16785	0	0	0
	21(SUS)	-324	317	-7136	0	0	0
	28(OPE)	-24308	-3617	-17440	0	0	0
	29(SUS)	562	511	-7671	0	0	0
	MAX	-24308/L28	-3617/L28	-17440/L28			
3360		Rigid +LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	767	-4115	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	767/L21	-4115/L21				

3493		Rigid GUI w/gap; Rigid Z					
	20(OPE)	0	0	-2540	0	0	0
	21(SUS)	0	0	-4461	0	0	0
	28(OPE)	0	0	-2457	0	0	0
	29(SUS)	4313	804	-4425	0	0	0
	MAX	4313/L29	804/L29	-4461/L21			
3552		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	20(OPE)	3628	-19458	5507	0	0	0
	21(SUS)	-50	267	-4760	0	0	0
	28(OPE)	-413	2216	2000	0	0	0
	29(SUS)	3138	712	-7333	0	0	0
	MAX	3628/L20	-19458/L20	-7333/L29			
3563		Rigid GUI w/gap; Rigid Z					
	20(OPE)	0	0	-7495	0	0	0
	21(SUS)	0	0	-6986	0	0	0
	28(OPE)	0	0	-7939	0	0	0
	29(SUS)	854	159	-7279	0	0	0
	MAX	854/L29	159/L29	-7939/L28			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	20(OPE)	-24967	22202	-7505	0	0	0
	21(SUS)	50	-267	-6433	0	0	0
	28(OPE)	-8455	2566	-10177	0	0	0
	29(SUS)	22	-119	-8605	0	0	0
	MAX	-24967/L20	22202/L20	-10177/L28			
3655		Rigid -LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	-638	3420	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	-638/L21	3420/L21				
3680		Rigid GUI; Rigid Z					
	20(OPE)	63691	-7360	-19811	0	0	0
	21(SUS)	883	-1409	-2536	0	0	0
	28(OPE)	42144	-10025	-22027	0	0	0
	29(SUS)	-11040	-4818	-7108	0	0	0
	MAX	63691/L20	-10025/L28	-22027/L28			
3825		Rigid ANC					

	20(OPE)	-9952	2993	2745	-369	-1227	-2735
	21(SUS)	-882	281	8633	-35	-109	316
	28(OPE)	-8355	1083	12706	-134	-1032	-3271
	29(SUS)	-339	-1081	17925	133	-43	-46
	MAX	-9952/L20	2993/L20	17925/L29	-369/L20	-1227/L20	-3271/L28
3830		Rigid GUI; Rigid GUI					
	20(OPE)	-247969	41803	0	0	0	0
	21(SUS)	-17907	-1764	0	0	0	0
	28(OPE)	-202516	5930	0	0	0	0
	29(SUS)	4659	-31412	0	0	0	0
	MAX	-247969/L20	41803/L20				
3840		Rigid GUI; Rigid GUI					
	20(OPE)	231790	-31653	0	0	0	0
	21(SUS)	16207	5742	0	0	0	0
	28(OPE)	203810	-9665	0	0	0	0
	29(SUS)	971	23230	0	0	0	0
	MAX	231790/L20	-31653/L20				
3920		Rigid GUI; Rigid Z					
	20(OPE)	-280	-3834	-26817	0	0	0
	21(SUS)	-129	-3766	-12381	0	0	0
	28(OPE)	-266	2370	-25546	0	0	0
	29(SUS)	-130	2917	-12501	0	0	0
	MAX	-280/L20	-3834/L20	-26817/L20			
4180		Rigid GUI; Rigid Z					
	20(OPE)	177	17542	16455	0	0	0
	21(SUS)	-44	4792	-4134	0	0	0
	28(OPE)	91	10657	8516	0	0	0
	29(SUS)	-126	-2122	-11778	0	0	0
	MAX	177/L20	17542/L20	16455/L20			
4875		Rigid GUI; Rigid Z					
	20(OPE)	0	2670	-22672	0	0	0
	21(SUS)	0	-220	-32155	0	0	0
	28(OPE)	0	-1749	-19014	0	0	0
	29(SUS)	0	-976	-33618	0	0	0
	MAX		2670/L20	-33618/L29			

Part 2 of 3: Integrity at 30 bar

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
--	Integrity at 30 bar	L60	W+P10+T6	D
		L61	W+P10	

L60

Node	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.	
70	-18792	-3468	0	0	0	0	Rigid GUI
70	-168	908	-17944	0	0	0	Rigid Z
80	18723	3455	0	0	0	0	Rigid GUI
80	-68	369	-7300	0	0	0	Rigid Z
151	94584	-507332	0	0	0	0	Rigid +LIM
160	-30559	-5697	0	0	0	0	Rigid GUI
160	0	0	-32682	0	0	0	Rigid Z
190	8820	2045	36025	-51568	-12385	2098	Rigid ANC
201	-113651	609606	0	0	0	0	Rigid -LIM
240	17099	1863	0	0	0	0	Rigid GUI
240	968	-8883	-15657	0	0	0	Rigid Z
396	-2352	3012	8798	-412	-321	832	Rigid ANC
400	0	84594	0	0	0	0	Rigid GUI
400	-109368	0	0	0	0	0	Rigid GUI
420	0	-64047	0	0	0	0	Rigid GUI
420	87150	0	0	0	0	0	Rigid GUI
600	0	2751	0	0	0	0	Rigid GUI
600	-463	0	-43074	0	0	0	Rigid Z
630	-21	0	-1944	0	0	0	Rigid Z
760	0	128	-12692	0	0	0	Rigid Z
1060	70	0	7102	0	0	0	Rigid Z
3120	47501	8873	0	0	0	0	Rigid GUI
3120	44	-234	4565	0	0	0	Rigid Z
3180	-9458	-1767	0	0	0	0	Rigid GUI
3180	-98	525	-10263	0	0	0	Rigid Z
3360	43841	-235149	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-3471	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	6573	-35253	0	0	0	0	Rigid LIM
3552	0	0	1268	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-6431	0	0	0	Rigid Z
3602	-18338	-3419	0	0	0	0	Rigid GUI w/gap
3602	-6711	35993	0	0	0	0	Rigid LIM
3602	0	0	-6007	0	0	0	Rigid Z
3655	-46448	249131	0	0	0	0	Rigid -LIM
3680	34423	2211	0	0	0	0	Rigid GUI
3680	384	-5974	-10377	0	0	0	Rigid Z

3825	-5442	2358	5618	-291	-670	-862	Rigid ANC
3830	0	25323	0	0	0	0	Rigid GUI
3830	-124826	0	0	0	0	0	Rigid GUI
3840	0	-20289	0	0	0	0	Rigid GUI
3840	103813	0	0	0	0	0	Rigid GUI
3920	0	3720	0	0	0	0	Rigid GUI
3920	-202	0	-19395	0	0	0	Rigid Z
4180	0	3041	0	0	0	0	Rigid GUI
4180	-34	0	-3128	0	0	0	Rigid Z
4875	0	4682	0	0	0	0	Rigid GUI
4875	0	0	-34456	0	0	0	Rigid Z

L61

Node	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.	
70	-291	-54	0	0	0	0	Rigid GUI
70	-51	276	-5453	0	0	0	Rigid Z
80	708	131	0	0	0	0	Rigid GUI
80	-115	625	-12356	0	0	0	Rigid Z
151	117268	-629006	0	0	0	0	Rigid +LIM
160	-987	-184	0	0	0	0	Rigid GUI
160	0	0	-26384	0	0	0	Rigid Z
190	1699	272	1473	-16621	-4347	-791	Rigid ANC
201	-122310	656048	0	0	0	0	Rigid -LIM
240	-2984	-325	0	0	0	0	Rigid GUI
240	2171	-19930	-35131	0	0	0	Rigid Z
396	-352	-162	11669	22	-49	144	Rigid ANC
400	0	-1890	0	0	0	0	Rigid GUI
400	-12368	0	0	0	0	0	Rigid GUI
420	0	-2157	0	0	0	0	Rigid GUI
420	19818	0	0	0	0	0	Rigid GUI
600	0	1052	0	0	0	0	Rigid GUI
600	-183	0	-17066	0	0	0	Rigid Z
630	-123	0	-11446	0	0	0	Rigid Z
760	0	326	-32181	0	0	0	Rigid Z
1060	-124	0	-12675	0	0	0	Rigid Z
3120	395	74	0	0	0	0	Rigid GUI
3120	-23	121	-2374	0	0	0	Rigid Z
3180	-243	-45	0	0	0	0	Rigid GUI
3180	-68	366	-7144	0	0	0	Rigid Z
3360	48340	-259279	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-4461	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	-41	220	0	0	0	0	Rigid LIM
3552	0	0	-4708	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-6991	0	0	0	Rigid Z

3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	42	-227	0	0	0	0	Rigid LIM
3602	0	0	-6395	0	0	0	Rigid Z
3655	-48208	258568	0	0	0	0	Rigid -LIM
3680	266	17	0	0	0	0	Rigid GUI
3680	105	-1639	-2847	0	0	0	Rigid Z
3825	-812	306	8640	-38	-100	123	Rigid ANC
3830	0	-5597	0	0	0	0	Rigid GUI
3830	-9104	0	0	0	0	0	Rigid GUI
3840	0	4759	0	0	0	0	Rigid GUI
3840	4663	0	0	0	0	0	Rigid GUI
3920	0	3109	0	0	0	0	Rigid GUI
3920	-126	0	-12086	0	0	0	Rigid Z
4180	0	-2164	0	0	0	0	Rigid GUI
4180	-128	0	-11899	0	0	0	Rigid Z
4875	0	-146	0	0	0	0	Rigid GUI
4875	0	0	-31875	0	0	0	Rigid Z

Part 3 of 3: Dynamic Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
21	DW+LOVA+VVICE +FA	L24	WW+P7+T3+F3	D
		L25	WW+P7+F3	
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L26	WW+P8+T3+F4	Ultimate Failure σ_u
		L27	WW+P8+F4	

L24

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.	)-------		-----Moments(N.m.		)-----	
70	-80453	-14847	0	0	0	0	Rigid GUI
70	236	-1279	25292	0	0	0	Rigid Z
80	55262	10198	0	0	0	0	Rigid GUI
80	-470	2550	-50410	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	-12830	-2392	0	0	0	0	Rigid GUI
160	0	0	-97639	0	0	0	Rigid Z
190	2072	-13004	84061	-96861	-24451	3388	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	37011	4031	0	0	0	0	Rigid GUI
240	999	-15571	-27051	0	0	0	Rigid Z
396	-4572	4920	6314	-672	-624	2017	Rigid ANC
400	0	138420	0	0	0	0	Rigid GUI
400	-203945	0	0	0	0	0	Rigid GUI
420	0	-100914	0	0	0	0	Rigid GUI
420	157103	0	0	0	0	0	Rigid GUI
600	0	11359	0	0	0	0	Rigid GUI
600	-883	0	-82191	0	0	0	Rigid Z
630	-77	0	-7223	0	0	0	Rigid Z
760	0	149	-14732	0	0	0	Rigid Z
1060	374	0	38230	0	0	0	Rigid Z
3120	97602	18231	0	0	0	0	Rigid GUI
3120	167	-894	17482	0	0	0	Rigid Z
3180	-39032	-7291	0	0	0	0	Rigid GUI
3180	-219	1176	-23001	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-3852	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	9869	-52933	0	0	0	0	Rigid LIM
3552	0	0	9514	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-11240	0	0	0	Rigid Z
3602	-34213	-6378	0	0	0	0	Rigid GUI w/gap
3602	-9269	49715	0	0	0	0	Rigid LIM

3602	0	0	-9628	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	80328	5159	0	0	0	0	Rigid GUI
3680	981	-15276	-26538	0	0	0	Rigid Z
3825	-12521	5481	1601	-675	-1542	-3087	Rigid ANC
3830	0	65496	0	0	0	0	Rigid GUI
3830	-294402	0	0	0	0	0	Rigid GUI
3840	0	-67151	0	0	0	0	Rigid GUI
3840	285828	0	0	0	0	0	Rigid GUI
3920	0	-28009	0	0	0	0	Rigid GUI
3920	-416	0	-39972	0	0	0	Rigid Z
4180	0	45222	0	0	0	0	Rigid GUI
4180	-100	0	-9384	0	0	0	Rigid Z
4875	0	8120	0	0	0	0	Rigid GUI
4875	0	0	-53770	0	0	0	Rigid Z

L 25

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	-580	-107	0	0	0	0	Rigid GUI
70	-102	557	-11010	0	0	0	Rigid Z
80	1388	256	0	0	0	0	Rigid GUI
80	-222	1205	-23820	0	0	0	Rigid Z
151	1504	-8069	0	0	0	0	Rigid +LIM
160	-1912	-356	0	0	0	0	Rigid GUI
160	0	0	-20020	0	0	0	Rigid Z
190	7152	-22127	-19182	-2555	-2839	-1395	Rigid ANC
201	-13121	70379	0	0	0	0	Rigid -LIM
240	-6339	-690	0	0	0	0	Rigid GUI
240	2151	-33503	-58202	0	0	0	Rigid Z
396	-864	536	10916	-73	-119	975	Rigid ANC
400	0	27047	0	0	0	0	Rigid GUI
400	-31705	0	0	0	0	0	Rigid GUI
420	0	-26770	0	0	0	0	Rigid GUI
420	41886	0	0	0	0	0	Rigid GUI
600	0	9365	0	0	0	0	Rigid GUI
600	-383	0	-35701	0	0	0	Rigid Z
630	-260	0	-24289	0	0	0	Rigid Z
760	0	623	-61564	0	0	0	Rigid Z
1060	-227	0	-23244	0	0	0	Rigid Z
3120	19490	3640	0	0	0	0	Rigid GUI
3120	-66	357	-6993	0	0	0	Rigid Z
3180	-16259	-3037	0	0	0	0	Rigid GUI
3180	-127	683	-13352	0	0	0	Rigid Z
3360	781	-4193	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-5700	0	0	0	Rigid Z

3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	6424	-34460	0	0	0	0	Rigid LIM
3552	0	0	-6898	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-10460	0	0	0	Rigid Z
3602	-11564	-2156	0	0	0	0	Rigid GUI w/gap
3602	-4309	23112	0	0	0	0	Rigid LIM
3602	0	0	-9579	0	0	0	Rigid Z
3655	-2233	11979	0	0	0	0	Rigid -LIM
3680	-7264	-466	0	0	0	0	Rigid GUI
3680	322	-5018	-8718	0	0	0	Rigid Z
3825	-2309	1752	8193	-215	-284	330	Rigid ANC
3830	0	-31736	0	0	0	0	Rigid GUI
3830	-38384	0	0	0	0	0	Rigid GUI
3840	0	57238	0	0	0	0	Rigid GUI
3840	56857	0	0	0	0	0	Rigid GUI
3920	0	-28569	0	0	0	0	Rigid GUI
3920	-250	0	-24067	0	0	0	Rigid Z
4180	0	32517	0	0	0	0	Rigid GUI
4180	-324	0	-30278	0	0	0	Rigid Z
4875	0	-4780	0	0	0	0	Rigid GUI
4875	0	0	-56170	0	0	0	Rigid Z

L26

NODE	------Forces(N.)------- FX	FY	FZ	-----Moments(N.m.)----- MX	MY	MZ	
70	-80454	-14847	0	0	0	0	Rigid GUI
70	236	-1279	25292	0	0	0	Rigid Z
80	55263	10198	0	0	0	0	Rigid GUI
80	-470	2550	-50410	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	-12831	-2392	0	0	0	0	Rigid GUI
160	0	0	-97640	0	0	0	Rigid Z
190	10342	-55866	91527	-94664	-24655	3727	Rigid ANC
201	-665	3568	0	0	0	0	Rigid -LIM
240	49863	5431	0	0	0	0	Rigid GUI
240	945	-8681	-15301	0	0	0	Rigid Z
396	-5887	8296	4772	-1134	-803	3527	Rigid ANC
400	0	243233	0	0	0	0	Rigid GUI
400	-270994	0	0	0	0	0	Rigid GUI
420	0	-180947	0	0	0	0	Rigid GUI
420	213440	0	0	0	0	0	Rigid GUI
600	0	23912	0	0	0	0	Rigid GUI
600	-1089	0	-101400	0	0	0	Rigid Z
630	-39	0	-3684	0	0	0	Rigid Z
760	0	216	-21387	0	0	0	Rigid Z
1060	441	0	45163	0	0	0	Rigid Z
3120	107829	20142	0	0	0	0	Rigid GUI

3120	173	-929	18168	0	0	0	Rigid Z
3180	-47586	-8888	0	0	0	0	Rigid GUI
3180	-230	1232	-24100	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-4117	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	14134	-75813	0	0	0	0	Rigid LIM
3552	0	0	13470	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-12273	0	0	0	Rigid Z
3602	-44392	-8276	0	0	0	0	Rigid GUI w/gap
3602	-10400	55787	0	0	0	0	Rigid LIM
3602	0	0	-8991	0	0	0	Rigid Z
3655	-1122	6019	0	0	0	0	Rigid -LIM
3680	99897	6416	0	0	0	0	Rigid GUI
3680	1089	-16972	-29484	0	0	0	Rigid Z
3825	-15153	7546	1217	-930	-1865	-3400	Rigid ANC
3830	0	101869	0	0	0	0	Rigid GUI
3830	-366610	0	0	0	0	0	Rigid GUI
3840	0	-106972	0	0	0	0	Rigid GUI
3840	361059	0	0	0	0	0	Rigid GUI
3920	0	-58347	0	0	0	0	Rigid GUI
3920	-479	0	-45979	0	0	0	Rigid Z
4180	0	74289	0	0	0	0	Rigid GUI
4180	-185	0	-17299	0	0	0	Rigid Z
4875	0	15627	0	0	0	0	Rigid GUI
4875	0	0	-84835	0	0	0	Rigid Z

L27

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	-581	-107	0	0	0	0	Rigid GUI
70	-102	557	-11011	0	0	0	Rigid Z
80	1389	256	0	0	0	0	Rigid GUI
80	-222	1205	-23821	0	0	0	Rigid Z
151	1504	-8069	0	0	0	0	Rigid +LIM
160	-1913	-356	0	0	0	0	Rigid GUI
160	0	0	-20021	0	0	0	Rigid Z
190	15845	-67020	-21438	-3855	-3229	-1683	Rigid ANC
201	-21328	114399	0	0	0	0	Rigid -LIM
240	-13505	-1471	0	0	0	0	Rigid GUI
240	3816	-35045	-61772	0	0	0	Rigid Z
396	-1168	-1337	11812	183	-161	1751	Rigid ANC
400	0	38699	0	0	0	0	Rigid GUI
400	-43648	0	0	0	0	0	Rigid GUI
420	0	-35111	0	0	0	0	Rigid GUI
420	56815	0	0	0	0	0	Rigid GUI

600	0	19953	0	0	0	0	Rigid GUI
600	-422	0	-39299	0	0	0	Rigid Z
630	-283	0	-26357	0	0	0	Rigid Z
760	0	699	-69095	0	0	0	Rigid Z
1060	-266	0	-27285	0	0	0	Rigid Z
3120	29716	5550	0	0	0	0	Rigid GUI
3120	-83	447	-8738	0	0	0	Rigid Z
3180	-24811	-4634	0	0	0	0	Rigid GUI
3180	-138	739	-14452	0	0	0	Rigid Z
3360	782	-4194	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	0	0	-5867	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	11129	-59696	0	0	0	0	Rigid LIM
3552	0	0	-7650	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	0	0	-11097	0	0	0	Rigid Z
3602	-18518	-3452	0	0	0	0	Rigid GUI w/gap
3602	-5456	29267	0	0	0	0	Rigid LIM
3602	0	0	-10403	0	0	0	Rigid Z
3655	-5631	30205	0	0	0	0	Rigid -LIM
3680	-18182	-1167	0	0	0	0	Rigid GUI
3680	-452	7052	12251	0	0	0	Rigid Z
3825	-3475	2409	8692	-296	-427	-954	Rigid ANC
3830	0	-52210	0	0	0	0	Rigid GUI
3830	-77036	0	0	0	0	0	Rigid GUI
3840	0	100411	0	0	0	0	Rigid GUI
3840	115026	0	0	0	0	0	Rigid GUI
3920	0	-59724	0	0	0	0	Rigid GUI
3920	-294	0	-28228	0	0	0	Rigid Z
4180	0	61643	0	0	0	0	Rigid GUI
4180	-414	0	-38574	0	0	0	Rigid Z
4875	0	-11365	0	0	0	0	Rigid GUI
4875	0	0	-77840	0	0	0	Rigid Z

B. APPENDIX: Loads on Supports *(with sliding friction)*

I) Service Level A

<u>Part 1 of 2:</u> Static Load Cases

Load Spec. No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
2	Hydrostatic Test	L1	WW+HP	Test
1	DW+NO	L2	W+P1+T1	A
		L3	W+P1	
5	DW+T Baking	L4	W+P1+T2	A
		L5	W+P1	
7	DW+VVICE II	L6	W+P2+T3	A
		L7	W+P2	
8	DW+VVICE III	L8	W+P2+T3	A
		L9	W+P2	
9	DW+LOCA VV-PHTS	L10	W+P3+T4	A
		L11	W+P3	
17	DW+LOVA+VVICE+FA	L18	W+P7+T3+F1	A
		L19	W+P7+F1	
20	DW+VV Dust Explosion	L22	W+P6+T1	A
		L23	W+P6	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	1(HYD)	-747	-524	-9280	0	0	0
	2(OPE)	-41824	8576	17638	0	0	0
	3(SUS)	-5293	1062	2135	0	0	0
	4(OPE)	-77528	15967	32991	0	0	0
	5(SUS)	-5293	1062	2135	0	0	0
	6(OPE)	-94622	18208	34843	0	0	0
	7(SUS)	47	-853	-5444	0	0	0
	8(OPE)	-94622	18208	34843	0	0	0
	9(SUS)	47	-853	-5444	0	0	0
	10(OPE)	-58508	13251	29985	0	0	0
	11(SUS)	-9868	3238	9306	0	0	0
	18(OPE)	-93029	17444	32318	0	0	0
	19(SUS)	332	-1206	-5695	0	0	0
	22(OPE)	-24789	7031	-12226	0	0	0
	23(SUS)	333	-1208	-5693	0	0	0
	MAX	-94622/L6	18208/L6	34843/L6			
80		Rigid GUI; Rigid Z					
	1(HYD)	1264	384	-22548	0	0	0
	2(OPE)	20488	20670	-26098	0	0	0
	3(SUS)	540	6465	-16078	0	0	0
	4(OPE)	40100	34667	-36033	0	0	0

	5(SUS)	540	6465	-16078	0	0	0
	6(OPE)	51590	41552	-38433	0	0	0
	7(SUS)	798	-639	-12420	0	0	0
	8(OPE)	51590	41552	-38433	0	0	0
	9(SUS)	798	-639	-12420	0	0	0
	10(OPE)	27670	27130	-33205	0	0	0
	11(SUS)	1032	8151	-19800	0	0	0
	18(OPE)	51422	40961	-37123	0	0	0
	19(SUS)	829	-1109	-12321	0	0	0
	22(OPE)	18700	13692	-10372	0	0	0
	23(SUS)	829	-1111	-12326	0	0	0
	MAX	51590/L6	41552/L6	-38433/L6			
151		Rigid +LIM					
	1(HYD)	0	0	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	1869	-10027	0	0	0	0
	22(OPE)	0	0	0	0	0	0
	23(SUS)	18346	-98403	0	0	0	0
	MAX	18346/L23	-98403/L23				
160		Rigid GUI; Rigid Z					
	1(HYD)	-781	-236	-19410	0	0	0
	2(OPE)	4607	-8106	-26333	0	0	0
	3(SUS)	6920	-1214	-18801	0	0	0
	4(OPE)	1536	-10689	-35518	0	0	0
	5(SUS)	6920	-1214	-18801	0	0	0
	6(OPE)	-4339	-32251	-92857	0	0	0
	7(SUS)	-860	-128	-12872	0	0	0
	8(OPE)	-4339	-32251	-92857	0	0	0
	9(SUS)	-860	-128	-12872	0	0	0
	10(OPE)	10266	-7031	-20507	0	0	0
	11(SUS)	14287	-2240	-24405	0	0	0
	18(OPE)	-6750	-32867	-90917	0	0	0
	19(SUS)	-1225	577	-12888	0	0	0
	22(OPE)	-24679	-13645	-2874	0	0	0

	23(SUS)	-1904	4210	-14703	0	0	0
	MAX	-24679/L22	-32867/L18	-92857/L6			
190	Rigid ANC						
	1(HYD)	1316	519	-15622	-613	-1822	-707
	2(OPE)	-2477	14218	-1995	-12176	-4364	-911
	3(SUS)	-1300	3340	-12044	104	-1389	-1231
	4(OPE)	-2547	21008	9314	-26629	-7405	-790
	5(SUS)	-1300	3340	-12044	104	-1389	-1231
	6(OPE)	-9154	39486	84623	-98040	-24128	3170
	7(SUS)	1577	298	-11503	-111	-1196	-758
	8(OPE)	-9154	39486	84623	-98040	-24128	3170
	9(SUS)	1577	298	-11503	-111	-1196	-758
	10(OPE)	-6478	13390	-11731	1168	-3605	3
	11(SUS)	-3223	6237	-13416	-117	-1885	-2116
	18(OPE)	-4812	18807	88815	-95985	-23712	3481
	19(SUS)	5915	-22570	-11349	-388	-1242	-745
	22(OPE)	8059	11381	-4264	-15723	-4557	569
	23(SUS)	2474	-4112	-9530	-2533	-1642	-745
	MAX	-9154/L6	39486/L6	88815/L18	-98040/L6	-24128/L6	3481/L18
201	Rigid -LIM						
	1(HYD)	-2047	10977	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	-3022	16208	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	-3022	16208	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	-9205	49374	0	0	0	0
	22(OPE)	-20651	110770	0	0	0	0
	23(SUS)	-21561	115648	0	0	0	0
	MAX	-21561/L23	115648/L23				
240	Rigid GUI; Rigid Z						
	1(HYD)	-2908	-7803	-36969	0	0	0
	2(OPE)	2964	-27889	-35100	0	0	0
	3(SUS)	-1211	-25789	-35452	0	0	0
	4(OPE)	2984	-27935	-35030	0	0	0
	5(SUS)	-1211	-25789	-35452	0	0	0
	6(OPE)	43868	-32732	-19601	0	0	0

7(SUS)	-4882	-6456	-32567	0	0	0
8(OPE)	43868	-32732	-19601	0	0	0
9(SUS)	-4882	-6456	-32567	0	0	0
10(OPE)	13963	-52630	-47997	0	0	0
11(SUS)	268	-54763	-49603	0	0	0
18(OPE)	44081	-9650	-13129	0	0	0
19(SUS)	-4862	-6433	-32451	0	0	0
22(OPE)	-816	-6517	-29585	0	0	0
23(SUS)	-4863	-6431	-32442	0	0	0
MAX	44081/L18	-54763/L11	-49603/L11			

396	Rigid ANC					
1(HYD)	-353	-44	-1929	6	-49	259
2(OPE)	-497	-223	11695	30	-69	602
3(SUS)	-343	-447	11918	61	-48	209
4(OPE)	-499	-221	11696	30	-69	603
5(SUS)	-343	-447	11918	61	-48	209
6(OPE)	-3684	3528	7866	-482	-503	2117
7(SUS)	-273	-376	11697	51	-38	49
8(OPE)	-3684	3528	7866	-482	-503	2117
9(SUS)	-273	-376	11697	51	-38	49
10(OPE)	-1656	-935	24181	128	-228	823
11(SUS)	-529	-932	24694	128	-74	309
18(OPE)	-3811	4631	6692	-633	-520	2153
19(SUS)	-274	-368	11698	50	-39	51
22(OPE)	-523	70	11303	-10	-72	410
23(SUS)	-275	-369	11698	50	-39	50
MAX	-3811/L18	4631/L18	24694/L11	-633/L18	-520/L18	2153/L18

400	Rigid GUI; Rigid GUI					
1(HYD)	-12909	7354	0	0	0	0
2(OPE)	-9674	-1637	0	0	0	0
3(SUS)	-9744	-10179	0	0	0	0
4(OPE)	-9742	-1558	0	0	0	0
5(SUS)	-9744	-10179	0	0	0	0
6(OPE)	-145254	99282	0	0	0	0
7(SUS)	-7954	-9818	0	0	0	0
8(OPE)	-145254	99282	0	0	0	0
9(SUS)	-7954	-9818	0	0	0	0
10(OPE)	-47747	-30535	0	0	0	0
11(SUS)	-12920	-25547	0	0	0	0
18(OPE)	-156748	129582	0	0	0	0
19(SUS)	-8000	-9483	0	0	0	0
22(OPE)	-14326	4795	0	0	0	0
23(SUS)	-8035	-9549	0	0	0	0
MAX	-156748/L18	129582/L18				

420	Rigid GUI; Rigid GUI						
1(HYD)	17727	-9721	0	0	0	0
2(OPE)	3771	-5048	0	0	0	0
3(SUS)	17818	5427	0	0	0	0
4(OPE)	3813	-5099	0	0	0	0
5(SUS)	17818	5427	0	0	0	0
6(OPE)	73623	-79227	0	0	0	0
7(SUS)	13094	3117	0	0	0	0
8(OPE)	73623	-79227	0	0	0	0
9(SUS)	13094	3117	0	0	0	0
10(OPE)	26152	20424	0	0	0	0
11(SUS)	27412	17943	0	0	0	0
18(OPE)	76950	-106063	0	0	0	0
19(SUS)	13060	2827	0	0	0	0
22(OPE)	6637	-11083	0	0	0	0
23(SUS)	13142	2927	0	0	0	0
MAX	76950/L18	-106063/L18				
600	Rigid GUI; Rigid Z					
1(HYD)	254	-681	-28048	0	0	0
2(OPE)	6753	4582	-18670	0	0	0
3(SUS)	-167	-326	-15439	0	0	0
4(OPE)	6752	4586	-18663	0	0	0
5(SUS)	-167	-326	-15439	0	0	0
6(OPE)	22061	15501	-60437	0	0	0
7(SUS)	1208	-48	-16980	0	0	0
8(OPE)	22061	15501	-60437	0	0	0
9(SUS)	1208	-48	-16980	0	0	0
10(OPE)	10185	7362	-27688	0	0	0
11(SUS)	-1040	-446	-14387	0	0	0
18(OPE)	24749	17001	-68203	0	0	0
19(SUS)	1119	85	-16988	0	0	0
22(OPE)	7275	3957	-21127	0	0	0
23(SUS)	1201	-49	-16973	0	0	0
MAX	24749/L18	17001/L18	-68203/L18			
630	Rigid Z					
1(HYD)	251	2629	-21099	0	0	0
2(OPE)	3133	-617	-11068	0	0	0
3(SUS)	-5	1615	-11922	0	0	0
4(OPE)	3134	-617	-11070	0	0	0
5(SUS)	-5	1615	-11922	0	0	0
6(OPE)	1206	-213	3931	0	0	0
7(SUS)	1081	1544	-11513	0	0	0
8(OPE)	1206	-213	3931	0	0	0
9(SUS)	1081	1544	-11513	0	0	0
10(OPE)	2177	-417	-7681	0	0	0
11(SUS)	-601	1616	-12213	0	0	0

	18(OPE)	2014	-358	6565	0	0	0
	19(SUS)	948	724	-11478	0	0	0
	22(OPE)	2915	-548	-10281	0	0	0
	23(SUS)	1075	1544	-11514	0	0	0
	MAX	3134/L4	2629/L1	-21099/L1			
760	Rigid Z						
	1(HYD)	172	296	-53559	0	0	0
	2(OPE)	4087	575	-29190	0	0	0
	3(SUS)	362	576	-32655	0	0	0
	4(OPE)	4086	574	-29191	0	0	0
	5(SUS)	362	576	-32655	0	0	0
	6(OPE)	4363	-521	14591	0	0	0
	7(SUS)	367	593	-32495	0	0	0
	8(OPE)	4363	-521	14591	0	0	0
	9(SUS)	367	593	-32495	0	0	0
	10(OPE)	2538	-248	-8536	0	0	0
	11(SUS)	392	596	-32754	0	0	0
	18(OPE)	4487	-507	14998	0	0	0
	19(SUS)	1239	1982	-32514	0	0	0
	22(OPE)	4244	693	-28990	0	0	0
	23(SUS)	368	593	-32496	0	0	0
	MAX	4487/L18	1982/L19	-53559/L1			
1060	Rigid Z						
	1(HYD)	-3199	-2917	-14065	0	0	0
	2(OPE)	-1261	-2168	-8216	0	0	0
	3(SUS)	-2660	-2401	-11639	0	0	0
	4(OPE)	-1261	-2167	-8215	0	0	0
	5(SUS)	-2660	-2401	-11639	0	0	0
	6(OPE)	7760	-11269	44723	0	0	0
	7(SUS)	-2697	-2407	-11739	0	0	0
	8(OPE)	7760	-11269	44723	0	0	0
	9(SUS)	-2697	-2407	-11739	0	0	0
	10(OPE)	2506	-4334	16403	0	0	0
	11(SUS)	-2626	-2406	-11572	0	0	0
	18(OPE)	7936	-10851	43904	0	0	0
	19(SUS)	-1766	-3242	-12107	0	0	0
	22(OPE)	-1290	-2196	-8343	0	0	0
	23(SUS)	-2696	-2407	-11738	0	0	0
	MAX	7936/L18	-11269/L6	44723/L6			
3120	Rigid GUI; Rigid Z						
	1(HYD)	92	-207	-3438	0	0	0
	2(OPE)	23565	13809	6739	0	0	0
	3(SUS)	-8273	1428	-1456	0	0	0
	4(OPE)	56177	32696	15215	0	0	0
	5(SUS)	-8273	1428	-1456	0	0	0

	6(OPE)	86093	49168	19749	0	0	0
	7(SUS)	-128	-31	-2359	0	0	0
	8(OPE)	86093	49168	19749	0	0	0
	9(SUS)	-128	-31	-2359	0	0	0
	10(OPE)	25798	15863	10214	0	0	0
	11(SUS)	-16608	2060	-581	0	0	0
	18(OPE)	89074	50640	19555	0	0	0
	19(SUS)	187	-241	-2415	0	0	0
	22(OPE)	48371	26103	5305	0	0	0
	23(SUS)	187	-241	-2415	0	0	0
	MAX	89074/L18	50640/L18	19749/L6			
3180		Rigid GUI; Rigid Z					
	1(HYD)	88	117	-10199	0	0	0
	2(OPE)	-11710	5133	-11104	0	0	0
	3(SUS)	-393	2703	-7537	0	0	0
	4(OPE)	-23614	7681	-14632	0	0	0
	5(SUS)	-393	2703	-7537	0	0	0
	6(OPE)	-30734	9039	-16262	0	0	0
	7(SUS)	-42	303	-7159	0	0	0
	8(OPE)	-30734	9039	-16262	0	0	0
	9(SUS)	-42	303	-7159	0	0	0
	10(OPE)	-16321	6223	-12769	0	0	0
	11(SUS)	-1528	2929	-8013	0	0	0
	18(OPE)	-30553	8966	-16108	0	0	0
	19(SUS)	128	-36	-7151	0	0	0
	22(OPE)	-12625	4811	-9869	0	0	0
	23(SUS)	128	-36	-7151	0	0	0
	MAX	-30734/L6	9039/L6	-16262/L6			
3360		Rigid +LIM					
	1(HYD)	0	0	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	706	-3785	0	0	0	0
	22(OPE)	3730	-20008	0	0	0	0
	23(SUS)	7502	-40239	0	0	0	0
	MAX	7502/L23	-40239/L23				

3493	Rigid GUI w/gap; Rigid Z						
	1(HYD)	-142	-8	-5121	0	0	0
	2(OPE)	3996	-707	-3939	0	0	0
	3(SUS)	2992	413	-4460	0	0	0
	4(OPE)	3679	-893	-3492	0	0	0
	5(SUS)	2992	413	-4460	0	0	0
	6(OPE)	244	-706	-2490	0	0	0
	7(SUS)	198	-8	-4483	0	0	0
	8(OPE)	244	-706	-2490	0	0	0
	9(SUS)	198	-8	-4483	0	0	0
	10(OPE)	7800	-1577	-3350	0	0	0
	11(SUS)	8662	1293	-4329	0	0	0
	18(OPE)	254	-745	-2625	0	0	0
	19(SUS)	-314	-58	-4518	0	0	0
	22(OPE)	-530	-1008	-3797	0	0	0
	23(SUS)	-876	643	-4520	0	0	0
	MAX	8662/L11	-1577/L10	-5121/L1			
3552	Rigid GUI w/gap; Rigid LIM; Rigid Z						
	1(HYD)	-63	339	-5747	0	0	0
	2(OPE)	582	-3120	-6739	0	0	0
	3(SUS)	2576	782	-7385	0	0	0
	4(OPE)	465	-2494	-6730	0	0	0
	5(SUS)	2576	782	-7385	0	0	0
	6(OPE)	1825	-9791	4179	0	0	0
	7(SUS)	164	-881	-5051	0	0	0
	8(OPE)	1825	-9791	4179	0	0	0
	9(SUS)	164	-881	-5051	0	0	0
	10(OPE)	-512	6689	-5177	0	0	0
	11(SUS)	6054	1788	-9704	0	0	0
	18(OPE)	3370	-18074	6991	0	0	0
	19(SUS)	666	-3575	-4765	0	0	0
	22(OPE)	57	-307	-4041	0	0	0
	23(SUS)	-37	197	-4736	0	0	0
	MAX	6054/L11	-18074/L18	-9704/L11			
3563	Rigid GUI w/gap; Rigid Z						
	1(HYD)	-133	-49	-8546	0	0	0
	2(OPE)	1571	-1389	-6991	0	0	0
	3(SUS)	2136	396	-7241	0	0	0
	4(OPE)	179	-1982	-6634	0	0	0
	5(SUS)	2136	396	-7241	0	0	0
	6(OPE)	-40	-2274	-7580	0	0	0
	7(SUS)	177	58	-6945	0	0	0
	8(OPE)	-40	-2274	-7580	0	0	0
	9(SUS)	177	58	-6945	0	0	0
	10(OPE)	778	-2250	-7937	0	0	0

	11(SUS)	2258	416	-7654	0	0	0
	18(OPE)	-48	-2320	-7735	0	0	0
	19(SUS)	-193	-120	-6938	0	0	0
	22(OPE)	-9142	-5158	-5767	0	0	0
	23(SUS)	81	737	-6942	0	0	0
	MAX	-9142/L22	-5158/L22	-8546/L1			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	1(HYD)	117	-625	-7719	0	0	0
	2(OPE)	-1851	9929	-8714	0	0	0
	3(SUS)	25	-133	-8435	0	0	0
	4(OPE)	-2528	13560	-8837	0	0	0
	5(SUS)	25	-133	-8435	0	0	0
	6(OPE)	-21514	16859	-8848	0	0	0
	7(SUS)	-123	660	-6475	0	0	0
	8(OPE)	-21514	16859	-8848	0	0	0
	9(SUS)	-123	660	-6475	0	0	0
	10(OPE)	-391	2099	-11589	0	0	0
	11(SUS)	50	-268	-10763	0	0	0
	18(OPE)	-26850	16480	-6907	0	0	0
	19(SUS)	1018	-5459	-6124	0	0	0
	22(OPE)	-942	5054	-6400	0	0	0
	23(SUS)	312	-1674	-6106	0	0	0
	MAX	-26850/L18	16859/L6	-11589/L10			
3655		Rigid -LIM					
	1(HYD)	0	0	0	0	0	0
	2(OPE)	0	0	0	0	0	0
	3(SUS)	0	0	0	0	0	0
	4(OPE)	0	0	0	0	0	0
	5(SUS)	0	0	0	0	0	0
	6(OPE)	0	0	0	0	0	0
	7(SUS)	0	0	0	0	0	0
	8(OPE)	0	0	0	0	0	0
	9(SUS)	0	0	0	0	0	0
	10(OPE)	0	0	0	0	0	0
	11(SUS)	0	0	0	0	0	0
	18(OPE)	0	0	0	0	0	0
	19(SUS)	-2126	11405	0	0	0	0
	22(OPE)	-7107	38118	0	0	0	0
	23(SUS)	-7220	38727	0	0	0	0
	MAX	-7220/L23	38727/L23				
3680		Rigid GUI; Rigid Z					
	1(HYD)	396	-1474	-6719	0	0	0
	2(OPE)	3959	-9445	-7807	0	0	0
	3(SUS)	-2633	-8140	-6258	0	0	0

4(OPE)	2787	-9259	-8019	0	0	0
5(SUS)	-2633	-8140	-6258	0	0	0
6(OPE)	127986	-43177	980	0	0	0
7(SUS)	-4793	339	-3221	0	0	0
8(OPE)	127986	-43177	980	0	0	0
9(SUS)	-4793	339	-3221	0	0	0
10(OPE)	30351	-22021	-11155	0	0	0
11(SUS)	-10266	-14073	-8222	0	0	0
18(OPE)	133485	-42497	3473	0	0	0
19(SUS)	-2335	273	-1106	0	0	0
22(OPE)	1247	-307	-3170	0	0	0
23(SUS)	-2607	269	-1387	0	0	0
MAX	133485/L18	-43177/L6	-11155/L10			
3825	Rigid ANC					
1(HYD)	-747	41	-1048	-5	-92	86
2(OPE)	-1233	-401	8258	50	-153	108
3(SUS)	-604	-728	8709	90	-75	86
4(OPE)	-1115	-442	8268	55	-138	104
5(SUS)	-604	-728	8709	90	-75	86
6(OPE)	-16730	6915	1617	-851	-2059	-919
7(SUS)	-582	-115	8785	14	-72	30
8(OPE)	-16730	6915	1617	-851	-2059	-919
9(SUS)	-582	-115	8785	14	-72	30
10(OPE)	-5920	258	15151	-31	-731	-1133
11(SUS)	-263	-1640	18000	202	-34	88
18(OPE)	-16912	7736	1191	-952	-2081	-701
19(SUS)	-917	135	8783	-17	-113	151
22(OPE)	-1318	372	8340	-46	-163	66
23(SUS)	-860	138	8788	-17	-106	63
MAX	-16912/L18	7736/L18	18000/L11	-952/L18	-2081/L18	-1133/L10
3830	Rigid GUI; Rigid GUI					
1(HYD)	-3612	-9280	0	0	0	0
2(OPE)	-11701	-12946	0	0	0	0
3(SUS)	213	-20422	0	0	0	0
4(OPE)	-9387	-13690	0	0	0	0
5(SUS)	213	-20422	0	0	0	0
6(OPE)	-360771	120521	0	0	0	0
7(SUS)	-1802	-10757	0	0	0	0
8(OPE)	-360771	120521	0	0	0	0
9(SUS)	-1802	-10757	0	0	0	0
10(OPE)	-120068	878	0	0	0	0
11(SUS)	10959	-36939	0	0	0	0
18(OPE)	-372307	133291	0	0	0	0
19(SUS)	-15779	-5989	0	0	0	0

	22(OPE)	-16355	-671	0	0	0	0
	23(SUS)	-7768	-6272	0	0	0	0
	MAX	-372307/L18	133291/L18				
3840		Rigid GUI; Rigid GUI					
	1(HYD)	-3563	5807	0	0	0	0
	2(OPE)	3646	4590	0	0	0	0
	3(SUS)	-1223	13921	0	0	0	0
	4(OPE)	2263	5056	0	0	0	0
	5(SUS)	-1223	13921	0	0	0	0
	6(OPE)	264979	-102219	0	0	0	0
	7(SUS)	-2462	5680	0	0	0	0
	8(OPE)	264979	-102219	0	0	0	0
	9(SUS)	-2462	5680	0	0	0	0
	10(OPE)	104215	-9764	0	0	0	0
	11(SUS)	-4239	25678	0	0	0	0
	18(OPE)	271958	-110025	0	0	0	0
	19(SUS)	13550	7919	0	0	0	0
	22(OPE)	3542	-5705	0	0	0	0
	23(SUS)	786	2561	0	0	0	0
	MAX	271958/L18	-110025/L18				
3920		Rigid GUI; Rigid Z					
	1(HYD)	3662	6474	-16348	0	0	0
	2(OPE)	6157	7580	-13476	0	0	0
	3(SUS)	3353	5383	-12097	0	0	0
	4(OPE)	6146	7563	-13456	0	0	0
	5(SUS)	3353	5383	-12097	0	0	0
	6(OPE)	13634	16389	-30248	0	0	0
	7(SUS)	3285	5249	-11935	0	0	0
	8(OPE)	13634	16389	-30248	0	0	0
	9(SUS)	3285	5249	-11935	0	0	0
	10(OPE)	8820	10078	-20113	0	0	0
	11(SUS)	3802	5773	-12555	0	0	0
	18(OPE)	12184	10461	-31367	0	0	0
	19(SUS)	-1302	-2265	-11916	0	0	0
	22(OPE)	6063	7432	-13303	0	0	0
	23(SUS)	3194	5239	-11926	0	0	0
	MAX	13634/L6	16389/L6	-31367/L18			
4180		Rigid GUI; Rigid Z					
	1(HYD)	-1178	-3198	-16724	0	0	0
	2(OPE)	1584	-1129	-10821	0	0	0
	3(SUS)	-916	-2483	-11746	0	0	0
	4(OPE)	1584	-1128	-10825	0	0	0
	5(SUS)	-916	-2483	-11746	0	0	0
	6(OPE)	6270	12048	8480	0	0	0
	7(SUS)	-906	-2468	-11778	0	0	0

	8(OPE)	6270	12048	8480	0	0	0
	9(SUS)	-906	-2468	-11778	0	0	0
	10(OPE)	1811	4610	-1501	0	0	0
	11(SUS)	-939	-2516	-11650	0	0	0
	18(OPE)	9372	17535	13135	0	0	0
	19(SUS)	472	2470	-7147	0	0	0
	22(OPE)	1597	-1114	-10856	0	0	0
	23(SUS)	-907	-2470	-11781	0	0	0
	MAX	9372/L18	17535/L18	-16724/L1			
4875		Rigid GUI; Rigid Z					
	1(HYD)	2641	108	-29857	0	0	0
	2(OPE)	-6079	-1927	-20515	0	0	0
	3(SUS)	-2787	-1748	-24140	0	0	0
	4(OPE)	-6680	-1930	-20338	0	0	0
	5(SUS)	-2787	-1748	-24140	0	0	0
	6(OPE)	-9324	2504	-28575	0	0	0
	7(SUS)	4393	308	-35448	0	0	0
	8(OPE)	-9324	2504	-28575	0	0	0
	9(SUS)	4393	308	-35448	0	0	0
	10(OPE)	-6838	-4191	-18602	0	0	0
	11(SUS)	-7853	-3864	-22314	0	0	0
	18(OPE)	-11489	5375	-32921	0	0	0
	19(SUS)	5705	533	-38374	0	0	0
	22(OPE)	3835	915	-36078	0	0	0
	23(SUS)	5577	550	-37950	0	0	0
	MAX	-11489/L18	5375/L18	-38374/L19			

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
6	DW+T baking + SL-1	S8 S1	W+P1+T2+0.34D1+SL-1 *(L30+SL-1)* W+P1+SL-1 *(L5+SL-1)*	A
10	DW+NO+SMHV	S9 S2	W+P1+T1+0.73D1+SMHV *(L31+SMHV)* W+P1+SMHV *(L3+SMHV)*	A
11	DW+ T baking + SMHV	S10 S3	W+P1+T2+0.73D1+SMHV *(L32+SMHV)* W+P1+SMHV *(L5+SMHV)*	A

S8

(SUS)COMBINATION # 8

------Forces(N.)-------   -----Moments(N.m.)-----

NODE	FX	FY	FZ	MX	MY	MZ	
70	77008	8463	1130	0	0	0	Rigid GUI
70	1427	7735	33182	0	0	0	Rigid Z
80	44192	22086	704	0	0	0	Rigid GUI
80	2400	13007	38936	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	1098	341	0	0	0	0	Rigid GUI
160	1952	10474	37407	0	0	0	Rigid Z
190	3180	22090	11552	27372	7878	972	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	2819	322	8	0	0	0	Rigid GUI
240	3247	29809	38394	0	0	0	Rigid Z
396	735	711	12207	97	101	944	Rigid ANC
400	0	17159	0	0	0	0	Rigid GUI
400	21788	0	0	0	0	0	Rigid GUI
420	0	18915	0	0	0	0	Rigid GUI
420	19056	0	0	0	0	0	Rigid GUI
600	1359	9018	14	0	0	0	Rigid GUI
600	5420	0	22837	0	0	0	Rigid Z
630	3165	652	13597	0	0	0	Rigid Z
760	4416	1074	35726	0	0	0	Rigid Z
1060	1317	2197	14411	0	0	0	Rigid Z
3120	57595	29418	954	0	0	0	Rigid GUI
3120	649	3478	15360	0	0	0	Rigid Z
3180	23306	2543	339	0	0	0	Rigid GUI
3180	998	5347	16621	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	4013	526	0	0	0	0	Rigid GUI w/gap
3493	864	590	4294	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	1025	5499	0	0	0	0	Rigid LIM
3552	0	0	7806	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	178	1982	7918	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3012	16155	0	0	0	0	Rigid LIM
3602	0	0	9921	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	7094	741	329	0	0	0	Rigid GUI
3680	659	10263	10833	0	0	0	Rigid Z
3825	1544	916	8552	113	191	281	Rigid ANC
3830	0	23531	0	0	0	0	Rigid GUI
3830	18458	0	0	0	0	0	Rigid GUI
3840	0	14373	0	0	0	0	Rigid GUI
3840	12531	0	0	0	0	0	Rigid GUI
3920	2254	10635	23	0	0	0	Rigid GUI
3920	3916	0	16472	0	0	0	Rigid Z
4180	316	3839	3	0	0	0	Rigid GUI
4180	1281	0	13368	0	0	0	Rigid Z

4875	579	3960	0	0	0	0	Rigid GUI
4875	6098	0	25243	0	0	0	Rigid Z

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(SUS)COMBINATION # 9

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	42991	4832	610	0	0	0	Rigid GUI
70	782	4242	19866	0	0	0	Rigid Z
80	25879	12057	368	0	0	0	Rigid GUI
80	1758	9529	31186	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	4622	612	0	0	0	0	Rigid GUI
160	1447	7765	30390	0	0	0	Rigid Z
190	3836	16542	6805	13772	5379	1303	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	6002	672	10	0	0	0	Rigid GUI
240	3478	31933	42313	0	0	0	Rigid Z
396	1004	1276	12792	174	138	1333	Rigid ANC
400	0	35132	0	0	0	0	Rigid GUI
400	35543	0	0	0	0	0	Rigid GUI
420	0	34712	0	0	0	0	Rigid GUI
420	36509	0	0	0	0	0	Rigid GUI
600	1339	14097	14	0	0	0	Rigid GUI
600	5473	0	27650	0	0	0	Rigid Z
630	3201	693	16496	0	0	0	Rigid Z
760	4795	1650	43223	0	0	0	Rigid Z
1060	1379	2232	21518	0	0	0	Rigid Z
3120	25521	12600	400	0	0	0	Rigid GUI
3120	306	1641	8699	0	0	0	Rigid Z
3180	12420	1442	164	0	0	0	Rigid GUI
3180	773	4142	14809	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5458	790	0	0	0	0	Rigid GUI w/gap
3493	1112	397	5661	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	1784	9571	0	0	0	0	Rigid LIM
3552	0	0	9050	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	1570	1389	9749	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	2890	15502	0	0	0	0	Rigid LIM
3602	0	0	11041	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	13860	1327	503	0	0	0	Rigid GUI
3680	762	11865	13646	0	0	0	Rigid Z
3825	2155	1420	8870	175	266	490	Rigid ANC
3830	0	34075	0	0	0	0	Rigid GUI
3830	31178	0	0	0	0	0	Rigid GUI
3840	0	24595	0	0	0	0	Rigid GUI
3840	25695	0	0	0	0	0	Rigid GUI
3920	2242	14177	23	0	0	0	Rigid GUI
3920	3966	0	19979	0	0	0	Rigid Z
4180	292	6950	3	0	0	0	Rigid GUI
4180	1320	0	16286	0	0	0	Rigid Z
4875	578	6285	0	0	0	0	Rigid GUI
4875	5507	0	31051	0	0	0	Rigid Z

S10

(SUS)COMBINATION # 10

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.	)-------		-----Moments(N.m.		)-----	
70	78036	8653	1130	0	0	0	Rigid GUI
70	1441	7812	34699	0	0	0	Rigid Z
80	46156	22448	704	0	0	0	Rigid GUI
80	2424	13135	41458	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	1879	487	0	0	0	0	Rigid GUI
160	1952	10474	39576	0	0	0	Rigid Z
190	3907	23332	14120	28225	8421	1181	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	5988	667	8	0	0	0	Rigid GUI
240	3484	31984	42243	0	0	0	Rigid Z
396	1006	1274	12793	174	138	1335	Rigid ANC
400	0	35055	0	0	0	0	Rigid GUI
400	35609	0	0	0	0	0	Rigid GUI
420	0	34762	0	0	0	0	Rigid GUI
420	36550	0	0	0	0	0	Rigid GUI
600	1341	14101	14	0	0	0	Rigid GUI
600	5471	0	27643	0	0	0	Rigid Z
630	3201	693	16498	0	0	0	Rigid Z
760	4794	1649	43224	0	0	0	Rigid Z
1060	1379	2232	21518	0	0	0	Rigid Z
3120	58488	29585	954	0	0	0	Rigid GUI
3120	661	3543	16622	0	0	0	Rigid Z
3180	24081	2688	339	0	0	0	Rigid GUI
3180	1016	5444	18513	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5388	782	0	0	0	0	Rigid GUI w/gap
3493	864	590	5214	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	1667	8945	0	0	0	0	Rigid LIM
3552	0	0	9041	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	178	1982	9392	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3567	19133	0	0	0	0	Rigid LIM
3602	0	0	11165	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	12686	1101	330	0	0	0	Rigid GUI
3680	764	11906	13685	0	0	0	Rigid Z
3825	2037	1461	8880	180	251	486	Rigid ANC
3830	0	34819	0	0	0	0	Rigid GUI
3830	28862	0	0	0	0	0	Rigid GUI
3840	0	25060	0	0	0	0	Rigid GUI
3840	24310	0	0	0	0	0	Rigid GUI
3920	2237	14159	23	0	0	0	Rigid GUI
3920	3960	0	19958	0	0	0	Rigid Z
4180	291	6949	3	0	0	0	Rigid GUI
4180	1321	0	16290	0	0	0	Rigid Z
4875	579	6288	0	0	0	0	Rigid GUI
4875	6094	0	30871	0	0	0	Rigid Z

S1

(SUS)COMBINATION # 1

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	6097	732	77	0	0	0	Rigid GUI
70	103	562	3379	0	0	0	Rigid Z
80	3295	1127	26	0	0	0	Rigid GUI
80	1063	5764	18302	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	7376	131	0	0	0	0	Rigid GUI
160	225	1210	20690	0	0	0	Rigid Z
190	1934	4423	14284	847	1861	1413	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	6624	1769	594	0	0	0	Rigid GUI
240	2856	26222	39399	0	0	0	Rigid Z
396	578	937	12429	128	80	548	Rigid ANC
400	0	25720	0	0	0	0	Rigid GUI
400	21792	0	0	0	0	0	Rigid GUI
420	0	19324	0	0	0	0	Rigid GUI
420	33062	0	0	0	0	0	Rigid GUI
600	0	4811	0	0	0	0	Rigid GUI
600	211	0	19630	0	0	0	Rigid Z
630	32	1615	14409	0	0	0	Rigid Z
760	362	645	39492	0	0	0	Rigid Z
1060	2719	2400	17754	0	0	0	Rigid Z
3120	8948	1018	122	0	0	0	Rigid GUI
3120	114	611	2678	0	0	0	Rigid Z
3180	777	178	1	0	0	0	Rigid GUI
3180	510	2734	9188	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	2876	392	0	0	0	0	Rigid GUI w/gap
3493	1315	244	5262	0	0	0	Rigid Z
3552	2629	490	0	0	0	0	Rigid GUI w/gap
3552	614	3298	0	0	0	0	Rigid LIM
3552	0	0	8461	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	2135	395	8526	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	508	2730	0	0	0	0	Rigid LIM
3602	0	0	9519	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	7956	1331	472	0	0	0	Rigid GUI
3680	549	8552	9215	0	0	0	Rigid Z
3825	1033	1203	8993	148	128	263	Rigid ANC
3830	0	30234	0	0	0	0	Rigid GUI
3830	9250	0	0	0	0	0	Rigid GUI
3840	0	23177	0	0	0	0	Rigid GUI
3840	11442	0	0	0	0	0	Rigid GUI
3920	1614	8504	16	0	0	0	Rigid GUI
3920	1769	0	15094	0	0	0	Rigid Z
4180	394	5267	4	0	0	0	Rigid GUI
4180	549	0	14360	0	0	0	Rigid Z
4875	524	3776	0	0	0	0	Rigid GUI
4875	2262	0	29056	0	0	0	Rigid Z

S2, S3

(SUS)COMBINATION # 2

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	7125	922	77	0	0	0	Rigid GUI
70	117	638	4896	0	0	0	Rigid Z
80	5260	1490	26	0	0	0	Rigid GUI
80	1087	5891	20824	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	8157	276	0	0	0	0	Rigid GUI
160	225	1210	22858	0	0	0	Rigid Z
190	2661	5664	16853	1699	2403	1623	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	9794	2114	594	0	0	0	Rigid GUI
240	3094	28404	43246	0	0	0	Rigid Z
396	849	1499	13015	205	116	938	Rigid ANC
400	0	43546	0	0	0	0	Rigid GUI
400	35613	0	0	0	0	0	Rigid GUI
420	0	35265	0	0	0	0	Rigid GUI
420	50547	0	0	0	0	0	Rigid GUI
600	0	9956	0	0	0	0	Rigid GUI
600	263	0	24439	0	0	0	Rigid Z
630	62	1615	17262	0	0	0	Rigid Z
760	362	724	47334	0	0	0	Rigid Z
1060	2788	2400	24769	0	0	0	Rigid Z
3120	9841	1185	122	0	0	0	Rigid GUI
3120	126	675	3940	0	0	0	Rigid Z
3180	1552	323	1	0	0	0	Rigid GUI
3180	528	2831	11080	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	4252	649	0	0	0	0	Rigid GUI w/gap
3493	1315	244	6182	0	0	0	Rigid Z
3552	2629	490	0	0	0	0	Rigid GUI w/gap
3552	1257	6746	0	0	0	0	Rigid LIM
3552	0	0	9696	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	2135	395	9999	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1064	5709	0	0	0	0	Rigid LIM
3602	0	0	10763	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	13539	1689	472	0	0	0	Rigid GUI
3680	654	10193	12067	0	0	0	Rigid Z
3825	1525	1747	9320	215	188	466	Rigid ANC
3830	0	41490	0	0	0	0	Rigid GUI
3830	19617	0	0	0	0	0	Rigid GUI
3840	0	33795	0	0	0	0	Rigid GUI
3840	23165	0	0	0	0	0	Rigid GUI
3920	1614	12084	16	0	0	0	Rigid GUI
3920	1806	0	18552	0	0	0	Rigid Z
4180	394	8460	4	0	0	0	Rigid GUI
4180	581	0	17355	0	0	0	Rigid Z
4875	524	6104	0	0	0	0	Rigid GUI
4875	2262	0	34695	0	0	0	Rigid Z

II) Service Level B

Part 1 of 1: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
--	DW+NO+SL-3	S16 S15	W+P1+T1+1.5D1+SL-3 *(L62+SL-3)* W+P1+SL-3 *(L3+SL-3)*	B

S16

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	44160	5048	610	0	0	0	Rigid GUI
70	803	4356	22126	0	0	0	Rigid Z
80	28210	12487	368	0	0	0	Rigid GUI
80	1789	9696	34494	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	5408	759	0	0	0	0	Rigid GUI
160	1447	7765	33758	0	0	0	Rigid Z
190	4377	17262	10553	14729	5877	1537	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	9703	1075	10	0	0	0	Rigid GUI
240	3771	34623	47082	0	0	0	Rigid Z
396	1327	1929	13477	264	182	1772	Rigid ANC
400	0	55929	0	0	0	0	Rigid GUI
400	51954	0	0	0	0	0	Rigid GUI
420	0	52750	0	0	0	0	Rigid GUI
420	57067	0	0	0	0	0	Rigid GUI
600	1301	19258	13	0	0	0	Rigid GUI
600	5533	0	33398	0	0	0	Rigid Z
630	3255	772	20706	0	0	0	Rigid Z
760	5531	2730	51908	0	0	0	Rigid Z
1060	1432	2306	29816	0	0	0	Rigid Z
3120	26488	12780	400	0	0	0	Rigid GUI
3120	322	1727	10372	0	0	0	Rigid Z
3180	13186	1585	164	0	0	0	Rigid GUI
3180	796	4263	17165	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	6750	1031	0	0	0	0	Rigid GUI w/gap
3493	1112	397	7132	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2499	13405	0	0	0	0	Rigid LIM
3552	0	0	10813	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	1570	1389	11698	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3485	18692	0	0	0	0	Rigid LIM
3602	0	0	12824	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	20547	1759	506	0	0	0	Rigid GUI
3680	892	13897	17175	0	0	0	Rigid Z
3825	2776	2075	9253	255	342	726	Rigid ANC
3830	0	47573	0	0	0	0	Rigid GUI
3830	44060	0	0	0	0	0	Rigid GUI
3840	0	37300	0	0	0	0	Rigid GUI
3840	39725	0	0	0	0	0	Rigid GUI
3920	2209	18143	23	0	0	0	Rigid GUI
3920	4026	0	24178	0	0	0	Rigid Z
4180	242	10366	2	0	0	0	Rigid GUI
4180	1376	0	19807	0	0	0	Rigid Z
4875	579	9071	0	0	0	0	Rigid GUI
4875	5513	0	38869	0	0	0	Rigid Z

S15

	Forces(N.)			Moments(N.m.)			
NODE	FX	FY	FZ	MX	MY	MZ	
70	8294	1137	77	0	0	0	Rigid GUI
70	139	753	7156	0	0	0	Rigid Z
80	7591	1920	26	0	0	0	Rigid GUI
80	1118	6059	24131	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	8943	423	0	0	0	0	Rigid GUI
160	225	1210	26225	0	0	0	Rigid Z
190	3202	6385	20599	2656	2900	1855	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	13495	2517	594	0	0	0	Rigid GUI
240	3388	31107	48009	0	0	0	Rigid Z
396	1172	2150	13700	294	160	1375	Rigid ANC
400	0	64207	0	0	0	0	Rigid GUI
400	52006	0	0	0	0	0	Rigid GUI
420	0	53493	0	0	0	0	Rigid GUI
420	71059	0	0	0	0	0	Rigid GUI
600	0	15246	0	0	0	0	Rigid GUI
600	324	0	30194	0	0	0	Rigid Z
630	106	1615	21379	0	0	0	Rigid Z
760	362	819	56699	0	0	0	Rigid Z
1060	2867	2400	32889	0	0	0	Rigid Z
3120	10808	1365	122	0	0	0	Rigid GUI
3120	142	761	5613	0	0	0	Rigid Z
3180	2318	466	1	0	0	0	Rigid GUI
3180	551	2951	13435	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5545	890	0	0	0	0	Rigid GUI w/gap
3493	1315	244	7653	0	0	0	Rigid Z
3552	2629	490	0	0	0	0	Rigid GUI w/gap
3552	1973	10582	0	0	0	0	Rigid LIM
3552	0	0	11459	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	2135	395	11949	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1659	8901	0	0	0	0	Rigid LIM
3602	0	0	12546	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	20210	2118	472	0	0	0	Rigid GUI
3680	785	12223	15594	0	0	0	Rigid Z
3825	2145	2402	9703	296	264	700	Rigid ANC
3830	0	54924	0	0	0	0	Rigid GUI
3830	32422	0	0	0	0	0	Rigid GUI
3840	0	46361	0	0	0	0	Rigid GUI
3840	37081	0	0	0	0	0	Rigid GUI
3920	1614	16161	16	0	0	0	Rigid GUI
3920	1849	0	22694	0	0	0	Rigid Z
4180	394	12040	4	0	0	0	Rigid GUI
4180	620	0	21022	0	0	0	Rigid Z
4875	524	8887	0	0	0	0	Rigid GUI
4875	2262	0	42532	0	0	0	Rigid Z

III) Service Level C

Part 1 of 2: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
12	DW+VVICE IV	L12	W+P4+T3	C
		L13	W+P4	
14	DW+VVICE V	L14	W+P4+T3	C
		L15	W+P4	
16	DW+FIRE	L16	W+P1+T5	C
		L17	W+P1	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	12(OPE)	-93029	17444	32318	0	0	0
	13(SUS)	332	-1206	-5695	0	0	0
	14(OPE)	-93029	17444	32318	0	0	0
	15(SUS)	332	-1206	-5695	0	0	0
	16(OPE)	-122870	25295	52240	0	0	0
	17(SUS)	-5293	1062	2135	0	0	0
	MAX	-122870/L16	25295/L16	52240/L16			
80		Rigid GUI; Rigid Z					
	12(OPE)	51422	40961	-37123	0	0	0
	13(SUS)	829	-1109	-12321	0	0	0
	14(OPE)	51422	40961	-37123	0	0	0
	15(SUS)	829	-1109	-12321	0	0	0
	16(OPE)	64975	52388	-48549	0	0	0
	17(SUS)	540	6465	-16078	0	0	0
	MAX	64975/L16	52388/L16	-48549/L16			
151		Rigid +LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	1869	-10027	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	1869	-10027	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	1869/L13	-10027/L13				
160		Rigid GUI; Rigid Z					
	12(OPE)	-6750	-32867	-90917	0	0	0

	13(SUS)	-1225	577	-12888	0	0	0
	14(OPE)	-6750	-32867	-90917	0	0	0
	15(SUS)	-1225	577	-12888	0	0	0
	16(OPE)	-3774	-7390	-16847	0	0	0
	17(SUS)	6920	-1214	-18801	0	0	0
	MAX	6920/L17	-32867/L12	-90917/L12			
190	Rigid ANC						
	12(OPE)	-8524	40497	86064	-97455	-24113	3302
	13(SUS)	1795	-474	-11347	-387	-1242	-745
	14(OPE)	-8524	40497	86064	-97455	-24113	3302
	15(SUS)	1795	-474	-11347	-387	-1242	-745
	16(OPE)	-6811	16905	-473	-5651	-6583	2975
	17(SUS)	-1300	3340	-12044	104	-1389	-1231
	MAX	-8524/L12	40497/L12	86064/L12	-97455/L12	-24113/L12	3302/L12
201	Rigid -LIM						
	12(OPE)	0	0	0	0	0	0
	13(SUS)	-5082	27262	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	-5082	27262	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	-5082/L13	27262/L13				
240	Rigid GUI; Rigid Z						
	12(OPE)	46722	-30019	-16086	0	0	0
	13(SUS)	-4863	-6431	-32442	0	0	0
	14(OPE)	46722	-30019	-16086	0	0	0
	15(SUS)	-4863	-6431	-32442	0	0	0
	16(OPE)	31372	-38714	-29159	0	0	0
	17(SUS)	-1211	-25789	-35452	0	0	0
	MAX	46722/L12	-38714/L16	-35452/L17			
396	Rigid ANC						
	12(OPE)	-3913	4353	7193	-595	-534	2299
	13(SUS)	-275	-369	11698	50	-39	50
	14(OPE)	-3913	4353	7193	-595	-534	2299
	15(SUS)	-275	-369	11698	50	-39	50
	16(OPE)	-2779	430	10041	-58	-380	1135
	17(SUS)	-343	-447	11918	61	-48	209
	MAX	-3913/L12	4353/L12	11918/L17	-595/L12	-534/L12	2299/L12
400	Rigid GUI; Rigid GUI						
	12(OPE)	-158437	123799	0	0	0	0

	13(SUS)	-8035	-9549	0	0	0	0
	14(OPE)	-158437	123799	0	0	0	0
	15(SUS)	-8035	-9549	0	0	0	0
	16(OPE)	-98907	4730	0	0	0	0
	17(SUS)	-9744	-10179	0	0	0	0
	MAX	-158437/L12	123799/L12				
420		Rigid GUI; Rigid GUI					
	12(OPE)	83058	-98450	0	0	0	0
	13(SUS)	13142	2927	0	0	0	0
	14(OPE)	83058	-98450	0	0	0	0
	15(SUS)	13142	2927	0	0	0	0
	16(OPE)	46323	-4002	0	0	0	0
	17(SUS)	17818	5427	0	0	0	0
	MAX	83058/L12	-98450/L12				
600		Rigid GUI; Rigid Z					
	12(OPE)	23518	16182	-64785	0	0	0
	13(SUS)	1201	-49	-16973	0	0	0
	14(OPE)	23518	16182	-64785	0	0	0
	15(SUS)	1201	-49	-16973	0	0	0
	16(OPE)	16197	11150	-44613	0	0	0
	17(SUS)	-167	-326	-15439	0	0	0
	MAX	23518/L12	16182/L12	-64785/L12			
630		Rigid Z					
	12(OPE)	1676	-298	5465	0	0	0
	13(SUS)	1075	1544	-11514	0	0	0
	14(OPE)	1676	-298	5465	0	0	0
	15(SUS)	1075	1544	-11514	0	0	0
	16(OPE)	457	-80	-1607	0	0	0
	17(SUS)	-5	1615	-11922	0	0	0
	MAX	1676/L12	1615/L17	-11922/L17			
760		Rigid Z					
	12(OPE)	4437	-534	14842	0	0	0
	13(SUS)	368	593	-32496	0	0	0
	14(OPE)	4437	-534	14842	0	0	0
	15(SUS)	368	593	-32496	0	0	0
	16(OPE)	4183	-445	13977	0	0	0
	17(SUS)	362	576	-32655	0	0	0
	MAX	4437/L12	593/L13	-32655/L17			
1060		Rigid Z					
	12(OPE)	7723	-11220	44523	0	0	0
	13(SUS)	-2696	-2407	-11738	0	0	0
	14(OPE)	7723	-11220	44523	0	0	0
	15(SUS)	-2696	-2407	-11738	0	0	0

	16(OPE)	8042	-11614	46170	0	0	0
	17(SUS)	-2660	-2401	-11639	0	0	0
	MAX	8042/L16	-11614/L16	46170/L16			
3120		Rigid GUI; Rigid Z					
	12(OPE)	89073	50640	19555	0	0	0
	13(SUS)	187	-241	-2415	0	0	0
	14(OPE)	89073	50640	19555	0	0	0
	15(SUS)	187	-241	-2415	0	0	0
	16(OPE)	98470	57101	25872	0	0	0
	17(SUS)	-8273	1428	-1456	0	0	0
	MAX	98470/L16	57101/L16	25872/L16			
3180		Rigid GUI; Rigid Z					
	12(OPE)	-30552	8966	-16108	0	0	0
	13(SUS)	128	-36	-7151	0	0	0
	14(OPE)	-30552	8966	-16108	0	0	0
	15(SUS)	128	-36	-7151	0	0	0
	16(OPE)	-38980	10917	-19034	0	0	0
	17(SUS)	-393	2703	-7537	0	0	0
	MAX	-38980/L16	10917/L16	-19034/L16			
3360		Rigid +LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	706	-3785	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	706	-3785	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	706/L13	-3785/L13				
3493		Rigid GUI w/gap; Rigid Z					
	12(OPE)	242	-709	-2496	0	0	0
	13(SUS)	-329	58	-4520	0	0	0
	14(OPE)	242	-709	-2496	0	0	0
	15(SUS)	-329	58	-4520	0	0	0
	16(OPE)	229	-625	-2219	0	0	0
	17(SUS)	2992	413	-4460	0	0	0
	MAX	2992/L17	-709/L12	-4520/L13			
3552		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	12(OPE)	2795	-14992	5093	0	0	0
	13(SUS)	-161	861	-4736	0	0	0
	14(OPE)	2795	-14992	5093	0	0	0
	15(SUS)	-161	861	-4736	0	0	0
	16(OPE)	-5874	31504	1376	0	0	0
	17(SUS)	2576	782	-7385	0	0	0

	MAX	-5874/L16	31504/L16	-7385/L17			
3563		Rigid GUI w/gap; Rigid Z					
	12(OPE)	-46	-2245	-7486	0	0	0
	13(SUS)	-219	-6	-6942	0	0	0
	14(OPE)	-46	-2245	-7486	0	0	0
	15(SUS)	-219	-6	-6942	0	0	0
	16(OPE)	-9520	-7124	-7600	0	0	0
	17(SUS)	2136	396	-7241	0	0	0
	MAX	-9520/L16	-7124/L16	-7600/L16			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	12(OPE)	-25530	21647	-8267	0	0	0
	13(SUS)	188	-1010	-6106	0	0	0
	14(OPE)	-25530	21647	-8267	0	0	0
	15(SUS)	188	-1010	-6106	0	0	0
	16(OPE)	3040	-16306	-10478	0	0	0
	17(SUS)	25	-133	-8435	0	0	0
	MAX	-25530/L12	21647/L12	-10478/L16			
3655		Rigid -LIM					
	12(OPE)	0	0	0	0	0	0
	13(SUS)	-423	2271	0	0	0	0
	14(OPE)	0	0	0	0	0	0
	15(SUS)	-423	2271	0	0	0	0
	16(OPE)	0	0	0	0	0	0
	17(SUS)	0	0	0	0	0	0
	MAX	-423/L13	2271/L13				
3680		Rigid GUI; Rigid Z					
	12(OPE)	135283	-44243	2385	0	0	0
	13(SUS)	-2607	269	-1387	0	0	0
	14(OPE)	135283	-44243	2385	0	0	0
	15(SUS)	-2607	269	-1387	0	0	0
	16(OPE)	100895	-38276	-3323	0	0	0
	17(SUS)	-2633	-8140	-6258	0	0	0
	MAX	135283/L12	-44243/L12	-6258/L17			
3825		Rigid ANC					
	12(OPE)	-17424	7569	1330	-931	-2144	-758
	13(SUS)	-860	138	8788	-17	-106	63
	14(OPE)	-17424	7569	1330	-931	-2144	-758
	15(SUS)	-860	138	8788	-17	-106	63
	16(OPE)	-14176	4591	2417	-564	-1746	-1621
	17(SUS)	-604	-728	8709	90	-75	86

	MAX	-17424/L12	7569/L12	8788/L13	-931/L12	-2144/L12	-1621/L16
3830		Rigid GUI; Rigid GUI					
	12(OPE)	-376131	130828	0	0	0	0
	13(SUS)	-7768	-6272	0	0	0	0
	14(OPE)	-376131	130828	0	0	0	0
	15(SUS)	-7768	-6272	0	0	0	0
	16(OPE)	-306311	82889	0	0	0	0
	17(SUS)	213	-20422	0	0	0	0
	MAX	-376131/L12	130828/L12				
3840		Rigid GUI; Rigid GUI					
	12(OPE)	272977	-109593	0	0	0	0
	13(SUS)	786	2561	0	0	0	0
	14(OPE)	272977	-109593	0	0	0	0
	15(SUS)	786	2561	0	0	0	0
	16(OPE)	238814	-74464	0	0	0	0
	17(SUS)	-1223	13921	0	0	0	0
	MAX	272977/L12	-109593/L12				
3920		Rigid GUI; Rigid Z					
	12(OPE)	13917	16750	-30855	0	0	0
	13(SUS)	3194	5239	-11926	0	0	0
	14(OPE)	13917	16750	-30855	0	0	0
	15(SUS)	3194	5239	-11926	0	0	0
	16(OPE)	12243	13917	-27993	0	0	0
	17(SUS)	3353	5383	-12097	0	0	0
	MAX	13917/L12	16750/L12	-30855/L12			
4180		Rigid GUI; Rigid Z					
	12(OPE)	6299	12020	8601	0	0	0
	13(SUS)	-907	-2470	-11781	0	0	0
	14(OPE)	6299	12020	8601	0	0	0
	15(SUS)	-907	-2470	-11781	0	0	0
	16(OPE)	6288	12372	8227	0	0	0
	17(SUS)	-916	-2483	-11746	0	0	0
	MAX	6299/L12	12372/L16	-11781/L13			
4875		Rigid GUI; Rigid Z					
	12(OPE)	-10621	3864	-31540	0	0	0
	13(SUS)	5577	550	-37950	0	0	0
	14(OPE)	-10621	3864	-31540	0	0	0
	15(SUS)	5577	550	-37950	0	0	0
	16(OPE)	-6500	-1949	-19718	0	0	0
	17(SUS)	-2787	-1748	-24140	0	0	0
	MAX	-10621/L12	3864/L12	-37950/L13			

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
13	DW+ NO+SL-2	S11 S4	W+P1+T1+D1+SL-2 *(L33+SL-2)* W+P1+SL-2 *(L3+SL-2)*	C
15	DW+T baking + SL-2	S12 S5	W+P1+T2+D1+SL-2 *(L34+SL-2)* W+P1+SL-2 *(L5+SL-2)*	C
16	DW+FIRE+SL-2	S13 S6	W+P1+T5+D1+SL-2 *(L35+SL-2)* W+P1+SL-2 *(L17+SL-2)*	C
19	DW+VVICE V+SL-3	S14 S7	W+P4+T3+1.5D1+SL-3 *(L36+SL-3)* W+P4+SL-3 *(L15+SL-3)*	C

S11

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  (SUS)COMBINATION # 11
         ------Forces(N. )-------      -----Moments(N.m.  )-----
 NODE      FX       FY       FZ          MX       MY       MZ
   70   43702     4963      610           0        0        0   Rigid GUI
   70     792     4295    20917           0        0        0   Rigid Z
   80   27239    12308      368           0        0        0   Rigid GUI
   80    1775     9617    32932           0        0        0   Rigid Z
  151       0        0        0           0        0        0   Rigid +LIM
  160    5164      713        0           0        0        0   Rigid GUI
  160    1447     7765    31891           0        0        0   Rigid Z
  190    4340    17402     8584       14363     5755     1448   Rigid ANC
  201       0        0        0           0        0        0   Rigid -LIM
  240    8196      911       10           0        0        0   Rigid GUI
  240    3642    33439    44978           0        0        0   Rigid Z
  396    1192     1666    13197         227      163     1604   Rigid ANC
  400       0    47521        0           0        0        0   Rigid GUI
  400   45116        0        0           0        0        0   Rigid GUI
  420       0    45682        0           0        0        0   Rigid GUI
  420   48626        0        0           0        0        0   Rigid GUI
  600    1326    17615       14           0        0        0   Rigid GUI
  600    5509        0    30977           0        0        0   Rigid Z
  630    3226      721    18504           0        0        0   Rigid Z
  760    5055     2050    48414           0        0        0   Rigid Z
 1060    1419     2257    26438           0        0        0   Rigid Z
 3120   26140    12715      400           0        0        0   Rigid GUI
 3120     315     1686     9573           0        0        0   Rigid Z
 3180   12956     1542      164           0        0        0   Rigid GUI
 3180     786     4209    16119           0        0        0   Rigid Z
 3360       0        0        0           0        0        0   Rigid +LIM
 3493    6411      967        0           0        0        0   Rigid GUI w/gap
 3493    1112      397     6299           0        0        0   Rigid Z
 3552       0        0        0           0        0        0   Rigid GUI w/gap
 3552    2229    11958        0           0        0        0   Rigid LIM
 3552       0        0     9905           0        0        0   Rigid Z
 3563       0        0        0           0        0        0   Rigid GUI w/gap
 3563    1570     1389    10769           0        0        0   Rigid Z
 3602       0        0        0           0        0        0   Rigid GUI w/gap
 3602    3274    17563        0           0        0        0   Rigid LIM
 3602       0        0    11902           0        0        0   Rigid Z
 3655       0        0        0           0        0        0   Rigid -LIM
 3680   17731     1576      504           0        0        0   Rigid GUI
 3680     835    13002    15621           0        0        0   Rigid Z
 3825    2497     1797     9097         221      308      632   Rigid ANC
 3830       0    41890        0           0        0        0   Rigid GUI
 3830   38382        0        0           0        0        0   Rigid GUI
 3840       0    31994        0           0        0        0   Rigid GUI
 3840   33850        0        0           0        0        0   Rigid GUI
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3920	2230	16617	23	0	0	0	Rigid GUI
3920	3997	0	22393	0	0	0	Rigid Z
4180	274	9104	2	0	0	0	Rigid GUI
4180	1348	0	18308	0	0	0	Rigid Z
4875	578	7897	0	0	0	0	Rigid GUI
4875	5509	0	34949	0	0	0	Rigid Z

S12

(SUS)COMBINATION # 12

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	78748	8784	1130	0	0	0	Rigid GUI
70	1451	7865	35749	0	0	0	Rigid Z
80	47516	22699	704	0	0	0	Rigid GUI
80	2440	13223	43204	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	2420	588	0	0	0	0	Rigid GUI
160	1952	10474	41077	0	0	0	Rigid Z
190	4410	24192	15899	28816	8796	1327	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	8182	905	8	0	0	0	Rigid GUI
240	3648	33490	44909	0	0	0	Rigid Z
396	1194	1664	13199	227	163	1605	Rigid ANC
400	0	47445	0	0	0	0	Rigid GUI
400	45180	0	0	0	0	0	Rigid GUI
420	0	45732	0	0	0	0	Rigid GUI
420	48666	0	0	0	0	0	Rigid GUI
600	1327	17619	14	0	0	0	Rigid GUI
600	5507	0	30970	0	0	0	Rigid Z
630	3226	721	18505	0	0	0	Rigid Z
760	5054	2049	48415	0	0	0	Rigid Z
1060	1419	2257	26437	0	0	0	Rigid Z
3120	59107	29701	954	0	0	0	Rigid GUI
3120	670	3587	17495	0	0	0	Rigid Z
3180	24618	2788	339	0	0	0	Rigid GUI
3180	1029	5511	19823	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	6341	960	0	0	0	0	Rigid GUI w/gap
3493	864	590	5851	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2112	11332	0	0	0	0	Rigid LIM
3552	0	0	9896	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	178	1982	10412	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	3951	21194	0	0	0	0	Rigid LIM
3602	0	0	12026	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	16557	1351	331	0	0	0	Rigid GUI
3680	837	13043	15660	0	0	0	Rigid Z
3825	2378	1838	9106	226	293	628	Rigid ANC
3830	0	42634	0	0	0	0	Rigid GUI
3830	36066	0	0	0	0	0	Rigid GUI
3840	0	32459	0	0	0	0	Rigid GUI
3840	32465	0	0	0	0	0	Rigid GUI
3920	2225	16599	23	0	0	0	Rigid GUI
3920	3991	0	22372	0	0	0	Rigid Z
4180	274	9102	2	0	0	0	Rigid GUI
4180	1349	0	18312	0	0	0	Rigid Z
4875	579	7900	0	0	0	0	Rigid GUI
4875	6091	0	34767	0	0	0	Rigid Z

S13

(SUS)COMBINATION # 13

	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	123265	13638	1792	0	0	0	Rigid GUI
70	2277	12339	54337	0	0	0	Rigid Z
80	73229	35877	1131	0	0	0	Rigid GUI
80	3278	17766	56146	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	6704	2795	0	0	0	0	Rigid GUI
160	926	4968	22406	0	0	0	Rigid Z
190	8679	20091	7042	7828	7964	3514	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	35715	4952	4012	0	0	0	Rigid GUI
240	4387	40276	43070	0	0	0	Rigid Z
396	3474	1885	11539	256	474	2117	Rigid ANC
400	0	51141	0	0	0	0	Rigid GUI
400	134451	0	0	0	0	0	Rigid GUI
420	0	45750	0	0	0	0	Rigid GUI
420	91351	0	0	0	0	0	Rigid GUI
600	3520	24928	37	0	0	0	Rigid GUI
600	12994	0	56940	0	0	0	Rigid Z
630	550	79	8976	0	0	0	Rigid Z
760	4396	601	34784	0	0	0	Rigid Z
1060	8439	11461	64143	0	0	0	Rigid Z
3120	101845	51720	1672	0	0	0	Rigid GUI
3120	1115	5973	27435	0	0	0	Rigid Z
3180	39679	4397	566	0	0	0	Rigid GUI
3180	1333	7138	24451	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	3528	657	0	0	0	0	Rigid GUI w/gap
3493	229	624	4578	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	7522	40349	0	0	0	0	Rigid LIM
3552	0	0	4542	0	0	0	Rigid Z
3563	9408	4847	0	0	0	0	Rigid GUI w/gap
3563	112	2277	11379	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	4465	23949	0	0	0	0	Rigid LIM
3602	0	0	13668	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	114004	20102	14728	0	0	0	Rigid GUI
3680	1496	23306	25360	0	0	0	Rigid Z
3825	15439	5985	3256	736	1901	2135	Rigid ANC
3830	0	111673	0	0	0	0	Rigid GUI
3830	332889	0	0	0	0	0	Rigid GUI
3840	0	101596	0	0	0	0	Rigid GUI
3840	268764	0	0	0	0	0	Rigid GUI
3920	4125	22932	43	0	0	0	Rigid GUI
3920	8185	0	36902	0	0	0	Rigid Z
4180	3795	20839	40	0	0	0	Rigid GUI
4180	2716	0	16127	0	0	0	Rigid Z
4875	582	7908	0	0	0	0	Rigid GUI
4875	5911	0	34164	0	0	0	Rigid Z

S14

(SUS)COMBINATION # 14

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	94746	10563	1361	0	0	0	Rigid GUI
70	1422	7709	36055	0	0	0	Rigid Z
80	59892	28724	894	0	0	0	Rigid GUI
80	2537	13751	46044	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	13998	6473	0	0	0	0	Rigid GUI
160	4998	26813	98342	0	0	0	Rigid Z
190	10435	43534	94641	99997	25606	3932	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	53674	7542	6405	0	0	0	Rigid GUI
240	3303	30330	34506	0	0	0	Rigid Z
396	4732	6055	8980	827	645	3428	Rigid ANC
400	0	178133	0	0	0	0	Rigid GUI
400	200391	0	0	0	0	0	Rigid GUI
420	0	147262	0	0	0	0	Rigid GUI
420	136261	0	0	0	0	0	Rigid GUI
600	5100	31923	54	0	0	0	Rigid GUI
600	18814	0	79458	0	0	0	Rigid Z
630	1746	276	14811	0	0	0	Rigid Z
760	4758	700	39933	0	0	0	Rigid Z
1060	8254	10995	65749	0	0	0	Rigid Z
3120	92521	46802	1510	0	0	0	Rigid GUI
3120	847	4537	22079	0	0	0	Rigid Z
3180	31681	3561	442	0	0	0	Rigid GUI
3180	1143	6119	22447	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	3868	721	0	0	0	0	Rigid GUI w/gap
3493	241	708	5689	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	4713	25281	0	0	0	0	Rigid LIM
3552	0	0	9162	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	45	2244	12192	0	0	0	Rigid Z
3602	20775	3873	0	0	0	0	Rigid GUI w/gap
3602	6392	34287	0	0	0	0	Rigid LIM
3602	0	0	12378	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	151300	26919	19823	0	0	0	Rigid GUI
3680	1510	23525	26274	0	0	0	Rigid Z
3825	18971	9243	2327	1137	2334	1361	Rigid ANC
3830	0	165303	0	0	0	0	Rigid GUI
3830	408399	0	0	0	0	0	Rigid GUI
3840	0	141953	0	0	0	0	Rigid GUI
3840	308710	0	0	0	0	0	Rigid GUI
3920	4951	27283	51	0	0	0	Rigid GUI
3920	9038	0	41541	0	0	0	Rigid Z
4180	3731	21994	40	0	0	0	Rigid GUI
4180	2877	0	18183	0	0	0	Rigid Z
4875	1156	10995	0	0	0	0	Rigid GUI
4875	9449	0	49890	0	0	0	Rigid Z

S4, S5, S6

(SUS)COMBINATION # 4

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	7837	1053	77	0	0	0	Rigid GUI
70	127	692	5946	0	0	0	Rigid Z
80	6619	1740	26	0	0	0	Rigid GUI
80	1103	5980	22570	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	8699	377	0	0	0	0	Rigid GUI
160	225	1210	24359	0	0	0	Rigid Z
190	3164	6524	18631	2289	2778	1768	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	11988	2353	594	0	0	0	Rigid GUI
240	3258	29915	45908	0	0	0	Rigid Z
396	1037	1888	13421	258	142	1208	Rigid ANC
400	0	55887	0	0	0	0	Rigid GUI
400	45181	0	0	0	0	0	Rigid GUI
420	0	46301	0	0	0	0	Rigid GUI
420	62653	0	0	0	0	0	Rigid GUI
600	0	13518	0	0	0	0	Rigid GUI
600	298	0	27768	0	0	0	Rigid Z
630	83	1615	19237	0	0	0	Rigid Z
760	362	779	52764	0	0	0	Rigid Z
1060	2835	2400	29626	0	0	0	Rigid Z
3120	10460	1300	122	0	0	0	Rigid GUI
3120	134	720	4814	0	0	0	Rigid Z
3180	2089	423	1	0	0	0	Rigid GUI
3180	541	2898	12389	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	5205	826	0	0	0	0	Rigid GUI w/gap
3493	1315	244	6820	0	0	0	Rigid Z
3552	2629	490	0	0	0	0	Rigid GUI w/gap
3552	1702	9133	0	0	0	0	Rigid LIM
3552	0	0	10551	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	2135	395	11020	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1448	7771	0	0	0	0	Rigid LIM
3602	0	0	11624	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	17404	1937	472	0	0	0	Rigid GUI
3680	727	11329	14040	0	0	0	Rigid Z
3825	1866	2124	9547	261	230	607	Rigid ANC
3830	0	49283	0	0	0	0	Rigid GUI
3830	26794	0	0	0	0	0	Rigid GUI
3840	0	41146	0	0	0	0	Rigid GUI
3840	31280	0	0	0	0	0	Rigid GUI
3920	1614	14563	16	0	0	0	Rigid GUI
3920	1830	0	20945	0	0	0	Rigid Z
4180	394	10671	4	0	0	0	Rigid GUI
4180	603	0	19429	0	0	0	Rigid Z
4875	524	7715	0	0	0	0	Rigid GUI
4875	2262	0	38600	0	0	0	Rigid Z

S7

(SUS)COMBINATION # 7

NODE	------Forces(N.)------- FX	FY	FZ	-----Moments(N.m.)----- MX	MY	MZ	
70	3204	583	1	0	0	0	Rigid GUI
70	267	1451	10792	0	0	0	Rigid Z
80	6644	1178	9	0	0	0	Rigid GUI
80	266	1446	20338	0	0	0	Rigid Z
151	1869	10026	0	0	0	0	Rigid +LIM
160	3389	541	0	0	0	0	Rigid GUI
160	84	454	20313	0	0	0	Rigid Z
190	3697	3518	19902	2939	2753	1369	Rigid ANC
201	5082	27261	0	0	0	0	Rigid -LIM
240	15289	1883	822	0	0	0	Rigid GUI
240	1530	14051	43582	0	0	0	Rigid Z
396	1104	2072	13479	283	151	1216	Rigid ANC
400	0	63577	0	0	0	0	Rigid GUI
400	50298	0	0	0	0	0	Rigid GUI
420	0	50993	0	0	0	0	Rigid GUI
420	66383	0	0	0	0	0	Rigid GUI
600	14	14970	0	0	0	0	Rigid GUI
600	1344	0	31728	0	0	0	Rigid Z
630	1176	1543	20972	0	0	0	Rigid Z
760	367	836	56540	0	0	0	Rigid Z
1060	2904	2406	32989	0	0	0	Rigid Z
3120	2784	508	2	0	0	0	Rigid GUI
3120	80	431	6448	0	0	0	Rigid Z
3180	2339	427	1	0	0	0	Rigid GUI
3180	60	324	13045	0	0	0	Rigid Z
3360	705	3785	0	0	0	0	Rigid +LIM
3493	3868	721	0	0	0	0	Rigid GUI w/gap
3493	328	57	7713	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	2079	11151	0	0	0	0	Rigid LIM
3552	0	0	8810	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	218	5	11649	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	1823	9778	0	0	0	0	Rigid LIM
3602	0	0	10217	0	0	0	Rigid Z
3655	423	2271	0	0	0	0	Rigid -LIM
3680	19742	1604	387	0	0	0	Rigid GUI
3680	342	5337	9863	0	0	0	Rigid Z
3825	2402	1811	9782	223	295	678	Rigid ANC
3830	0	40774	0	0	0	0	Rigid GUI
3830	39977	0	0	0	0	0	Rigid GUI
3840	0	35002	0	0	0	0	Rigid GUI
3840	36644	0	0	0	0	0	Rigid GUI
3920	1571	16017	16	0	0	0	Rigid GUI
3920	1733	0	22523	0	0	0	Rigid Z
4180	390	12026	4	0	0	0	Rigid GUI
4180	616	0	21057	0	0	0	Rigid Z
4875	165	7690	0	0	0	0	Rigid GUI
4875	5411	0	56342	0	0	0	Rigid Z

IV) Service Level D

Part 1 of 3: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L20	W+P5+T3+F2	D
		L21	W+P5+F2	
23	DW+LOCA PC III+ICE II	L28	W+P9+T3	D
		L29	W+P9	

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
70		Rigid GUI; Rigid Z					
	20(OPE)	-93029	17444	32318	0	0	0
	21(SUS)	332	-1206	-5695	0	0	0
	28(OPE)	-99146	20377	42011	0	0	0
	29(SUS)	-5035	940	1731	0	0	0
	MAX	-99146/L28	20377/L28	42011/L28			
80		Rigid GUI; Rigid Z					
	20(OPE)	51422	40961	-37123	0	0	0
	21(SUS)	829	-1109	-12321	0	0	0
	28(OPE)	52065	43230	-42155	0	0	0
	29(SUS)	513	6370	-15868	0	0	0
	MAX	52065/L28	43230/L28	-42155/L28			
151		Rigid +LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	1869	-10027	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	1869/L21	-10027/L21				
160		Rigid GUI; Rigid Z					
	20(OPE)	-6750	-32867	-90917	0	0	0
	21(SUS)	-1225	577	-12888	0	0	0
	28(OPE)	2510	-30502	-98363	0	0	0
	29(SUS)	6505	-1156	-18485	0	0	0
	MAX	-6750/L20	-32867/L20	-98363/L28			
190		Rigid ANC					
	20(OPE)	-8529	40497	86085	-97445	-24105	3305

	21(SUS)	1795	-474	-11349	-388	-1242	-745
	28(OPE)	-10326	36965	82075	-98814	-24243	2426
	29(SUS)	-628	3371	-11012	656	-1374	-1507
	MAX	-10326/L28	40497/L20	86085/L20	-98814/L28	-24243/L28	3305/L20
201		Rigid -LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	-5088	27290	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	-5088/L21	27290/L21				
240		Rigid GUI; Rigid Z					
	20(OPE)	46715	-30084	-16152	0	0	0
	21(SUS)	-4864	-6435	-32461	0	0	0
	28(OPE)	34940	-46539	-35861	0	0	0
	29(SUS)	-7193	-16060	-46088	0	0	0
	MAX	46715/L20	-46539/L28	-46088/L29			
396		Rigid ANC					
	20(OPE)	-3910	4356	7191	-595	-534	2284
	21(SUS)	-274	-368	11698	50	-38	51
	28(OPE)	-3334	1520	21640	-207	-456	1484
	29(SUS)	-328	-859	24228	117	-47	-32
	MAX	-3910/L20	4356/L20	24228/L29	-595/L20	-534/L20	2284/L20
400		Rigid GUI; Rigid GUI					
	20(OPE)	-158605	123907	0	0	0	0
	21(SUS)	-7984	-9480	0	0	0	0
	28(OPE)	-124529	35010	0	0	0	0
	29(SUS)	-7067	-27408	0	0	0	0
	MAX	-158605/L20	123907/L20				
420		Rigid GUI; Rigid GUI					
	20(OPE)	83608	-98512	0	0	0	0
	21(SUS)	13039	2816	0	0	0	0
	28(OPE)	68962	-28973	0	0	0	0
	29(SUS)	16231	14978	0	0	0	0
	MAX	83608/L20	-98512/L20				
600		Rigid GUI; Rigid Z					
	20(OPE)	23539	16232	-64805	0	0	0
	21(SUS)	1102	110	-16988	0	0	0
	28(OPE)	18913	12455	-52676	0	0	0
	29(SUS)	1942	141	-17623	0	0	0

	MAX	23539/L20	16232/L20	-64805/L20			
630		Rigid Z					
	20(OPE)	1717	-303	5597	0	0	0
	21(SUS)	917	560	-11467	0	0	0
	28(OPE)	371	-63	1209	0	0	0
	29(SUS)	1641	1463	-11360	0	0	0
	MAX	1717/L20	1463/L29	-11467/L21			
760		Rigid Z					
	20(OPE)	4357	-475	14559	0	0	0
	21(SUS)	1132	2910	-32555	0	0	0
	28(OPE)	4217	-470	14093	0	0	0
	29(SUS)	404	633	-32414	0	0	0
	MAX	4357/L20	2910/L21	-32555/L21			
1060		Rigid Z					
	20(OPE)	8123	-10660	43746	0	0	0
	21(SUS)	-427	-3536	-12237	0	0	0
	28(OPE)	7848	-11373	45166	0	0	0
	29(SUS)	-2705	-2418	-11784	0	0	0
	MAX	8123/L20	-11373/L28	45166/L28			
3120		Rigid GUI; Rigid Z					
	20(OPE)	89073	50640	19555	0	0	0
	21(SUS)	187	-241	-2415	0	0	0
	28(OPE)	76816	44588	20349	0	0	0
	29(SUS)	-8564	1450	-1427	0	0	0
	MAX	89073/L20	50640/L20	20349/L28			
3180		Rigid GUI; Rigid Z					
	20(OPE)	-30552	8966	-16108	0	0	0
	21(SUS)	128	-36	-7151	0	0	0
	28(OPE)	-31288	9266	-16742	0	0	0
	29(SUS)	-424	2693	-7554	0	0	0
	MAX	-31288/L28	9266/L28	-16742/L28			
3360		Rigid +LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	706	-3785	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	706/L21	-3785/L21				
3493		Rigid GUI w/gap; Rigid Z					
	20(OPE)	241	-707	-2491	0	0	0
	21(SUS)	-331	58	-4517	0	0	0

	28(OPE)	243	-684	-2419	0	0	0
	29(SUS)	3200	442	-4446	0	0	0
	MAX	3200/L29	-707/L20	-4517/L21			
3552		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	20(OPE)	2792	-14975	5038	0	0	0
	21(SUS)	-162	871	-4783	0	0	0
	28(OPE)	-1184	6349	1630	0	0	0
	29(SUS)	2987	756	-7537	0	0	0
	MAX	2987/L29	-14975/L20	-7537/L29			
3563		Rigid GUI w/gap; Rigid Z					
	20(OPE)	-46	-2243	-7479	0	0	0
	21(SUS)	-220	-7	-6935	0	0	0
	28(OPE)	-20	-2379	-7932	0	0	0
	29(SUS)	2137	396	-7246	0	0	0
	MAX	2137/L29	-2379/L28	-7932/L28			
3602		Rigid GUI w/gap; Rigid LIM; Rigid Z					
	20(OPE)	-25566	21628	-8313	0	0	0
	21(SUS)	190	-1020	-6135	0	0	0
	28(OPE)	-8786	2125	-10867	0	0	0
	29(SUS)	9	-48	-8589	0	0	0
	MAX	-25566/L20	21628/L20	-10867/L28			
3655		Rigid -LIM					
	20(OPE)	0	0	0	0	0	0
	21(SUS)	-430	2305	0	0	0	0
	28(OPE)	0	0	0	0	0	0
	29(SUS)	0	0	0	0	0	0
	MAX	-430/L21	2305/L21				
3680		Rigid GUI; Rigid Z					
	20(OPE)	136041	-44033	2841	0	0	0
	21(SUS)	-2159	274	-928	0	0	0
	28(OPE)	101936	-39315	-3980	0	0	0
	29(SUS)	-7079	-7688	-3823	0	0	0
	MAX	136041/L20	-44033/L20	-3980/L28			
3825		Rigid ANC					
	20(OPE)	-17515	7532	1326	-927	-2155	-472
	21(SUS)	-953	133	8779	-16	-118	206
	28(OPE)	-14685	4836	11503	-595	-1809	-1387
	29(SUS)	-878	-828	17971	102	-109	82
	MAX	-17515/L20	7532/L20	17971/L29	-927/L20	-2155/L20	-1387/L28

3830		Rigid GUI; Rigid GUI					
	20(OPE)	-384222	133892	0	0	0	0
	21(SUS)	-20838	-5814	0	0	0	0
	28(OPE)	-314789	84209	0	0	0	0
	29(SUS)	-3604	-23845	0	0	0	0
	MAX	-384222/L20	133892/L20				
3840		Rigid GUI; Rigid GUI					
	20(OPE)	282317	-107810	0	0	0	0
	21(SUS)	21602	11302	0	0	0	0
	28(OPE)	241939	-77411	0	0	0	0
	29(SUS)	1971	15270	0	0	0	0
	MAX	282317/L20	-107810/L20				
3920		Rigid GUI; Rigid Z					
	20(OPE)	11226	7365	-31257	0	0	0
	21(SUS)	-4120	-6994	-11909	0	0	0
	28(OPE)	13178	15655	-29429	0	0	0
	29(SUS)	3888	5823	-12618	0	0	0
	MAX	13178/L28	15655/L28	-31257/L20			
4180		Rigid GUI; Rigid Z					
	20(OPE)	11212	20773	15910	0	0	0
	21(SUS)	1339	5584	-4232	0	0	0
	28(OPE)	6249	12138	8327	0	0	0
	29(SUS)	-942	-2519	-11638	0	0	0
	MAX	11212/L20	20773/L20	15910/L20			
4875		Rigid GUI; Rigid Z					
	20(OPE)	-10666	3774	-31781	0	0	0
	21(SUS)	5787	523	-38645	0	0	0
	28(OPE)	-8447	-455	-27703	0	0	0
	29(SUS)	1425	-1141	-36088	0	0	0
	MAX	-10666/L20	3774/L20	-38645/L21			

Part 2 of 3: Integrity at 30 bar

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
--	Integrity at 30 bar	L60	W+P10+T6	D
		L61	W+P10	

L60

Node	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.	
70	-22399	2442	333	0	0	0	Rigid GUI
70	-1106	5995	-17076	0	0	0	Rigid Z
80	18479	9470	307	0	0	0	Rigid GUI
80	-486	2633	-7501	0	0	0	Rigid Z
151	95007	-509603	0	0	0	0	Rigid +LIM
160	-28400	-14633	0	0	0	0	Rigid GUI
160	1845	-9895	-33551	0	0	0	Rigid Z
190	5050	20634	36864	-51846	-12493	2151	Rigid ANC
201	-112942	605799	0	0	0	0	Rigid -LIM
240	16736	6364	-2576	0	0	0	Rigid GUI
240	410	-3762	-16373	0	0	0	Rigid Z
396	-2043	2697	8843	-369	-279	1039	Rigid ANC
400	0	76489	0	0	0	0	Rigid GUI
400	-86986	0	0	0	0	0	Rigid GUI
420	0	-65320	0	0	0	0	Rigid GUI
420	50444	0	0	0	0	0	Rigid GUI
600	2327	7757	-25	0	0	0	Rigid GUI
600	12661	0	-43914	0	0	0	Rigid Z
630	608	-127	-2153	0	0	0	Rigid Z
760	3590	-442	-12120	0	0	0	Rigid Z
1060	1316	-2551	9418	0	0	0	Rigid Z
3120	51825	26702	871	0	0	0	Rigid GUI
3120	-218	1165	4856	0	0	0	Rigid Z
3180	-12724	1359	191	0	0	0	Rigid GUI
3180	-670	3588	-10205	0	0	0	Rigid Z
3360	44304	-237629	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	-102	-1035	-3468	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	4998	-26808	0	0	0	0	Rigid LIM
3552	0	0	358	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	-701	-1800	-6439	0	0	0	Rigid Z
3602	-15489	-2888	0	0	0	0	Rigid GUI w/gap
3602	-5606	30070	0	0	0	0	Rigid LIM
3602	0	0	-6658	0	0	0	Rigid Z

3655	-47031	252258	0	0	0	0	Rigid -LIM
3680	55099	-10602	8140	0	0	0	Rigid GUI
3680	574	-8930	-8439	0	0	0	Rigid Z
3825	-7706	3506	5403	-432	-948	-151	Rigid ANC
3830	0	54205	0	0	0	0	Rigid GUI
3830	-160499	0	0	0	0	0	Rigid GUI
3840	0	-48847	0	0	0	0	Rigid GUI
3840	109723	0	0	0	0	0	Rigid GUI
3920	3611	12036	-38	0	0	0	Rigid GUI
3920	5943	0	-20588	0	0	0	Rigid Z
4180	933	3110	-10	0	0	0	Rigid GUI
4180	948	0	-3287	0	0	0	Rigid Z
4875	-1152	3990	0	0	0	0	Rigid GUI
4875	-1152	0	-36694	0	0	0	Rigid Z

L61

Node	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.	
70	162	-18	-2	0	0	0	Rigid GUI
70	228	-1233	-5643	0	0	0	Rigid Z
80	586	-64	-9	0	0	0	Rigid GUI
80	200	-1082	-12386	0	0	0	Rigid Z
151	117191	-628590	0	0	0	0	Rigid +LIM
160	-1135	122	0	0	0	0	Rigid GUI
160	-1437	7706	-26130	0	0	0	Rigid Z
190	3049	-7505	1936	-16091	-4138	-717	Rigid ANC
201	-120437	646005	0	0	0	0	Rigid -LIM
240	-5593	825	-813	0	0	0	Rigid GUI
240	794	-7290	-31730	0	0	0	Rigid Z
396	-287	-369	11713	50	-40	50	Rigid ANC
400	0	-9550	0	0	0	0	Rigid GUI
400	-8452	0	0	0	0	0	Rigid GUI
420	0	2880	0	0	0	0	Rigid GUI
420	13626	0	0	0	0	0	Rigid GUI
600	15	-52	0	0	0	0	Rigid GUI
600	1144	0	-16858	0	0	0	Rigid Z
630	1045	1594	-11599	0	0	0	Rigid Z
760	371	565	-32525	0	0	0	Rigid Z
1060	-2665	-2408	-11666	0	0	0	Rigid Z
3120	151	-16	-2	0	0	0	Rigid GUI
3120	42	-226	-2411	0	0	0	Rigid Z
3180	112	-12	-2	0	0	0	Rigid GUI
3180	4	-23	-7157	0	0	0	Rigid Z
3360	48282	-258969	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	-1128	751	-4515	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap

3552	-13	71	0	0	0	0	Rigid LIM
3552	0	0	-4726	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	72	2082	-6944	0	0	0	Rigid Z
3602	0	0	0	0	0	0	Rigid GUI w/gap
3602	518	-2776	0	0	0	0	Rigid LIM
3602	0	0	-6108	0	0	0	Rigid Z
3655	-47999	257450	0	0	0	0	Rigid -LIM
3680	-2685	517	-397	0	0	0	Rigid GUI
3680	16	-242	-1029	0	0	0	Rigid Z
3825	-851	136	8792	-17	-105	66	Rigid ANC
3830	0	-6366	0	0	0	0	Rigid GUI
3830	-7627	0	0	0	0	0	Rigid GUI
3840	0	2652	0	0	0	0	Rigid GUI
3840	754	0	0	0	0	0	Rigid GUI
3920	1564	5214	-16	0	0	0	Rigid GUI
3920	1613	0	-11915	0	0	0	Rigid Z
4180	-387	-2477	4	0	0	0	Rigid GUI
4180	-514	0	-11801	0	0	0	Rigid Z
4875	168	560	0	0	0	0	Rigid GUI
4875	5398	0	-37864	0	0	0	Rigid Z

Part 3 of 3: Dynamic Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
21	DW+LOVA+VVICE +FA	L24	WW+P7+T3+F3	D
		L25	WW+P7+F3	
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L26	WW+P8+T3+F4	Ultimate Failure σ_u
		L27	WW+P8+F4	

L24

NODE	FX	FY	FZ	MX	MY	MZ	
	------Forces(N.)-------			-----Moments(N.m.)-----			
70	-92493	10085	1373	0	0	0	Rigid GUI
70	-1151	6239	25923	0	0	0	Rigid Z
80	54625	27994	906	0	0	0	Rigid GUI
80	-3217	17435	-49669	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	-12126	-6247	0	0	0	0	Rigid GUI
160	5413	-29039	-98465	0	0	0	Rigid Z
190	-5205	21558	85942	-97032	-24768	3535	Rigid ANC
201	0	0	0	0	0	0	Rigid -LIM
240	42257	10600	-3435	0	0	0	Rigid GUI
240	639	-14091	-38212	0	0	0	Rigid Z
396	-3913	4889	5941	-668	-534	2615	Rigid ANC
400	0	141343	0	0	0	0	Rigid GUI
400	-160645	0	0	0	0	0	Rigid GUI
420	0	-119787	0	0	0	0	Rigid GUI
420	85016	0	0	0	0	0	Rigid GUI
600	4995	24395	-53	0	0	0	Rigid GUI
600	24099	0	-86894	0	0	0	Rigid Z
630	1264	-248	-6498	0	0	0	Rigid Z
760	3056	-361	-14208	0	0	0	Rigid Z
1060	6424	-9800	44628	0	0	0	Rigid Z
3120	109220	50077	1518	0	0	0	Rigid GUI
3120	-776	4155	17896	0	0	0	Rigid Z
3180	-45341	4636	444	0	0	0	Rigid GUI
3180	-1376	7370	-22702	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	344	-1009	-3868	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	8960	-48061	0	0	0	0	Rigid LIM
3552	0	0	8509	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	-61	-3000	-11121	0	0	0	Rigid Z
3602	-35082	-6540	0	0	0	0	Rigid GUI w/gap
3602	-9228	49498	0	0	0	0	Rigid LIM

3602	0	0	-10224	0	0	0	Rigid Z
3655	0	0	0	0	0	0	Rigid -LIM
3680	160110	-30351	22862	0	0	0	Rigid GUI
3680	1326	-20657	-21119	0	0	0	Rigid Z
3825	-20715	10594	499	-1303	-2548	-783	Rigid ANC
3830	0	173882	0	0	0	0	Rigid GUI
3830	-441439	0	0	0	0	0	Rigid GUI
3840	0	-157923	0	0	0	0	Rigid GUI
3840	340571	0	0	0	0	0	Rigid GUI
3920	7027	46102	-73	0	0	0	Rigid GUI
3920	11191	0	-43771	0	0	0	Rigid Z
4180	2875	45172	-30	0	0	0	Rigid GUI
4180	785	0	-9373	0	0	0	Rigid Z
4875	-1520	6592	0	0	0	0	Rigid GUI
4875	-12664	0	-60642	0	0	0	Rigid Z

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	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	283	-30	-4	0	0	0	Rigid GUI
70	434	-2356	-11361	0	0	0	Rigid Z
80	1165	-127	-17	0	0	0	Rigid GUI
80	384	-2082	-23894	0	0	0	Rigid Z
151	1359	-7290	0	0	0	0	Rigid +LIM
160	-2166	61	0	0	0	0	Rigid GUI
160	-83	450	-19836	0	0	0	Rigid Z
190	7173	-23054	-18177	-1993	-2547	-1272	Rigid ANC
201	-10333	55428	0	0	0	0	Rigid -LIM
240	-10518	1236	-944	0	0	0	Rigid GUI
240	319	-13954	-54093	0	0	0	Rigid Z
396	-745	-717	10980	97	-103	785	Rigid ANC
400	0	14840	0	0	0	0	Rigid GUI
400	-25714	0	0	0	0	0	Rigid GUI
420	0	-18455	0	0	0	0	Rigid GUI
420	33628	0	0	0	0	0	Rigid GUI
600	107	7384	-1	0	0	0	Rigid GUI
600	1212	0	-35354	0	0	0	Rigid Z
630	1166	2667	-24527	0	0	0	Rigid Z
760	296	491	-62045	0	0	0	Rigid Z
1060	-3662	-3249	-21812	0	0	0	Rigid Z
3120	19098	3498	-3	0	0	0	Rigid GUI
3120	79	-423	-7056	0	0	0	Rigid Z
3180	-15584	-2967	-2	0	0	0	Rigid GUI
3180	53	-285	-13371	0	0	0	Rigid Z
3360	672	-3607	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap

3493	-527	-56	-5784	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	6196	-33235	0	0	0	0	Rigid LIM
3552	0	0	-6932	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	-392	-197	-10376	0	0	0	Rigid Z
3602	-11564	-2156	0	0	0	0	Rigid GUI w/gap
3602	-4095	21966	0	0	0	0	Rigid LIM
3602	0	0	-9151	0	0	0	Rigid Z
3655	-1940	10410	0	0	0	0	Rigid -LIM
3680	-10638	672	-252	0	0	0	Rigid GUI
3680	-315	4916	6774	0	0	0	Rigid Z
3825	-2412	1546	8393	-190	-296	-370	Rigid ANC
3830	0	-32283	0	0	0	0	Rigid GUI
3830	-37339	0	0	0	0	0	Rigid GUI
3840	0	53940	0	0	0	0	Rigid GUI
3840	51997	0	0	0	0	0	Rigid GUI
3920	2247	30166	-23	0	0	0	Rigid GUI
3920	2280	0	-23856	0	0	0	Rigid Z
4180	-559	32062	5	0	0	0	Rigid GUI
4180	-883	0	-30134	0	0	0	Rigid Z
4875	207	-3820	0	0	0	0	Rigid GUI
4875	7274	0	-64260	0	0	0	Rigid Z

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	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	-92494	10085	1373	0	0	0	Rigid GUI
70	-1151	6239	25923	0	0	0	Rigid Z
80	54626	27994	906	0	0	0	Rigid GUI
80	-3217	17435	-49669	0	0	0	Rigid Z
151	0	0	0	0	0	0	Rigid +LIM
160	-12127	-6248	0	0	0	0	Rigid GUI
160	5413	-29039	-98465	0	0	0	Rigid Z
190	3889	-22558	92513	-95332	-25001	3864	Rigid ANC
201	-614	3296	0	0	0	0	Rigid -LIM
240	50810	17934	-7034	0	0	0	Rigid GUI
240	773	-7103	-20694	0	0	0	Rigid Z
396	-5135	7677	4845	-1050	-700	4119	Rigid ANC
400	0	229191	0	0	0	0	Rigid GUI
400	-217688	0	0	0	0	0	Rigid GUI
420	0	-188398	0	0	0	0	Rigid GUI
420	127412	0	0	0	0	0	Rigid GUI
600	5836	37803	-62	0	0	0	Rigid GUI
600	27936	0	-103589	0	0	0	Rigid Z
630	80	-10	-3967	0	0	0	Rigid Z
760	2788	-486	-20858	0	0	0	Rigid Z

1060	6329	-9550	51363	0	0	0	Rigid Z
3120	119447	51988	1518	0	0	0	Rigid GUI
3120	-792	4244	18581	0	0	0	Rigid Z
3180	-53894	5784	444	0	0	0	Rigid GUI
3180	-1387	7426	-23802	0	0	0	Rigid Z
3360	0	0	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	338	-993	-3976	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	13598	-72938	0	0	0	0	Rigid LIM
3552	0	0	10361	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	-63	-3037	-11883	0	0	0	Rigid Z
3602	-42351	-7896	0	0	0	0	Rigid GUI w/gap
3602	-10397	55770	0	0	0	0	Rigid LIM
3602	0	0	-11179	0	0	0	Rigid Z
3655	-3134	16812	0	0	0	0	Rigid -LIM
3680	168828	-31763	23408	0	0	0	Rigid GUI
3680	1543	-24038	-25606	0	0	0	Rigid Z
3825	-22737	11499	-1598	-1415	-2796	-1266	Rigid ANC
3830	0	191902	0	0	0	0	Rigid GUI
3830	-498092	0	0	0	0	0	Rigid GUI
3840	0	-184474	0	0	0	0	Rigid GUI
3840	408654	0	0	0	0	0	Rigid GUI
3920	7230	65084	-75	0	0	0	Rigid GUI
3920	11619	0	-49134	0	0	0	Rigid Z
4180	2862	74254	-30	0	0	0	Rigid GUI
4180	912	0	-17432	0	0	0	Rigid Z
4875	-2780	13286	0	0	0	0	Rigid GUI
4875	-6095	0	-91560	0	0	0	Rigid Z

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	------Forces(N.)-------			-----Moments(N.m.)-----			
NODE	FX	FY	FZ	MX	MY	MZ	
70	287	-30	-4	0	0	0	Rigid GUI
70	434	-2356	-11362	0	0	0	Rigid Z
80	1166	-128	-17	0	0	0	Rigid GUI
80	384	-2082	-23895	0	0	0	Rigid Z
151	1359	-7290	0	0	0	0	Rigid +LIM
160	-2167	61	0	0	0	0	Rigid GUI
160	-83	449	-19836	0	0	0	Rigid Z
190	15863	-67948	-20422	-3288	-2935	-1559	Rigid ANC
201	-18516	99318	0	0	0	0	Rigid -LIM
240	-17450	1686	-1113	0	0	0	Rigid GUI
240	1695	-15567	-57535	0	0	0	Rigid Z
396	-1046	-1665	11876	227	-144	1559	Rigid ANC

400	0	-41702	0	0	0	0	Rigid GUI
400	-37490	0	0	0	0	0	Rigid GUI
420	0	-26709	0	0	0	0	Rigid GUI
420	48345	0	0	0	0	0	Rigid GUI
600	109	17982	-1	0	0	0	Rigid GUI
600	1316	0	-38956	0	0	0	Rigid Z
630	1211	2669	-26597	0	0	0	Rigid Z
760	296	567	-69573	0	0	0	Rigid Z
1060	-3702	-3249	-25856	0	0	0	Rigid Z
3120	29324	5408	-3	0	0	0	Rigid GUI
3120	85	-458	-8801	0	0	0	Rigid Z
3180	-24137	-4564	-2	0	0	0	Rigid GUI
3180	78	-419	-14470	0	0	0	Rigid Z
3360	672	-3607	0	0	0	0	Rigid +LIM
3493	0	0	0	0	0	0	Rigid GUI w/gap
3493	-495	-287	-5951	0	0	0	Rigid Z
3552	0	0	0	0	0	0	Rigid GUI w/gap
3552	10858	-58242	0	0	0	0	Rigid LIM
3552	0	0	-7684	0	0	0	Rigid Z
3563	0	0	0	0	0	0	Rigid GUI w/gap
3563	-339	-424	-11013	0	0	0	Rigid Z
3602	-18518	-3452	0	0	0	0	Rigid GUI w/gap
3602	5469	-29338	0	0	0	0	Rigid LIM
3602	0	0	-9976	0	0	0	Rigid Z
3655	-5339	28637	0	0	0	0	Rigid -LIM
3680	-21549	994	-251	0	0	0	Rigid GUI
3680	-600	9349	14474	0	0	0	Rigid Z
3825	-3578	2203	8892	-271	-440	-1027	Rigid ANC
3830	0	-52755	0	0	0	0	Rigid GUI
3830	-75991	0	0	0	0	0	Rigid GUI
3840	0	97114	0	0	0	0	Rigid GUI
3840	110167	0	0	0	0	0	Rigid GUI
3920	2247	-56736	-23	0	0	0	Rigid GUI
3920	2361	0	-28018	0	0	0	Rigid Z
4180	-559	61188	5	0	0	0	Rigid GUI
4180	-972	0	-38431	0	0	0	Rigid Z
4875	206	-10406	0	0	0	0	Rigid GUI
4875	7267	0	-85920	0	0	0	Rigid Z

C. APPENDIX: Nozzle Loads *(Without Sliding Friction)*

I) Service Level A

Part 1 of 2: Static Load Cases

Load Spec. No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
2	Hydrostatic Test	L1	WW+HP	Test
1	DW+NO	L2	W+P1+T1	A
		L3	W+P1	
5	DW+T Baking	L4	W+P1+T2	A
		L5	W+P1	
7	DW+VVICE II	L6	W+P2+T3	A
		L7	W+P2	
8	DW+VVICE III	L8	W+P2+T3	A
		L9	W+P2	
9	DW+LOCA VV-PHTS	L10	W+P3+T4	A
		L11	W+P3	
17	DW+LOVA+ VVICE+FA	L18	W+P7+T3+F1	A
		L19	W+P7+F1	
20	DW+VV Dust Explosion	L22	W+P6+T1	A
		L23	W+P6	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	34243	105186	-2945	1056	24446	87499
	Min	-3356	-60675	-22411	-21140	7130	-68354
3000	Max	50167	22021	-2519	8823	27049	48986
	Min	-16255	-14147	-16026	746	481	-8748
4500	Max	73146	10012	17815	12065	34277	5740
	Min	-4329	-12680	-35206	-22842	-42120	-6469
1200	Max	19118	-537	-275	16568	-2174	1947
	Min	312	-10892	-48381	-1841	-35370	-1834
1650	Max	6059	-237	-9839	42	-11519	8448
	Min	503	-12317	-30238	-8932	-43380	939
1850	Max	-1257	3783	-6002	-5597	4355	-1142
	Min	-4402	1577	-34171	-33650	-19821	-13042

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	7997	20580	16420	22155	7155	-671
	Min	723	776	-8007	-4429	-18059	-42465
1000	Max	19192	-449	1081	10056	6720	29515
	Min	233	-11238	-1091	-32891	-18023	-235
1350	Max	-592	10342	11615	14116	2148	16584
	Min	-8912	103	-11711	-10863	-4823	1145

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	Service Level
6	DW+T baking + SL-1	S8 S1	W+P1+T2+0.34D1+SL-1 *(L30+SL-1)* W+P1+SL-1 *(L5+SL-1)*	A
10	DW+NO+SMHV	S9 S2	W+P1+T1+0.73D1+SMHV *(L31+SMHV)* W+P1+SMHV *(L3+SMHV)*	A
11	DW+ T baking + SMHV	S10 S3	W+P1+T2+0.73D1+SMHV *(L32+SMHV)* W+P1+SMHV *(L5+SMHV)*	A

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	24566	32803	18751	16839	23138	47431
3000	29265	15785	13710	8239	21330	47722
4500	5983	7837	39335	22407	58860	21712
1200	8220	10354	9293	8610	9628	9946
1650	7135	6524	17706	9875	29793	13075
1850	7556	4886	12703	17247	8415	12396

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	9567	6474	18082	13526	19194	21802
1000	6330	5297	7524	11733	12376	15678
1350	9905	7882	15923	17758	10684	13265

II) Service Level B

Part 1 of 1: Dynamic Load Cases

Load case no. (LS)	**Event**	**Load case No. (Caesar)**	**Caesar Load Case**	Service Level
--	DW+NO+SL-3	S16 S15	W+P1+T1+1.5D1+SL-3 *(L62+SL-3)* W+P1+SL-3 *(L3+SL-3)*	B

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	12009	34413	14162	9546	18851	40968
3000	12124	14242	9954	5914	13160	33285
4500	8493	12310	52549	30497	78324	32029
1200	12109	15728	13053	11549	12508	15083
1650	11008	9787	21802	15244	39832	20290
1850	11235	6552	15839	23308	11720	18594

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	14679	8972	22484	21112	27030	32448
1000	9081	7664	11572	14891	17887	23745
1350	15286	12256	20441	23718	15011	20030

III) Service Level C

Part 1 of 2: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
12	DW+VVICE IV	L12	W+P4+T3	C
		L13	W+P4	
14	DW+VVICE V	L14	W+P4+T3	C
		L15	W+P4	
16	DW+FIRE	L16	W+P1+T5	C
		L17	W+P1	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	40132	26399	-4206	630	28362	2992
	Min	-1610	-29839	-24746	-25884	7276	-53890
3000	Max	51173	16168	-2996	10935	31785	63675
	Min	-7965	-374	-18508	746	1496	-603
4500	Max	-1728	524	-16936	9307	-26723	5790
	Min	-4392	-12813	-35374	-67	-42355	-4852
1200	Max	19179	-1009	-424	15415	-3027	788
	Min	711	-10986	-48996	-1494	-35739	-1425
1650	Max	6141	-350	-9962	-146	-11571	8455
	Min	512	-12467	-30473	-9103	-43778	939
1850	Max	-1556	3764	-6140	-5618	3082	-1331
	Min	-4414	1650	-34475	-34056	-19660	-13145

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	8196	20695	11003	21633	6618	-1644
	Min	860	1347	-7766	-1217	-18676	-42730
1000	Max	19252	-926	1016	6665	3493	29584
	Min	629	-11340	-1620	-33067	-17481	777
1350	Max	-628	10466	11851	14396	2121	16803
	Min	-9028	210	-8727	-8327	-3617	1331

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
13	DW+ NO+SL-2	S11 S4	W+P1+T1+D1+SL-2 *(L33+SL-2)* W+P1+SL-2 *(L3+SL-2)*	C
15	DW+T baking + SL-2	S12 S5	W+P1+T2+D1+SL-2 *(L34+SL-2)* W+P1+SL-2 *(L5+SL-2)*	C
16	DW+FIRE+SL-2	S13 S6	W+P1+T5+D1+SL-2 *(L35+SL-2)* W+P1+SL-2 *(L17+SL-2)*	C
19	DW+VVICE V+SL-3	S14 S7	W+P4+T3+1.5D1+SL-3 *(L36+SL-3)* W+P4+SL-3 *(L15+SL-3)*	C

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	40925	33899	27425	27518	32379	57725
3000	53049	18579	20173	12580	33550	67229
4500	10916	24683	69758	30522	92748	33618
1200	29495	25038	58131	27314	42938	15041
1650	16215	21039	40878	23468	69743	27217
1850	13931	8550	42219	49629	27999	29630

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	21320	27117	22353	41934	38546	70953
1000	26614	17377	11714	41592	32327	50901
1350	23067	21785	23479	29803	14990	34355

IV) Service Level D

Part 1 of 3: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L20	W+P5+T3+F2	D
		L21	W+P5+F2	
23	DW+LOCA PC III+ICE II	L28	W+P9+T3	D
		L29	W+P9	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	34243	26399	-4277	606	24446	2992
	Min	-1511	-28102	-22411	-21140	7285	-47265
3000	Max	50167	15007	-2980	8918	27049	54000
	Min	-8242	-363	-16026	746	1462	-588
4500	Max	120325	15994	39708	9296	72707	5697
	Min	-4338	-12689	-35217	-37327	-42173	-7531
1200	Max	19058	-239	-182	17357	-1638	2497
	Min	43	-10902	-48471	-1504	-35402	-1390
1650	Max	6078	-166	-9762	160	-11487	8594
	Min	498	-12343	-30265	-8996	-43452	933
1850	Max	-1065	3698	-5915	-5584	3045	-1022
	Min	-4360	1603	-34174	-33731	-19968	-13047

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	8080	20550	10978	21173	7206	-37
	Min	636	404	-7661	-1331	-18233	-42408
1000	Max	19131	-149	1122	7376	3259	29400
	Min	-35	-11250	-1336	-32647	-17480	-907
1350	Max	-569	10363	11643	14143	2081	16638
	Min	-8937	36	-8928	-8339	-3637	1028

Part 2 of 3: Integrity at 30 bar

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
--	Integrity at 30 bar	L60	W+P10+T6	D
		L61	W+P10	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	20871	128417	-5587	135	14925	107587
	Min	276	3428	-17202	-10533	7509	3048
3000	Max	33992	-376	-3458	3890	14076	-603
	Min	368	-15211	-9332	735	2465	-9312
4500	Max	-1735	531	-16922	9281	-26652	-293
	Min	-2771	-4904	-24465	5571	-32893	-4813
1200	Max	8467	-1031	-473	5288	-3070	-413
	Min	744	-5198	-20029	-1571	-16168	-1383
1650	Max	2747	-332	-9931	-122	-11507	3854
	Min	495	-5182	-18195	-3581	-24483	889
1850	Max	-1587	2609	-6114	-5583	3067	-1316
	Min	-2652	1683	-17539	-16868	-6302	-6258

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	3659	9474	10922	9458	6563	-1589
	Min	849	1378	2827	-733	-3235	-18379
1000	Max	8452	-947	997	6419	3238	12729
	Min	663	-5287	696	-10278	-5900	782
1350	Max	-608	4302	-467	808	-1167	7538
	Min	-3968	196	-8758	-8379	-3570	1309

Part 3 of 3: Dynamic Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
21	DW+LOVA+VVICE +FA	L24	WW+P7+T3+F3	D
		L25	WW+P7+F3	
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L26	WW+P8+T3+F4	Ultimate Failure σ_u
		L27	WW+P8+F4	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	34371	27363	-11034	218	31493	5930
	Min	529	6622	-27788	-21062	14490	-6843
3000	Max	69327	-12256	-5576	10099	31436	53476
	Min	12819	-21836	-18198	1736	5842	-31565
4500	Max	95739	60309	-99959	80499	-153100	-46379
	Min	55795	19663	-183451	40480	-267822	-99791
1200	Max	38763	-16581	-5751	29884	-17072	18332
	Min	10370	-44077	-60693	-36402	-60250	-9612
1650	Max	11683	-4832	-18563	-7658	-24183	16113
	Min	3289	-20296	-41340	-22450	-63144	-13529
1850	Max	-13429	7331	-13389	-11643	18103	-12349
	Min	-29001	3461	-46840	-43351	-24958	-32512

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	11861	45511	19935	31883	15516	-27228
	Min	3062	15153	-7399	-14013	-30733	-88825
1000	Max	33756	-9007	3860	16831	21920	67961
	Min	8498	-25516	-4626	-44324	-22156	21819
1350	Max	-6501	18338	13611	13627	4933	33587
	Min	-20916	3724	-16413	-16330	-7079	11039

D. APPENDIX: Nozzle Loads *(With Sliding Friction)*

I) Service Level A

Part 1 of 2: Static Load Cases

Load Spec. No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
2	Hydrostatic Test	L1	WW+HP	Test
1	DW+NO	L2	W+P1+T1	A
		L3	W+P1	
5	DW+T Baking	L4	W+P1+T2	A
		L5	W+P1	
7	DW+VVICE II	L6	W+P2+T3	A
		L7	W+P2	
8	DW+VVICE III	L8	W+P2+T3	A
		L9	W+P2	
9	DW+LOCA VV-PHTS	L10	W+P3+T4	A
		L11	W+P3	
17	DW+LOVA+ VVICE+FA	L18	W+P7+T3+F1	A
		L19	W+P7+F1	
20	DW+VV Dust Explosion	L22	W+P6+T1	A
		L23	W+P6	

Maximum nozzle loads from above load cases

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	38784	125372	-3591	978	27533	106557
	Min	-2459	-48613	-25684	-21534	7266	-46622
3000	Max	77080	12250	-2973	9164	30906	24555
	Min	-11119	-35231	-18404	736	1217	-34600
4500	Max	73191	10007	17770	12011	33871	7004
	Min	-4086	-11965	-34400	-21016	-41187	-6408
1200	Max	10077	-2247	-967	17850	-1842	758
	Min	-299	-12102	-52417	-4439	-29171	-1652
1650	Max	6473	-134	-9765	318	-11308	9851
	Min	470	-14310	-32287	-12770	-45927	1399
1850	Max	-1445	2305	-6069	-5444	4180	-265
	Min	-9252	1718	-36043	-37356	-16226	-7804

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	4358	22744	16784	21453	8407	-1188
	Min	-620	104	-6373	-4740	-14846	-44958
1000	Max	25077	918	923	11287	5838	30767
	Min	614	-9262	-4733	-30620	-21702	301
1350	Max	-533	12162	13671	14099	2427	16583
	Min	-9810	12	-11844	-10796	-4901	669

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
6	DW+T baking + SL-1	S8 S1	W+P1+T2+0.34D1+SL-1 *(L30+SL-1)* W+P1+SL-1 *(L5+SL-1)*	A
10	DW+NO+SMHV	S9 S2	W+P1+T1+0.73D1+SMHV *(L31+SMHV)* W+P1+SMHV *(L3+SMHV)*	A
11	DW+ T baking + SMHV	S10 S3	W+P1+T2+0.73D1+SMHV *(L32+SMHV)* W+P1+SMHV *(L5+SMHV)*	A

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	28508	35513	21593	17181	25797	24474
3000	48689	14472	15426	8489	24114	12425
4500	5919	7748	39143	22413	58666	21557
1200	6856	12163	9980	10701	8430	9517
1650	7122	6759	18002	10213	29801	13541
1850	9170	5065	13419	17808	8295	11143

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	9230	4727	18314	13604	20250	21448
1000	5446	3938	7440	12677	11557	14839
1350	9951	8112	16062	17706	10729	12684

II) Service Level B

Part 1 of 1: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
--	DW+NO+SL-3	S16 S15	W+P1+T1+1.5D1+SL-3 *(L62+SL-3)* W+P1+SL-3 *(L3+SL-3)*	B

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	14421	27045	15902	9756	20478	26002
3000	21628	7530	10794	6036	14522	13649
4500	8461	12041	52344	30503	78059	31874
1200	10737	17566	13566	15113	11198	14267
1650	10955	9965	22056	15430	39634	20685
1850	13034	6964	16660	23731	11813	17449

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	13984	7249	21716	21189	28085	32933
1000	8277	6688	11487	15835	17068	23702
1350	15279	12441	20579	23666	15056	19347

III) Service Level C

Part 1 of 2: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
12	DW+VVICE IV	L12	W+P4+T3	C
		L13	W+P4	
14	DW+VVICE V	L14	W+P4+T3	C
		L15	W+P4	
16	DW+FIRE	L16	W+P1+T5	C
		L17	W+P1	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	46223	87467	-4601	582	32470	50114
	Min	-1062	-22472	-29137	-26413	7266	-21674
3000	Max	83343	4951	-3277	11348	36395	7167
	Min	-4780	-35231	-21350	736	1953	-21159
4500	Max	-1708	428	-17089	9288	-27200	7064
	Min	-4159	-12133	-34599	798	-41550	-4714
1200	Max	10095	-3361	-1279	16237	-3032	-253
	Min	413	-12223	-53148	-3585	-29543	-1981
1650	Max	6585	-204	-9834	180	-11442	9913
	Min	498	-14510	-32563	-13067	-46467	1399
1850	Max	-1447	1799	-6069	-5449	2941	-651
	Min	-9278	1525	-36290	-37865	-16226	-7963

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	4605	22926	11234	21233	7634	-1197
	Min	-34	685	-6209	-1295	-15559	-45334
1000	Max	25190	138	869	7610	2674	30841
	Min	666	-9402	-5452	-30795	-21496	344
1350	Max	-579	12326	13949	14374	2405	16912
	Min	-9968	72	-8856	-8268	-3663	842

Part 2 of 2: Dynamic Load Cases

Load case no. (LS)	Event	Load case No. (Caesar)	Caesar Load Case	Service Level
13	DW+ NO+SL-2	S11 S4	W+P1+T1+D1+SL-2 *(L33+SL-2)* W+P1+SL-2 *(L3+SL-2)*	C
15	DW+T baking + SL-2	S12 S5	W+P1+T2+D1+SL-2 *(L34+SL-2)* W+P1+SL-2 *(L5+SL-2)*	C
16	DW+FIRE+SL-2	S13 S6	W+P1+T5+D1+SL-2 *(L35+SL-2)* W+P1+SL-2 *(L17+SL-2)*	C
19	DW+VVICE V+SL-3	S14 S7	W+P4+T3+1.5D1+SL-3 *(L36+SL-3)* W+P4+SL-3 *(L15+SL-3)*	C

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	47016	92041	31816	28047	36487	54442
3000	85220	37810	23015	12993	38160	24978
4500	10675	23934	68908	30498	91695	34881
1200	20481	25828	61989	28618	36687	15058
1650	16617	23043	42943	27316	72240	28591
1850	18928	6641	44168	53342	24387	24426

Node	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	17793	29236	22637	41639	35468	73548
1000	32403	15457	15107	39474	36277	52254
1350	23956	23618	25551	29788	15046	34367

IV) Service Level D

Part 1 of 3: Static Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
18	DW+LOVA+ VVICE+Explosion in VSTs+FD	L20	W+P5+T3+F2	D
		L21	W+P5+F2	
23	DW+LOCA PC III+ICE II	L28	W+P9+T3	D
		L29	W+P9	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	38784	87467	-4658	560	27600	50114
	Min	-983	-20997	-25684	-21534	7266	-20267
3000	Max	77080	5222	-3265	9247	30906	7568
	Min	-5012	-35231	-18404	736	1925	-21159
4500	Max	120387	16045	39736	9300	72369	6922
	Min	-4102	-11975	-34416	-34970	-41282	-7478
1200	Max	10023	-1486	-826	18847	-948	1414
	Min	-937	-12108	-52541	-3594	-29241	-1844
1650	Max	6504	-115	-9745	353	-11264	9903
	Min	459	-14352	-32325	-12878	-46056	1399
1850	Max	-1453	1898	-6064	-5442	2928	-447
	Min	-9131	1614	-36011	-37472	-16441	-7861

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	4500	22709	11220	20931	8016	-1226
	Min	-1385	275	-6242	-1253	-15087	-44937
1000	Max	24981	1324	909	8134	2454	30638
	Min	660	-9295	-5052	-30344	-21326	370
1350	Max	-518	12194	13709	14124	2390	16690
	Min	-9851	-4	-8945	-8273	-3647	615

Part 2 of 3: Integrity at 30 bar

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
--	Integrity at 30 bar	L60	W+P10+T6	D
		L61	W+P10	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	22169	145166	-5418	153	15868	123313
	Min	39	370	-18132	-10633	7336	178
3000	Max	47124	43	-3427	4095	15975	20
	Min	48	-33469	-10534	725	2421	-36611
4500	Max	-1718	435	-17074	9258	-27138	118
	Min	-2724	-4622	-24153	6010	-32407	-4735
1200	Max	5699	-3354	-1329	5769	-3053	-270
	Min	412	-5404	-21180	-3622	-14246	-1359
1650	Max	2857	-191	-9807	192	-11384	4405
	Min	483	-5830	-18886	-4793	-25190	1350
1850	Max	-1481	2140	-6046	-5421	2940	-628
	Min	-4664	1809	-18388	-18174	-4869	-4158

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	3485	8826	11204	9188	7567	-1152
	Min	-42	694	3308	-953	-2285	-17646
1000	Max	8703	120	847	7417	2519	11489
	Min	675	-4429	-477	-9439	-6926	333
1350	Max	-560	4901	226	860	-1008	7341
	Min	-4237	64	-8882	-8319	-3625	823

Part 3 of 3: Dynamic Load Cases

Load Spec.No.	Event	Load case No. (Caesar)	Caesar Load Combination	Service Level
21	DW+LOVA+VVICE +FA	L24	WW+P7+T3+F3	D
		L25	WW+P7+F3	
22	DW+LOVA+VVICE +Explosion in VSTs+FD	L26	WW+P8+T3+F4	Ultimate Failure σ_u
		L27	WW+P8+F4	

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
10	Max	39092	90856	-10707	251	34677	53141
	Min	75	698	-31192	-21472	14158	341
3000	Max	96811	-13752	-5529	10452	35375	-19883
	Min	12358	-57582	-20625	1719	5780	-53460
4500	Max	95761	60171	-100173	80450	-153770	-45301
	Min	55929	20172	-182839	41112	-266870	-99682
1200	Max	31647	-19811	-6949	30327	-17073	17267
	Min	9903	-45341	-63965	-39289	-55416	-9078
1650	Max	11996	-4656	-18408	-7264	-24057	17319
	Min	3280	-21802	-42903	-25325	-65041	-12885
1850	Max	-13279	5904	-13287	-11461	17922	-11378
	Min	-32815	3588	-48347	-46181	-22181	-28318

Node	Max/Min	fx N.	fy N.	fz N.	mx N.m.	my N.m.	mz N.m.
800	Max	8758	47301	20329	31065	16917	-26302
	Min	-4425	14355	-5990	-14334	-28218	-90677
1000	Max	38559	-7697	-2341	18203	20926	68951
	Min	8562	-23880	-7628	-42164	-25097	20935
1350	Max	-6448	19712	15179	13668	5132	33475
	Min	-21596	3556	-16569	-16252	-7160	10392