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Engineering stress analysis to optimize the 3 Dimensional Piping Loops in Oil and Gas Industry

Jasjeet Singh[1], Siddharth[2]

Mechanical Engineering Department
Lingaya's Vidyapeeth, Faridabad

Abstract- In an Oil & Gas refinery, fluid are transferred from one location to another by means of Piping. Pipe will expand if the fluid temperature is higher than that of the atmosphere. In the case where the expansion is controlled by support/equipment, it give rise to slight deformations and stresses on the piping along with connecting devices. As per ASME (American Society of Mechanical Engineers) B31.3 code, thermal stresses with its allowable limits are calculated. The allowable limits of another type of stress which forms part of the piping are set out in this code and its permitted value, e.g.: pressures from pressure, weight, wind etc. Where the connection equipment is distant, it will be moved to a rack of pipes in order to facilitate accessibility into the process plant. For absorption of the heat expansion, a pipe rack loop is used. In the paper, optimization in the loops and deflection observation has been performed for the two process critical piping lines and finally calculated the loop dimensions under safety limits in relation to corresponding pipe size, temperature, pressure etc. Caesar II Software based on Finite Element Method (FEM) is being used in the analysis in designing two piping loops as per the guidelines strictly prescribed in ASME B 31.3. The analysis performed by considering an anchor/restraint position on both sides of PR (pipe rack) loop, as common practice followed in processing plants.

Index Terms-
Index Terms - Introduction, Literature Survey, Piping Design & Stress Methodology, Experimental Results and discussion with reports, Verification for ASME B31.3, conclusion, references.

I. Introduction

Stress analysis governs the efficient Piping System. Stress critical pipelines which are process and power governed are diligently analyzed by piping stress engineer so that ensure correct placement and selection of pipe routing, nozzle load, hanger, and supports to counter balance a variety of sustained loads, service loads, pressures, etc. Do not exceed allowable pipe stress under heavy load. method, such as test load Required by ASME (American Society of Mechanical Engineers) B31.3 and other codes and standards (applicable).

The mechanical behavior of pipelines should be analyzed not only under usual loading i.e. internal pressure & thermal stresses, but also analyzed for occasional/intermittent loads namely earthquakes, high winds, certain vibrations alongwith water hammer cases. This analysis is specifically performed using a specialized CAESER-II finite element (FE) pipe stress analysis computer software program.

For design and analysis of complicated/complex systems, a CAESER-II, which is an interactive computer software, was developed and is being used worldwide by various EPC (Engineering, Procurement & Construction) Contractors/Vendors. CAESER-II applies the finite element method to perform stress analysis and analyzes permitted code compliance stresses, code stresses, element moments and forces, and various cases such as sustained, hydrostatic, experimental and operational cases to convert to coordinates and displacements at every node in the piping layout.

STRESS ANALYSIS

Pipeline stress analysis is a term applied to calculations dealing with static and dynamic loads resulting from temperature changes, gravity, external and internal pressure, changes in fluid flow, and the effects of seismic activity. The hot piping system expands or lengthens whereas contraction will be experienced in Cold piping systems. Both lead to stress problems. Stress analysis will determine the forces that will be applied to piping, pipe system restraints, anchor points, and stresses induced in pipes should be compared with allowable limits according to relevant standards and guidelines.

LOAD TYPES

- Sustained load- This load occurs during normal plant operation. Typical long-term loads are internal or external pressure and dead Weight.
- Expansion load- Because of the displacement in piping such loads are generate. Typical loads are Seismic movement of anchor,

thermal expansion, thermal anchor movements in supports.

- Occasional load- The main cause of generation of occasional load is due to infrequent interval during plant operation. Examples of such loads are wind, earthquake, fluid transient like water hammers, and discharge of relief valves.

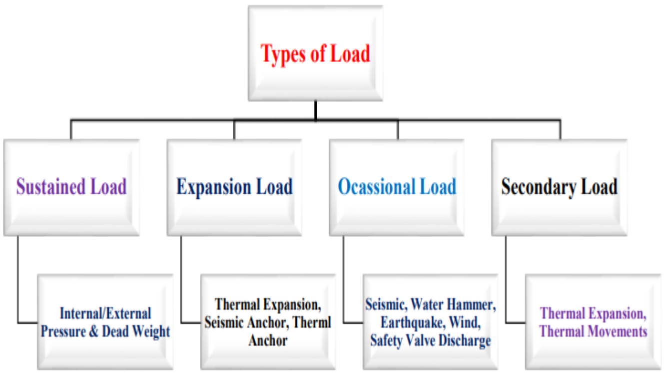

Fig. 1 Types of Loads

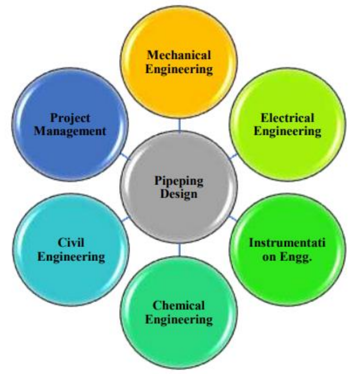

Fig 2. Application of Piping Design.

LOAD CASES TERMINOLOGY

- Hydrostatic Loads (P_{f+} W). It is defined the sum of fluid pressure + pipe weight.
- Sustained Loads (P_i+W). It is defined as the sum of internal pressure + pipe weight.
- Operating Loads (T+W+P). It is the sum of thermal expansions + weight + pressures.
- Experimental Loads (T+W+S+P). It is the sum of pipe thermal expansion + weight + terminal point displacements + Pressures.
- Occasional Loads. This load will happen during operation, not on a regular basis.

During the Engineering stage of a petrochemical plant pipe rack with thousands of pipe estimating these loop dimensions is a major concern for a layout Engineer. A combination of different design cases must be considered when optimizing along with finalizing loop dimensions. design influences design Material cost and safety of the system. In this paper optimization in two loops and deflection observation has been performed for the two process critical piping lines and finally calculated the loop dimensions under safety limits in relation to corresponding pipe size, temperature, pressure etc as per ASME B 31.3 [4] with the help of CAESER-II software. Analysis has performed assuming an anchor both sides of a pipe rack loop common in process plants.

Pipe rack (PR) improves accessibility around the system. A pipe rack is a "Pi" shaped structure used to support pipes, usually made of steel or concrete. To maintain process plant safety, piping systems must be designed so that they do not collapse under the stress of weight, pressure, temperature, and other contingency conditions. ASME provides guidelines that must be followed to maintain process plant safety. This guideline is published as ASME B 31.3 code [4].

Pipes are routed in pipe rack when the two equipment are located farther in unit of a refinery. PR (Pipe racks) allows easy access around the plant system. "Pi " shaped structure used to supporting pipes is known as Pipe rack. On this pipe rack several Tiers are maintained on which pipes are routed on different level. Pipe rack may be of Steel or sometimes concrete.

Pipe Racks (PR) are structures, which are designed and constructed specifically to support multiple pipelines as such where sufficient support structure is unavailable. Laying pipes on pipe rack required preliminary transposition study which must be carried out during the FEED (Front End Engineering Design) stage of a project.

Depending on the number of lines routed through the pipe rack, it is built in one or more levels called pipe racks. According to the standards of the ASME (American Society of Mechanical Engineers,) B, 36.10[7], 36.19[8], pipe is a hollow cylindrical object having outside diameter and thickness. Fluids should be transferred from one processing equipment to another in order to produce the desired output product of the process plant. These fluids are transported using pipes. These pipes will be directed through a pipe rack when the connection facilities are farther away.

All primary process lines, relief and bottom headers, and all lines entering and exiting the plant, including utility lines, are transported by pipe rack. The pipe rack is used to route instrument and electrical cable trays.

- Contents of Pipe Rack :
- Process Lines
- Utility Lines
- Cable Trays
- Equipment (mainly air coolers)

This can also be used to support upcoming pipes inside and outside of the tubular frame. If the carrier liquid is hot, the heat will cause the piping to expand. This expansion increases proportionally to all parameters. Lines in a pipe rack generally travel long distances, which increases the length of the pipes in the pipe rack, resulting in greater expansion. These extensions should be limited to keep the piping system in the intended position. However, using pipe supports to reduce these displacements puts some stress on the piping system. These so-called thermal stresses must be optimized for safe system operation. Piping loops are used to alleviate these thermal stresses. It is characterized by the pipe running transversely to the actual pipe direction. If the pipe runs in both orthogonal directions, it is called a three-dimensional loop (6 arcs); if it runs in only one direction, it is called a two-dimensional loop (4 arcs).
3D loops are most commonly used because they are more flexible than 2D loops. 2D loops also interfere with the routing of other pipes that are not hot. So a 2D loop is used when a 3D loop is not possible due to process limitations.

II. LITERATURE SURVEY

Literature review for this study was conducted on different aspects.
1. Cost reduction techniques and case studies conducted by other researchers. The main bullets which are the essence of this paper are as follows:

1. Literature survey for cost reduction

[1] Applying the maximum bending stress hypothesis, the maximum span between pipe supports was established. The intention of this paper is to increase the distance between supports while maintaining acceptable levels of loads and deflection and also to use fewer supports in order to lower the overall cost of erection. They described various value-engineering methods, which can yield quick results in product cost reduction.

[2] studied the evaluation of a pipe system to enhance a process unit's system. Through this paper, stress analysis was performed to determine the best cost-effective configuration with sufficient safety by examining the behavior as the system temperature changes from ambient to operational.

[3] studied Plant Layout Optimization with Pipe Rack and Frames. Through this paper, they by maximizing the locations of departments inside the plant and constructing the in-plant pipe rack, as well as taking into consideration the material handling points, this work expands on the content of plant layout studies and creates a thorough industrial layout.

III. PIPING DESIGN & PIPING STRESS METHODOLOGY

In practical research, a two-dimensional unfolding loop is created. Uses anchors on both ends pipe rack. The distance between anchors is calculated based on the maximum distance the shoe support can travel. The length of the shoe support is generally 200-300 mm in length. The maximum possible travel is limited to 100 mm in order to maintain support in the structure of the tubular frame. This is on one side of the stretch loop. An extension of 100 mm is also possible on the other side of the tubular frame.

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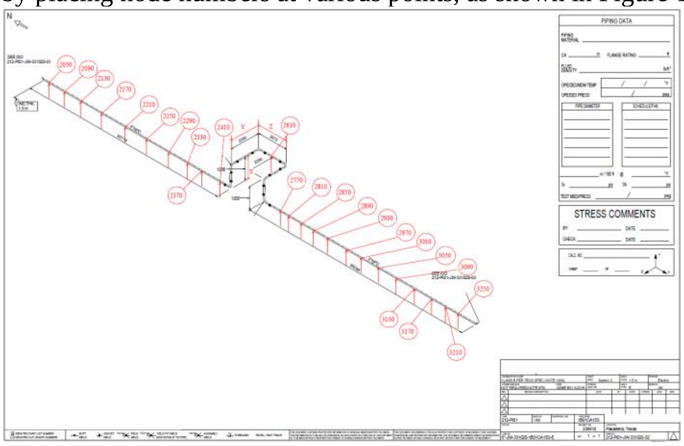
S. No.	INPUT PARAMETERS (Pipe Size 8")	
1	Pressure	9.15 kg/sq.cm
2	T1 (Operating Temperature)	43°C
3	T2 (Design Temperature)	148°C
4	T3(Minimum Design Temperature MDMT)	minus(-) 10°C
5	Pipe Size	8"
6	Schedule	8.179mm
7	Pipe Material	ASTM A 106 Gr. B
8	ASME Code	ASME B 31.3 [1]
9	Supports	6m Span
10	Fluid Density	1000 kg/m3
11	Hydro Test Pressure	13.7250 kg/sq.cm
12	Insulation Thickness	40mm
13	Insulation Material	Mineral Wool
14	Insulation Density	136.15 kg/cu.m
15	Wind Shape Factor	0.7
16	Corrosion Allowance	1.6mm

S. No.	INPUT PARAMETERS (Pipe Size 6")	
1	Pressure	9.15 kg/sq.cm
2	T1 (Operating Temperature)	40°C
3	T2 (Design Temperature)	120°C
4	T3(Minimum Design Temperature MDMT)	minus(-) 10°C
5	Pipe Size	6"
6	Schedule	7.112mm
7	Pipe Material	ASTM A 106 Gr. B
8	ASME Code	ASME B 31.3 [1]
9	Supports	6m Span
10	Fluid Density	1000 kg/m3
11	Hydro Test Pressure	13.7250 kg/sq.cm
12	Insulation Thickness	40mm
13	Insulation Material	Mineral Wool
14	Insulation Density	136.15 kg/cu.m
15	Wind Shape Factor	0.7
16	Corrosion Allowance	1.6mm

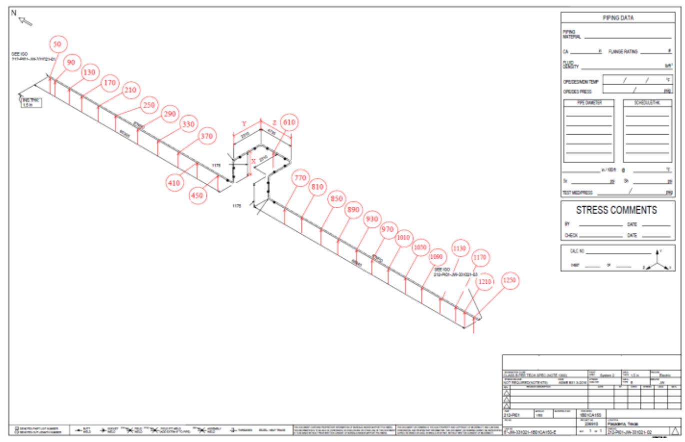
Figure 3 - CAESER-II Input

The distance between anchors is therefore, calculated based on the length required for a thermal displacement of 200mm.

Piping isometrics are created in Smart Plant 3D (Advanced Piping Engineering Software). Piping systems are divided into finite elements by placing node numbers at various points, as shown in Figure 1.



Stress Sketch Isometric Drawing 6"-JW-331020-1B01CA15S-E



Stress Sketch Isometric Drawing 8"-JW-331021-1B01CA15S-E

Figure 4 Iso view of the pipeline to be analyzed

The stress (Piping) system is modeled in Caesar II software. Pressure, weight, temperature, and wind are imposed on the system. Atmospheric temperature is 210°C. To maintain process plant safety, piping systems must be designed so that they do not collapse under stress due to weight, pressure, temperature, and other destructive conditions. ASME provides guidelines that must be followed to keep process equipment safe. This guideline is published as ASME B 31.3 code [4]. It is crucial for engineers and designers to estimate the lengths of these loops while designing the piping racks for petrochemical plants, which are built up of thousands of pipeline systems. A combination of different design cases must be considered when optimizing loop sizes. Design impacts plant design, material costs, and safety. In this paper, the various load cases are made and systematically stress analyzed for all the possible failure condition in case of worst case scenario. This is common practice in process plants.

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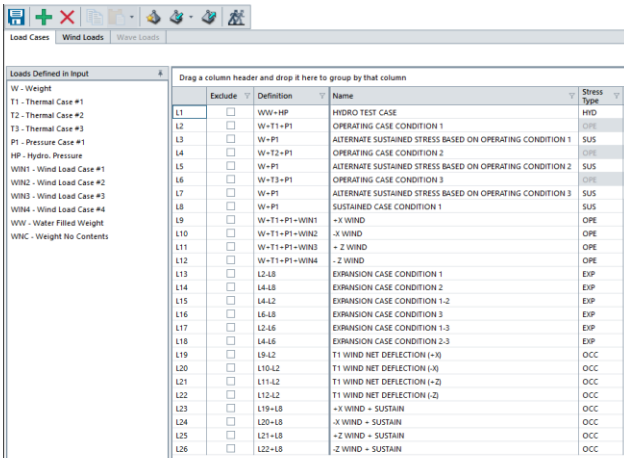

	Exclude	Definition	Name	Stress Type
L1	☐	WW+HP	HYDRO TEST CASE	HYD
L2	☐	W+T1+P1	OPERATING CASE CONDITION 1	OPE
L3	☐	W+P1	ALTERNATE SUSTAINED STRESS BASED ON OPERATING CONDITION 1	SUS
L4	☐	W+T2+P1	OPERATING CASE CONDITION 2	OPE
L5	☐	W+P1	ALTERNATE SUSTAINED STRESS BASED ON OPERATING CONDITION 2	SUS
L6	☐	W+T3+P1	OPERATING CASE CONDITION 3	OPE
L7	☐	W+P1	ALTERNATE SUSTAINED STRESS BASED ON OPERATING CONDITION 3	SUS
L8	☐	W+P1	SUSTAINED CASE CONDITION 1	SUS
L9	☐	W+T1+P1+WIN1	+X WIND	OPE
L10	☐	W+T1+P1+WIN2	-X WIND	OPE
L11	☐	W+T1+P1+WIN3	+ Z WIND	OPE
L12	☐	W+T1+P1+WIN4	- Z WIND	OPE
L13	☐	L2-L8	EXPANSION CASE CONDITION 1	EXP
L14	☐	L4-L8	EXPANSION CASE CONDITION 2	EXP
L15	☐	L4-L2	EXPANSION CASE CONDITION 1-2	EXP
L16	☐	L6-L8	EXPANSION CASE CONDITION 3	EXP
L17	☐	L2-L6	EXPANSION CASE CONDITION 1-3	EXP
L18	☐	L4-L6	EXPANSION CASE CONDITION 2-3	EXP
L19	☐	L9-L2	T1 WIND NET DEFLECTION (+X)	OCC
L20	☐	L10-L2	T1 WIND NET DEFLECTION (-X)	OCC
L21	☐	L11-L2	T1 WIND NET DEFLECTION (+Z)	OCC
L22	☐	L12-L2	T1 WIND NET DEFLECTION (-Z)	OCC
L23	☐	L19+L8	+X WIND + SUSTAIN	OCC
L24	☐	L20+L8	-X WIND + SUSTAIN	OCC
L25	☐	L21+L8	+Z WIND + SUSTAIN	OCC
L26	☐	L22+L8	-Z WIND + SUSTAIN	OCC

Figure 5 Load combination for Design

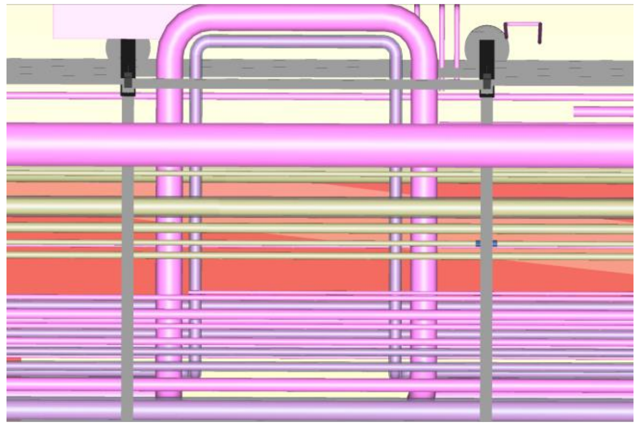

Figure 6 Smart Plant Review of 3D model

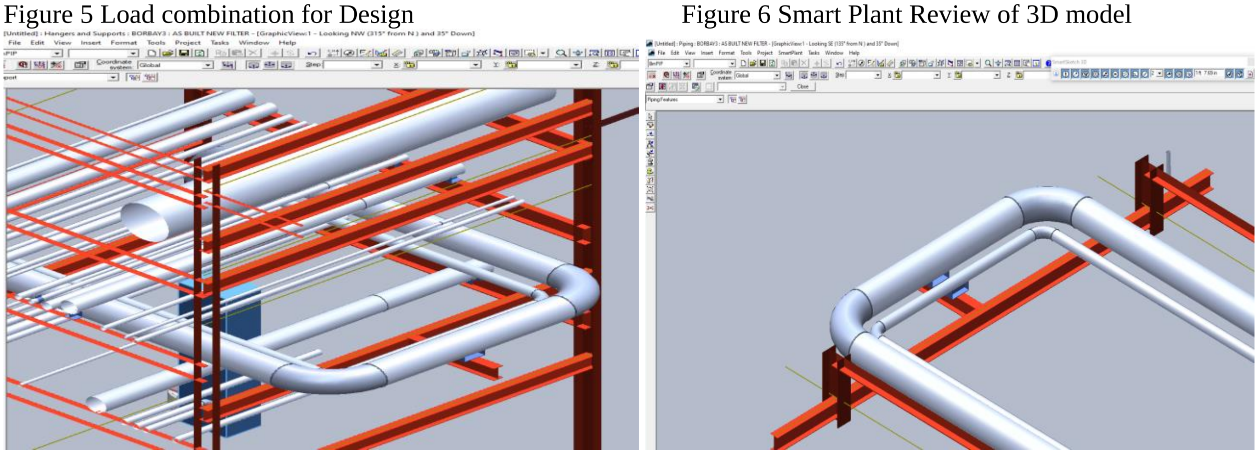

Figure 7: Computer (SP3D) Model of 3 dimensional Expansion loop

The vertical leg of the 3D loop has the limitation that it cannot move beyond the next level (layer) of the tubular frame. In general, the vertical loop length is taken as half the distance between two levels of the pipe rack. At these levels, the Pipe-rack has tie beams on either side from which can get support if needed. Horizontal legs required for extended loops play an important role in laying pipes frame structure. If the horizontal legs are large, they should be placed so that the loops do not leave the tubular rack.

An extension loop is erected approximately midway along the entire length of the Pipe-rack. Anchors are placed on both sides of the expansion loop, so all expansion is absorbed by this loop and does not extend into the device. This project creates an 3D unfolding loop. Anchors are used at both ends of the pipe rack. The distance between anchors is calculated based on the maximum distance that shoe supports (supports for insulating pipes) can travel. Shoe support length is generally 200-500mm.

The maximum possible expansion is limited to 100 mm for maintaining support in the structure of PR (pipe-rack). This is on one side of the stretch loop. An extension of 100 mm is also possible on the other side of the tubular frame. The distance between anchors is therefore calculated based on the length required for a thermal displacement of 200mm. Piping isometrics are created in Smart Plant 3D (Advanced Piping Engineering Software) and simultaneously 3D model is reviewed in Navis review/Smart Plant Review SPR software which is used for 3D model review. Piping systems are divided into finite elements by placing node numbers at various points, as shown in Figure 5.

INPUT PARAMETERS FOR ANALYSIS

The piping system is modeled in Caesar II software. Loads due to Weight, Pressure, Temperature and Wind are imposed on the system. The atmospheric temperature is assumed as 210C. (Figure 3)

IV. RESULTS AND DISCUSSION

The final loop dimensions are obtained which solves our the intension of completing the technical paper which is to investigate the expansion of two piping system and I return calculating the optimized 3D piping loop. By evaluating the following reports the purpose is solved.

Stress Summary Report shown in table.
Displacement Report shown in table.
Restraint Summary Report shown in table.
The movement of the pipes near expansion loop is plotted in the figure 9.

Stress Summary Report

CASE 1 (HYD) WW+HP
CASE 3 (Alt-SUS) W+P1
CASE 5 (Alt-SUS) W+P1
CASE 7 (Alt-SUS) W+P1
CASE 8 (SUS) W+P1
CASE 13 (EXP) L13=L2-L8
CASE 14 (EXP) L14=L4-L8
CASE 15 (EXP) L15=L4-L2
CASE 16 (EXP) L16=L6-L8
CASE 17 (EXP) L17=L2-L6
CASE 18 (EXP) L18=L4-L6
CASE 23 (OCC) L23=L19+L8
CASE 24 (OCC) L24=L20+L8
CASE 25 (OCC) L25=L21+L8
CASE 26 (OCC) L26=L22+L8

CODE STRESS CHECK PASSED:	LOADCASE 1 (HYD) WW+HP				**CODE STRESS CHECK PASSED:**	LOADCASE 16 (EXP) L16=L6-L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 1 (HYD) WW+HP				Highest Stresses: (kg/sq.cm)	LOADCASE 16 (EXP) L16=L6-L8		
Ratio (%):	**8.3**	@Node	610		**Ratio (%):**	**18.5**	@Node	570
Code Stress:	203.9	Allowable Stress:	2464		Code Stress:	390.2	Allowable Stress:	2112
Axial Stress:	81.8	@Node	488		Axial Stress:	22.7	@Node	930
Bending Stress:	128	@Node	3210		Bending Stress:	383.9	@Node	570
Torsion Stress:	5.8	@Node	2530		Torsion Stress:	60.8	@Node	490
Hoop Stress:	170.1	@Node	50		Hoop Stress:	0	@Node	50
Max Stress Intensity:	208.5	@Node	610		Max Stress Intensity:	474.6	@Node	570
CODE STRESS CHECK PASSED:	LOADCASE 3 (Alt-SUS) W+P1				**CODE STRESS CHECK PASSED:**	LOADCASE 17 (EXP) L17=L2-L6		
Highest Stresses: (kg/sq.cm)	LOADCASE 3 (Alt-SUS) W+P1				Highest Stresses: (kg/sq.cm)	LOADCASE 17 (EXP) L17=L2-L6		
Ratio (%):	**16.7**	@Node 3210			**Ratio (%):**	**25**	@Node	570
Code Stress:	235.8	Allowable Stress:	1408		Code Stress:	528.1	Allowable Stress:	2112
Axial Stress:	69.6	@Node	488		Axial Stress:	46	@Node	930
Bending Stress:	172.7	@Node	3210		Bending Stress:	519.5	@Node	570

Torsion Stress:	8.4	@Node	2530		Torsion Stress:	83.2	@Node	490
Hoop Stress:	143.2	@Node	50		Hoop Stress:	0	@Node	50
Max Stress Intensity:	235.8	@Node	610		Max Stress Intensity:	642.3	@Node	570
CODE STRESS CHECK PASSED:	LOADCASE 5 (Alt-SUS) W+P1				**CODE STRESS CHECK PASSED:**	LOADCASE 18 (EXP) L18=L4-L6		
Highest Stresses: (kg/sq.cm)	LOADCASE 5 (Alt-SUS) W+P1				Highest Stresses: (kg/sq.cm)	LOADCASE 18 (EXP) L18=L4-L6		
Ratio (%):	**17**	@Node	610		**Ratio (%):**	**75.5**	@Node	648
Code Stress:	238.9	Allowable Stress:	1408		Code Stress:	1593.9	Allowable Stress:	2112
Axial Stress:	69.7	@Node	488		Axial Stress:	45.2	@Node	930
Bending Stress:	172.7	@Node	3210		Bending Stress:	1569.4	@Node	648
Torsion Stress:	9.1	@Node	2530		Torsion Stress:	237.4	@Node	490
Hoop Stress:	143.2	@Node	50		Hoop Stress:	0	@Node	50
Max Stress Intensity:	238.9	@Node	610		Max Stress Intensity:	1938.6	@Node	648
CODE STRESS CHECK PASSED:	LOADCASE 7 Alt-SUS) W+P1				**CODE STRESS CHECK PASSED:**	LOADCASE 23 (OCC) L23=L19+L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 7 Alt-SUS) W+P1				Highest Stresses: (kg/sq.cm)	LOADCASE 23 (OCC) L23=L19+L8		
Ratio (%):	**16.7**	@Node	3210		**Ratio (%):**	**12.6**	@Node	3210
Code Stress:	235.8	Allowable Stress:	1408		Code Stress:	235.8	Allowable Stress:	1872.6
Axial Stress:	69.6	@Node	488		Axial Stress:	71.2	@Node	410
Bending Stress:	172.7	@Node	3210		Bending Stress:	172.7	@Node	3210
Torsion Stress:	8.6	@Node	2530		Torsion Stress:	16.9	@Node	2530
Hoop Stress:	143.2	@Node	50		Hoop Stress:	143.2	@Node	50
Max Stress Intensity:	235.8	@Node	610		Max Stress Intensity:	235.8	@Node	3210
CODE STRESS CHECK PASSED:	LOADCASE 8 (SUS) W+P1				**CODE STRESS CHECK PASSED:**	LOADCASE 24 (OCC) L23=L19+L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 8 (SUS) W+P1				Highest Stresses: (kg/sq.cm)	LOADCASE 24 (OCC) L23=L19+L8		
Ratio (%):	**16.7**	@Node	3210		**Ratio (%):**	**12.6**	@Node	3210
Code Stress:	235.8	Allowable Stress:	1408		Code Stress:	235.8	Allowable Stress:	1872.6
Axial Stress:	69.4	@Node	488		Axial Stress:	71.2	@Node	850
Bending Stress:	172.7	@Node	3210		Bending Stress:	172.7	@Node	3210
Torsion Stress:	7.8	@Node	2530		Torsion Stress:	16.9	@Node	2650
Hoop Stress:	143.2	@Node	50		Hoop Stress:	143.2	@Node	50
Max Stress Intensity:	235.8	@Node	610		Max Stress Intensity:	235.8	@Node	3210
CODE STRESS CHECK PASSED:	LOADCASE 13 (EXP) L13=L2-L8				**CODE STRESS CHECK PASSED:**	LOADCASE 25 (OCC) L25=L21+L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 13 (EXP) L13=L2-L8				Highest Stresses: (kg/sq.cm)	LOADCASE 25 (OCC) L25=L21+L8		

Ratio (%):	**6.5**	@Node	570
Code Stress:	137.9	Allowable Stress:	2112
Axial Stress:	23.3	@Node	930
Bending Stress:	135.6	@Node	570
Torsion Stress:	22.5	@Node	690
Hoop Stress:	0	@Node	690
Max Stress Intensity:	167.7	@Node	570
CODE STRESS CHECK PASSED:	LOADCASE 14 (EXP) L14=L4-L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 14 (EXP) L14=L4-L8		
Ratio (%):	**57**	@Node	648
Code Stress:	1203.7	Allowable Stress:	2112
Axial Stress:	26.7	@Node	370
Bending Stress:	1185.5	@Node	648
Torsion Stress:	176.6	@Node	490
Hoop Stress:	0	@Node	50
Max Stress Intensity:	1464	@Node	648
CODE STRESS CHECK PASSED:	LOADCASE 15 (EXP) L15=L4-L2		
Highest Stresses: (kg/sq.cm)	LOADCASE 15 (EXP) L15=L4-L2		
Ratio (%):	**50.5**	@Node	648
Code Stress:	1065.8	Allowable Stress:	2112
Axial Stress:	16.3	@Node	370
Bending Stress:	1049.9	@Node	648
Torsion Stress:	154.2	@Node	490
Hoop Stress:	0	@Node	50
Max Stress Intensity:	1296.3	@Node	648

Ratio (%):	**21.3**	@Node	3170
Code Stress:	397.7	Allowable Stress:	1872.6
Axial Stress:	69.6	@Node	648
Bending Stress:	332.6	@Node	3170
Torsion Stress:	14.5	@Node	2689
Hoop Stress:	143.2	@Node	50
Max Stress Intensity:	398.5	@Node	3170
CODE STRESS CHECK PASSED:	LOADCASE 26 (OCC) L26=L22+L8		
Highest Stresses: (kg/sq.cm)	LOADCASE 26 (OCC) L26=L22+L8		
Ratio (%):	**21.3**	@Node	3170
Code Stress:	398.7	Allowable Stress:	1872.6
Axial Stress:	69.9	@Node	410
Bending Stress:	332.9	@Node	3170
Torsion Stress:	13.1	@Node	2690
Hoop Stress:	143.2	@Node	50
Max Stress Intensity:	399.5	@Node	3170

This shows ratio of maximum stress produced in the analyzed system to allowable stress ratio as per ASME B31.3 (7) (for different combination of the load cases). The ratio should be less than 100% for safe system and this is achieved as tabulated in the stress summary report.

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Displacement Report

Node	Load Case	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
LOAD CASE DEFINITION KEY CASE 2 (OPE) W+T1+P1 CASE 4 (OPE) W+T2+P1 CASE 8 (SUS) W+P1							
410							
	2(OPE)	1.92	0.00	0.18	-0.01	0.00	-0.01
	4(OPE)	17.66	0.00	6.26	-0.06	-0.05	-0.03
	8(SUS)	0.00	0.00	0.00	-0.02	0.00	-0.01
	MAX	17.66/L4	-0.00/L4	6.26/L4	-0.06/L4	-0.05/L4	-0.03/L4
450							
	2(OPE)	2.89	0.00	0.00	-0.01	0.01	0.03
	4(OPE)	26.50	0.00	0.00	-0.06	0.24	0.12
	8(SUS)	0.00	0.00	0.00	-0.02	-0.01	0.02
	MAX	26.50/L4	-0.00/L8	-0.00/L4	-0.06/L4	0.24/L4	0.12/L4
570	2(OPE)	-0.34	-0.85	-1.21	-0.04	0.01	0.04
	4(OPE)	-3.03	-2.39	-11.75	-0.21	0.23	0.12
	8(SUS)	0.00	-0.71	-0.23	-0.02	-0.01	0.03
	MAX	-3.03/L4	-2.39/L4	-11.75/L4	-0.21/L4	0.23/L4	0.12/L4
610	2(OPE)	0.00	0.00	-1.37	-0.04	0.00	0.00
	4(OPE)	0.01	0.00	-15.80	-0.21	0.00	0.00
	8(SUS)	0.00	0.00	0.00	-0.02	0.00	0.00
	MAX	0.01/L4	-0.00/L8	-15.80/L4	-0.21/L4	0.00/L4	0.00/L4
770	2(OPE)	-2.89	0.00	0.00	-0.01	-0.01	-0.03
	4(OPE)	-26.50	0.00	0.00	-0.06	-0.25	-0.12
	8(SUS)	0.00	0.00	0.00	-0.02	0.01	-0.02
	MAX	-26.50/L4	-0.00/L8	-0.00/L4	-0.06/L4	-0.25/L4	-0.12/L4
810	2(OPE)	-1.92	0.00	0.18	-0.01	0.00	0.01
	4(OPE)	-17.66	0.00	6.43	-0.06	0.05	0.03
	8(SUS)	0.00	0.00	0.00	-0.02	0.00	0.01
	MAX	-17.66/L4	-0.00/L4	6.43/L4	-0.06/L4	0.05/L4	0.03/L4
850	2(OPE)	-0.96	0.00	0.00	-0.01	0.00	0.00
	4(OPE)	-8.83	0.00	0.00	-0.06	0.04	-0.01
	8(SUS)	0.00	0.00	0.00	-0.02	0.00	0.00
	MAX	-8.83/L4	-0.00/L8	0.00/L4	-0.06/L4	0.04/L4	-0.01/L4
2330	2(OPE)	0.00	0.00	0.00	0.00	0.00	0.00
	4(OPE)	0.00	0.00	0.00	-0.07	0.01	0.00
	8(SUS)	0.00	0.00	0.00	-0.01	0.00	0.00
	MAX 0.00/L2 - 0.00/L4	0.00/L2	-0.00/L4	-0.00/L4	-0.07/L4	0.01/L4	-0.00/L4
2370	2(OPE)	0.74	0.00	0.00	0.00	0.00	0.00
	4(OPE)	6.66	0.00	0.00	-0.07	-0.02	0.01
	8(SUS)	0.00	0.00	0.00	-0.01	0.00	0.00
	MAX	6.66/L4	-0.00/L8	0.00/L4	-0.07/L4	-0.02/L4	0.01/L4
2410	2(OPE)	1.50	0.00	0.04	0.00	0.00	0.00
	4(OPE)	13.33	0.00	3.88	-0.07	-0.04	-0.03
	8(SUS)	0.00	0.00	0.00	-0.01	0.00	0.00
	MAX	13.33/L4	-0.00/L4	3.88/L4	-0.07/L4	-0.04/L4	-0.03/L4
2610	2(OPE)	0.00	0.00	-0.83	-0.03	0.00	0.00

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	4(OPE)	0.00	0.00	-12.70	-0.16	0.00	0.00
	8(SUS)	0.00	0.00	0.00	-0.01	0.00	0.00
	MAX	-0.00/L4	-0.00/L8	-12.70/L4	-0.16/L4	-0.00/L4	0.00/L4
2770	2(OPE)	-2.26	0.00	0.00	0.00	0.00	-0.02
	4(OPE)	-20.00	0.00	0.00	-0.07	-0.17	-0.10
	8(SUS)	0.00	0.00	0.00	-0.01	0.01	-0.01
	MAX	-20.00/L4	-0.00/L2	0.00/L2	-0.07/L4	-0.17/L4	-0.10/L4
2810	2(OPE)	-1.50	`	0.04	0.00	0.00	0.00
	4(OPE)	-13.33	0.00	3.88	-0.07	0.04	0.03
	8(SUS)	0.00	0.00	0.00	-0.01	0.00	0.00
	MAX	-13.33/L4	-0.00/L4	3.88/L4	-0.07/L4	0.04/L4	0.03/L4

The displacement report will show the movements of the pipe at different node numbers. This movement will vary from case to case. Displacement report in Case 8: W+P1 (Sustained) was instrumental in deciding the supporting span to avoid excessive sagging as shown in table e.

Similarly, the displacements report in Operating condition Case 2: W+P1+T1 was helpful to check the movements of the pipe at operating conditions as shown in table e. It is restricted to 5mm in vertical, 25mm in horizontal and 100mm axial so that practical inconvenience is avoided. We could see the displacement report of different nodes in the X, Y and Z direction in table e.

Restraint Summary Report

Node	Load Case	FX kg.	FY kg.	FZ kg.	MX kg.m.	MY kg.m.	MZ kg.m.
330	1(HYD)	0	-450	-1	0.0	0.0	0.0
	2(OPE)	389	-479	-1	0.0	0.0	0.0
	4(OPE)	-459	-489	-56	0.0	0.0	0.0
	6(OPE)	-179	-474	12	0.0	0.0	0.0
	8(SUS)	0	-477	-1	0.0	0.0	0.0
	9(OPE)	467	-478	-1	0.0	0.0	0.0
	10(OPE)	316	-479	-1	0.0	0.0	0.0
	11(OPE)	488	-478	120	0.0	0.0	0.0
	12(OPE) MAX	545 545/L12	-479 -489/L4	-124 - 124/L12	0.0	0.0	0.0
370	1(HYD)	0	-440	2	0.0	0.0	0.0
	2(OPE)	140	-461	0	0.0	0.0	0.0
	4(OPE)	156	-422	105	0.0	0.0	0.0
	6(OPE)	-149	-478	-19	0.0	0.0	0.0
	8(SUS)	0	-466	2	0.0	0.0	0.0
	9(OPE)	141	-464	0	0.0	0.0	0.0
	10(OPE)	140	-459	0	0.0	0.0	0.0
	11(OPE)	227	-463	228	0.0	0.0	0.0

Node	Load Case	FX kg.	FY kg.	FZ kg.	MX kg.m.	MY kg.m.	MZ kg.m.
2250	1(HYD)	0	-281	0	0.0	0.0	0.0
	2(OPE)	-94	-303	0	0.0	0.0	0.0
	4(OPE)	-91	-303	0	0.0	0.0	0.0
	6(OPE)	92	-303	0	0.0	0.0	0.0
	8(SUS)	0	-303	0	0.0	0.0	0.0
	9(OPE)	-94	-303	0	0.0	0.0	0.0
	10(OPE)	-94	-303	0	0.0	0.0	0.0
	11(OPE)	-48	-303	82	0.0	0.0	0.0
	12(OPE) MAX	0	-303 -303/L4	-82 -82/L12	0.0	0.0	0.0
2290	1(HYD)	0	-281	0	0.0	0.0	0.0
	2(OPE)	-94	-302	0	0.0	0.0	0.0
	4(OPE)	-91	-301	3	0.0	0.0	0.0
	6(OPE)	92	-303	-1	0.0	0.0	0.0
	8(SUS)	0	-302	0	0.0	0.0	0.0
	9(OPE)	-94	-302	0	0.0	0.0	0.0
	10(OPE)	-94	-302	0	0.0	0.0	0.0
	11(OPE)	-149	-302	175	0.0	0.0	0.0

	12(OPE)	207	-459	-221	0.0	0.0	0.0
	MAX	227/L11	-478/L6	228/L11			
410	1(HYD)	0	-480	-8	0.0	0.0	0.0
	2(OPE)	152	-526	15	0.0	0.0	0.0
	4(OPE)	194	-676	69	0.0	0.0	0.0
	6(OPE)	-126	-462	-35	0.0	0.0	0.0
	8(SUS)	0	-508	-9	0.0	0.0	0.0
	9(OPE)	151	-518	13	0.0	0.0	0.0
	10(OPE)	152	-535	17	0.0	0.0	0.0
	11(OPE)	95	-519	113	0.0	0.0	0.0
	12(OPE) MAX	107 194/L4	-534 -676/L4	-93 113/L11	0.0	0.0	0.0
450	1(HYD)	1	-421	46	0.0	0.0	0.0
	2(OPE)	151	-445	54	0.0	0.0	0.0
	4(OPE)	113	-329	-58	0.0	0.0	0.0
	6(OPE)	-138	-414	-50	0.0	0.0	0.0
	8(SUS)	1	-446	48	0.0	0.0	0.0
	9(OPE)	147	-440	47	0.0	0.0	0.0
	10(OPE)	152	-448	55	0.0	0.0	0.0
	11(OPE)	247	-486	260	0.0	0.0	0.0
	12(OPE) MAX	165 247/L11	-405 - 486/L11	-148 260/L11	0.0	0.0	0.0
610	1(HYD)	0	-467	-78	0.0	0.0	0.0
	2(OPE)	0	-468	-135	0.0	0.0	0.0
	4(OPE)	0	-464	-143	0.0	0.0	0.0
	6(OPE)	0	-633	188	0.0	0.0	0.0
	8(SUS)	0	-495	-83	0.0	0.0	0.0
	9(OPE)	42	-471	-130	0.0	0.0	0.0
	10(OPE)	-42	-471	-130	0.0	0.0	0.0
	11(OPE)	0	-399	-105	0.0	0.0	0.0
	12(OPE) MAX	-0 42/L9	-536 -633/L6	-167 188/L6	0.0	0.0	0.0
770	1(HYD)	-1	-421	46	0.0	0.0	0.0
	2(OPE)	-151	-445	54	0.0	0.0	0.0
	4(OPE)	-112	-329	-54	0.0	0.0	0.0
	6(OPE)	138	-414	-50	0.0	0.0	0.0
	8(SUS)	-1	-446	48	0.0	0.0	0.0
	9(OPE)	-152	-448	55	0.0	0.0	0.0

	12(OPE) MAX	-148 - 149/L11	-302 -303/L6	-174 175/L11	0.0	0.0	0.0
2330	1(HYD)	0	-281	0	0.0	0.0	0.0
	2(OPE)	264	-303	0	0.0	0.0	0.0
	4(OPE)	-28	-307	-13	0.0	0.0	0.0
	6(OPE)	-156	-302	2	0.0	0.0	0.0
	8(SUS)	0	-303	0	0.0	0.0	0.0
	9(OPE)	335	-303	0	0.0	0.0	0.0
	10(OPE)	213	-304	0	0.0	0.0	0.0
	11(OPE)	314	-303	102	0.0	0.0	0.0
	12(OPE) MAX	346 346/L12	-304 -307/L4	-104 - 104/L12	0.0	0.0	0.0
2370	1(HYD)	0	-280	1	0.0	0.0	0.0
	2(OPE)	91	-300	0	0.0	0.0	0.0
	4(OPE)	93	-286	22	0.0	0.0	0.0
	6(OPE)	-92	-306	-3	0.0	0.0	0.0
	8(SUS)	0	-301	1	0.0	0.0	0.0
	9(OPE)	92	-301	0	0.0	0.0	0.0
	10(OPE)	91	-298	0	0.0	0.0	0.0
	11(OPE)	153	-302	189	0.0	0.0	0.0
	12(OPE) MAX	151 153/L11	-298 -306/L6	-185 189/L11	0.0	0.0	0.0
2410	1(HYD)	0	-286	-3	0.0	0.0	0.0
	2(OPE)	95	-313	2	0.0	0.0	0.0
	4(OPE)	100	-365	29	0.0	0.0	0.0
	6(OPE)	-88	-290	-14	0.0	0.0	0.0
	8(SUS)	-1	-308	-4	0.0	0.0	0.0
	9(OPE)	92	-308	3	0.0	0.0	0.0
	10(OPE)	95	-320	3	0.0	0.0	0.0
	11(OPE)	27	-306	79	0.0	0.0	0.0
	12(OPE) MAX	30 100/L4	-321 -365/L4	-81 -81/L12	0.0	0.0	0.0
2450	1(HYD)	-3	-295	18	0.0	0.0	0.0
	2(OPE)	113	-324	35	0.0	0.0	0.0
	4(OPE)	83	-284	-2	0.0	0.0	0.0
	6(OPE)	-100	-291	-46	0.0	0.0	0.0
	8(SUS)	-3	-318	20	0.0	0.0	0.0
	9(OPE)	104	-316	27	0.0	0.0	0.0
	10(OPE)	108	-327	34	0.0	0.0	0.0
	11(OPE)	174	-356	215	0.0	0.0	0.0

	10(OPE)	-147	-440	47	0.0	0.0	0.0
	11(OPE)	-247	-486	260	0.0	0.0	0.0
	12(OPE) MAX	-165 -247/L11	-405 - 486/L11	-148 260/L11	0.0	0.0	0.0
810	1(HYD)	0	-480	-8	0.0	0.0	0.0
	2(OPE)	-152	-526	15	0.0	0.0	0.0
	4(OPE)	-172	-676	63	0.0	0.0	0.0
	6(OPE)	126	-462	-35	0.0	0.0	0.0
	8(SUS)	0	-508	-9	0.0	0.0	0.0
	9(OPE)	-152	-535	17	0.0	0.0	0.0
	10(OPE)	-151	-518	13	0.0	0.0	0.0
	11(OPE)	-95	-519	113	0.0	0.0	0.0
	12(OPE) MAX	-107 -172/L4	-534 -676/L4	-93 113/L11	0.0	0.0	0.0
850	1(HYD)	0	-440	2	0.0	0.0	0.0
	2(OPE)	-140	-461	0	0.0	0.0	0.0
	4(OPE)	-165	-422	110	0.0	0.0	0.0
	6(OPE)	149	-478	-19	0.0	0.0	0.0
	8(SUS)	0	-466	2	0.0	0.0	0.0
	9(OPE)	-140	-459	0	0.0	0.0	0.0
	10(OPE)	-141	-464	0	0.0	0.0	0.0
	11(OPE)	-227	-463	228	0.0	0.0	0.0
	12(OPE) MAX	-207 -227/L11	-459 -478/L6	-221 228/L11	0.0	0.0	0.0
890	1(HYD)	-0	-450	-1	0.0	0.0	0.0
	2(OPE)	-699	-479	-1	0.0	0.0	0.0
	4(OPE)	213	-489	-58	0.0	0.0	0.0
	6(OPE)	471	-474	12	0.0	0.0	0.0
	8(SUS)	0	-477	-1	0.0	0.0	0.0
	9(OPE)	-627	-479	-1	0.0	0.0	0.0
	10(OPE)	-778	-478	-1	0.0	0.0	0.0
	11(OPE)	-886	-478	120	0.0	0.0	0.0
	12(OPE) MAX	-966 -966/L12	-479 -489/L4	-125 - 125/L12	0.0	0.0	0.0

	12(OPE) MAX	129 174/L11	-295 - 356/L11	-137 215/L11	0.0	0.0	0.0
2610	1(HYD)	0	-263	-31	0.0	0.0	0.0
	2(OPE)	0	-262	-74	0.0	0.0	0.0
	4(OPE)	0	-259	-79	0.0	0.0	0.0
	6(OPE)	0	-365	123	0.0	0.0	0.0
	8(SUS)	0	-283	-33	0.0	0.0	0.0
	9(OPE)	42	-266	-66	0.0	0.0	0.0
	10(OPE)	-42	-266	-66	0.0	0.0	0.0
	11(OPE)	0	-210	-56	0.0	0.0	0.0
	12(OPE) MAX	-0 42/L9	-309 -365/L6	-102 123/L6	0.0	0.0	0.0
2770	1(HYD)	3	-295	18	0.0	0.0	0.0
	2(OPE)	-113	-324	35	0.0	0.0	0.0
	4(OPE)	-83	-284	-2	0.0	0.0	0.0
	6(OPE)	100	-291	-46	0.0	0.0	0.0
	8(SUS)	3	-318	20	0.0	0.0	0.0
	9(OPE)	-108	-327	34	0.0	0.0	0.0
	10(OPE)	-104	-316	27	0.0	0.0	0.0
	11(OPE)	-174	-356	215	0.0	0.0	0.0
	12(OPE) MAX	-129 - 174/L11	-295 - 356/L11	-138 215/L11	0.0	0.0	0.0
2810	1(HYD)	0	-286	-3	0.0	0.0	0.0
	2(OPE)	-95	-313	2	0.0	0.0	0.0
	4(OPE)	-100	-365	29	0.0	0.0	0.0
	6(OPE)	88	-290	-14	0.0	0.0	0.0
	8(SUS)	1	-308	-4	0.0	0.0	0.0
	9(OPE)	-95	-320	3	0.0	0.0	0.0
	10(OPE)	-92	-308	3	0.0	0.0	0.0
	11(OPE)	-26	-306	79	0.0	0.0	0.0
	12(OPE) MAX	-30 -100/L4	-321 -365/L4	-81 -81/L12	0.0	0.0	0.0
2850	1(HYD)	0	-280	1	0.0	0.0	0.0
	2(OPE)	-91	-300	0	0.0	0.0	0.0
	4(OPE)	-93	-286	22	0.0	0.0	0.0
	6(OPE)	92	-306	-3	0.0	0.0	0.0
	8(SUS)	0	-301	1	0.0	0.0	0.0
	9(OPE)	-91	-298	0	0.0	0.0	0.0
	10(OPE)	-92	-301	0	0.0	0.0	0.0
	11(OPE)	-153	-302	189	0.0	0.0	0.0

	12(OPE) MAX	-150 - 153/L11	-298 -306/L6	-185 189/L11	0.0	0.0	0.0
2890	1(HYD)	0	-281	0	0.0	0.0	0.0
	2(OPE)	-440	-303	0	0.0	0.0	0.0
	4(OPE)	-154	-307	-13	0.0	0.0	0.0
	6(OPE)	343	-302	2	0.0	0.0	0.0
	8(SUS)	0	-303	0	0.0	0.0	0.0
	9(OPE)	-389	-304	0	0.0	0.0	0.0
	10(OPE)	-511	-303	0	0.0	0.0	0.0
	11(OPE)	-546	-303	103	0.0	0.0	0.0
	12(OPE) MAX	-596 - 596/L12	-304 -307/L4	-105 - 105/L12	0.0	0.0	0.0

The piping System is analysed between two anchors placed between 42 m apart for both the loops. The dimensions X, Y and Z are the outcomes according to ASME B 31.3 [7] which is given below:

For 6"-JW-331020-1B01CA15S-E (Optimized Loop Design for 6” Pipe Size)

X = 1.2m, Y= 2.29m, Z= 3.8m.

For 8"-JW-331021-1B01CA15S-E (Optimized Loop Design for 8” Pipe Size)

X = 1.175m, Y= 2.31m, Z= 4.735m.

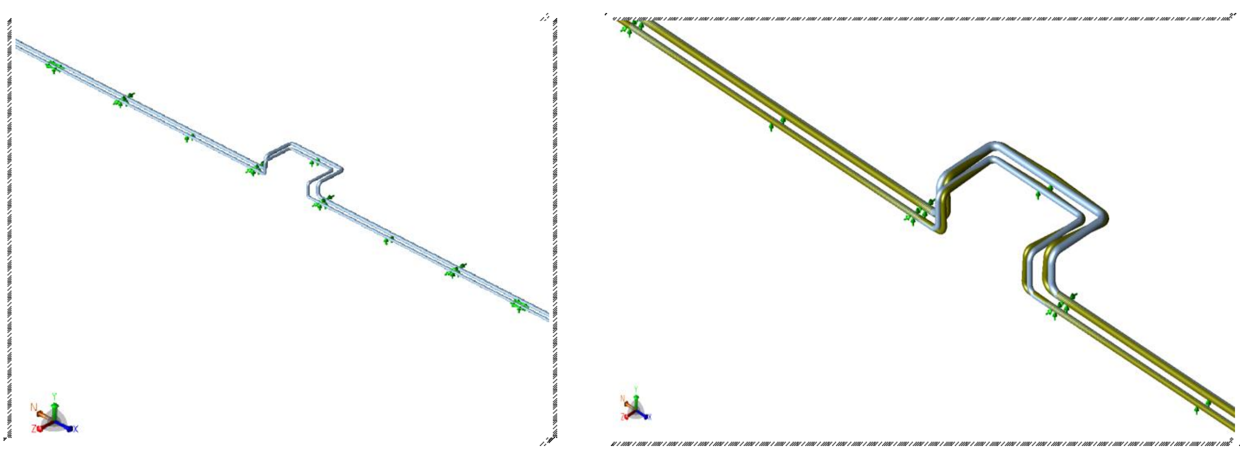
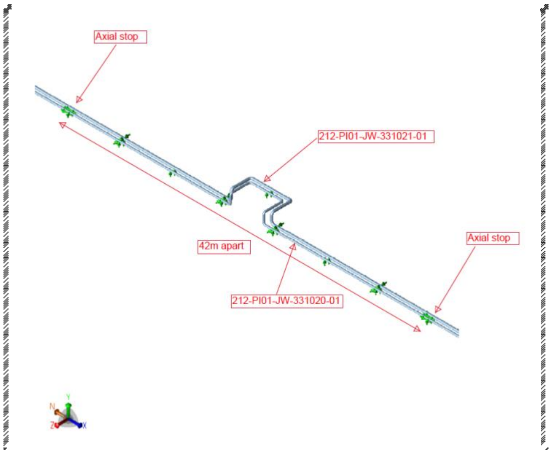


Figure 8 Movement of Expansion loop at Operating condition



(12) **Table A-1 Basic Allowable Stresses in Tension for Metals[1] (Cont'd)**
Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Material	Spec. No.	Type/ Grade	UNS No.	Class/ Condition/ Temper	Size, in.	P-No. (5)	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi Tensile	Specified Min. Strength, ksi Yield	Min. Temp. to 100	200	300
Carbon Steel													
Pipes and Tubes (2)													
A285 Gr. A	A134	...	...	...	...	1	(8b)(57)	B	45	24	15.0	14.7	14.2
A285 Gr. A	A672	A45	K01700	...	...	1	(57)(59)(67)	B	45	24	15.0	14.7	14.2
Butt weld	API 5L	A25	...	...	...	1	(8a)	−20	45	25	15.0	15.0	14.7
Smls & ERW	API 5L	A25	...	...	...	1	(57)(59)	B	45	25	15.0	15.0	14.7
...	A179	...	K01200	...	...	1	(57)(59)	−20	47	26	15.7	15.7	15.3
Type F	A53	A	K02504	...	...	1	(8a)(77)	20	48	30	16.0	16.0	16.0
...	A139	A	...	...	...	1	(8b)(77)	A	48	30	16.0	16.0	16.0
...	A587	...	K11500	...	...	1	(57)(59)	−20	48	30	16.0	16.0	16.0
...	A53	A	K02504	...	...	1	(57)(59)	B	48	30	16.0	16.0	16.0
...	A106	A	K02501	...	...	1	(57)	B	48	30	16.0	16.0	16.0
...	A135	A	...	...	...	1	(57)(59)	B	48	30	16.0	16.0	16.0
...	A369	FPA	K02501	...	...	1	(57)	B	48	30	16.0	16.0	16.0
...	API 5L	A	...	...	...	1	(57)(59)(77)	B	48	30	16.0	16.0	16.0
A285 Gr. B	A134	...	...	...	...	1	(8b)(57)	B	50	27	16.7	16.5	15.9
A285 Gr. B	A672	A50	K02200	...	...	1	(57)(59)(67)	B	50	27	16.7	16.5	15.9
A285 Gr. C	A134	...	...	...	...	1	(8b)(57)	A	55	30	18.3	18.3	17.7
...	A524	II	K02104	...	...	1	(57)	−20	55	30	18.3	18.3	17.7
...	A333	1	K03008	...	...	1	(57)(59)	−50	55	30	18.3	18.3	17.7
...	A334	1	K03008	...	...	1	(57)(59)	−50	55	30	18.3	18.3	17.7
A285 Gr. C	A671	CA55	K02801	...	...	1	(59)(67)	A	55	30	18.3	18.3	17.7
A285 Gr. C	A672	A55	K02801	...	...	1	(57)(59)(67)	A	55	30	18.3	18.3	17.7
A516 Gr. 55	A672	C55	K01800	...	...	1	(57)(67)	C	55	30	18.3	18.3	17.7
A516 Gr. 60	A671	CC60	K02100	...	...	1	(57)(67)	C	60	32	20.0	19.5	18.9
A515 Gr. 60	A671	CB60	K02401	...	...	1	(57)(67)	B	60	32	20.0	19.5	18.9
A515 Gr. 60	A672	B60	K02401	...	...	1	(57)(67)	B	60	32	20.0	19.5	18.9
A516 Gr. 60	A672	C60	K02100	...	...	1	(57)(67)	C	60	32	20.0	19.5	18.9
...	A139	B	K03003	...	...	1	(8b)	A	60	35	20.0	20.0	20.0
...	A135	B	K03018	...	...	1	(57)(59)	B	60	35	20.0	20.0	20.0
...	A524	I	K02104	...	...	1	(57)	−20	60	35	20.0	20.0	20.0
...	A53	B	K03005	...	...	1	(57)(59)	B	60	35	20.0	20.0	20.0
...	A106	B	K03006	...	...	1	(57)	B	60	35	20.0	20.0	20.0
...	A333	6	K03006	...	...	1	(57)	−50	60	35	20.0	20.0	20.0
...	A334	6	K03006	...	...	1	(57)	−50	60	35	20.0	20.0	20.0
...	A369	FPB	K03006	...	...	1	(57)	−20	60	35	20.0	20.0	20.0

Figure 9 (Stress analyzed system)

V. VERIFICATION FROM ASME B31.3

The analysis results is verified from ASME B31.3 [4].

VI. CONCLUSION

In this actual case report, a pipe rack expansion loop is investigated and analysed for two piping systems as per ASME 31.3 [4] code with different loads and boundary conditions. Then after the dimensions of piping loops are optimised and checked for delection if they are not impinging each other under the real time plant operation for the given input parameters. The dimension X,Y, & Z are the final safe dimensions for optimum designing of piping system as per ASME B31.3 [4] is obtained and is given below:

- Isometric drawing with support node numbers and 3D loops dimensions are drawn.
- Movements of piping at particular points are thoroughly evaluated by CAESER-II.
- Supports location, its type and forces acting on are found for under the potimised design of pipe rack and support.

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