Design Conditions:

Code:	**ASME B31.3**	
Year:	**2018**	
Addenda:	**-**	
MAWP Internal:	**2337**	psi
MAWP External:	**0**	psi
Max. Temperature:	**374**	°F
MDMT:	**32**	°F
MDMT Pressure:	**2337**	psi
Corrosion Allowance:	**0**	in
Hydrostatic Test:	**N/A**	psi
Impact Testing:	**None**	
Impact Exemption:	**323.2.2**	
Radiography:	**None**	

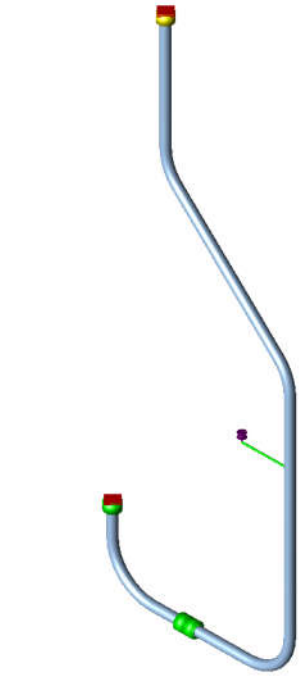
Conclusion:

The Piping w/Spring Hanger Analysis Sample Report has been analyzed to ASME B31.3, 2018 edition rules and is found acceptable.

ASME B31.3 Piping Stress Analysis

Cust: **PVEng**
File: **16579psa-1 R0**
Desc: **Piping w/Spring Hanger Analysis Sample Report**
Dwg: **General Arrangement Drawings**

Date: **January 28, 2021**



Author: **Valentina Ivanova, M.Eng., P.Eng.**
Reviewer: **Martin Hopgood, P.Eng.**

Engineering Notes

Notes:

1. This analysis represents the piping displacement, Nozzle loads and stress evaluation of connection pipe line from Nozzle N4 to Nozzle N5.

2. This analysis does not guarantee leak tightness of gasketed joints.

3. The piping system is located indoor, therefore this analysis only includes effect of Earthquake loading for site data provided by client.

4. NPS 3" SCH 80 used for the Trunnion at the Spring Hanger location.

5. All recommendations outlined in this report must be accommodated and no change in any part to the layout and supports (types and locations) can be made for the results to remain valid.

6. This analysis only represents information received from the client. Pressure Vessel Engineering has no part in the fabrication and construction activities to control alignment with the calculations and assumptions made.

301 Loads Considered:

(301.2) Design Pressure: **Yes**
(301.3) Design Temperature: **Yes**
(301.4) Ambient Effects: **Yes**
(301.5) Dynamic Effects: **Yes**
(301.6) Weight Effects: **Yes**
(301.7) Thermal Expansion Effects: **Yes**
(301.8) Support Effects: **Yes**
(301.9) Reduced Ductility Effects: **No**
(301.10) Cyclic Effects: **No**
(301.11) Air Condensation Effects: **No**

Revisions:

Rev	Description	Date	Initials
0	Release	2021-01-28	VDI

Contents

Scope of work:

This document presents the input data and stress analysis results for piping installed in Canada. The piping system installed and anlaysed in this report is comprised of the following components (see Figure 1):

- NPS 4" SCH 80 Inlet (Interface point: N4)
- NPS 4" SCH 80 Outlet (Interface point: N5)

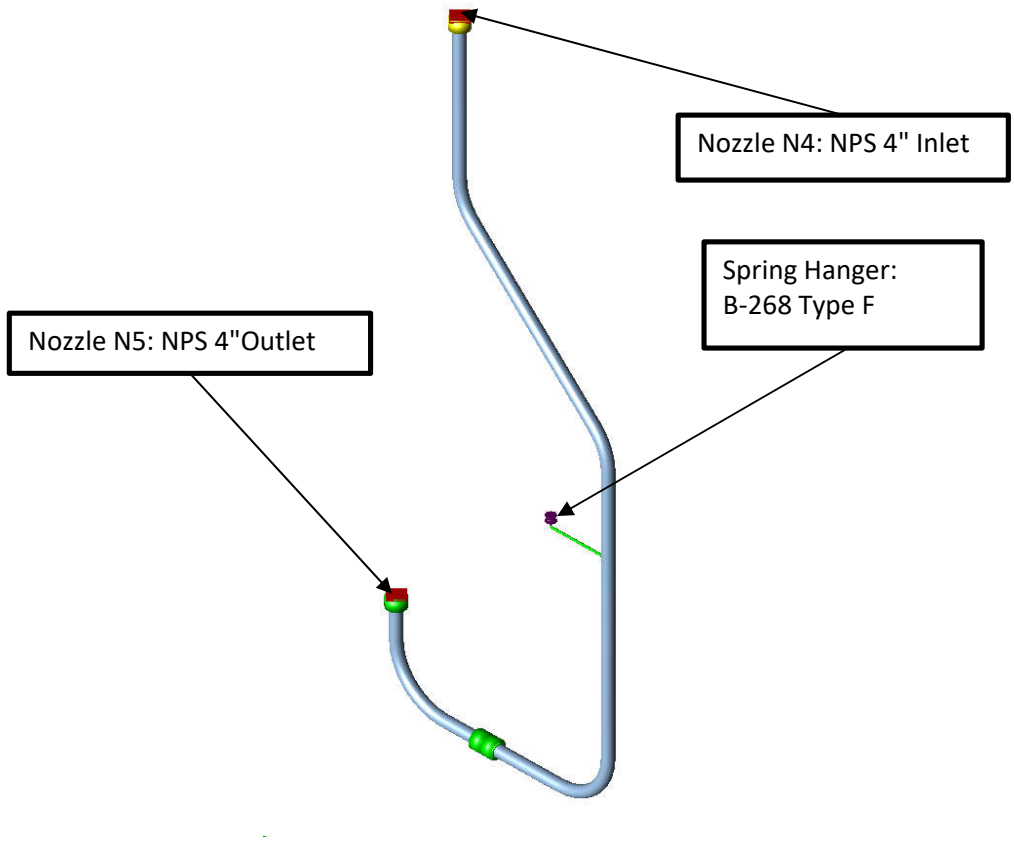


Fig-1: NPS 4" Connecting Inlet and Outlet Piping

The following sections present the analysis methodology, considerations and results.
Applicable references are presented in Section " References".

Goal:

In accordance with the rules of ASME B31.3, Chapter II, Part 5, a piping flexibility (stress) analysis (PSA) is conducted to validate the design. The PSA is performed in accordance with ASME B31.3 rules and evaluated at the code allowable stresses for each load case.

Summary Conclusions:

Analysis Software

CAESAR II v.12 Build 20040

Analysis Type

A static linear elastic study is performed using small displacement theory.

Materials

Material properties used in this report are obtained from ASME B31.3, 2018 Edition. Stress limits are set in accordance with the B31.3 code rules.

Model Information, Restraints & Loads

A model of the piping system was created in Caesar II using the client provided drawings and design data. Conservatively it was assumed that the Nozzles N4 and N5 are fully restrained. The loads setup values for the existing Spring Hanger were not provided, the client requested PVEng to make recommendations on Spring Hanger operating load value, size and type. The Spring Hanger location was determined by client and it will be located at 25.59 in (650 mm) in -X direction supported by trunnion. Trunnion will be designed by others and is not part of this analysis report.
The internal design pressure of 2,337 psi @ 374 °F was applied to all elements. The fluid media is urea solution.

Results

In summary, all the analysis results and observed stresses satisfied the evaluation criteria and are below their respective allowable limits. With the analysis methodology, considerations and results presented in this document, the piping system is deemed structurally adequate for the specified design purposes.

Recommendations

Recommended Spring Hanger to be used in this application based on CAESER II Output vales is:
Anvil B-268, Type F, Size 8

Analysis Conclusion:

The Piping w/Spring Hanger Analysis Sample Report has been analyzed to ASME B31.3, 2018 edition rules and is found acceptable.

Methodology

Analysis Type

A piping flexibility analysis was performed according to ASME B31.3, 2018 Edition rules using CAESAR II v.12 Build 200403 software. All documents were received electronically. Communication with and documentation supplied by the client provided the basis for the data used in the analysis. The data is summarized as follows:

Analysis Data

Design Conditions:
Design Pressure: 2,337 psi
Design Temperature: 374 °F

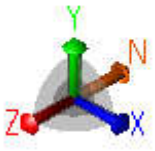
Material and Restraint types along with their general locations were indicated on the piping layout general arrangement drawings.
Seismic load was applied as uniform seismic horizontal acceleration in accordance with NBC-2015

Piping system is located indoor, Wind and Snow load is not applicable.

The piping stress model was built to analyze the system and meet all the necessary requirements.

Nomenclature

The coordinate system in CAESAR II is shown below. The N - North direction is arbitrary as no plant N direction was provided.



Elements and Nodes

Beam elements were used based on the differential length between nodes. Each element has two nodes represented as FROM and TO.

Node numbers are referred as N- # where required.
Element length units are inches.

Load Nomenclature

W = Dead Weight
T1 = Design Temperature
T2 = MDMT Temperature
P1 = Design Pressure
H = Spring Hanger Loads
U1 = Seismic Load " X" direction
U3 = Seismic Load " Z" direction

Load Case Nomenclature

EXP = Expansion (Thermal Only)
SUS = Sustained (Pressure and Weight)
OPE = Operating (SUS + Thermal Load + Spring Hanger Load)
OCC = Occasional (Seismic Only; SUS + Seismic)

Units

F = Force (Units =lb)
M = Moment (Units = lb-ft)
D = Displacement (Units = in)

Input Parameters

Design Code : ASME B31.3, 2018 Edition
Design Temperature : 374 °F
Design Pressure : 2,337 psi
MDMT : 32 °F
Fluid Service : Urea Solution No Lethal

Material and Specification Data

Material was determined from the drawings with allowable stresses taken from ASME B31.3 Appendix A. Tolerances and physical properties are taken from ASME BPVC Section VIII-1 Part II. The following table summarizes the information in the model.

Component	Material	Size (NPS)	Thickness / Rating	Corrosion Allowance
Pipe	A-790 Pipe S32906	4	Sch. 80	None
Flanges	A105	4		None

Model

Figure 2 shows the ISO piping model.

Fig-2. Piping Model

Nodes

Figure 3 shows all the nodes ID used in the model.

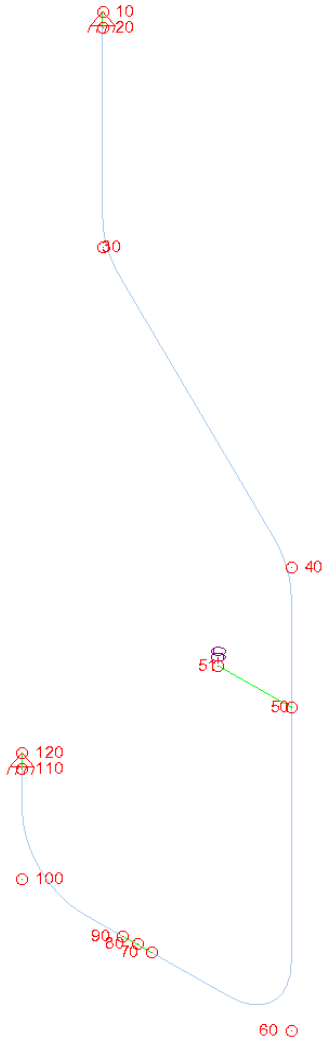


Fig-3. Model Nodes Labels

Material

Figure 4 shows the material assignment.

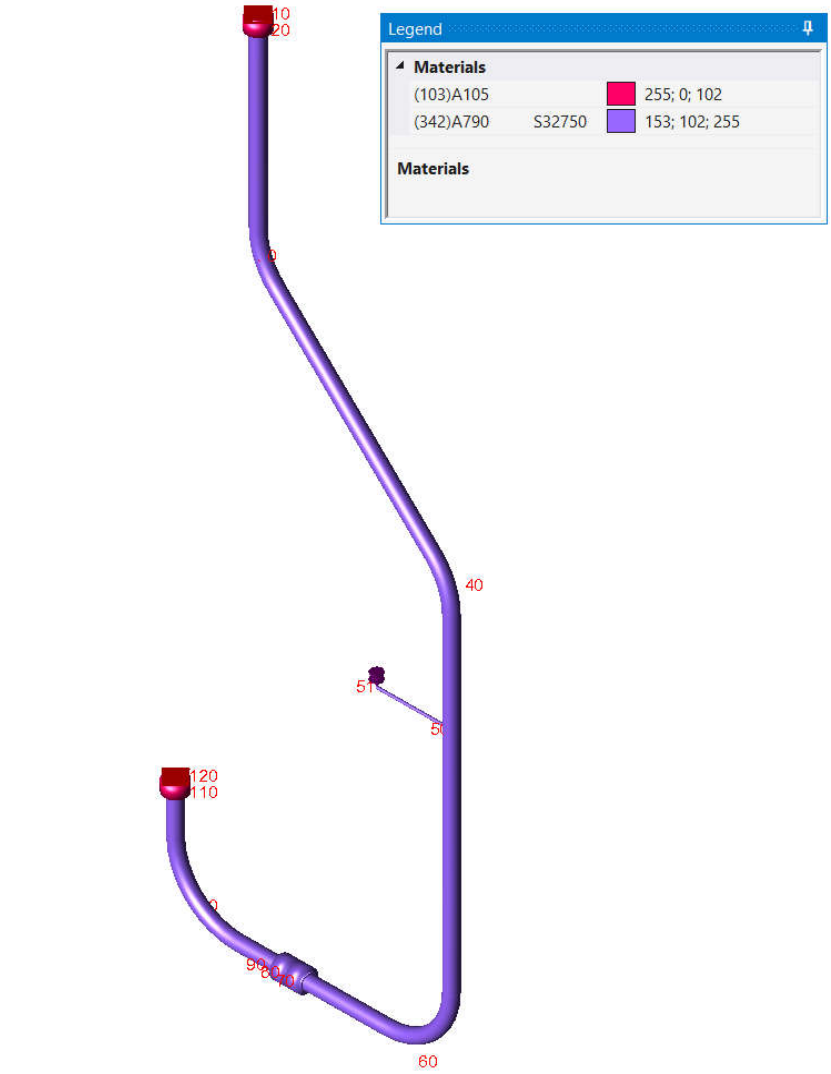


Fig-4. Model Material Assignment

Insulation

Figure 5 show insulation assignment.

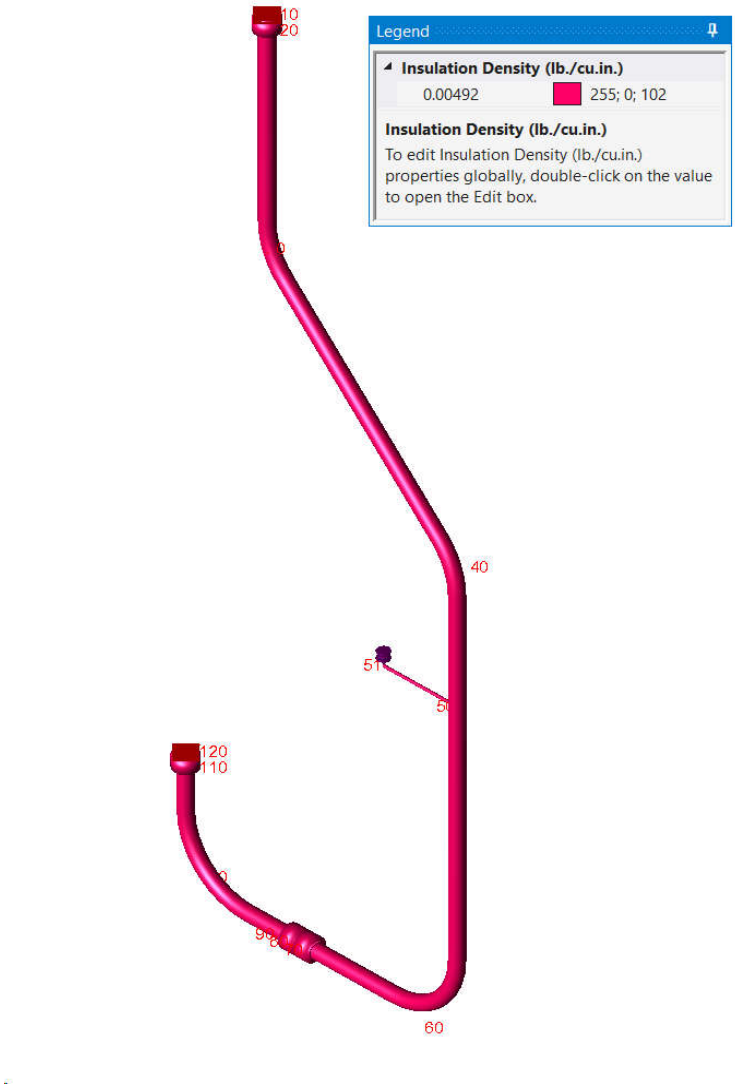


Fig-5. Model Insulation Assignment

Dead Weight W

Self weight of pipes has been modeled by assigning material and insulation density to each component as applicable.
All flanges are modeled as rigid element with appropriate weight assigned. Client provided Insulation design data were thickness of 3" Mineral Wool with density of 0.00492 lb/in^3 is used in the model.

Temperature T1

Assignment of Design Temperature T1 is to simulate the behavior of the pipeline at fluid design temperature and is shown on Figure 6.

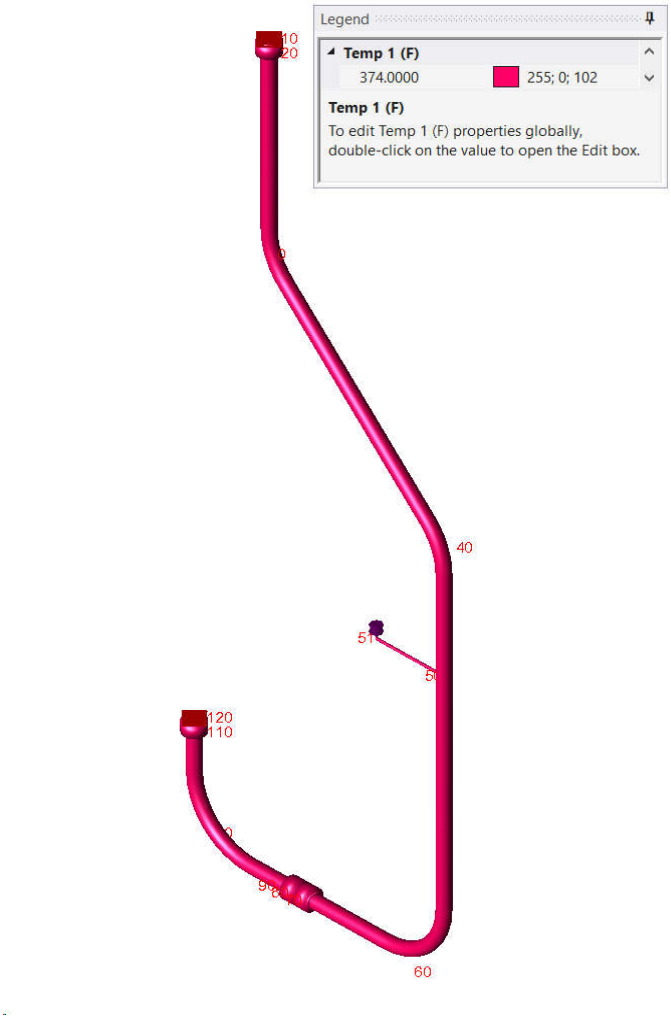


Fig-6. Model Design Temperature T1 Distribution.

Pressure P1

Assignment of corresponding Design Pressure P1 for Design Temperature T1 and is shown on Figure 7.

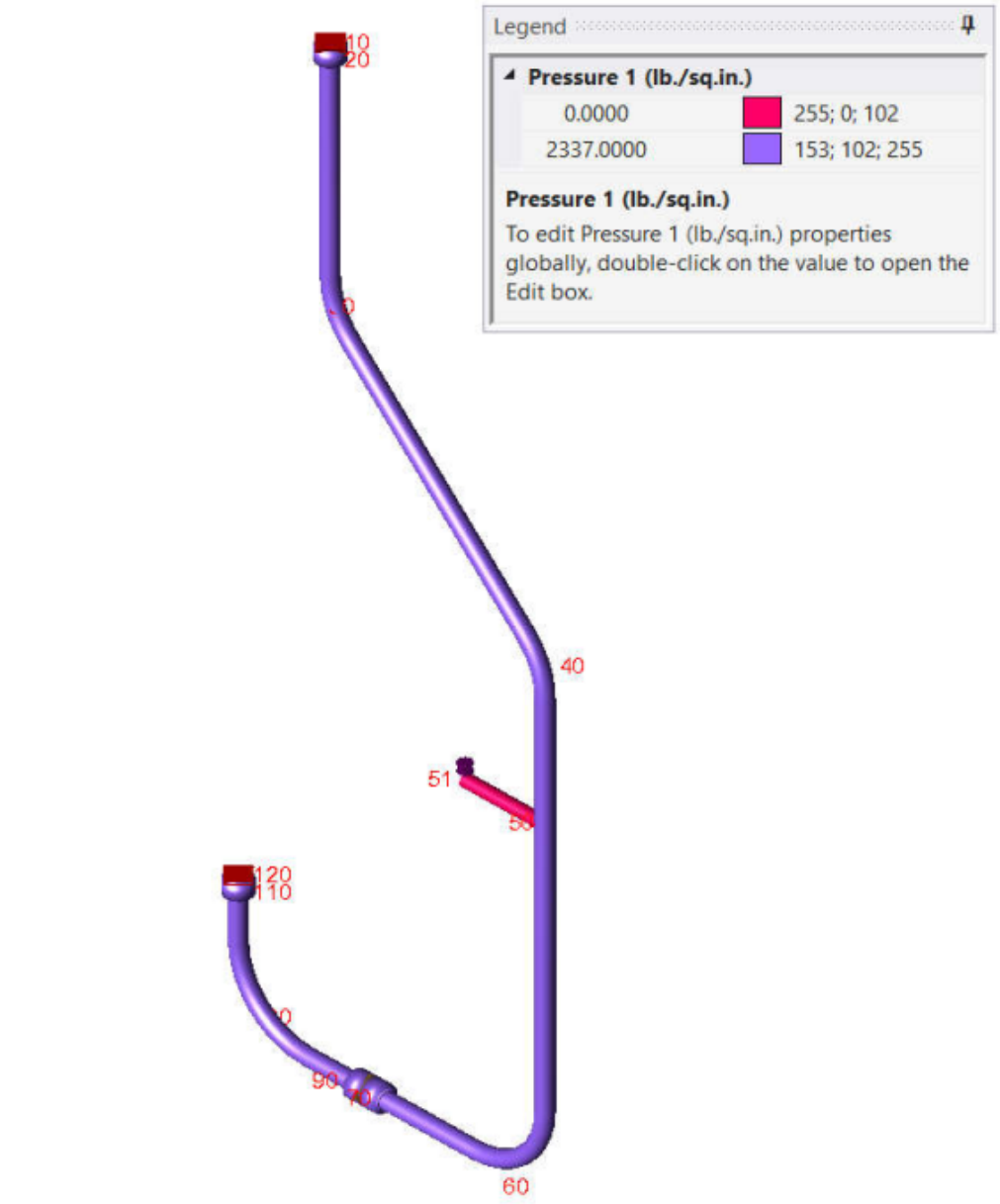


Fig-7. Model Design Pressure P1 Distribution.

Seismic Load U

Seismic Load per NBC-2015 was used in the model.

Seismic Horizontal Acceleration for non-structural components and equipment (NBC-2015; 4.1.8.18)
Importance Factor: I_E = 1.3 Provided by client - NBC-2015; Table 4.1.8.5
Component Factor: Cp=1.5 NBC-2015; Table 4.1.8.18; Category 16
Component Response Factor: Rp=1.25 Provided by client
Component Force Amplification Factor: Ar=1.0 NBC-2015; Table 4.1.8.18; Category 16
Spectral acceleration: Sa(0.2) = 0.086
Site Class: D
Seismic Horizontal Acceleration for non-structural components and equipment (NBC-2015; 4.1.8.18): ah=0.106 (m/s^2)

Loads Combinations

Loads combination defined and analyised in Caesar II model are shown on Figure 8 below.

	Exclude	Definition	Name	Stress Type
L1	☐	W	WEIGHT FOR HANGER LOAD	HGR
L2	☐	W+T1+P1	OPERATING FOR HANGER LOAD CASE CONDITION	HGR
L3	☐	W+T1+P1+H	OPERATING CASE CONDITION	OPE
L4	☐	W+P1+H	ALTERNATE SUSTAINED STRESS BASED ON OPERATING	SUS
L5	☐	W+P1+H	SUSTAINED CASE CONDITION	SUS
L6	☐	W+T2+P1+H	MDMT OPERATING CASE CONDITION	OPE
L7	☐	W+T1+P1+H+U1	OPP+EX	OPE
L8	☐	W+T1+P1+H-U1	OPP-EX	OPE
L9	☐	W+T1+P1+H+U3	OPP+EZ	OPE
L10	☐	W+T1+P1+H-U3	OPP-EZ	OPE
L11	☐	L7-L3	+EX ONLY	OCC
L12	☐	L8-L3	-EX ONLY	OCC
L13	☐	L9-L3	+EZ ONLY	OCC
L14	☐	L10-L3	-EZ ONLY	OCC
L15	☐	L11+L5	EX+SUS	OCC
L16	☐	L12+L5	-EX+SUS	OCC
L17	☐	L13+L5	EZ+SUS	OCC
L18	☐	L14+L5	-EZ+SUS	OCC
L19	☐	L7,L8,L9,L10	OPP + E (MAX)	OPE
L20	☐	L15,L16,L17,L18	E+SUS (MAX)	OCC
L21	☐	L3-L5	EXPANSION CASE CONDITION	EXP
L22	☐	L3-L6	FULL EXPANSION CASE CONDITION	EXP

Fig-8. Load Combinations used in the analysis.

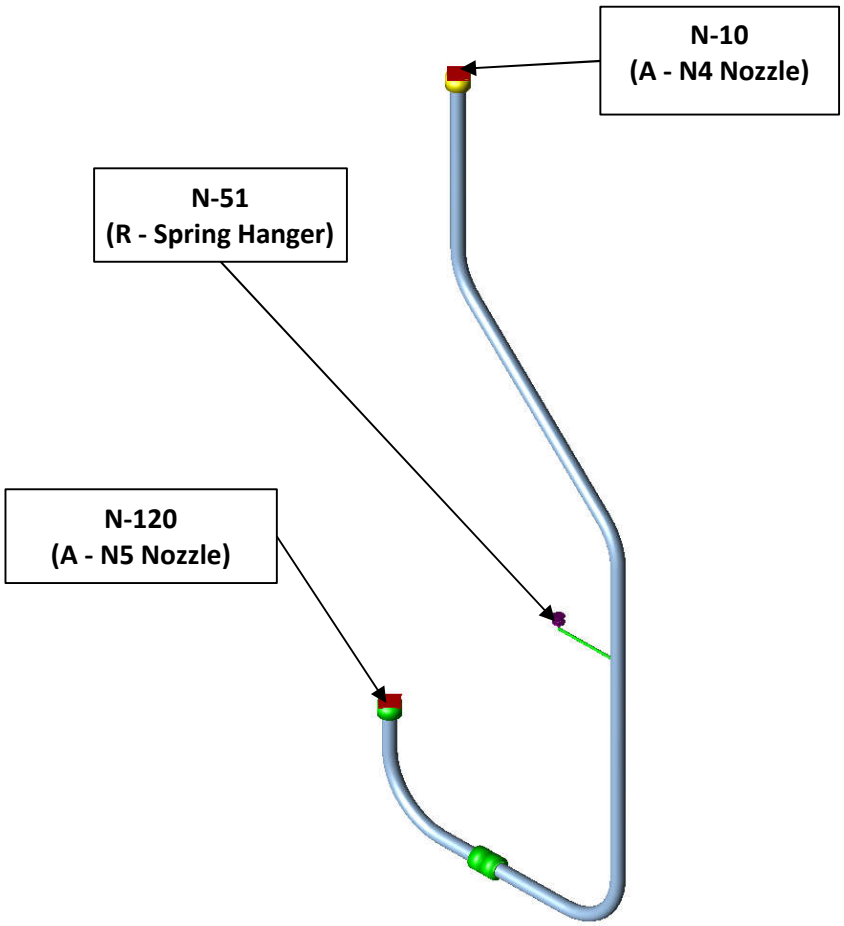


Fig-9. System Analysis Model

Maximum Code Stresses

The maximum code stress for SUS; SUS+OCC and EXP cases were evaluated and are below the code allowable stress and less than 30% of allowable code stresses. The maximum code stresses are shown in Figure 10.
SUS Maximum : N-50 @ 8186.3 (22.8%) (L5)
SUS + OCC Maximum : N-50 @ 8395.9(17.6%) (L20)
EXP Maximum : N-100 @ 5932.6 (13.6%) (L22)

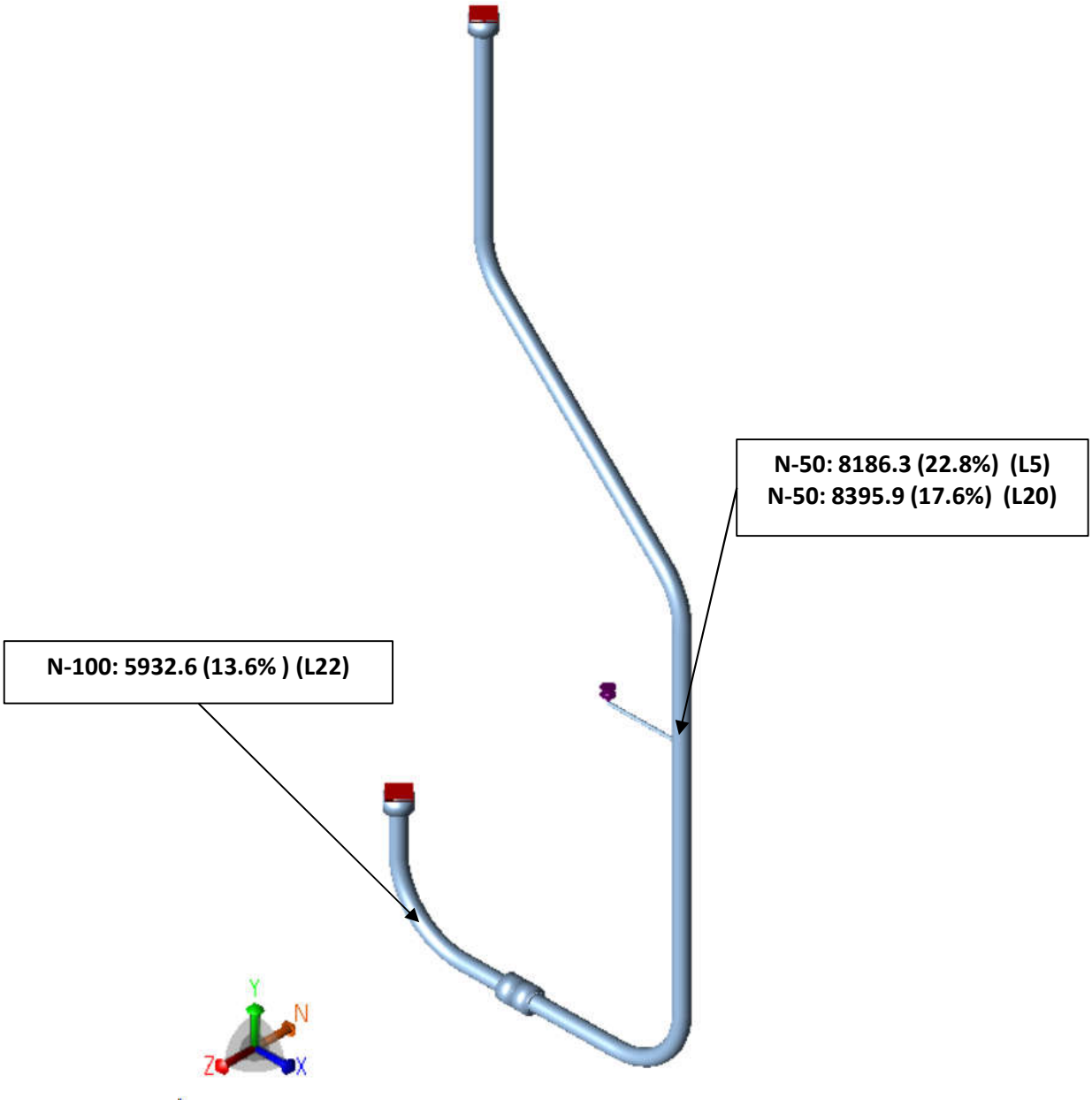


Fig-10. Maximum code stresses

Node N-50 Displacements

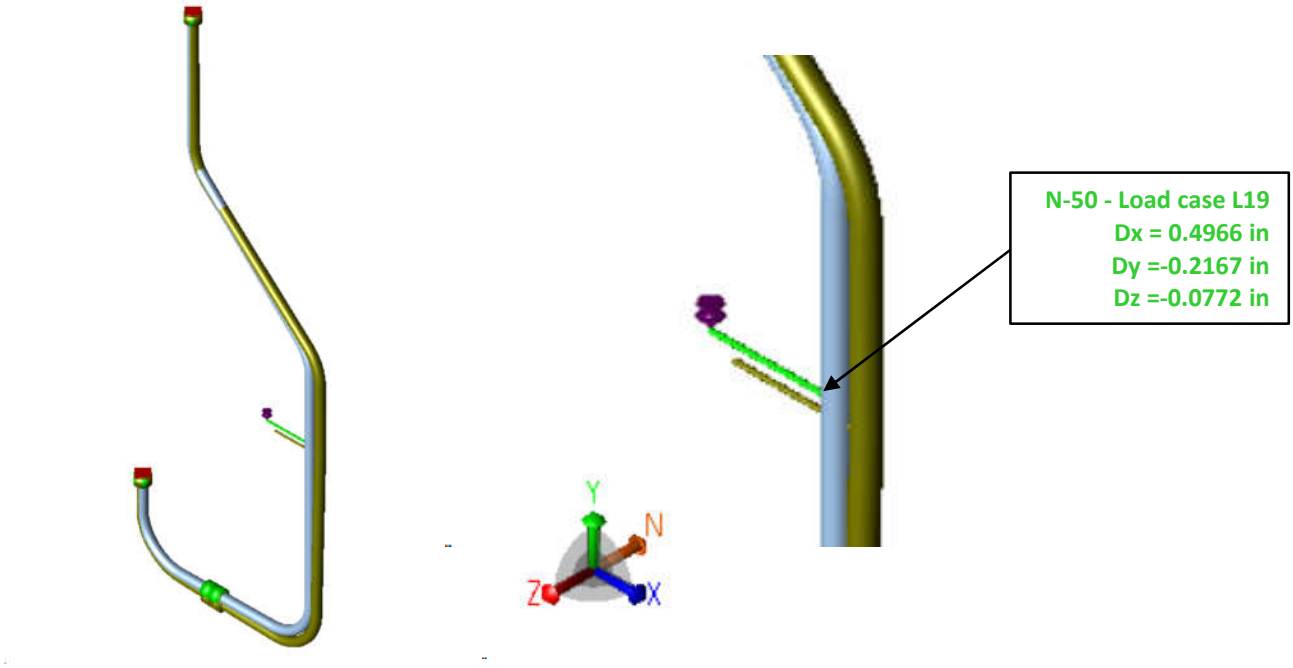


Fig-11. Node N-50 Maximum Displacements

Maximum displacement values were taken from all operating conditions design cases (L19). The values in the X, Y, and Z directions are shown above.

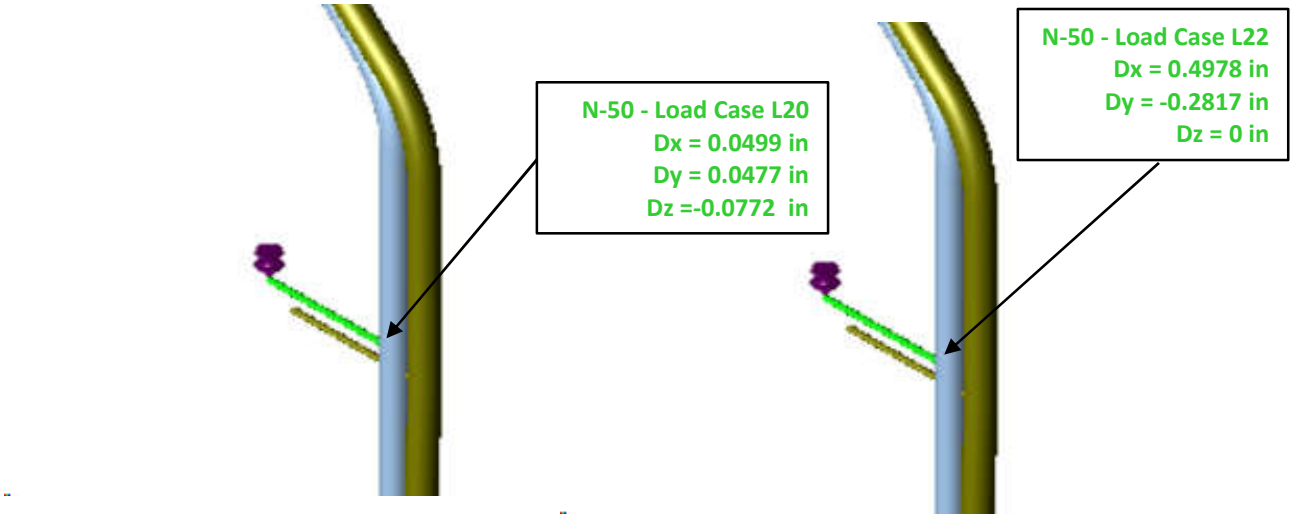


Fig-12. Node N-50 Maximum Displacements

Maximum displacement values were taken from all occasional cases (L20) and expansion case (L22). The values in the X, Y, and Z directions are shown above.

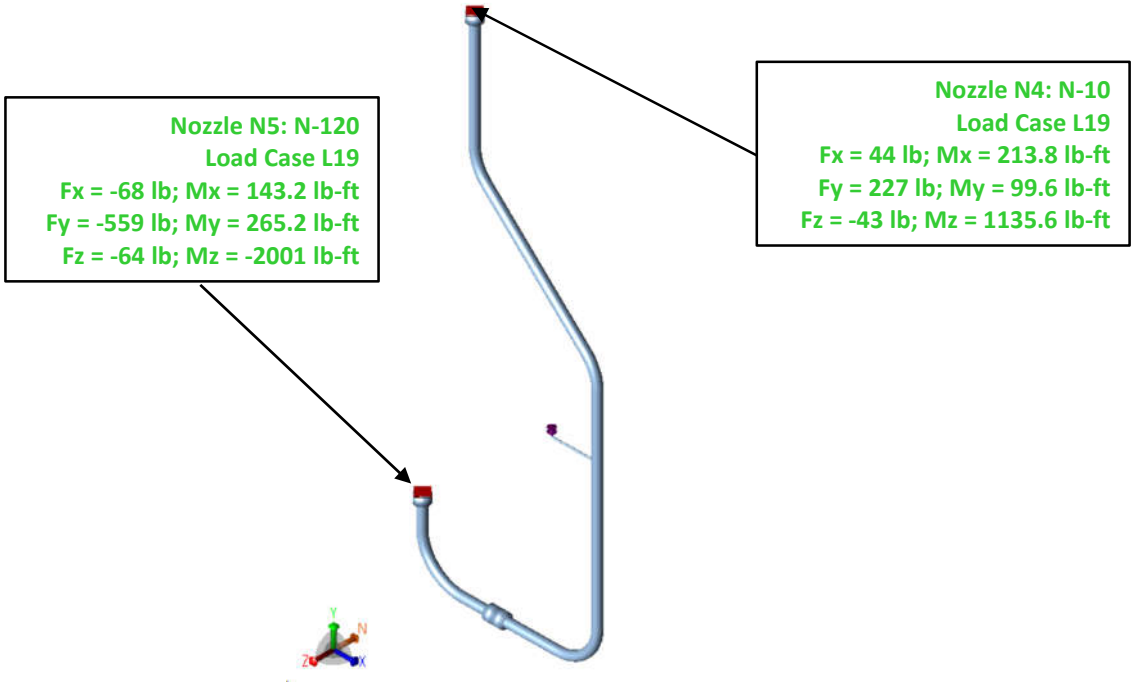


Fig-13. OPE Maximum Forces

Maximum nozzle load values were taken from all operating conditions design cases (L19). The values in the X, Y, and Z directions are shown above.

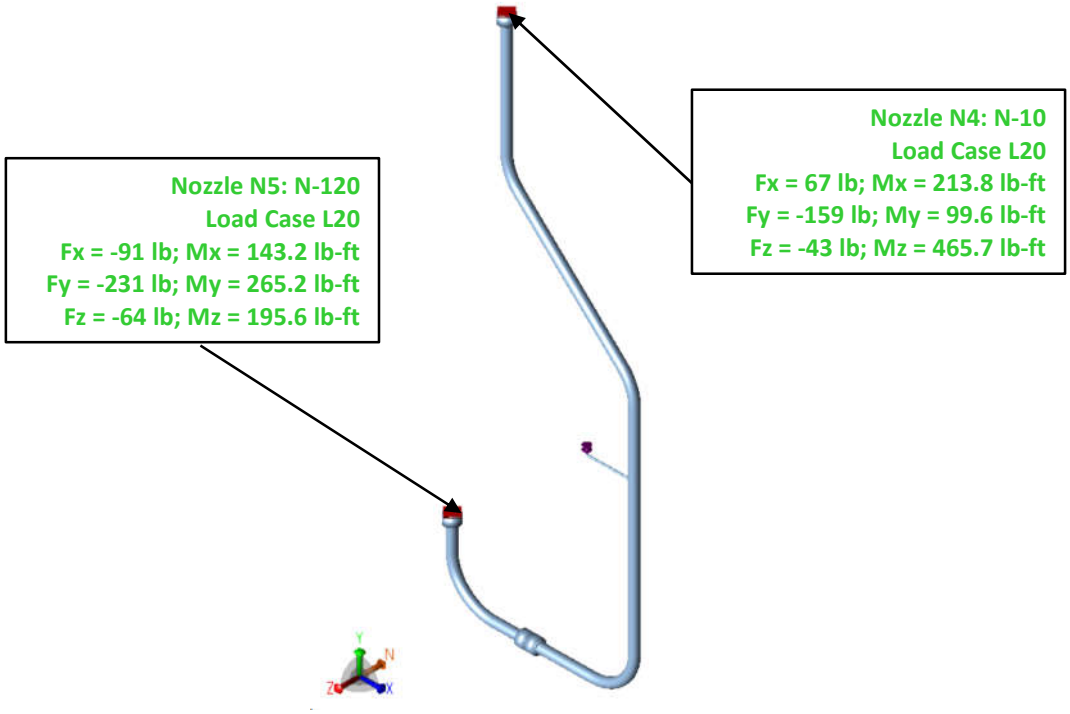


Fig-14. OCC Maximum Forces

Maximum nozzle load values were taken from all occasional cases (L20). The values in the X, Y, and Z directions are shown above.

Nozzle Loads for L22

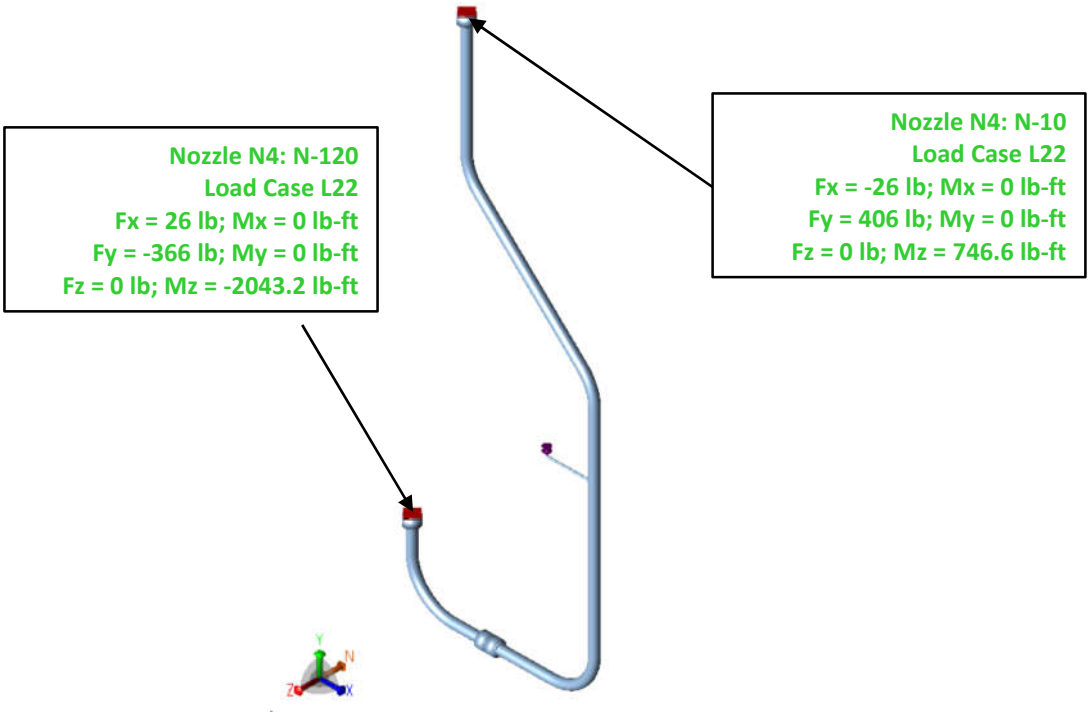


Fig-15. EXP Maximum Loads

Maximum nozzle load values were taken from expansion case (L22). The values in the X, Y, and Z directions are shown above.

Node	Load Case	FX lb.	FY lb.	FZ lb.	MX ft.lb.	MY ft.lb.	MZ ft.lb.
N-10 / Nozzle N4		TYPE=Rigid ANC;					
	5(SUS)	25	-148	0	0	0	313.5
	19(OPE)	44	227	-43	213.8	99.6	1135.6
	20(OCC)	67	-159	-43	213.8	99.6	465.7
	21(EXP)	-23	364	0	0	0	670
	22(EXP)	-26	406	0	0	0	746.6
	MAX	**67/L20**	**406/L22**	**-43/L19**	**213.8/L19**	**99.6/L19**	**1135.6/L19**
N-120 / Nozzle N5		TYPE=Rigid ANC;					
	5(SUS)	-25	-221	0	0	0	14.1
	19(OPE)	-68	-559	-64	143.2	265.2	-2001
	20(OCC)	-91	-231	-64	143.2	265.2	195.6
	21(EXP)	23	-328	0	0	0	-1833.5
	22(EXP)	26	-366	0	0	0	-2043.2
	MAX	**-91/L20**	**-559/L19**	**-64/L19**	**143.2/L19**	**265.2/L19**	**-2043.2/L22**

Fig-26. Maximum Load at Nozzle N4 and N5

Maximum nozzle load values were taken from all 3 load cases (L18; L19 and L20). The values in the X, Y, and Z directions are shown above.

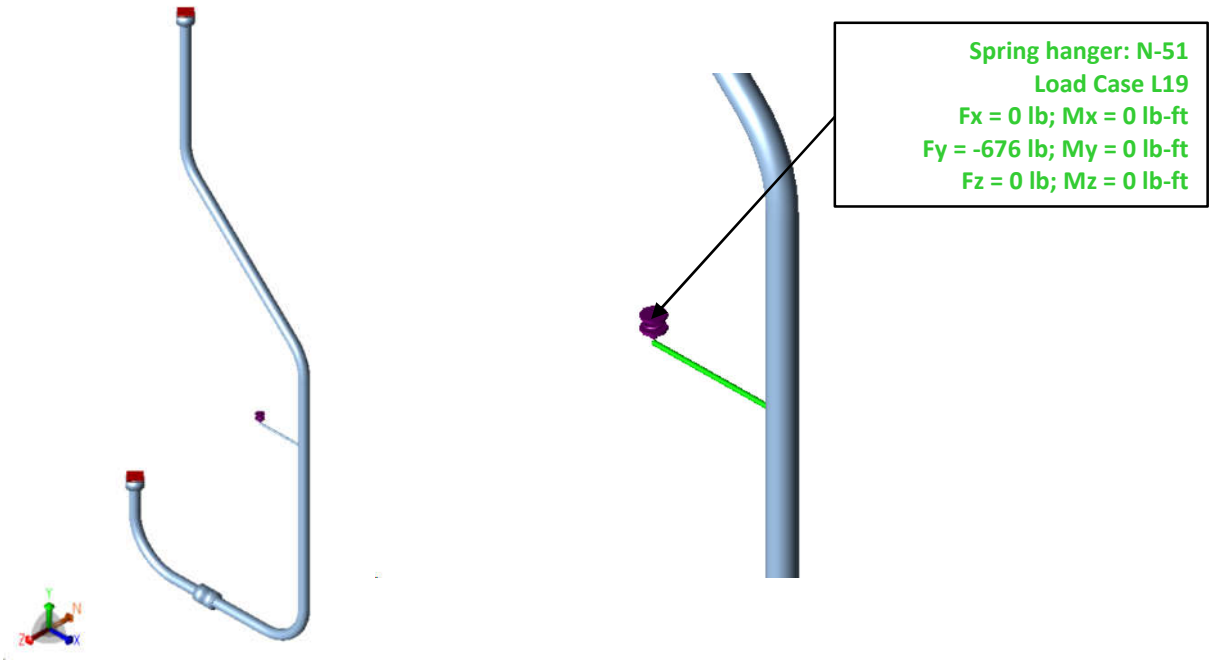


Fig-16. Spring Hanger Maximum Loads

Spring Hanger operation load values were taken from operation case (L19). The values in the X, Y, and Z directions are shown above.

Node	Load Case	FX lb.	FY lb.	FZ lb.	MX ft.lb.	MY ft.lb.	MZ ft.lb.
N-51 / Spring Hanger		TYPE=Prog Design	VSH;Tag=B-268, Size 8, Type F				
	5(SUS)	0	-639	0	0	0	0
	19(OPE)	0	-676	0	0	0	0
	20(OCC)	0	-641	0	0	0	0
	21(EXP)	0	-36	0	0	0	0
	22(EXP)	0	-40	0	0	0	0
	MAX	**0**	**-676/L19**	**0**	**0**	**0**	**0**

Spring Hanger Selection

Spring Hanger Recommended Type, Size and loads are presented in the table below:

Hanger Table W/Text

```
CAESAR II  Ver.12.00.00.4000,  (Build 200403)   Date: MAR 2, 2021   Time: 11:8
Job Name: 16579 - PIPING LINE N4-N5 WITH LOADS, SPRING HANGER AND TRUNNION
Licensed To: Edit name in <system>\company.txt

 CAESAR II  HANGER REPORT (TABLE DATA FROM DESIGN RUNS)

                                                 THEORETICAL   ACTUAL
            NUM    FIG.       VERTICAL    HOT     INSTALLED   INSTALLED    SPRING    HORIZONTAL
   NODE     RQD    NO.  SIZE  MOVEMENT    LOAD      LOAD        LOAD       RATE     MOVEMENT

----------+-----+-----+----+---(in.)--+--(lb.)--+---(lb.)---+---(lb.)---+-(lb./in.)-+--(in.)---
        51    1   B-268    8     -0.125      675.        656.          0.        150.       0.425
          ANVIL                                          LOAD  VARIATION =    3%
Tag=B-268;
          ** VARIABLE SUPPORT SPRING DESIGNED ...................   MID RANGE
             MINIMUM ALLOWED SINGLE SPRING LOAD ........... (lb.)     525.000
             MAXIMUM ALLOWED SINGLE SPRING LOAD ........... (lb.)     900.000
             RECOMMENDED INSTALLATION CLEARANCE ........... (in.)      12.125
----------+-----+-----+----+----------+---------+-----------+-----------+-----------+----------
```

Fig-17. Spring Hanger Table - CEASAR II Output

LIMITS OF LIABILITY FOR PRESSURE VESSEL ENGINEERING

This report was prepared through consultation with the client to obtain an accurate description of the working system and was designed using standard industry practices. All design data and the relevant loads were provided by the client.

The PSA models generated represent the drawings provided with the revision number identified in the first page and in the reference list of the report. All restraint recommendations must be followed for the system to be acceptable. Any change to the piping layout would alter the accuracy of the results. Pressure Vessel Engineering does not participate in the construction or fabrication and therefore cannot take responsibility for the as-built system.