Piping & Structure Stress Analysis of Oil Metering System & Gas Metering Systems

Key Features

Technology:

CAESAR-II 2013 R1

STAAD Pro V8i Select Series 6

Duration:

The project was completed in a period of 20 days

Deliverables:

1. Caesar Analysis Outputs.
2. Flange Leakage Report.
3. Trunnion Calculation.
4. Stress Isometrics.
5. Section properties of the Skid member.
6. Crane capacity & sling size during lifting of skid.
7. Tying of skid during transportation

The Client

One of the largest producer-independent distributor of steel, metal and one of the leading steel service center companies worldwide. They offer a unique combination of expertise in mechanical engineering, instrumentation, electrical engineering and process automation. The client has expertise in designing, manufacturing, delivering and commissioning (fiscal) oil and gas metering systems, metering control systems equipped with flow computers, proving and validation systems, in-line analyzer and sampling systems and other related equipment.

The Business Need

The existing project fulfills the technical requirement, and the client wants an optimized solution for pipe stress analysis & optimum sections of the structure with adequate safety against all the failures possible. The project size & scope of work included following:

For Piping:

Pipe Stress analysis report to be provided including Introduction, Nomenclature, Stress ISO's, Load cases, Basic assumptions, and Conclusions as well as tabulated calculated results.

For Structure:

Structural Steel calculations to be provided including anchor/foundation loads. (Report requirements similar to Pipe Stress Analysis). The present project dimensions are **6.9m x 26m** and **6m x 21.85m** respectively. Industries need to support or elevate the structures or objects as per its requirements and skids are the supporting structures which keep the objects elevated as per the need for the industrial procedures.

Rishabh's Solution

We performed the required calculations and submitted our analysis which includes:

- **Load Cases/Combinations**: As per the design data and specific codes & standards, we had analyzed Piping & Structure of both Gas Metering & Oil Metering Skids under all the stresses, deflections as well the loads on it.

For Piping:

Load case No	Description	Load Cases	Stress	Comb
L1	Operating Temp	W+T1+P1+F1	OPE	
L2	Max Design Temp	W+T2+P1+F1	OPE	
L3	Min Design Temp	W+T3+P1+F1	OPE	
L4	Alternate Operating Temp	W+T4+P1+F1	OPE	
L5	Alternate Operating Temp	W+T5+P1+F1	OPE	
L6	Alternate Operating Temp	W+T6+P1+F1	OPE	
L7	Alternate Operating Temp	W+T7+P1+F1	OPE	
L8	Sustain	W+P1+F1	SUS	
L9	Hydro Test	WW+HP	HYD	
L10	Max Ope. Temp with Wind +X	W+T1+P1+F1+WIN1	OPE	
L11	Max Ope. Temp with Wind +X	W+T1+P1+F1+WIN2	OPE	
L12	Max Ope. Temp with Wind +Z	W+T1+P1+F1+WIN3	OPE	
L13	Max Ope. Temp with Wind –Z	W+T1+P1+F1+WIN4	OPE	
L14	Max Ope. Temp with Seismic +X	W+T1+P1+U1+F1	OPE	
L15	Max Ope. Temp with Seismic –X	W+T1+P1-U1+F1	OPE	
L16	Max Ope. Temp with Seismic +Z	W+T1+P1+U3+F1	OPE	
L17	Max Ope. Temp with Seismic –Z	W+T1+P1-U3+F1	OPE	
L18	Expansion with Ope. Temp	L1-L8	EXP	ALG
L19	Expansion with Max Design. Temp	L2-L8	EXP	ALG
L20	Expansion with Min Design. Temp	L3-L8	EXP	ALG
L21	Expansion with Alternate Ope. Temp	L4-L8	EXP	ALG
L22	Expansion with Alternate Ope. Temp	L5-L8	EXP	ALG
L23	Expansion with Alternate Ope. Temp	L6-L8	EXP	ALG
L24	Expansion with Alternate Ope. Temp	L7-L8	EXP	ALG
L25	Stress range $T_{design\ max}$ - $T_{design\ min}$	L2-L3	EXP	ALG
L26	Wind net deflection (+X)	L10-L1	OCC	ALG
L27	Wind net deflection (-X)	L11-L1	OCC	ALG
L28	Wind net deflection (+Z)	L12-L1	OCC	ALG
L29	Wind net deflection (-Z)	L13-L1	OCC	ALG
L30	Seismic net deflection (+X)	L14-L1	OCC	ALG
L31	Seismic net deflection (-X)	L15-L1	OCC	ALG
L32	Seismic net deflection (+Z)	L16-L1	OCC	ALG
L33	Seismic net deflection (-Z)	L17-L1	OCC	ALG
L34	Combined stress Wind (+X)	L8+L26	OCC	SCL
L35	Combined stress Wind (-X)	L8+L27	OCC	SCL
L36	Combined stress Wind (+Z)	L8+L28	OCC	SCL
L37	Combined stress Wind (-Z)	L8+L29	OCC	SCL
L38	Combined stress Seismic (+X)	L8+L30	OCC	SCL
L39	Combined stress Seismic (-X)	L8+L31	OCC	SCL
L40	Combined stress Seismic (+Z)	L8+L32	OCC	SCL
L41	Combined stress Seismic (-Z)	L8+L33	OCC	SCL

For Structure:

The method used for the design is ***Limit Stress Method***.

The Load cases considered are detailed as below:

Load 1: dead load: self-weight of structure & grating
Load 2: pipe empty+ eqpt empty
Load 3: pipe and eqpt operating
Load 4: pipe test load excluding self-weight
Load 5: live load on platforms
Load 6: pipe anchor + guide load
Load 61: pipe anchor + guide load
Load 7: pipe anchor + guide load
Load 71: pipe anchor + guide load
Load 8: friction load in x-direction
Load 9: friction load in z-direction
Load 10: wind in x direction
Load 101: wind in -x direction
Load 11: wind in z-direction
Load 111: wind in -z-direction
Load 12: expansion
Load 13: contraction
Load 14 : earthquake in x direction
Load 15 : earthquake in z direction

Various Load combinations & Temperature profiles are checked with standard safety factors concerning Operating conditions, Lifting conditions and Transportation conditions.

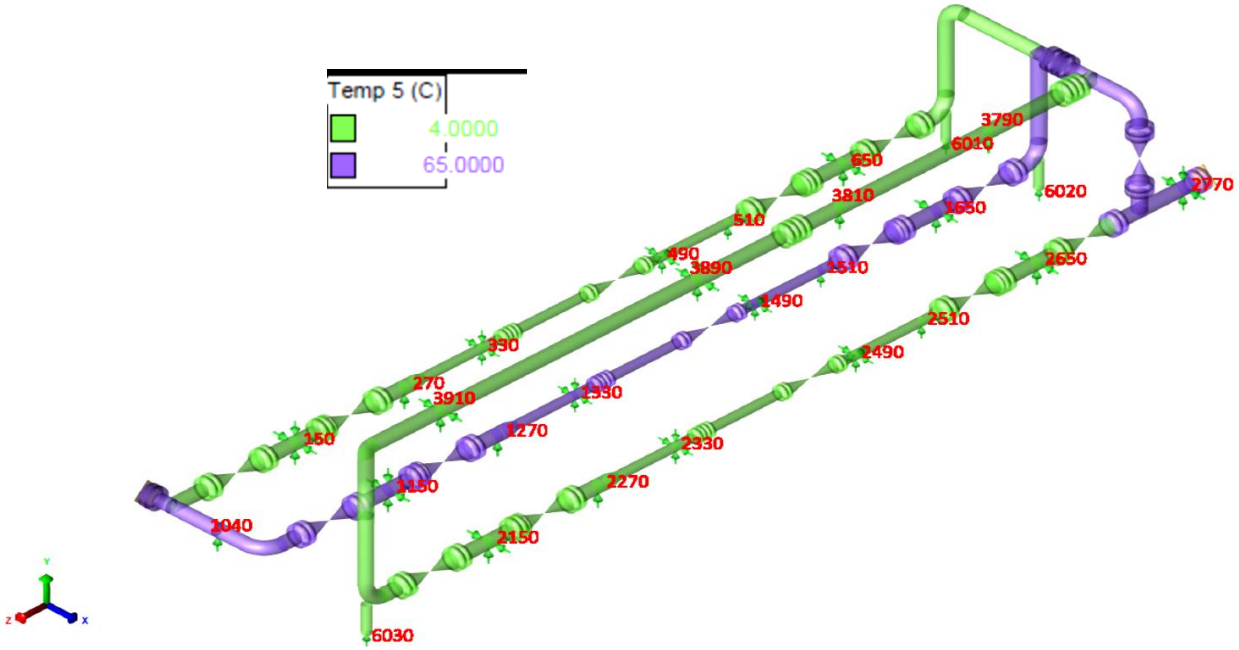
- **Design Conditions for Piping**:

Design Parameter		Unit
Density	178	Kg/m3
Operating Pressure	140	bar.g
Operating Temp	65	°C
Design Pressure	158	bar.g
Design Max. Temp	85	°C
Design Min. Temp	-43	°C
CA	1.5	mm

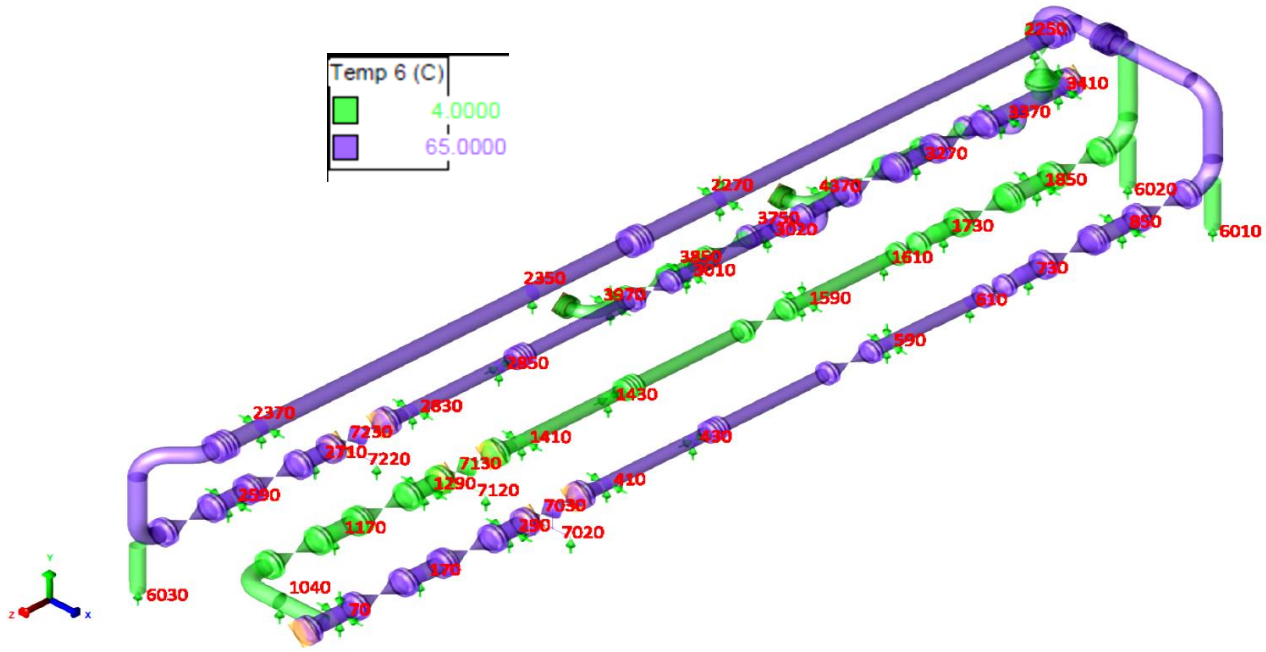
- **Design Conditions for Structure**:

Conditions	Results
Operating Conditions	Safe
Lifting Conditions	Safe
Transportation Conditions	Safe

- **Project Execution for Piping:** We have analyzed both Metering Systems with a different combination of temperature including operating bypass condition (some portion in ambient and some in working condition). Below are some instance of the combination for reference.

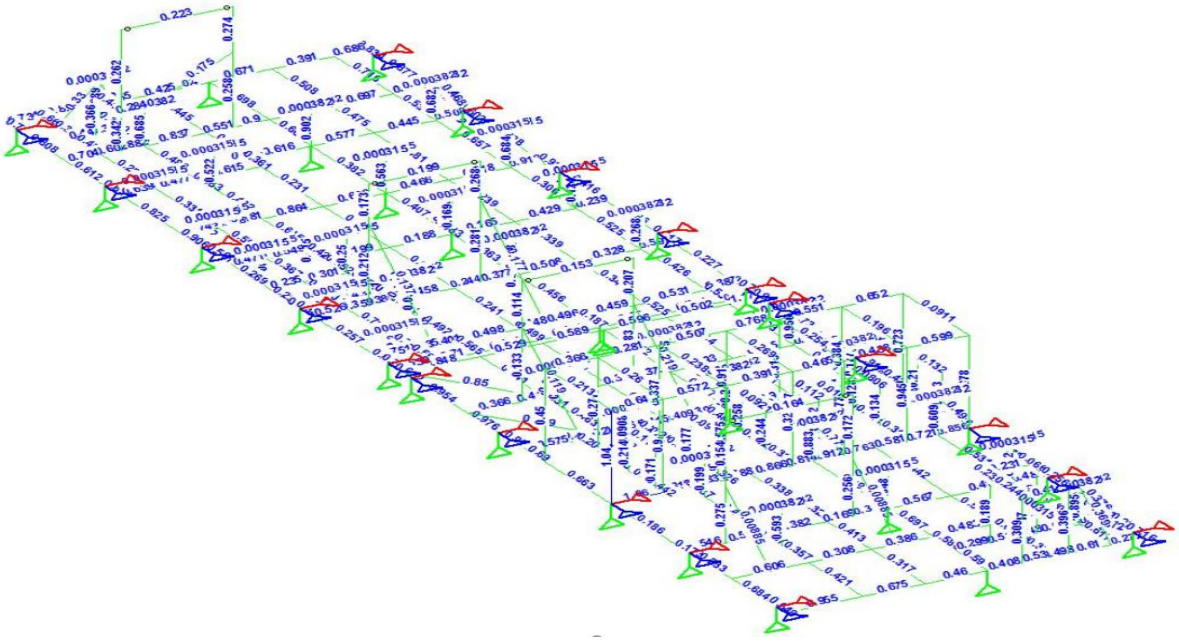


Gas Metering System

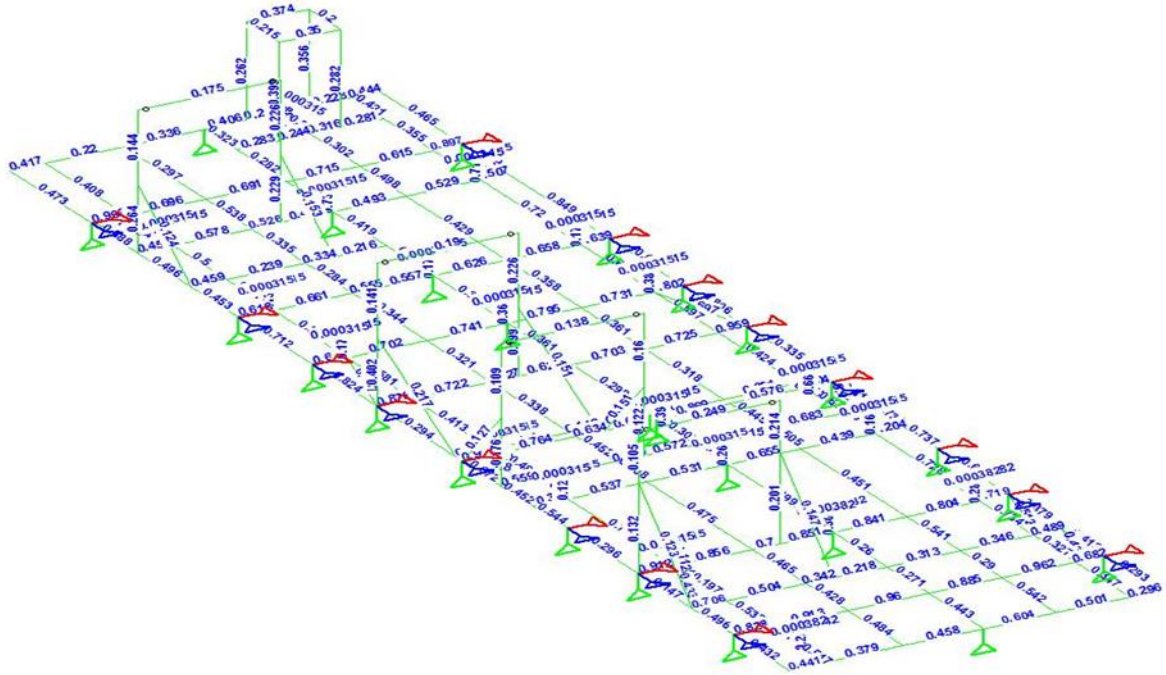


Oil Metering System

- **Project Execution for Structure:** The **Utility ratio** is the ratio of actual to the maximum allowable performance of the structural element. Staad pro performs the check for utilization ratio and ensures that the structure is safe. The ratio of actual to maximum permissible performance should be less than 1. The Utilization Ratios for the current structures has been shown below:



Utilization Ratio for all members in OIL METERING SYSTEM



Utilization Ratio for all members in GAS METERING SYSTEM

Challenges

Technical Challenges:

- The technical problem for Piping Stress analysis was to ensure that (no) stress failure in the system during transportation condition. We have reviewed the transportation point considering a G value of 0.2 upwards +Y-same as lateral seismic G factor and again with a value of 0.3. The maximum upward +Y deflection is less than 0.5 mm. Based on which it is considered SAFE for transportation as we believe that the +Y transportation G factor should not be more than 0.2 and generally empty pipe.

- Additionally, we have decided to consider hold-downs points from local to 04 Tie Points at either ends and at the center where guides are available. Other hold-downs points may also be considered only for transportation, and it has to be removed for operating conditions at the site. Transportation analysis was not in the scope of Rishabh Engineering; however, we have provided our inputs for the same additionally.

- Shear force on the Anchor bolt is on a very high side, and it is not possible for the bolt to carry the same. Also, the anchor bolt has M42 dia. making it very difficult to fit in. To overcome the challenge Rishabh has provided a shear key just below the structure member and had to reduce the anchor bolt size from M42 to M24.

- Primarily the thermal load was 35 Deg.C. However the client revised it to 42 Deg.C resulting in increasing the size of the structural member; also, the structural member is even failing on the thermal expansion load criteria. To overcome the challenge Rishabh has to provide a stiffener in the structure member to maintain the same section size.

Project Level Challenges:

- Piping load has to be revised fully

- Support arrangement of Strainer changed by the Client after submission of first review report

- Natural frequency achieved is more than 5 hertz

Project Execution Methodology:

Stress analysis is performed as per ASME B31.3 piping code & Piping stress analysis philosophy of the Client. Piping Design and Stress analysis have been done concerning the Standard & Codes in CAESAR-II software.

Structure Design analysis had been done concerning Standard Codes with the Staad Pro software.
The methodology used for the design is **Limit Stress method**.

Rishabh Engineering had completed the stress analysis of this project within 20 Days with a team of 03 members (including 1 Project Engineer, 1 Piping Engineer & 1 Structure Engineer).

Technology Used

- CAESAR-II 2013 R1
- STAAD Pro V8i SELECT SERIES 6

Key Deliverables

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- Trunnion Calculation
- Stress Isometrics
- Section Properties of The Skid Member
- Crane Capacity & Sling Size During Lifting of Skid
- Tying of Skid During Transportation

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Rishabh Engineering provides multidisciplinary engineering support services to EPC companies in industries like Oil and Gas, Petrochemical, Power and Water treatment. Our parent company, Rishabh Software is a CMMI level-3, ISO9001 and ISO27001 company that provides services in Software Development, Business Process Outsourcing (BPO) and Engineering Services Outsourcing (ESO) to clients globally. Rishabh has offices in USA, UK and India with their main delivery center in Vadodara, India.