Pipe Stress Analyis Guide Report

By Mr.HungHong http://www.azpiping.com

This whole document is reported by HungHong You may freely copy, redistribute or share this report in anyway you like as long as you distribute it in its entirety and unedited.

Az Piping Solution

1. Information Needed for Pipe Stress-Analysis

See example Iso.



Here are needed information.

1. Outside diameter of piping, wall thickness (or nominal diameter, schedule number)

2. Temperature, internal pressure

3. Material of piping. (Expansion coeffcient, Young's modulus, and

material density will be selected for this material.)

4. Insulation thickness and insulation material. (If not given, standard

thickness for calcium silicate will be selected.)

5. Specifc gravity of contents

6. Any wind load to be considered? If yes, the direction of application

is important.

7. Any anchor initial translation. (For towers, exchangers, and so on, nozzle initial ranslation is important.)

8. Corrosion allowance for piping

9. Flange rating, (ANSI B16.5)

10. Standard valve weight and fange weight will be used. (For special valves mark the weight on pipe stress isometric.)

11. Long radius elbows will be used. (If short radius or any other bend radius, mark on the isometric.) For short-radius elbow, radius= diameter

12. Any allowable loading from manufacturers on pumps, turbines, compressors? (From the vendor drawing for equipment.)

13. Any preference to use expansion loops, expansion joints, and so on, if needed?

14. Mark type of intersection (reinforced fabricated tee, etc.)

15. Mark support locations (available steel crossing, and so on) on the isometric

16. Is hydraulic testing load condition to be considered to get structural support loads?

17. Pipe stress isometrics (x-, y-, z-axis) piping plans, and sections are necessary.

Reference

-Experienced in piping stress analysis using Caesar II

-Introduction to pipe stress analysis book, by Sam Kannappan, P.E. Engineer

2. Temperature Conditions for Piping Stress Analysis Consideration

Before you start piping stress calculation, you have to refer to line index (or called the line classification lists or process line lists) to check design temperature and an operating temperature for line to be checked. Stress analysis shall be carried out on the basis of the design temperature.

Secondly, you have to know requirements base on your project specification such as

Minimum Ambient Temperature. (TAMIN)

Maximum Ambient Temperature. (TAMAX)

Maximum Solar Radiation Temperature. (Ts)

Site Installation Temperature. (TAs)

We will use value below in our piping stress analysis tutorials:

 $\begin{array}{l} T_{AMIN} = 16^{\circ}C \mbox{ (For Stress Range Purpose, in case hot lines)} \\ T_{AMAX} = 36^{\circ}C \mbox{ (For Stress Range Purpose, incase cold lines)} \\ T_S = 70^{\circ}C \\ T_{As} = 21^{\circ}C \\ Line \mbox{ design temperature shall be taken from process line lists (or line index).} \end{array}$

In case plus design temperatures <70°C , 70°C will be taken as design temperature

Example 1:

Line design temperature as per line index is 65°C so we will take 70°C as design temperature for stress calculation $T_{AMIN}=16^\circ C$ (For Stress Range Purpose) $T_{As}=21^\circ C$

Example 2: Line design temperature as per line index is -250°C so we will take -250°C as design temperature for stress calculation $T_{AMAX} = 36^{\circ}C$ (For Stress Range Purpose with) $T_{As} = 21^{\circ}C$

Noted:

T_{AMIN}= 16°C in example 1 (for hot line) and T_{AMAX} = 36°C in example 2 (for cold line) You have to find Minimum Ambient Temperature, Maximum Ambient Temperature, Maximum Solar Radiation Temperature, Site Installation Temperature in your project specifications

3. How to setup load cases

a. LOAD CASE DEFINITION KEY (3 PUMPS) Reference to Iso. In Fig.1

CASE	1 (1	HYD)	WW+HP	(without friction, or called none-friction)
CASE	2 (0	OPE)	W+T1+P1	(with friction)
CASE	3 (0	OPE)	W+T1+P1	(without friction, or called none-friction)
CASE	4 (0	OPE)	W+T2+P1	(with friction)
CASE	5 (0	OPE)	W+T3+P1	(with friction)
CASE	6 (0	OPE)	W+T4+P1	(with friction)
CASE	7 (0	OPE)	W+T5+P1	(without friction, or called none-friction)
CASE	8 (;	SUS)	W+P1	(with friction)
CASE	9 (:	SUS)	W+P1	(without friction, or called none-friction)
CASE	10	(OCC)	Ul	(without friction, or called none-friction)
CASE	11	(OCC)	U2	(without friction, or called none-friction)
CASE	12	(OCC)	L12=L10+L11	(without friction, or called none-friction)
CASE	13	(OCC)	L13=L12+L9	(without friction, or called none-friction)
CASE	14	(EXP)	L14=L2-L8	(with friction)
CASE	15	(EXP)	L15=L3-L9	(without friction, or called none-friction)
CASE	16	(EXP)	L16=L7-L9	(without friction, or called none-friction)
CASE	17	(EXP)	L17=L15+L16	(without friction, or called none-friction)

Explain

Hydro Test Case

Case1: Hydro Test case, none-friction with WW=Water Filled Weight, HP=Hydro Pressure

Operation Case

Case2: Operating case with friction at operating temperature (T1=80°C), 3 pumps working

Case3: Operating case none-friction at operating temperature (T1=80°C), 3 pumps working

Case4: Operating case with friction, pumpA and pumpB working (T2=80°C), pump C standby (T2=21°C)

Case5: Operating case with friction, pumpA and pumpC working (T3=80°C), pump B standby (T3=21°C)

Case6: Operating case with friction, pumpB and pumpC working (T4=80°C), pump A standby (T4=21°C)

Case7: Operating case *none-friction* at TAMIN = 16°C (For Stress Range Purpose), 3 pumps at T5=16°C

Sustain Case

Case8: Sustain case with friction Case9: Sustain case none- friction

Occational Case

Case10: Seismic Load (X direction), none- friction Case11: Seismic Load (Z direction), none- friction

Case12: Seismic Load (2 direction), none- friction

Case12. Seisine Load combined, none- metion

Case13: Sustain Case + Occational due to seismic, none- friction

Expansion Case

Case14:Expansion Case check with friction at operating temperature (T1=80°C)

Case15:Expansion Case check none- friction at operating temperature (T1=80°C)

This is stress check at maximum temperature, none- friction

Case16:Expansion Case check none- friction at mininum temperature (T5=16°C)

This is stress check at maximum temperature, none- friction

Case17:This case for stress range purpose, none- friction

[minimum stress check(case16)+maximum stress check(case15)]

Please click link below to see videos about above tutorials
http://www.azpiping.com/tutorials/temperature-3pumps.htm
http://www.azpiping.com/tutorials/loads-3pumps.htm

\boldsymbol{b} load case definition key ($2 \ \text{pumps}$)

Reference to Iso. In Fig.2

Write down pump nozzle loads allowablein iso., node number, support mark...

150

CASE	1	(HYD)	WW+HP
CASE	2	(OPE)	W+T1+P1
CASE	3	(OPE)	W+T1+P1
CASE	4	(OPE)	W+T2+P1
CASE	5	(OPE)	W+T3+P1
CASE	б	(OPE)	W+T4+P1
CASE	7	(SUS)	W+P1
CASE	8	(SUS)	W+P1
CASE	9	(OCC)	Ul
CASE	10	(OCC) U2
CASE	11	(OCC) L11=L9+L10
CASE	12	(OCC) L12=L11+L8
CASE	13	(EXP) L13=L2-L7
CASE	14	(EXP) L14=L3-L8
CASE	15	(EXP) L15=L6-L8
CASE	16	(EXP) L16=L14+L15

Operating Temperature = 45 °CDesign Temperature = 80 °COperating Pressure = $7.5 \text{ Kg/cm}^2 \text{ g}$ Design Pressure = $15.0 \text{ Kg/cm}^2 \text{ g}$

Mat. A106 Gr.B #150 Lbs Pipe Size 4", Sch.Std Corrosion Allowance 1.5mm None Insulation Density $= 1000 (\text{kg/m}^3)$

(without friction, or called none-friction) (with friction) (without friction, or called none-friction) (with friction) (with friction) (without friction, or called none-friction) (with friction) (without friction, or called none-friction) (with friction) (without friction, or called none-friction) (without friction, or called none-friction) (without friction, or called none-friction)

Explain

Hydro Test Case

Case1: Hydro Test case, none-friction with WW=Water Filled Weight, HP=Hydro Pressure

Operation Case

Case2: Operating case with friction at operating temperature (T1=80°C), 2 pumps working

Case3: Operating case none-friction at operating temperature (T1=80°C), 2 pumps working

- Case4: Operating case with friction, pumpA and (T2=80°C), pump B standby (T2=21°C)
- Case5: Operating case with friction, pumpB working (T3=80°C), pump A standby (T3=21°C)

Case6: Operating case *none-friction* at $T_{AMIN} = 16^{\circ}C$ (For Stress Range Purpose), 2 pumps at T4=16°C

Sustain Case

Case7: Sustain case with friction Case8: Sustain case none- friction

Occational Case

Case9: Seismic Load (X direction), none- friction Case10: Seismic Load (Z direction), none- friction Case11: Seismic Load combined, none- friction Case12: Sustain Case + Occational due to seismic, none- friction

Expansion Case

Case13:Expansion Case check with friction at operating temperature (T1=80°C) Case14:Expansion Case check none- friction at operating temperature (T1=80°C) This is stress check at maximum temperature, none- friction Case15:Expansion Case check none- friction at mininum temperature (T4=16°C) This is stress check at maximum temperature, none- friction Case16:This case for stress range purpose, none- friction [minimum stress check(case15)+maximum stress check(case14)]

Please click link below to see videos about above tutorials

http://www.azpiping.com/tutorials/temperature-2pumps.htm http://www.azpiping.com/tutorials/loads-2pumps.htm

3. Some notes when making new calculation

When you first run Caesar II program and making new calculation, you need to be careful some noted as below a. Unit System -Checking unit For example: You want to use unit file named TRAINING.FIL for your calculation note, you need to check before proceed input data. From Tools menu, select Configure/Setup



Then select Database Difinitions In Units File Name Field, select file name of unit system (like: TRAINING.FIL in this example)

SIF's and Stresses FRP Properties	Geometry Directives Database Definitions Select	Plot Colors Miscellaneous
-General CAESAR II Data	•	ODBC Specification
Structural Database:	AISC89.BIN 💌 D	Enable data export to OD
Piping Size Specification	r Ansi 💌 🗾	Append re-runs to existing
Valves and Flanges:		Export CAESAR II data to:
Expansion Joints:	FLEXPATH.JHD	
Units File Name:		from drop menu
Load Case Template	LOAD.TPL	
	5155 State 10	

Then click Exit w/save if you want to save changed settings, otherwise, click Quit-no save



- Making unit

If you want to make new unit file name, follow steps below: From Tools menu, select Make Units files



Follow 4 steps as shown be low:



From appeared spread, make change anything you want even Units File Label then click ${\rm Ok}/{\rm Save}$

ITEM Inte	ernal Units		Constant			User Units	ITEM I	nternal Uni	ts	Constant			User Un	nits
Length	inches	×	25.400000	-	=	mm 💌	Fluid Den.	lbs./cu.in	×	27679.900	•	=	Kg/cu.m.	-
Force	pounds	×	0.453592	-	=	Kgf 💌	Transl.	lbs./in.	×	0.017858	•	=	Kg/mm.	Ŧ
Mass-dynamics	pounds	×	0.453592	•	=	Kg 💌	Rotl. Stiff.	in-lb/deg	×	0.011521	•	=	Kgm/deg	-
Moment-input	inIb.	×	0.011521	•	=	Kgfm 💌	Unif. Load	lb./in.	×	0.017858	•	=	Kg/mm.	•
Moment-output	inIb.	×	0.011521	-	=	Kgfm 💌	G Load	g's	×	1.0000	•	=	g's	-
Stress	lbs./sq.in.	×	0.070307	-	=	Kgf/sq.cm. 💌	Wind Load	lbs./sq.in.	×	0.070307	•	=	Kg/sq.cm.	-
Temp. Scale	degrees F	×	0.5556	-	=	C 💌	Elevation	inches	×	.0254	•	=	m.	-
Pressure	psig	×	0.070307	•	=	Kg/sq.cm. 💌	Cmpd Lng	inches	×	25.4	•	=	mm.	Ŧ
Elastic Modulus	lbs./sq.in.	×	0.070307	•	=	Kg/sq.cm. 💌	Diameter	inches	×	1.0000	•	=	lin.	-
Pipe Density	lbs./cu.in.	×	27679.9003	•	=	Kg/cu.m. 💌	Thickness	inches	×	25.4000	•	=	mm.	•
Insulation Den.	lbs./cu.in.	×	27679.9003	•	=	Kg/cu.m. 💌	Nominals					=	ON	-
Units File Label:			training	_	_									
			1		2	0K / Saus 1	Canad	-1						

b. Uniform load

If you select wrong unit file and wrong uniform load, you will face problem like stress over or overload and it takes a lot of time to solve these.

Az Piping Solution

http://www.azpiping.com

After you correcting unit file name using for your calculation note, you need to check uniform load. Base on your project requirement, you will know value for uniform load in this example we will take uniform load as below GX=0.05 GZ=0.05 So, how can we check these one

In Spread sheet, tick Uniform Loads You see, Caesar II default by UX, UY, UZ (Not GX, GY, GZ as we want)



Please following steps below From Kaux menu, Select Special Excution Parameters

🔃 Piping Inp	ut - [C:\A_TUTURIAL\TEST]						
File Edit Model	Kaux Plot Help						
	Review SIFs at Intersection Nodes						
	Review SIFs at Bend Nodes						
	Special Execution Parameters						
	Include Piping Input Files が						
From: [10	Include Structural Input Files						
To: 20	Show Informational Messages						

Tick Uniform load in G's



Then input value we have (in this example, we use GX=0.05, GY=0, GZ=0.05 See piture)

2		Uniform Loads		
 Bend Rigid Expansion Joint 	Reducer SIFs & Tees Structural			
Restraints Hangers Nozzles	Displacements Equipment	Vector 1 GX: 0.050 GY: 0.000	Vector 2 0.000 0.000	Vector 3
Forces/Moments Uniform Loads Wind / Wave	 Thermal Bowing Pitch & Roll 	GZ: 0.000	0.050	

If your project require using UX, UY, UZ instead of GX, GY, GZ then you need to input your value as requirement and check these carefully (You need to uncheck / UN Tick Uniform load in G's in Special Execution Parameters above) For Example

Bend Re Rigid SIF Expansion Joint Str	ducer 5 & Tees uctural	.1
☐ Restraints ☐ Dis ☐ Hangers ☐ Eq ☐ Nozzles	uipment UX: 0.000	
Forces/Moments Th Uniform Loads Pit Wind / Wave So, what you nee	ermalBowing ch&Roll ed to do when make new	v calculation note is as
File Edit Model Kaux	Plot Hep <u>X XX</u> ₩ .≪[∋€ AA 28 © 쿄i⊨ pipe size, thickness, sion allowable, insulation	画 郎 碑 一 日 章 田 夕 日 回 岡 瓜 二 Firstly, check unit
From: 10 thickr To: 11 Name	BSBend ☐ Reducer Figid ☐ SIFs & Tees Expansion Joint ☐ Structural	basic input as shown here
DX:	Restraints Displacements Hangers Nozzles	Vector 1 Vector 2 Vector 3 GX 0.050 0.000
Diameter: 4 5000 Wt/Schr 6.0198	Forces/Moments 1 Thermal Bowing Uniform Loads Prich & Roll Wind / Wave	check uniform loads
+Mill Tol 2 12 5000 -Mill Tol 2 12 5000	Allowable Stress Elastic Modulus (C): 2.0741E+006	Check material we use
Corrosion: 1.5000 V Insul Thic: V	Elastic Medu/us (H1) put temperature Elastic Modulus (H2) pressure Elastic Medulus (H3)	tick Allowable Stress and correct Code we use
Temp 1: 80.0000 Temp 2: 80.0000 Temp 3: 80.0000	Poisson's Ratio: 0.2920	Automatic selected
Pressure 1: 15.0000 in Pressure 2: pr Hydro Press: 22.5000 pr	Exid Density. 1000.0000	Input fluid density insulation density or default

Az Piping Solution

Please click link below to see all videos about above tutorials
http://www.azpiping.com/tutorials/temperature-3pumps.htm
http://www.azpiping.com/tutorials/loads-3pumps.htm

http://www.azpiping.com/tutorials/temperature-2pumps.htm http://www.azpiping.com/tutorials/loads-2pumps.htm

If you are interested in piping, please visit http://www.azpiping.com for more details

Any comments any suggestion, please visit http://www.azpiping.com/guide/

Noted: -This is first revision made on 16-Oct-2006 -This report will be updated in http://www.azpiping.com/pipe-stress-analysis-reports.htm

Please visit <u>http://www.azpiping.com/pipe-stress-analysis-reports.htm</u> to check update

