



Society of Piping Engineers and Designers  
Egypt Chapter

## WEBINAR

- 1- INTRODUCTION TO PIPE STRESS ANALYSIS
- 2- CODE REQUIREMENTS
- 3- CASE STUDY ON SOFTWARE
- 4- Q & A

Online | 25 December, 2020 | 08:00 p.m (Egypt)  
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Alex Matveev, Ph.D.

Head of development team of pipe stress analysis software PASS/START-PROF that is developed since 1965 and is industry standard in Russia for oil&gas, process, power, and district heating piping. Also he is one of the authors of the pipe stress analysis standards: GOST 32388-2013 Process piping/The standard for the stress, vibration and seismic analysis, GOST R 55506-2013 District heating systems/The standard for stress and seismic analysis.

Alex Matveev, Ph.D.

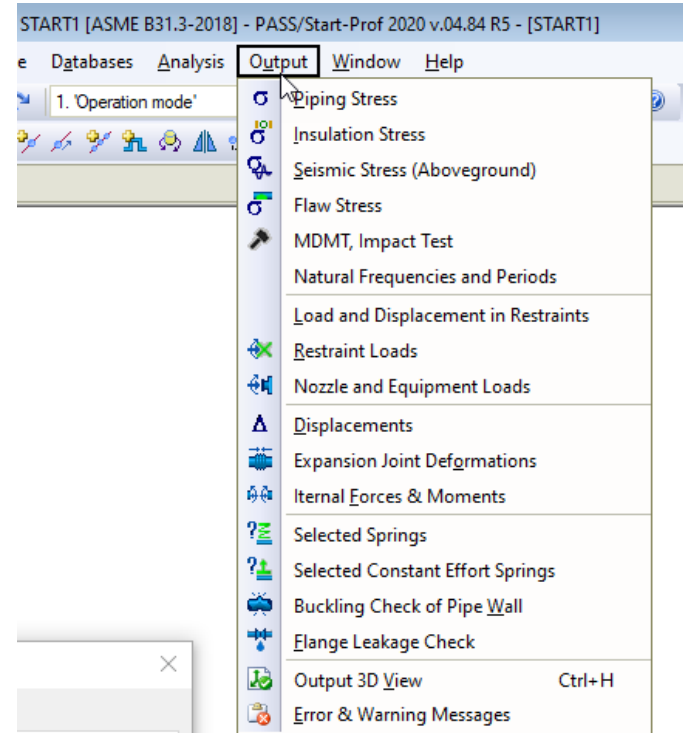
# Pipe Stress Analysis with PASS/START-PROF Software

Piping Stress analysis involves examining the flexibility of a stress critical piping system under different loading conditions.

Piping stress analysis determines the

- Stresses in Pipes and Fittings
- Stresses in Insulation
- Stresses in Flaws
- Displacements
- Forces, and Moments at Restraints and Equipment
- Longitudinal Buckling Check
- Buckling Check under External Pressure
- Flange Leakage Check
- Expansion Joint Deformations
- Spring Hangers and Supports Selection
- Natural Frequencies

And it suggests necessary modifications for satisfying the ASME Code requirements for limits of sustained, displacement & occasional load allowable stresses.



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# Pipe Stress Analysis with PASS/START-PROF Software

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## Loads on Piping System

- Primary Loads: Internal Pressure, Weight of Pipe, Piping component, Insulation, Fluid, etc.
- Secondary Loads: Pipe expansion and contraction
- Occasional Loads: Wind, Snow, Ice, Seismic, Discharge Reaction Loads (Relief valve, PSV, etc.), Slug Flow Loads, Water Hammer Loads, etc.



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# Pipe Stress Analysis with PASS/START-PROF Software

When do pipe stress analysis required?

There are rules for when pipe stress analysis is required. Different industries or companies use own guidelines. Here are the most common rules

- If the operating temperature exceeds 150F and the pipe size is 4" or above
- If the system temperature exceeds 300F need to analyze lines smaller than 4" also
- If any line size is above 8"
- If the line >2 1/2" is connected to rotating equipment
- If the line >6" is connected to pressure vessels
- If the piping is cryogenic
- If the piping system carries hazardous chemicals
- If the piping system is located in a high seismic zone
- etc.

When not required?

- If the exactly the same piping has been previously analyzed
- If there is no thermal growth in the piping system and the line is small



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## 319.4 Flexibility Analysis

**319.4.1 Formal Analysis Not Required.** No formal analysis of adequate flexibility is required for a piping system that

- (a) duplicates, or replaces without significant change, a system operating with a successful service record
- (b) can readily be judged adequate by comparison with previously analyzed systems
- (c) is of uniform size, has no more than two points of fixation, no intermediate restraints, and falls within the limitations of empirical eq. (16)<sup>8</sup>

$$\frac{D_y}{(L - U)^2} \leq K_1 \quad (16)$$

where

$D$  = outside diameter of pipe, mm (in.)

$E_a$  = reference modulus of elasticity at 21°C (70°F), MPa (ksi)

$K_1$  = 208 000  $S_A/E_a$ , (mm/m)<sup>2</sup>  
= 30  $S_A/E_a$ , (in./ft)<sup>2</sup>

<sup>8</sup> **WARNING:** No general proof can be offered that this equation will yield accurate or consistently conservative results. It is not applicable to systems used under severe cyclic conditions. It should be used with caution in configurations such as unequal leg U-bends or near-straight "sawtooth" runs, or for large thin-wall pipe ( $i \geq 5$ ), or where extraneous displacements (not in the direction connecting anchor points) constitute a large part of the total displacement. There is no assurance that terminal reactions will be acceptably low, even if a piping system falls within the limitations of eq. (16).

$L$  = developed length of piping between anchors, m (ft)

$S_A$  = allowable displacement stress range in accordance with eq. (1a), MPa (ksi)

$U$  = anchor distance, straight line between anchors, m (ft)

$y$  = resultant of total displacement strains, mm (in.), to be absorbed by the piping system



# Wall Thickness Calculation using PASS/START-PROF

## ASME B31.1:

$$t \geq t_m = \left( \frac{PD_o}{2(SW_l + Py)} + C \right) / (1 - mt\%)$$

$$\frac{P_t(D_o - 2t)}{2t} \leq 0.9S_y$$

## ASME B31.3:

Low Pressure

$$t \geq t_m = \left( \frac{PD_o}{2(SEW_l + Py)} + C \right) / (1 - mt\%)$$

$$\frac{P_t(D_o - 2t)}{2t} \leq 1.0S_y$$

High Pressure (Chapter IX)

$$t \geq t_m = \left( \frac{D_o}{2} \left[ 1 - \exp\left(\frac{-P}{S}\right) \right] + C \right) / (1 - mt\%)$$

$$\frac{P_t}{\ln\left(\frac{D_o}{D_o - 2t}\right)} \leq 1.0S_y$$

## ASME B31.9:

$$t \geq t_m = \left( \frac{PD_o}{2SE} + C \right) / (1 - mt\%)$$

$$\frac{P_t(D_o - 2t)}{2t} \leq 0.9S_y$$

## ASME B31.5:

$$t \geq t_m = \left( \frac{PD_o}{2(S + Py)} + C \right) / (1 - mt\%)$$

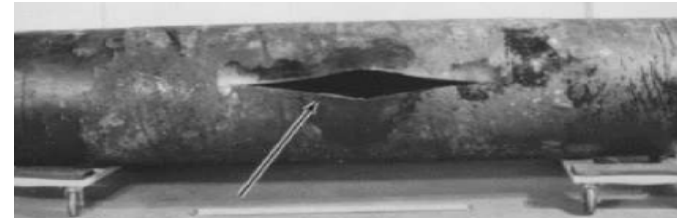
Test pressure is not checked

$t$  – Nominal wall thickness  
 $t_m$  – Design wall thickness  
 $mt\%$  – Mill tolerance  
 $C$  – Corrosion allowance  
 $D_o$  – Outside Diameter  
 $S$  – Allowable stress from database  
 $E$  – Longitudinal weld joint efficiency factor. Specified by user in pipe properties. For ASME B31.1 and B31.5 used  $E=1$ , because it is already added to database values.  
 $S_y$  – Yield stress  
 $W_l$  – Longitudinal weld strength reduction factor. Specified by user in pipe properties  
 $P$  – Design Pressure  
 $P_t$  – Test Pressure

The screenshot displays the software's configuration window. On the left, a 'Project tree...' pane shows a hierarchy: 'Pipe, Above ground' (selected), 'Wall thickness analysis.: 1', and 'Bend'. The main area contains input fields for:
 

- Date: 13-06-2019
- Object Number: (empty)
- Code: (empty)
- ASME B31.3-2018 Process Piping (USA)
- Outer Diameter, D: 219.1 mm
- Operating Temperature: 150 °C
- Mill Tolerance: 12.5 %
- Corrosion Allowance: 1 mm
- Longitudinal Weld Strength Reduction Factor, Wl: 1
- Factor 'y': 0.5
- Factor 'E': 1
- Material: A106 A
- Operating Pressure: 60 kgf/sq.cm
- Wall Thickness, S: 7.78 mm (selected)

 A 'High Pressure' checkbox is present but unchecked. To the right, a diagram shows a circular pipe cross-section with diameter 'D', wall thickness 'S', and design pressure 'P' indicated by arrows.



**ASME B31.4:**If  $D_o/t \geq 20$  then

Pipeline:

$$t \geq t_m = \left( \frac{PD_o}{2E \cdot 0.72S_y} + C \right) / (1 - mt\%)$$

Riser and Platform for Inland Waterways:

$$t \geq t_m = \left( \frac{PD_o}{2E \cdot 0.6S_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t D_o}{2t} \leq 0.9S_y$$

If  $D_o/t < 20$  then

Pipeline:

$$t \geq t_m = \left( \frac{P(D_o - t)}{2E \cdot 0.72S_y} + C \right) / (1 - mt\%)$$

Riser and Platform for Inland Waterways:

$$t \geq t_m = \left( \frac{P(D_o - t)}{2E \cdot 0.6S_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t(D_o - t)}{2t} \leq 0.9S_y$$

**ASME B31.4 Chapter IX (Offshore pipelines):**If  $D_o/t \geq 20$  then

Pipeline:

$$t \geq t_m = \left( \frac{PD_o}{2 \cdot 0.72S_y} + C \right) / (1 - mt\%)$$

Riser and Platform piping:

$$t \geq t_m = \left( \frac{PD_o}{2 \cdot 0.6S_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t D_o}{2t} \leq 0.9S_y$$

If  $D_o/t < 20$  then

Pipeline:

$$t \geq t_m = \left( \frac{P(D_o - t)}{2 \cdot 0.72S_y} + C \right) / (1 - mt\%)$$

Riser and Platform piping:

$$t \geq t_m = \left( \frac{P(D_o - t)}{2 \cdot 0.6S_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t(D_o - t)}{2t} \leq 0.9S_y$$

**ASME B31.4 Chapter XI (Slurry Pipes):**If  $D_o/t \geq 20$  then

$$t \geq t_m = \left( \frac{PD_o}{2 \cdot 0.8ES_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t D_o}{2t} \leq 0.9S_y$$

If  $D_o/t < 20$  then

$$t \geq t_m = \left( \frac{P(D_o - t)}{2 \cdot 0.8ES_y} + C \right) / (1 - mt\%)$$

Test:

$$\frac{P_t(D_o - t)}{2t} \leq 0.9S_y$$

**ASME B31.8:**

$$t \geq t_m = \left( \frac{PD_o}{2EFS_y} + C \right) / (1 - mt\%)$$

$$\frac{P_t D_o}{2t} \leq FS_y$$

Offshore: F=0.72 for Pipeline and F=0.5 for platform piping and risers

Onshore: F – specified by user

If option "Use alternative formula 841.1.1 (b)"

activated and  $D_o/t < 30$ , then

$$t \geq t_m = \left( \frac{PD_o}{2EFS_y + P} + C \right) / (1 - mt\%)$$



**B31.4, B31.8, B31.5:**

Bends are not checked.

Bend wall thickness should not be less than pipe wall thickness.

**B31.9:**

$$t_{bend} = \left( \frac{PD_o}{2SE} k + C \right) / (1 - mt\%)$$

**B31.1, B31.3:**

$$t_m = \left( \frac{PD_o}{2(SEW/I + Py)} + C \right) / (1 - mt\%)$$

ASME B31.1: E=1

GBT 20801: W=1

Centerline:

$$I = 1$$

Intrados:

$$I = \frac{4(R/D_o) - 1}{4(R/D_o) - 2}$$

Extrados:

$$I = \frac{4(R/D_o) + 1}{4(R/D_o) + 2}$$

**EN 13480:**

For  $D_o/(D_o - 2t) \leq 1.7$

$$t \geq \left( \frac{PD_o}{2(fE + 0.5P)} \frac{R/D_o - 0.25}{R/D_o - 0.5} + C \right) / (1 - mt\%)$$

For  $D_o/(D_o - 2t) > 1.7$

$$t \geq \left( \frac{D_o}{2} \left( 1 - \sqrt{\frac{fE - P}{fE + P}} \right) \frac{R/D_o - 0.25}{R/D_o - 0.5} + C \right) / (1 - mt\%)$$

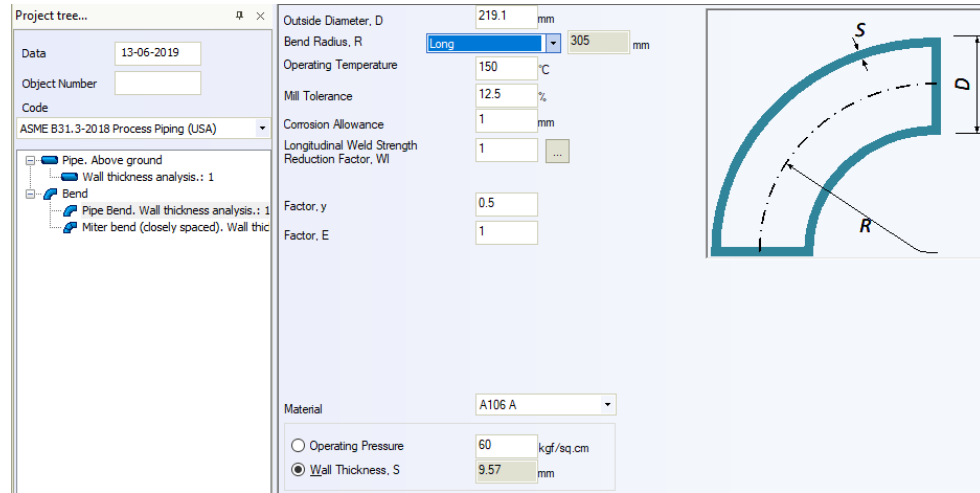
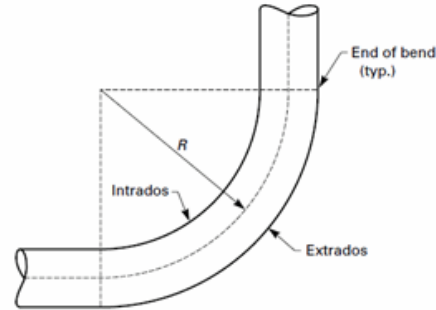


Fig. 102.4.5 Nomenclature for Pipe Bends



**ASME B31.4, B31.5, B31.8:**

Miter bends are not checked.

Bend wall thickness should not be less than pipe wall thickness.

**ASME B31.1:**

If  $\theta > 22.5^\circ$  or  $B < 6t_m$  then allowable pressure is 0.07 MPa.

If  $\theta \leq 22.5^\circ$  and  $B \geq 6t_m$  then allowable pressure is 0.7 MPa.

Wall thickness should be not less than

$$t_s \geq t_m = \left( \frac{PD_o}{2(SW + Py)} + C \right) / (1 - mt\%)$$

$$t_s = \left( t_m \frac{2 - r/R}{2(1 - r/R)} + C \right) / (1 - mt\%)$$

$$r = \frac{D_o - t_s}{2}$$

**ASME B31.3, B31.9, EN 13480:**

For ASME B31.9, EN 13480:  $W=1$

Allowable pressure for miter bends with  $\theta \leq 22.5^\circ$  (minimum of 2 equations):

$$P_m = \frac{S \cdot E \cdot W \cdot tc^2}{r_2 [tc + 0.643 \tan(\theta) \sqrt{r_2 tc}]}$$

$$P_m = \frac{S \cdot E \cdot W \cdot tc [R_1 - r_2]}{r_2 [R_1 - 0.5r_2]}$$

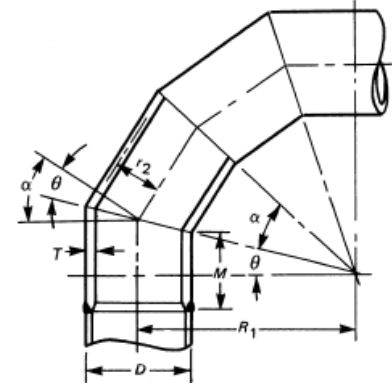
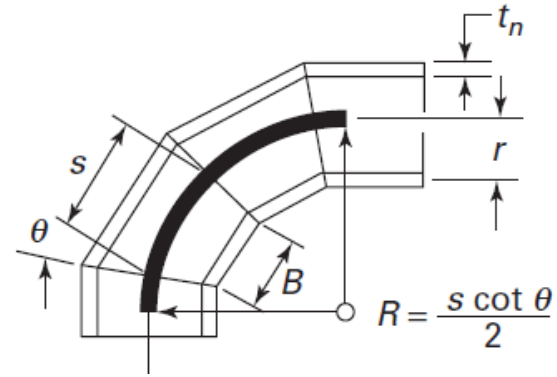
$$tc = (T - C) \cdot (1 - mt\%)$$

$$r_2 = \frac{D_o - T}{2}$$

Error message if  $\theta > 22.5^\circ$

T – Miter bend wall thickness,

C – Corrosion allowance





This presentation will be available to download at passuite.com

The screenshot shows the PASS website interface. The browser address bar contains `passuite.com/start#resources-tab`. The main navigation bar includes links for Overview, Codes, Integration, START-Elements, Configurations, Download, and Resources. The Resources menu is open, displaying a list of categories: PASS/HYDROSYSTEM, PASS/START-PROF, PASS/EQUIP, PASS/Integration, PASS/INDUSTRY, and PASS/ACADEMIC. Below the navigation, the 'Supporting Materials' section lists various PDF documents, each with a red PDF icon and a title.

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- PASS START-PROF Capabilities for District Heating Industry
- PASS START-PROF Capabilities for District Heating Industry (Spanish)
- PASS START-PROF Capabilities for Oil & Gas Gathering, Upstream and Midstream Pipelines
- PASS START-PROF Capabilities for Oil & Gas Gathering, Upstream and Midstream Pipelines (Spanish)
- PASS START-PROF Capabilities for Pipe Stress Analysis of Power and Process Piping Systems
- PASS START-PROF Capabilities for Pipe Stress Analysis of Power and Process Piping Systems (Spanish)
- PASS START-PROF Datasheet 2020
- PASS START-PROF Overview 4.84 version (Italian)
- PASS START-PROF What's New in 4.84 version
- PASS START-PROF What's New in 4.84 version (Spanish)
- START-PROF Training Agenda

# PASS/Start-Prof | Resources

Subscribe to YouTube channel,  
you will find a lot of PASS/START-  
PROF training videos

[www.youtube.com/passuite](http://www.youtube.com/passuite)

The screenshot displays the YouTube channel page for PASS, which has 716 subscribers. The page is organized into a grid of video thumbnails. Each thumbnail includes a video player preview, the video title, and the view count and upload date. The videos cover a wide range of topics related to piping and equipment analysis, including software overviews, import tutorials, and specific case studies.

Video Title	Views	Upload Date
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PASS/START-PROF Overview Webinar: Your software for...	334 views	2 months ago
PASS/Equip Nozzle-FEM Overview Webinar: Powerful...	135 views	2 months ago
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16 Interface between Hydrosystem and START-...		
Buried Piping/Pipelines Stress Analysis with...		



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# Sustained Stress

## ASME B31.1, ASME B31.9, DLT 5366 (input: $i$ )

For nonstandard tee, non-standard bend, joint and ASME B31J:

$$S_L = \frac{P(D_o - 2t_n)^2}{D_o^2 - (D_o - 2t_n)^2} \pm \frac{0.75 \cdot \max(i_i, i_o, i_t) \cdot \sqrt{M_i^2 + M_o^2 + M_t^2}}{Z}$$

For pipes and other fittings:

$$S_L = \frac{P(D_o - 2t_n)^2}{D_o^2 - (D_o - 2t_n)^2} \pm \frac{(0.75i \geq 1) \cdot \sqrt{M_i^2 + M_o^2 + M_t^2}}{Z}$$

## ASME B31.5 (input: $i_i, i_o$ )

$F$  – Axial force without pressure thrust,  $c$  – corrosion allowance

$$F = F' + P \left[ \frac{\pi(D_o - 2(t_n - c))^2}{4} - \frac{\pi(D_o - 2t_n)^2}{4} \right] - P \frac{\pi(D_o - 2(t_n - c))^2}{4}$$

$F$  with pressure thrust

$$F = F' + P \left[ \frac{\pi(D_o - 2(t_n - c))^2}{4} - \frac{\pi(D_o - 2t_n)^2}{4} \right]$$

For pipes and fittings:

$$S_L = \frac{P(D_o - 2(t_n - c))^2}{D_o^2 - (D_o - 2(t_n - c))^2} + \frac{F}{A_p} \pm \frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z}$$

For nonstandard tee, non-standard bend, joint and ASME B31J:

$$S_L = \frac{P(D_o - 2(t_n - c))^2}{D_o^2 - (D_o - 2(t_n - c))^2} + \frac{i_a F}{A_p} \pm \frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z}$$

## ASME B31.3 (input: $i_i, i_o$ )

$F$  – Axial force without pressure thrust,  $c$  – corrosion allowance

For pipes, bends, reducers, tees:

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

$$S_a = \frac{F}{A_p}$$

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

$$S_b = \frac{\sqrt{((0.75i_i \geq 1)M_i)^2 + ((0.75i_o \geq 1)M_o)^2}}{Z}$$

For nonstandard tee, non-standard bend, joint and ASME B31J:

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

$$S_a = \frac{(0.75i_a \geq 1)F}{A_p}$$

$$S_t = \frac{(0.75i_t \geq 1)M_t}{2Z}$$

$$S_b = \frac{\sqrt{((0.75i_i \geq 1)M_i)^2 + ((0.75i_o \geq 1)M_o)^2}}{Z}$$



# Allowable Sustained Stress

## ASME B31.1

$$S_L \leq S_h \cdot W_c / E$$

## ASME B31.3

$$S_L \leq S_h \cdot W_c$$

## ASME B31.5

$$S_L \leq S_h / E$$

## ASME B31.9

$$S_L \leq S_h$$

## EN 13480

$$\sigma_1 \leq f_f = \min(f(T); f_{cr})$$

If  $f_{cr} = 0$  Then  $\sigma_1 \leq f_f = f(T)$

If  $R_p = 0$  and  $t < 720$  then  $R_p = R_m \frac{720-t}{1400}$ ,  $t$  – temperature in Degrees Celsius

$R_p, R_m, S_{RTt}$  – From database at operating (hot) temperature

Not austenitic steel and austenitic with  $A < 35\%$

$$f(T) = \min\left(\frac{R_p}{1.5}, \frac{R_m}{2.4}\right)$$

Austenitic steel  $A \geq 35\%$

If  $R_m = 0$  then

$$f(T) = \frac{R_p}{1.5}$$

If  $R_m > 0$

$$f(T) = \min\left(\frac{R_p}{1.2}, \frac{R_m}{3}\right)$$

Creep allowable:

$$f_{cr} = \frac{S_{RTt}}{S_{fcr}}$$

If temp lower creep limit then  $f_{cr} = 0$ .

$S_{RTt}$  – from database for specified lifetime (hours).

If “With surveillance of creep exhaustion”=Off (in Project Settings) then

$$S_{fcr} = 1.5$$

If at specified  $t$   $S_{RTt} \neq 0.01$  then

Use  $S_{RTt}$

Else if at specified  $t$   $S_{RTt} = 0.01$  then use  $S_{RTt} =$

$$S_{RT200000h}$$

If lifetime  $> 100'000h$  then

If  $\frac{S_{RT200000}}{S_{RT100000}} < 0.781$  then error message show

“SRT20000/SRT1000 is lower than 0.781 see Table 5.3.2-1”

If “With surveillance of creep exhaustion”=On then

If at specified  $t$   $S_{RTt} \neq 0.01$  then

Use  $S_{RTt}$ ,  $S_{fcr} = 1.25$

Else if at specified  $t$   $S_{RTt} = 0.01$  then

If  $S_{RT200000h} \neq 0.01$  use  $S_{RTt} = S_{RT200000h}$ ,  $S_{fcr} = 1.25$

If  $S_{RT200000h} = 0.01$  use  $S_{RTt}$ , for  $t=150000$   $S_{fcr} = 1.35$ , for  $t=100000$   $S_{fcr} = 1.5$

$$\sigma_1 \leq f_f = \min(f(T); f_{cr})$$

If  $R_p = 0$  and  $t < 720$  then  $R_p = R_m \frac{720-t}{1400}$ ,  $t$  – temperature in Degrees Celsius

$R_p, R_m, S_{RTt}$  – From database at operating (hot) temperature

Not austenitic steel and austenitic with  $A < 35\%$

$$f(T) = \min\left(\frac{R_p}{1.5}, \frac{R_m}{2.4}\right)$$

Austenitic steel  $A \geq 35\%$

If  $R_m = 0$  then

$$f(T) = \frac{R_p}{1.5}$$

If  $R_m > 0$

$$f(T) = \min\left(\frac{R_p}{1.2}, \frac{R_m}{3}\right)$$

Creep allowable:

$$f_{cr} = \frac{S_{RTt}}{S_{fcr}}$$

$S_{RTt}$  – from database for specified lifetime (hours).

If “With surveillance of creep exhaustion”=Off (in Project Settings) then

$$S_{fcr} = 1.5$$

If at specified  $t$   $S_{RTt} \neq 0.01$  then

Use  $S_{RTt}$

Else if at specified  $t$   $S_{RTt} = 0.01$  then use  $S_{RTt} = S_{RT200000h}$

If lifetime  $> 100'000h$  then

If  $\frac{S_{RT200000}}{S_{RT100000}} < 0.781$  then error message show

“SRT20000/SRT1000 is lower than 0.781 see Table 5.3.2-1”

If “With surveillance of creep exhaustion”=On then

If at specified  $t$   $S_{RTt} \neq 0.01$  then

Use  $S_{RTt}$ ,  $S_{fcr} = 1.25$

Else if at specified  $t$   $S_{RTt} = 0.01$  then

If  $S_{RT200000h} \neq 0.01$  use  $S_{RTt} = S_{RT200000h}$ ,  $S_{fcr} = 1.25$

If  $S_{RT200000h} = 0.01$  use  $S_{RTt}$ , for  $t=150000$   $S_{fcr} = 1.35$ , for  $t=100000$   $S_{fcr} = 1.5$



# Allowable Occasional Stress

## ASME B31.1

$$S_L \leq k \cdot S_h / E$$
$$k = 1.15, 1.2$$

## ASME B31.9

$$S_L \leq k \cdot S_h$$
$$k = 1.15, 1.2$$

## ASME B31.5

$$S_L \leq k \cdot S_h / E$$
$$k = 1.33$$

## ASME B31.3

If  $T \leq 426.667^\circ\text{C}$  (800°F) then

$$S_L \leq k \cdot S_h$$

Else

$$S_L \leq \min(k \cdot S_h; 0.9W_c S_y)$$

For Low Pressure piping  $k = 1.33$

For High Pressure piping  $k = 1.2$

## EN 13480

$$S_L \leq k f_f$$

$k = 1.15, 1.2, 1.3, 1.8$

# Allowable Test Stress

## ASME B31.1, ASME B31.9

$$S_L \leq 0.9S_y$$

## ASME B31.3

$$S_L \leq 1.0S_y$$

## ASME B31.5

Not calculated

## EN 13480

$$\sigma_1 \leq 0.95R_p$$



# Expansion Stress

Option "Add axial force and torsion stress" in Project Settings turned ON

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

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

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

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

## ASME B31.1, ASME B31.9

$$I_a = 1, I_t = 0.75i \geq 1, I_i = 0.75i \geq 1, I_o = 0.75i \geq 1$$

For ASME B31J:

$$I_a = 1, I_t = 0.75 \max(i_i, i_o, i_t) \geq 1, I_i = 0.75 \max(i_i, i_o, i_t) \geq 1,$$

$$I_o = 0.75 \max(i_i, i_o, i_t) \geq 1$$

For Non-standard TEE, Non-standard BEND, Joint:

$$I_a = 0.75i_a \geq 1, I_t = 0.75i_t \geq 1, I_i = 0.75i_i \geq 1, I_o = 0.75i_o \geq 1$$

## ASME B31.5

$$I_a = 1, I_t = 1, I_i = i_i, I_o = i_o$$

For Non-standard TEE, Non-standard BEND, Joint, ASME B31J:

$$I_a = i_a, I_t = i_t, I_i = i_i, I_o = i_o$$

## EN 13480

$$S_a = \frac{I_a F}{A_p} + \frac{P}{2}$$

If "Use ii/io"=false (input:  $i$ )

$$I_a = 1, I_t = 0.75i \geq 1, I_i = 0.75i \geq 1, I_o = 0.75i \geq 1$$

If "Use ii/io"=true (input:  $i_i, i_o$ )

$$I_a = 1, I_t = 1, I_i = 0.75i_i \geq 1, I_o = 0.75i_o \geq 1$$

For Non-standard TEE, Non-standard BEND, Joint, ASME B31J:

$$I_a = 0.75i_a \geq 1, I_t = 0.75i_t \geq 1, I_i = 0.75i_i \geq 1, I_o = 0.75i_o \geq 1$$



# Expansion Stress

## ASME B31.1, ASME B31.9

For nonstandard tee, non-standard bend, joint and ASME B31J:

$$S_E = \max(i_i, i_o, i_t) \frac{\sqrt{M_i^2 + M_o^2 + M_t^2}}{Z} \leq S_A$$

For other fittings:

$$S_E = i \frac{\sqrt{M_i^2 + M_o^2 + M_t^2}}{Z} \leq S_A$$

## ASME B31.5

For other fittings

$$S_E = \sqrt{(S_b)^2 + (2S_t)^2} \leq S_A$$

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

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

For nonstandard tee, non-standard bend, joint and ASME B31J:

$$S_E = \sqrt{(S_b)^2 + (2S_t)^2} \leq S_A$$

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

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

## ASME B31.3 (input: $i_i, i_o$ )

For bends:

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

$$S_a = \frac{F}{A_p}$$

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

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

For other fittings:

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

$$S_a = \frac{i_o F}{A_p}$$

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

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

For nonstandard tee, non-standard bend, joint and ASME B31J:

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

$$S_a = \frac{i_a F}{A_p}$$

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

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

## EN 13480

If "Liberal Stress

Allowable"=True

$$\sigma_4 = P \left( \frac{(D_o - 2t_n)^2}{D_o^2 - (D_o - 2t_n)^2} + \frac{1}{2} \right) + S_b^{sus} + S_b^{exp}$$

If "Liberal Stress

Allowable"=False

$$\sigma_3 = S_b^{exp}$$

Creep Check

$$\sigma_5 = P \left( \frac{(D_o - 2t_n)^2}{D_o^2 - (D_o - 2t_n)^2} + \frac{1}{2} \right) + S_b^{sus} + S_b^{exp} \frac{1}{3}$$

$S_b^{sus}$  - From sustained forces (load case L1)

$S_b^{exp}$  - From expansion range forces (load case L9)

If "Use  $i_i/i_o$ "=false (input:  $i$ )

For nonstandard tee, non-standard bend, joints and ASME B31J:

$$S_b^{sus} = \frac{(0.75 \max(i_i, i_o) \geq 1) \sqrt{M_i^2 + M_o^2 + M_t^2}}{Z}$$

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

For other fittings:

$$S_b^{sus} = \frac{(0.75i \geq 1) \sqrt{M_i^2 + M_o^2 + M_t^2}}{Z}$$

$$S_b^{exp} = \frac{i \sqrt{M_i^2 + M_o^2 + M_t^2}}{Z}$$

If "Use  $i_i/i_o$ "=true (input:  $i_i, i_o$ )

For nonstandard tee, non-standard bend, joint and ASME B31J:

$$S_b^{sus} = \frac{\sqrt{((0.75i_i \geq 1)M_i)^2 + ((0.75i_o \geq 1)M_o)^2 + ((0.75i_t \geq 1)M_t)^2}}{Z}$$

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

For other fittings:

$$S_b^{sus} = \frac{\sqrt{((0.75i_i \geq 1)M_i)^2 + ((0.75i_o \geq 1)M_o)^2 + (M_t)^2}}{Z}$$

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



# Allowable Expansion Stress

## ASME B31.1

$$S_c \leq 138 \text{ MPa}$$

$$S_h \leq 138 \text{ MPa}$$

If  $S_L \geq S_h$ , then

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

If  $S_L < S_h$  and liberal allowable=true then

$$S_A = f(1.25S_c/E + 1.25S_h/E - S_L)$$

$$0.15 \leq f \leq 1.0$$

$$f = 6/N^{0.2}$$

## ASME B31.9

$$S_c \leq 138 \text{ MPa}$$

$$S_h \leq 138 \text{ MPa}$$

If  $S_L \geq S_h$ , then

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

If  $S_L < S_h$  and liberal allowable=true then

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

$$0.15 \leq f \leq 1.0$$

$$f = 6/N^{0.2}$$

## ASME B31.3

$$S_c \leq 138 \text{ MPa}$$

$$S_h \leq 138 \text{ MPa}$$

For Low Pressure piping

If  $S_L \geq S_h$  or liberal allowable=false then

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

If  $S_L < S_h$  and liberal allowable=true then

$$S_A = f(1.25S_c + 1.25S_h - \max S_L)$$

For High Pressure piping (Chapter IX)

$$S_A = 1.25S_c + 0.25S_h$$

$\max S_L$  – Maximum  $S_L$  stress calculated from **all sustained load cases (L1 and L2) from all available operating modes!**

$$f = 6/N^{0.2}$$

If temperature  $T \leq 371^\circ\text{C}$  **AND** material (option in database) “Maximum  $f=1.2$ ”=True then

$$0.15 \leq f \leq 1.2 \text{ Else } 0.15 \leq f \leq 1.0$$

## ASME B31.5

$$S_c \geq 0$$

$$S_h \geq 0$$

If  $S_L \geq S_h$ , then

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

If  $S_L < S_h$  and liberal allowable=true then

$$S_A = f(1.25S_c/E + 1.25S_h/E - S_L)$$

$$0.5 \leq f \leq 1.0$$

$$f = 6/N^{0.2}$$

## EN 13480

If “**Liberal Stress Allowable**”=True

$$\sigma_4 \leq f_f + S_A$$

$$f_f = \min(f(T); f_{CR})$$

If  $f_{CR} = 0$  then  $f_f = f(T)$

If “**Liberal Stress Allowable**”=False

$$\sigma_3 \leq S_A$$

Creep Check

$$\sigma_5 \leq f_{cr}$$

$$f_c \geq 0$$

$$f_h \geq 0$$

$$S_A = U(1.25f_c + 0.25f_h) \frac{E_h}{E_c}$$

$$f_h = \min(f_c; f(T); f_{CR})$$

If  $f_{CR} = 0$  then  $f_h = \min(f_c; f(T))$

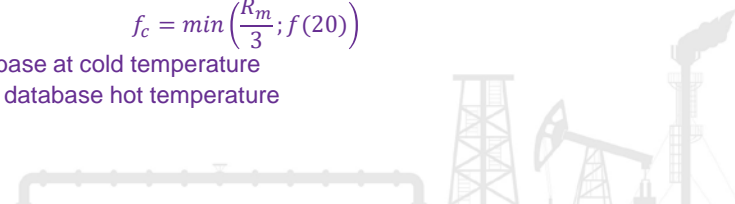
$$0.5 \leq U \leq 1.0$$

$$U = 6/N^{0.2}$$

$$f_c = \min\left(\frac{R_m}{3}; f(20)\right)$$

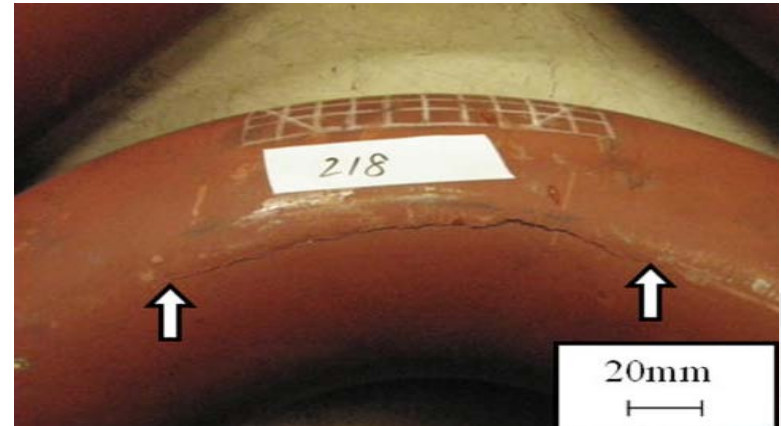
$R_p, R_m$  – From database at cold temperature

$R_p, R_m, S_{RTt}$  – From database hot temperature





# Importance of Expansion Stress Check (Cow Cycle Fatigue Failure)



# Importance of Buckling Check



# Importance of Buckling Check



Рубрике параметров трубопровода  
Табл=31 С = Рубрике 31 в таблице 2  
Примечание: Максимальная длина с 12% от 1000 м  
Скорость движения по реконструктивной графике 150/70  
Трубопровода DN20, с толщиной DN=25

**Trubodetal2**

Project tree...

Data: 13-06-2019

Object Number: [ ]

Code: [ ]

SNP 2.05.06-85 Gas & oil transmission piping : [ ]

- [-] Pipe, Above ground
- [-] Pipe, Buried
- [-] Wall thickness analysis.: 0
- [-] Stability analysis.: 1.0**
- [-] Pipe elongation: 0
- [-] Long-radius bend stability: 0
- [-] Pipe strength against surface load: 0
- [-] Pipe, Buried pipe in embankment
- [-] Wall thickness analysis.: 0
- [-] Bend
- [-] Tee
- [-] Reducer
- [-] Cap
- [-] L-, Z-, U-shaped pipe loops. Above-ground
- [-] L-, Z-, U-shaped pipe loops. Above-ground
- [-] L-, Z-, U-shaped pipe loops. Buried

Pipe Outside Diameter, D: 0 mm

External Casing Diameter (if absent), Dc: 0 mm

Pipe Wall Thickness, S: 0 mm

Operating Temperature: 0 °C

Pipe Weight: 0 kgf/m

Fluid Weight: 0 kgf/m

Insulation Weight: 0 kgf/m

Pipeline Category: B

Pressure safety factor (SNP table 13): 1.1

Material: [ ]

Backfill Soil Code: 04

Friction Factor: 0.67

Axis force: 0 kgf

Depth, Z: 0 m

# Importance of Checking of Pipeline Upheaval Buckling



# Importance of Checking of Local Buckling from External Pressure



# Importance of Checking of Local Buckling from External Pressure



Trubodetal2

Project tree...

- Data: 13-06-2019
- Object Number: [ ]
- Code: GOST 32388-2013 Process piping (Russia)
- Pipe, Above ground
  - Wall thickness analysis.: 0
  - Strength analysis of vacuum element**
  - Analysis of allowable load capacity fo
  - Stability analysis.: 0
  - Span length analysis.: 0
- Pipe, Buried
  - Bend
  - Tee
  - Reducer
  - Flange
  - Cap
  - Expansion joint
  - L-, Z-, U-shaped pipe loops. Above-ground
  - L-, Z-, U-shaped pipe loops. Above-ground
  - L-, Z-, U-shaped pipe loops. Buried

Outside Diameter, D: 0 mm

Operating Temperature: 0 °C

Pipe: Electric-welded

Weld Quality Factor for Pressure: 1

Mill Tolerance: 0 mm

Corrosion Allowance: 0 mm

Availability of stiffening ribs

Stability Safety Factor: 2.4

Material: [ ]

Pressure

External Operating Pressure (vacuum): -0 kgf/sq.cm

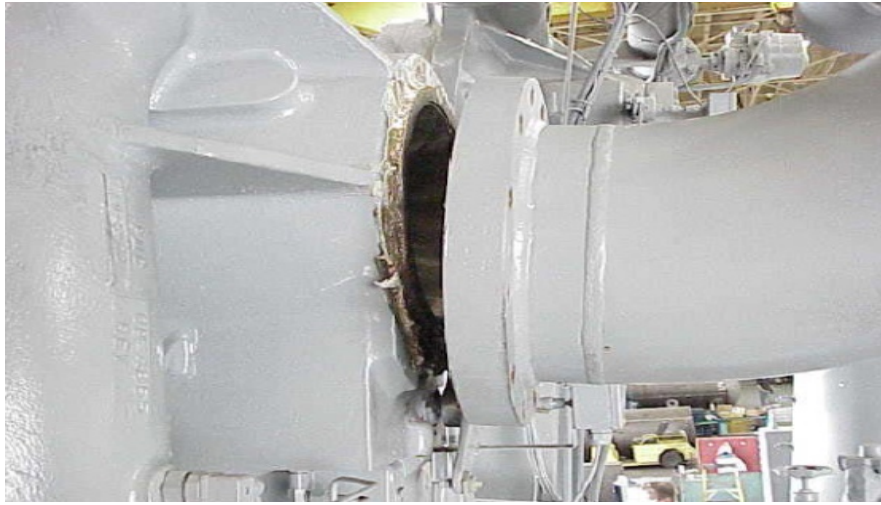
Test Pressure: 2 kgf/sq.cm

Pipe Wall Thickness, S: 0 mm

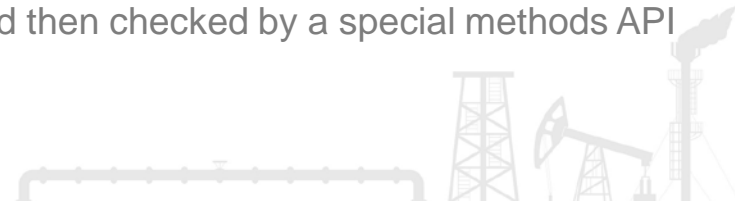
# Importance of Checking of Piping Displacements



# Importance of Checking of Supports and Equipment loads



- Option 1. The equipment manufacturer provides allowable loads. It is necessary that the calculated loads from START-PROF be less than those allowed by the manufacturer.
- Option 2. Loads are determined using START-PROF are transferred to equipment manufacturers or steel structure engineers for the subsequent evaluation of the strength of the structure or equipment
- Option 3. The loads are determined with the START-PROF and then checked by a special methods API 610, API 617, NEMA SM 23, API 650, Nozzle-FEM, etc.





# Importance of Checking of Allowable Deformations of Expansion Joints



# PASS/Start-Prof | Broad Applicability

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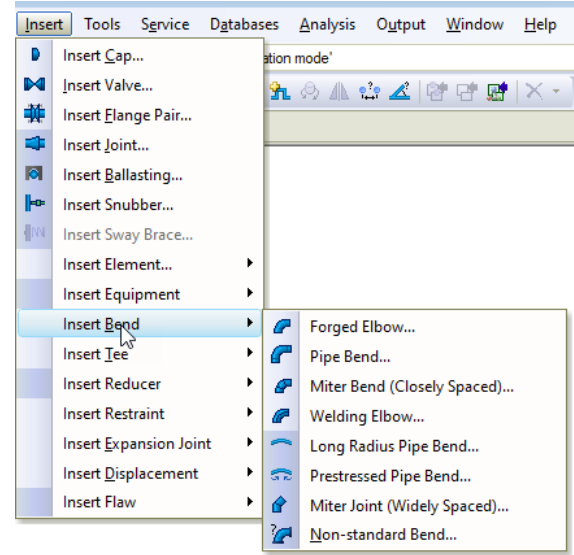
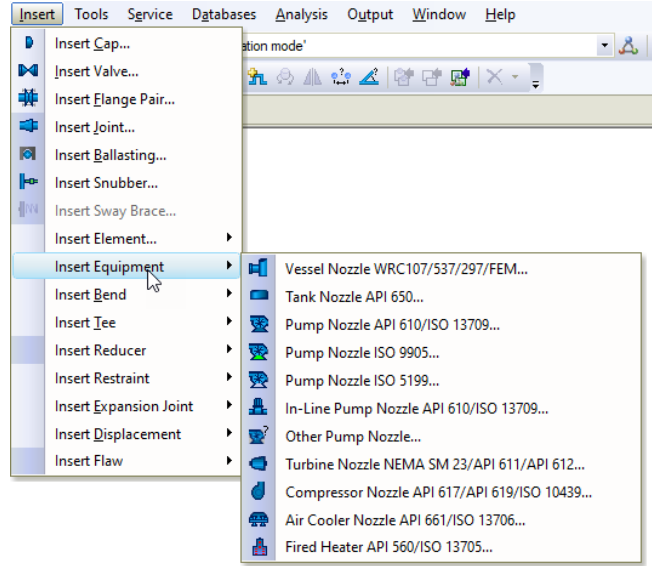
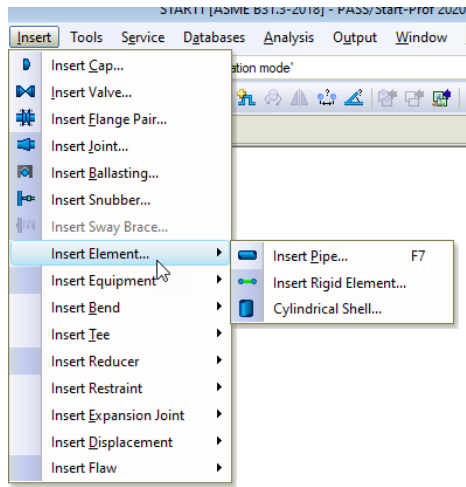
- Developed since 1965
- 3000+ Active users (companies). Licenses 8000+
- User interface and documentation languages: English, Chinese, Russian
- Piping codes: 32
- Wind, Seismic, Snow, Ice codes: 18



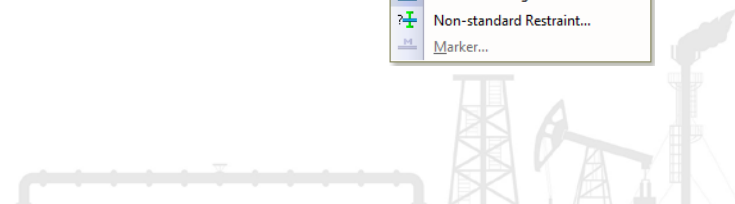
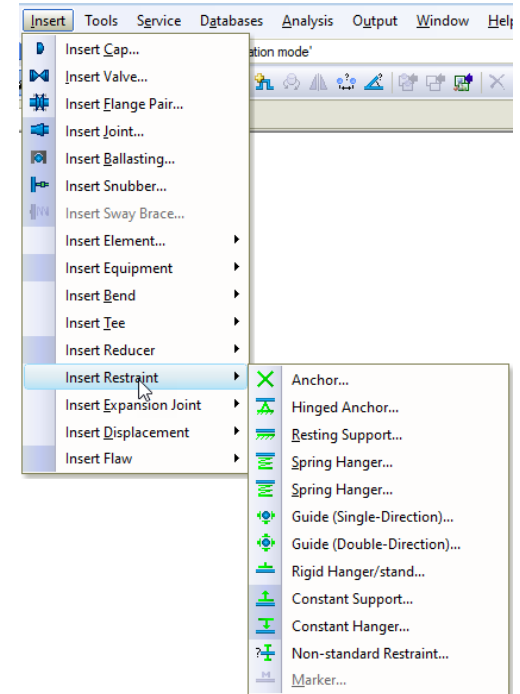
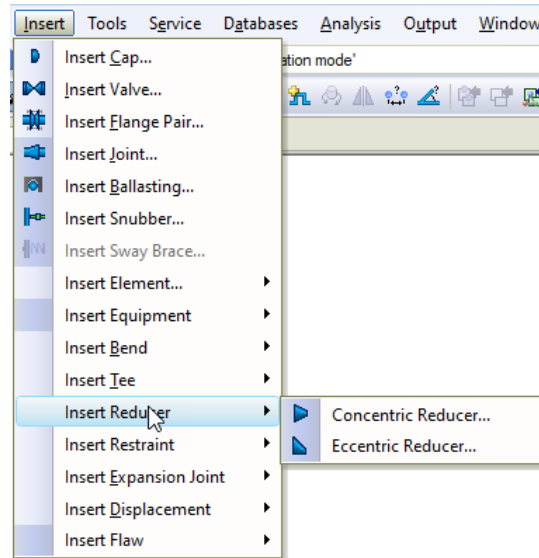
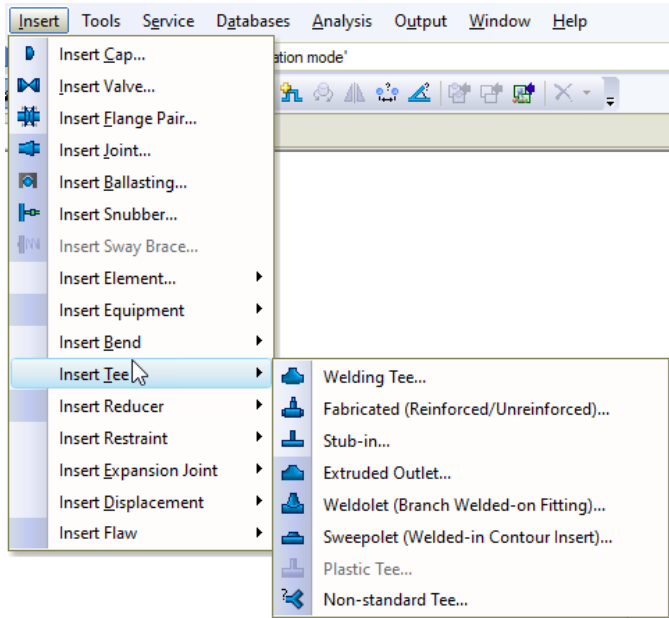
PIPING AND EQUIPMENT  
ANALYSIS & SIZING SUITE



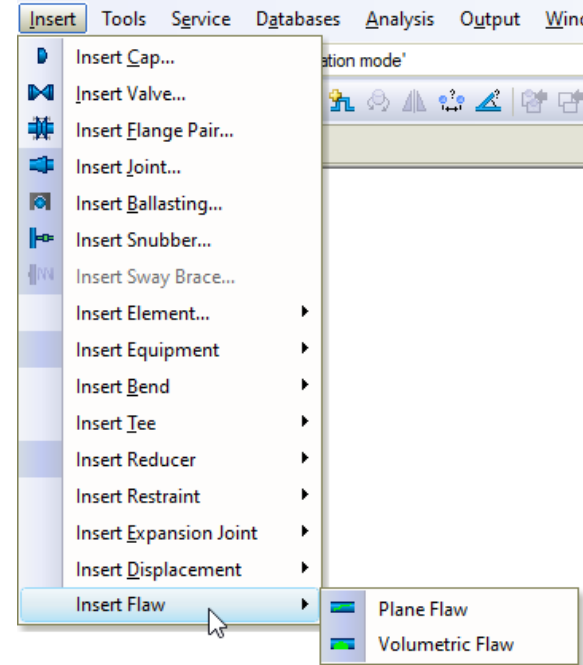
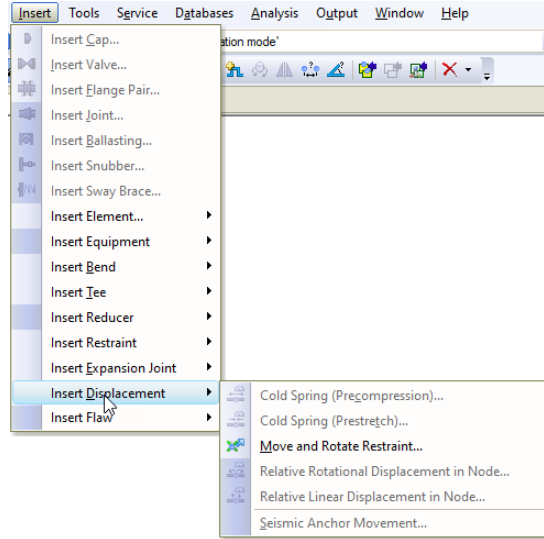
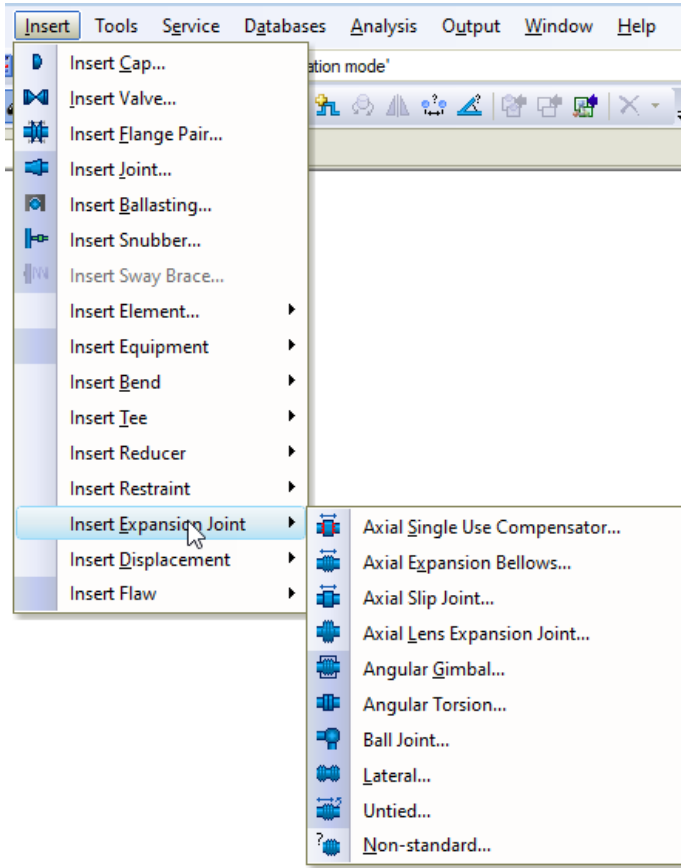
# PASS/START-PROF Object-Oriented Piping Model



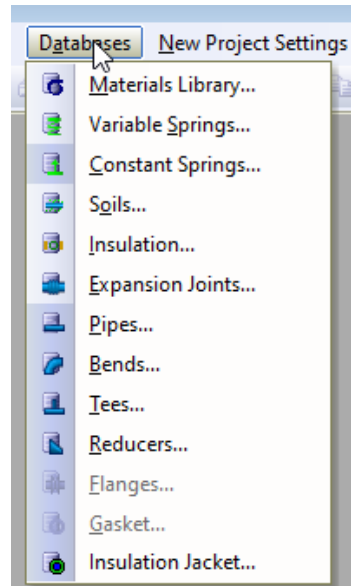
# PASS/START-PROF Object-Oriented Piping Model



# PASS/START-PROF Object-Oriented Piping Model



# Databases



# Occasional allowable calculation for elevated temperature fluid service 302.3.6 (2) ASME B31.3-2018 appendix V.

Material: A106 A Class: Carbon or Low Alloy Steel

Database can only be edited if database files are open for editing and if stress units are set as MPa for ASME -ksi

Data source: ASME B31.3-2018 Carbon(CcSh)

Density: 7833.41303  Maximum f=1.2

Larson-Miller constant C: 20

Creep Factors: Carbon, SiMn Steel

Temperature F	Allowable Stress (S), ksi	Yield Stress (Sy), ksi	Elastic Modulus ksi	Expansion Coeff. 1/F	Poisson's Ratio (ν)	Wt
-325	16	30	31400	5.5e-006	0.292	1.0
-200	16	30	30800	5.79e-006	0.292	1.0
-150	16	30	30300	5.9e-006	0.292	1.0
-50	16	30	29891	6.2e-006	0.292	1.0
70	16	30	29400	6.4e-006	0.292	1.0
100	16	30	29262	6.47e-006	0.292	1.0
200	16	27.500	28800	6.7e-006	0.292	1.0

Buttons: Save, OK, Cancel, Help

Input Stress

Operating Mode: 1.1 'occ1.1'

Show Equations  Stress  Creep Stress

Object	Start End node	Primary Loads Stress, (ksi)			Notes
		SI_Alt	k*Sh	%	
Above ground pipe	14	5.012	5.960	84.1	
	29,2 Flange	7.181	5.960	120.5	1
Forged Elbow	29,2 Flange	8.444			Sh, 4.684 ksi
Above ground pipe	29,2 Flange	7.805			Sy, 18.616 ksi
	15	4.266			ti=5000 hour
Above ground pipe	14	5.172			C=20
	16	5.325			Te, 481.384305068139 °C
Weldolet (branch welded-on-fitting)	16	12.256			S02, 5.960 ksi
Above ground pipe	16	3.967			min(4Sh,0.8*0.9Sy,S02), 5.960 ksi

include same or like material, weld metal composition, and welding process under equivalent, or more severe, sustained operating conditions.

### 302.3.6 Limits of Calculated Stresses Due to Occasional Loads

(a) Operation. Stresses due to occasional loads may be calculated using the equations for stress due to sustained loads in para. 320.2.

(1) Subject to the limits of para. 302.2.4, the sum of the stresses due to sustained loads, such as pressure and weight,  $S_p$ , and of the stresses produced by occasional loads, such as wind and earthquake, may be as much as 1.33 times the basic allowable stress provided in Table A-1 or Table A-1M at the metal temperature for the occasional condition being considered. Wind and earthquake forces need not be considered as acting concurrently.

(2) For Elevated Temperature Fluid Service (see definition in para. 300.2) of materials having ductile behavior, as an alternative to the use of 1.33 times the basic allowable stress provided in Table A-1 or Table A-1M, the allowable stress for occasional loads of short duration, e.g., surge, extreme wind, or earthquake, may be taken as the lowest of the following:

(-a) the weld strength reduction factor times 90% of the yield strength at the metal temperature for the occasional condition being considered

(-b) four times the basic allowable stress provided in Appendix A

(-c) for occasional loads that exceed 10 h over the life of the piping system, the stress resulting in a 20% creep usage factor in accordance with Appendix V

For (-a), the yield strength shall be as listed in ASME BPVC Section II, Part D, Table Y-1 or determined in accordance with para. 302.3.2. The strength reduction factor represents the reduction in yield strength with long-term exposure of the material to elevated temperatures and, in the absence of more-applicable data, shall be taken as 1.0 for austenitic stainless steel and 0.8 for other materials.

For (-b), the basic allowable stress for castings shall also be multiplied by the casting quality factor,  $E_c$ . Where the allowable stress value exceeds two-thirds of yield strength at temperature, the allowable stress value must be reduced as specified in para. 302.3.2(e).

(b) Test. Stresses due to test conditions are not subject to the limitations in para. 302.3. It is not necessary to consider other occasional loads, e.g., wind and earthquake, as occurring concurrently with test loads.

### Smart Operation Mode Editor

#	Name	Hanger Sizing	High temperature	Cold State	Seismic	Wind	Snow/Ice	Friction Multiplier	Weight Multiplier	Time Duration, hour	Mode Type	Stress Range Between	Help
1 (0)	OPE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.00	1.00	0.00	SUS	1-1A	?
1.1 (0)	occ1.1	-	-	-	-	-	-	-	-	-	OCC Std		?
2 (2)	occ	<input type="checkbox"/>	-	-	-	-	-	1.00	1.00	0.00	OCC Std	2-1A	?
3 (1)	Test mode	-	-	-	-	-	-	-	-	-	SUS OCC Std OCC Alt Test		?

Automatic creep-rupture usage factor calculation according to ASME B31.3-2018 Appendix V (V303.1-V303.3).

### V303.2 Determine Creep-Rupture Usage Factor

The usage factor,  $u$ , is the summation of individual usage factors,  $t_i / t_{ri}$ , for all service conditions considered in para. V303.1. See eq. (V4).

$$u = \sum (t_i / t_{ri}) \quad (V4)$$

where

- $i$  = as a subscript, 1 for the prevalent operating condition;  $i = 2, 3$ , etc., for each of the other service conditions considered
- $t_i$  = total duration, h, associated with any service condition,  $i$ , at pressure,  $P_i$ , and temperature,  $T_i$
- $t_{ri}$  = as defined in para. V303.1.4

### V303.3 Evaluation

The calculated value of  $u$  indicates the nominal amount of creep-rupture life expended during the service life of the piping system. If  $u \leq 1.0$ , the usage factor is acceptable including excursions. If  $u > 1.0$ , the designer shall either increase the design conditions (selecting piping system components of a higher allowable working pressure if necessary) or reduce the number and/or severity of excursions until the usage factor is acceptable.

Material: A106 A    Class: Carbon or Low Alloy Steel

Database can only be edited if database files are open for editing and if stress units are set as MPa (for ASME - ksi)

Data source: ASME B31.3-2018 Carbon(C<0.3)

Density: 7833.41303     Maximum f=1.2

Larson-Miller constant C: 20

Creep Factors: Carbon, SiMn Steel

Temperature F	Allowable Stress (S), ksi	Yield Stress (Sy), ksi	Elastic Modulus ksi	Expansion Coeff. 1/F	Poisson's Ratio (ν)	WI
-325	16	30	31400	5.5e-006	0.292	1.0
-200	16	30	30800	5.79e-006	0.292	1.0
-150	16	30	30300	5.9e-006	0.292	1.0
-50	16	30	29891	6.2e-006	0.292	1.0
70	16	30	29400	6.4e-006	0.292	1.0
100	16	30	29262	6.47e-006	0.292	1.0
200	16	27.500	28800	6.7e-006	0.292	1.0

Buttons: Save, OK, Cancel, Help



Minimum Design Metal Temperature (MDMT) calculation according to 323.2.2 (a), (b), (d), (e), (f), (g), (h), (i), (j) of ASME B31.3-2018. Added into material database. START-PROF calculates the MDMT according to figure 323.2.2A and figure 323.2.2B depending on the calculated stress ratio if user select appropriate option in project settings, taking into account the code requirements 323.2.2 (g), (h), (i).

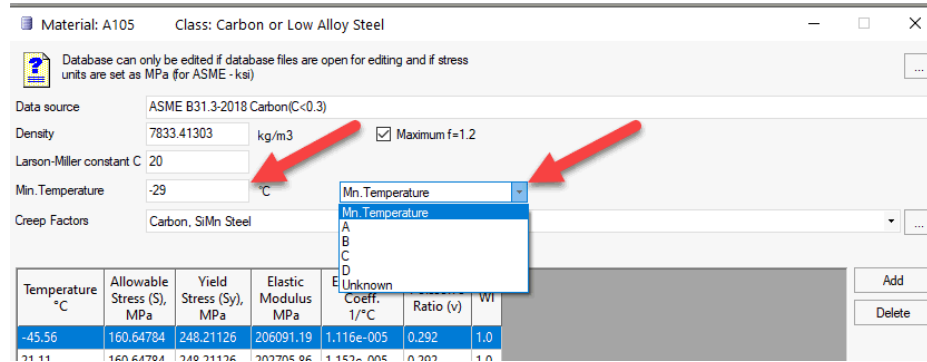


Figure 323.2.2A Minimum Temperatures Without Impact Testing for Carbon Steel Materials  
(See Table A-1 or Table A-1M for Designated Curve for a Listed Material; see Table 323.2.2A for Tabular Values)

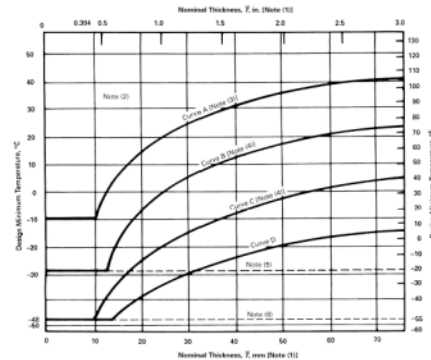
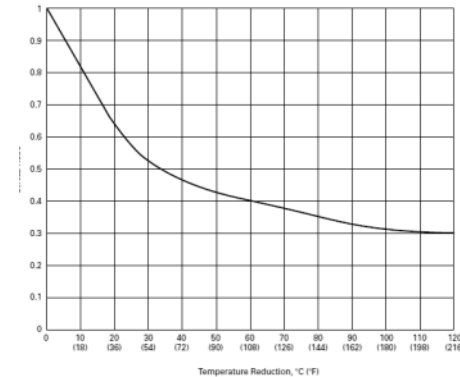
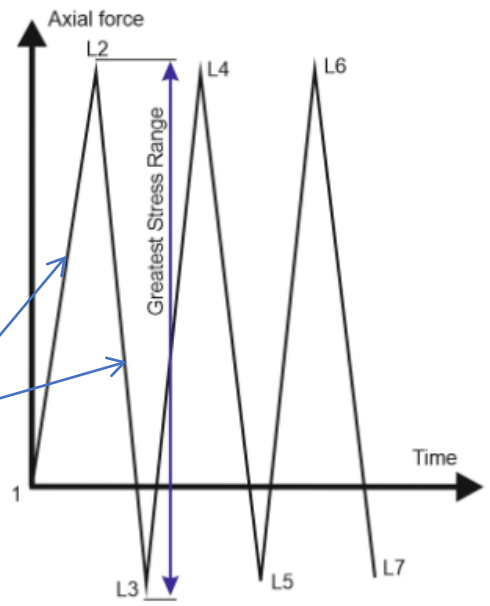


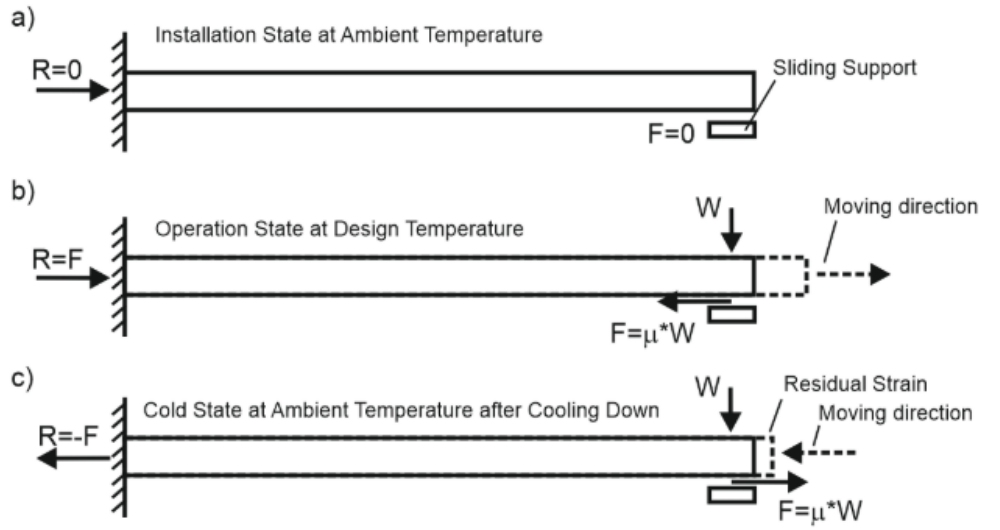
Figure 323.2.2B Reduction in Lowest Exemption Temperature for Steels Without Impact Testing  
(See Table 323.2.2B for Tabular Values)



START-PROF calculates the cold state after cooling down from the hot state. It allows to get more realistic expansion stress range.



START-PROF



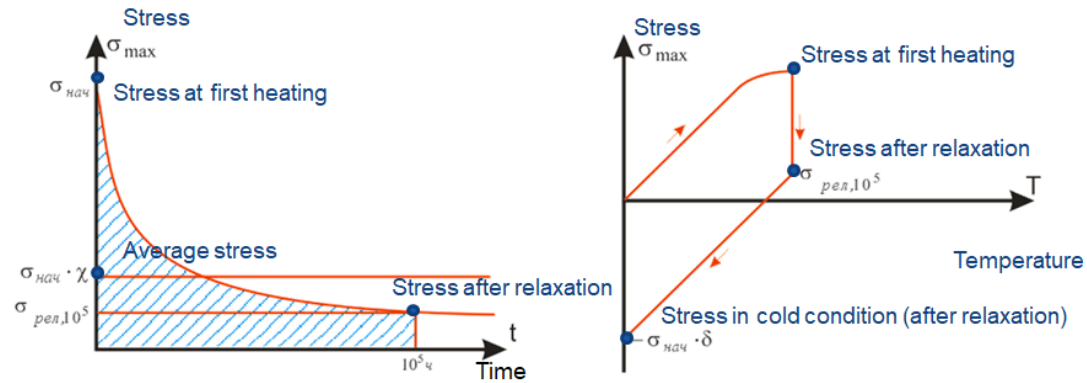
ASME B31.3 319.2.3 (a) code requires to analyze self-springing after creep relaxation, but doesn't give a detailed analysis method for this. CAESAR II can consider creep stress relaxation effect in hot state according to EN 13480 code, but can't consider self-springing in cold state.

- Can consider creep stress relaxation effect in hot state according to EN 13480 code like CAESAR II.
- Can consider creep stress relaxation and creep self-springing effect in the cold state using Russian RD 10-249-98 code method. It is available for ASME B31.3, B31.1 and some other codes.

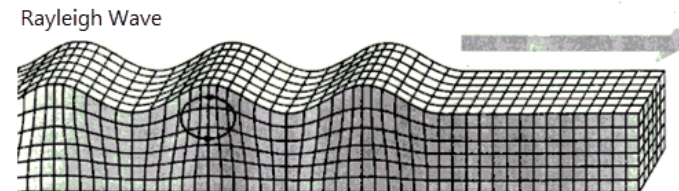
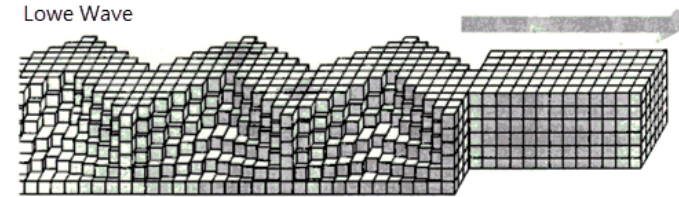
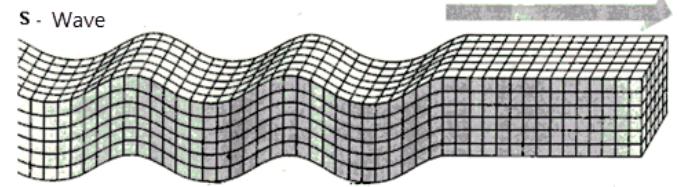
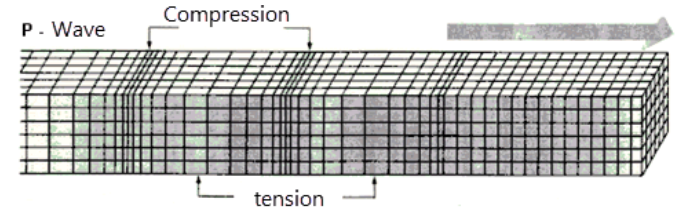
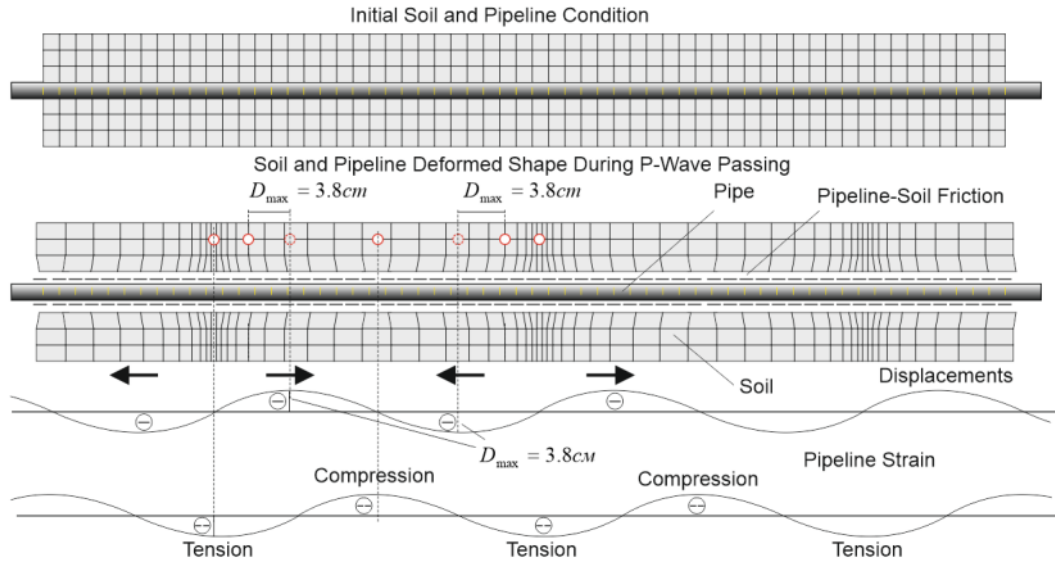
### 319.2.3 Displacement Stress Range

(a) In contrast with stresses from sustained loads, such as internal pressure or weight, displacement stresses may be permitted to attain sufficient magnitude to cause local yielding in various portions of a piping system. When the system is initially operated at the condition of greatest displacement (highest or lowest temperature, or greatest imposed movement) from its installed condition, any yielding or creep brings about a reduction or relaxation of stress. When the system is later returned to its original condition (or a condition of opposite displacement), a reversal and redistribution of stresses occurs that is referred to as self-springing. It is similar to cold springing in its effects.

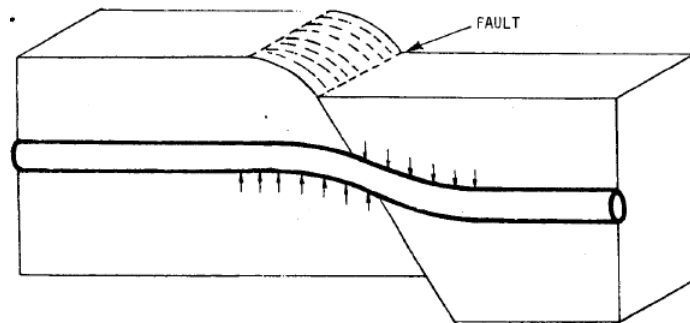
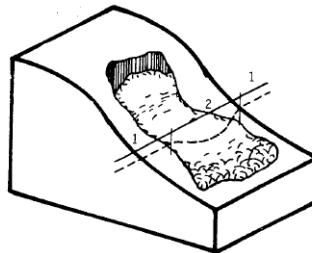
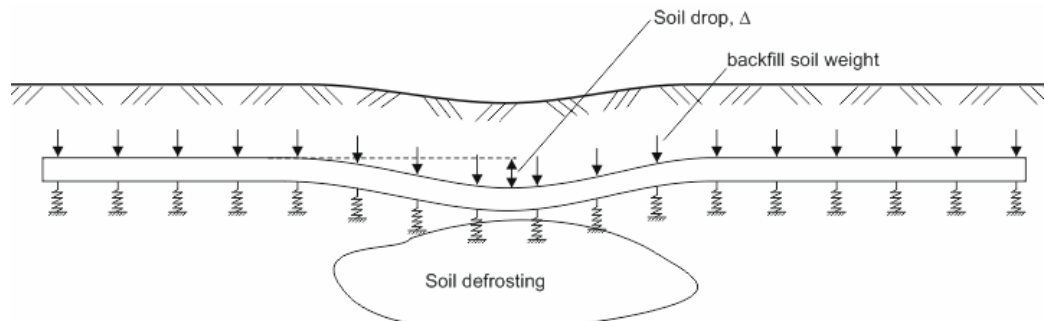
Creep lead to piping self cold-spring in cold condition



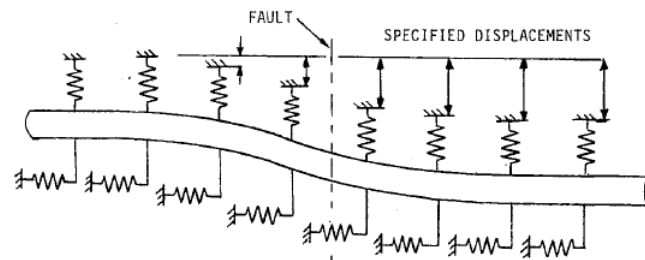
Seismic wave propagation analysis for underground pipelines. START-PROF calculates stress and strain in buried pipeline caused by seismic wave propagation, and checks the stress and strain limits according to ASCE 2001 Guidelines for the Design of Buried Steel Pipe (American Lifelines Alliance).



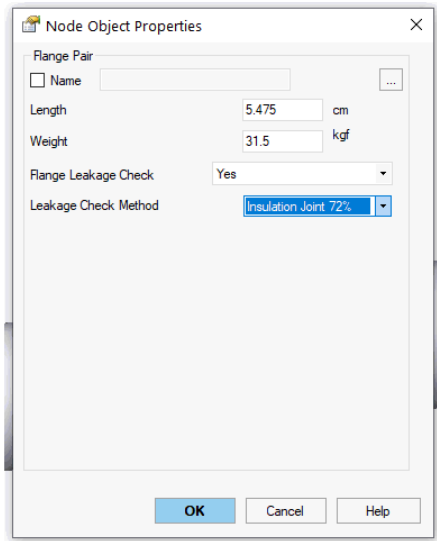
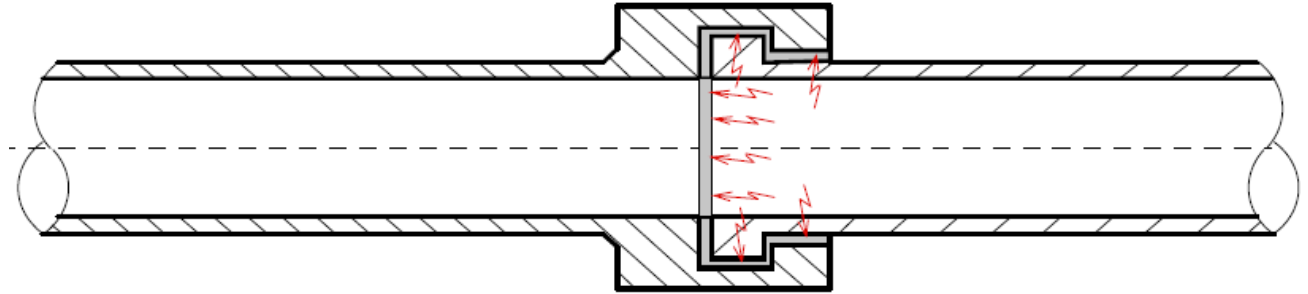
Landslide, Soil subsidence, frost heaving, Permanent ground deformation (seismic fault crossing) can also be modeled. The pipeline strain check is made according to ASCE 2001 (ALA) and GB 50470.



(A) ACTUAL GEOMETRY



Insulation Joint (Insulation Kit) stress analysis. The axial stress and stress from torsion moment is checked automatically.



# Automatic snow and ice load generation according to national codes.

Ice Loads

Code

Don't Apply Ice

- Don't Apply Ice
- SP 20.13330.2016 (Russia)
- GB 50135-2006 (China)
- ASCE 7-16 (USA)
- IBC 2012 (International)

Wind Loads

Code

Don't Apply Wind

- Don't Apply Wind
- SP 20.13330.2016 (Russia)
- GB 50009-2012 (China)
- ASCE 7-16 (USA)
- NBC 2010 (Canada)
- EN 1991-1-4 2005+A1-2010
- UBC 1997 (International)
- IBC 2012 (International)
- IS.875.3.1987 (India)
- AS/NZS 1170.2:2011 (New Zeland)
- NBR 06123-1988 (Brazil)
- BS 6399-2 (Britain)
- CNS (Taiwan)
- EN 1991-1-4 2009 (Belarus)
- Wind Pressure vs Elevation
- Wind Velocity vs Elevation
- NSR-10 (Colombia)
- KBC 2016 (Korea)
- CFE 2008 (Mexico)

Pipe Properties

Pipe 117-118  Pipe is Buried

Name

Main Additional **Wind, Snow, Ice**

Insulation Outer Diameter 300 mm

Elevation of Start Node 4 m

Elevation of End Node 4 m

Snow Shape Factor 0.4

Thermal Coefficient 1

Snow (and Rain) Load 0.084 kgf/m

Ice Shape Factor 0.6

Ice Load 7.45763830 kgf/m

Correlation Factor 1

Autocalc factors

Wind Direction Number Wind N1

Wind Load 4.70342237 kgf/m

X: 0 kgf/m

Y: 0 kgf/m

Z: 0 kgf/m

OK Cancel Help

Project Settings... - AntiSymmetric1.ctp

General Additional Seismic **Wind, Snow, Ice** Other Dynamic

Snow Loads

Code ASCE 7-16 (USA)

Ground Snow Load Don't Apply Snow Load Type SUS

Exposure factor, C ASCE 7-16 (USA)

Importance factor, I NBC 2010 (Canada)  
EN 1991-1-3-2003+A1-2015  
IBC 2012 (International)  
EN 1991-1-3 2009 (Belarus)  
KBC 2016 (Korea)

Ice Loads

Code

Importance factor, Is 1 Load Type SUS

Hill Shape No Hill Wind Exposure B

Basic ice thickness, t 7 mm

Wind Loads

Code CFE 2008 (Mexico)

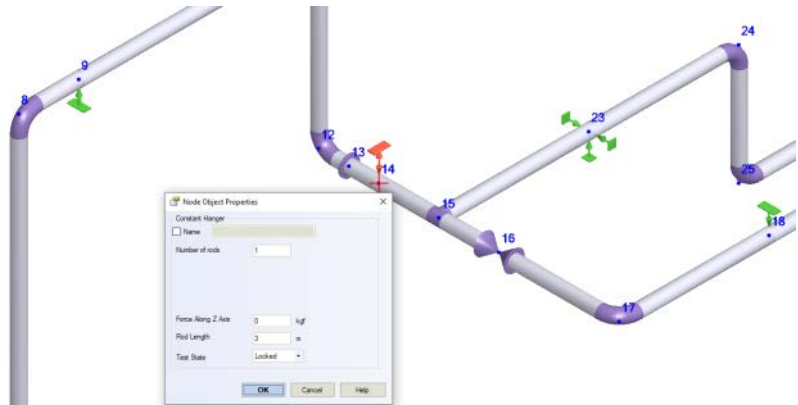
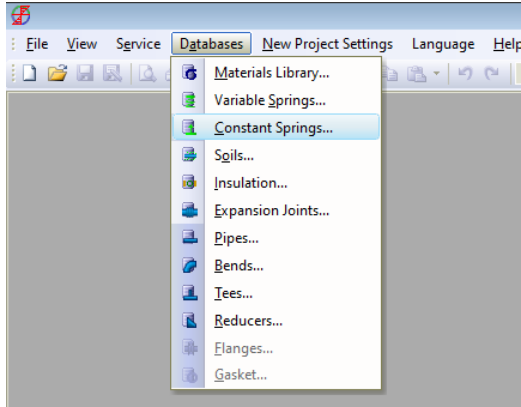
< 1 : 1 > Add Delete

Wind Direction +X

Parameter		Load Type
Basic Wind Speed, V0, m/s	0	SUS
Outdoor Temperature, s, °C	0	
Altitude, hm, m	0	
Surface Roughness, hr, mm	0	
Total Structure Height, Zt, m	0	
Terrain Category	1	

OK Cancel Help

# Automatic selection of constant effort hangers and supports.



Constant Hangers and Supports

Standards: WITZENMANN | Restraint Type: Hanger

CH size: 07 08 9 10 11 12 13 14 15 16 17 18 19 20

Nominal tra: WITZENMANN, NBT 47038-2013, ANVIL, Carpenter & Paterson, Pipe Supports Ltd, SEONGHWA

Maximum required load, kgf

Nominal tra	07	08	9	10	11	12	13	14	15	16	17	18	19	20	Load group LGV						
50																					
60	39	78	154	310	540	930	1540		2280	3770											
70	33	67	132	266	463	797	1320	1960	3230		4430	6100									
80	29	59	116	233	405	698	1150	1710	2820	3880	5880										
90	26	52	103	207	360	620	1030	1520	2510	3450	5230	7330	10500								
100	23	47	92	186	324	558	924	1370	2260	3100	4700	6600	9410	14000							
110	21	43	84	169	295	507	840	1250	2050	2820	4280	6000	8550	12800							
120	20	39	77	155	270	465	770	1140	1880	2590	3920	5500	7840	11700	15400						
130	18	36	71	143	249	429	710	1050	1740	2390	3620	5080	7240	10800	14200						
140	17	33	66	133	231	399	660	978	1610	2220	3360	4710	6720	10000	13200	20000					
150	16	31	62	124	216	372	616	913	1510	2070	3140	4400	6270	9350	12300	18700	26100				
160	15	29	58	116	203	349	577	856	1410	1940	2940	4120	5880	8770	11600	17500	24600				
170	14	28	54	109	191	328	543	806	1330	1830	2770	3880	5530	8250	10900	16500	23200	33000			
180	13	26	51	103	180	310	513	761	1260	1720	2610	3670	5230	7790	10300	15600	21900	31200	43500		
190	12	25	49	98	171	294	486	721	1190	1630	2480	3470	4950	7380	9740	14700	20700	29500	41400		
200	12	23	46	93	162	279	462	685	1130	1550	2350	3300	4700	7010	9250	14000	19700	28100	39400		
225	10	21	41	83	144	248	410	609	1000	1380	2090	2930	4180	6230	8220	12400	17500	24900	35000		
250	9	19	37	74	130	223	369	548	904	1240	1880	2640	3760	5610	7400	11200	15700	22400	31500	43500	
275	9	17	34	68	118	203	336	498	821	1130	1710	2400	3420	5100	6730	10200	14300	20400	28600	40800	
300	8	16	31	62	108	186	308	457	753	1030	1570	2200	3140	4680	6170	9340	13100	18700	26200	37400	
325						172	284	421	695	988	1450	2030	2890	4320	5690	8620	12100	17300	24200	34500	
350						159	264	391	645	887	1340	1890	2690	4010	5290	8000	11200	16000	22500	32100	
375								365	602	828	1250	1760	2510	3740	4930	7470	10500	15000	21000	29900	43500
400								342	565	776	1180	1650	2350	3510	4630	7000	9840	14000	19700	28100	
425								322	532	730	1110	1550	2210	3300	4350	6590	9260	13200	18500	26400	
450								304	502	690	1050	1470	2090	3120	4110	6220	8750	12500	17500	24900	
475								288	476	653	990	1390	1980	2950	3900	5900	8290	11800	16600	23600	
500								274	452	621	941	1320	1880	2810	3700	5600	7870	11200	15700	22400	
Load group LGV						12					16	20		24	30	36	42	48	56	64	

Print | Export... | Close | Help



# Integration with Autodesk Revit is supported.

The screenshot displays the Kerosene software interface, which is integrated with Autodesk Revit. The interface is divided into several key areas:

- Project Browser (Left):** Lists various project elements such as Views (Floor Plans, Ceiling Plans, 3D Views, Elevations), Schedules/Quantities, Sheets, Families, and Piping Systems.
- Main View (Center):** Shows a 3D model of a piping system with various components like pipes, valves, and fittings.
- Properties Panel (Right):** Displays the properties of the selected pipe (Pipe 1-2), including Start Node, End Node, Name, Input Type, Projections/angles, Diameter x Thickness, Pipe Material, Mill Tolerance, Corrosion Allowance, Pressure, Test Pressure, Temperature, Uniform Weight, and Additional Loads.
- Input Panel (Right):** Shows a 2D schematic diagram of the piping system with numbered nodes (1-31) and a coordinate system (X, Y, Z).

At the bottom of the interface, there is an "Error and warning messages" panel and a "Pipes list" panel.

# Two-way integration with AVEVA PDMS, AVEVA E3D

The image displays two software windows illustrating the integration between AVEVA PDMS and AVEVA E3D.

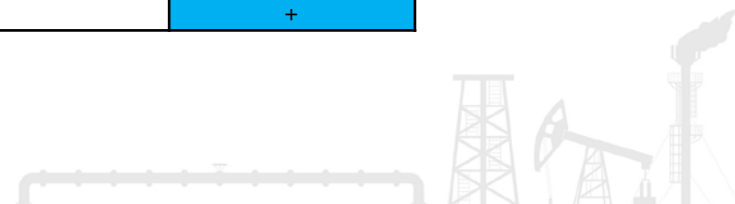
**AVEVA PDMS (Left Window):** Shows a 2D schematic of a vertical pipe structure. The Properties table for 'VE-1810' is as follows:

Attribute	Value
Name	VE-1810
Type	BRANCH
Lock	<input type="checkbox"/>
Owner	VE-1
Description	upset
Function	upset
Purpose	upset
Sub	<input type="checkbox"/>
Shop	<input type="checkbox"/>
Isolation	<input type="checkbox"/>
Position BRK Cw	W 410mm S 470mm U 280mm
Position BRK Cc	E 1621 170mm S 216 270mm U
Position BRK D	S 38 E
Ref	TEE 1 of BRANCH VE-481
Trsf	VE-1810
Lead	<input type="checkbox"/>
Lim	<input type="checkbox"/>
Flare	200mm
Thick	8mm
Flarecut	8WD
Turncut	8WD
Dist	<input type="checkbox"/>
Latched	<input type="checkbox"/>
Unlatch	upset
Elastic	0
Temperature	-1000000C
Pressure	0.000000
Thrust	0.000000
Flowdirection	upset
Module	GEARPOINT200
Color	0
Class	0
Subclass	0
Material	None
Fluid	None
Control	None

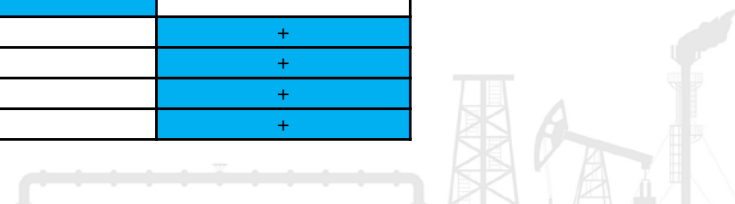
**AVEVA E3D (Right Window):** Shows a 3D model of the pipe structure. The List of exported BRANCH objects includes:

- VE-181
- VE-481
- 2575-2023
- VE-181
- VE-281
- VE-2811
- VE-2812
- VE-2813
- VE-2814
- VE-2815
- VE-2816
- VE-2817
- VE-2818
- VE-2819
- VE-2820
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- VE-2896
- VE-2897
- VE-2898
- VE-2899
- VE-2900

Code	START-PROF
ASME B31.1 Power piping USA	+
ASME B31.3+Ch IX USA Process piping	+
ASME B31.4 + Ch IX&XI USA Fluid Pipelines	+
ASME B31.5 USA Refrigeration Piping and Heat Transfer	+
ASME B31.8 + Ch VIII USA Gas Pipelines	+
ASME B31.9 Building Services Piping	+
ASME B31.12-2014 Hydrogen piping and pipelines	+
ASME B31J-2017 New SIF	+
EN 13480 Europe Industrial Piping	+
EN 13941 Europe District heating	+
CSA Z662 Canada 2015	+
BS PD 8010-1 (2016) Pipeline systems. Steel pipelines on land, UK	+
BS PD 8010-2 (2016) Pipeline systems. Subsea pipelines, UK	+
ISO 14692 International, FRP	+
Plastic piping	+
DLT 5366-2006 Power piping China	+
GB 20801-2006 Process Piping China	+
GB 50316-2008 Process Piping China	+
GB 50251-2015 Gas Pipeline China	+
GB 50253-2014 Oil Pipeline China	+
CJJ/T 81-2013 District heating China	+
11 Russian codes for all industries	+



Feature	START-PROF
Wind load codes	
SP 20.13330.2011, Russia	+
ASCE 7, USA	+
GB 50009, China	+
Wind pressure vs elevation	+
Wind velocity vs elevation	+
IBC 2012 International	+
NBC 2010, Canada	+
EN 1991-1-4 2005, Europe	+
NBR 6123-1998, Brazil	+
IS 875.3.1987, India	+
As/Nz 1170:2002, New Zeland	+
BS 6399-2, UK	+
UBC 1997, International	+
CNS, Taiwan	+
NSR-10, Colombia	+
KBC 2016, Korea	+
CFE 2008 Mexico	+
Snow load codes	
СП 20.13330.2011	+
ASCE 7, USA	+
IBC 2012 International	+
GB 50009, China	+
NBC 2010, Canada	+
EN 1991-1-3 2003, Europe	+
KBC 2016, Korea	+
Ice load codes	
СП 20.13330.2011	+
ASCE 7, USA	+
IBC 2012 International	+
GB 50135-2006, China	+



Feature	START-PROF
Equipment Connection	
Insulation Joint (Insulation Kit) stress analysis	+
WRC 297 Nozzle Flexibility	+
PD 5500 Nozzle Flexibility	+
ASME NB-3630 Tee Flexibility	+
API 610 Centrifugal Pump load check / ISO 13709	+
API 617 Centrifugal Compressor load check / API 619 / ISO 10440 / ISO 10439	+
API 650 Tank Nozzle Flexibility	+
API 650 Tank Nozzle Allowable Loads Check	+
NEMA SM 23 Steam Turbine Allowable Loads/API 611/API 612/ISO 10437	+
WRC 107/537	+
API 560 Allowable loads fired heaters	+
API 661 Allowable loads	+
ISO 5199 Centrifugal Pump load check	+
ISO 9905 Centrifugal Pump load check	+
Flange check	
NC 3658.3 Method	+
Equivalent pressure method / Kellogg	+
PVP / Code Case 2901	+
DNV	+



Stress Analysis Features	START-PROF
Load Case Editor / Operation Mode Editor (Many Pressures, Temperatures, Loads, etc.)	+
Seismic Analysis (Static method)	+
Seismic Anchor Movements	+
Pipe and Bend Wall Thickness Check	+
Translation Bourdon Effect	+
Rotational Bourdon Effect for Bends	+
Friction, Gap, One-way, Rotation Rod Restraints Nonlinear Analysis	+
Thermal Bowing (Stratification)	+
Insulation Weight Calculation by Diameter and Density	+
MDMT Minimum Design Temperature, Impact Test	+
MDMT Minimum Design Temperature, Impact Test with Reduction Depending on Stress Ratio	+
Built-in Calculator in Fields	+
SIF Scratchpad	+
Creep Rupture Factor Calculation ASME B31.3 app. V	+
Friction at Cold State (Follow up load case)	+
Automatic Water Hammer Loads Analysis	+
Expansion Joint Deformation Check	+
Tee and Reducer Wall Thickness Check	+
Pipe, Bend, Reducer, Tee Wall Thickness Calculation	+



Feature	START- PROF
CAD Interfaces	
Import and Export to Own Neutral Format	INI
Export/Import Displacements Using File (.csv)	CSV
Export to TXT	+
PCF	+
Hydrosystem Import Dynamic Forces	TXT
Caesar II (.CII) Import/Export	CII
AutoCAD Export	DXF
Autopipe Import and Export	CII
AutoPlant Import	PCF
CADISON	PCF
CadWorx	PCF
I-Sketch	PCF
Marine Import and Export	API
Microstation Export	DXF
ModelStudioCS	PCF
OpenPlant	PCF
PDMS Import and Export	API
Plant3D Import	PCF
Plant4D	PCF
PlantSpace	PCF
Revit	INI
Smart3D	PCF
SmartPlant3D	PCF

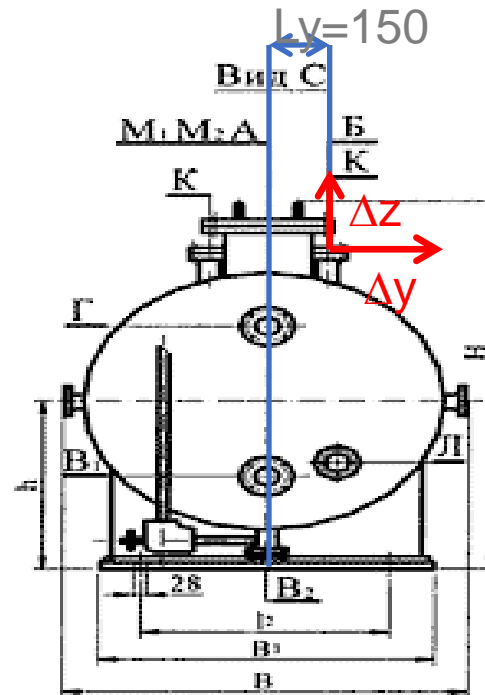
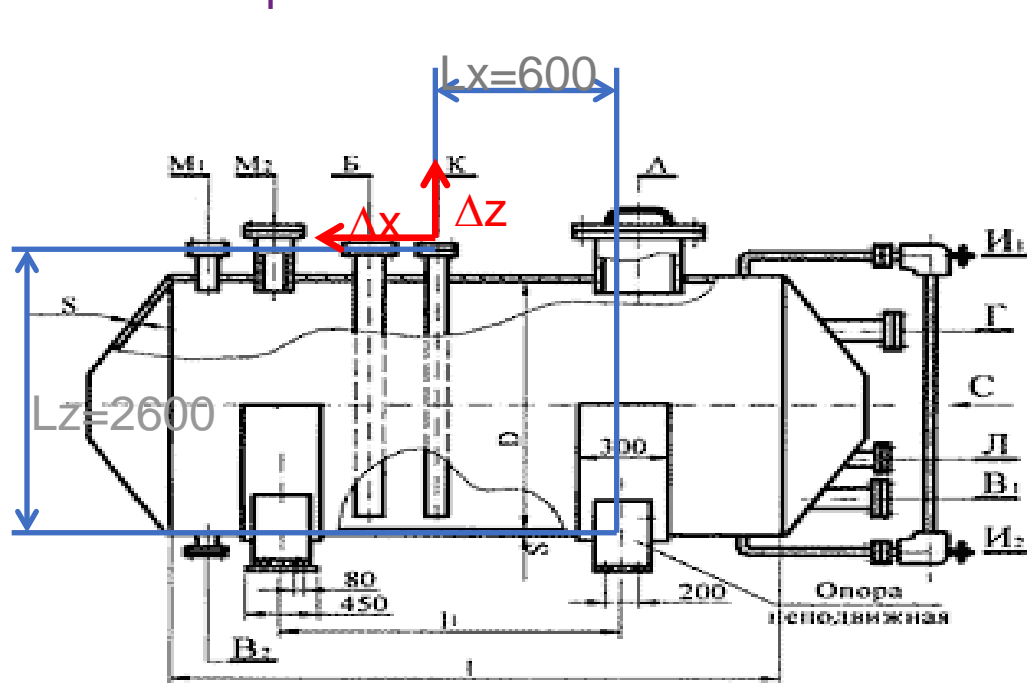


- Affordable price ~ \$6'000 - \$7'800  
Permanent License, \$2'400 - \$3'120  
Annual License
- Technical support for the 1<sup>st</sup> year is provided for free (!)
- Different configurations based on customer needs are available





# Nozzle Displacements



$$\Delta x = Lx \cdot \alpha \cdot \Delta T = 600 \text{ мм} \cdot 1.2 \cdot 10^{-5} \cdot (250^\circ - (-20^\circ)) = 1.94 \text{ мм}$$

$$\Delta y = Ly \cdot \alpha \cdot \Delta T = 150 \text{ мм} \cdot 1.2 \cdot 10^{-5} \cdot (250^\circ - (-20^\circ)) = 0.49 \text{ мм}$$

$$\Delta z = Lz \cdot \alpha \cdot \Delta T = 2600 \text{ мм} \cdot 1.2 \cdot 10^{-5} \cdot (250^\circ - (-20^\circ)) = 8.42 \text{ мм}$$



# Nozzle Object

**Node Object Properties** [X]

Vessel Nozzle WRC107/537/297/FEM

Node [ ] >>

Auto calculation of nozzle temperature movements

Material: A335 P91

Manufacturing Technology: Electric-welded

Temperature of Vessel: L 150 °C

Remove Restraints for Hanger Selection: Don't Remove

Inside Diameter of Vessel, Di: 1000 mm

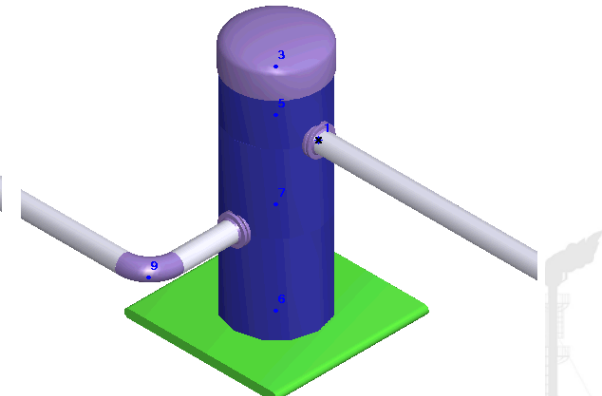
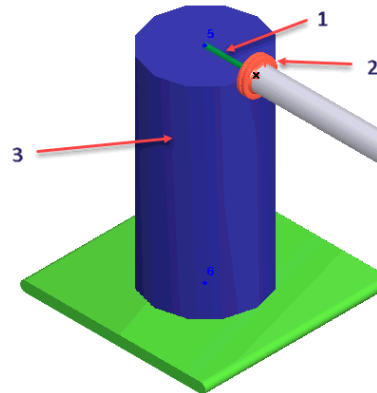
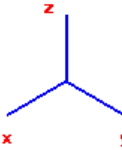
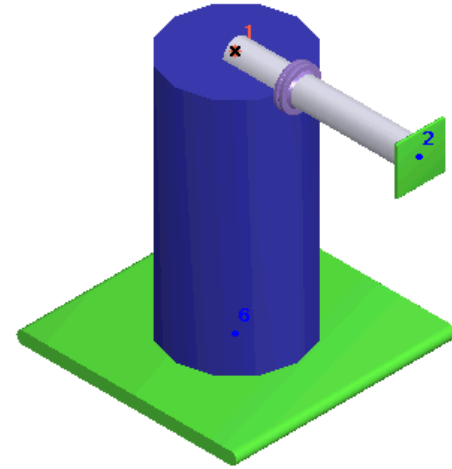
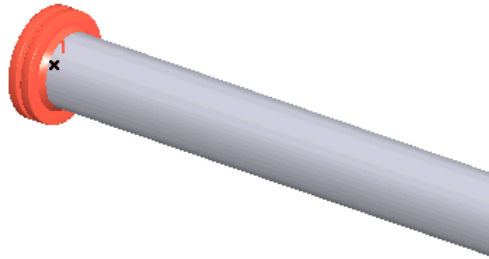
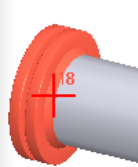
Vessel Axis: Z

Nozzle Flexibility: By WRC 297

Allowable Loads / Stresses: Manually

Lrad	9.3218e-005	mm/kgf	Frad	500	kgf
Lcir	0	mm/kgf	Fcir	200	kgf
Llong	0	mm/kgf	Flong	500	kgf
Rrad	0	°/kgf·m	Mrad	30	kgf·m
Rcir	0.00014612	°/kgf·m	Mcir	80	kgf·m
Rlong	0.00054708	°/kgf·m	Mlong	15	kgf·m

OK Cancel Help



# Nozzle Flexibility Using WRC 297, PD 5500

**Node Object Properties**

Vessel Nozzle WRC107/537/297/FEM

Node

Auto calculation of nozzle temperature movements

Material: A335 P91

Manufacturing Technology: Electric-welded

Temperature of Vessel: 150 °C

Remove Restraints for Hanger Selection: Don't Remove

Inside Diameter of Vessel, Di: 1000 mm

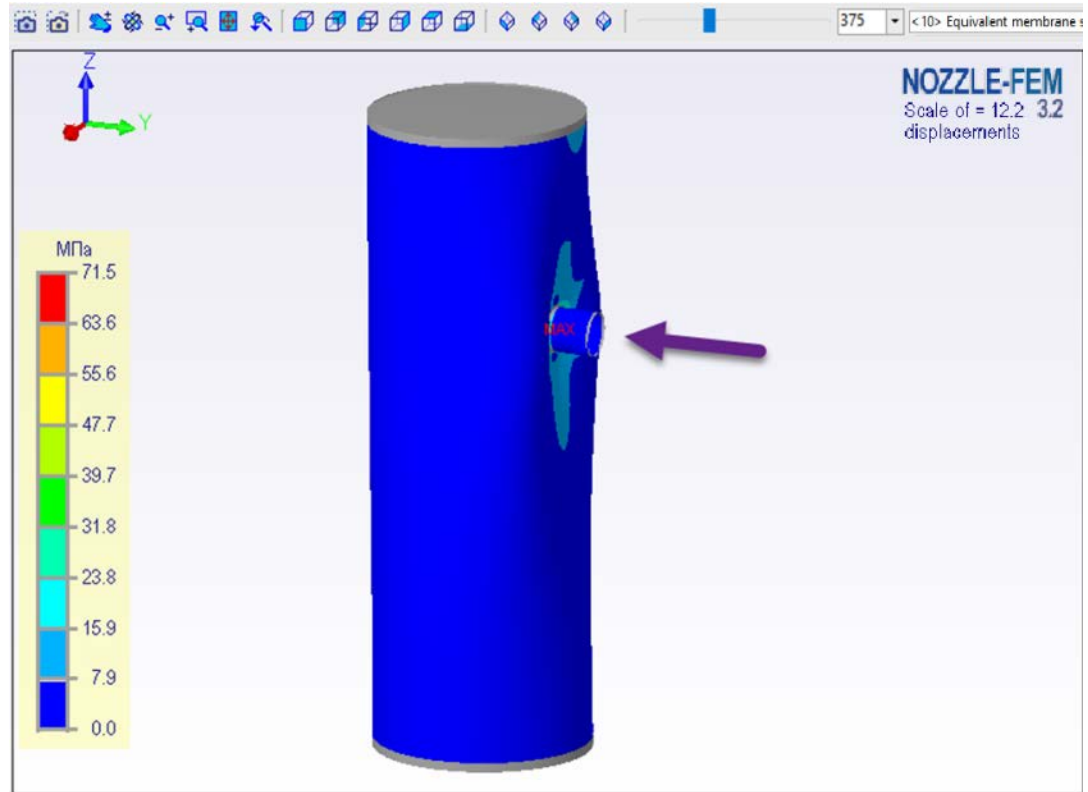
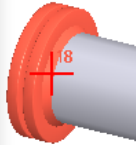
Vessel Axis: Z

Nozzle Flexibility: By WRC 297

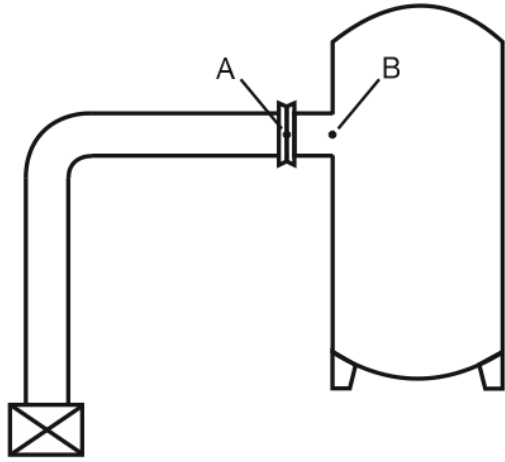
Allowable Loads / Stresses: Manually

Lrad	9.3218e-005	mm/kgf	Frad	500	kgf
Lcir	0	mm/kgf	Fcir	200	kgf
Llong	0	mm/kgf	Flong	500	kgf
Rrad	0	°/kgf·m	Mrad	30	kgf·m
Rcir	0.00014612	°/kgf·m	Mcir	80	kgf·m
Rlong	0.00054708	°/kgf·m	Mlong	15	kgf·m

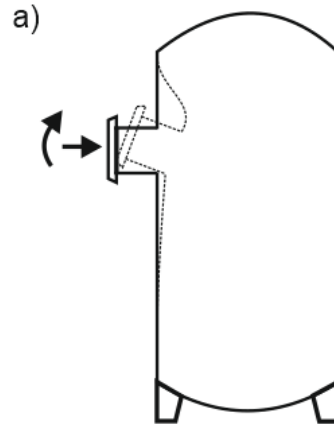
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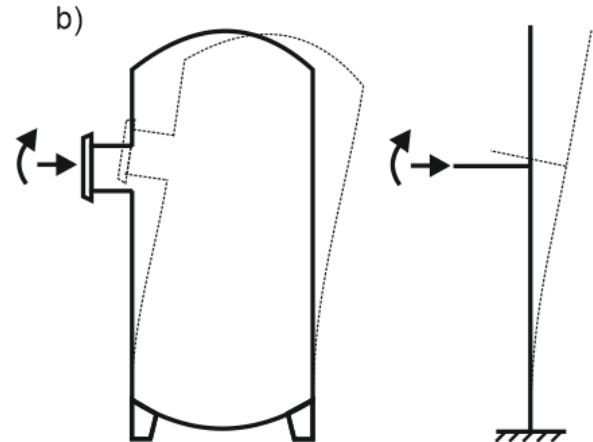
# Local and Global Nozzle Flexibility

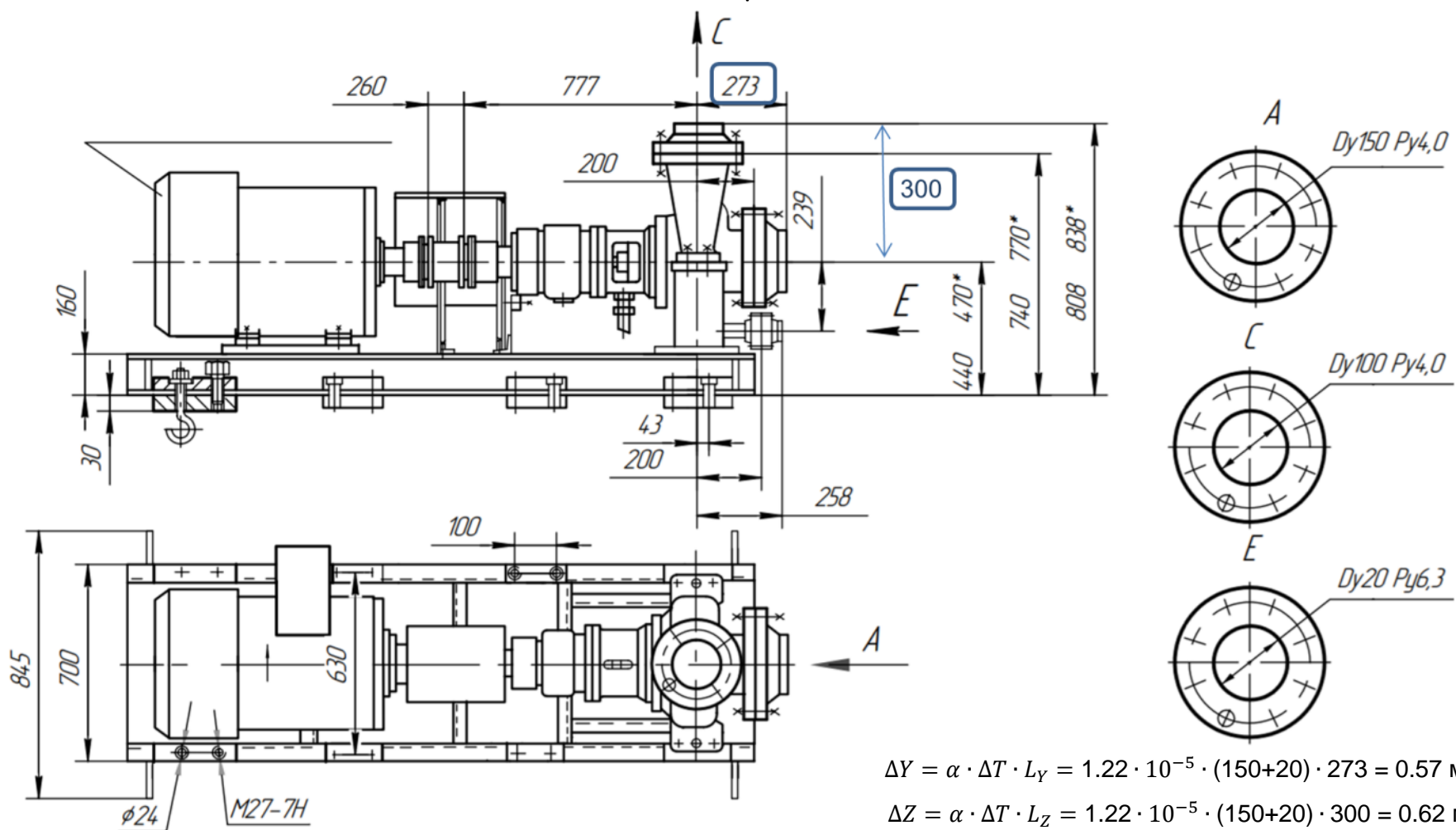


Local Flexibility  
Vessel Shell Deformations



Global Flexibility  
(Entire vessel Deformations)



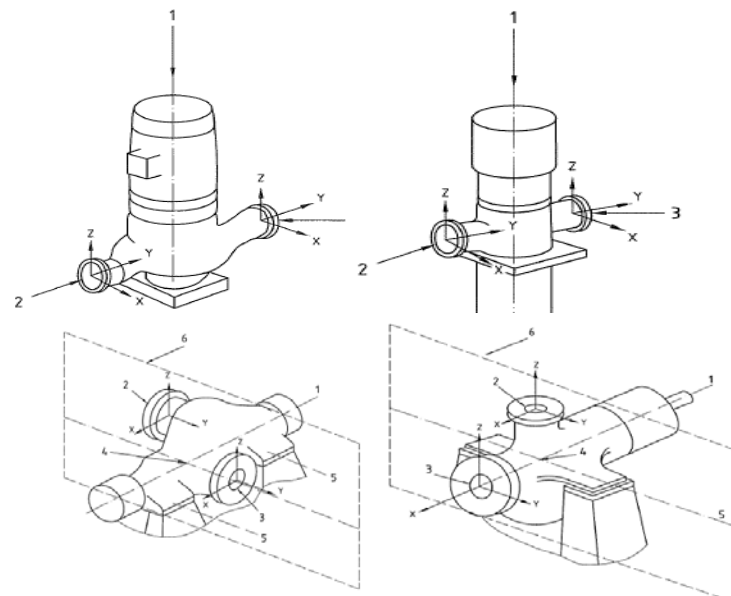


$$\Delta Y = \alpha \cdot \Delta T \cdot L_Y = 1.22 \cdot 10^{-5} \cdot (150+20) \cdot 273 = 0.57 \text{ mm}$$

$$\Delta Z = \alpha \cdot \Delta T \cdot L_Z = 1.22 \cdot 10^{-5} \cdot (150+20) \cdot 300 = 0.62 \text{ mm}$$

**Table 4 — Nozzle loadings**

	SI units								
	Nominal size of flange (DN)								
	50	80	100	150	200	250	300	350	400
<b>Forces (N)</b>									
Each top nozzle									
$F_X$	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
$F_Y$	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
$F_Z$	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
$F_R$	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
Each side nozzle									
$F_X$	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
$F_Y$	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
$F_Z$	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
$F_R$	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
Each end nozzle									
$F_X$	890	1 330	1 780	3 110	4 890	6 670	8 000	8 900	10 230
$F_Y$	710	1 070	1 420	2 490	3 780	5 340	6 670	7 120	8 450
$F_Z$	580	890	1 160	2 050	3 110	4 450	5 340	5 780	6 670
$F_R$	1 280	1 930	2 560	4 480	6 920	9 630	11 700	12 780	14 850
<b>Moments (N m)</b>									
Each nozzle									
$M_X$	460	950	1 330	2 300	3 530	5 020	6 100	6 370	7 320
$M_Y$	230	470	680	1 180	1 760	2 440	2 980	3 120	3 660
$M_Z$	350	720	1 000	1 760	2 580	3 800	4 610	4 750	5 420
$M_R$	620	1 280	1 800	3 130	4 710	6 750	8 210	8 540	9 820



# API 610

## F.1 Horizontal pumps

**F.1.1** Acceptable piping configurations should not cause excessive misalignment between the pump and driver. Piping configurations that produce component nozzle loads lying within the ranges specified in Table 5 limit casing distortion to one-half the pump vendor's design criterion (see 6.3.3) and ensure pump shaft displacement of less than 250 µm (0,010 in).

**F.1.2** Piping configurations that produce loads outside the ranges specified in Table 5 are also acceptable without consultation with the pump vendor if the conditions specified in F.1.2 a) through F.1.2 c) as follows are satisfied. Satisfying these conditions ensures that any pump casing distortion is within the vendor's design criteria (see 6.3.3) and that the displacement of the pump shaft is less than 380 µm (0,015 in).

a) The individual component forces and moments acting on each pump nozzle flange shall not exceed the range specified in Table 5 (T4) by a factor of more than 2.

b) The resultant applied force ( $F_{RSA}$ ,  $F_{RDA}$ ) and the resultant applied moment ( $M_{RSA}$ ,  $M_{RDA}$ ) acting on each pump-nozzle flange shall satisfy the appropriate interaction equations as given in Equations (F.1) and (F.2):

$$[F_{RSA}/(1,5 \times F_{RST4})] + [M_{RSA}/(1,5 \times M_{RST4})] < 2 \quad (F.1)$$

$$[F_{RDA}/(1,5 \times F_{RDT4})] + [M_{RDA}/(1,5 \times M_{RDT4})] < 2 \quad (F.2)$$

c) The applied component forces and moments acting on each pump nozzle flange shall be translated to the centre of the pump. The magnitude of the resultant applied force,  $F_{RCA}$ , the resultant applied moment,  $M_{RCA}$ , and the applied moment shall be limited by Equations (F.3) to (F.5). (The sign convention shown in Figures 21 through 25 and the right-hand rule should be used in evaluating these equations.)

$$F_{RCA} < 1,5(F_{RST4} + F_{RDT4}) \quad (F.3)$$

$$|M_{YCA}| < 2,0(M_{YST4} + M_{YDT4}) \quad (F.4)$$

$$M_{RCA} < 1,5(M_{RST4} + M_{RDT4}) \quad (F.5)$$

where

$$F_{RCA} = [(F_{XCA})^2 + (F_{YCA})^2 + (F_{ZCA})^2]^{0,5}$$

where

$$F_{XCA} = F_{XSA} + F_{XDA}$$

$$F_{YCA} = F_{YSA} + F_{YDA}$$

$$F_{ZCA} = F_{ZSA} + F_{ZDA}$$

$$M_{RCA} = [(M_{XCA})^2 + (M_{YCA})^2 + (M_{ZCA})^2]^{0,5}$$

where

$$M_{XCA} = M_{XSA} + M_{XDA} - [(F_{YSA})(zS) + (F_{YDA})(zD) - (F_{ZSA})(yS) - (F_{ZDA})(yD)]/1\ 000$$

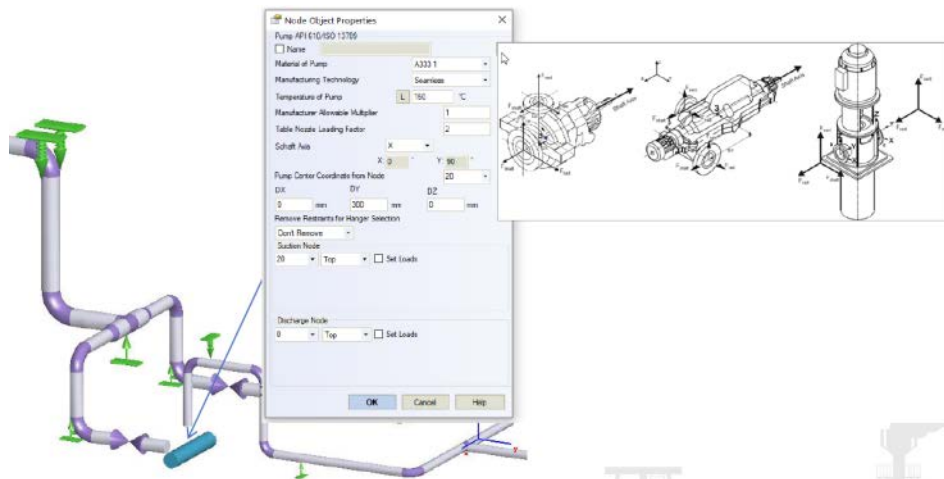
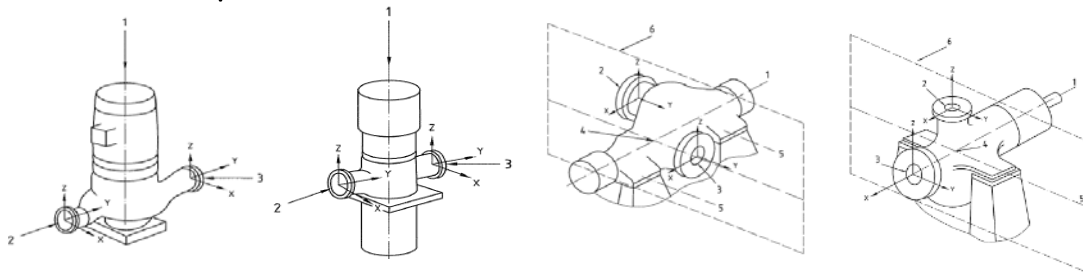
$$M_{YCA} = M_{YSA} + M_{YDA} + [(F_{XSA})(zS) + (F_{XDA})(zD) - (F_{ZSA})(xS) - (F_{ZDA})(xD)]/1\ 000$$

$$M_{ZCA} = M_{ZSA} + M_{ZDA} - [(F_{XSA})(yS) + (F_{XDA})(yD) - (F_{YSA})(xS) - (F_{YDA})(xD)]/1\ 000$$

In USC units, the constant 1 000 shall be changed to 12. This constant is the conversion factor to change millimetres to metres or inches to feet.

**F.1.3** Piping configurations that produce loads greater than those allowed in F.1.2 shall be approved by the purchaser and the vendor.

**NOTE** In order to evaluate the actual machine distortion (at ambient conditions), the piping alignment checks required in API RP 686, Chapter 6, should be performed. API RP 686 allows only a small fraction of the permitted distortion resulting from use of the values from this annex.



# Compressor API 617

**Node Object Properties** ✕

Compressor API 617/ISO 10439

Name

Material of Compressor

Manufacturing Technology

Temperature of Compressor   °C

Factor for Allowable Loads

Shaft Axis

Center of Compressor Coordinate from Node

DX  mm    DY  mm    DZ  mm

Remove Restraints for Hanger Selection

Suction Nozzle  
  Set Manual Loads

Discharge Node  
  Set Manual Loads

Additional Nozzle 1  
  Set Manual Loads

Additional Nozzle 2  
  Set Manual Loads



In SI units:

$$F_r + 1.09 M_r \leq 54.1 D_e \quad (F.1a)$$

In U.S. customary (USC) units:

$$3 F_r + M_r \leq 927 D_e \quad (F.1b)$$

$F_r$  is the resultant force, Newtons (lb) (see Figure F.1);

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \quad (F.2)$$

$M_r$  resultant moment, in Newton-meters (ft-lb) from Figure F.1;

$$M_r = \sqrt{M_x^2 + M_y^2 + M_z^2} \quad (F.3)$$

For sizes greater than 200 mm (8 in.), use the following values.

In SI units:

$$D_e = \frac{(400 + D_{nom})}{3} \quad (\text{mm}) \quad (F.4a)$$

In USC units:

$$D_e = \frac{(16 + D_{nom})}{3} \quad (\text{in.}) \quad (F.4b)$$

In SI units:

$$F_r + 1.64 M_r \leq 40.4 D_e \quad (F.5a)$$

In USC units:

$$2 F_r + M_r \leq 462 D_e \quad (F.5b)$$

In SI units:

$$F_r + 1.64 M_r \leq 40.4 D_e \quad (F.5a)$$

In USC units:

$$2 F_r + M_r \leq 462 D_e \quad (F.5b)$$

where

$F_r$  is the combined resultant of inlet, sidestream, and discharge forces, Newtons (lb);

$M_r$  is the combined resultant of inlet, sidestream, and discharge moments, and moments resulting from forces, Newton-meters (ft-lb);

$D_e$  is the diameter [mm (in.)] of one circular opening equal to the total areas of the inlet, sidestream, and discharge openings. If the equivalent nozzle diameter is greater than 230 mm (9 in.), use a value of  $D_e$  equal to the following.

In SI units:

$$D_e = \frac{(460 + \text{Equivalent Diameter})}{3} \quad (\text{mm}) \quad (F.6a)$$

In USC units:

$$D_e = \frac{(18 + \text{Equivalent Diameter})}{3} \quad (\text{in.}) \quad (F.6b)$$

The absolute value of the individual components (Figure F.1) of these resultants should not exceed the following.

In SI units:

$$F_x = 16.1 D_e \quad M_x = 24.6 D_e$$

$$F_y = 40.5 D_e \quad M_y = 12.3 D_e$$

$$F_z = 32.4 D_e \quad M_z = 12.3 D_e$$

Input		Equipment													
Operating Mode		Load Case		<input checked="" type="checkbox"/> Show Equations											
1 'Рабочий режим' (0)		Operating W+P+T		?											
Object	Start End node	Type	DN, mm	Frad, N	Fcir, N	Flong N	FR, N	Mrad, N-m	Mcir, N-m	Mlong, N-m	MR, N-m	Sum	Notes		
Compressor API 617/API 619/ISO 10439	Node (1)	Suction, Top	200	-15918	12907	-23209	30962	-2577.83	11010.28	8677.81	14253.98	4.30	1		
	Node (3)	Discharge, Top	200	1440505	-173	0	1440505	0		28.89	28.89	133.14	1		
		ext1													
		ext2													
		Summary Loads		250.91	1424587	12734	-23209	1424833	-2577.83	22615.01	15246.83	27396.16	144.99		
			8130		Dc=250.9141 mm				86.24	6172.49					
					[Fcir]=k1*40.5Dc=1.00*10162.02=10162.02 N										



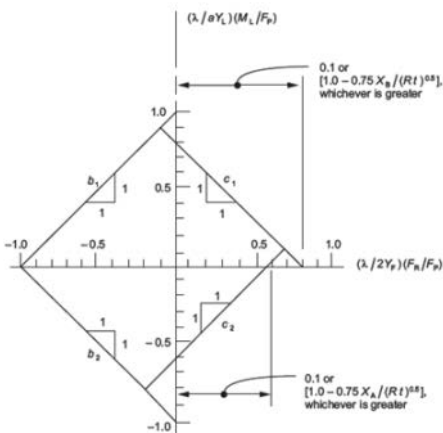


Figure P.3a—Construction of Nomogram for  $b_1, b_2, c_1, c_2$  Boundary

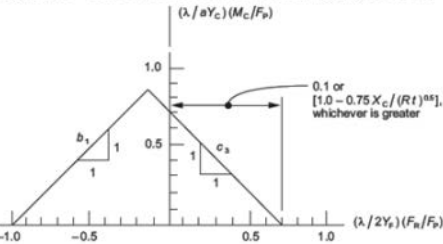
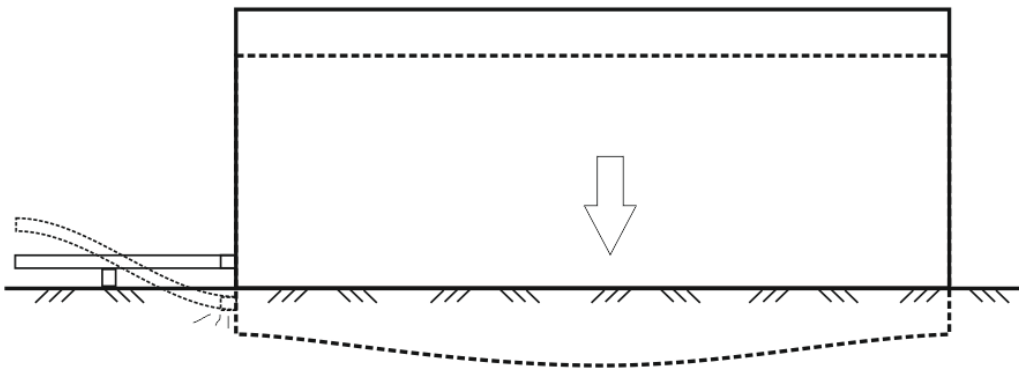
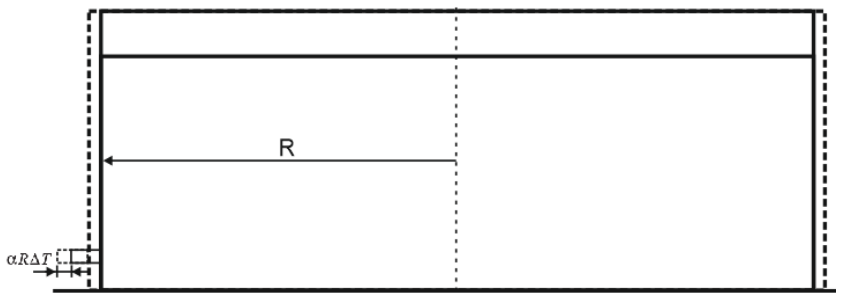
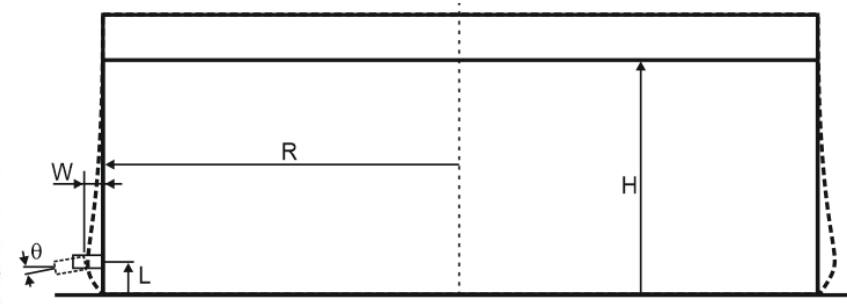


Figure P.3b—Construction of Nomogram for  $b_1, c_1$  Boundary

$$W = \frac{9.8 \times 10^{-6} GHR^2}{Et} \times \left[ 1 - e^{-\beta L} \cos(\beta L) - \frac{L}{H} \right]$$

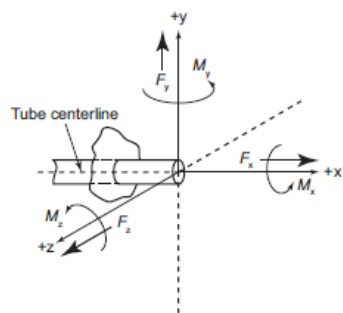
$$\theta = \frac{9.8 \times 10^{-6} GHR^2}{Et} \times \left\{ \frac{1}{H} - \beta e^{-\beta L} [\cos(\beta L) + \sin(\beta L)] \right\}$$



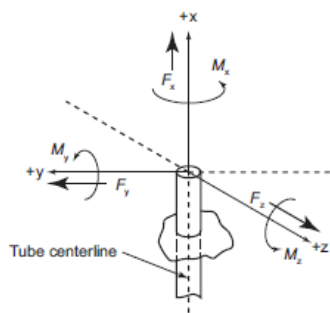
- G is the design specific gravity of the liquid;
- H is the maximum allowable tank filling height, in mm (in.);
- L is the vertical distance from the nozzle center line to the tank bottom, in mm (in.);
- R is the nominal tank radius, in mm (in.);
- t is the shell thickness at the opening connection, in mm (in.);
- $\beta$  is the characteristic parameter,  $1.285/(R \cdot t)^{0.5}$  (1/mm) (1/in.);
- E is the modulus of elasticity, in MPa (lbf/in.<sup>2</sup>);
- $\Delta T$  is the normal design temperature minus installation temperature, in °C (°F);
- $\alpha$  is the thermal expansion coefficient of the shell material, in mm/[mm·°C] (in./[in.·°F])

# Fired Heater Modelling

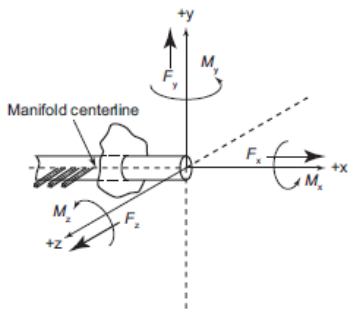
- Allowable loads calculated according to API 560
- Method 1: Use an anchor at the point where the piping goes inside the heater. The heater vendor must provide the allowable loads for this anchor point. Or API 560 code may be used



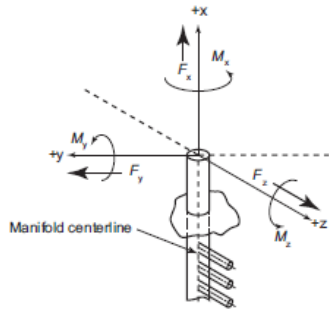
a) Horizontal Tubes



b) Vertical Tubes



a) Horizontal Manifold



b) Vertical Manifold

Table 6—Allowable Forces and Moments for Tubes

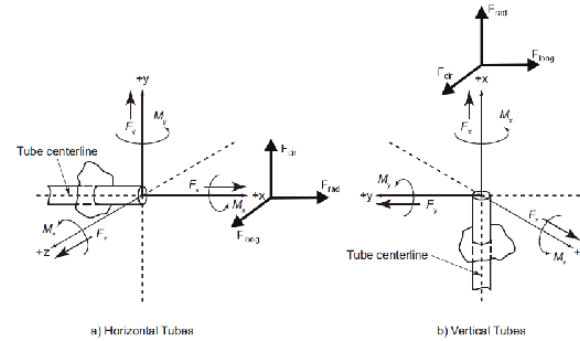
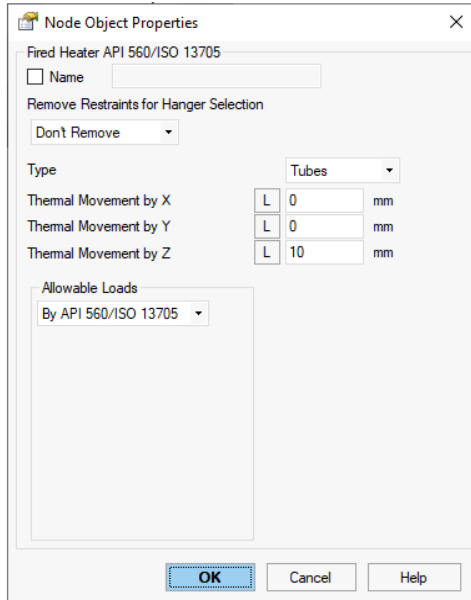
Pipe Size DN (NPS)	Force						Moment					
	$F_x$		$F_y$		$F_z$		$M_x$		$M_y$		$M_z$	
	N	(lbf)	N	(lbf)	N	(lbf)	N-m	(ft.lbf)	N-m	(ft.lbf)	N-m	(ft.lbf)
50 (2)	445	(100)	890	(200)	890	(200)	475	(350)	339	(250)	339	(250)
75 (3)	667	(150)	1334	(300)	1334	(300)	610	(450)	475	(350)	475	(350)
100 (4)	890	(200)	1779	(400)	1779	(400)	813	(600)	610	(450)	610	(450)
125 (5)	1001	(225)	2002	(450)	2002	(450)	895	(660)	678	(500)	678	(500)
150 (6)	1112	(250)	2224	(500)	2224	(500)	990	(730)	746	(550)	746	(550)
200 (8)	1334	(300)	2669	(600)	2669	(600)	1166	(860)	881	(650)	881	(650)
250 (10)	1557	(350)	2891	(650)	2891	(650)	1261	(930)	949	(700)	949	(700)
300 (12)	1779	(400)	3114	(700)	3114	(700)	1356	(1000)	1017	(750)	1017	(750)

Table 8—Allowable Forces and Moments for Manifolds

Manifold Size DN (NPS)	Force						Moment					
	$F_x$		$F_y$		$F_z$		$M_x$		$M_y$		$M_z$	
	N	(lbf)	N	(lbf)	N	(lbf)	N-m	(ft.lbf)	N-m	(ft.lbf)	N-m	(ft.lbf)
150 (6)	2224	(500)	4448	(1000)	4448	(1000)	1980	(1460)	1492	(1100)	1492	(1100)
200 (8)	2668	(600)	5338	(1200)	5338	(1200)	2332	(1720)	1762	(1300)	1762	(1300)
250 (10)	3114	(700)	5782	(1300)	5782	(1300)	2522	(1860)	1898	(1400)	1898	(1400)
300 (12)	3558	(800)	6228	(1400)	6228	(1400)	2712	(2000)	2034	(1500)	2034	(1500)
350 (14)	4004	(900)	6672	(1500)	6672	(1500)	2902	(2140)	2170	(1600)	2170	(1600)
400 (16)	4448	(1000)	7117	(1600)	7117	(1600)	3092	(2280)	2305	(1700)	2305	(1700)
450 (18)	4893	(1100)	7562	(1700)	7562	(1700)	3282	(2420)	2441	(1800)	2441	(1800)
500 (20)	5338	(1200)	8006	(1800)	8006	(1800)	3471	(2560)	2576	(1900)	2576	(1900)
600 (24)	5782	(1300)	8451	(1900)	8451	(1900)	3661	(2700)	2712	(2000)	2712	(2000)

# Fired Heater Modelling

- ❑ Allowable loads calculated according to API 560
- ❑ Method 1: Use an anchor at the point where the piping goes inside the heater. The heater vendor must provide the allowable loads for this anchor point. Or API 560 code may be used



played. In the second row the allowable values are displayed.

Input		Equipment													
Operating Mode 1 main mode (0)		Load Case Operating W+P+T		<input type="checkbox"/> Show Equations											
Object	Start End node	Type	DN, mm	Frad, kgf	Fcir, kgf	Flong, kgf	FR, kgf	Mrad, kgf-cm	Mcir, kgf-cm	Mlong, kgf-cm	MR, kgf-cm	Sum	Notes		
Fired Heater API 560/ISO 13705	Node (1)	calculated	219	-96033.70		40605.70			-2029708.86				1		
		allowable		133.40	266.90	266.90		11660	8810	8810					



- Method 2: Model whole or part of the furnace coil that is inside the heater. Vendor should provide allowable displacements at the point where the pipe goes inside the heater (+dx, -dx, +dy, -dy, +dz, -dz). Usually it's the gap values between the pipe and heater shell

Table 7—Allowable Movements for Tubes

Dimensions in millimeters (inches)

Terminals	Allowable Movement											
	Horizontal Tubes					Vertical Tubes						
	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_z$		
Radiant	a	a	+25	(+1)	25	(1)	a	a	25	(1)	25	(1)
Convection	a	a	+13	(+0.5)	13	(0.5)	—	—	—	—	—	—

NOTE Except where noted, the above movements are allowable in both directions ( $\pm$ ).

<sup>a</sup> To be specified by heater vendor.

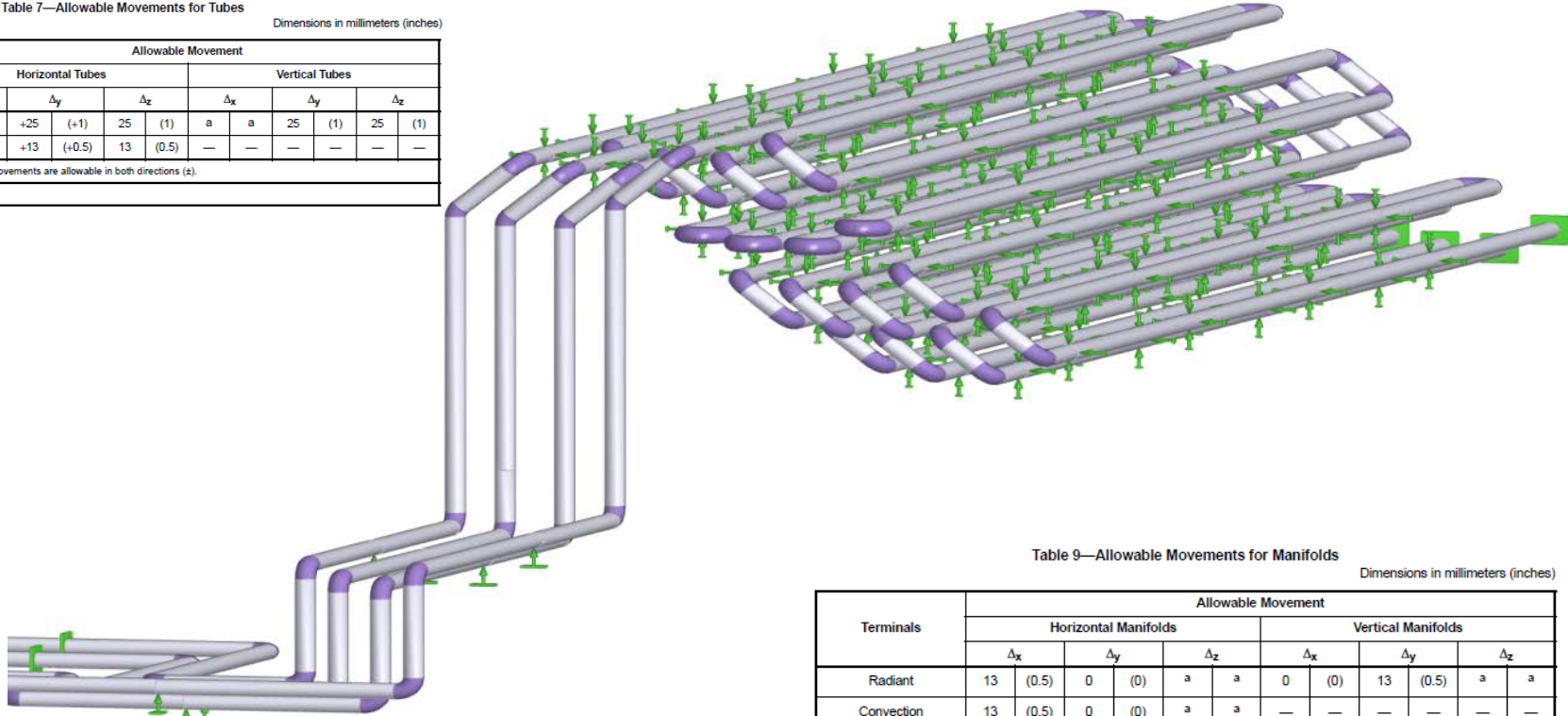


Table 9—Allowable Movements for Manifolds

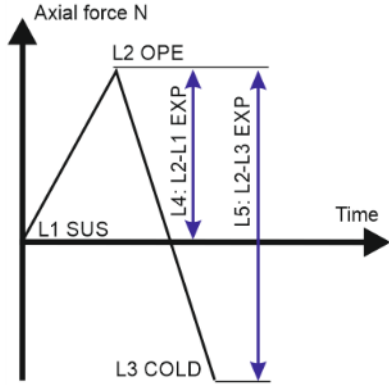
Dimensions in millimeters (inches)

Terminals	Allowable Movement											
	Horizontal Manifolds					Vertical Manifolds						
	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_x$	$\Delta_y$	$\Delta_z$	$\Delta_z$		
Radiant	13	(0.5)	0	(0)	a	a	0	(0)	13	(0.5)	a	a
Convection	13	(0.5)	0	(0)	a	a	—	—	—	—	—	—

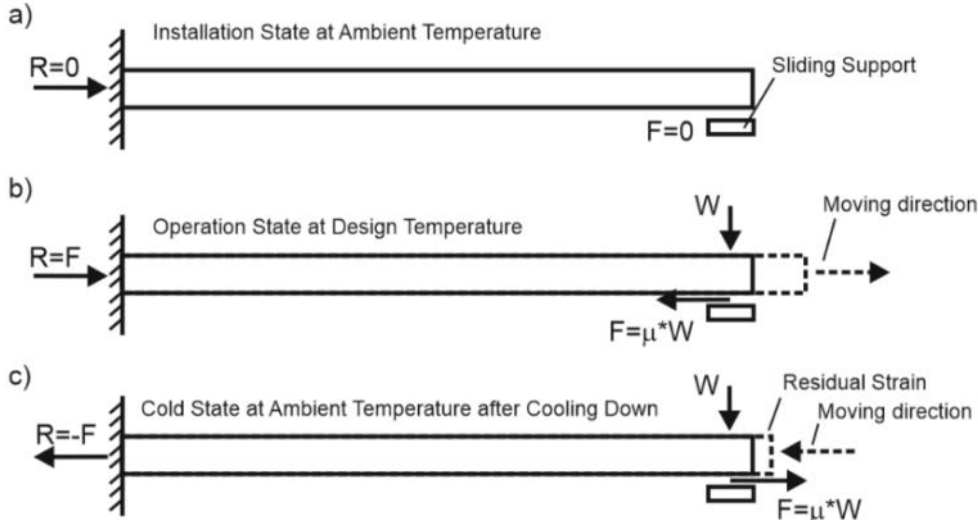
NOTE The above movements are allowable in both directions ( $\pm$ ).

<sup>a</sup>  $\Delta_z$  is to be specified by heater vendor.

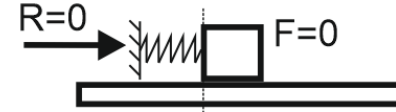
# Effect of Friction in Operating and Cold State



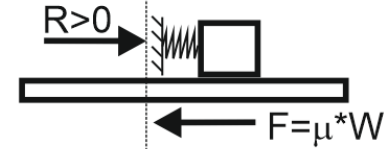
L1: W+P SUS  
 L2: W+P+T OPE  
 L3: L2-T COLD (follow up L2)  
 L4: L2-L1 EXP  
 L5: L2-L3 EXP



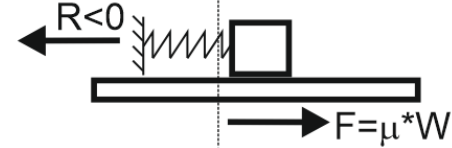
a) Installation State at Ambient Temperature



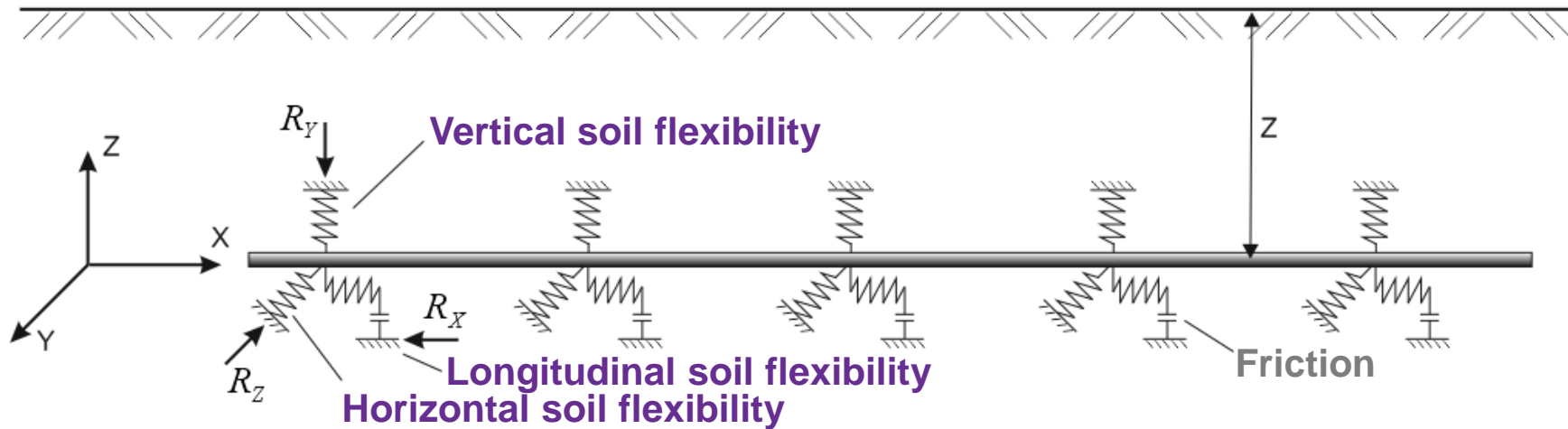
b) Operation State at Design Temperature



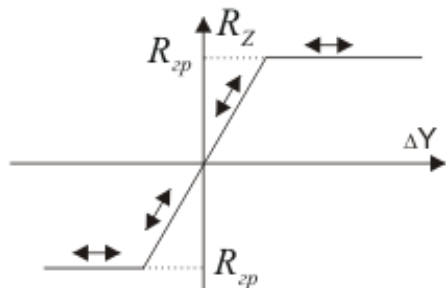
c) Cold State at Ambient Temperature after Cooling Down



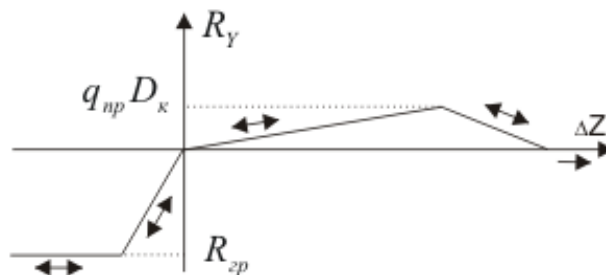
# The Pipe and Soil Interaction Model



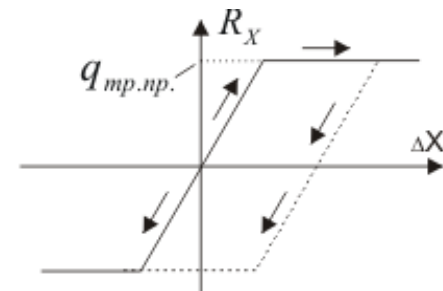
Horizontal soil P- $\Delta$  diagram



Vertical soil P- $\Delta$  diagram



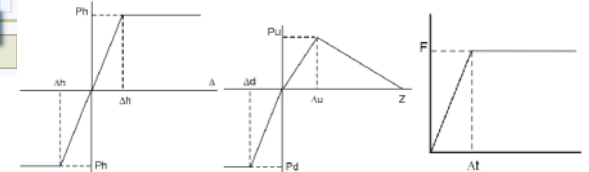
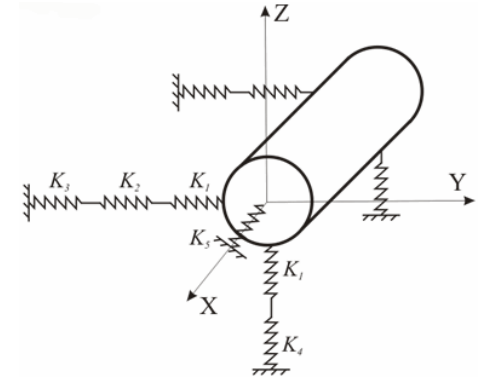
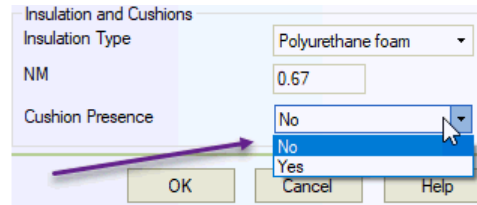
Longitudinal soil P- $\Delta$  diagram (friction)



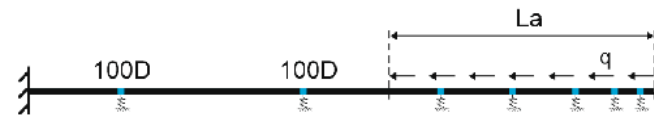
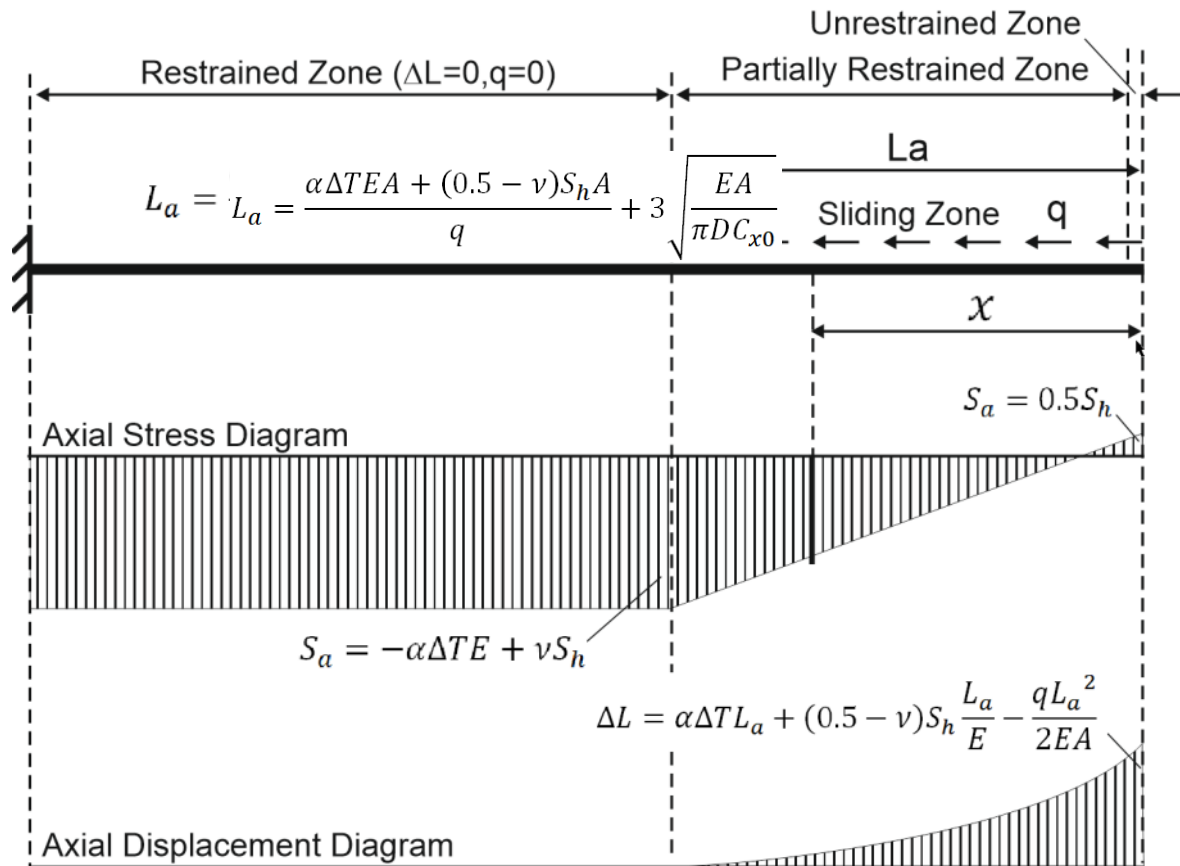
# PASS/Start-Prof | Soil Model

Each soil support stiffness consist of vertical, horizontal and longitudinal nonlinear springs

- Horizontal spring consist of 3 springs  $K_1$ ,  $K_2$ ,  $K_3$ .
- Vertical Spring consist of 2 (or 3) springs  $K_1$ ,  $K_4$  (and  $K_2$ ).
- Longitudinal spring  $K_5$



# Restrained and Unrestrained Zones



$$L_a = \frac{\alpha\Delta TE A + (0.5 - \nu)S_h A}{q} + 3 \sqrt{\frac{EA}{\pi DC x_0}}$$

$S_h$  is the ring stress,  $q$  is the friction force,  $E$  is the modulus of elasticity,  $A$  is the area,  $DT$  is the temperature difference,  $a$  is the linear expansion coefficient,  $\nu$  is the Poisson coefficient





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PIPING AND EQUIPMENT  
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# PASS/Start-Prof | Resources

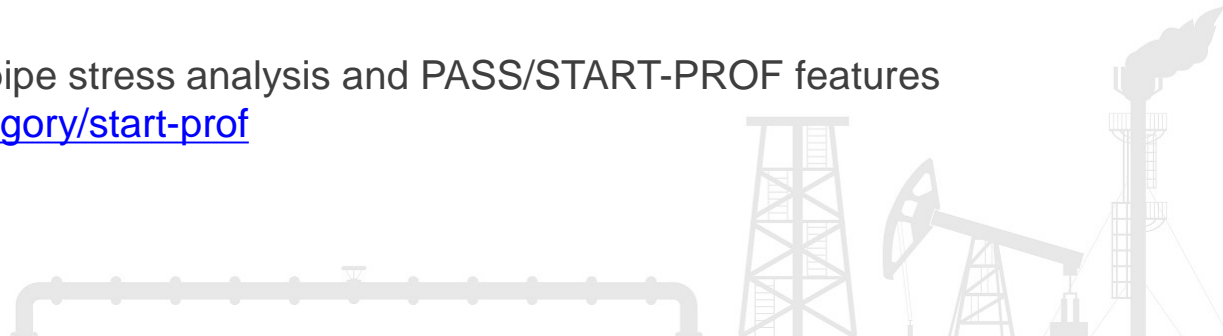
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- Twitter: [twitter.com/passuitecom](http://twitter.com/passuitecom)
- More than 50 articles about pipe stress analysis and PASS/START-PROF features  
<https://whatispiping.com/category/start-prof>



PIPING AND EQUIPMENT  
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# PASS/Start-Prof | Resources

- Online Help: [https://www.passuite.com/kbase/doc/start/WebHelp\\_en/index.htm](https://www.passuite.com/kbase/doc/start/WebHelp_en/index.htm)

✓PASS Start-Prof 4.84R1 User's Guide

The screenshot displays the PASS START-PROF software interface. On the left is a navigation tree with categories like Temperature Cycles, Valve, Marker, Pipe Elements, Bends, Tees and Stub-ins, Reducers, Expansion Joints, Restraints, Equipment, Loads, Flaw, and Analysis Results. The main content area features the title "Pump API 610 / ISO 13709" and a 3D model of a blue pump. Below the title, text explains that this element allows modeling pumps and checking loads according to API 610 / ISO 13709 standards. It notes that one "Pump" object can be connected to one or two nodes, and allowable loads are checked for each individual nozzle and for the whole pump. Analysis results are found in "Loads on Nozzles and Equipment Table". It also references "How to Reduce the Nozzle Loads in START-PROF" and lists two options for using the pump element: 1. Put Pump nozzles into the pipe end nodes. In this case, the pump nozzles are automatically modeled as anchors. Pump temperature expansions are automatically modeled as anchor movements.

Related Topics

Read about [START-PROF pipe stress analysis software](#)

Node Object Properties dialog box:

- Node Object Properties
- Pump API 610-ISO 13709
- Material of Pump: 20
- Temperature of Pump: 50 °C
- Manufacturer Allowable Multiplier: 1
- Table Nozzle Loading Factor: 2
- Schall Age: K
- Pump Center Coordinate from Node: 742
- Discharge Node: 715