District Heating Networks

Increase Productivity and Save your Time Twice with PASS/START-PROF 4.84

Dr. Alex Matveev,
START-PROF Product Owner

PASS
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/START-PROF

Smart Pipe Stress Analysis & Optimal Sizing

Presenter:

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START-PROF Product Owner
Development, Training, Support of START-PROF Since 2005

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PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

Webinar Agenda – Part 1

Introduction

- Quick introduction of PASS/START-PROF
- Supported codes for district heating networks
- Underground and aboveground pipeline modeling abilities

How to model and analyze district heating pipelines

- Soil model for horizontal, inclined, vertical pipelines
- Polyurethane foam insulation stiffness, expansion cushion stiffness
- Database of polyurethane pre-insulated pipes: LOGSTOR, POWERPIPE, +GF+ Urecon, etc.
- Polyurethane foam insulation stress check
- Check stresses from surface vehicle loads
- Pre-heating analysis
- Single use compensators analysis. Calculate the distance
- Seismic wave propagation analysis

Webinar Agenda – Part 2

PASS/START-PROF features and usability

- Object-oriented piping model creation principle
- Piping object types: pipe, tees, bends, reducers, etc.
- Equipment objects: Pump, Nozzle
- Expansion joint objects
- Material Database for EN 13480 and 13941 codes
- Ring bending calculation using nonlinear FEA
- Databases, wind, ice, snow, seismic loads
- Natural arch of collapse phenomena, horizontal directional drilling
- Pipe and fittings wall thickness calculation
- Analysis reports: Stress in piping, Stress in insulation, Seismic stress, Flaw stress, Restraint loads, Displacements, Expansion joints check, variable spring selection

PASS/Start-Prof

Comprehensive pipe stress, flexibility, stability, and fatigue strength analysis with related sizing calculations

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Quick Pipe Stress Analysis & Optimal Sizing

- Broad Applicability
- Unsurpassed Usability
- Powerful Capabilities
- Extensive Databases
- Flexible Configurations
- Extensive Code Support
- Widely Used

PASS/Start-Prof | Broad Applicability

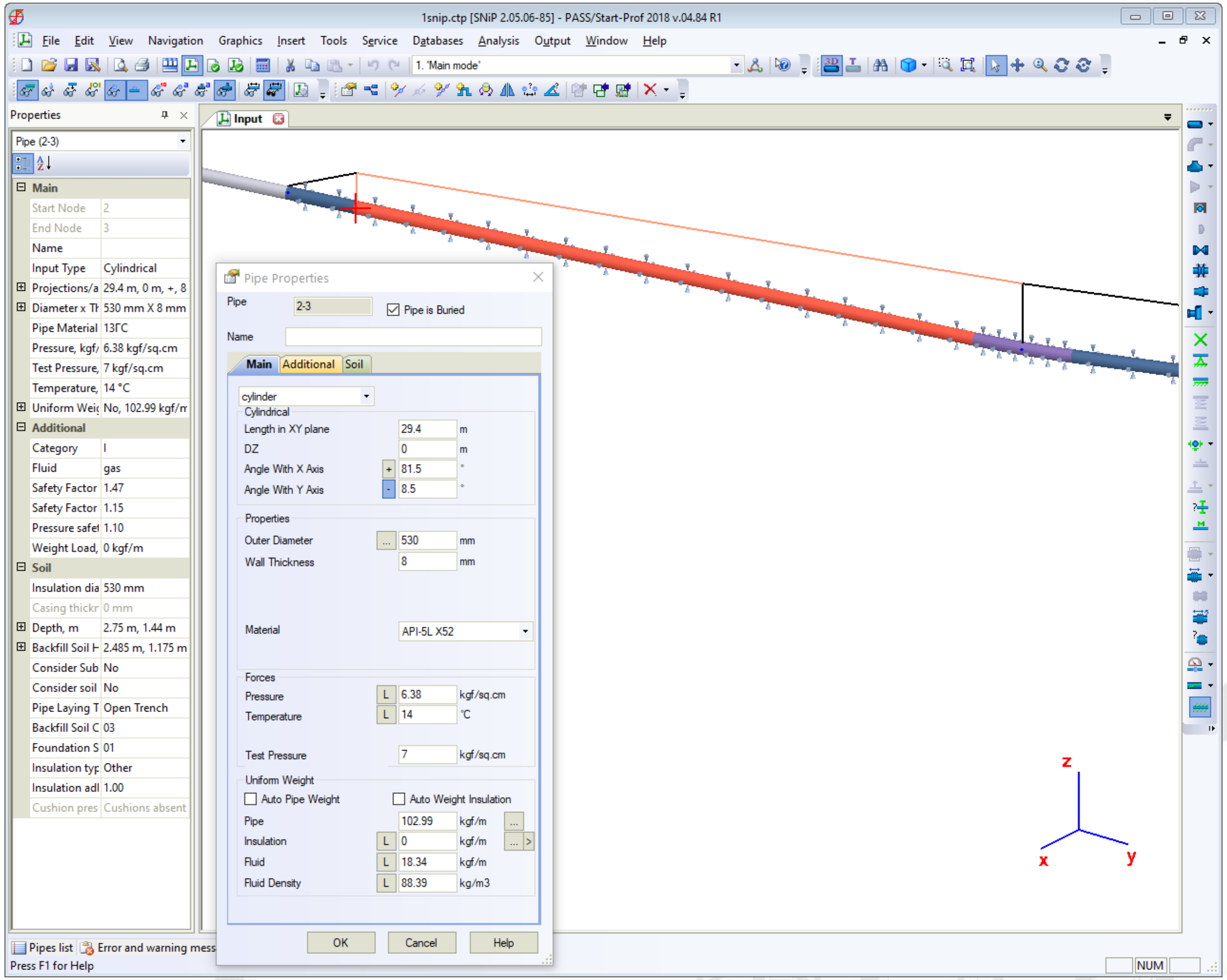
PASS/START-PROF is an Industry standard in Russia, Kazakhstan and Belarus for:

- Process Industry Piping
- Oil and Gas Pipelines
- Utility Network Pipelines
  - District Heating
  - Natural Gas
  - Water
- Power Generation Piping

PASS PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features

- Increase your Productivity and Save your Time
- Save your Money (we have a friendly pricing policy)
- Increase the Accuracy of Pipe Stress Analysis



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PASS/Start-Prof | Broad Applicability

- Active development since 1965
- 2000+ Active users (companies) & 8000+ Licenses
- User interface and documentation languages: English, Chinese, Russian
- Piping codes: 32
- Wind, Seismic, Snow, Ice codes: 18

PASS/Start-Prof | Our Customers

ROSNEFT
TechnipFMC
LUKOIL OIL COMPANY
GAZPROM NEFT
GAZPROM
UNG O'ZLITINEFTGAZ
CEEC CHINA POWER ENGINEERING CONSULTING GROUP NORTHWEST ELECTRIC POWER DESIGN INSTITUTE CO., LTD.
中国石油天然气股份有限公司 PetroChina Company Limited
SNC·LAVALIN
Northern Reflections DESIGN AND DRAFTING
TRANSNEFT
КазМунайГаз NATIONAL COMPANY ҰЛТТЫҚ КОМПАНИЯСЫ
WorleyParsons resources & energy
Caspian Pipeline Consortium
中国市政工程华北设计研究总院有限公司
Tecnimont
Severstal
THE LINDE GROUP
NOVATEK
thyssenkrupp
KEPCO
SIBUR
KazTransOil
SEPA MÜHENDİSLİK & MÜŞAVİRLİK ENGINEERING & CONSULTING
E&R
DAELIM
MITSUBISHI HEAVY INDUSTRIES AMERICA, INC.
ТД Мосфлоулайн
ГРУППА КОМПАНИЙ МОСФЛОУЛАЙН

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PASS/Start-Prof | Features

- Direct support from developers via e-mail is provided
- Easy to learn, fast and simple to work with for a new pipe stress analyst
- Due to intuitive modern object-oriented user interface, you can start working immediately. Companies can put PASS/START-PROF into application immediately after purchase, significantly reducing costs and save the time without compromising on the quality of end results

PASS/Start-Prof | Features

PASS/START-PROF is a part of PASS Suite:

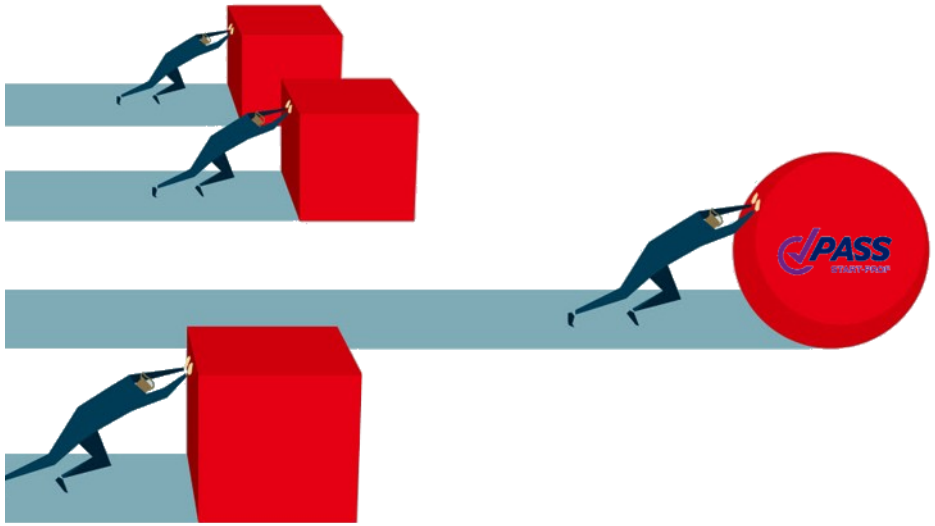
- PASS/START-PROF – Pipe Stress Analysis Software
- PASS/HYDROSYSTEM – Piping hydraulic and Thermal Analysis Software
- PASS/ NOZZLE-FEM – Nozzle to Shell Junction Finite Element Analysis Software. Calculate SIF, k-factors, Nozzle Flexibility and Stress Analysis, etc.
- PASS/EQUIP – Pressure Vessel, Column, Heat Exchanger, Tank Design and Analysis Software

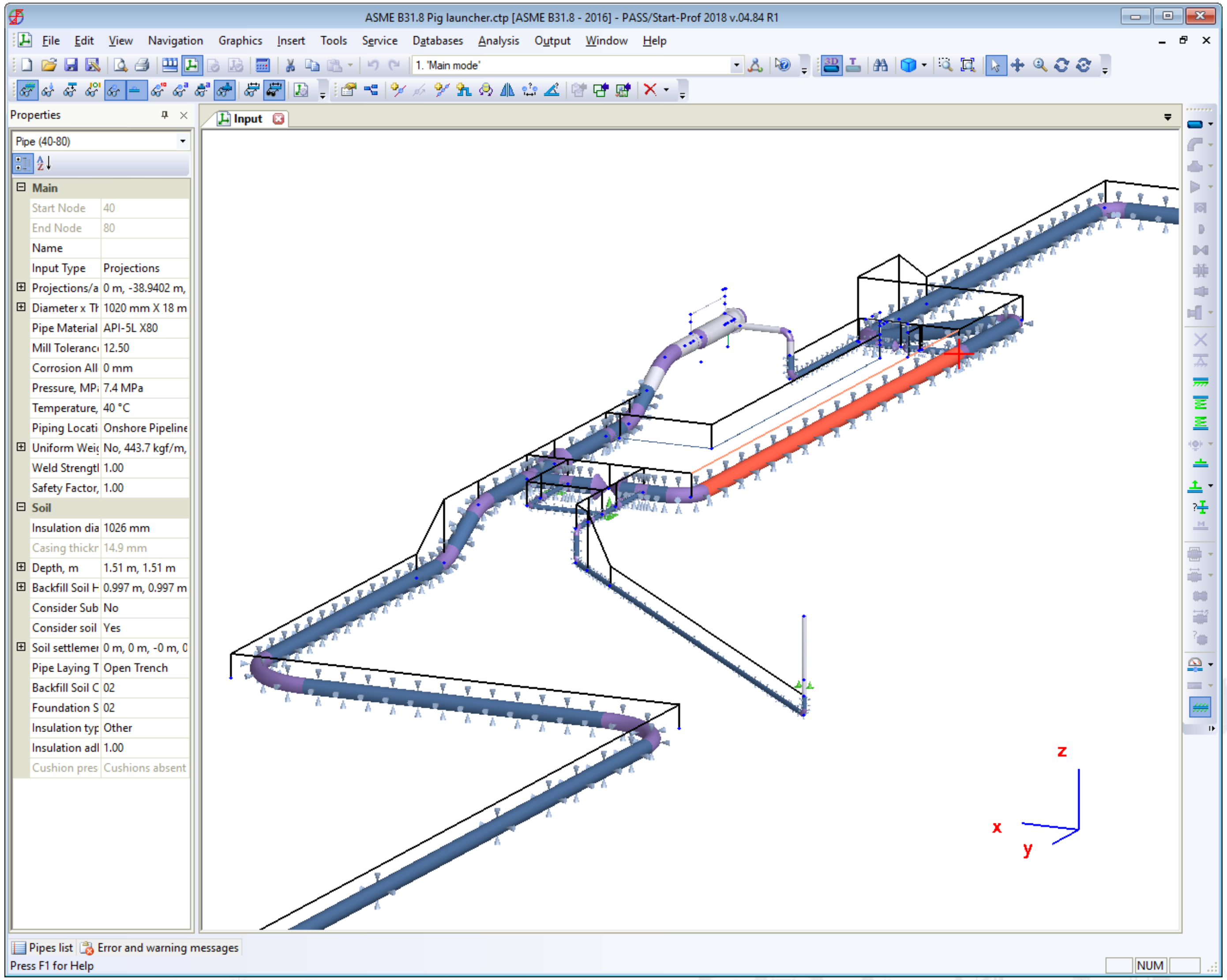
PASS/Start-Prof | Increase Productivity

PASS/START-PROF is a Professional Modern Pipe Stress Analysis Software

PASS/START-PROF Makes Complex Things Simple

You will Get the Same Result, but Faster and Easier





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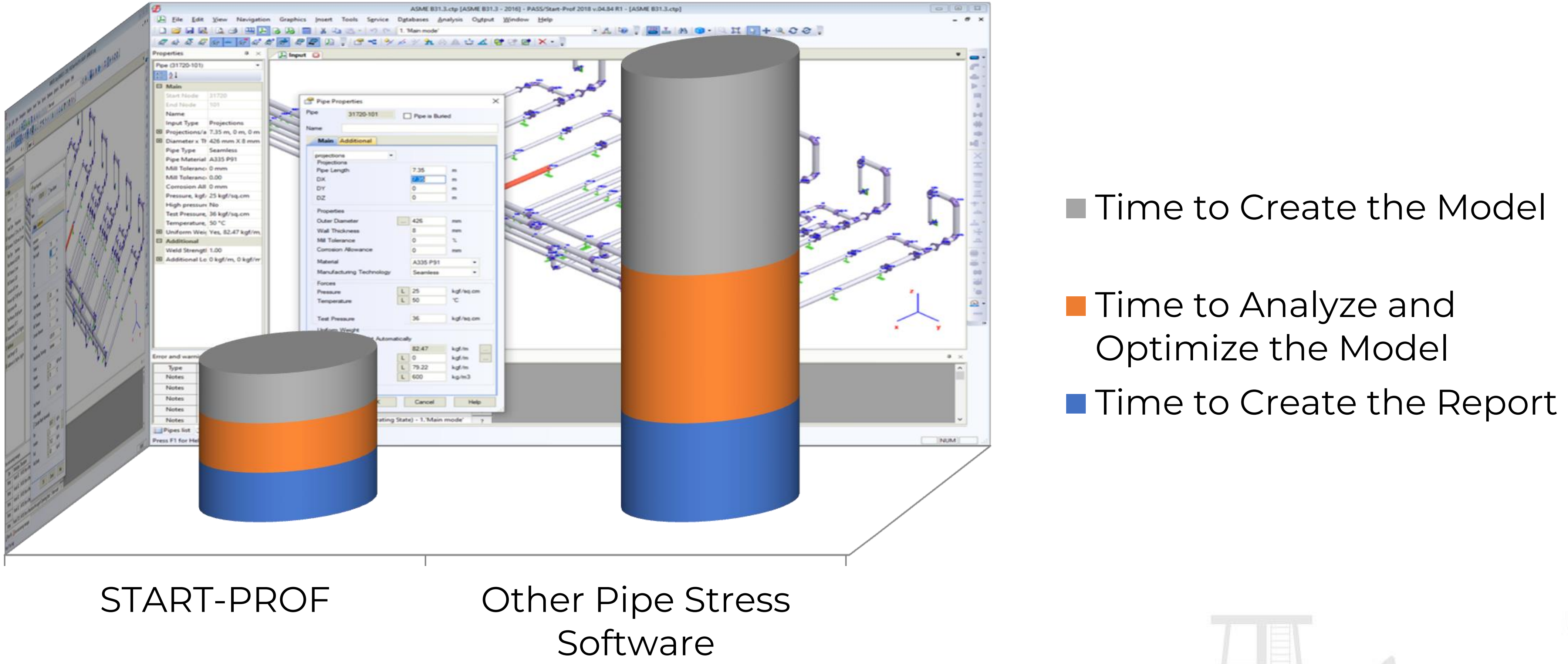
PASS/Start-Prof |How START-PROF Saves your Time



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PASS/Start-Prof | Supported Codes

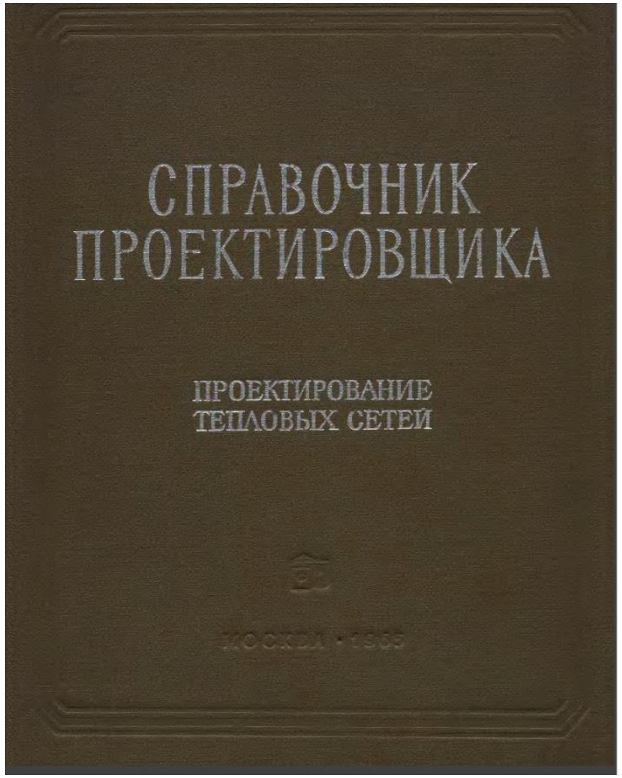
PASS/START-PROF can analyze piping according to 32 piping codes.

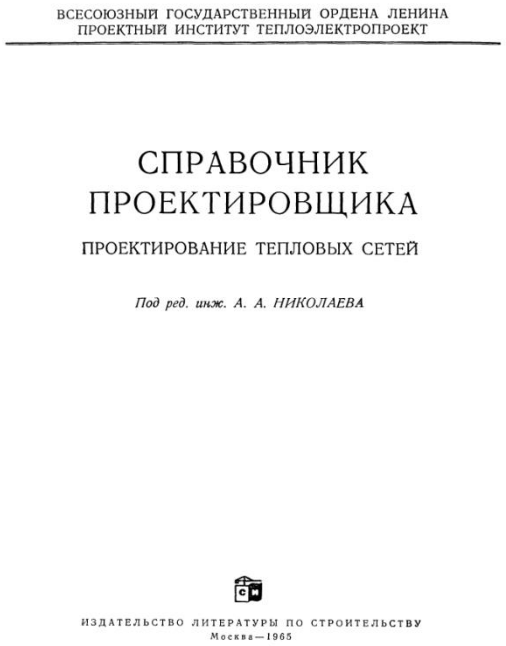
The software contains all needed and latest codes for district heating analysis:

- **EN 13941-2019**
- EN 13480-2017
- GOST R 55596-2013 (Russia)
- CJJ/T 81-2013 (China)
- ASME B31.4-2019 (USA)

PASS/Start-Prof | History

Nikolaev’s Handbook was a very popular for District Heating Pipeline Thermal Expansion Design 1965- 1990x




ВСЕСОЮЗНЫЙ ГОСУДАРСТВЕННЫЙ ОРДЕНА ЛЕНИНА
ПРОЕКТНЫЙ ИНСТИТУТ ТЕПЛОЭЛЕКТРОПРОЕКТ

СПРАВОЧНИК
ПРОЕКТИРОВЩИКА

ПРОЕКТИРОВАНИЕ ТЕПЛОВЫХ СЕТЕЙ

Под ред. инж. А. А. НИКОЛАЕВА

ИЗДАТЕЛЬСТВО ЛИТЕРАТУРЫ ПО СТРОИТЕЛЬСТВУ
Москва—1965

Рис. 10 20 Г-образный участок трубопровода с углом поворота 90° (с учетом гибкости отвода)

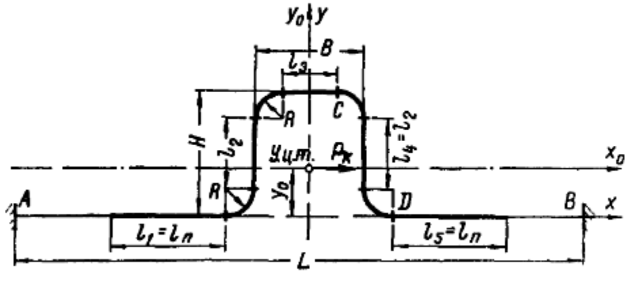


Рис. 10.43. Участок трубопровода с симметричным П-образным компенсатором с гнутыми гладкими отводами при $l_1=l_5=l_п$

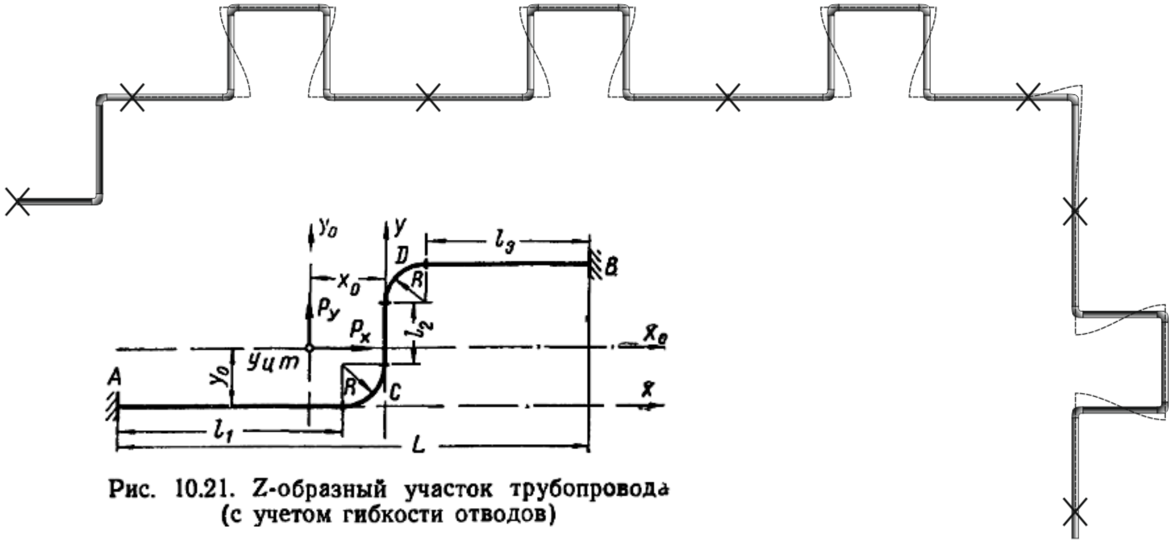


Рис. 10.21. Z-образный участок трубопровода (с учетом гибкости отводов)

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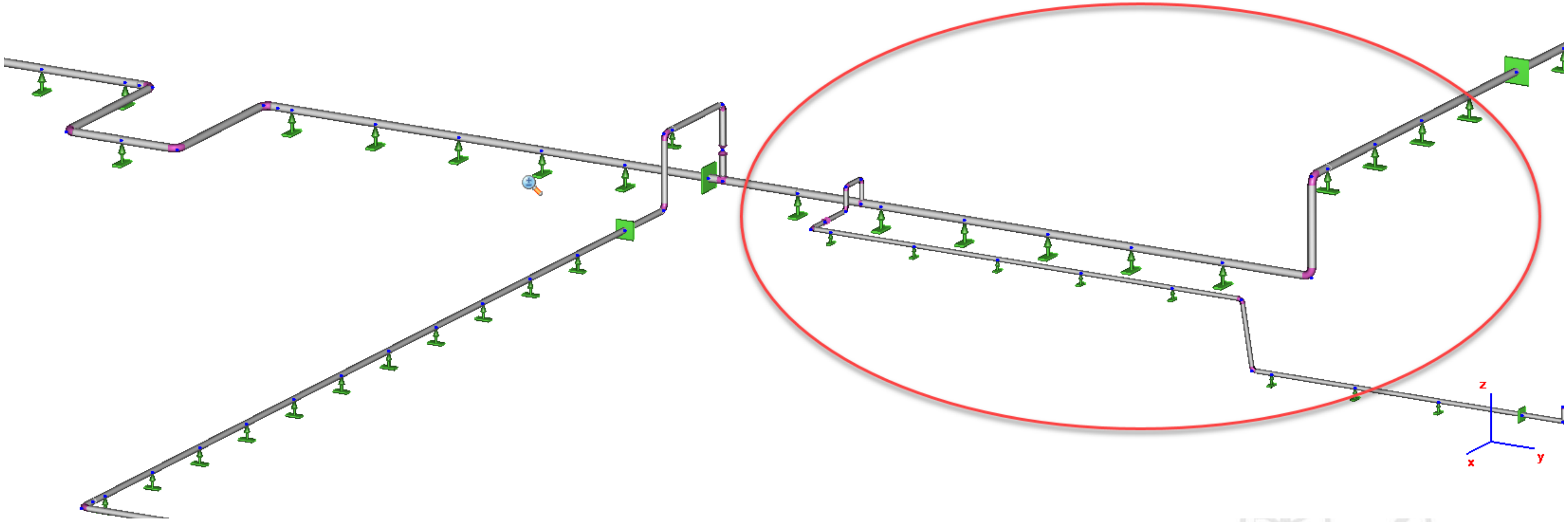
PASS/Start-Prof | History

Since 1998, the Buried Pre-insulated Pipelines with Polyurethane Foam Insulation Began to be Widely Used in Russia.
The Peter Randlov Handbook Become Popular Worldwide since 1997

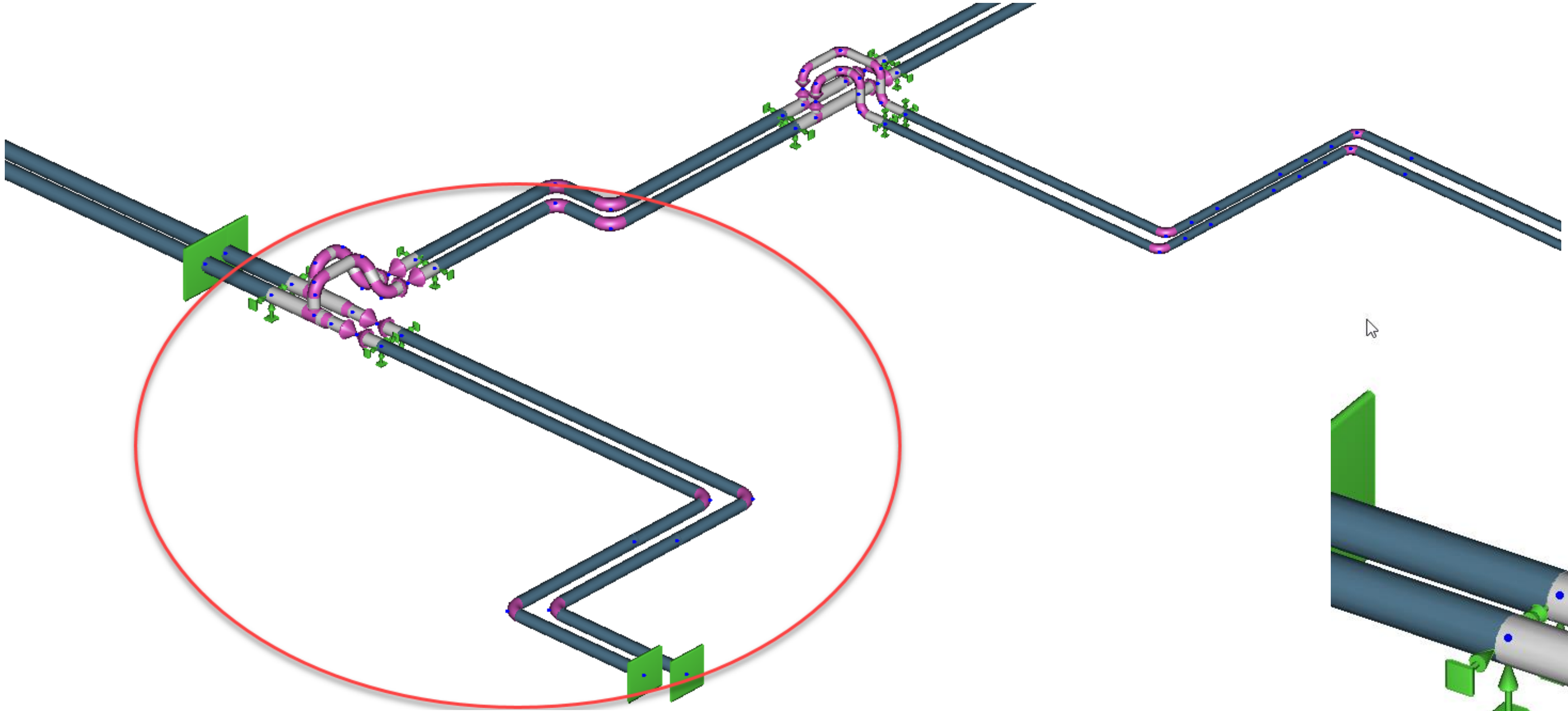
PASS/Start-Prof | History

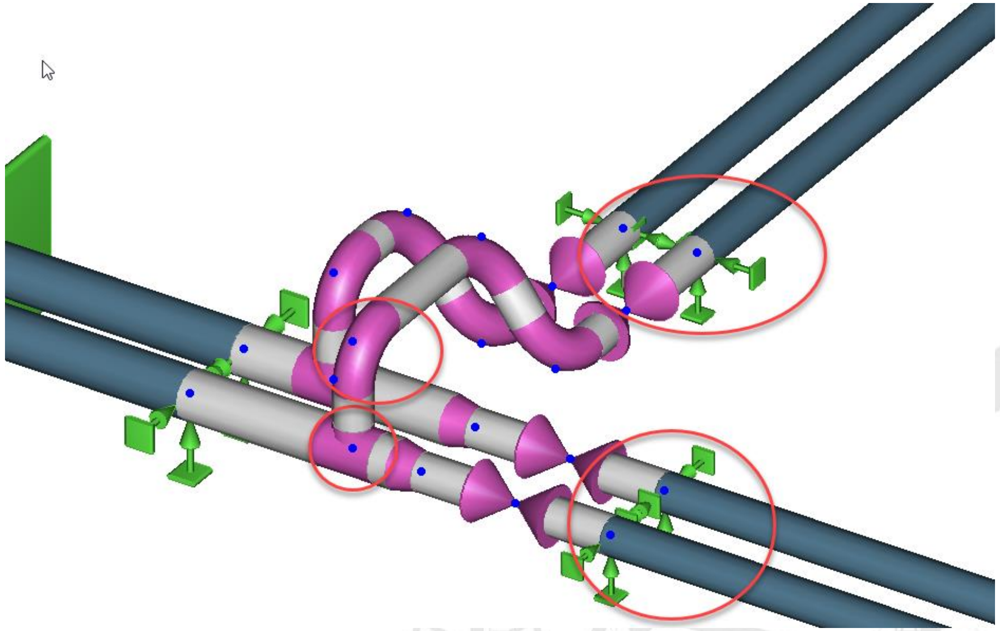
This piping model can't be properly designed using simple manual methods from handbooks. PASS/START-PROF was already popular for power and process piping design 1970-2000, but the most of district heating design companies was still used the inaccurate manual methods (nomograph) till 2000



PASS/Start-Prof | History

Manual analysis methods doesn’t allow to properly check the complex design piping systems. It is impossible to check the tee, bend, reducer fitting stresses. Especially for directly buried design





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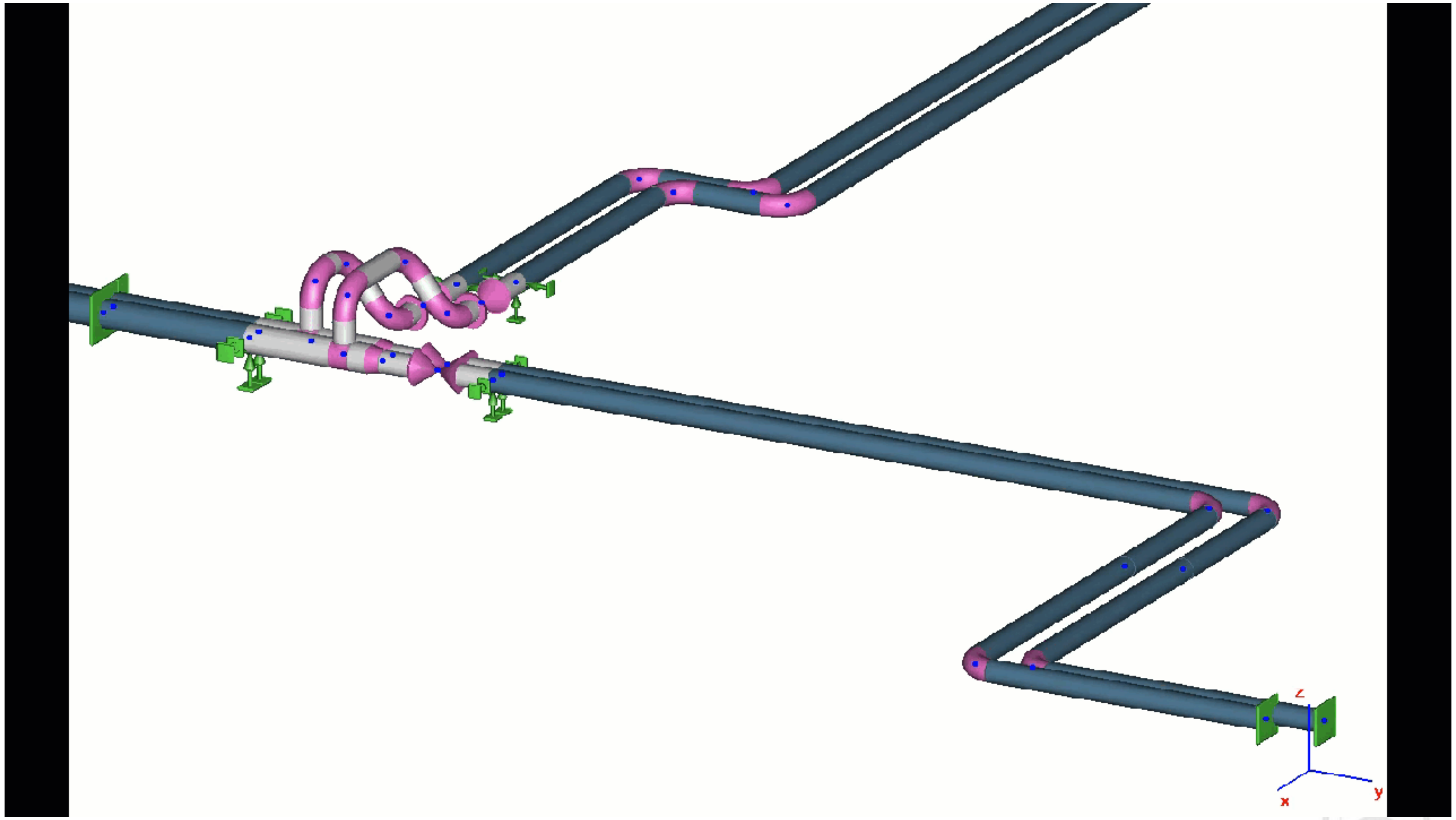
PASS/Start-Prof | History

Since 2000 situation start changing. START-PROF became more and more popular for district heating design



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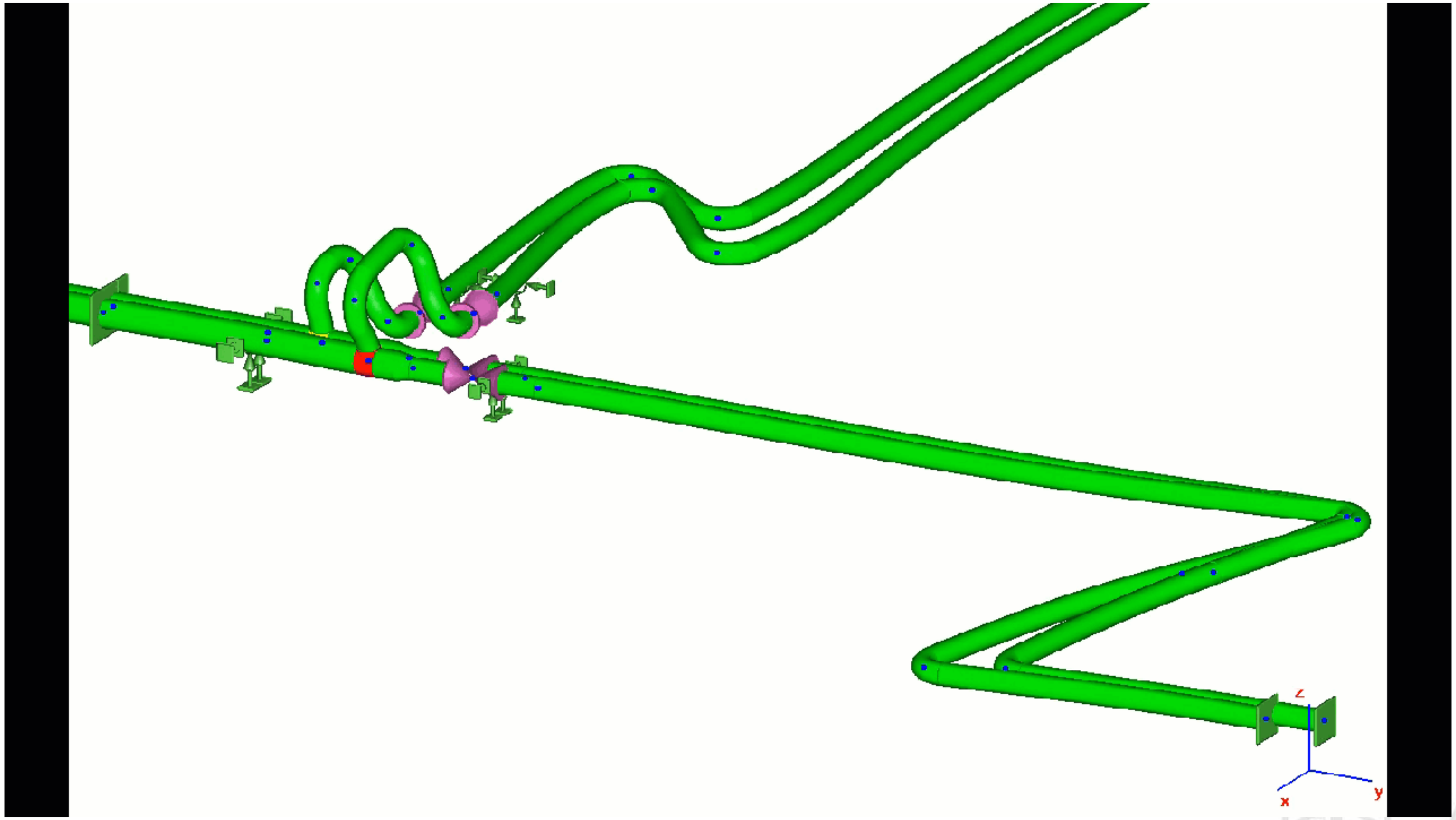
PASS/Start-Prof | History

Manual analysis methods doesn't allow to properly check the complex design piping systems. It is impossible to check the tee, bend, reducer fitting stresses. Especially for directly buried design



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PASS/Start-Prof | History

Sometimes the accidents was happened due to the wrong design

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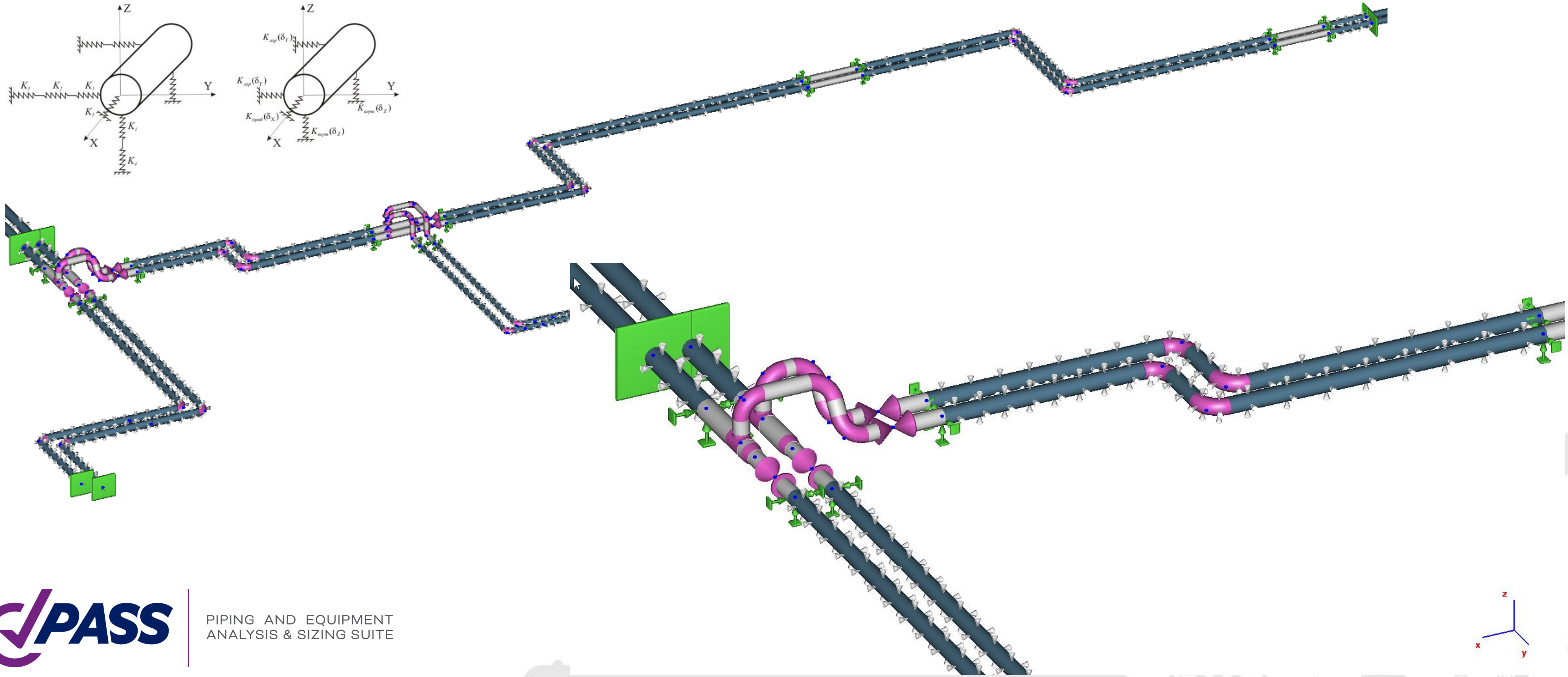
PASS/Start-Prof | History

In fact PASS/START-PROF Become an Industry Standard for District Heating Network Design.
Nowadays the inaccurate manual methods are almost never used



PASS/Start-Prof | History

Successfully designed a Lot of district heating systems 219 mm – 1400 mm over Russia since 1998 using PASS/START-PROF

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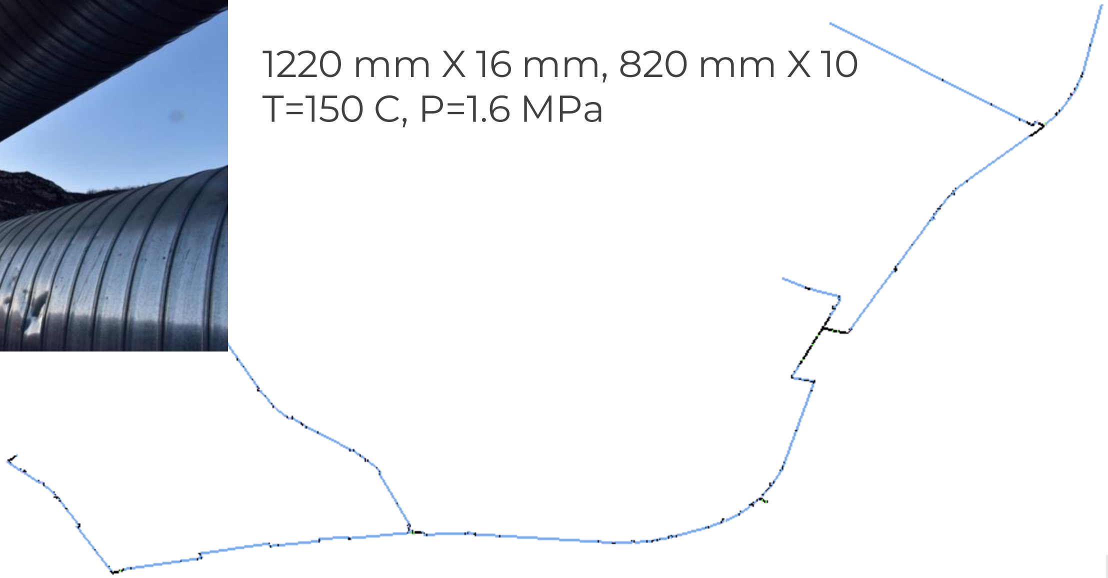
PASS/Start-Prof | Application Examples

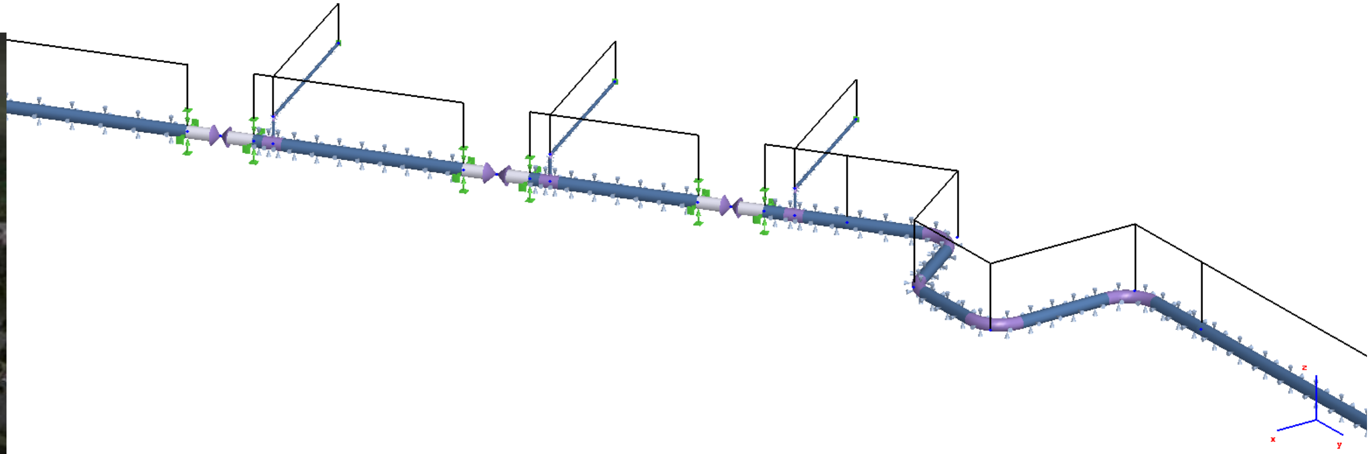
Since 2015 START-PROF become popular in China. Already designed a lot of district heating networks in China using PASS/START-PROF, It become an industry standard too

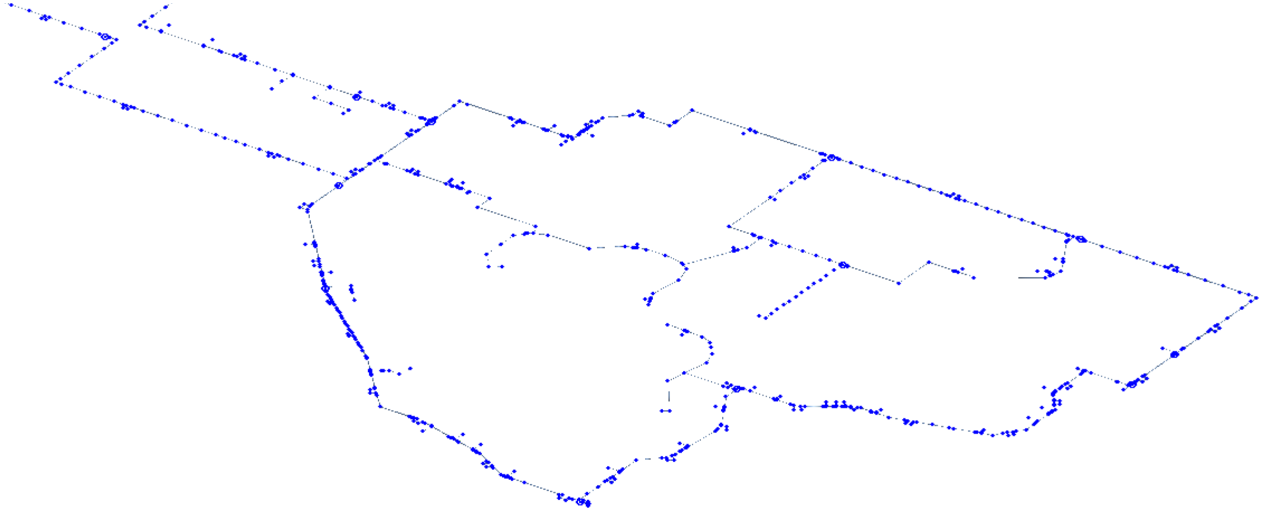


1220 mm X 16 mm, 820 mm X 10
T=150 C, P=1.6 MPa

PASS/Start-Prof | Application Examples

Beijing Universal Amusement Park Buried Hot Water Piping Network Project in PASS/START-PROF





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PASS/Start-Prof | Training

PASS/START-PROF Training

PASS/Start-Prof | Training

PASS/START-PROF Training

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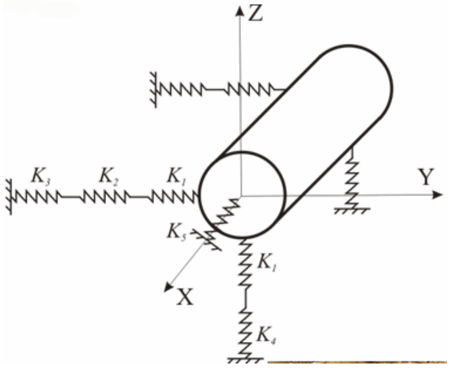
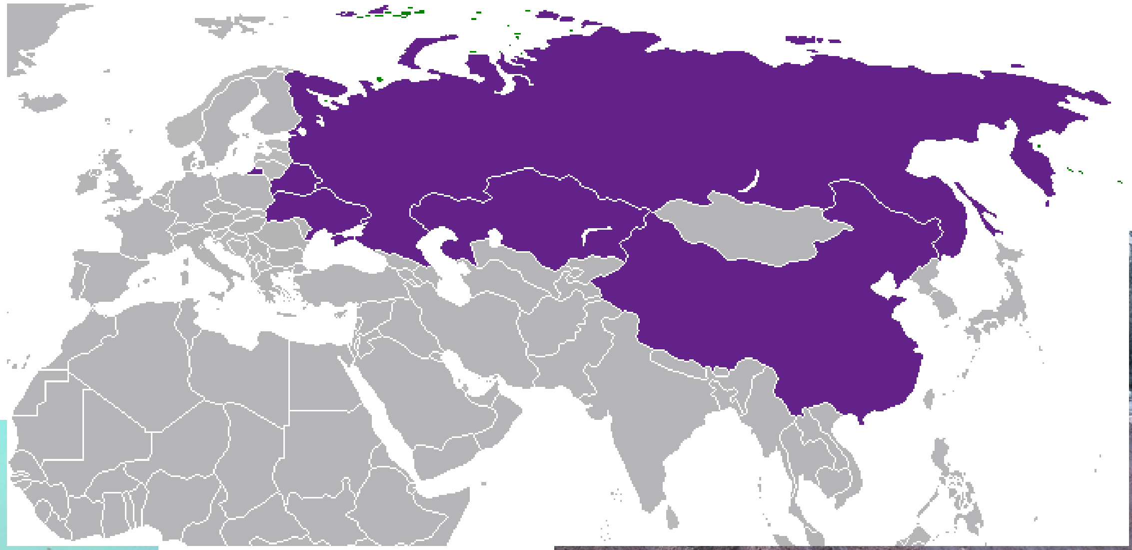
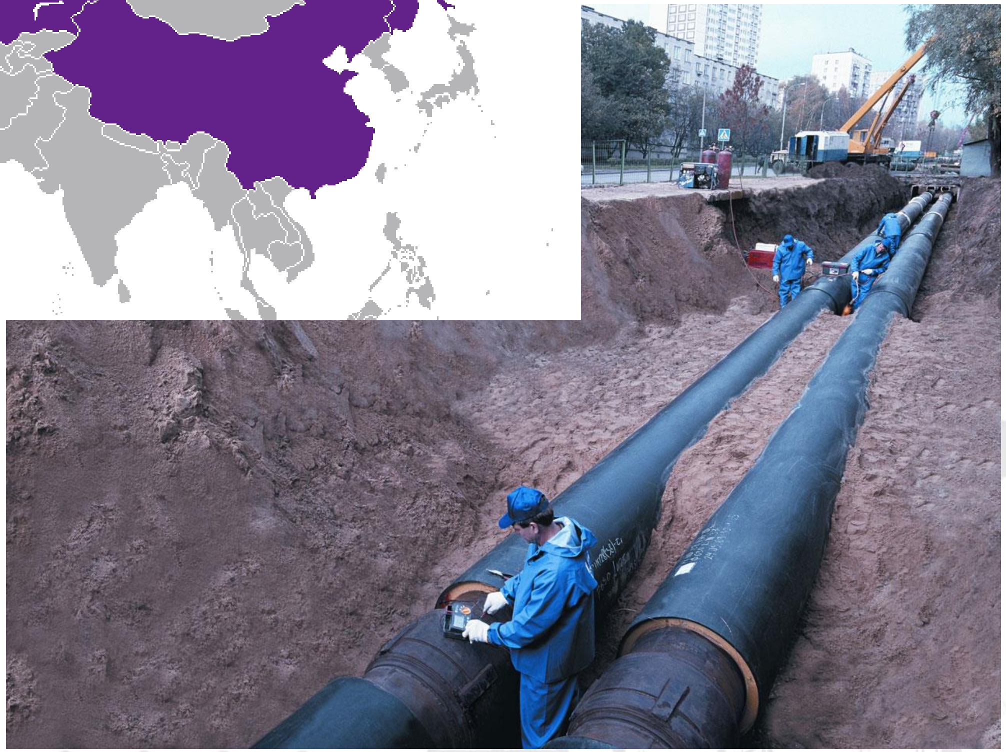
PASS/Start-Prof | Features

PASS/START-PROF is the Industry Standard for District Heating Network Analysis in China, Russia, Ukraine, Belarus, Kazakhstan. More than 800 District Heating Companies are Active Users







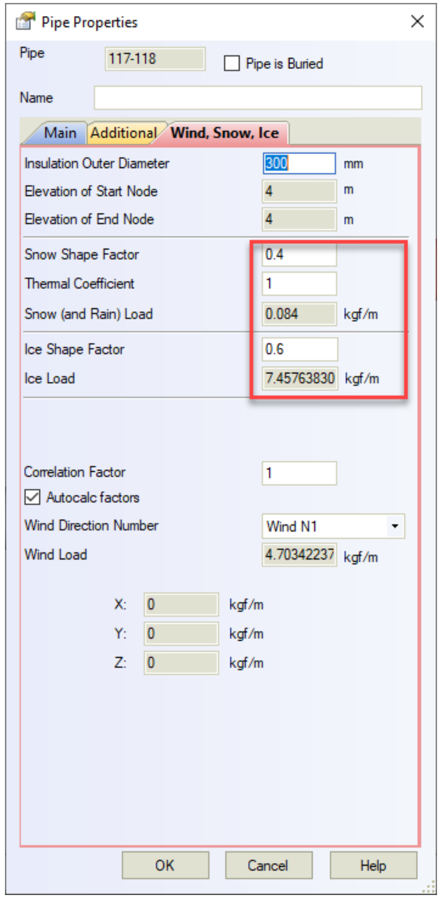
PASS/Start-Prof | Analysis Capabilities

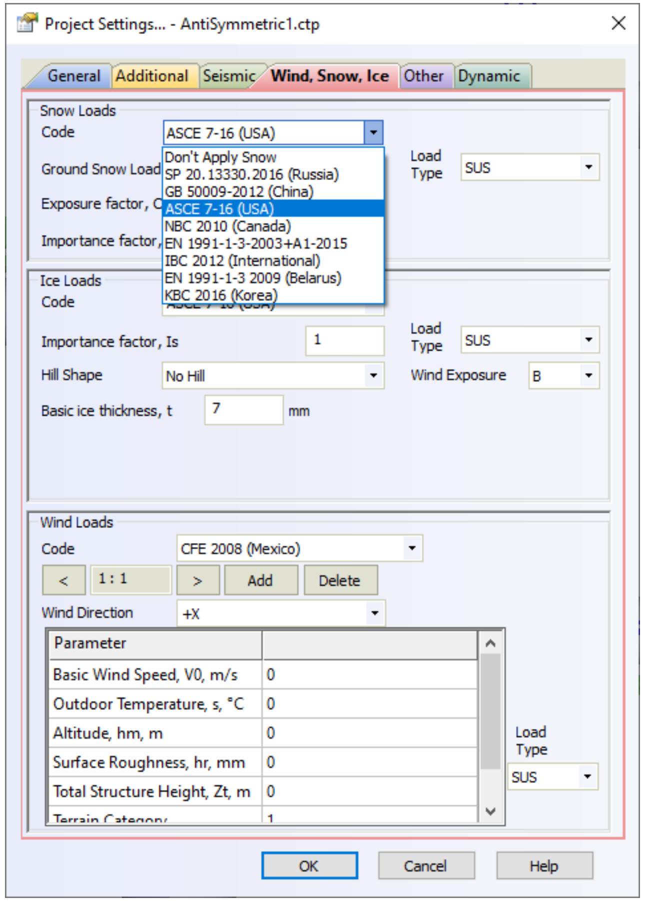
PASS/START-PROF has professional analysis abilities needed for District Heating Stress Analysis:

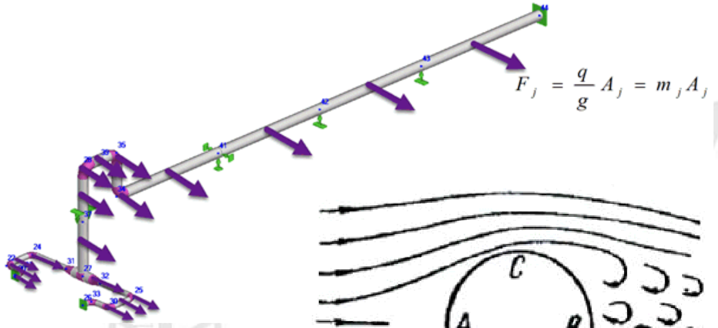
- Nonlinear analysis of gaps, friction, one-way restraints, rotating rods, etc.
- Special algorithm that improves the nonlinear model convergence on-the-fly without manual tuning (gaps and one-way restraints cycling, friction force cycling etc.). We receive from users the models that didn’t converge, put it into our collection and continuously improve that algorithm for past 55 years. It allow to achieve convergence in 99.9% models

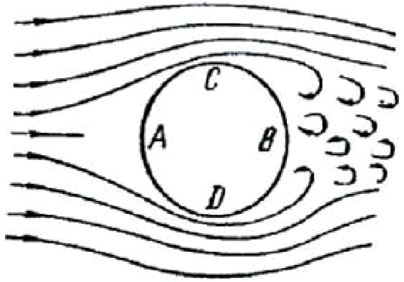
PASS/Start-Prof | Analysis Capabilities

Automatic generation of a wind, snow, ice, seismic loads according to 18 national codes









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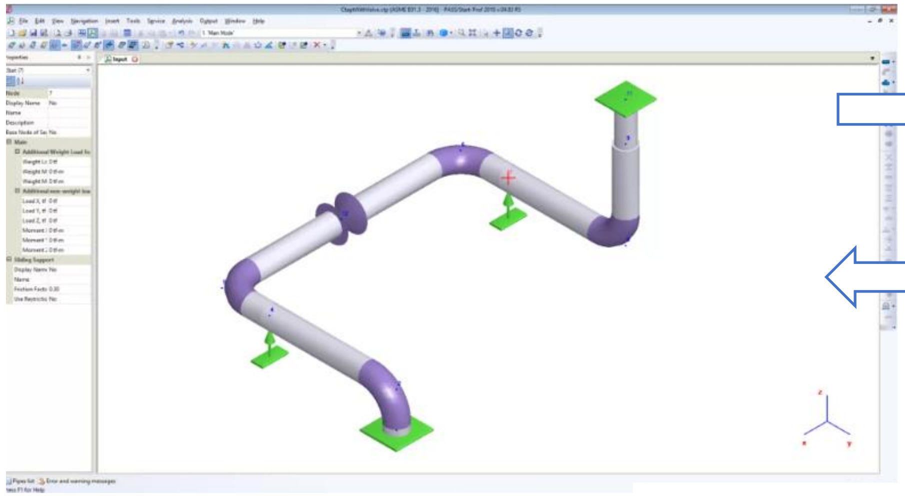
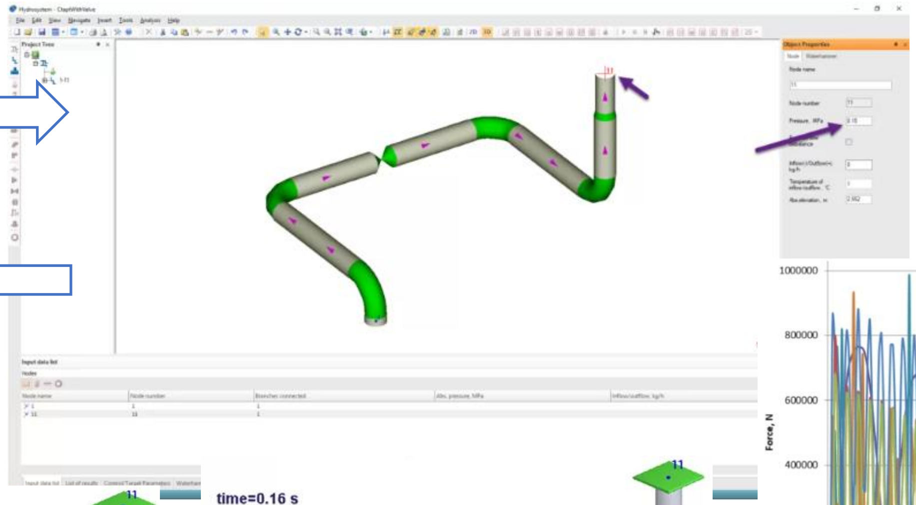
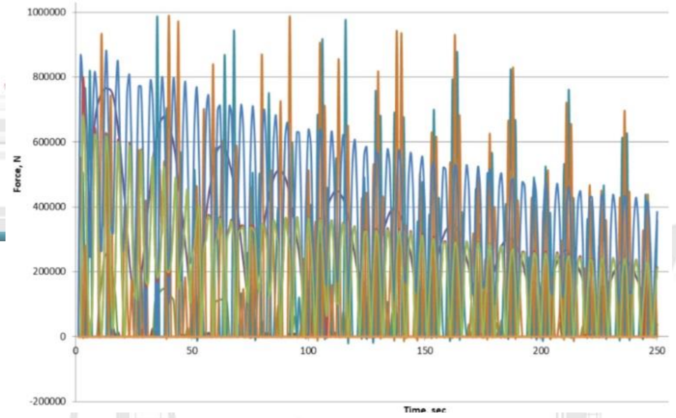
PASS/Start-Prof | Analysis Capabilities

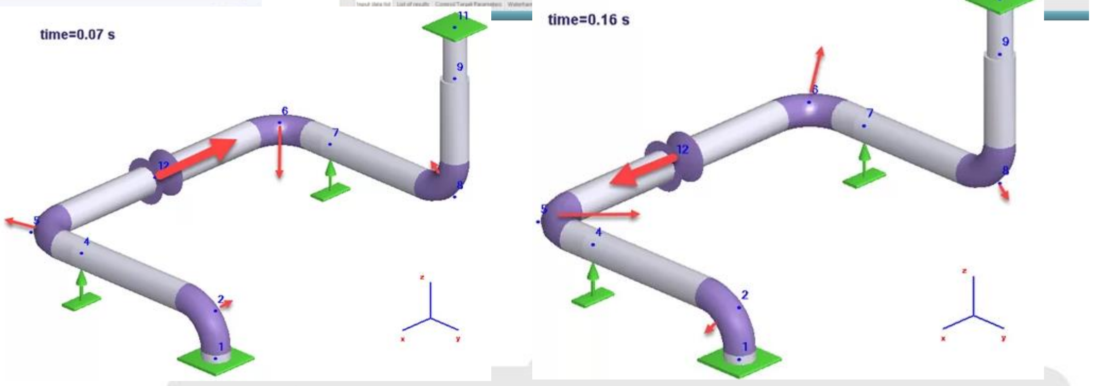
PASS/START-PROF + PASS/HYDROSYSTEM Allows to Water Hammer Surge Analysis

- 3D piping Models converted automatically from START-PROF to HYDROSYSTEM and back
- 3D loading is converted simultaneously for all nodes in the system at the same moment of time









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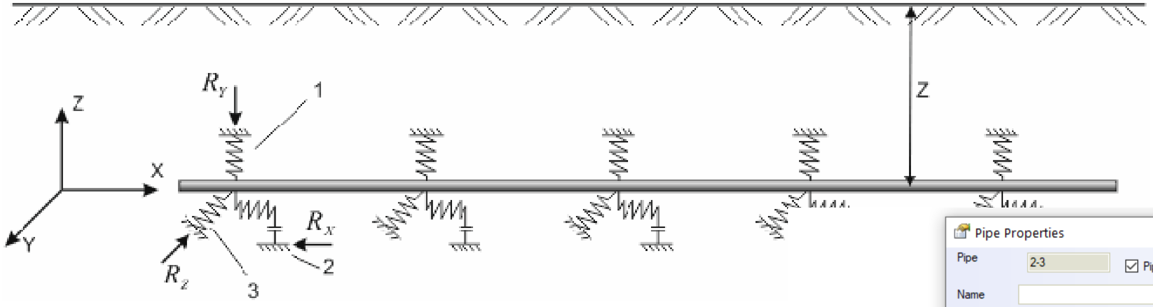
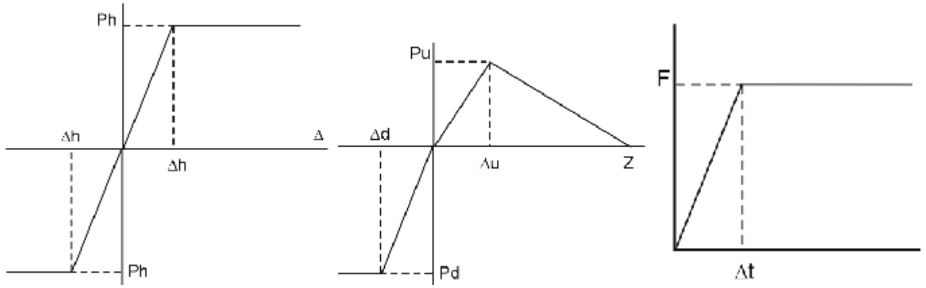
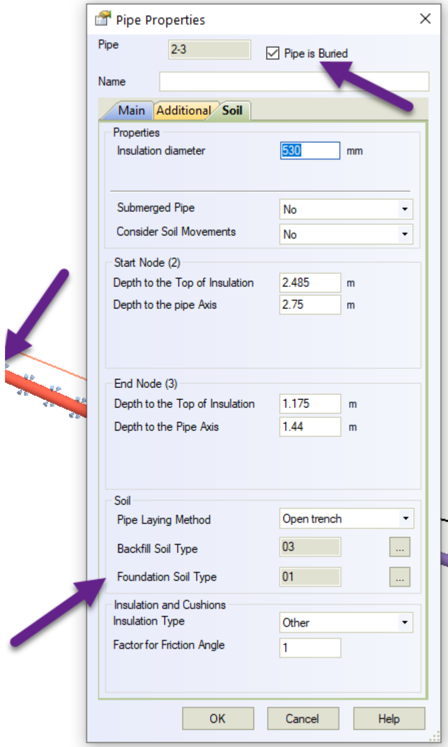
PASS/Start-Prof | Dry Soil Model

The main goal of dry soil model is to save on the number of supports in whole model to increase analysis speed without loss of result accuracy





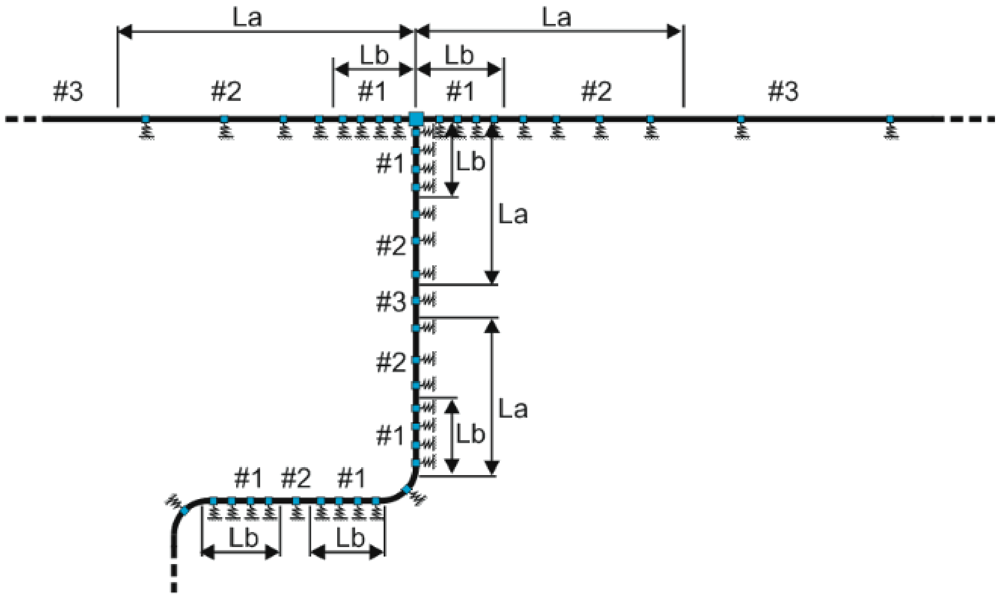


PASS/Start-Prof | Dry Soil Model

Zone #1: Lateral bearing zone (unrestrained) with the length of Lb. Four supports are placed at equal distance

Zone #2: Axial sliding zone (unrestrained) with the length of La. Four supports are placed at a distance increasing exponentially from zone #1 to zone #3

Zone #3: Restrained zone. Supports are placed at 100D spacing, where D - pipe external diameter



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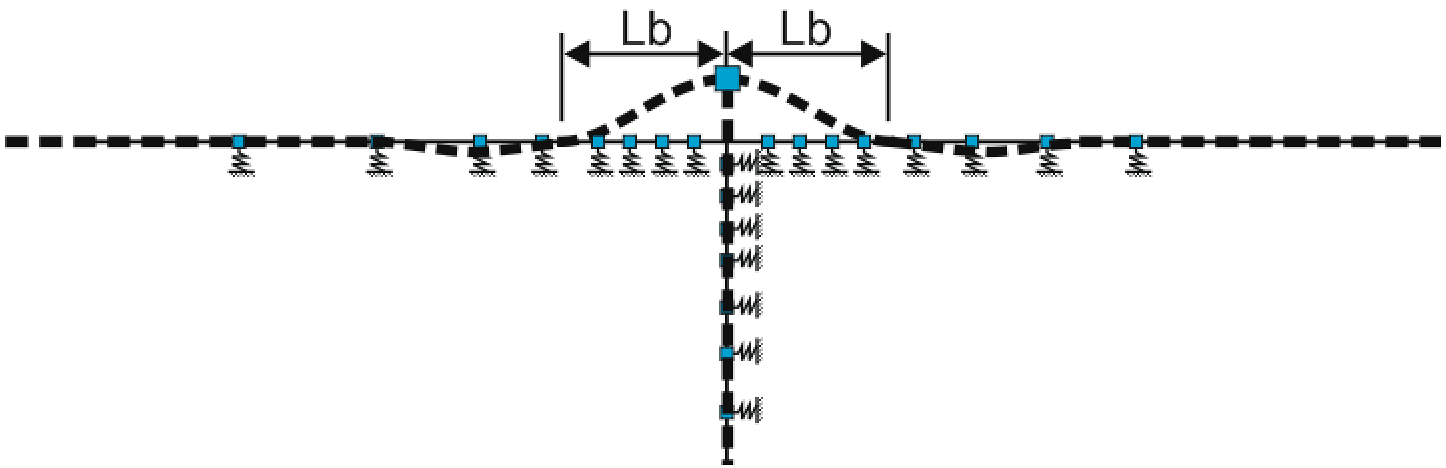
PASS/Start-Prof | Dry Soil Model

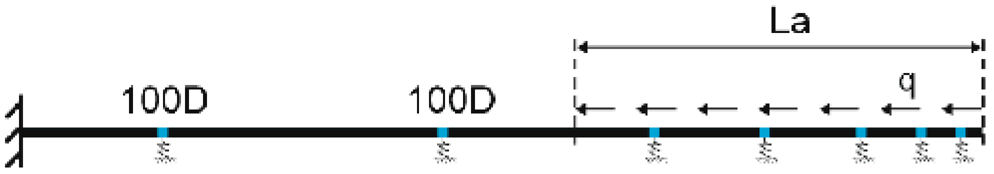
Zone #1: Lateral bearing zone (unrestrained) with the length of Lb. Four supports are placed at equal distance

$$L_b = \frac{3\pi}{4}\sqrt[4]{\frac{4EI}{k}}$$

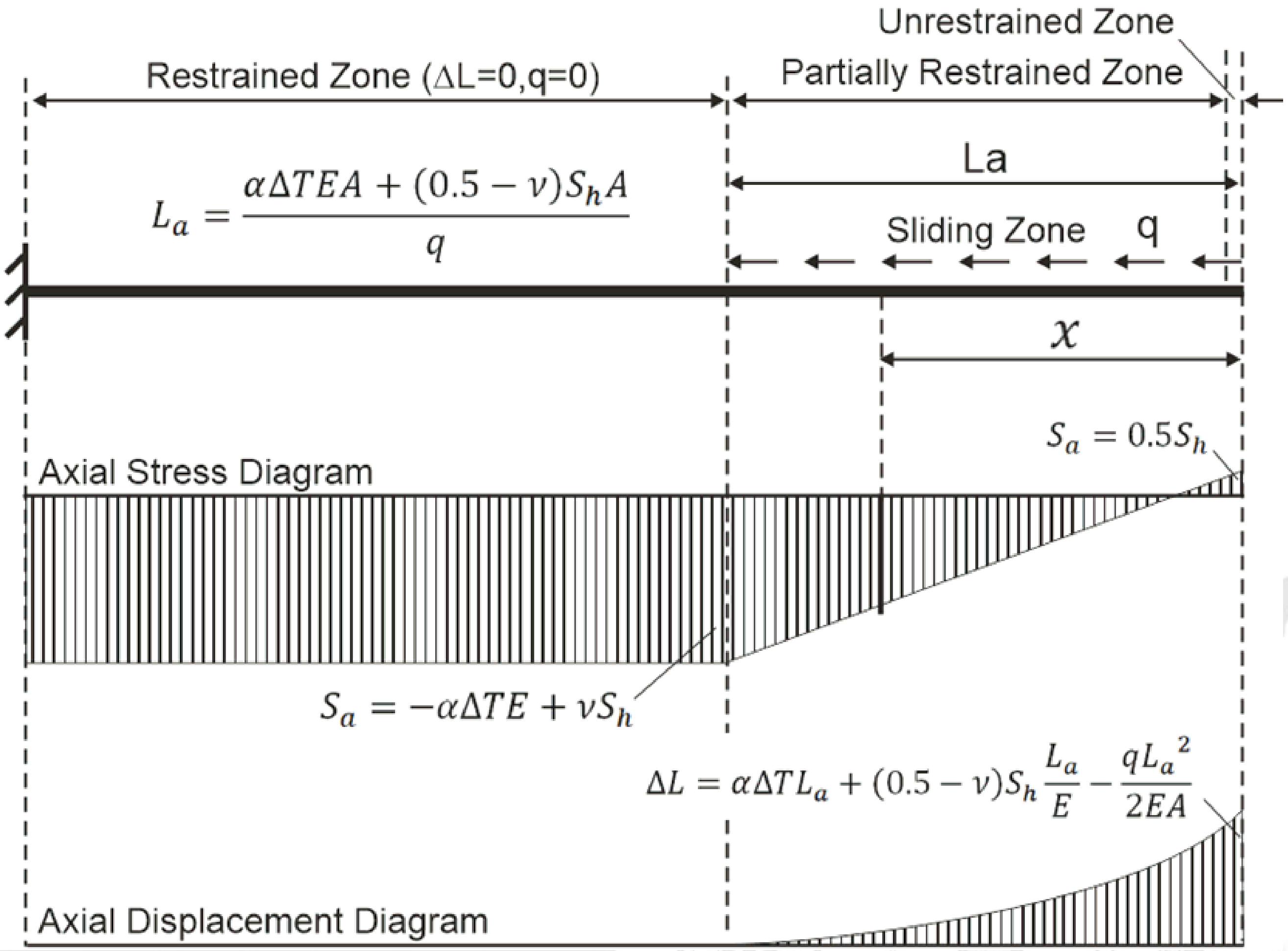


PASS/Start-Prof | Dry Soil Model

Zone #2: Axial sliding zone (unrestrained) with the length of La. Four supports are placed at a distance increasing exponentially from zone #1 to zone #3



$$L_a = \frac{\alpha \Delta T E A + (0.5 - \nu) S_h A}{q} + 3\sqrt{\frac{EA}{\pi D C_{x0}}}$$



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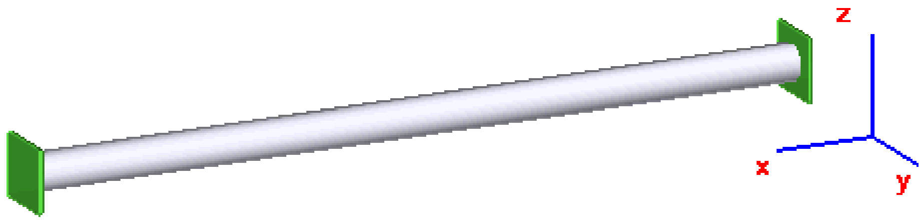
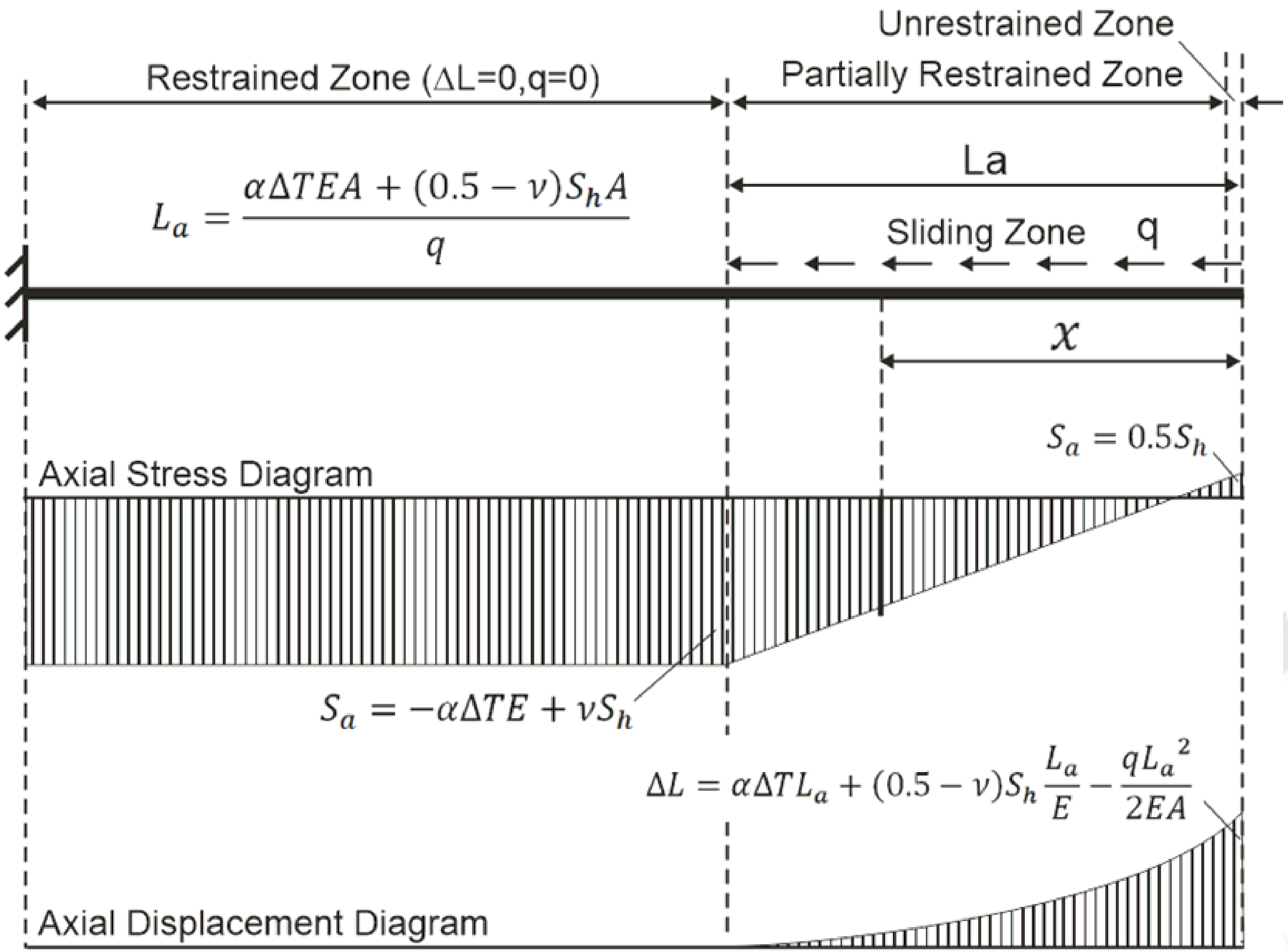
PASS/Start-Prof | Dry Soil Model

Zone #3: Restrained zone. Supports are placed at 100D spacing, where D - pipe external diameter





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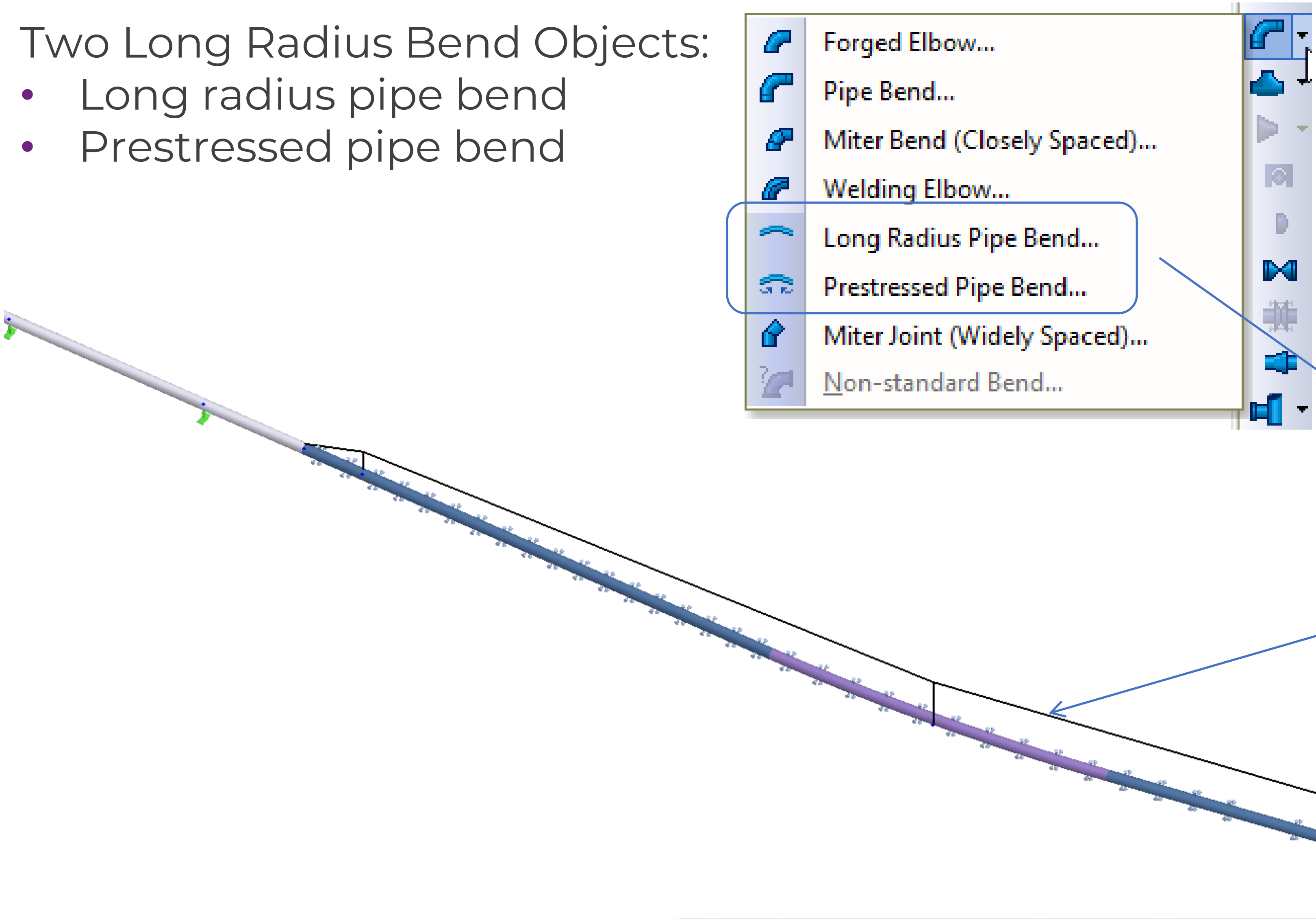
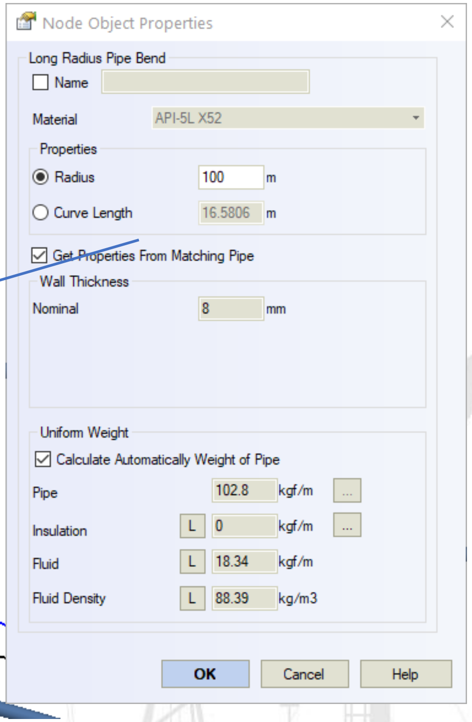
PASS/Start-Prof | Soil Model

Two Long Radius Bend Objects:

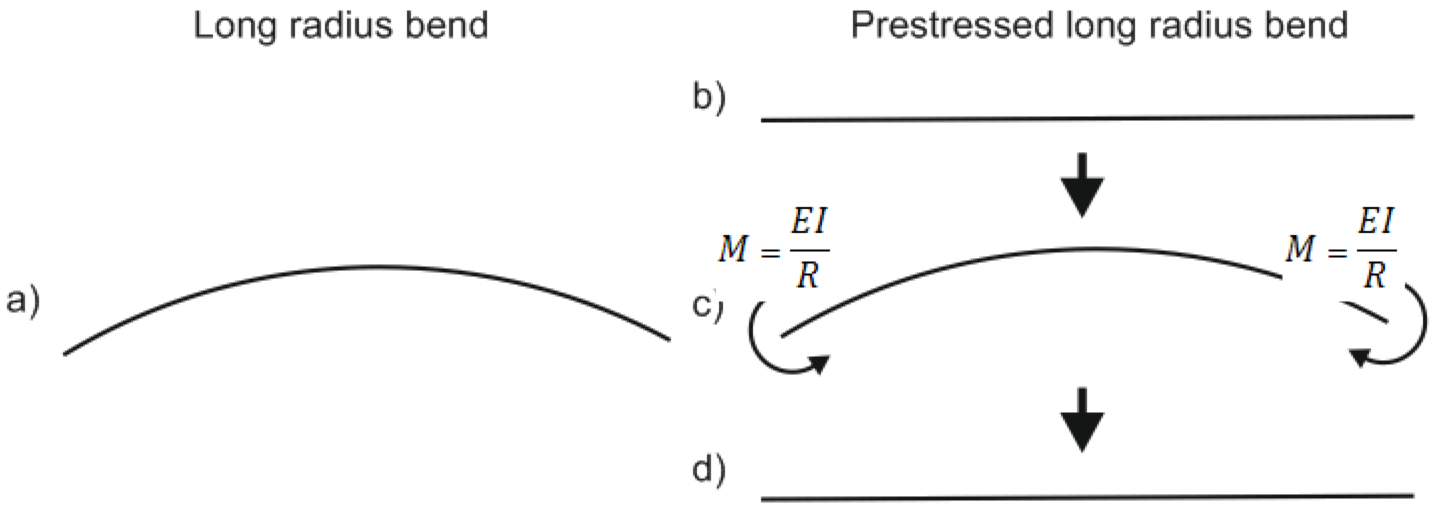
- Long radius pipe bend
- Prestressed pipe bend

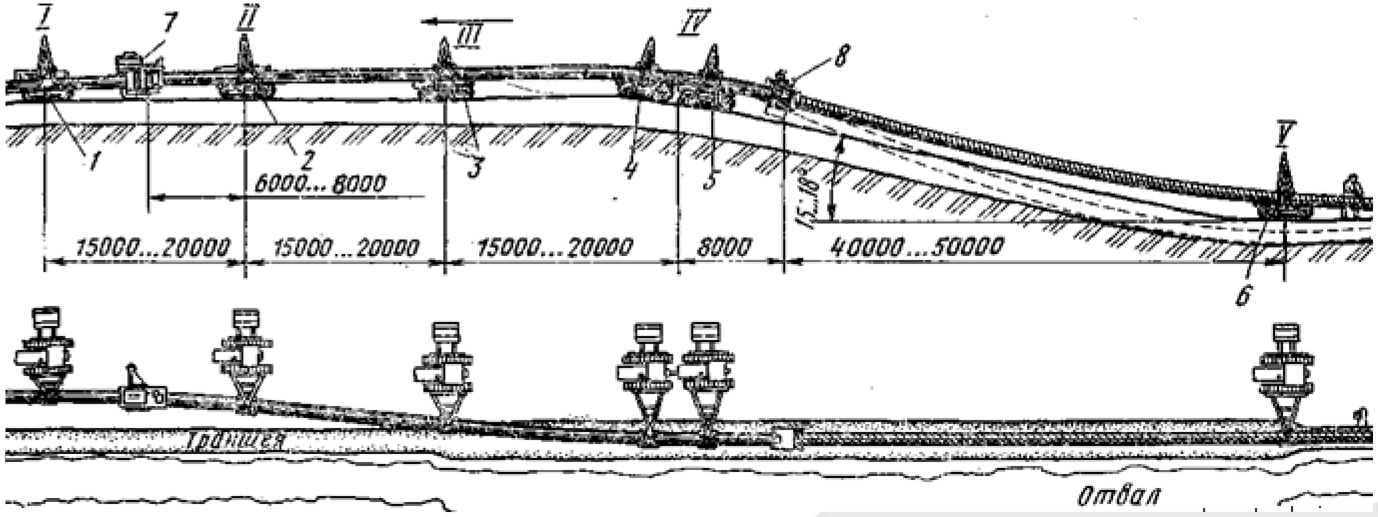




PASS/Start-Prof | Soil Model

Prestressed pipe bend – Initial elastic bend curvature in vertical and horizontal plane

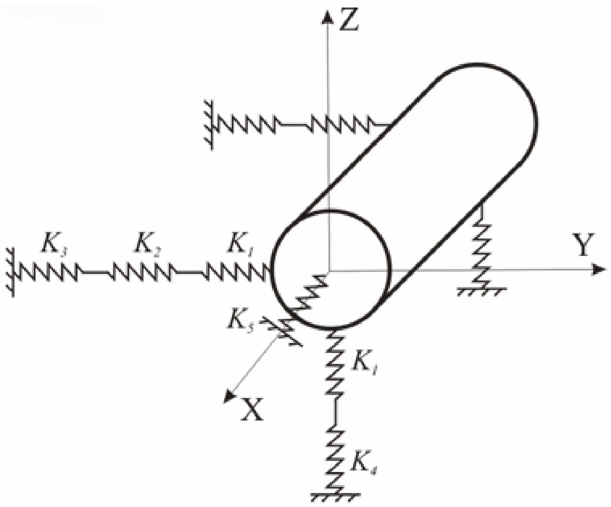


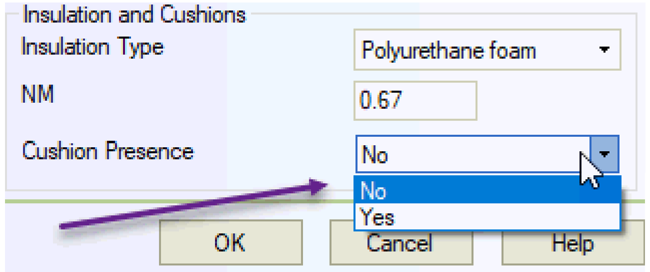


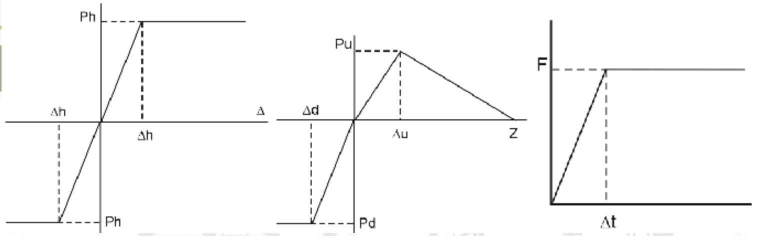
PASS/Start-Prof | Soil Model

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

- Horizontal spring consist of 3 springs K1, K2, K3.
- Vertical Spring consist of 2 (or 3) springs K1, K4 (and K2).
- Longitudinal spring K5





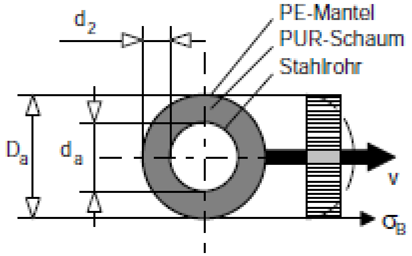


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

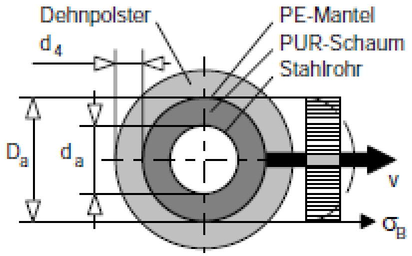
PASS/Start-Prof | Soil Model

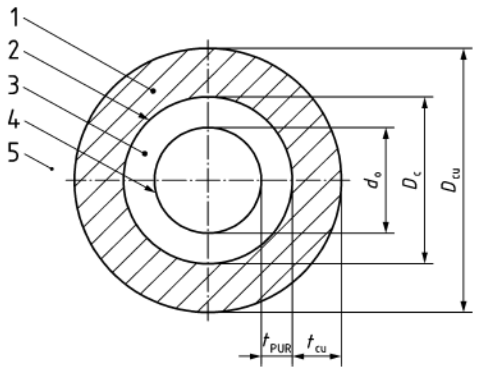
Expansion cushion (pad) and polyurethane insulation flexibility

Faktor	Ersatzwert
B_1	1016.2
B_2	-4.0397
B_3	83.339
B_4	-1.1678
B_5	-0.56135
$E_{s,Grenz}$	8.8 N/mm²



Faktor	steif
B_1	1.5026E-06
B_2	16.347
B_3	0.1242
B_4	1.286

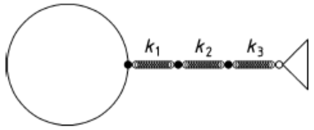




Key

1 cushion
2 casing
3 PUR
4 steel
5 soil

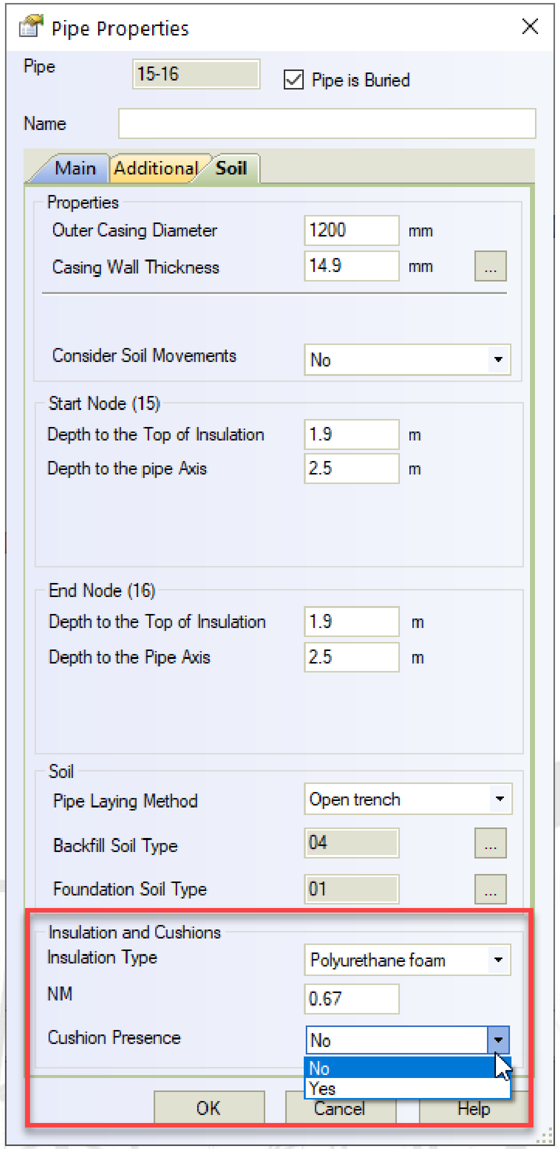
Figure 13 — Symbols for bedding constants



Key

k_1 line bedding constant for PUR
k_2 line bedding constant for expansion cushion
k_3 line bedding constant for surrounding soil

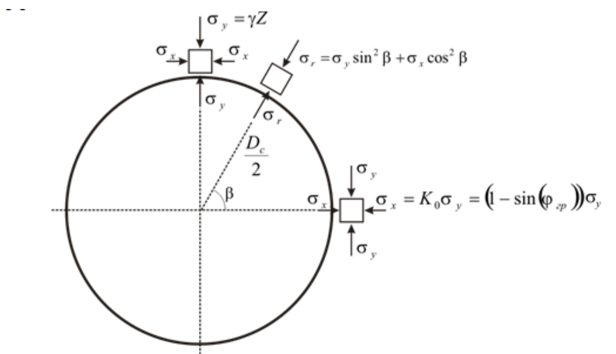
Figure 14 — Combined soil spring constant



PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Soil Model

Longitudinal Bi-linear Soil Spring Model



D_c – Insulation casing outer diameter

Vertical soil stress $\sigma_y = \gamma Z$

Horizontal soil stress $\sigma_x = K_0\sigma_y = (1-\sin(\varphi_{zp}))\sigma_y$

The soil stress at any point of the pipe (normal to pipe surface) $\sigma_r = \sigma_y \sin^2\beta + \sigma_x \cos^2\beta$

The unit friction at any point of the pipe is $\mu\sigma_r$

So the result friction force is $F = \int_S \mu\sigma_r ds$

Let's convert to polar coordinates

$$ds = Rd\beta = \frac{D_c}{2}d\beta$$

So

$$q = \int_0^{2\pi} \mu\sigma_r \frac{D_c}{2} d\beta$$

And

$$q = \mu\frac{D_c}{2}\int_0^{2\pi}\sigma_r d\beta$$

Let's substitute $\sigma_r = \sigma_y \sin^2\beta + \sigma_x \cos^2\beta$, $\sigma_y = \gamma Z$ and $\sigma_x = K_0\sigma_y = (1-\sin(\varphi_{zp}))\sigma_y$ here and we got

$$q = \mu\frac{D_c}{2}\gamma Z\left(\int_0^{2\pi}\sin^2\beta d\beta + (1-\sin(\varphi_{zp}))\int_0^{2\pi}\cos^2\beta d\beta\right)$$

The $\int_0^{2\pi}\sin^2\beta d\beta = \pi$ and $\int_0^{2\pi}\cos^2\beta d\beta = \pi$ so

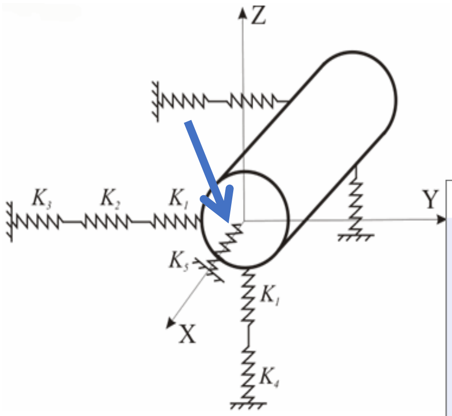
$$q = \mu D_c \gamma Z\pi\frac{(1+1-\sin(\varphi_{zp}))}{2} \quad \text{or} \quad q = \mu\frac{(1+K_0)}{2}\gamma_s Z\pi D_c$$

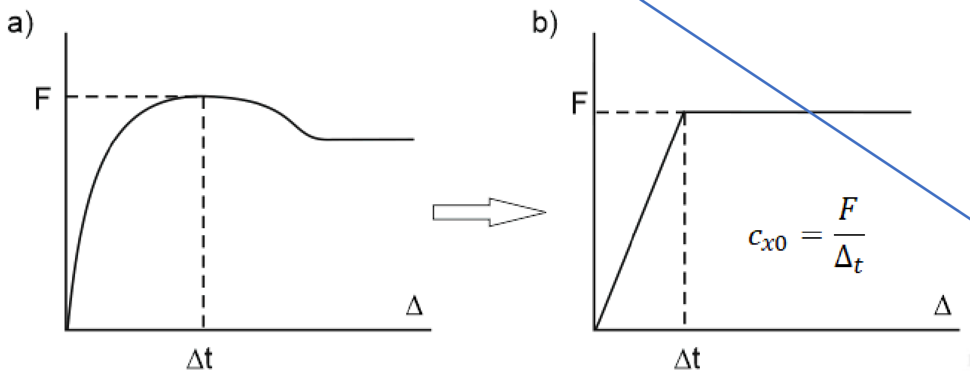
After that we must add here the weight G of the pipe and we got the formula

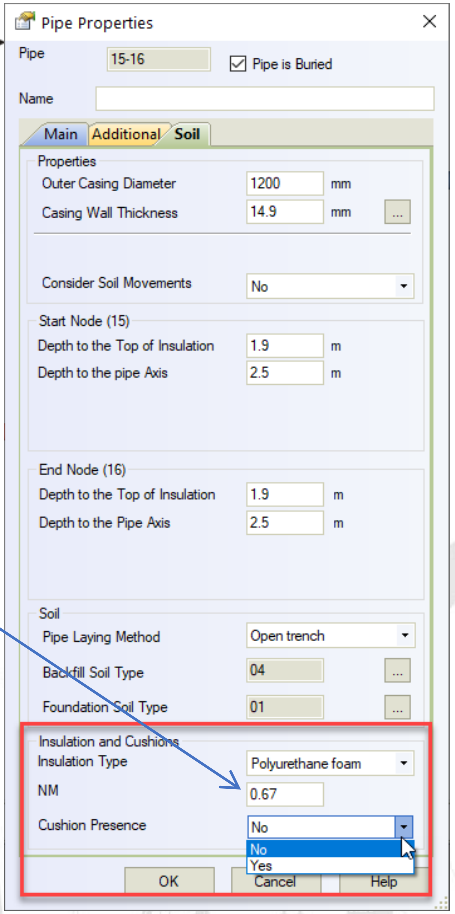
$$F = \mu\left(\frac{1+K_0}{2}\cdot\gamma_s\cdot Z\cdot\pi\cdot D_c + G\right)$$

$$\mu = tg(\varphi\cdot n_m)$$

$$K_0 = 1 - \sin\varphi$$





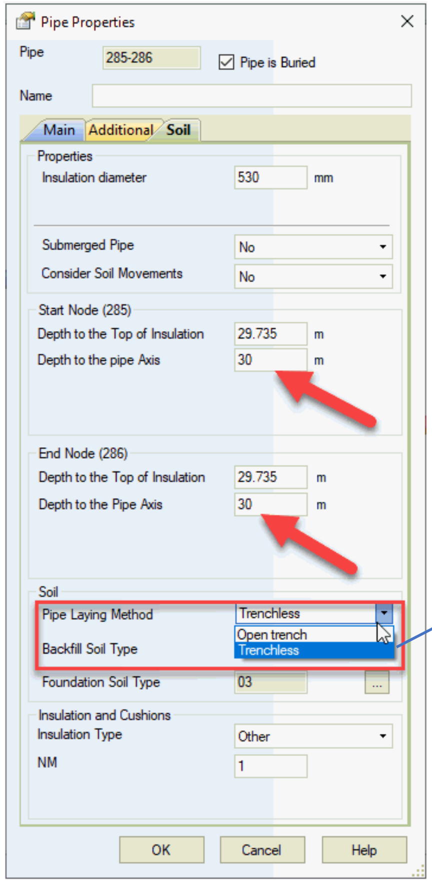


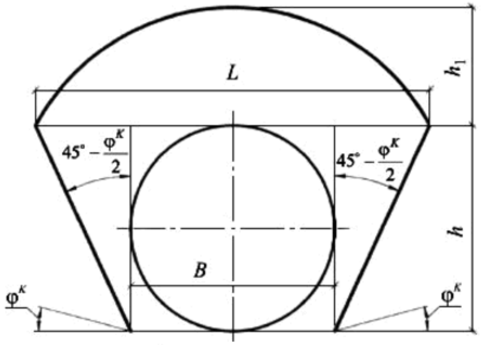
PASS

PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Soil Model

Natural Arch of Collapse Phenomena

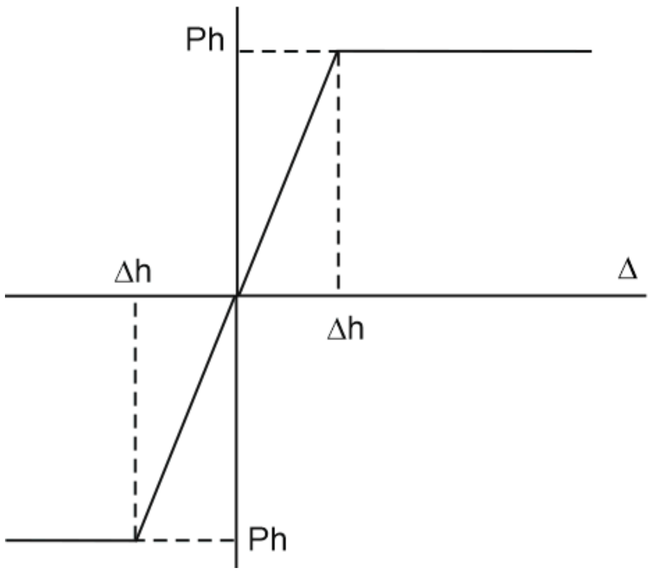


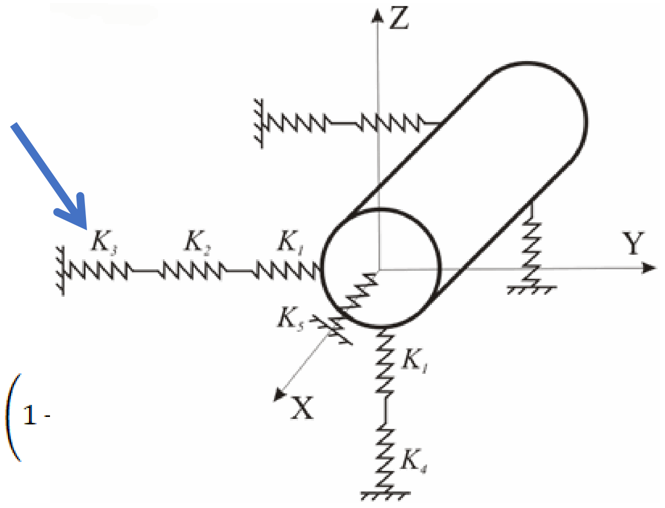


$h_1 = \frac{L}{2f}$; $L = b + 2h\,tg(45° - \varphi^K/2)$;

PASS/Start-Prof | Soil Model

Lateral Bi-linear Soil Spring Properties





Lateral soil stiffness is calculated using the equation

$$K_L = \frac{P_h}{\Delta_h} = \frac{0.12E\eta}{(1-\nu^2)\sqrt{D_c}}\left(1 -\right.$$

$$P_h = R_s$$

Z – Soil spring depth from the surface to the pipe axis

$$\eta = 0.547\beta^2 - \beta + 0.854$$

$$\beta = \begin{cases} \frac{a}{Z} \; if \; a/Z < 1 \\ 1 \; if \; a/Z \geq 1 \end{cases}$$

$$a = \begin{cases} 150 \; if \; D_c < 700mm \\ 0.25D_c \; if \; D_c \geq 700mm \end{cases}$$

E – Backfilling Soil Elastic modulus from database
ν – Backfilling Soil Poisson's factor from database
R_s – Backfilling Soil maximum lateral force from database

PASS/Start-Prof | Soil Model

Vertical Tri-linear Soil Spring Properties

Trilinear diagram is used for vertical springs
Vertical downward soil stiffness is calculated using the equation

$$K_d = \frac{P_d}{\Delta_d} = \frac{0.144E_2}{(1-\nu_2^2)\sqrt{D_c}}$$

$$P_d = R_{s2}$$

Vertical upward soil stiffness is calculated using the equation

$$K_u = \frac{P_d}{\Delta_u} = \frac{0.072E\eta_v}{(1-\nu^2)\sqrt{D_c}}\left(1 - e^{\frac{-2Z}{D_c}}\right)$$

$$\eta_v = \begin{cases} 1 \; if \; Z_w \le Z \\ 0.5(2 - Z_w/Z) \; if \; 0 < Z_w < Z \\ 0.5 \; if \; Z_w > Z \end{cases}$$

$$P_d = \overline{\gamma} D_c \left(Z - \frac{\pi}{8} D_c\right) + k\left(\overline{\gamma} Z^2 \tan 0.7\varphi + \frac{0.7ZC}{\cos 0.7\varphi}\right)$$

$\overline{\gamma}$ – Effective soil unit weight, considering the water liquefaction effect.
For horizontal pipes it is calculated using the following method:

- If the pipe is above the water level, then

$$\overline{\gamma} = \gamma$$

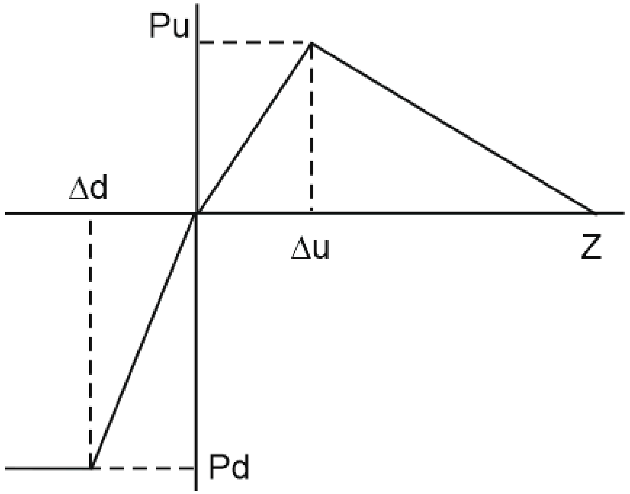
- If the pipe is below the water level, then

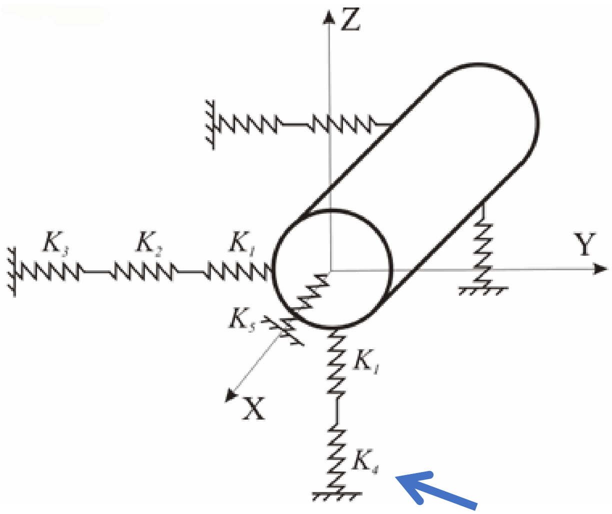
$$\overline{\gamma} = \gamma \frac{Z - \frac{\pi}{8} D_c - Z_w}{Z - \frac{\pi}{8} D_c} + \frac{\gamma_s - \gamma_w}{1+e} \frac{Z_w}{Z - \frac{\pi}{8} D_c}$$

- If the water level is within the pipe then

$$\overline{\gamma} = \gamma \frac{Z - Z_w - \frac{\pi}{4} D_c + V_w/D_c}{Z - \frac{\pi}{8} D_c} + \frac{\gamma_s - \gamma_w}{1+e} \frac{Z_w + \frac{\pi}{8} D_c - V_w/D_c}{Z - \frac{\pi}{8} D_c}$$

$$V_w = \frac{D_c^2}{8}(\alpha - \sin\alpha)$$

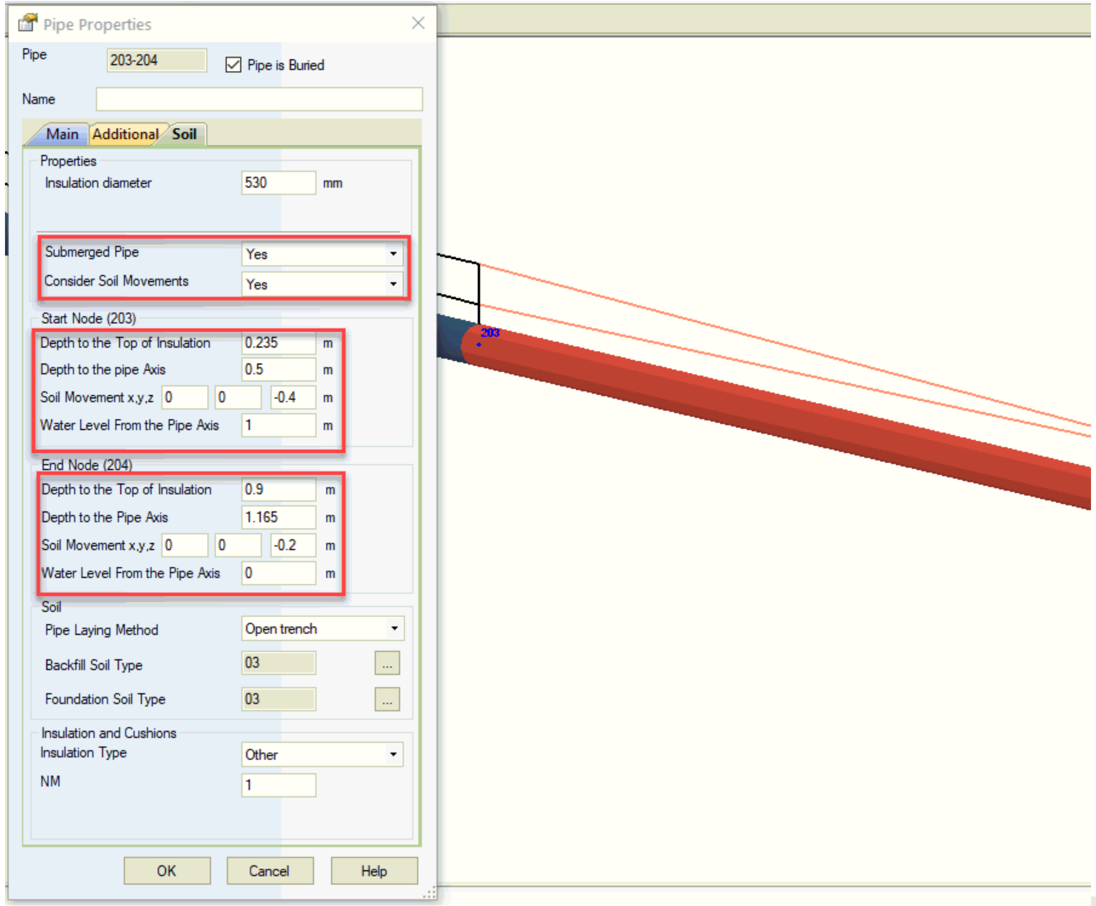


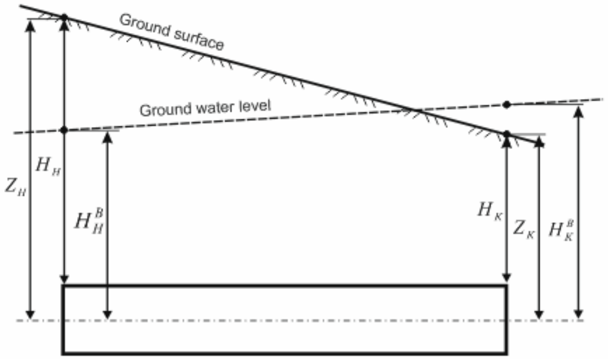


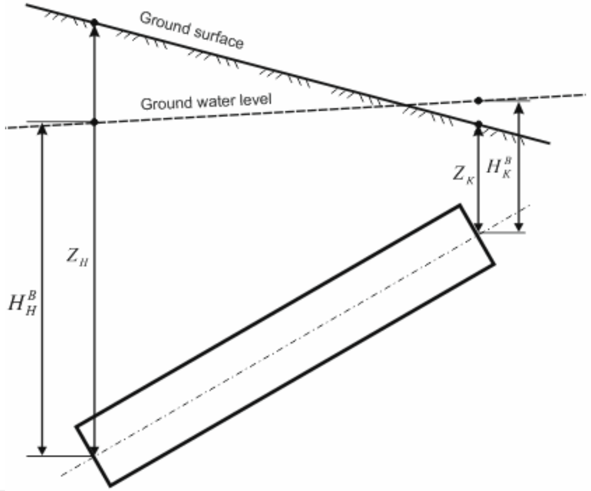
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

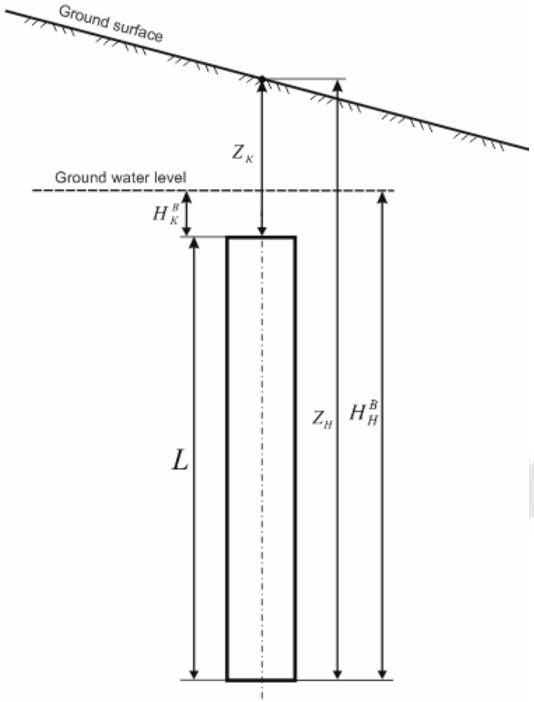
PASS/Start-Prof | Soil Model

You can define the depth from the surface at any node of the pipeline. Depth, water height and subsidence can change along the pipe length





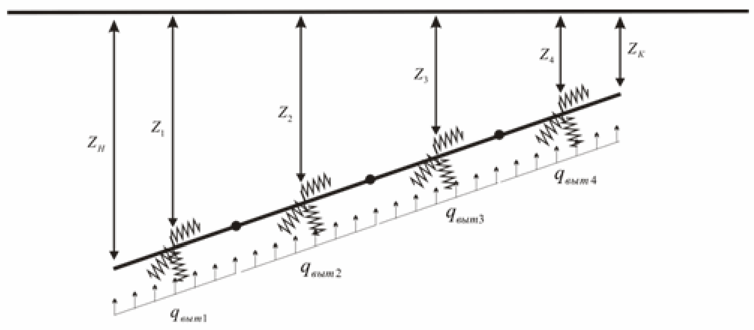


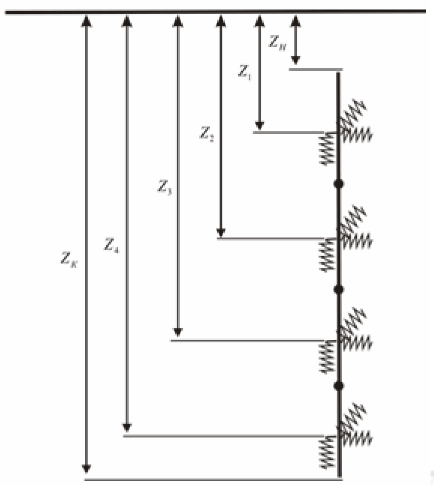


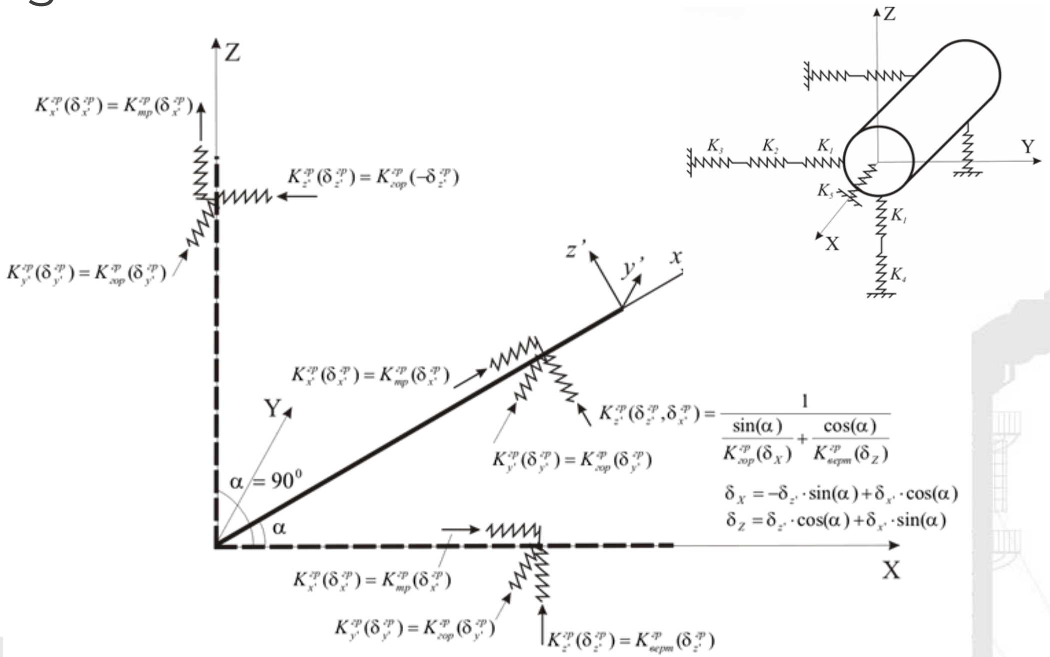
PASS/Start-Prof | Soil Model

For inclined and vertical pipes:

- The bilinear properties of each soil spring (stiffness, water buoyancy, spring displacement etc.) are calculated using individual depth of the specific spring
- Stiffness of the springs K3, K4 and K5 are also depend on the pipe angle to the horizontal plane (from 0 to 90 degrees). For vertical pipe elements the vertical stiffness K4 behavior becomes the same as behavior of horizontal spring K3



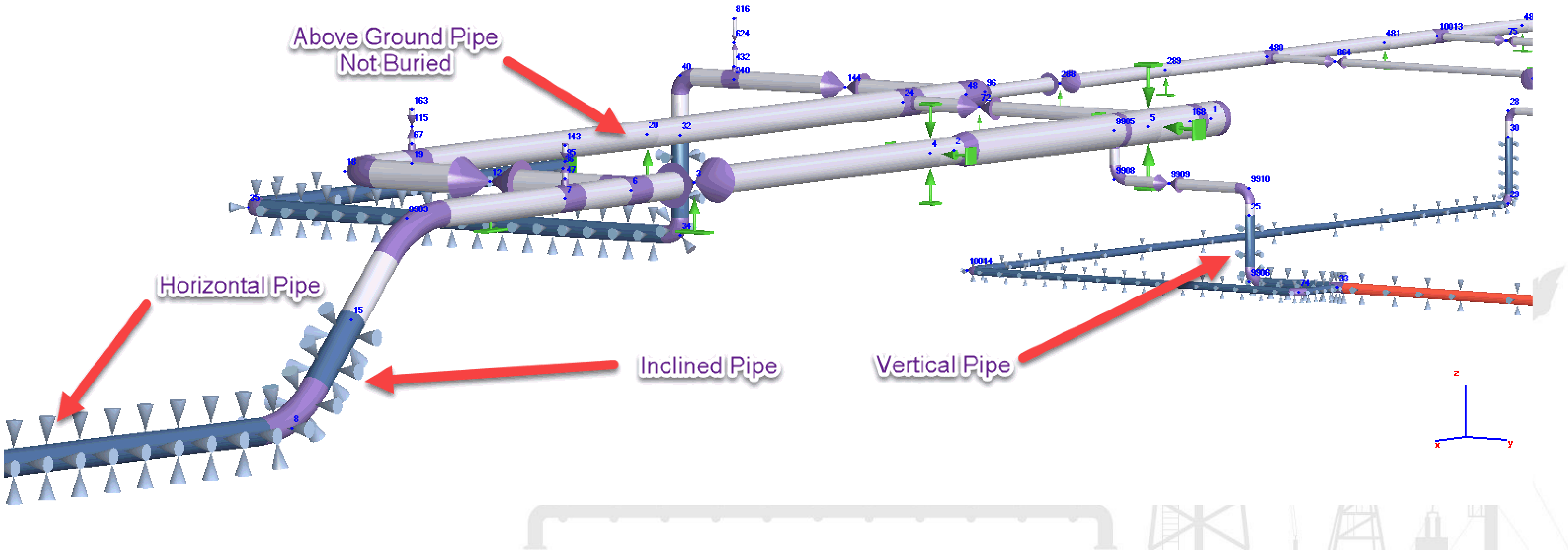




PASS/Start-Prof | Soil Model

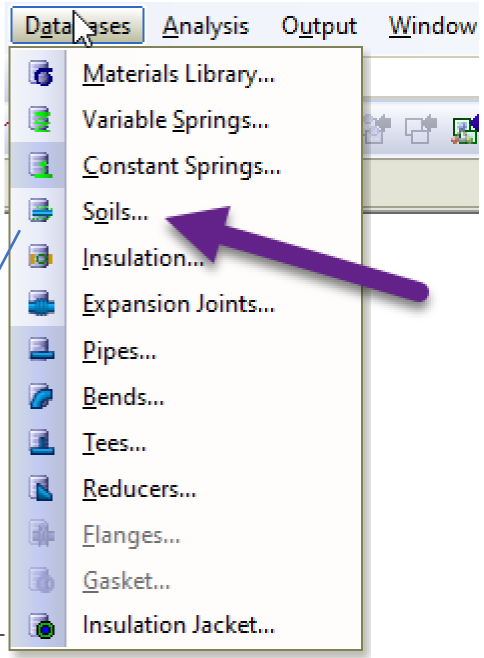
PASS/START-PROF can automatically calculate the mixed pipeline models with above ground pipes, horizontal pipes, inclined pipes, vertical pipes.

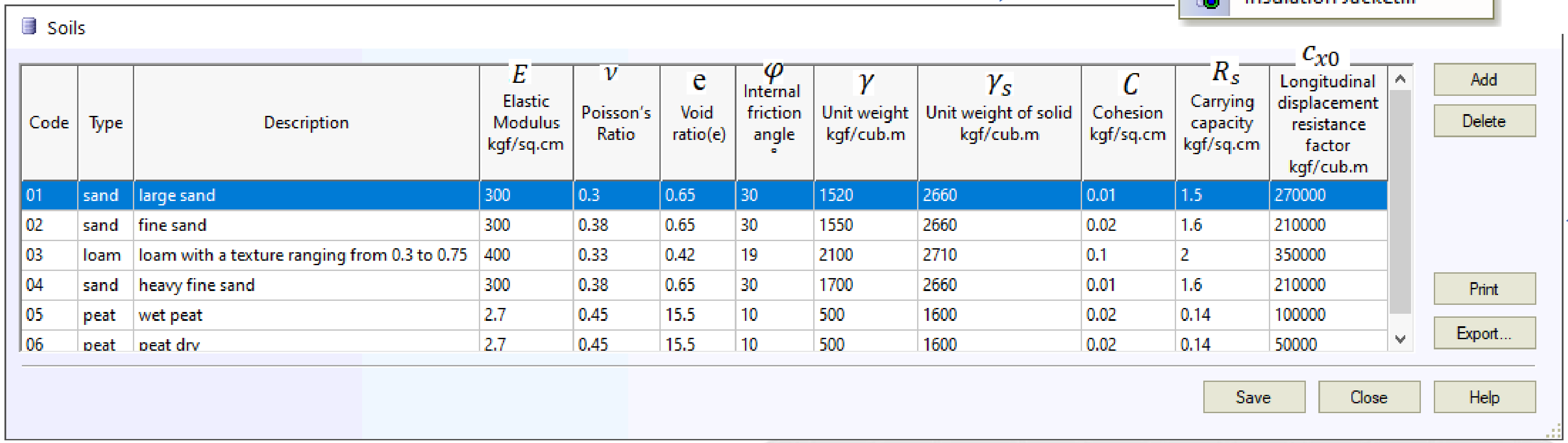
You don’t need to do something manually. Just draw the pipeline “as is” and run analysis



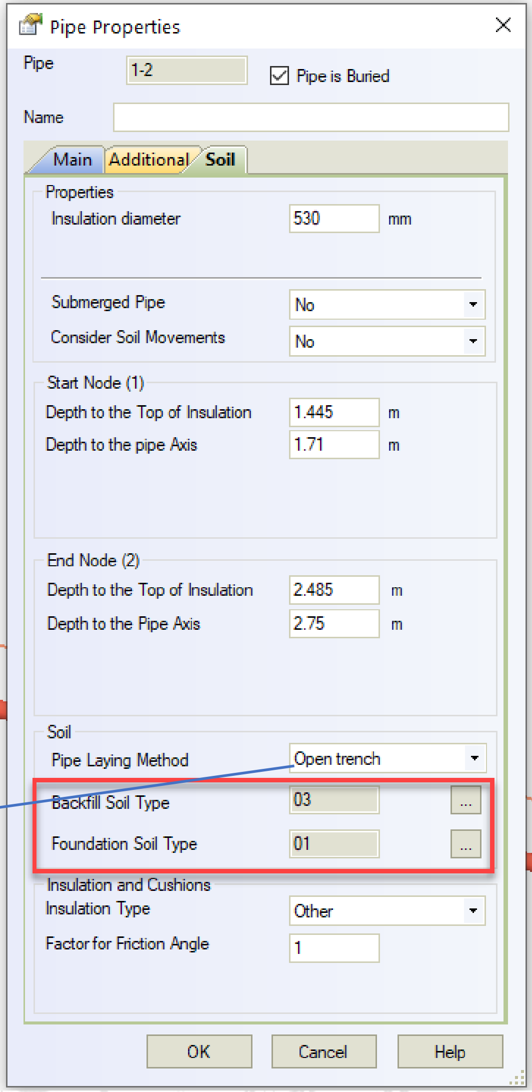
PASS/Start-Prof | Soil Model

Soil Database

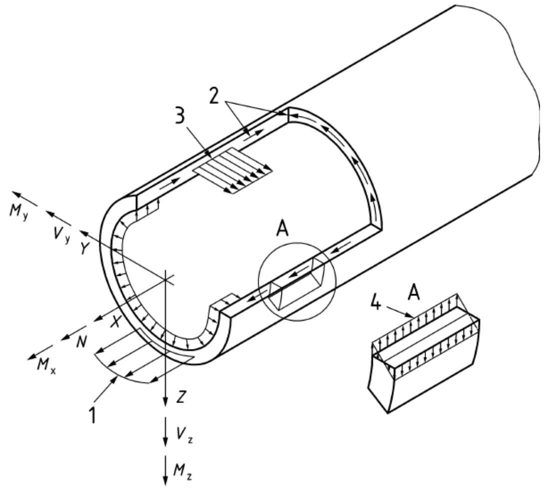




Code	Type	Description	E Elastic Modulus kgf/sq.cm	ν Poisson's Ratio	e Void ratio(e)	φ Internal friction angle °	γ Unit weight kgf/cub.m	γ_s Unit weight of solid kgf/cub.m	C Cohesion kgf/sq.cm	R_s Carrying capacity kgf/sq.cm	c_{x0} Longitudinal displacement resistance factor kgf/cub.m
01	sand	large sand	300	0.3	0.65	30	1520	2660	0.01	1.5	270000
02	sand	fine sand	300	0.38	0.65	30	1550	2660	0.02	1.6	210000
03	loam	loam with a texture ranging from 0.3 to 0.75	400	0.33	0.42	19	2100	2710	0.1	2	350000
04	sand	heavy fine sand	300	0.38	0.65	30	1700	2660	0.01	1.6	210000
05	peat	wet peat	2.7	0.45	15.5	10	500	1600	0.02	0.14	100000
06	peat	peat dry	2.7	0.45	15.5	10	500	1600	0.02	0.14	50000



PASS/Start-Prof | Stress Analysis



1 Maximum axial stress: $\Delta\sigma_a = i_{a1}\dfrac{\Delta N_x}{A} \pm i_{a2}\dfrac{\sqrt{\Delta M_y^2 + \Delta M_z^2}}{W}$

2 Maximum shear stress: $\Delta\tau = i_{a3}\dfrac{\Delta M_x}{2W} \pm i_{a4}\dfrac{2\cdot\sqrt{\Delta V_y^2 + \Delta V_z^2}}{A}$

3 Maximum membrane tangential stress: $\Delta\sigma_t = i_{ap}\dfrac{p\cdot d_i}{2t_{min}}$

4 Maximum bending tangential stress: $\Delta\sigma_t = i_{a5}\dfrac{\sqrt{\Delta M_y^2 + \Delta M_z^2}}{W} + \sigma$

(Ultimate) Limit state (reference clause)	Limit state	Load combinations	Components to investigate	Load factors (γ_{gi})	Material factor (γ_{mi})	Limit value	Reference and Remarks
Force controlled action (membrane stress,)	**A1**	1,2		Table 2	1,1	$\sigma v \le Re(T)/\gamma m \quad \left.\begin{matrix}\sigma_m \\ \sigma_{j,m}\end{matrix}\right\} \le \sigma_d = \dfrac{R_e(T)}{\gamma_m}$	7.2.2.2
Force controlled action (D.3.1.1) (membrane + bending stresses)	**A1**	2,3,4		Table 2	1,1	$\sigma_{res} \le \begin{cases} 1,5\cdot\dfrac{R_{e(T)}}{\gamma_m} & for\ \sigma_m \le 0,67\cdot\dfrac{R_{e(T)}}{\gamma_m} \\ 2,5\cdot\dfrac{R_{e(T)}}{\gamma_m} - 1,5\cdot\sigma_m & for\ \sigma_m > 0,67\cdot\dfrac{R_{e(T)}}{\gamma_m}\end{cases}$ $\sigma_{j,res} \le \begin{cases} 1,5\cdot\dfrac{R_{e(T)}}{\gamma_m} & for\ \sigma_{j,m} \le 0,67\cdot\dfrac{R_{e(T)}}{\gamma_m} \\ 2,5\cdot\dfrac{R_{e(T)}}{\gamma_m} - 1,5\cdot\sigma_{j,m} & for\ \sigma_{j,m} > 0,67\cdot\dfrac{R_{e(T)}}{\gamma_m}\end{cases}.$	7.2.2.2 Including forced displacements
Stepwise plastic deformation Force + deformation controlled)	**A2**	2, 3, 4		Table 2	1,1	$\varepsilon_{max} = \alpha\cdot\Delta T \le \left[\dfrac{R_e(\theta)}{E}\sqrt{1-\dfrac{3}{4}\left(\dfrac{\sigma_p}{R_e(\theta)}\right)^2} + \sqrt{0,9-\dfrac{3}{4}\left(\dfrac{\sigma_p}{R_e}\right)^2}\right]$	7.2.2.3
Low cycle fatigue Force + deformation controlled)	**B1**			Table 2		$\Sigma\dfrac{n_i}{N_i} \le \dfrac{1}{\gamma_{fat}}$ and $S = k\cdot N^{-1/m}$	6.7 and 7.2.3

Input | Stress

Operating Mode: 1 'Operation mode'

Expansion Stress Range: 1 'Operation mode' (1-1A)

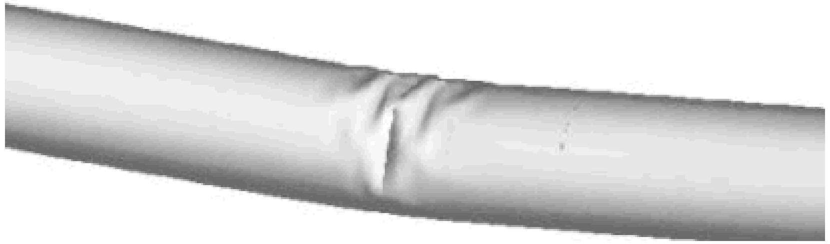
Show Equations

?

Object	Start End node	A1 Force Controlled Membrane, (MPa)			A1 Force Controlled Membrane+Bending, (MPa)			A2 Force+Deformation, (MPa)			Expansion Stress Range, (MPa)			Notes
		calcu-lated	allow-able	%	calcu-lated	allow-able	%	calcu-lated	allow-able	%	calcu-lated	allow-able	%	
Buried pipe	33	79.84	191.40	41.7	149.41	287.10	52.0	39.92	293.10	13.6	160.63	500	32.1	
	34	71.34	191.40	37.3	139.50	287.10	48.6	138.88	293.10	47.4	496.82	500	99.4	
Buried pipe	34	71.34	191.40	37.3	139.50	287.10	48.6	138.88	293.10	47.4	496.82	500	99.4	
	35	70.40	191.40	36.8	137.89	287.10	48.0	242.23	293.10	82.6	696.86	500	139.4	333
Buried pipe	35	70.40	191.40	36.8	137.89	287.10	48.0	242.23	293.10	82.6	696.86	500	139.4	333
	36	70.24	191.40	36.7	137.58	287.10	47.9	311.08	293.10	106.1	720.78	500	144.2	16,333
Buried pipe	36	70.24	191.40	36.7	137.58	287.10	47.9	311.08	293.10	106.1	720.78	500	144.2	16,333
	37	70.24	191.40	36.7	137.58	287.10	47.9	311.08	293.10	106.1	720.78	500	144.2	16,333
Buried pipe	37	70.24	191.40	36.7	137.58	287.10	47.9	311.08	293.10	106.1	720.78	500	144.2	16,333
	38	70.22	191.40	36.7	137.53	287.10	47.9	310.78	293.10	106.0	722.78	500	144.6	16,333
Buried pipe	38	70.22	191.40	36.7	137.53	287.10	47.9	310.78	293.10	106.0	722.78	500	144.6	16,333
	39	70.22	191.40	36.7	137.53	287.10	47.9	310.78	293.10	106.0	723.12	500	144.6	16,333
Buried pipe	39	70.22	191.40	36.7	137.53	287.10	47.9	310.78	293.10	106.0	723.12	500	144.6	16,333
	40	70.13	191.40	36.6	137.35	287.10	47.8	238.61	293.10	81.4	714.57	500	142.9	333
Buried pipe	40	70.13	191.40	36.6	137.35	287.10	47.8	238.61	293.10	81.4	714.57	500	142.9	333

PASS/Start-Prof | Stress Analysis

Automatic local pipe wall buckling check per EN 13941-2019 7.2.4.2



Local buckling	C1	1,3,4		Table 2	1,1	$\varepsilon \le \frac{1}{2}\left(0,25\frac{t}{r_m} - 0,0025\right)$ (for uniform ε) for $\frac{rm}{t} \le 28,7$: $\Delta\varepsilon \le 0,16$ % for $\frac{rm}{t} > 28,7$: $\left(4,58\frac{t}{r_m} + 0,003\right)$%

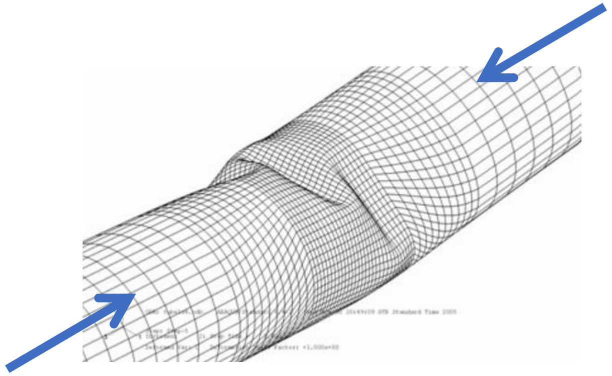
- For $(D_o - t_n)/(2t_n) \le 28.7$
$$S_{st} = 0.0016E$$
- For $(D_o - t_n)/(2t_n) > 28.7$
$$S_{st} = (0.0458 \cdot 2t_n/(D_o - t_n) + 0.00003)E$$

Input | Stress | **Stability**

Operating Mode

1 'Operation mode' | ?

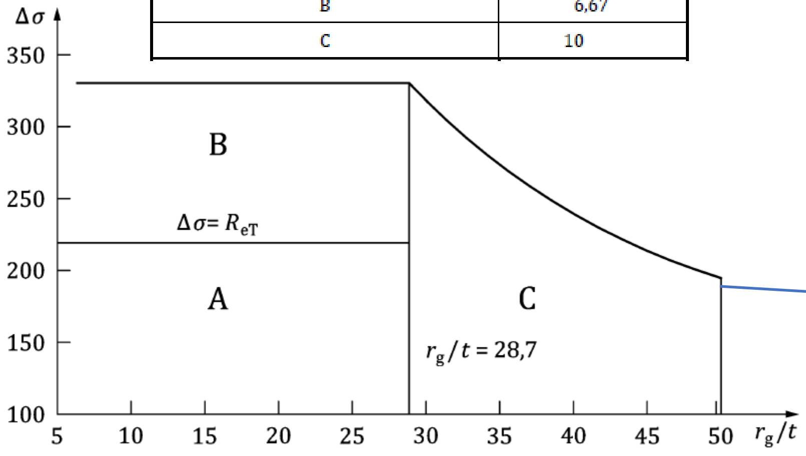
Object	Start End node	C1 Local Buckling in Hot Condition, (MPa) calcu-lated	C1 Local Buckling in Hot Condition, (MPa) allow-able	C1 Local Buckling in Cold Condition, (MPa) calcu-lated	C1 Local Buckling in Cold Condition, (MPa) allow-able	C1 Local Buckling in Test Condition, (MPa) calcu-lated	C1 Local Buckling in Test Condition, (MPa) allow-able	Notes
Buried pipe	8	317.54	198.41	7.92	198.41	16.62	198.41	1
Buried pipe	8	317.54	198.41	7.92	198.41	16.62	198.41	1
	9	318.59	198.41	10.40	198.41	16.63	198.41	1
Buried pipe	9	318.59	198.41	10.40	198.41	16.63	198.41	1
	10	318.77	198.41	10.95	198.41	16.63	198.41	1
Buried pipe	10	318.77	198.41	10.95	198.41	16.63	198.41	1
	11	318.80	198.41	11.06	198.41	16.63	198.41	1
Buried pipe	11	318.80	198.41	11.06	198.41	16.63	198.41	1
	12	318.81	198.41	11.08	198.41	16.63	198.41	1



PASS/Start-Prof | Stress Analysis

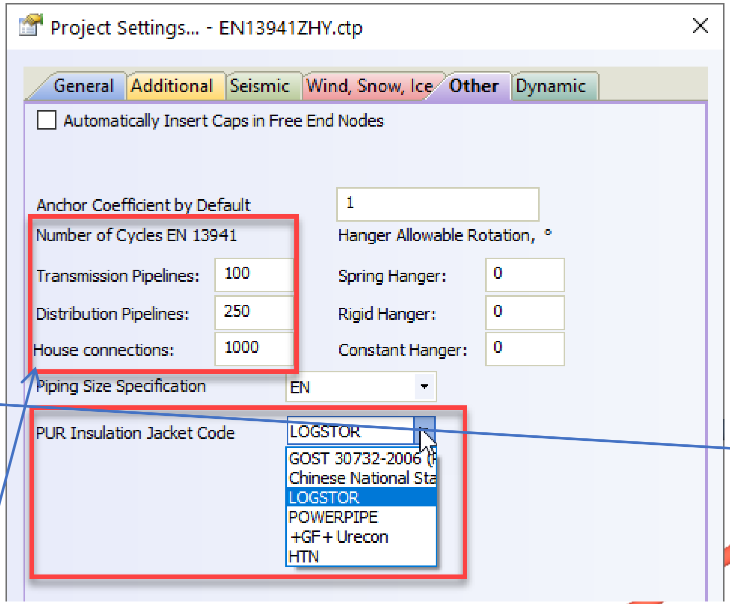
PASS/START-PROF can Automatically select the project class or it can be specified manually

Project class	γ_{fat}
A	5
B	6,67
C	10



Key

- A project class A (low)
- B project class B (medium)
- C project class C (high)
- $\Delta\sigma$ axial stress range from the temperature difference



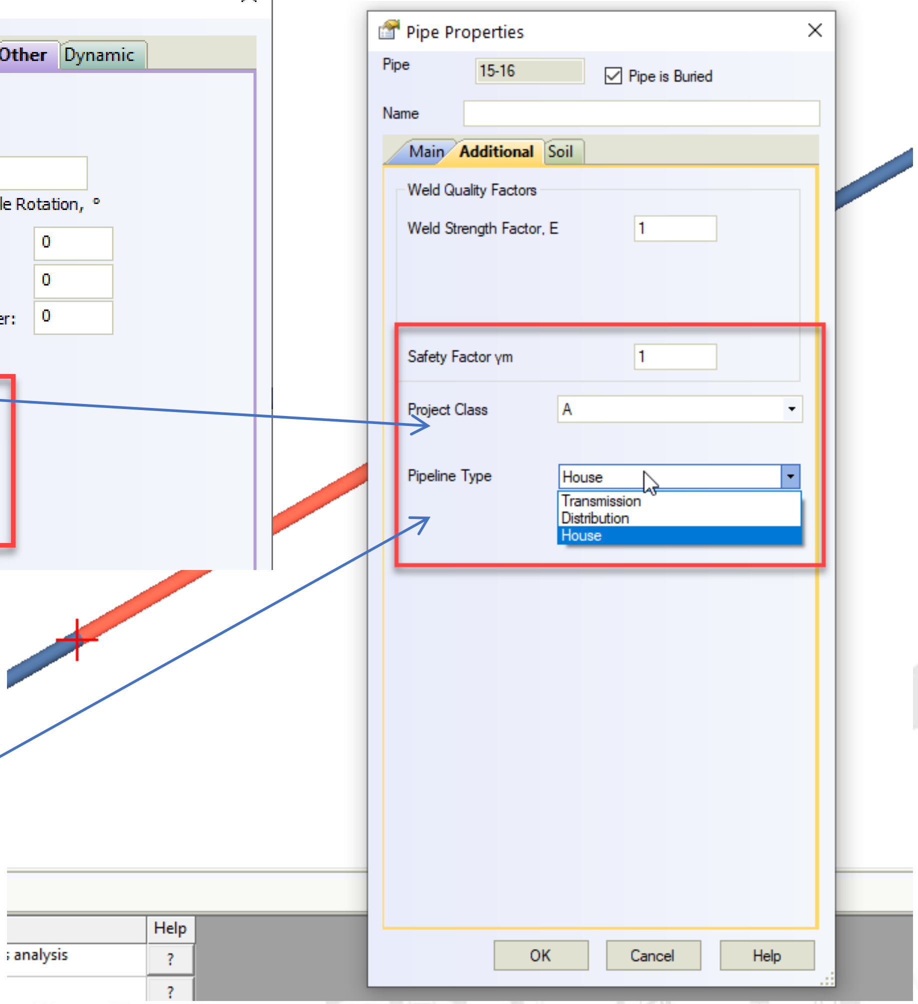
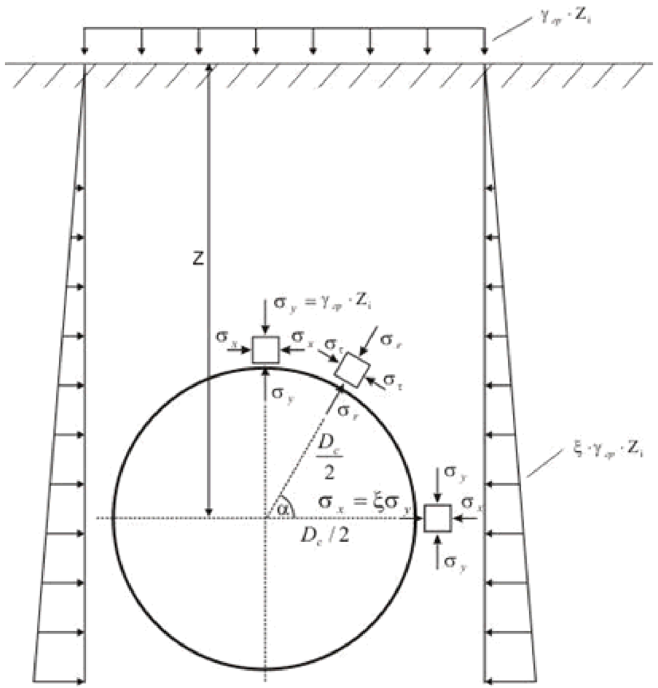


Table 14 — Equivalent full action cycles for m = 4 and ΔT_{ref} = 110 °C

Character of pipeline	Number of full action cycles	
	30 years operation	50 years operation
Transmission pipelines	100 to 250	170 to 420
Distribution pipelines	250 to 500	420 to 840
House connections	1000 to 2500	1700 to 4200

PASS/Start-Prof | Stress Analysis

To calculate the ring bending stresses the finite element model of pipe cross-section is used. The loads from the soil weight are calculated and applied for each point of pipe cross-section at whole perimeter

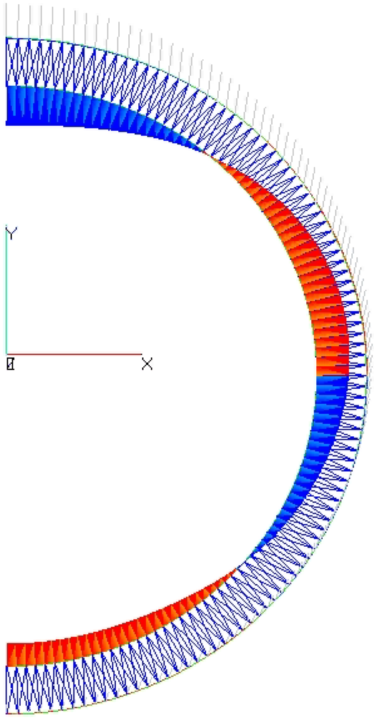


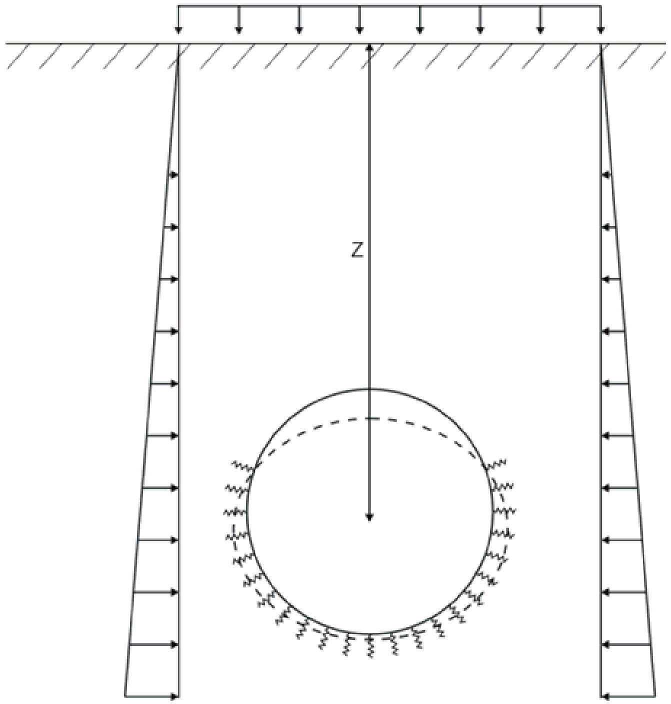
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

PASS/Start-Prof | Stress Analysis

Soil is modeled as discrete springs around pipe perimeter. The springs are switched off if tension is detected (usually at the top of the pipe). Flexible insulation also modeled if exist

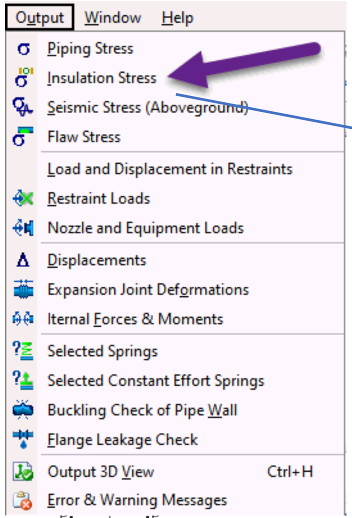
Internal pressure and product hydrostatic pressure is applied. The analysis consider geometric nonlinearity, the additional internal pressure stiffening effect is taken into account

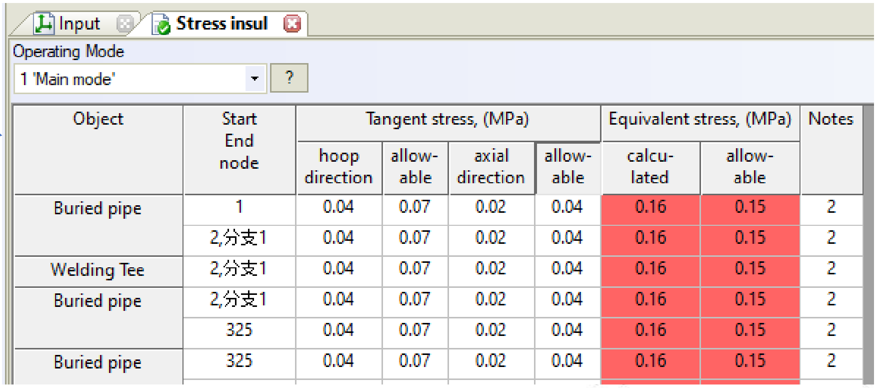




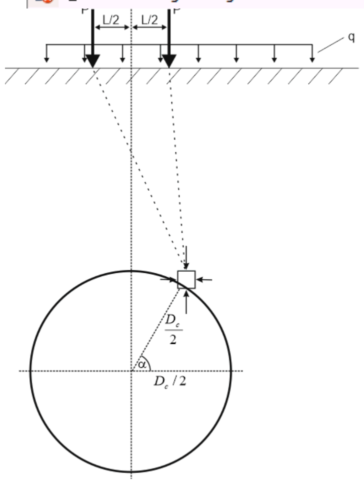
PASS/Start-Prof | Stress Analysis

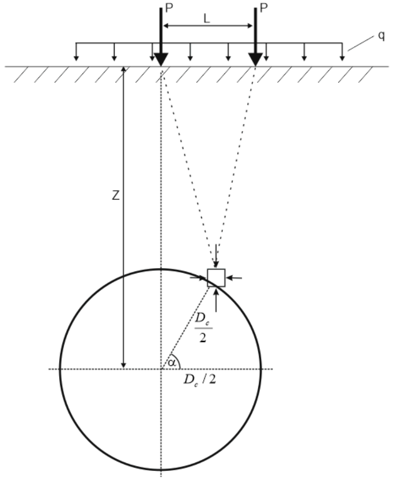
Calculate And Check Stresses In Polyurethane Insulation (EN 13941 7.3.1, 7.3.2, EN 253).
Check Stresses from Surface Vehicle Loads

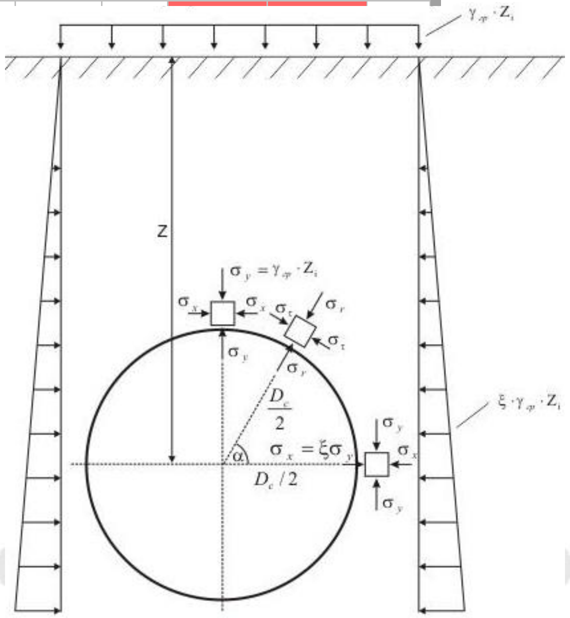


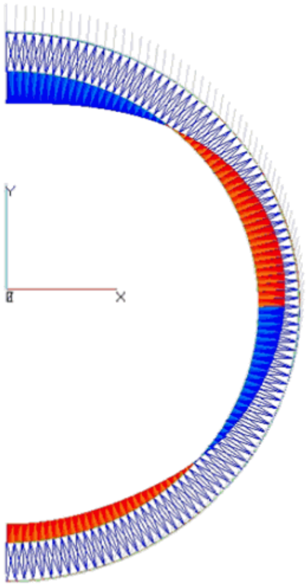


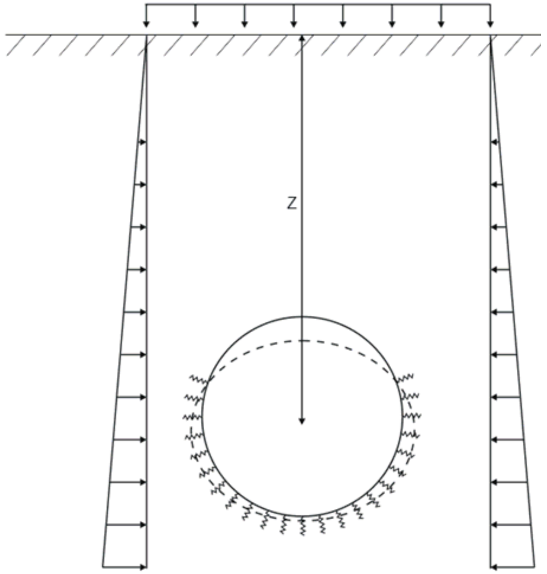
Object	Start End node	Tangent stress, (MPa) hoop direction	allow-able	axial direction	allow-able	Equivalent stress, (MPa) calcu-lated	allow-able	Notes
Buried pipe	1	0.04	0.07	0.02	0.04	0.16	0.15	2
	2,分支1	0.04	0.07	0.02	0.04	0.16	0.15	2
Welding Tee	2,分支1	0.04	0.07	0.02	0.04	0.16	0.15	2
Buried pipe	2,分支1	0.04	0.07	0.02	0.04	0.16	0.15	2
	325	0.04	0.07	0.02	0.04	0.16	0.15	2
Buried pipe	325	0.04	0.07	0.02	0.04	0.16	0.15	2





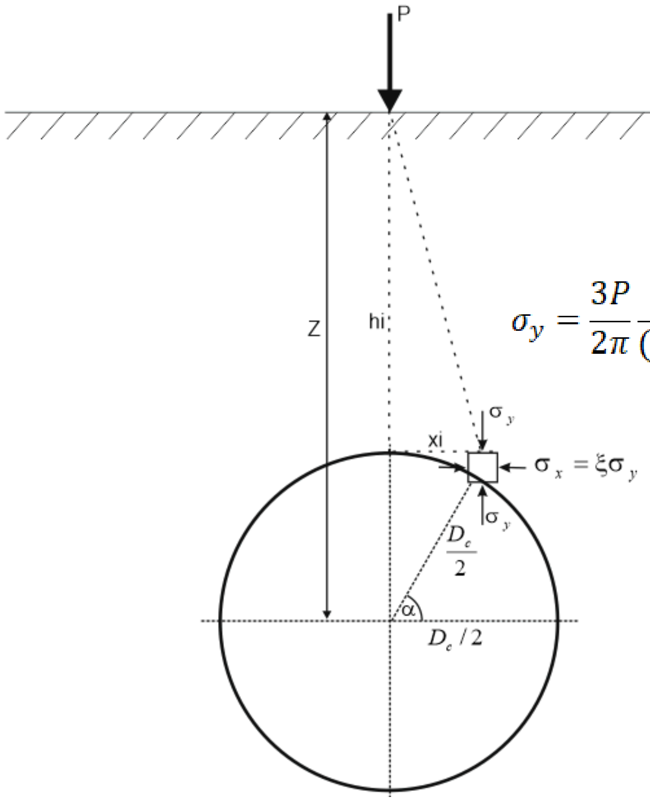




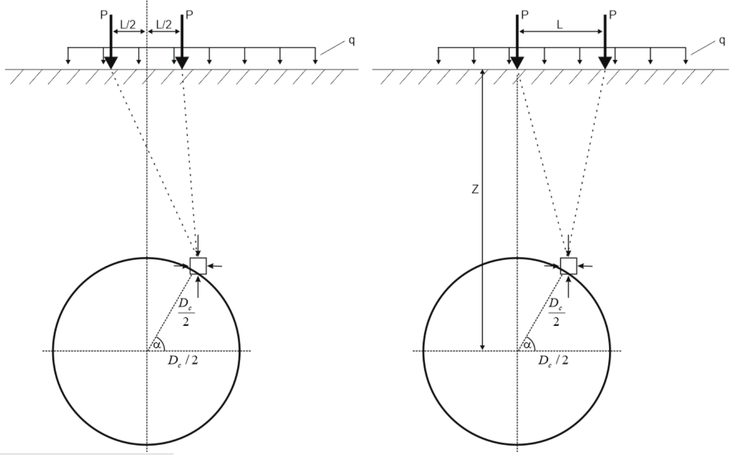


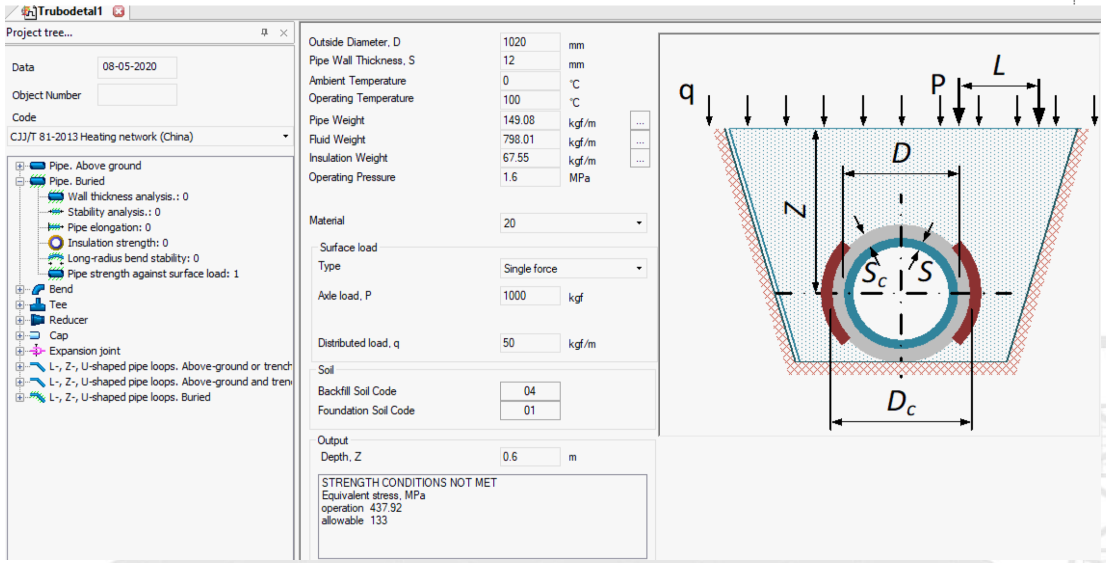
PASS/Start-Prof | Stress Analysis

Pipe and Insulation Strength Against the Surface Heavy Truck Loading



$$\sigma_y = \frac{3P}{2\pi}\frac{h_i^3}{(h_i^2 + x_i^2)^{5/2}}$$

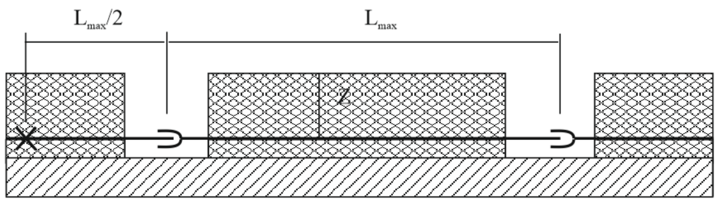


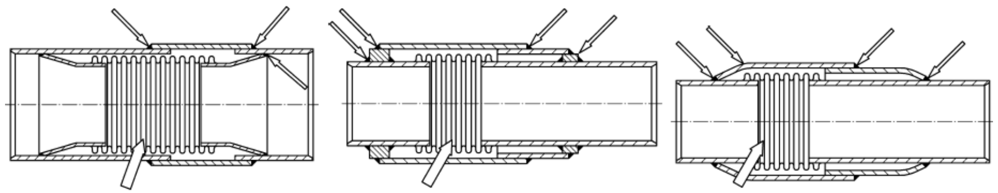


PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

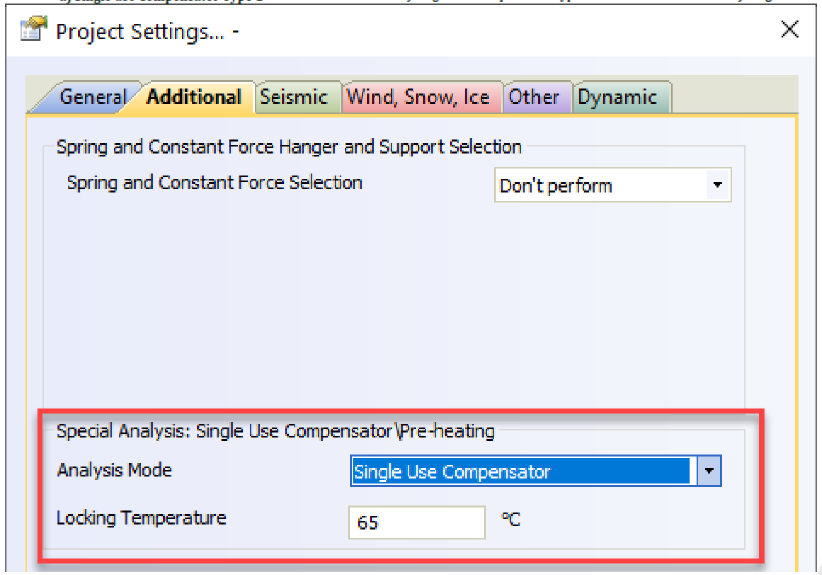
PASS/Start-Prof | Stress Analysis

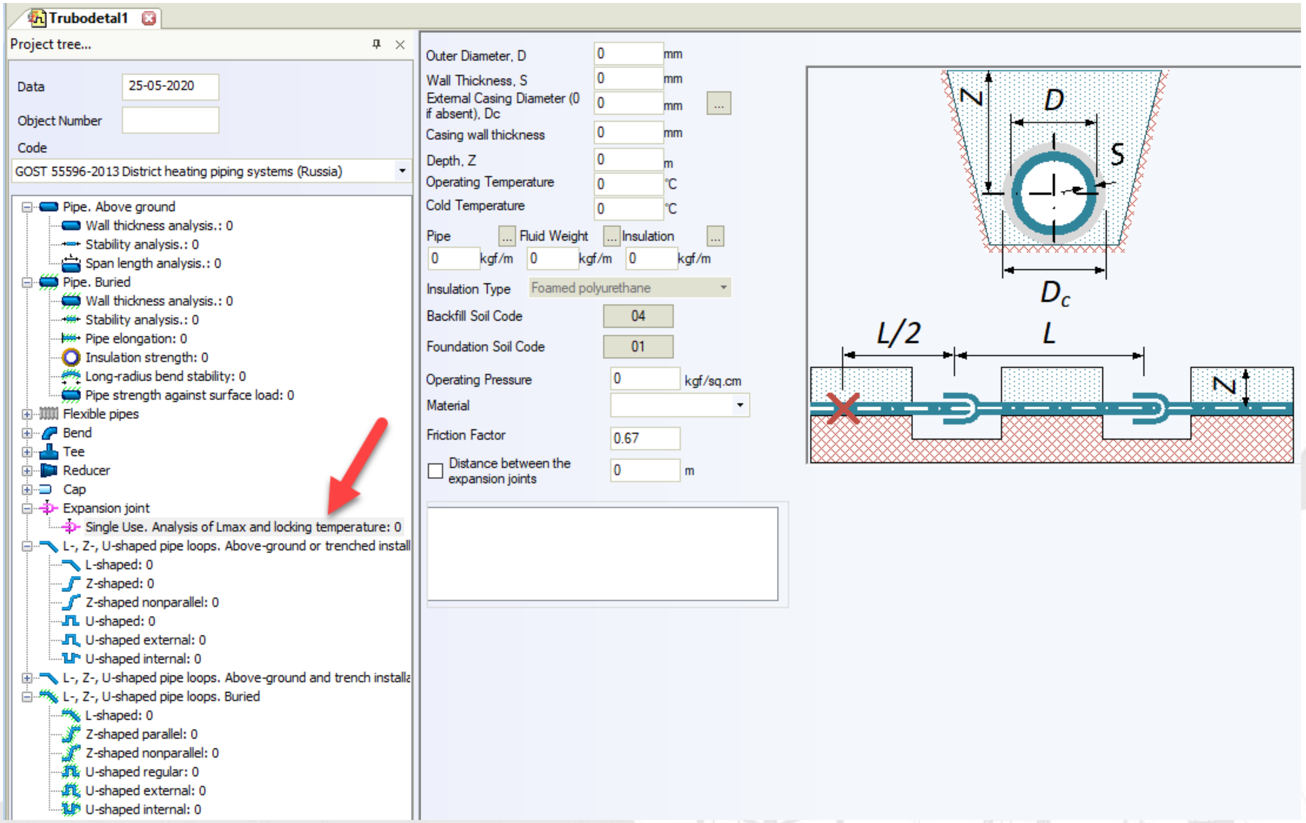
- Pre-heating analysis
- Single use compensators analysis + Database + Distance Calculation





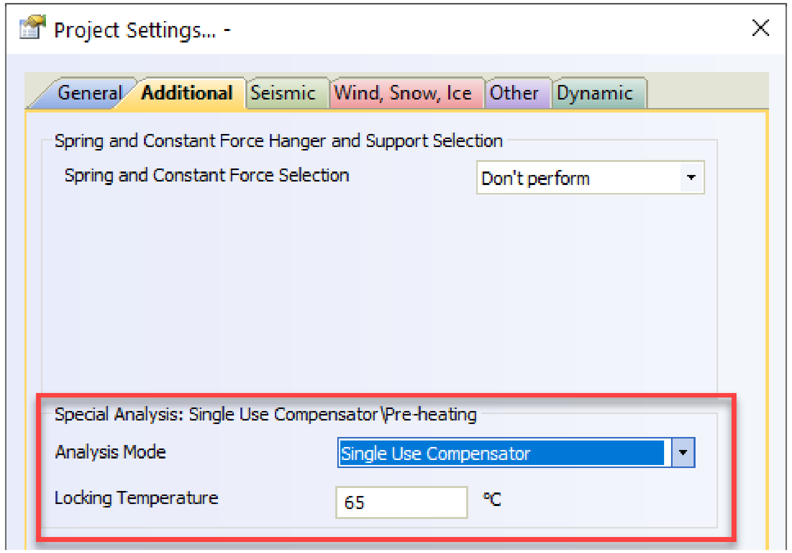
a) Single use Compensator Type 1 b) Single use Compensator Type 2 c) Single use Compensator Type 3

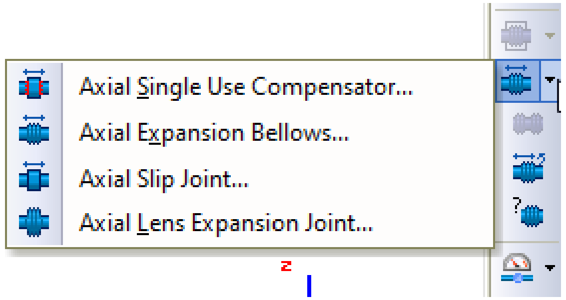


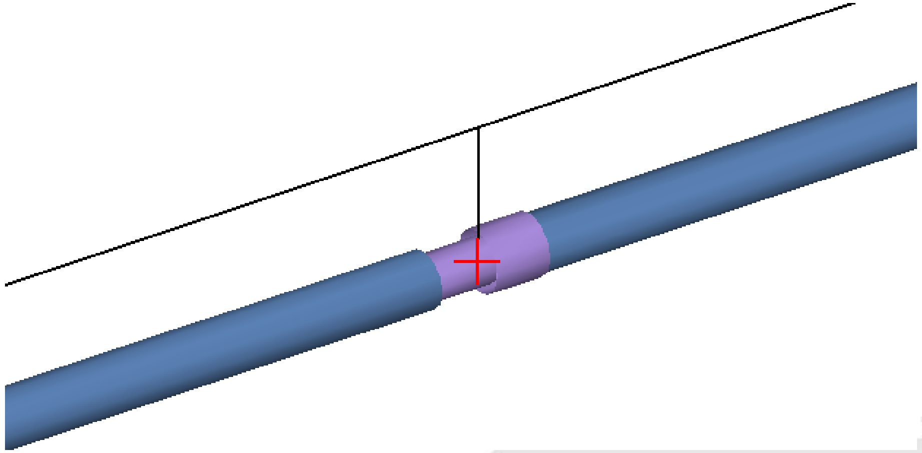


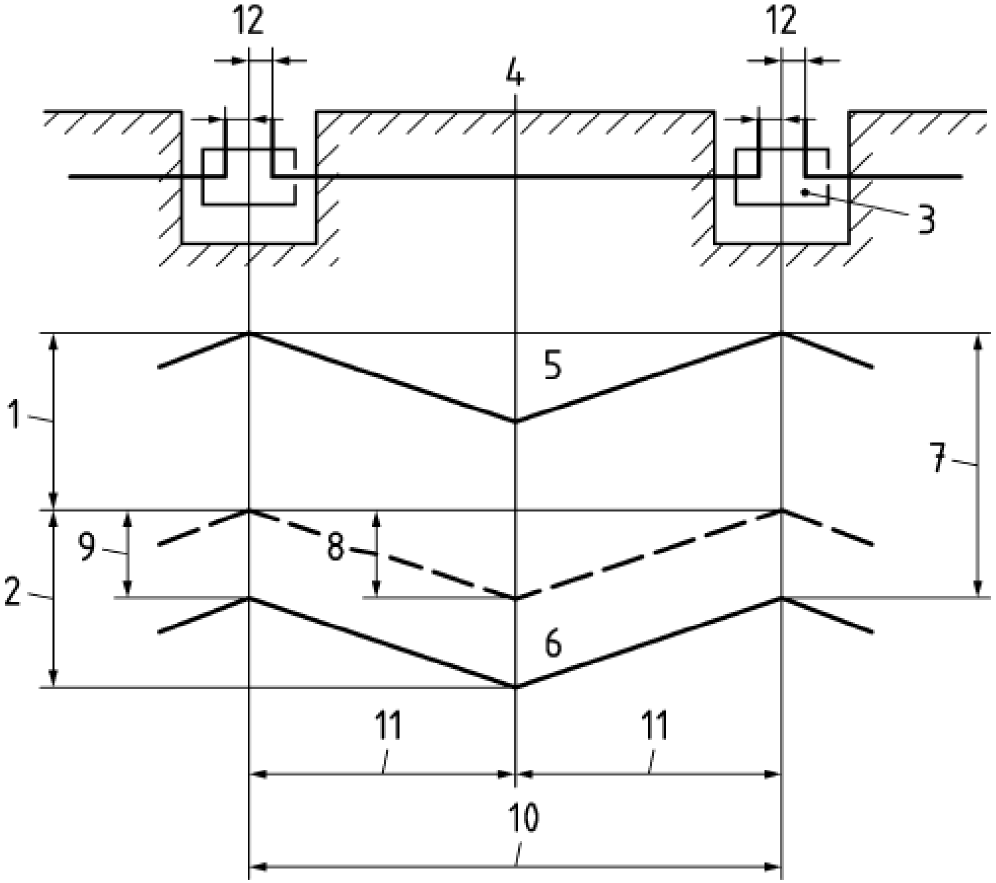
PASS/Start-Prof | Stress Analysis

PASS/START-PROF Automatically calculates networks with single use compensators



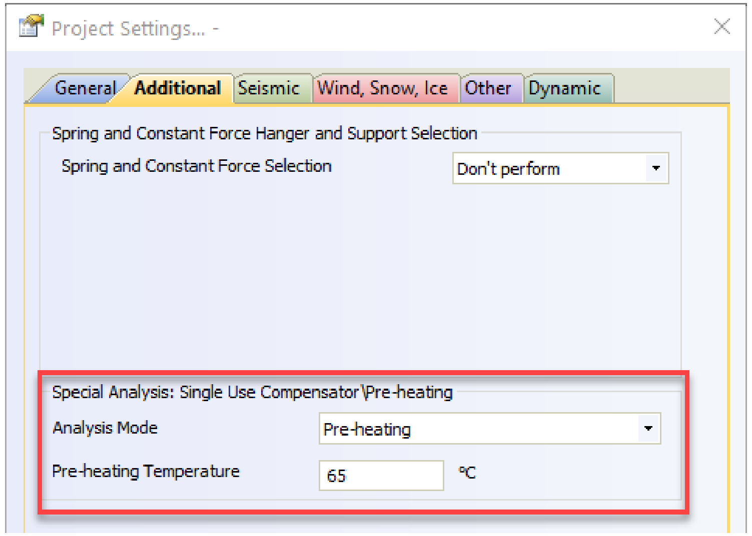




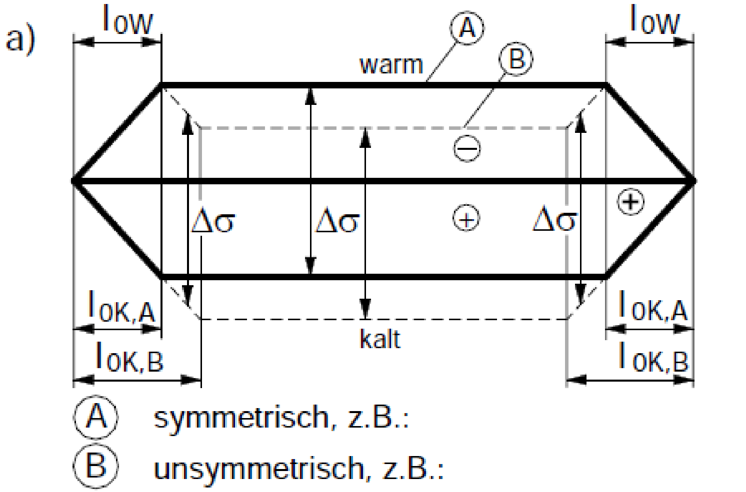


PASS/Start-Prof | Stress Analysis

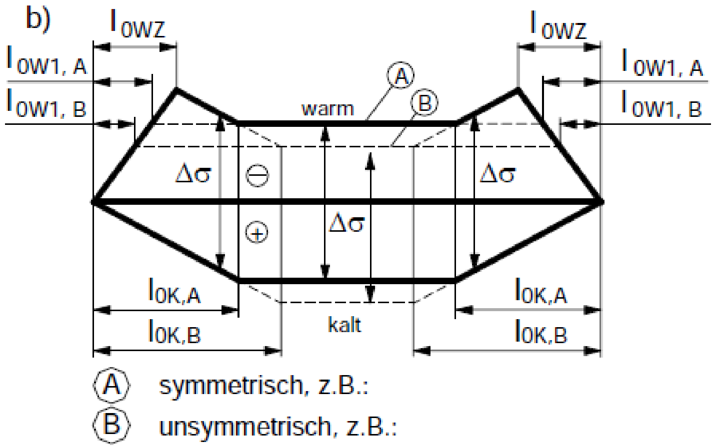
Automatic Analysis of District Heating Networks Installed with Pre-Heating. Friction factors can be varied for heating and cooling



Full friction when heating up, full friction when cooling

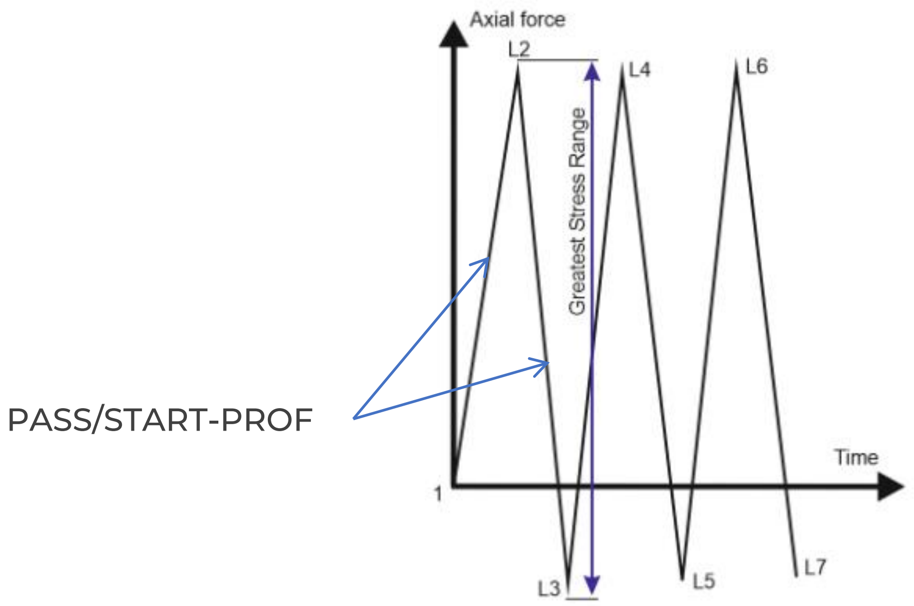


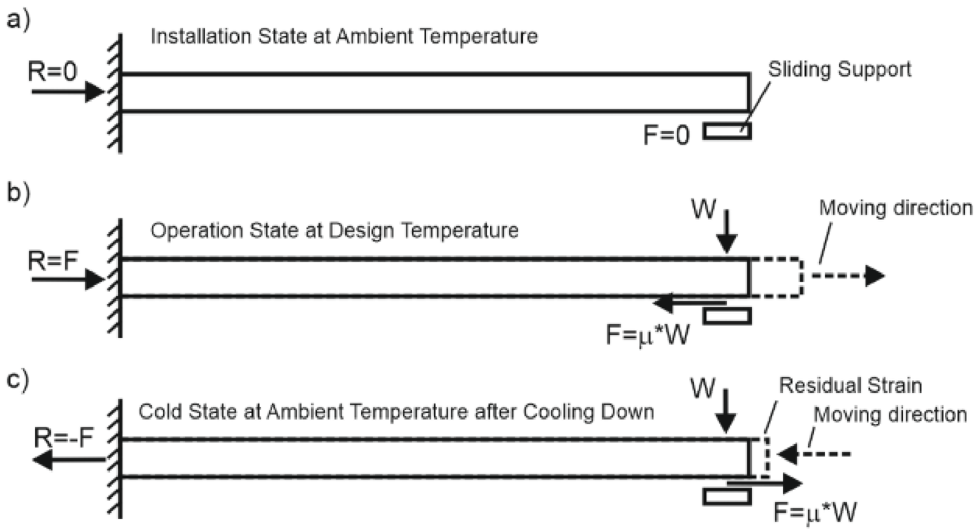
Full friction when heating up, half friction when cooling



PASS/Start-Prof | Stress Analysis

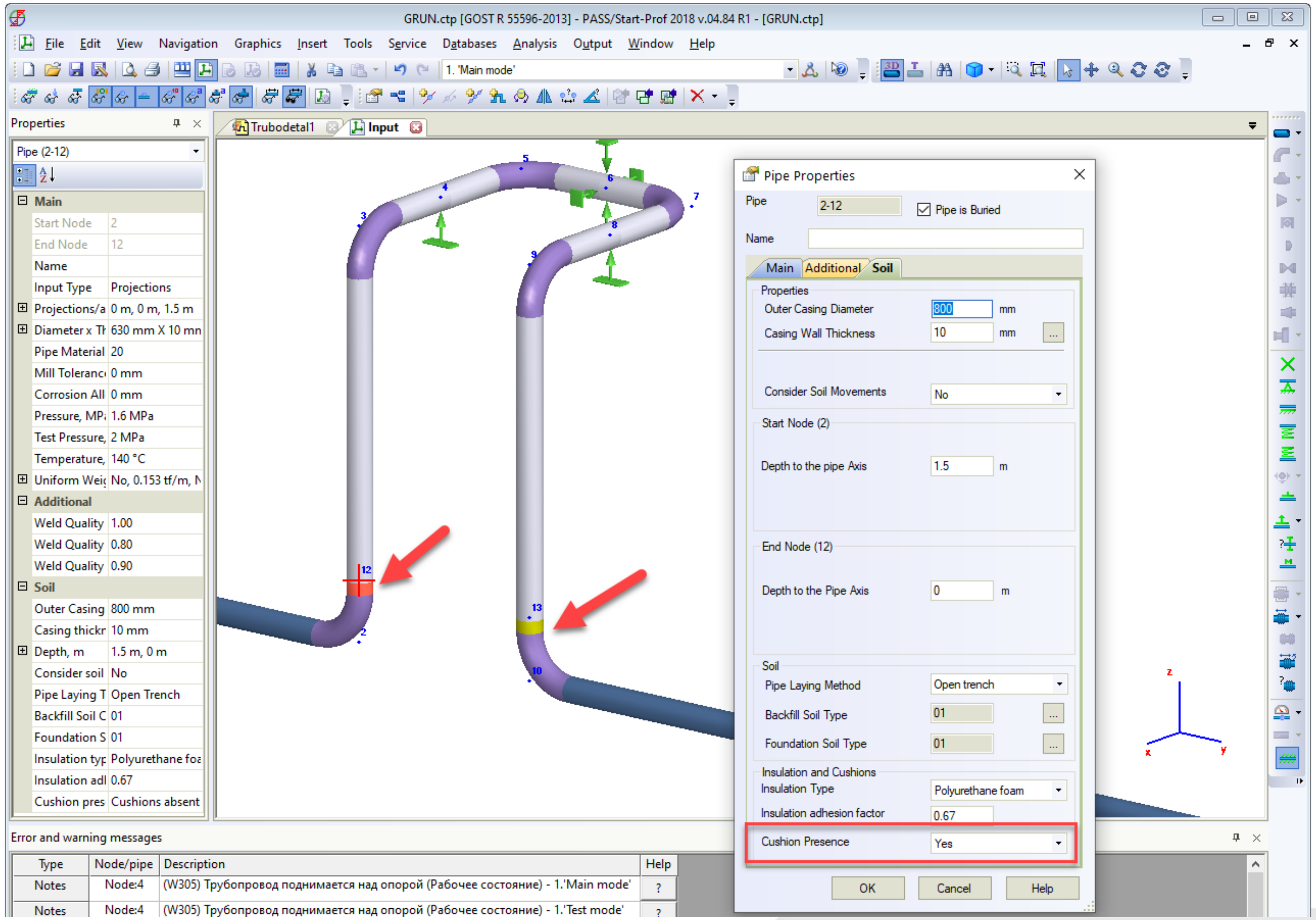
PASS/START-PROF calculates the cold state after cooling down from the hot state. It allows to get more realistic expansion stress range

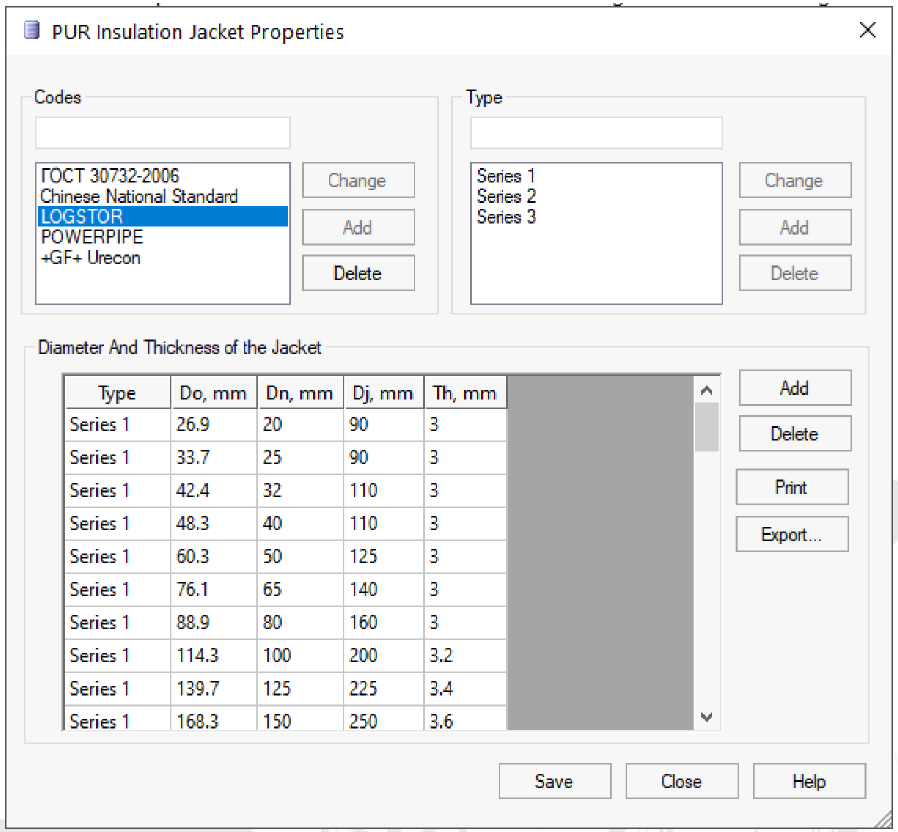




PASS/Start-Prof | Features

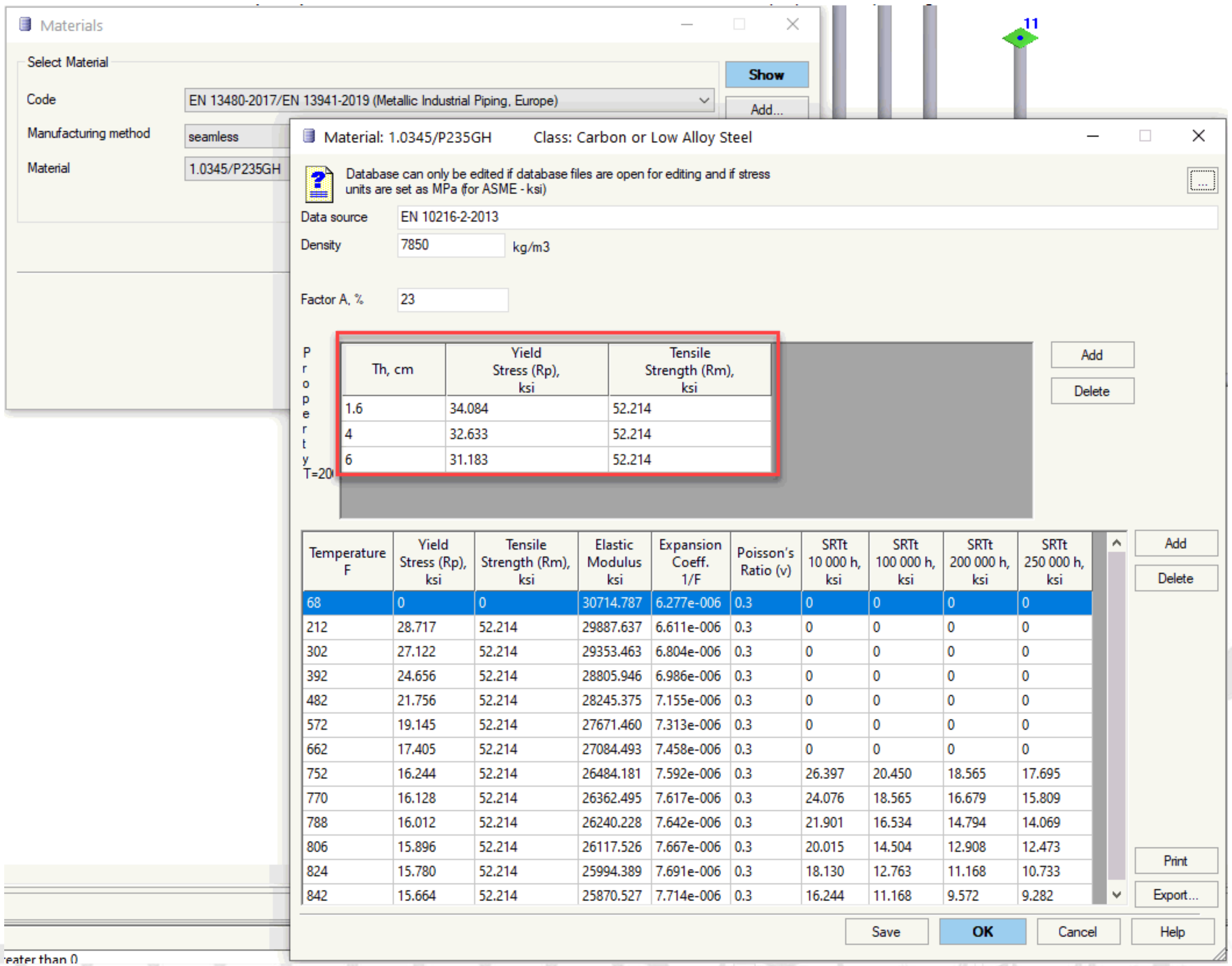
Added LOGSTOR, POWERPIPE, +GF+ Urecon Polyurethane Pre-insulated Pipe Jacket Sizes Database for district heating and district cooling networks





PASS/Start-Prof | Code Updates

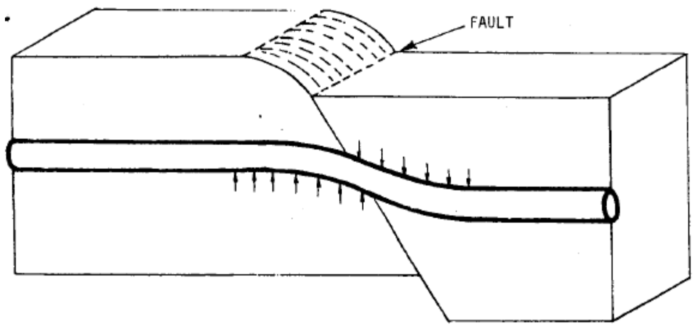
Updated material database EN 13480/EN 13941.
Added all piping materials by EN 10216-1-2013, EN 10216-2-2013, EN 10216-3-2013, EN 10216-4-2013, EN 10216-5-2013, EN 10217-1-2019, EN 10217-1-2019, EN 10217-2-2019, EN 10217-3-2019, EN 10217-4-2019, EN 10217-5-2019, EN 10217-6-2019, EN 10217-7-2014, EN 10220-2002 (2007), EN 10253-2-2007.
Added automatic material properties selection depending on wall thickness and seamless/welding option



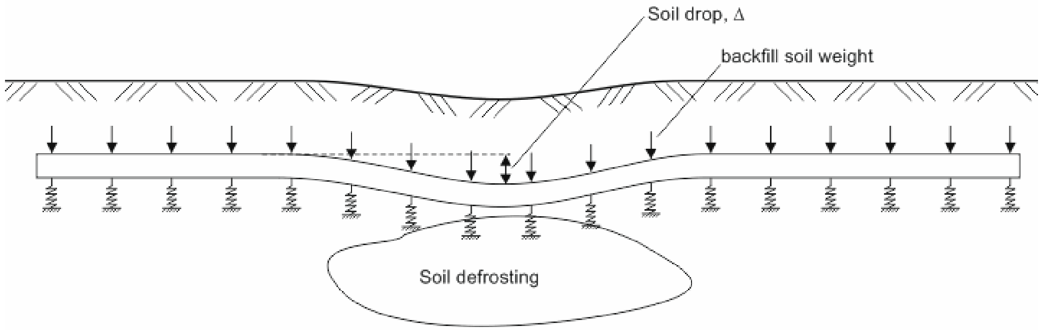
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

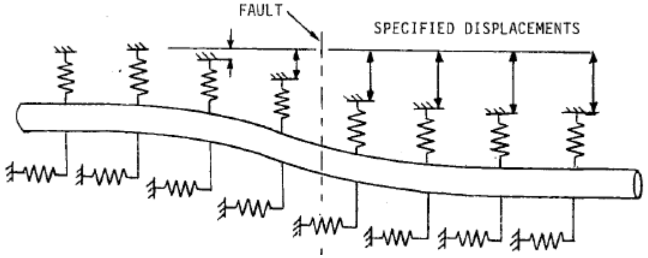
PASS/Start-Prof | Features

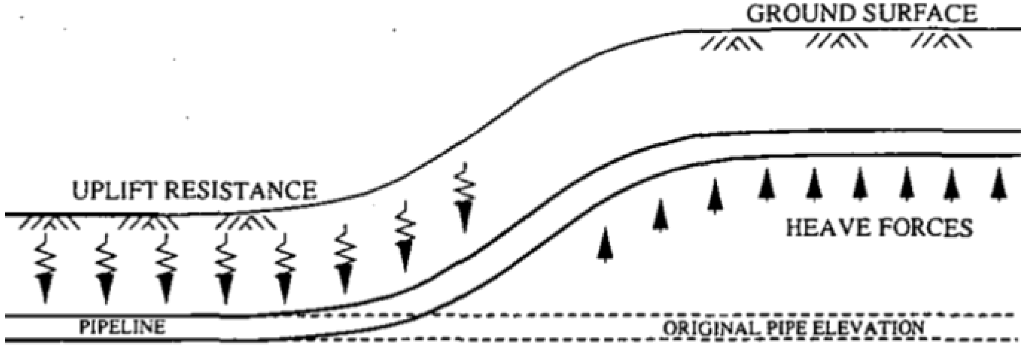
Modeling of Soil Subsidence, Frost Heaving, Landslide, Seismic Fault Crossing
It is modeled as soil movements at the both ends of the each pipe at X, Y, Z directions

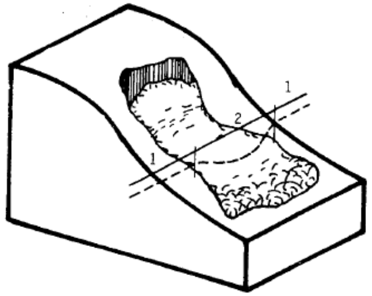


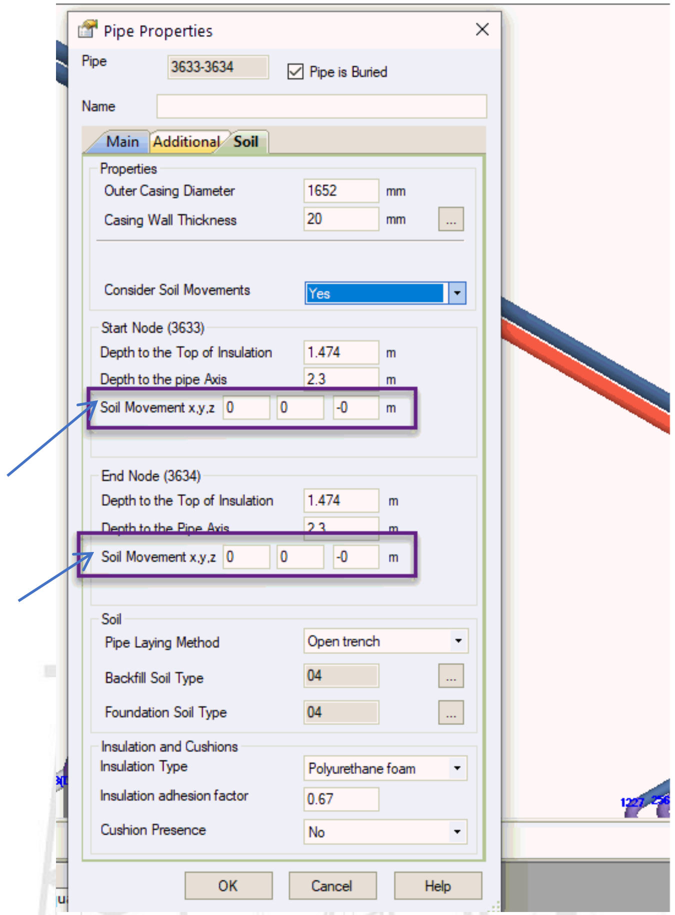
(A) ACTUAL GEOMETRY







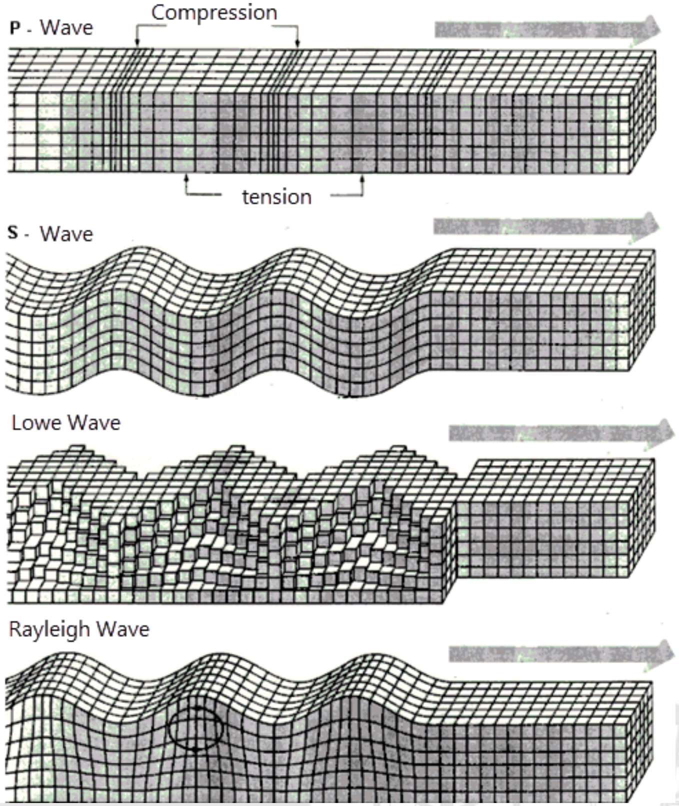




PASS/Start-Prof | Features

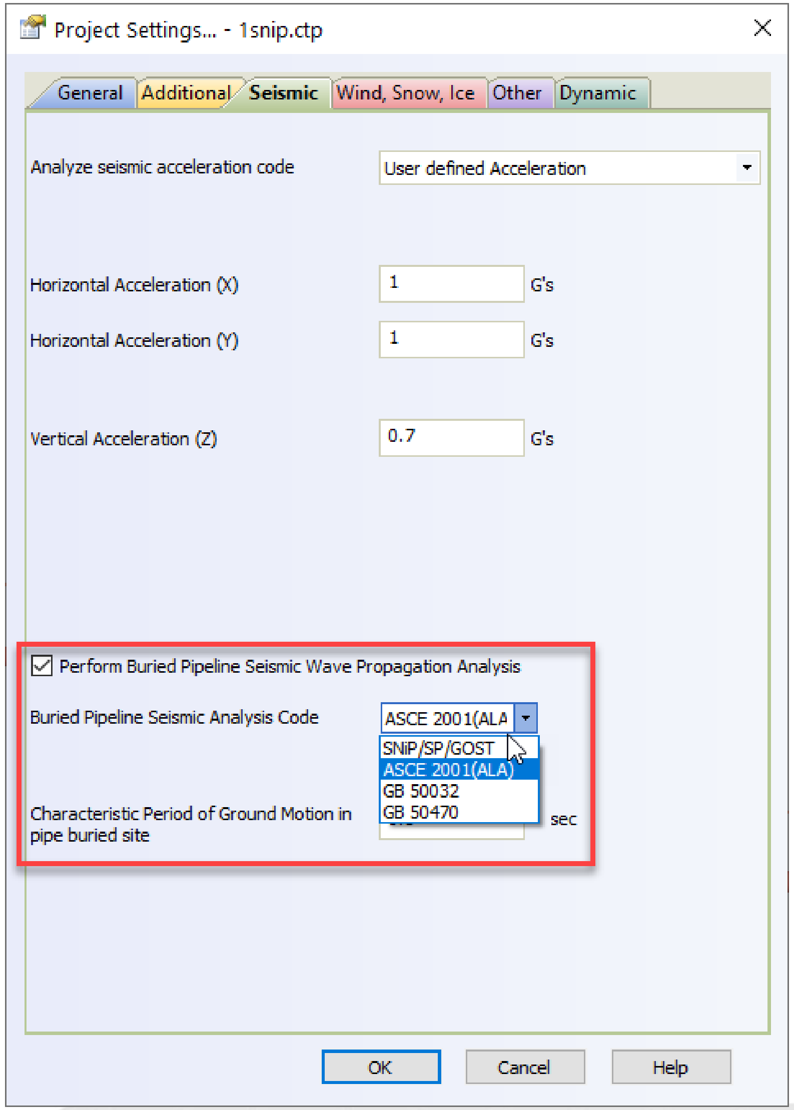
Seismic wave propagation analysis for underground pipelines. START-PROF calculate stress and strain in buried pipeline caused by seismic wave propagation and check the stress and strain limits according to

- ASCE 2001 Guidelines for the Design of Buried Steel Pipe (American Lifelines Alliance). Improved by START-PROF authors, added shear wave effect
- GB 50032 (China)
- GB 50470 (China)
- SNiP 2.05.06-85 (Russia)
- SP 36.13330.2012 (Russia)
- GOST R 55989-2014 (Russia)
- GOST R 55990-2014 (Russia)
- SP 284.1325800.2016 (Russia)
- SP 33.13330.2012 (Russia)

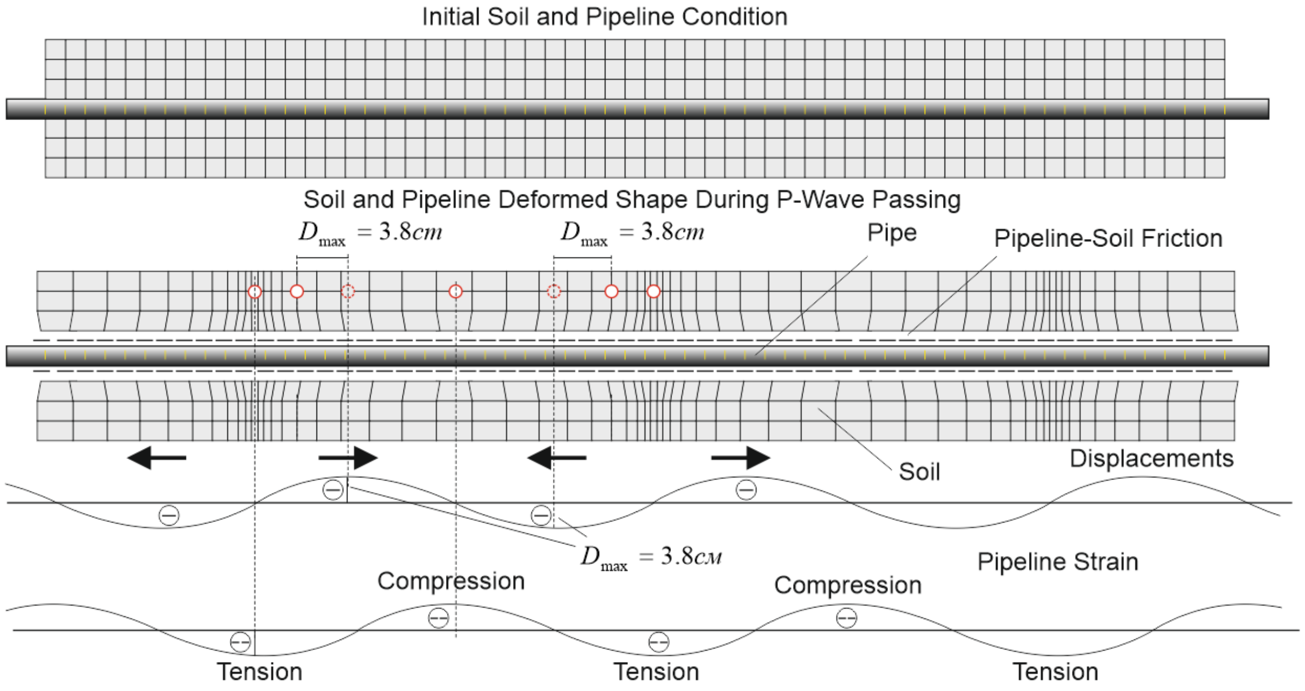


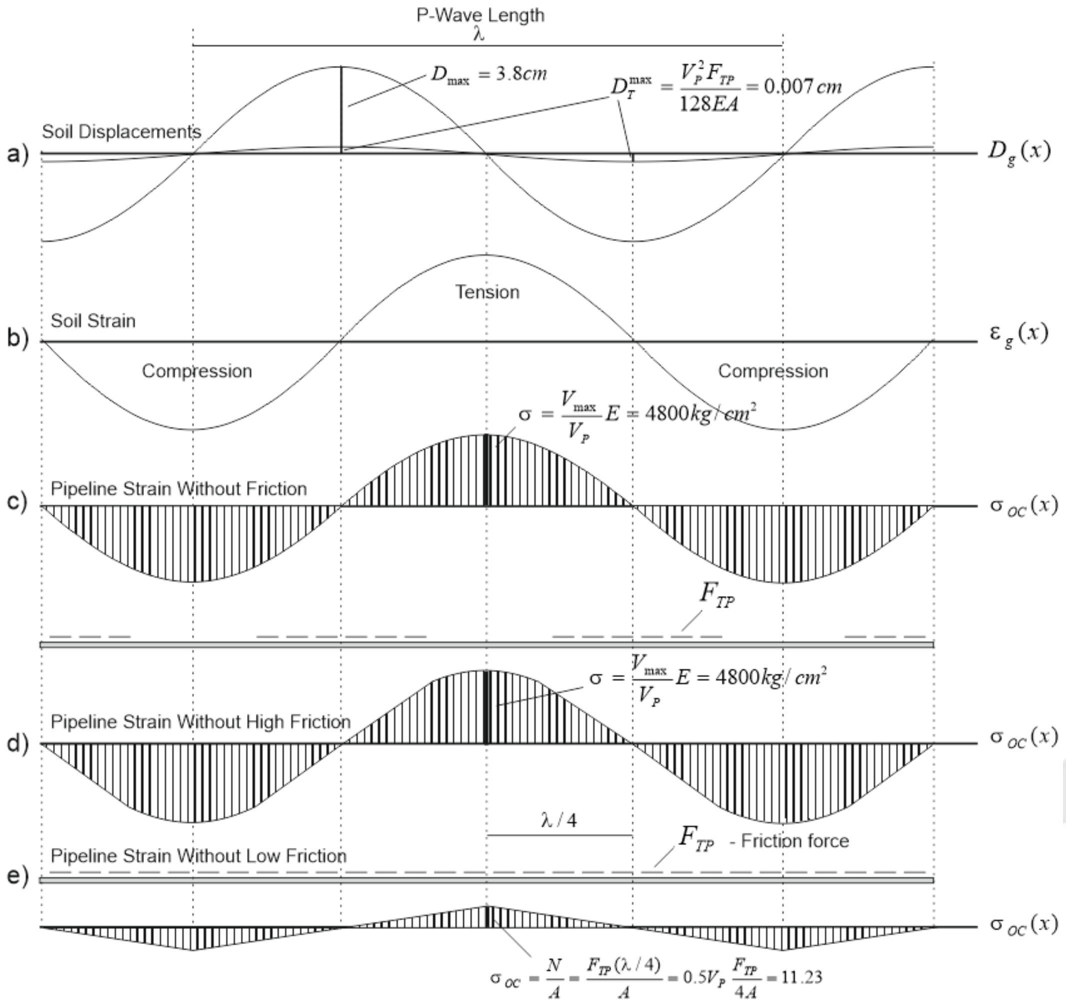
PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | Features



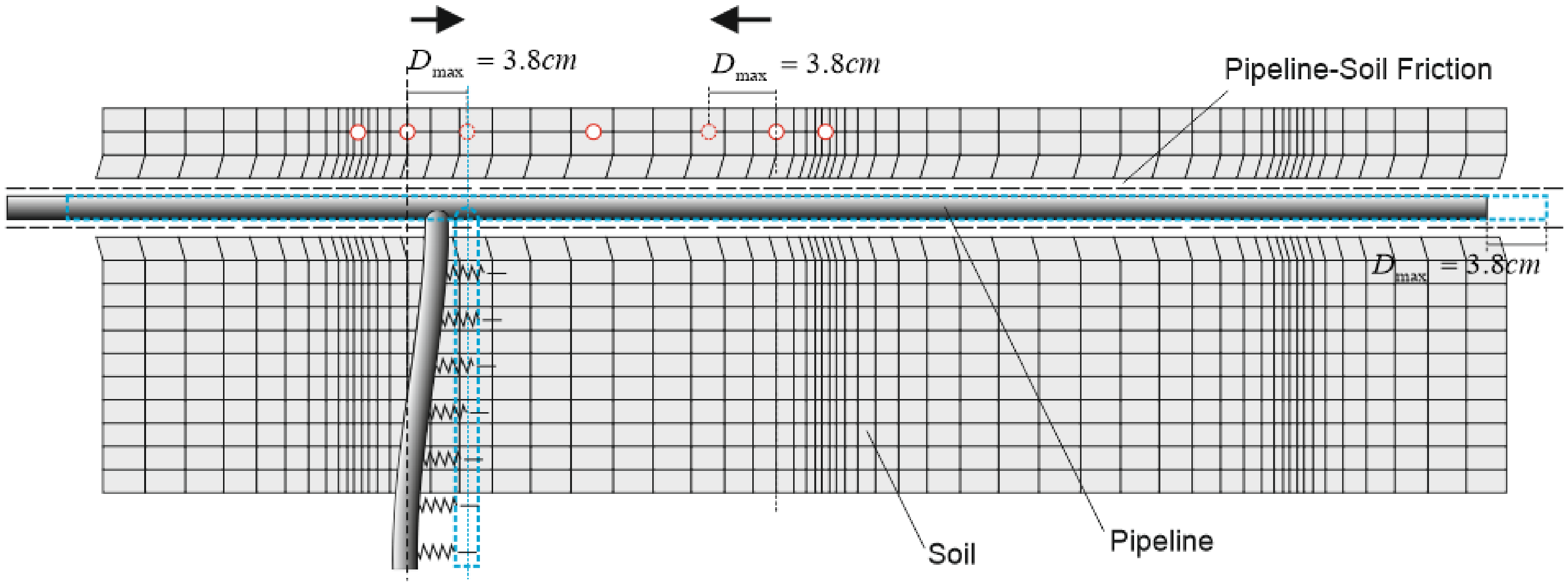
PASS/Start-Prof | Features





PASS/Start-Prof | Features

Every pipe branch, turn or anchor cause great axial and bending stresses



PASS/Start-Prof | Features

Axial seismic strain due to wave propagation is calculated using equation:

$$\varepsilon = \pm max\left(min(\varepsilon_a, \varepsilon_{fr}); \frac{D}{2}\rho_{max}\right)\cos\omega$$

Actually, pipe curvature can cause only the bending moments, but we convert it into equivalent axial strain to simplify the stress analysis procedure in START-PROF software.

ω – Incline angle of the pipe. 0 for horizontal pipe, 90 for vertical pipe

D – Pipe diameter, m

ε_a – Maximum axial strain from P-, S-, R-waves

$$\varepsilon_a = max\left(\frac{V_g}{C_P}; \frac{V_g}{2C_S}; \frac{V_g}{C_R}\right)$$

Maximum strain from P-wave friction forces is

$$\frac{T_u\lambda}{4EA}$$

λ –Wave length, m

$$\lambda = 0.5C_P$$

So maximum strain caused by friction from P-, S-, R-waves is

$$\varepsilon_{fr} = max\left(0.5C_P\frac{T_u}{4EA}; 0.5C_S\frac{T_u}{4EA}; 0.5C_R\frac{T_u}{4EA}\right)$$

ρ_{max} – Maximum curvature from P-, S-, R-waves

$$\rho_{max} = max\left(\frac{0.385A_g}{(C_P)^2}; \frac{A_g}{(C_S)^2}; \frac{A_g}{(C_R)^2}\right)$$

V_g – Peak ground velocity, m/s. Specified by user in pipe properties

A_g – Peak ground acceleration, m/s2. Specified by user in pipe properties

A – Pipe cross-section area, m2

T_u – Peak friction force, t/m

$$T_u = \tan(n_m \cdot \varphi)\left[\gamma_a Z\pi D_c\left(\frac{1+K_0}{2}cos^2\alpha - K_0\sin^2\alpha\right)\right] + \pi D_c\omega c$$

$$\omega = 0.608 - 0.123c - \frac{0.274}{c^2+1} + \frac{0.695}{c^3+1}$$

c – Soil cohesion

C_P – Apparent P-wave propagation velocity, m/s. Specified by user in START-PROF pipe properties. Default value 2 km/s

C_S – Apparent S-wave propagation velocity, m/s. Specified by user in START-PROF pipe properties. Default value 1 km/s

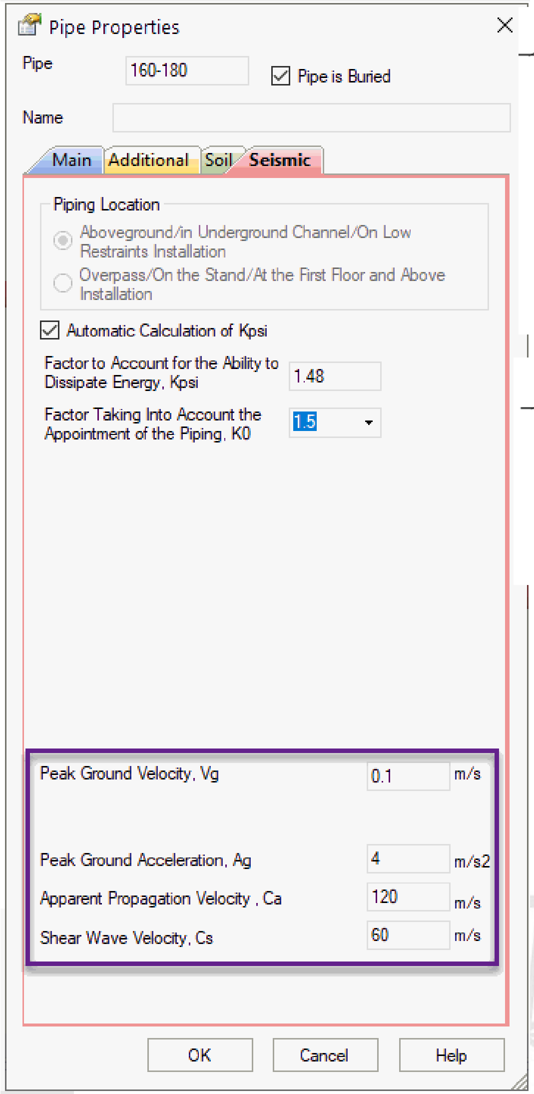
C_R – Apparent R-wave propagation velocity, m/s

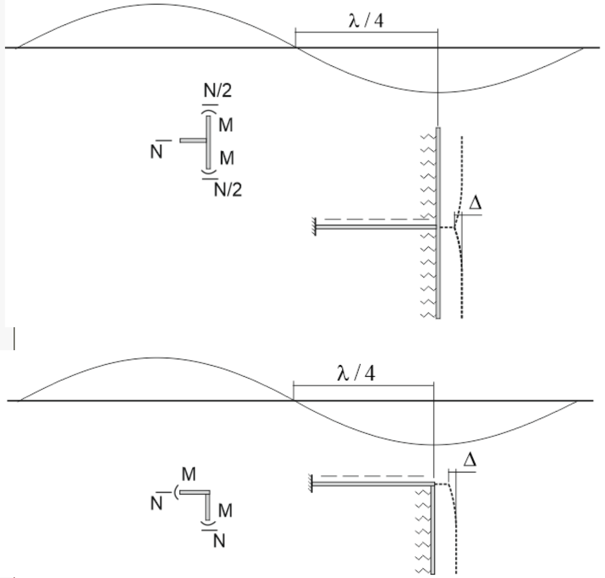
Rayleigh wave velocity is equal to $C_R = kC_S$, where k is obtained from the equation

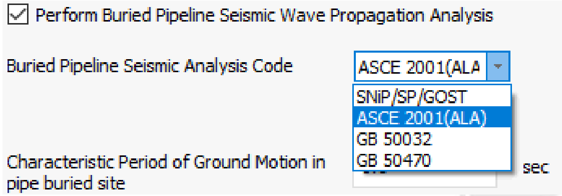
$$\frac{1}{8}k^6 - k^4 + \frac{2-\nu}{1-\nu}k^2 - \frac{1}{1-\nu} = 0.$$

Depending on Poisson's ratio values the k values are within $0.92 < k < 0.95$ We approximately assume that $k = 0.92$

$$C_R \approx 0.92C_S$$







PASS/Start-Prof | Features

Added strain check according to ASCE 2001 Guidelines for the Design of Buried Steel Pipe (American Lifelines Alliance), SNiP, SP, GOST, GB Codes.

Input | **Stress**

Operating Mode: 1.1 'Soil Seismic Wave Propaga

☑ Show Equations ☐ Stress Range from Operation to Cold ☐ Add Axial Force and Torsion Stress ?

Object	Start End node	Buried piping Seismic Check, (MPa)			Buried piping Seismic Check, (%)			Notes
		SI	Allow	%	Σ	Allow	%	
Buried pipe	9	515.60	965.27	53.4	0.2009	0.2939	68.4	
	3	515.58	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	8	510.81	965.27	52.9	0.1985			
	9	515.60	965.27	53.4	0.2009			
Buried pipe	7	490.91	965.27	50.9	0.1884			
	8	510.81	965.27	52.9	0.1985	0.2939	67.5	

E, 201051.12 MPa
[εa]=0.75(0.5t/D-0.0025+3000(PD/(2Et))²), 0.002939
[εa]%, 0.2939

Tension strain limit 5%

Compression strain limit

$$0.75\left[0.50\left(\frac{t}{D'}\right)-0.0025+3000\left(\frac{pD}{2Et}\right)^2\right]$$

$$D'=\frac{D}{1-\frac{3}{D}\left(D-D_{\min}\right)}$$

Input | **Stress**

Operating Mode: Maximum

☑ Show Equations ☐ Stress Range from Operation to Cold ☐ Add Axial Force and Torsion Stress ?

Object	Start End node	Hoop Stress, (MPa)			Primary Loads Stress in Hot State, (MPa)						Primary&Secondary Loads Stress in Hot State, (MPa)						Expansion Stress Range, (MPa)			Buried piping Seismic Check, (MPa)			Buried piping Seismic Check, (%)			Notes
		Sh	F*E*Sy	%	Seq	F*Sy	%	SI	F*Sy	%	Seq	F*Sy	%	SI	F*Sy	%	Se	Sa	%	SI	Allow	%	Σ	Allow	%	
Buried pipe	9	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.60	965.27	53.4	0.2009	0.2939	68.4	
	3	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.58	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	8	85	173.75	48.9				24.69	180.99	13.6	153.55	217.18	70.7	68.55	217.18	31.6	93.23	217.18	42.9	510.81	965.27	52.9	0.1985	0.2939	67.5	
	9	85	173.75	48.9				24.62	180.99	13.6	154	217.18	70.9	69	217.18	31.8	93.61	217.18	43.1	515.60	965.27	53.4	0.2009	0.2939	68.4	
Buried pipe	7	85	173.75	48.9				24.98	180.99	13.8	151.70	217.18	69.9	66.70	217.18	30.7	91.60	217.18	42.2	490.91	965.27	50.9	0.1884	0.2939	64.1	
	8	85	173.75	48.9				24.69	180.99	13.6	153.55	217.18	70.7	68.55	217.18	31.6	93.23	217.18	42.9	510.81	965.27	52.9	0.1985	0.2939	67.5	
Long Radius Pipe Bend	2	85	173.75	48.9				35.27	180.99	19.5	204.13	217.18	94.0	119.13	217.18	54.9	84.97	217.18	39.1	732.51	965.27	75.9	0.1589	0.2939	54.1	
Buried pipe	2	85	173.75	48.9				30.03	180.99	16.6	169.99	217.18	78.3	84.99	217.18	39.1	84.91	217.18	39.1	568.23	965.27	58.9	0.1588	0.2939	54.0	
	7	85	173.75	48.9				24.98	180.99	13.8	151.70	217.18	69.9	66.70	217.18	30.7	91.60	217.18	42.2	490.91	965.27	50.9	0.1884	0.2939	64.1	

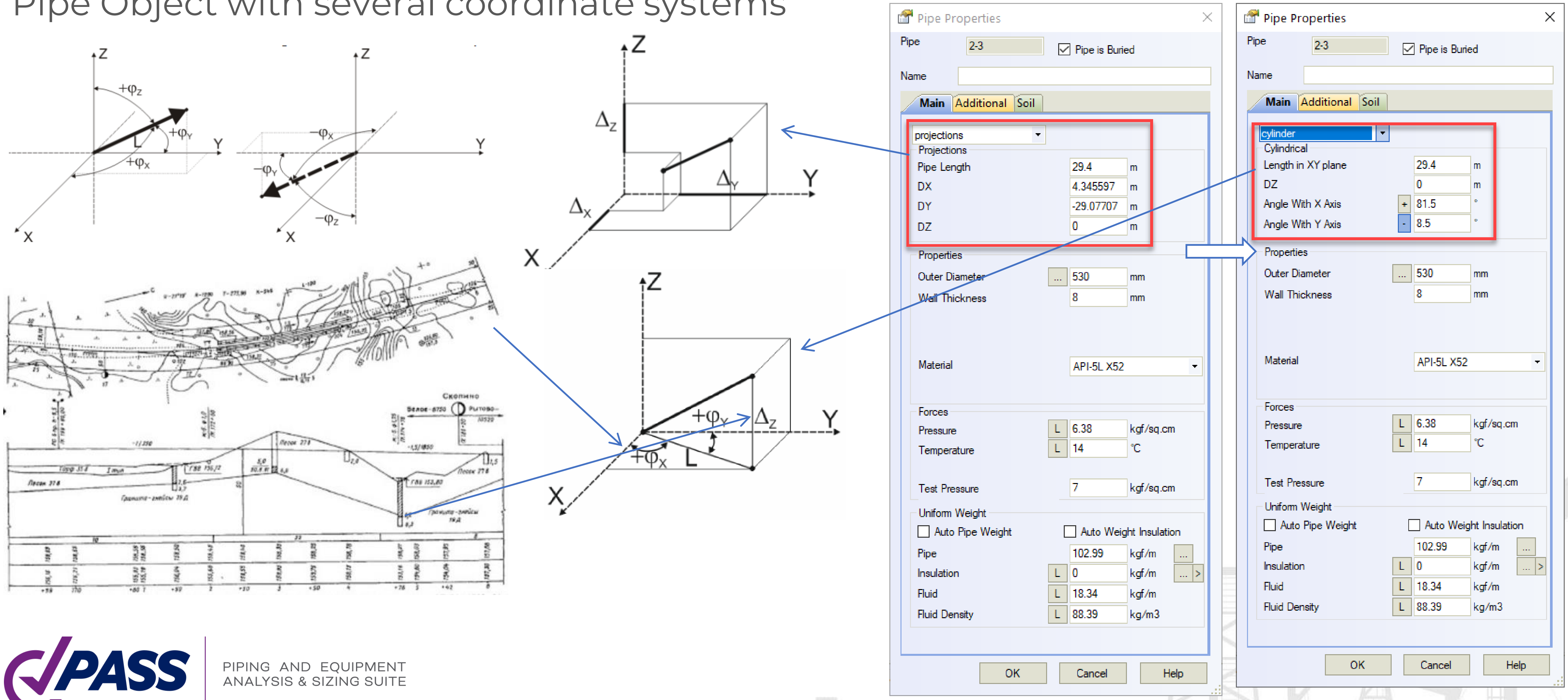
PASS/Start-Prof | Piping Model Creation

In PASS/START-PROF the piping model creation is simple and straightforward.
Even a beginner will understand what to do.
Create the Piping and Equipment Model by Combining the Objects
Like LEGO

- Fast Model Creation
- Fast and Easy Existing Model Modification
- You can Add, Delete, Modify, Copy, Rotate, Mirror, Split Objects
- Work With Object Groups

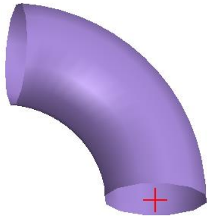
PASS/Start-Prof | Piping Model Creation

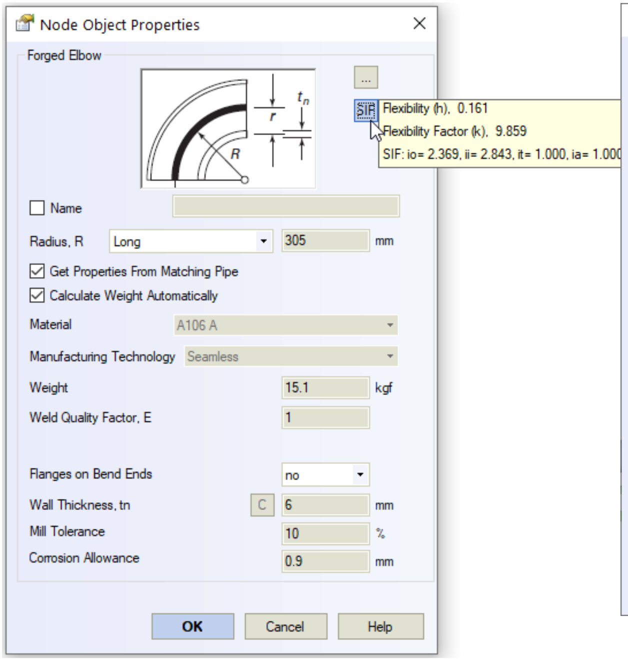
Pipe Object with several coordinate systems

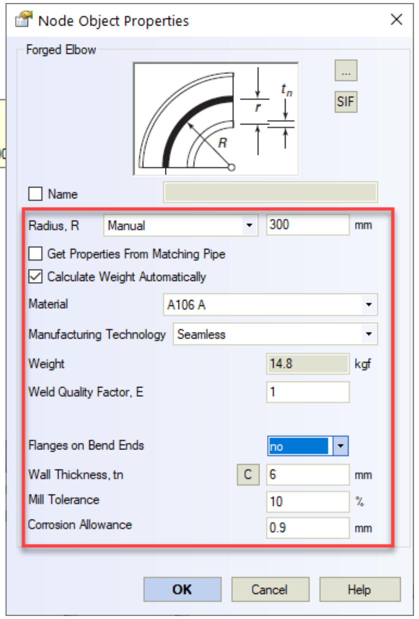


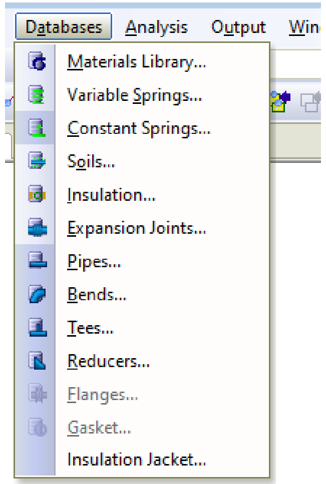
PASS/Start-Prof | Piping Model Creation

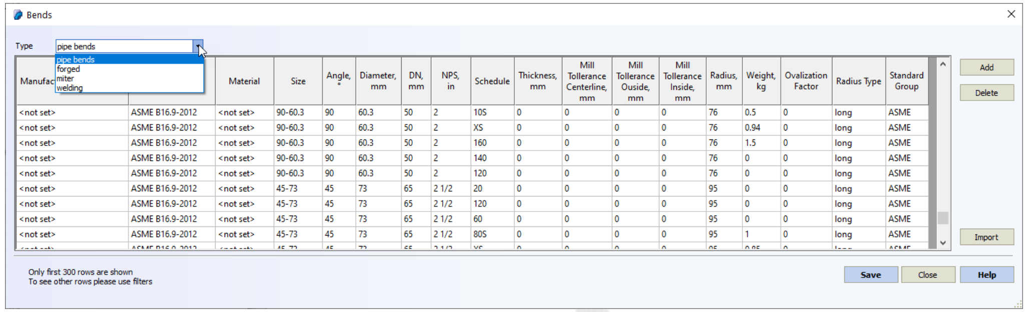
Bend Object










Bends

Type: pipe bends (pipe bends / forged / miter / welding)

Manufac		Material	Size	Angle, °	Diameter, mm	DN, mm	NPS, in	Schedule	Thickness, mm	Mill Tollerance Centerline, mm	Mill Tollerance Ouside, mm	Mill Tollerance Inside, mm	Radius, mm	Weight, kg	Ovalization Factor	Radius Type	Standard Group
<not set>	ASME B16.9-2012	<not set>	90-60.3	90	60.3	50	2	10S	0	0	0	0	76	0.5	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	90-60.3	90	60.3	50	2	XS	0	0	0	0	76	0.94	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	90-60.3	90	60.3	50	2	160	0	0	0	0	76	1.5	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	90-60.3	90	60.3	50	2	140	0	0	0	0	76	0	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	90-60.3	90	60.3	50	2	120	0	0	0	0	76	0	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	45-73	45	73	65	2 1/2	20	0	0	0	0	95	0	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	45-73	45	73	65	2 1/2	120	0	0	0	0	95	0	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	45-73	45	73	65	2 1/2	60	0	0	0	0	95	0	0	long	ASME
<not set>	ASME B16.9-2012	<not set>	45-73	45	73	65	2 1/2	80S	0	0	0	0	95	1	0	long	ASME

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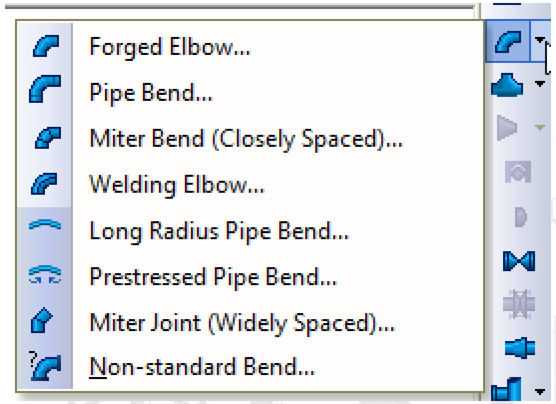
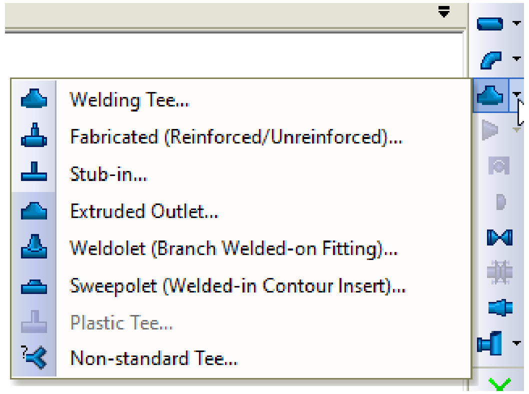
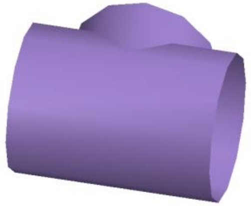
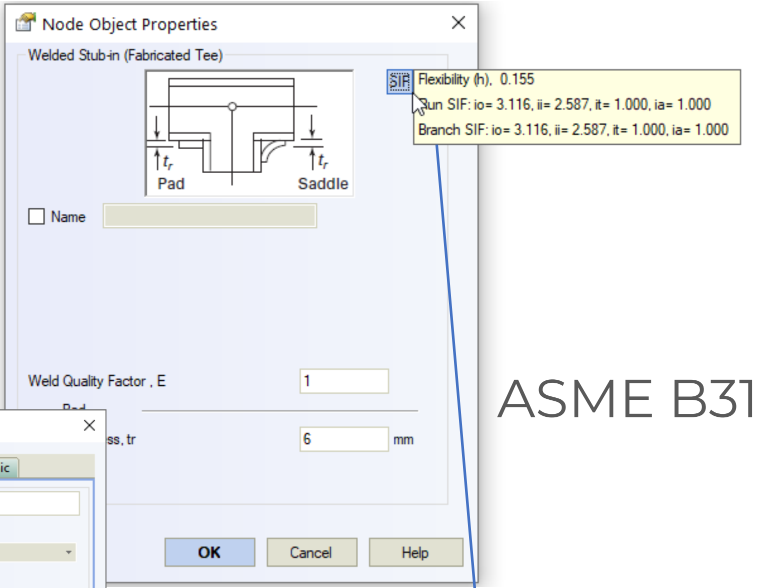


PASS/Start-Prof | Piping Model Creation

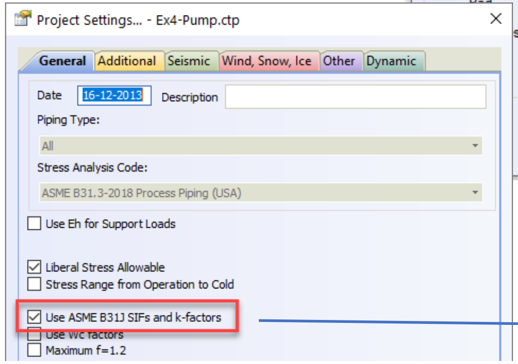


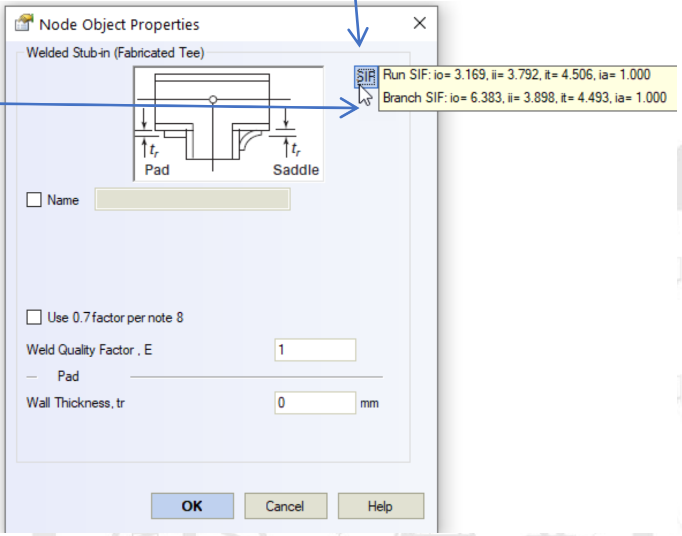
Tee Object

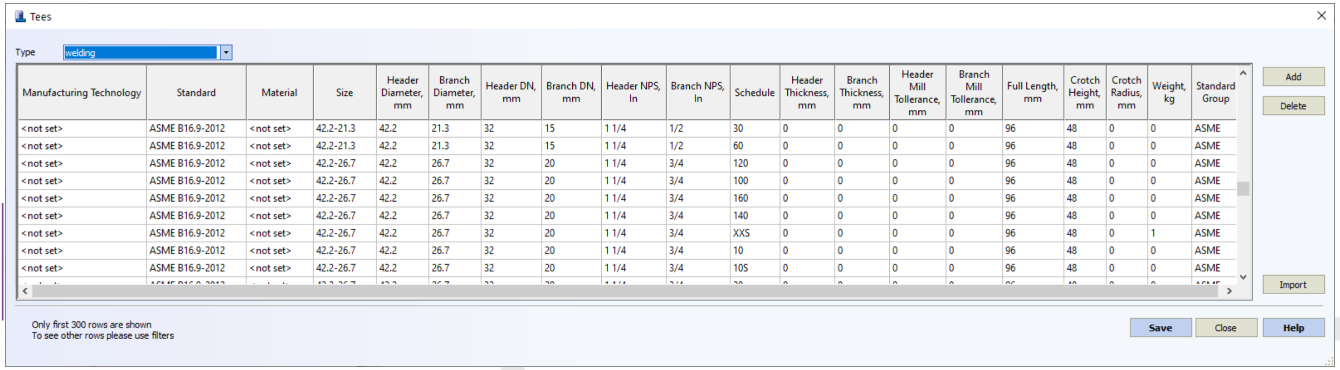




ASME B31J







Tees

Type: welding

Manufacturing Technology	Standard	Material	Size	Header Diameter, mm	Branch Diameter, mm	Header DN, mm	Branch DN, mm	Header NPS, In	Branch NPS, In	Schedule	Header Thickness, mm	Branch Thickness, mm	Header Mill Tollerance, mm	Branch Mill Tollerance, mm	Full Length, mm	Crotch Height, mm	Crotch Radius, mm	Weight, kg	Standard Group
<not set>	ASME B16.9-2012	<not set>	42.2-21.3	42.2	21.3	32	15	1 1/4	1/2	30	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-21.3	42.2	21.3	32	15	1 1/4	1/2	60	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	120	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	100	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	160	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	140	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	XXS	0	0	0	0	96	48	0	1	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	10	0	0	0	0	96	48	0	0	ASME
<not set>	ASME B16.9-2012	<not set>	42.2-26.7	42.2	26.7	32	20	1 1/4	3/4	10S	0	0	0	0	96	48	0	0	ASME

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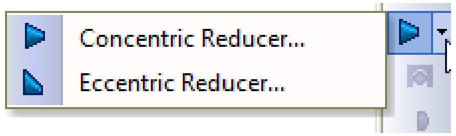
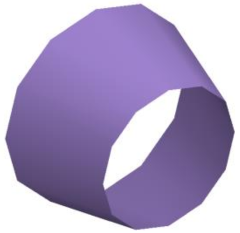
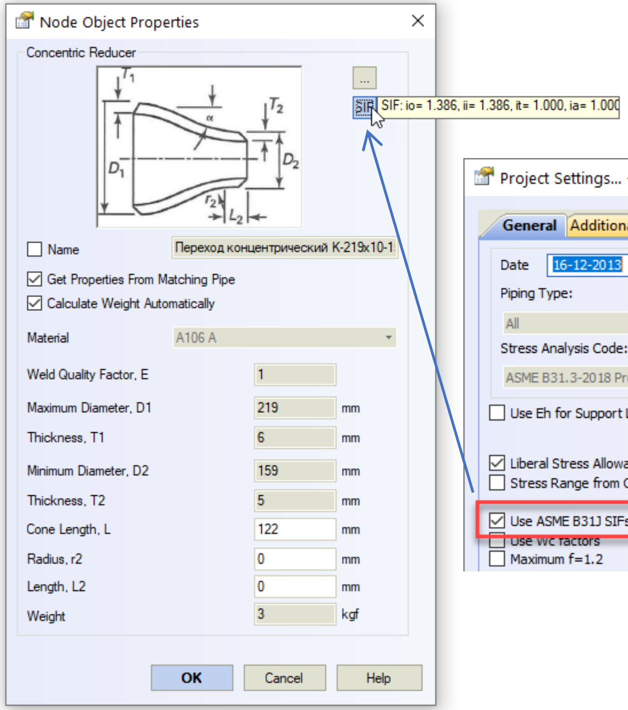
PASS/Start-Prof | Piping Model Creation

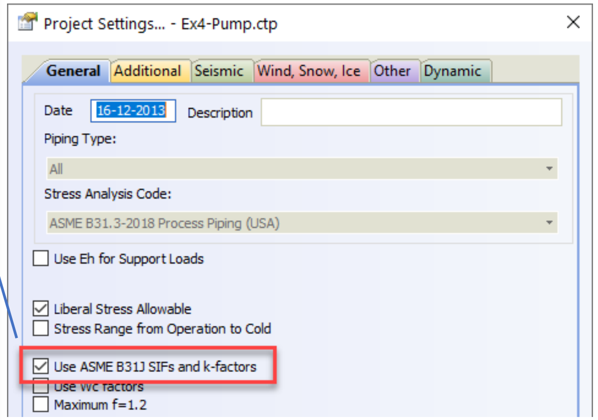


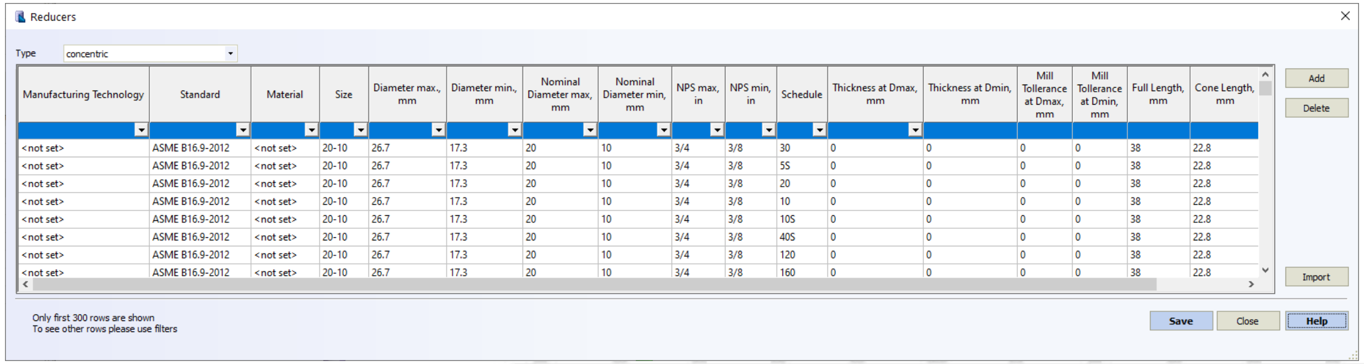
Reducer Object





ASME B31J

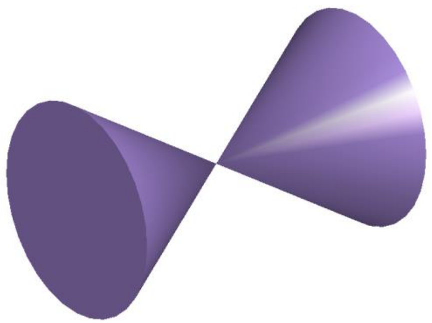


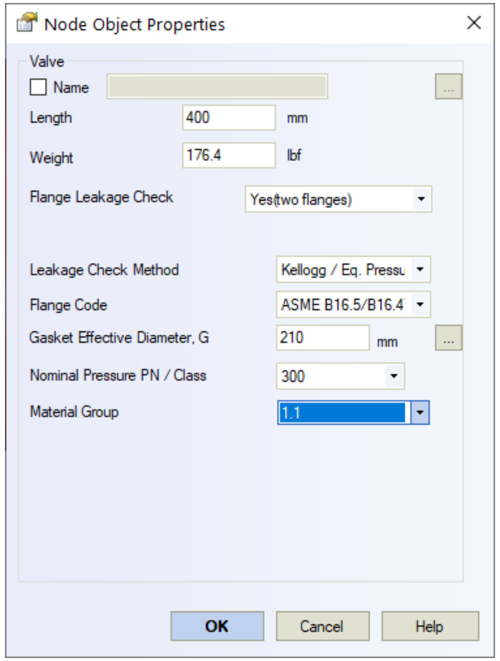


Manufacturing Technology	Standard	Material	Size	Diameter max., mm	Diameter min., mm	Nominal Diameter max, mm	Nominal Diameter min, mm	NPS max, in	NPS min, in	Schedule	Thickness at Dmax, mm	Thickness at Dmin, mm	Mill Tollerance at Dmax, mm	Mill Tollerance at Dmin, mm	Full Length, mm	Cone Length, mm
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	30	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	5S	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	20	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	10	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	10S	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	40S	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	120	0	0	0	0	38	22.8
<not set>	ASME B16.9-2012	<not set>	20-10	26.7	17.3	20	10	3/4	3/8	160	0	0	0	0	38	22.8

PASS/Start-Prof | Piping Model Creation

Valve Object

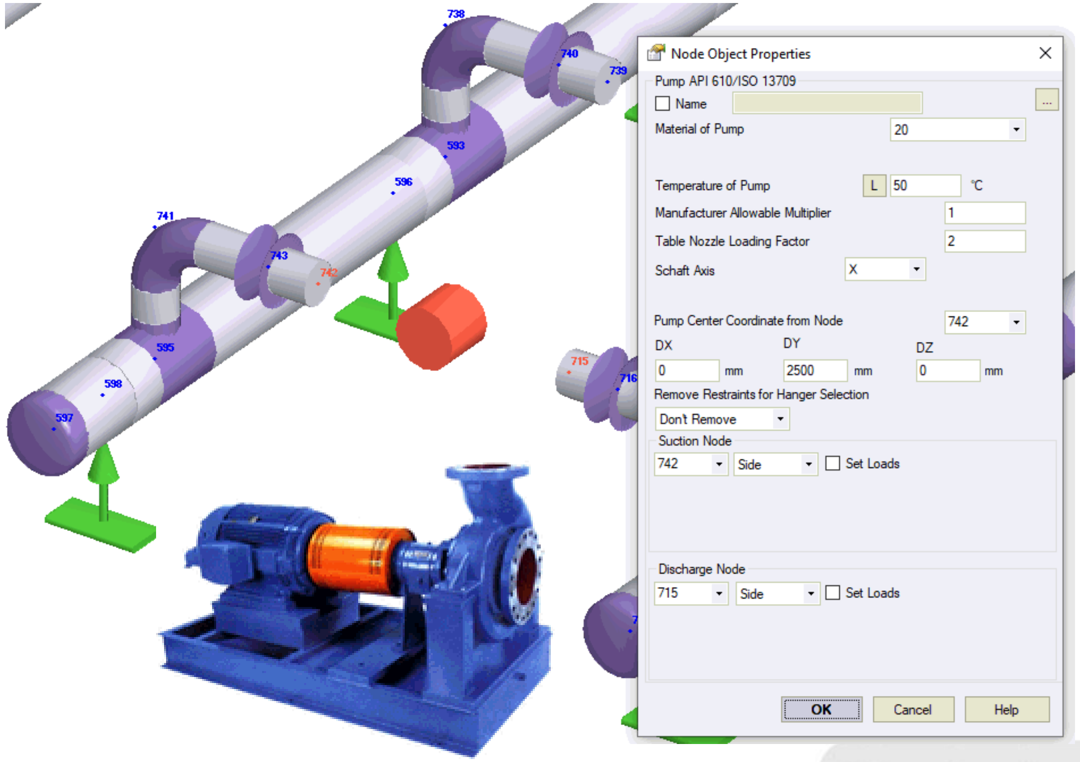




Automatic Flange Leakage Check

PASS/Start-Prof | Piping Model Creation

- Object "Pump API 610/ISO 13709", allows to automatically model the pumps, consider thermal movements of the nozzles, checks allowable loads using API 610 and ISO 13709
- Object "Pump ISO 9905“, "Pump ISO 5199“
- etc.



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):

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

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

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.)

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

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

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

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

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

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

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

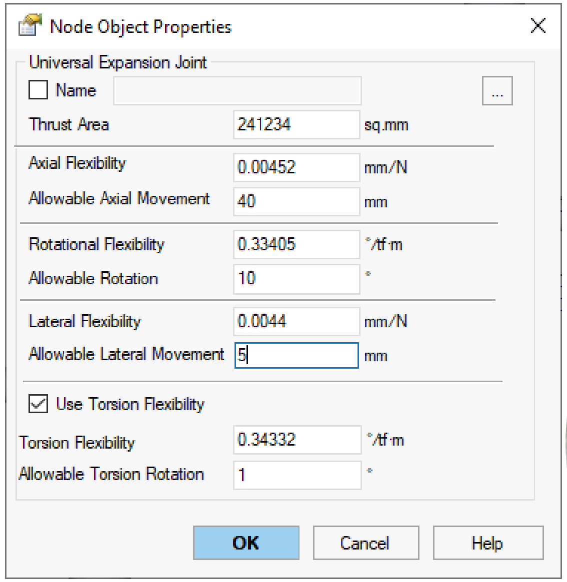
Input | Equipment

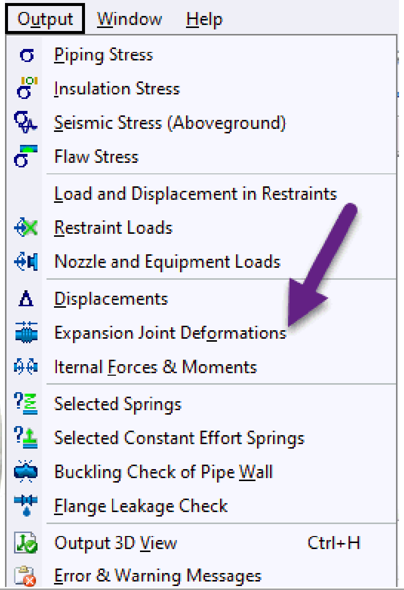
Operating Mode: 1 'main mode' (0) | Load Case: Operating W+P+T | Show Equations | ?

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
Pump API 610/ISO 13709	Node (1)	Suction, Side	200	-7333	5887	-29592	31050	-2626.53	18306.88	4598.20	19057.39	2.84	1
				9780	6220	7560	6920	3520	5160	7060	4710		
	Node (3)	Discharge, Side	200	1440505	-173	0	1440505	0		28.89	28.89	69.39	1
				9780	6220	7560	6920	3520	5160	7060	4710		
		Summary Loads		1433173	5714	-29592	1433490	-2626.53	33102.90	7657.21	34078.35		1
							20760	[My_sum]=2([MradT1] + [MradT2])=2*(1760+1760)=7040 N·m					

PASS/Start-Prof | Piping Model Creation

Added new object Untied Expansion Joint and database of Untied Expansion Joints, allows to specify the axial, rotational, shear and torsion flexibility and automatically checks the individual and combined allowable deformations. No need to manually model it using nonstandard expansion joint any more.





$$\frac{|\lambda_p|}{[\lambda_p]} + \frac{|\lambda_\theta|}{[\lambda_\theta]} + \frac{|\lambda_\Delta|}{[\lambda_\Delta]} \leq 1.$$

Input | Def exp

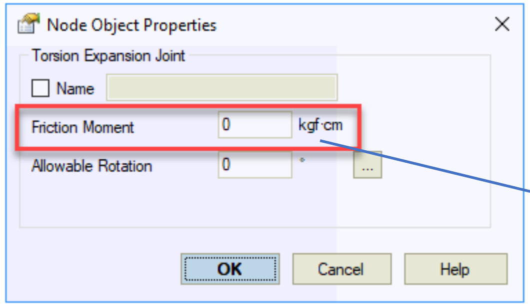
Operating Mode: 1 操作模式 (0) | Load Case: Operating W+P+T | Axis: Local axis (Design/Allowable) | ?

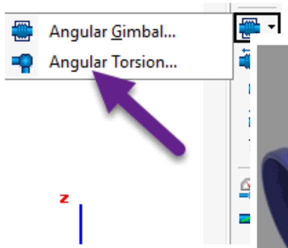
Node Number	Type	Local axis	Axial, (mm)	Allowable, (mm)	Shear, (mm)	Allowable, (mm)	Angular, (°)	Allowable, (°)	Torsion, (°)	Allowable, (°)	Summary	Notes
12	Untied Expansion Joint	Pipe 3 - 12	2.41	50	1.22	15	9.59131	10	-2.05119	No	1.09	1
13	Torsion Expansion Joint	Pipe 5 - 13	0	No	0	No	0	No	13.9229	51.5662	0.27	
15	Torsion Expansion Joint	Pipe 7 - 15	0	No	0	No	0	No	10.1299	51.5662	0.20	
21	Torsion Expansion Joint	Pipe 19 - 21	0	No	0	No	0	No	-4.36021	51.5662	0.08	

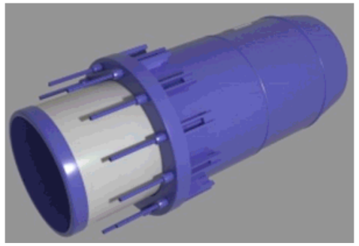
PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

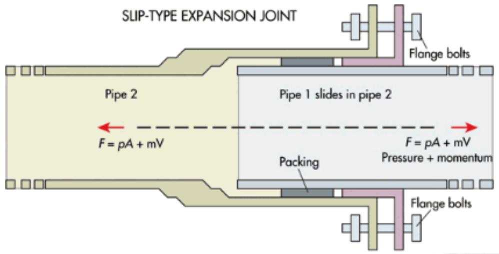
PASS/Start-Prof | Piping Model Creation

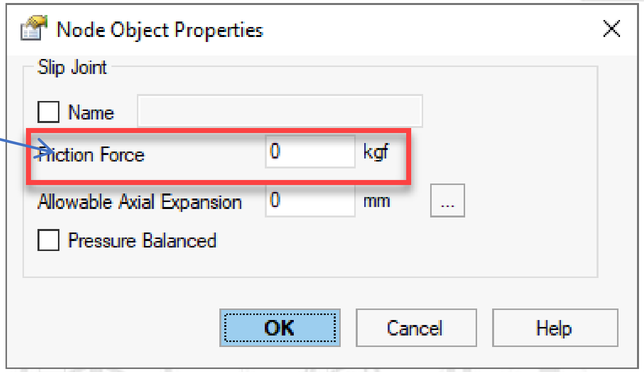
Added new object Torsion Expansion Joint and database of torsion expansion joints, automatically model torsion friction (friction moment) and checks allowable rotation angle





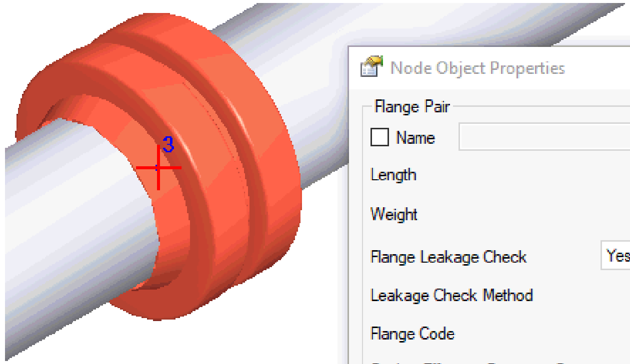


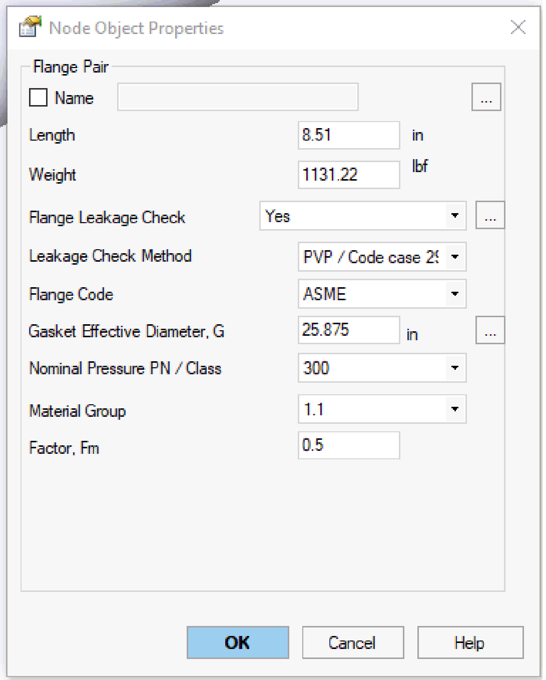




PASS/Start-Prof | Piping Model Creation

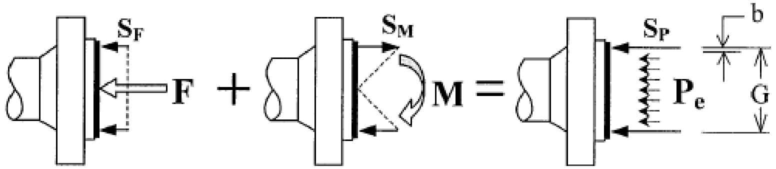
Flange Object





Automatic Flange Leakage Check:

- Equivalent pressure / Kellogg Method
- Code Case 2901 / PVP2013-97814 Method
- DNV Method
- NC 3658.3 Method



Input | Flange leakage

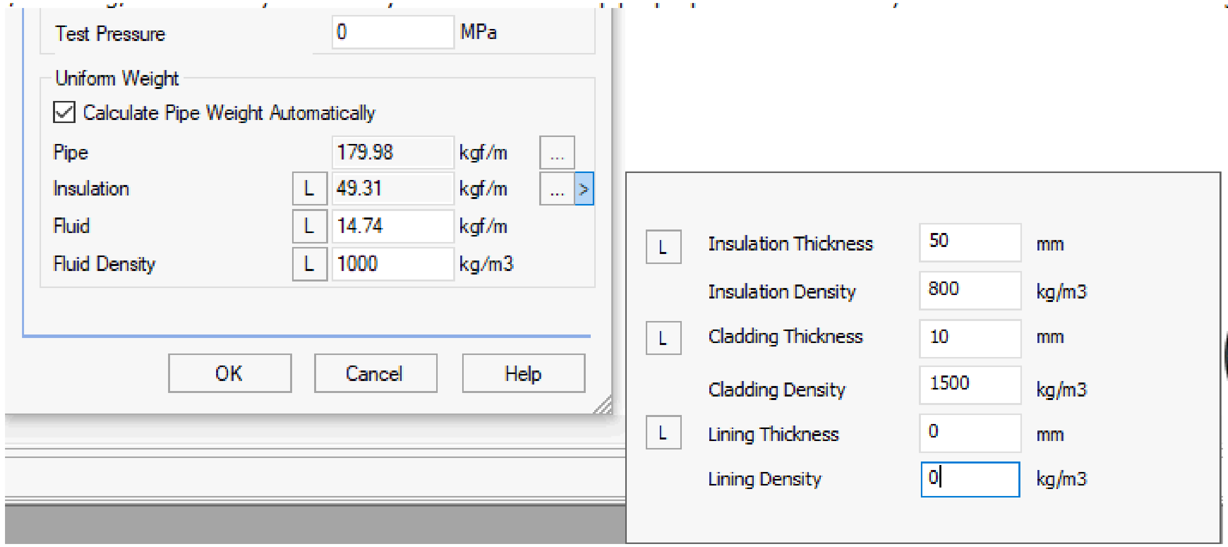
Operating Mode: 1 'Operation mode' (0)

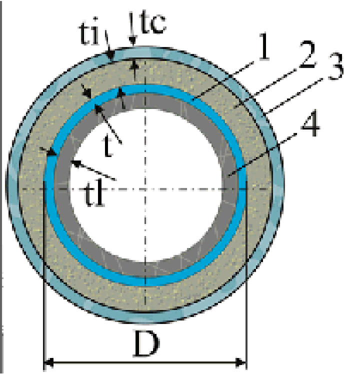
Submode: Operation (all loads)

Node Number	Object	Flange on the side of node	Pipe outside diameter, (mm)	Temperature, (°C)	Axial Force, (kgf)	Bending Moment, (kgf·m)	Parameters	Condition, (MPa)			Notes
								calcu-lated	allow-able	%	
3	Flange Pair	-	219.08	400	-1000	1499.98	1.60 MPa	4.29 MPa	17.36 MPa	24.70	

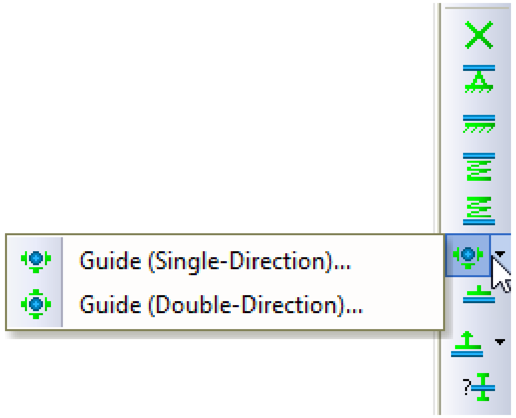
PASS/Start-Prof | Piping Model Creation

Added ability to specify insulation, cladding, and liner layers density and thickness in pipe properties. The ability to choose an insulation weight from the database still exist

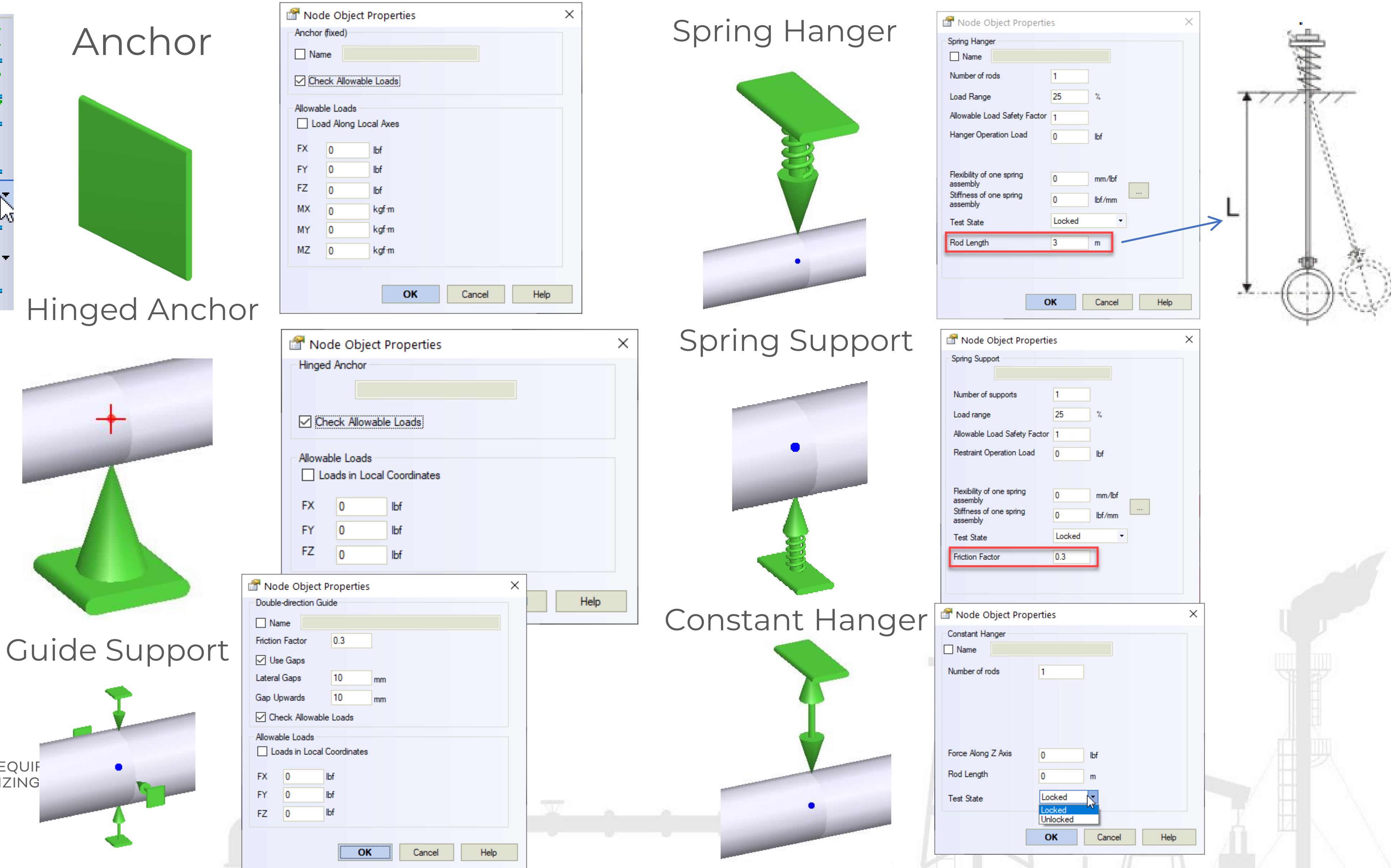




PASS/Start-Prof | Piping Model Creation



- Automatic Variable Spring Selection
- Automatic Constant Spring Selection



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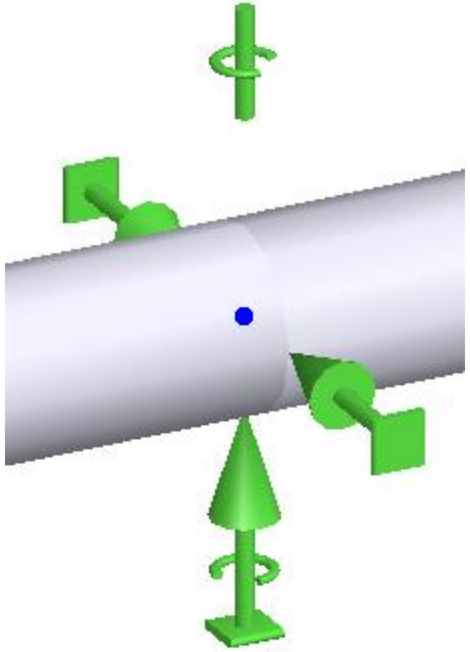
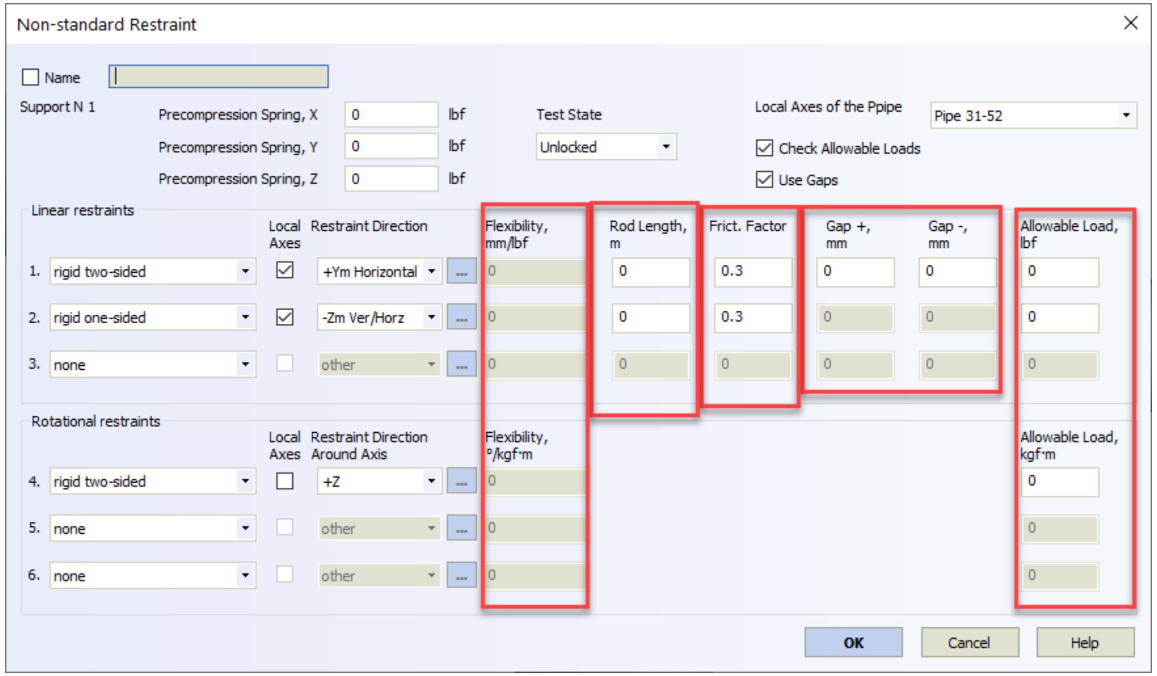
PIPING AND EQUI
ANALYSIS & SIZING

PASS/Start-Prof | Piping Model Creation

Custom Non-Standard Restraint Object





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ANALYSIS & SIZING SUITE

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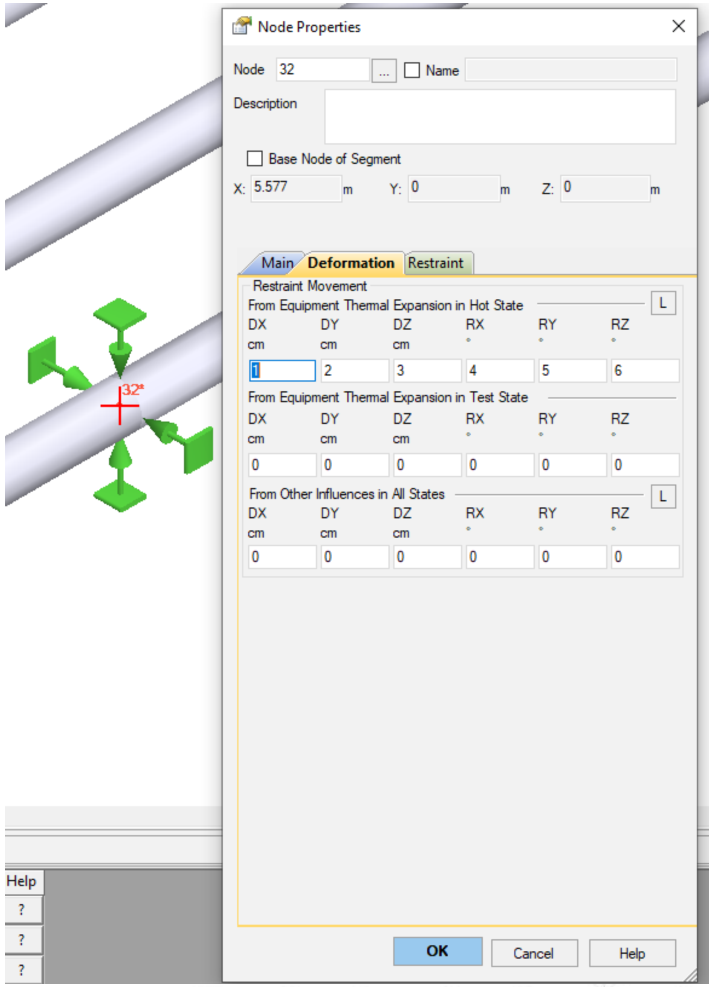
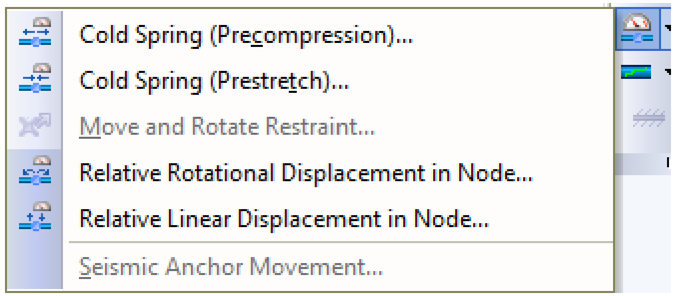
To specify support movement, just add displacement object to the support object





PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

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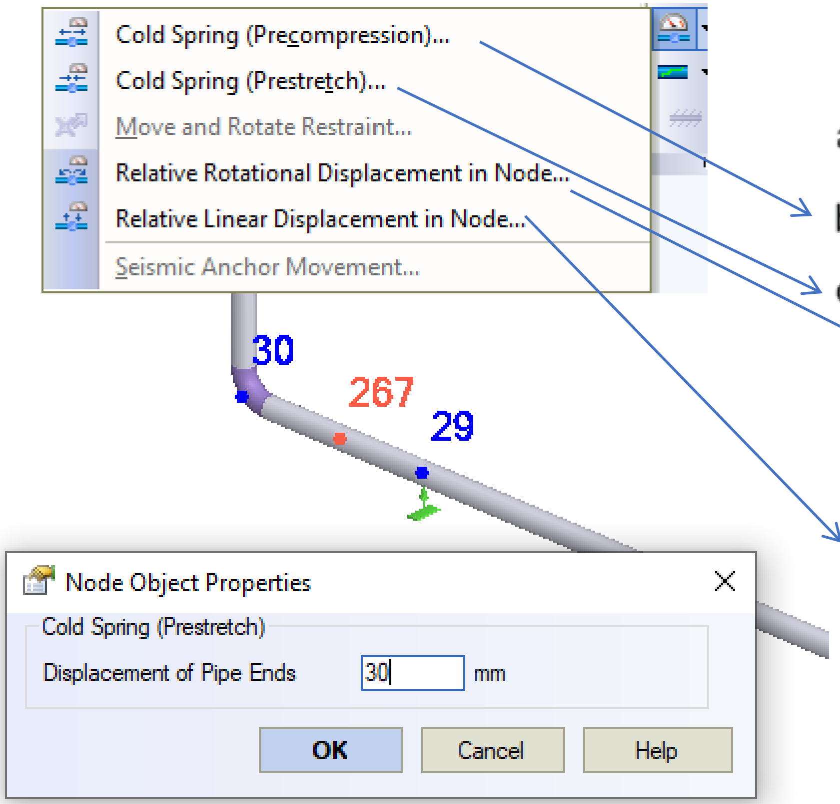
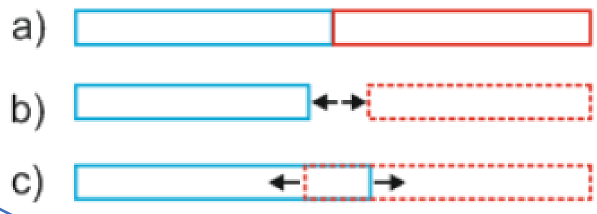
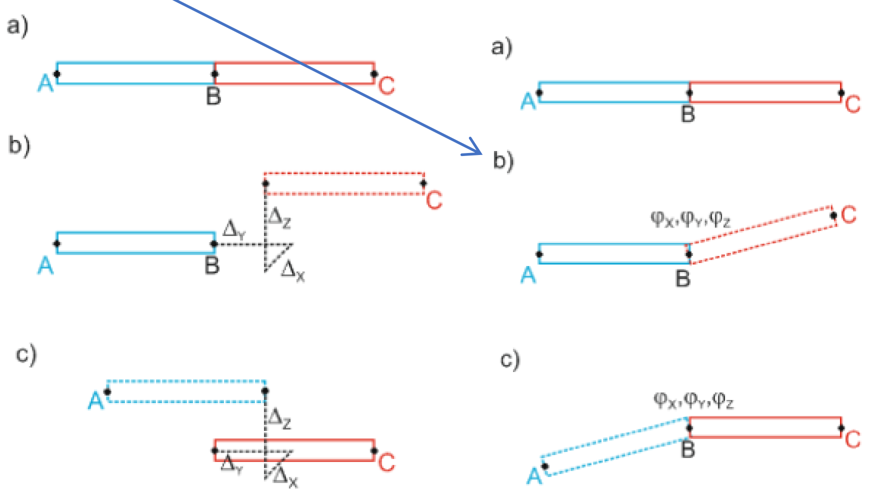
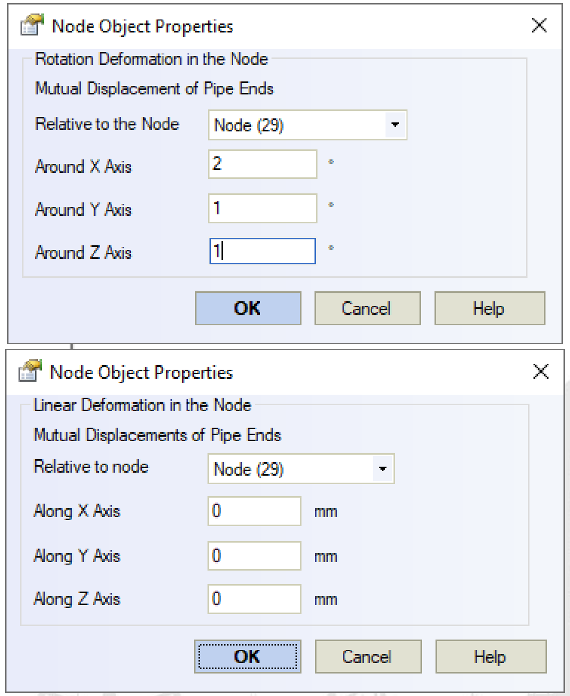
To specify the cold spring (cold pull, pre-stretch), just add the cold spring object in the node

Also pre-compression, and relative rotational or linear displacements of the pipe ends





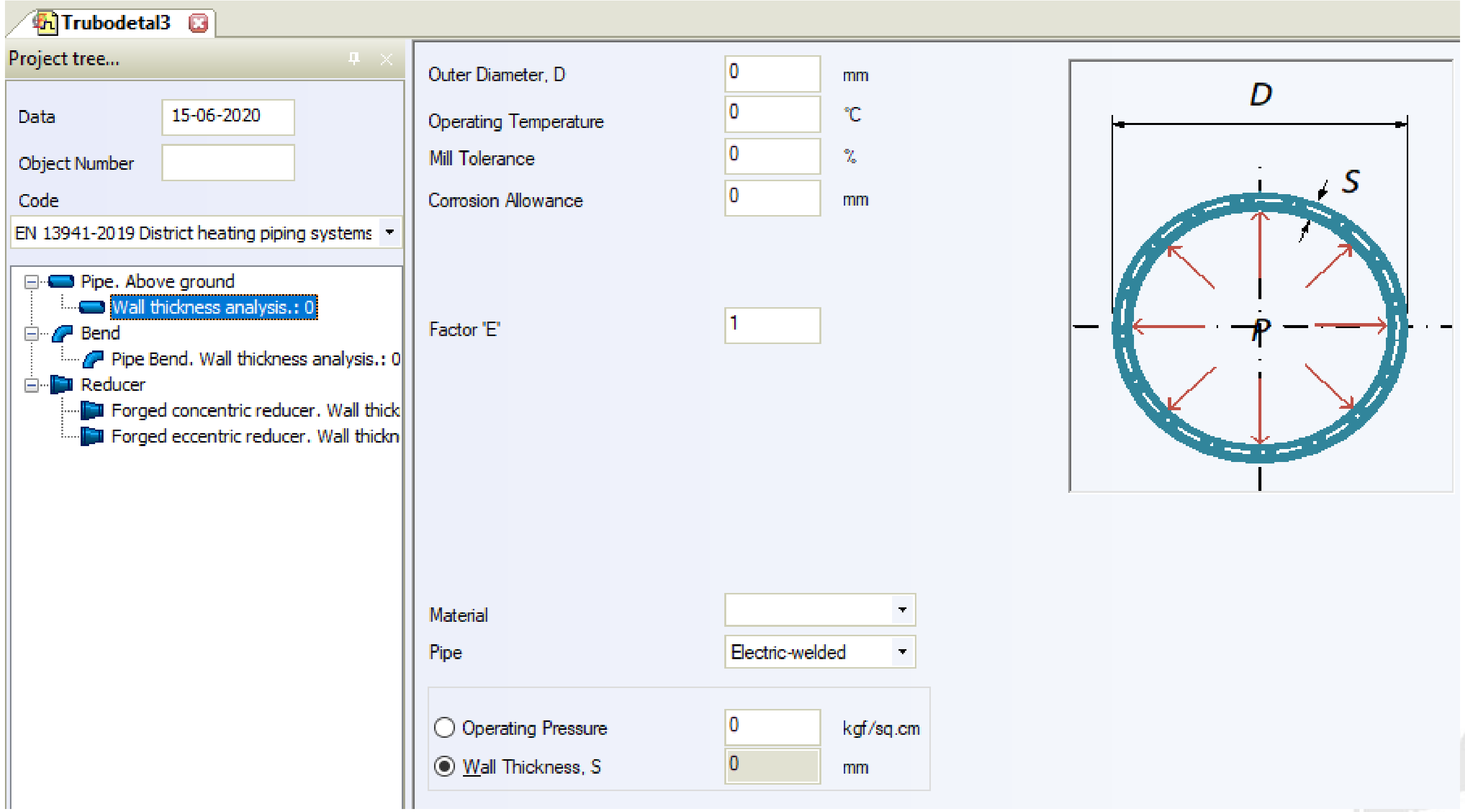




PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

PASS/Start-Prof | START-Elements

Pipe wall thickness calculator and bend wall thickness calculator for all codes



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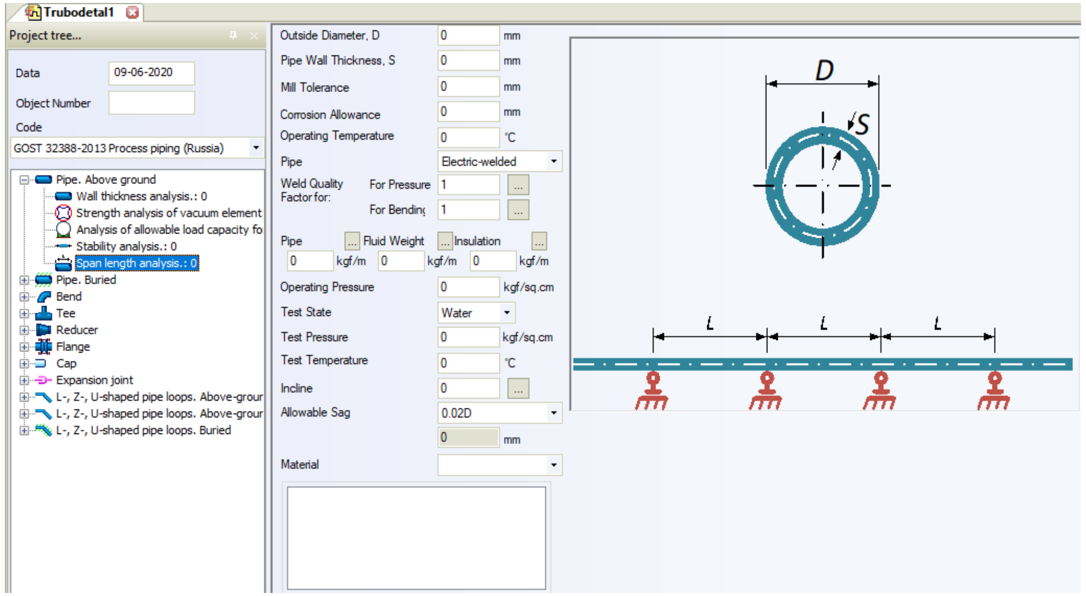
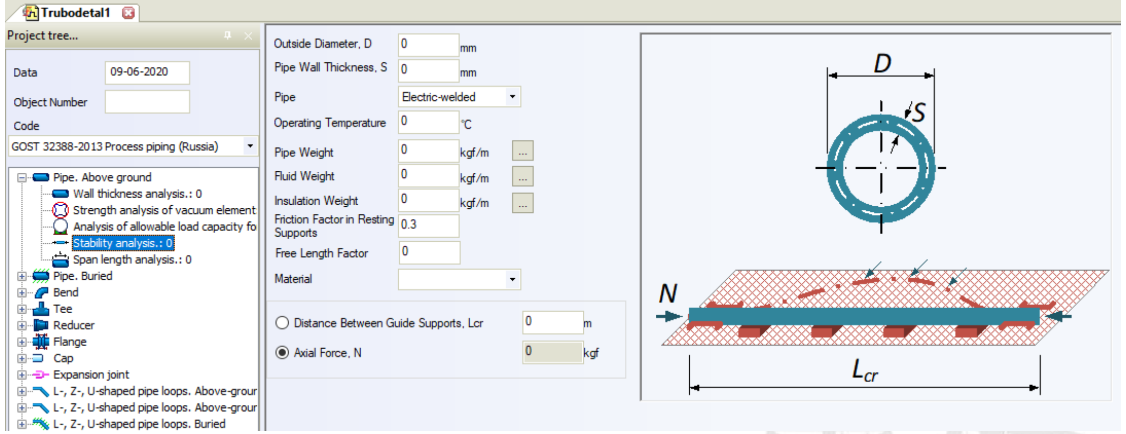
Pipe Span Length Analysis

Longitudinal Stability Analysis





PIPING AND EQUIPMENT
ANALYSIS & SIZING SUITE

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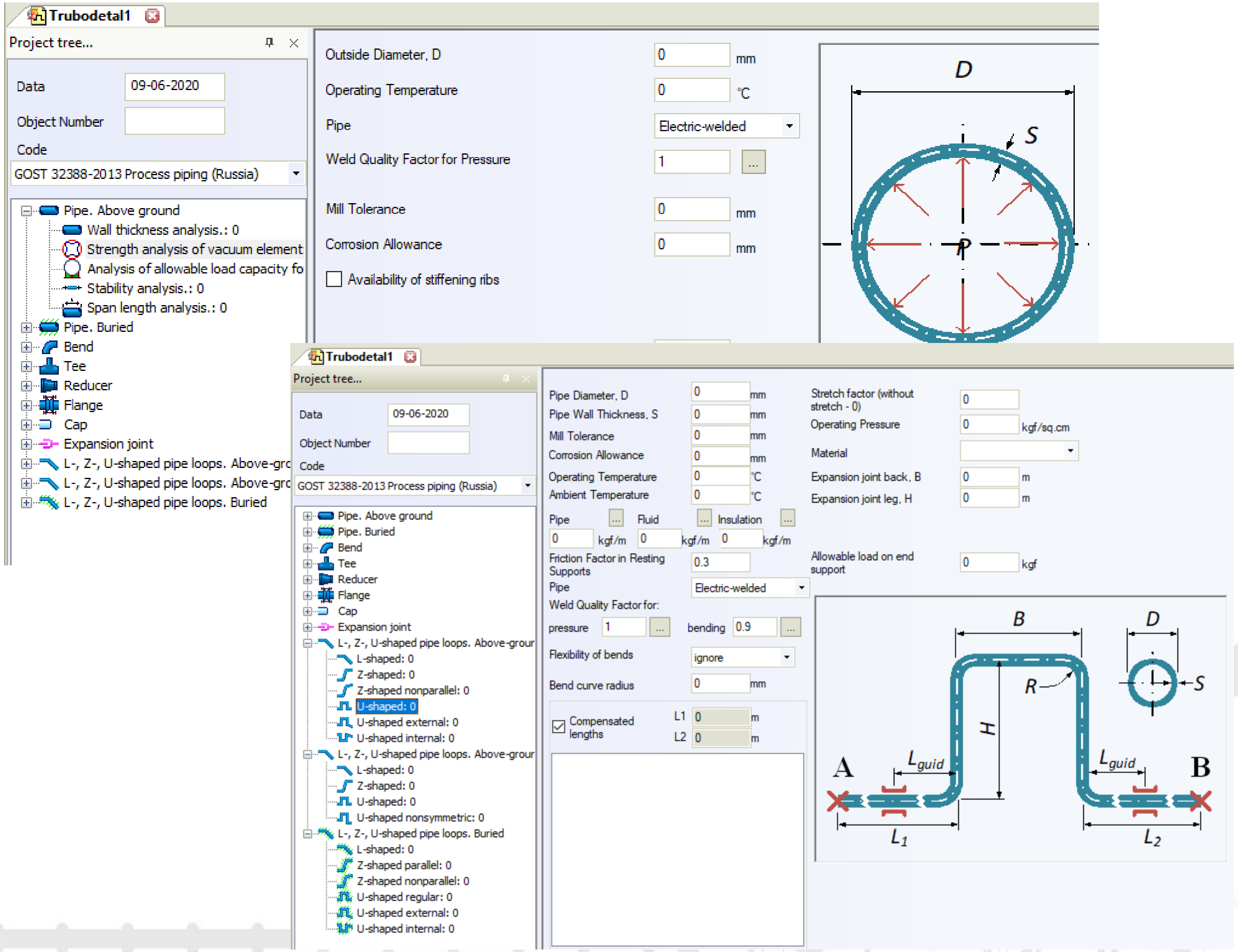
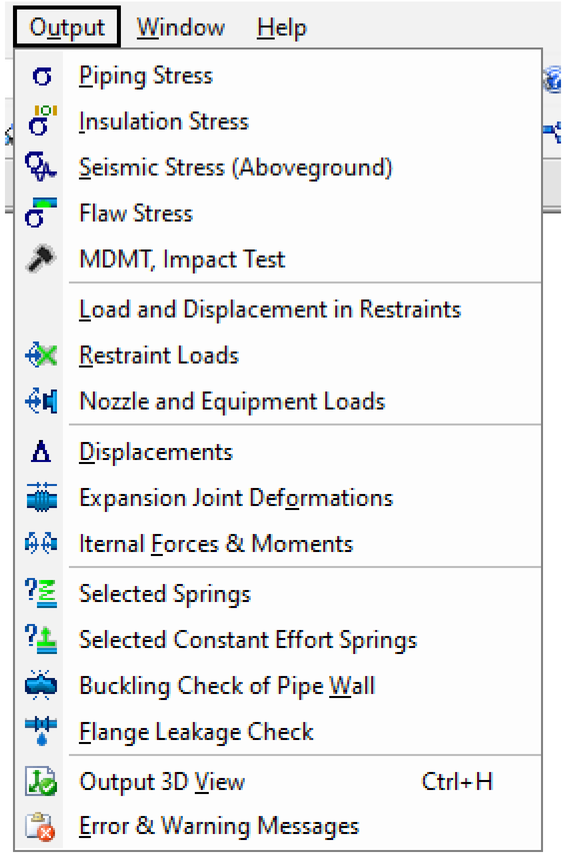
Calculate Wall Thickness Under Vacuum and External Loading

Simple Expansion Loop Analysis



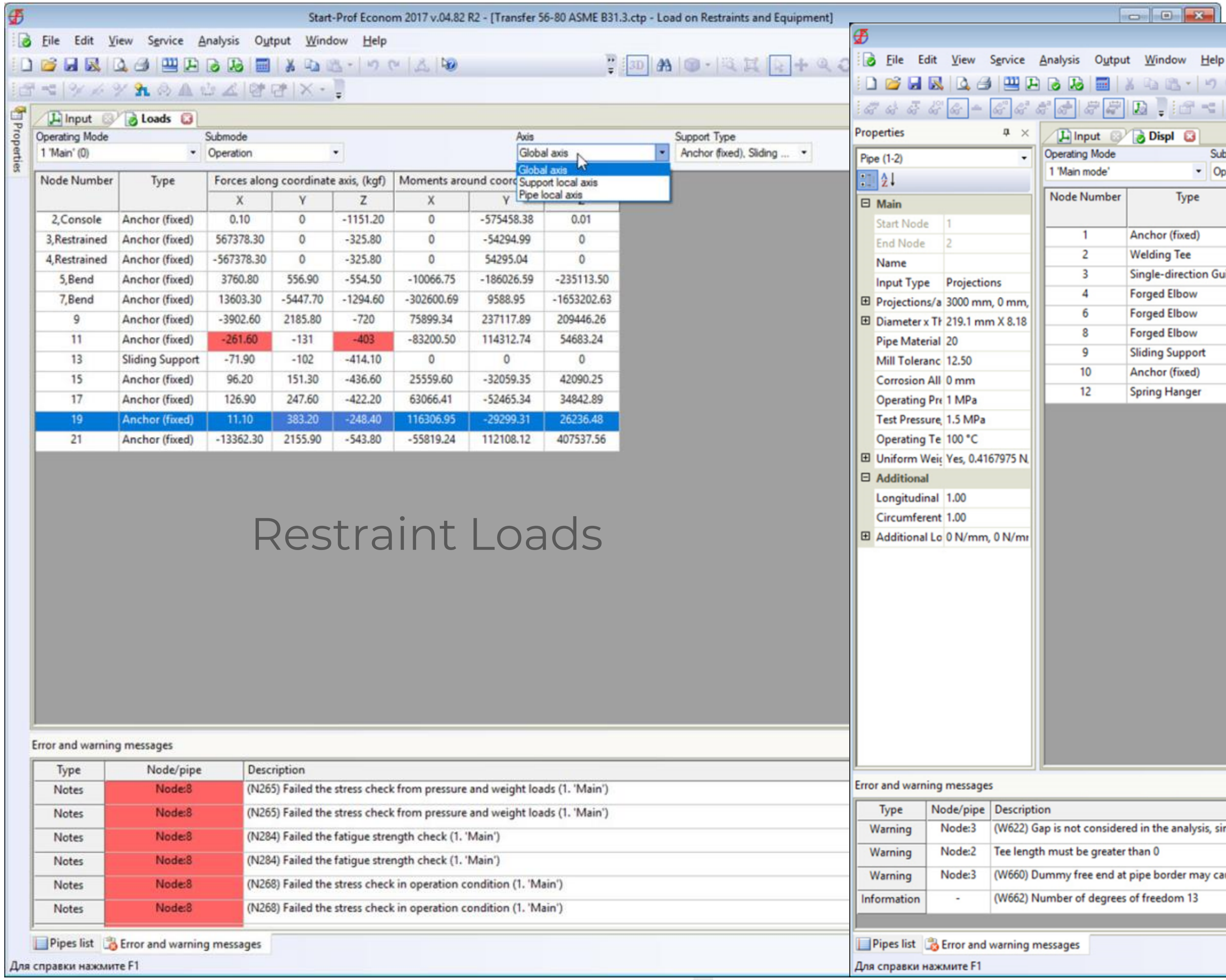
PASS/Start-Prof | Reports

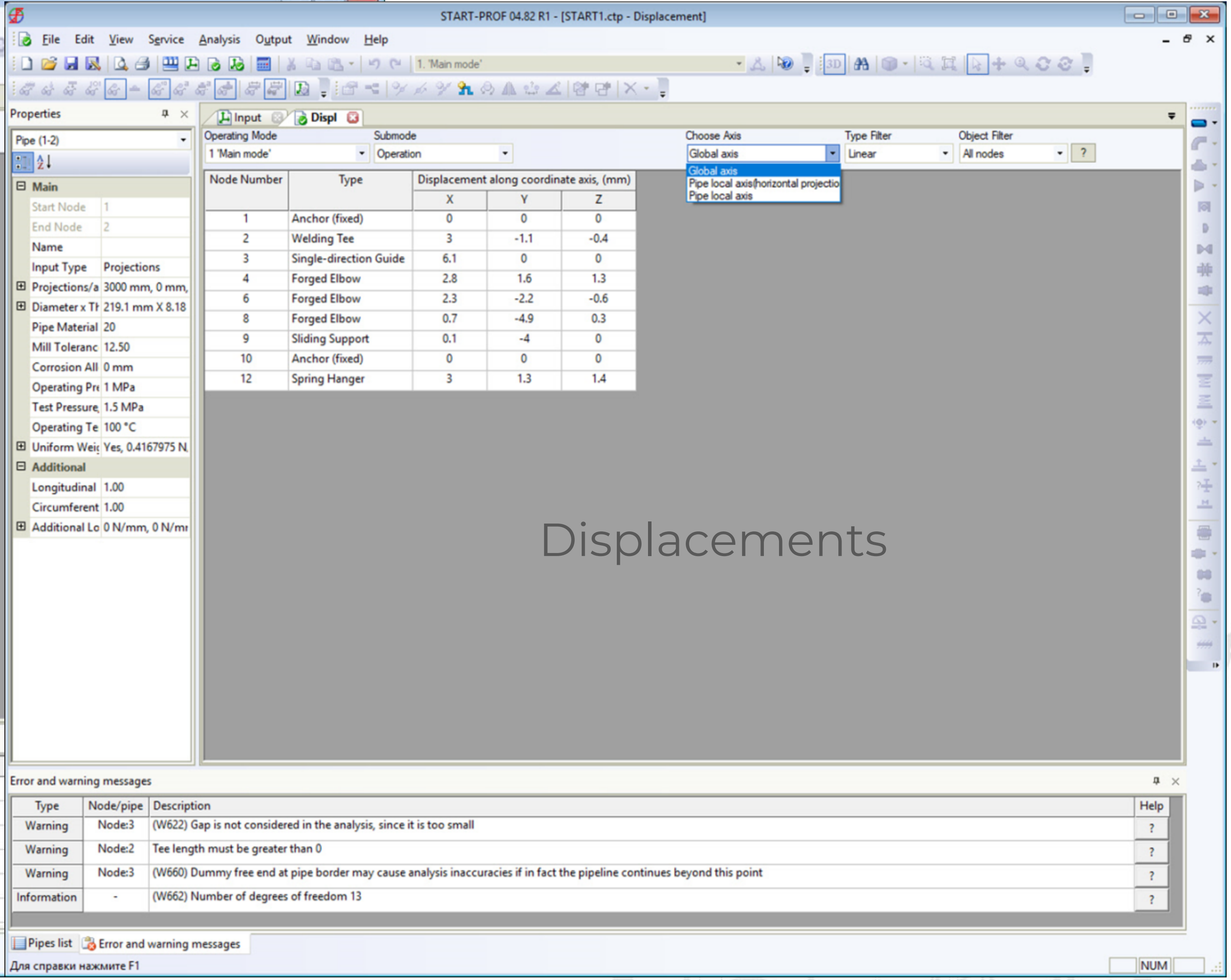
Full scope of the needed interactive reports after analysis



- Reports are interactive. For example, you can add or remove stresses from axial force on-the-fly, change global/local coordinates, add or remove creep stress etc.
- Reports can be copied to MS Excel
- Reports can be exported into MS Word
- Free Viewer is Available
  You can send your piping model to customer, who can open it using viewer and review piping model and all analysis results

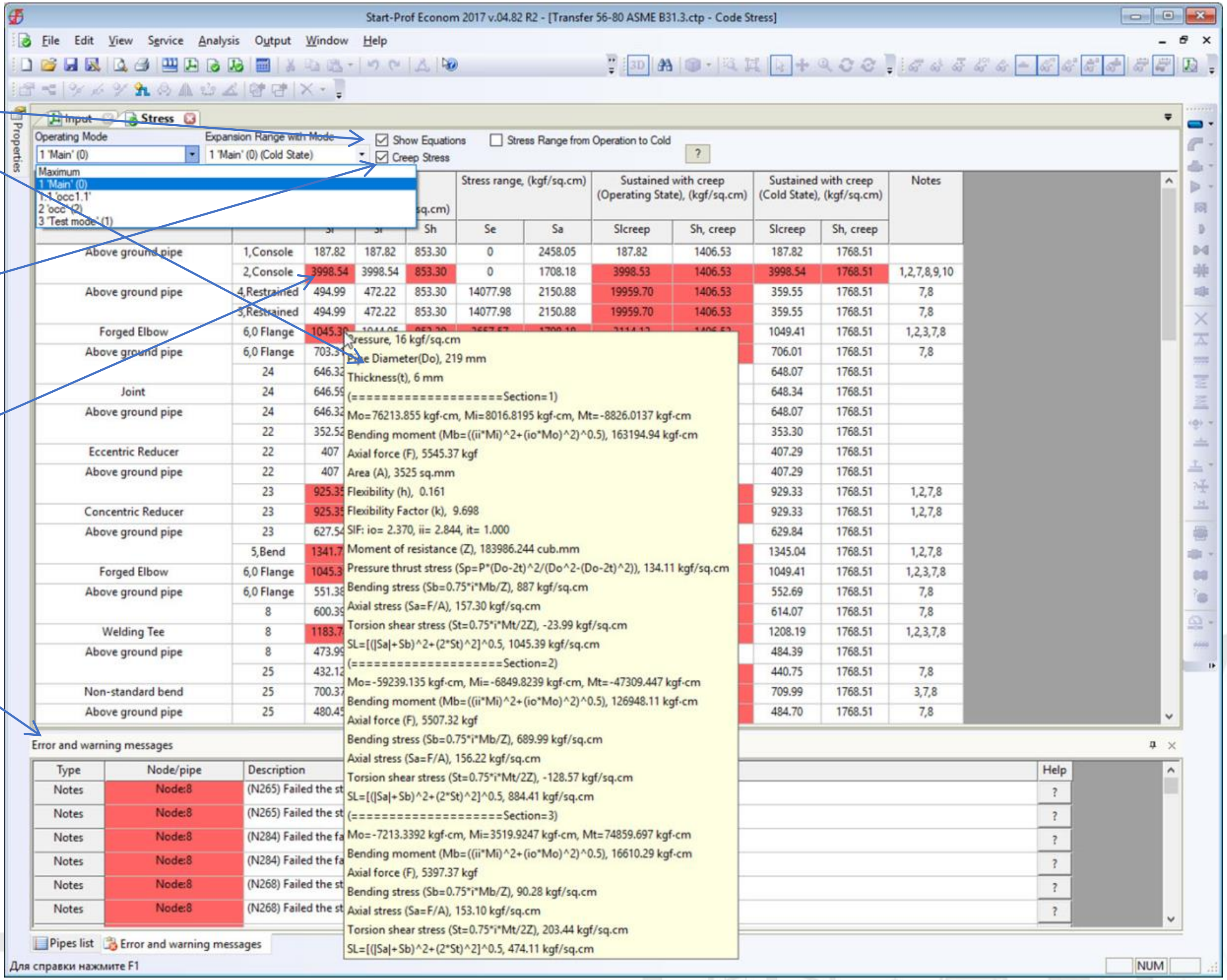
PASS/Start-Prof | Reports





PASS/Start-Prof | Reports

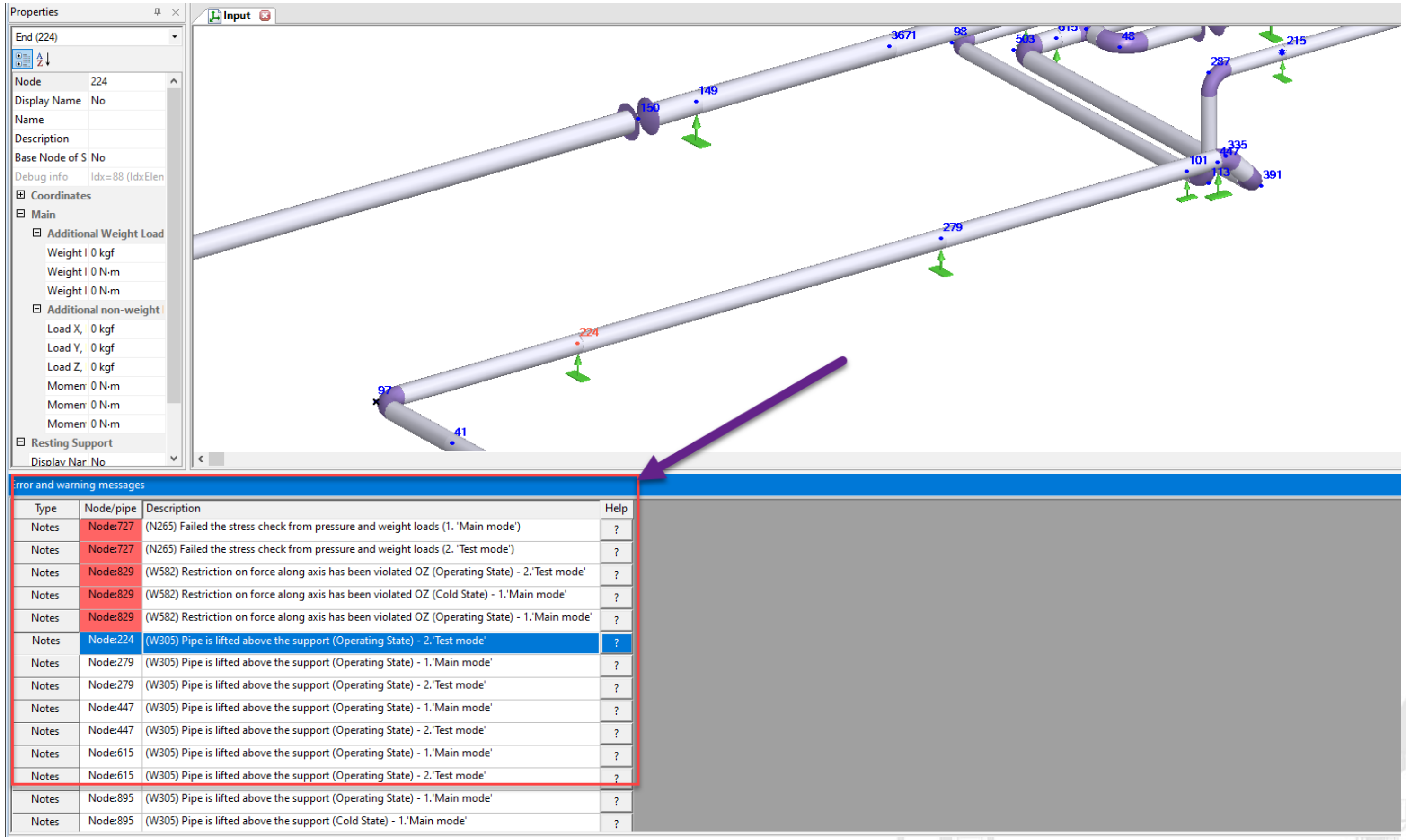
- Stress report show all used equations
- You can add/remove stress from axial force
- Activate individual features for each pipe stress code
- Cells where the check fails has a red color
- Messages about stress check fail duplicated in the errors and warning window



PASS/Start-Prof | Reports

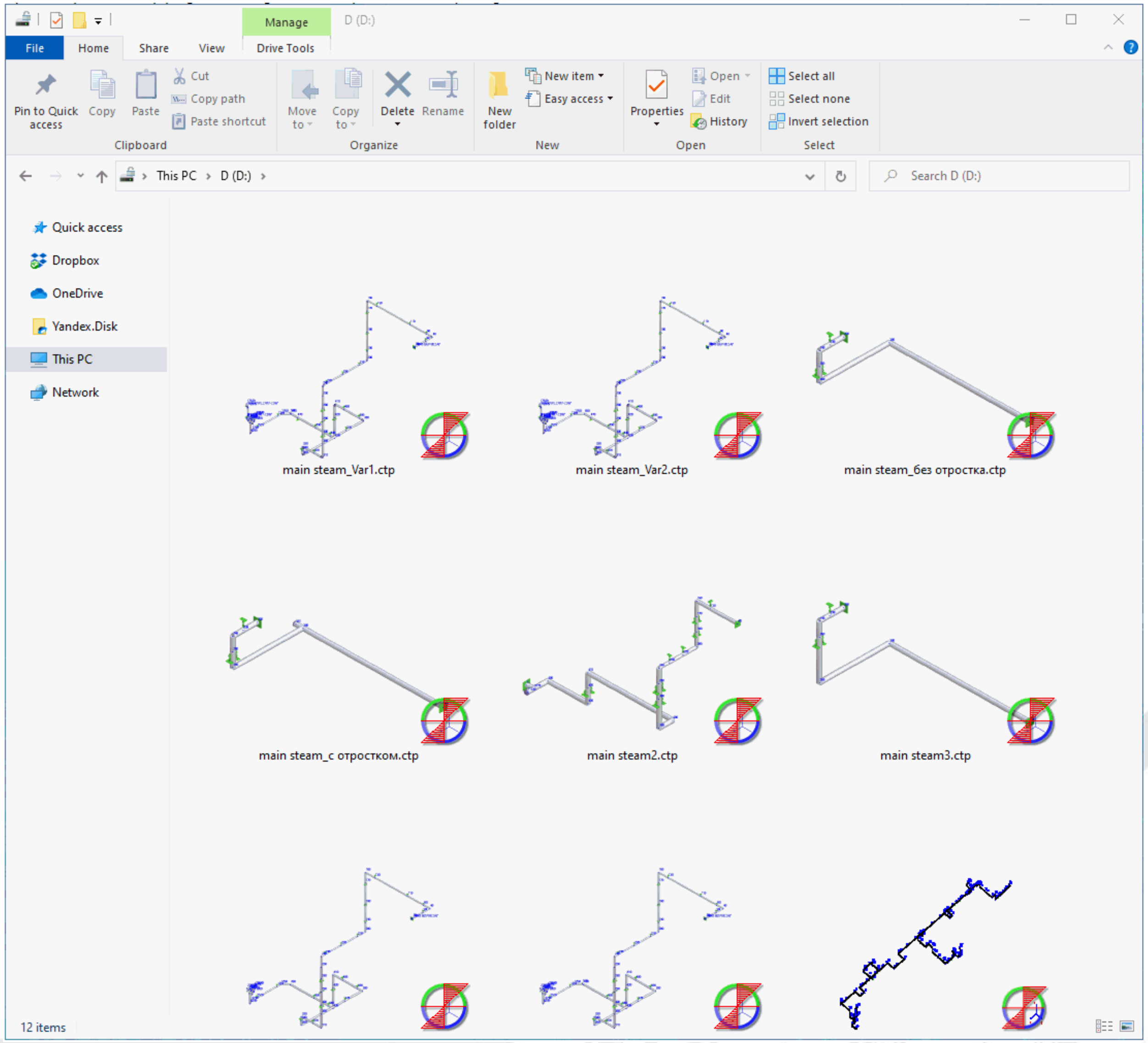
PASS/START-PROF has smart warnings in error checker.

It show all engineering warnings like support is lifting off, support loads are greater than allowable, expansion joint deformation exceed the limits, buckling analysis failed, flange leakage failed, spring hanger variable range greater than 25%, spring load in one of load cases is greater than allowable, rod rotation exceed the limit and many others.



PASS/Start-Prof | Features

- Each piping system project is stored in just one file
- Thumbnails for windows explorer. You can preview all piping models right in the explorer before opening the file
- Fast opening even big models
- High speed of stress analysis and working with a really big models



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ANALYSIS & SIZING SUITE

PASS/Start-Prof | Reliability

Each new PASS/START-PROF release is:

- Automatically verified on more than 300 examples with previous versions (quality assurance system)
- Checked manually with group of pipe stress experts (testers)
- Each release passes through 1-3 pipe stress trainings with 10-20 students before official release
- After release, all bugs reported by 2000 companies of our active users are quickly fixed and new release is provided

PASS/Start-Prof | Licensing

Configurations/Pricing Options

PASS/Start-Prof Complete Advanced

Simulation and sizing for any piping network considering all applicable national codes.

PASS/Start-Prof Complete Standard

configuration includes only worldwide popular standarts.

PASS/Start-Prof Process Advanced

Simulation and sizing for piping networks based on applicable national codes for process plants as well as for gas and oil transportation systems.

PASS/Start-Prof Process Standard

configuration includes only worldwide popular standarts.

PASS/Start-Prof Power Advanced

Simulation and sizing for any piping networks based on applicable national codes for power generation piping as well as for central heating networks.

PASS/Start-Prof Power Standard

configuration includes only worldwide popular standarts.

PASS/START-PROF HDPE+FRP

Piping stress analysis of high density polyethylene and/or fiberglass reinforced plastic piping systems.

- Permanent License at Affordable Price (+1 year maintenance for free!)
- Maintenance Renew 1 Year: 25%
- Annual License: 40%
- Semi-Annual License: 25%

PIPING AND EQUIPMENT ANALYSIS & SIZING SUITE

Configurations Comparison

Code	Complete Advanced	Process Advanced	Power Advanced	Complete Standard (40% discount)	Process Standard (40% discount)	Power Standard (40% discount)	HDPE+FRP (40% discount)
ISO 14692	✔	✔	✔				✔
HDPE Piping	✔	✔	✔				✔
ASME B31.1	✔		✔	✔		✔	
ASME B31.3	✔	✔		✔	✔		
ASME B31.4	✔	✔		✔	✔		
ASME B31.5	✔	✔	✔	✔	✔	✔	
ASME B31.8	✔	✔		✔	✔		
ASME B31.9	✔	✔	✔	✔	✔	✔	
EN 13480	✔	✔	✔	✔	✔	✔	
GB 50316	✔	✔	✔	✔	✔		
GB/T 20801	✔	✔		✔	✔		
GB 50251	✔	✔		✔	✔		
GB 50253	✔	✔		✔	✔		
DL/T 5366	✔		✔	✔		✔	
CJJ/T 81	✔		✔				
RD 10-249-98	✔		✔				
GOST R 55596	✔		✔				
GOST 32388	✔	✔					
SNiP 2.05.06-85	✔	✔					
SP 36.13330	✔	✔					

PASS/Start-Prof | Resources

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- Facebook: www.facebook.com/PASSuite
- Twitter: twitter.com/passuitecom
- More than 50 articles about pipe stress analysis and PASS/START-PROF features https://whatispiping.com/category/start-prof

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

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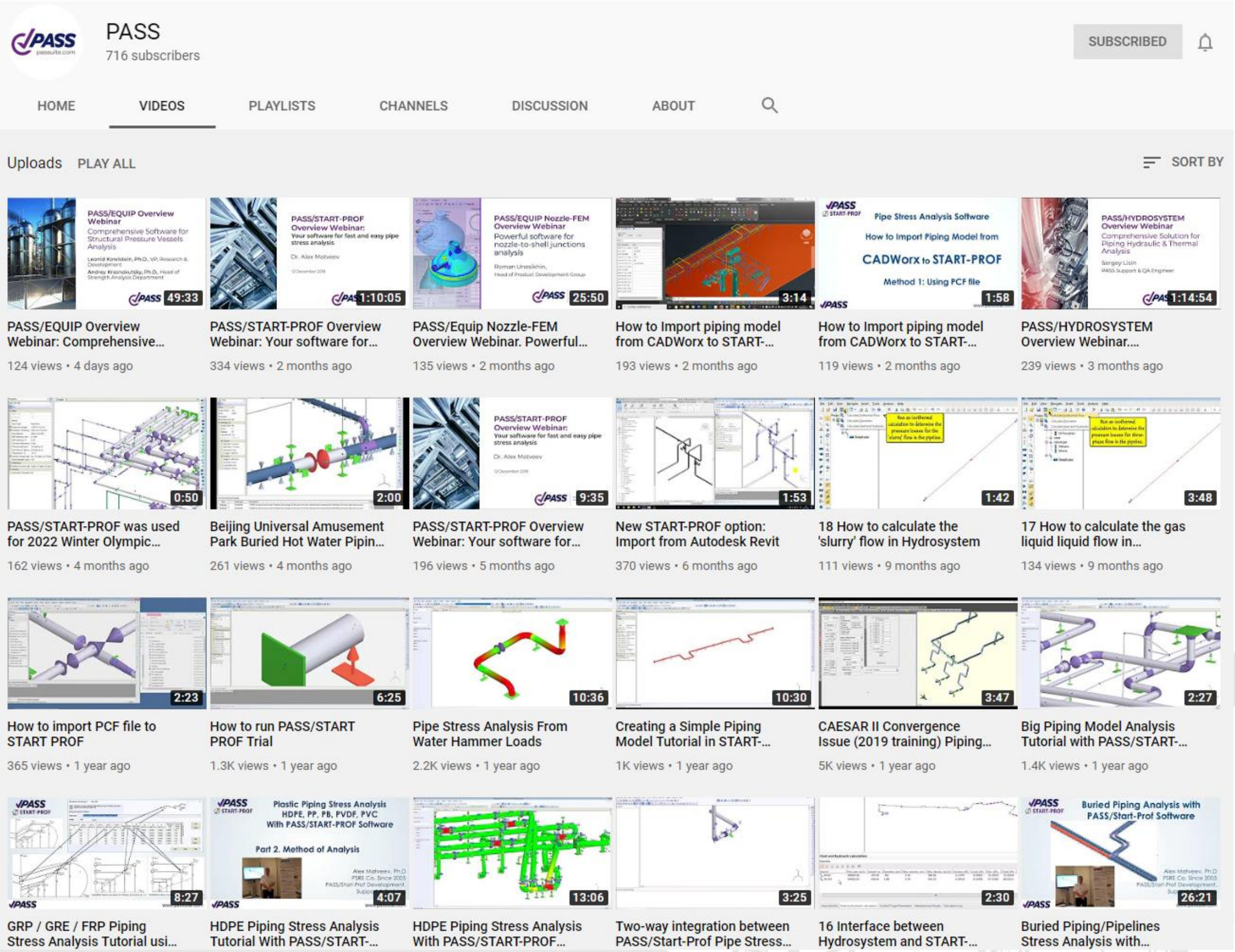

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Thank YOU!