

# Stress Analysis of GRP / GRE / FRP Piping using START-PROF

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GRP / GRE / FRP / HDPE piping modeling in START-PROF is as easy as for steel piping. Your job is only to select the appropriate code and choose the material. That's all!

## Difference between GRE/GRP/FRP and Steel

The main differences of GRP / GRE / FRP piping to steel piping is:

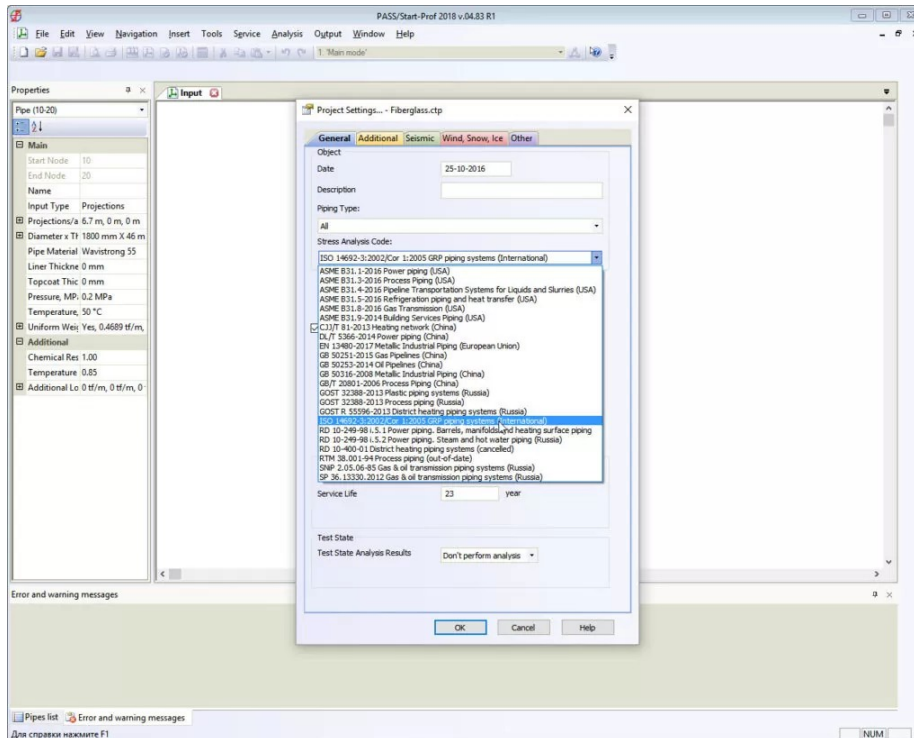
The material is orthotropic. The stress values in axial as well as hoop direction need to be considered during analysis. Mechanical properties needed for analysis differ from steel piping:  $E_a$  – Elasticity modulus in the axial direction,  $E_h$  – Elasticity modulus in hoop direction,  $G$  – Shear modulus,  $\nu_{h/a}$  – Poisson ratio hoop/axial,  $\nu_{a/h}$  – Poisson ratio axial/hoop. Material properties are different for each vendor, so please ask manufacturer for values needed for stress analysis in the database.

Linear expansion for GRP / GRE / FRP piping is much greater than for steel piping. Pressure elongation is significant ([Bourdon effect](#)), and thermal expansion is also great. Due to uneven heating of pipe wall thickness, the real thermal expansion is lower than thermal expansion for the full temperature range. To consider this piping behavior thermal expansion is multiplied by temperature range factor that is usually considered as 0.85.

Long-term failure envelope is used instead of single allowable stress. See the material database for more details. Allowable stresses depend on load type factor  $f_2$ , temperature factor  $A_1$ , chemical resistance factor  $A_2$ , fatigue factor  $A_3$ . A different envelope is used for pipes and fittings.

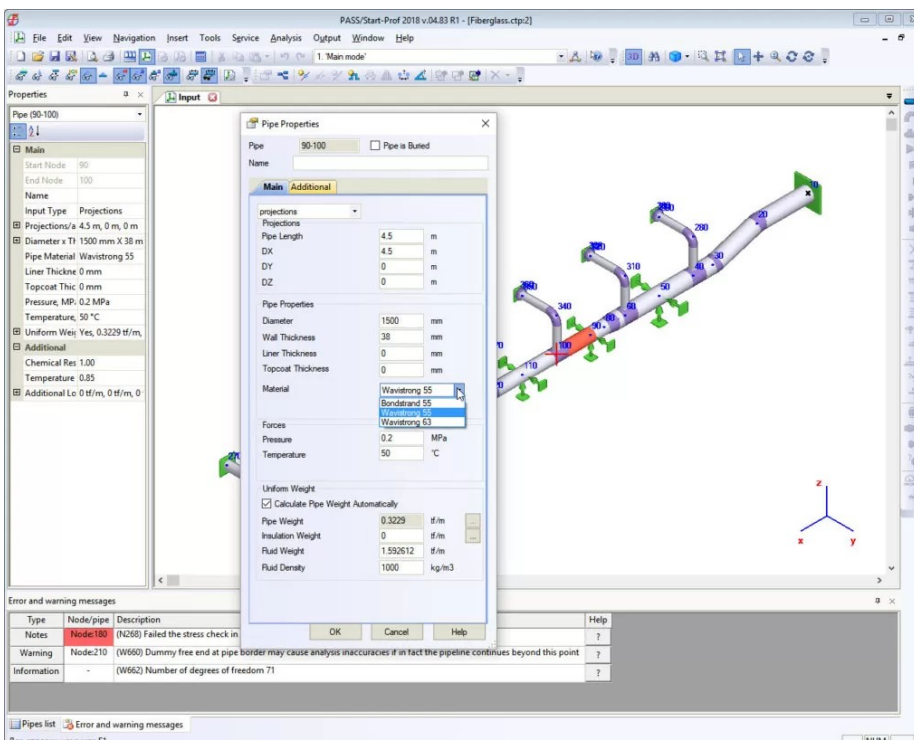
# Modeling of GRP / GRE / FRP / Reinforced HDPE Piping using PASS/Start-Prof

To model GRP / GRE / FRP piping choose **ISO 14692** code. This code is also suitable for modeling of reinforced HDPE or other plastic piping:



**Selecting the piping code for Analysis**

Then select material from the database:



**Selecting the Material Database**

That's all. All other job is the same as for steel piping.

The material Database contains all material properties. If there's no material you need in the database, please ask your vendor to fill the table and add it to the database manually. Future pipe industries and NOV already provided needed data and it is included in the START-PROF database.

The screenshot displays the 'Mechanical Properties of Material' window for 'Material: Wavistrong 55 Class FRP'. It includes a table of material properties and three diagrams illustrating failure envelopes for fittings and joints at different radii (r=1 and r>1).

Temperature °C	all(0-1), kgf/sq.cm	all(1-1), kgf/sq.cm	all(1-1), kgf/sq.cm	all(2-1), kgf/sq.cm	all(2-1), kgf/sq.cm	qs bend.reducer, kgf/sq.cm	qs tee.noise, kgf/sq.cm	Ea, kgf/sq.cm	Eh, kgf/sq.cm	G, kgf/sq.cm	Expansion Coeff. 1/°C	Poisson factor Vh/a
20	325	0	0	625	1250	800	640	105000	205000	115000	0.00002	0.65
40	325	0	0	625	1250	800	640	105000	194750	109250	0.00002	0.65
60	325	0	0	625	1250	800	640	91350	184500	103500	0.00002	0.65
80	325	0	0	625	1250	800	640	77610	180910	101490	0.00002	0.65
100	293	0	0	563	1125	720	575	92200	170150	95450	0.00002	0.65
120	261	0	0	501	1000	640	515	70000	147000	88400	0.00003	0.64

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### Sample Failure Envelope for GRE/GRP/FRP

All load cases for the ISO 14692 code will be created automatically. Just draw piping. After analysis, you get results according to ISO 14692 code.

The screenshot shows the 'Input Stress' window with a table of analysis results and two stress equations. A small table at the top right defines loading types and their corresponding factors.

Loading type	Load duration	f <sub>2</sub>	Example of loading type
Occasional	Short-term	0.89	Hydrotest
Sustained including thermal loads	Long-term	0.83	Self-mass plus thermal expansion
Sustained excluding thermal loads	Long-term	0.67	Self-mass

Object	Start End node	Weight+Pressure Stress in Hot State, (MPa)				Weight+Pressure +Expansion Stress in Hot State, (MPa)				Weight+Pressure +Expansion Stress in Cold State, (MPa)				Notes
		hoop direction	allowable	axial direction	allowable	hoop direction	allowable	axial direction	allowable	hoop direction	allowable	axial direction	allowable	
Above ground pipe	10	3.81	83.75	11.11	22.69	3.85	103.75	8.17	27.90	0.06	103.75	12.40	26.99	
	20	3.81	83.75	3.72	22.69	3.85	103.75	0.77	27.90	0.06	103.75	4.10	26.99	
Forged Elbow	20	10.92	53.60	8.34	26.80	5.89	66.40	2.30	33.20	9.23	66.40	10.40	33.20	
	30	3.81	83.75	4.62	22.69	3.85	103.75	1.23	27.90	0.06	103.75	4.96	26.99	
Above ground pipe	30	3.81	83.75	5.73	22.69	3.85	103.75	7.19	27.90	0.06	103.75	3.41	26.99	
	30	14.12	53.60	11.11	26.80	20.62	66.40	16.01	33.20	5.78	66.40	6.80	33.20	
Above ground pipe	30	3.82	83.75	5.33	22.69	3.85	103.75	6.80	27.90	0.11	103.75	2.98	27	

$$\sigma_{h,sum} \leq f_2 \cdot A_1 \cdot A_2 \cdot A_3 \cdot \sigma_{qs}$$

$$\sigma_{a,sum} \leq f_2 \cdot A_1 \cdot A_2 \cdot A_3 \left[ \left( \frac{\sigma_{qs}}{2} - \sigma_{al(0:1)} \right) \frac{\sigma_{h,sum}}{\sigma_{qs}} + \sigma_{al(0:1)} \right]$$

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### Output Results after Analysis

Also, we did a job for the vendor of MRPP pipes to add material properties into the START-PROF database for 50-year service life and now START-PROF used for stress analysis of MRPP piping.

MRPP – a HDPE pipe, reinforced by a rigid steel carcass made of a welded wire.



**MRPP Pipes**

# Stress Analysis Methodology

The complete video explaining the stress analysis methodology using Start/Prof is given below for your quick reference.

<https://youtu.be/KftZl5rmcHc>

[Download the FRP piping example file.](#) See [how to open the piping model file.](#)



**Alex Matveev**

Alex Matveev is one of the authors of pipe stress analysis codes GOST 32388-2013 Process Piping, and GOST 55596-2013 District Heating Networks. He is also one of the developers of PASS/Start-Prof software, which is developed since 1965 and used in 95% of process, power, district heating, gas and oil transportation design companies in Russia and CIS countries; it is a standard de facto in that region