VACUUM INSULATED TUBING

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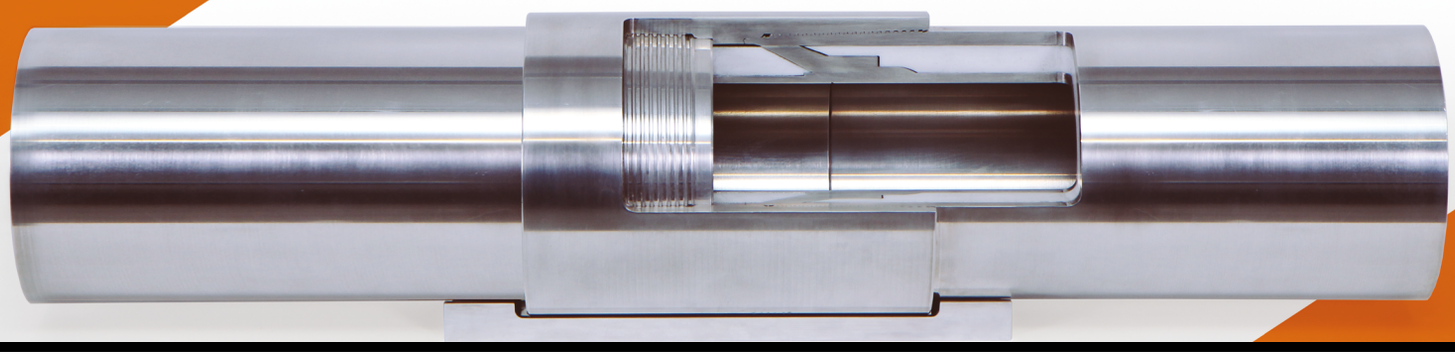
Vacuum Insulated Tubing (VIT) is designed to develop oil and gas fields located in the most challenging oil and gas production conditions in the permafrost and/or in zones characterized by gas hydrate / paraffin deposition, high viscosity of extracted hydrocarbons.



TIMELINE OF VIT DEVELOPMENT IN TMK

Type of thermal insulation	Design features	Performance specifications
	Since 2010	
Vacuum Insulated Tubing Vacuum shield thermal insulation	In accordance with the design, a shield of foil and basalt fiber fabric (together with gas absorbers) is installed in the annular space. Vacuum is created in the annular space. A fluoroplastic coupling insert is placed inside the coupling. "Pre-stressing" of the internal pipe is performed in the VIT designed for operation at high temperatures.	Operating temperature: up to +350°C Operating pressure: up to 16MPa Thermal conductivity (K-factor) along the pipe body, W/(m*K): up to 0.012 (+220°C), up to 0.02 (+350°C) Thermal conductivity (K-factor) of the fluoroplastic coupling insert, W/(m*K): up to 0.25 **The pipes are used for the following:** • Prevention of wellbore thawing in permafrost zones • Prevention of formation of gas hydrate, asphalt, resin, and paraffin depositions • Injection of superheated fluids into the reservoir in order to heat up high-viscosity oils during development by cyclic steam heating methods (including such as CSS and SAGD)
	Since 2015	
Non-Vacuum Insulated Tubing Insulation with inorganic thermal insulation materials	In accordance with the design, a shield of foil and basalt fiber fabric is installed in the annular space. A fluoroplastic coupling insert is placed inside the coupling. The design was developed with account of additional requirements of our customers – oil companies.	Operating temperature: up to +180°C Operating pressure: up to 16MPa Thermal conductivity (K-factor) along the pipe body, W/(m*K): up to 0.03 (+50°C), up to 0.06 (+180°C) Thermal conductivity (K-factor) of the fluoroplastic coupling insert, W/(m*K): up to 0.25 **The pipes are used for the following:** • Prevention of wellbore thawing in permafrost zones • Prevention of formation of gas hydrate, asphalt, resin, and paraffin depositions • Injection of superheated fluids into the reservoir in order to heat up high-viscosity oils during development by cyclic steam heating methods (including such as CSS and SAGD)

KEY PERFORMANCE AND TECHNICAL PARAMETERS OF VIT

Performance parameters	Limit value
Operating temperature, °C	up to +350
String length, max	determined by calculation and depends on the type of threaded connection
Thermal conductivity coefficient (k–factor) along the pipe body, max	see table below
Thermal conductivity coefficient (k–factor) of coupling insert, max, W/(m*K)	0.25

Indicator	Non–Vacuum		Vacuum	
VIT operating temperature, °C	up to +50	up to +180	up to +220	up to +350
K–factor, W/(m*K)	0.03	0.06	0.012	0.02

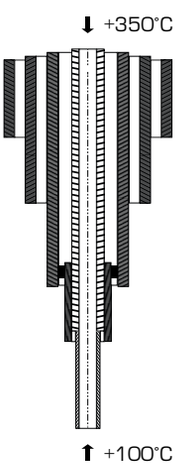
Technical parameters	Limit value
Residual air pressure in the annular space, max, mm Hg	$8*10^{-2}$ Pa ($6*10^{-4}$)
Pipe length, m	10–11.7*
Weld seam requirements	The seams should be heat treated
Hydrotesting	VIT with made up couplings is subjected to hydrotesting at R = 0.8 σ_T
Grades	Carbon (55–95 ksi); 13Cr (80 ksi)
Charpy test	Not less than 50 J/cm^2 at –60°C

*based on customer requirements we can produce pipe with the length of 6–10 m

APPLICATION OF VACUUM INSULATED TUBING

⬆ +100°C

- Prevention of wellbore thawing in permafrost zones
- Prevention of formation of gas hydrate, asphalt, resin, and paraffin depositions



⬇ +350°C

- Injection of superheated fluids into the reservoir in order to heat up high–viscosity oils during devel–opment by cyclic steam heating methods (including such as CSS and SAGD)

VIT PRODUCTION PROCESS

Rolling, heat treatment, testing,measure cutting, surface cleaning

Assembly of the external and the internal pipe

Welding of the external and the internal pipe with vacuum-tight seams

Inspection of the weld joints

Creation of vacuum in the VIT at the exhaust cart and tightness testing of the weld joints

Thermal conductivity testing and finishing of VIT

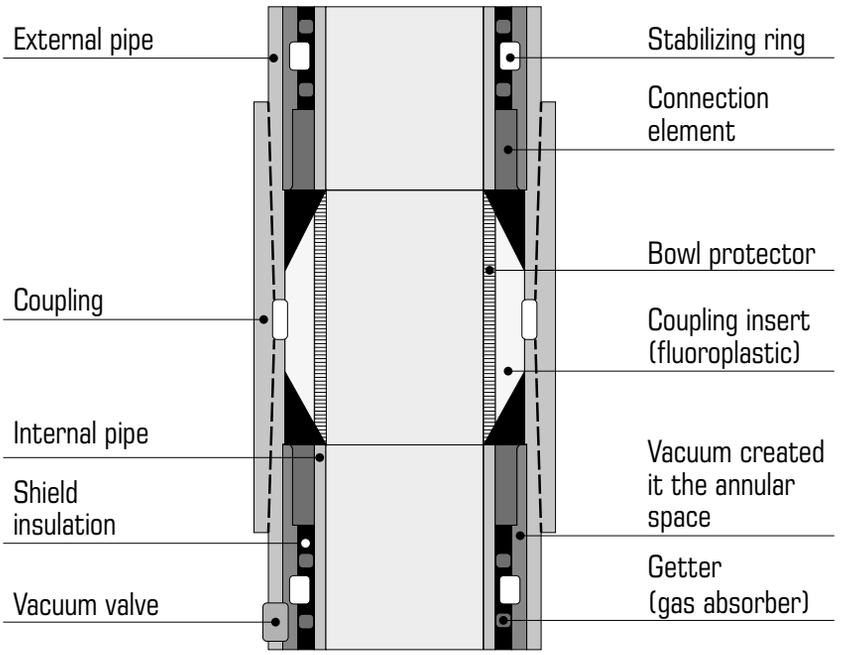
PRODUCT MIX

VIT size	External supporting pipe		Internal pipe	
	OD, mm	WT, mm	OD, mm	WT, mm
9 5/8 x 0.395 – 6 5/8 x 0.352	9 5/8	0.395	6 5/8	0.352
7 x 0.317 – 5 1/2 x 0.304	7	0.317	5 1/2	0.304
7 x 0.408 – 5 x 0.296	7	0.408	5	0.296
7 x 0.362 – 5 x 0.296	7	0.362	5	0.296
6 5/8 x 0.352 – 5 x 0.296	6 5/8	0.352	5	0.296
6 5/8 x 0.352 – 4 1/2 x 0.290	6 5/8	0.352	4 1/2	0.290
6 5/8 x 0.352 – 4 1/2 x 0.271	6 5/8	0.352	4 1/2	0.271
6 5/8 x 0.352 – 4 x 0.262	6 5/8	0.352	4	0.262
6 5/8 x 0.352 – 4 x 0.226	6 5/8	0.352	4	0.226
5 3/4 x 0.374 – 4 x 0.262	5 3/4	0.374	4	0.262
5 3/4 x 0.374 – 4 x 0.226	5 3/4	0.374	4	0.226
5 1/2 x 0.361 – 4 x 0.262	5 1/2	0.361	4	0.262
5 1/2 x 0.361 – 4 x 0.226	5 1/2	0.361	4	0.226
5 1/2 x 0.361 – 3 1/2 x 0.254	5 1/2	0.361	3 1/2	0.254
5 x 0.362 – 3 1/2 x 0.254	5	0.362	3 1/2	0.254
5 x 0.296 – 3 1/2 x 0.254	5	0.296	3 1/2	0.254
4 1/2 x 0.271 – 3 1/2 x 0.254	4 1/2	0.271	3 1/2	0.254
4 1/2 x 0.271 – 2 7/8 x 0.217	4 1/2	0.271	2 7/8	0.217
4 1/2 x 0.250 – 3 1/2 x 0.254	4 1/2	0.250	3 1/2	0.254
4 1/2 x 0.250 – 3.268 x 0.197	4 1/2	0.250	3.268	0.197
4 1/2 x 0.250 – 2 7/8 x 0.217	4 1/2	0.250	2 7/8	0.217
4 x 0.262 – 2 7/8 x 0.217	4	0.262	2 7/8	0.217
4 x 0.226 – 2 7/8 x 0.217	4	0.226	2 7/8	0.217
3 1/2 x 0.256 – 2 3/8 x 0.197	3 1/2	0.256	2 3/8	0.197
3 1/2 x 0.254 – 2 3/8 x 0.190	3 1/2	0.254	2 3/8	0.190
3 1/2 x 0.256 – 1.900 x 0.157	3 1/2	0.256	1.900	0.157

☐ Developed product mix

☐ Product mix that is currently being developed

BASIC VIT DESIGN (VACUUM SHIELD THERMAL INSULATION)



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