Overview of trunk pipeline practice in Russian permafrost

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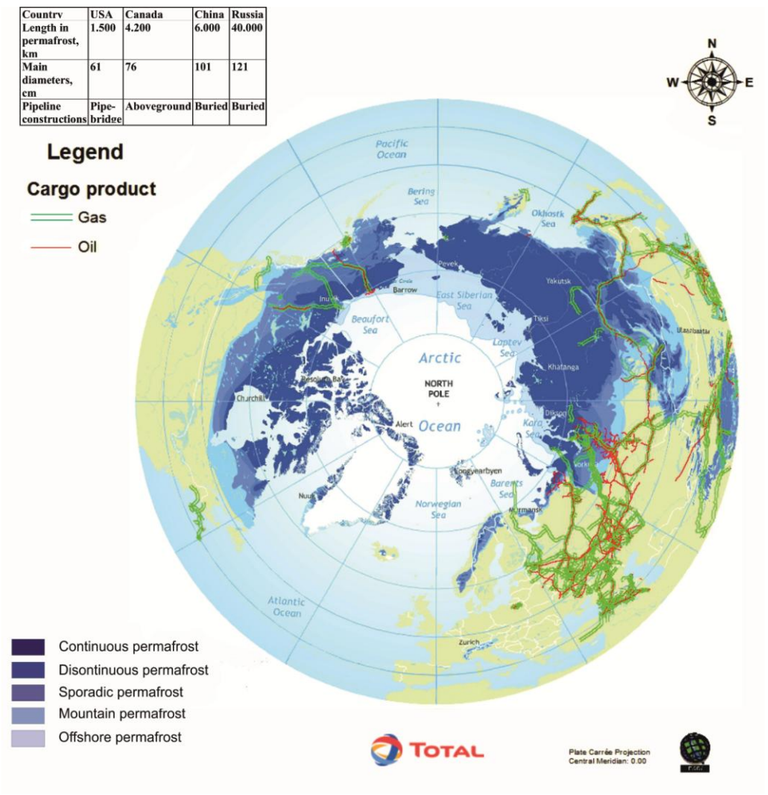
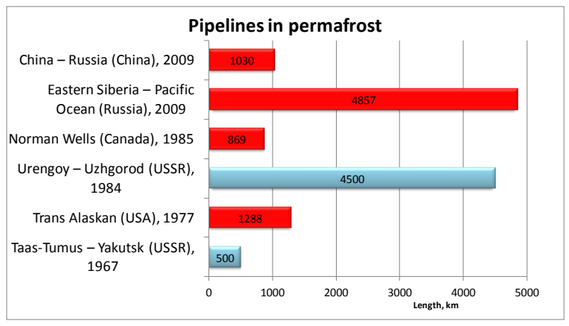
Location of pipelines

Country	USA	Canada	China	Russia
Length in permafrost, km	1.500	4.200	6.000	40.000
Main diameters, cm	61	76	101	121
Pipeline constructions	Pipe-bridge	Aboveground	Buried	Buried

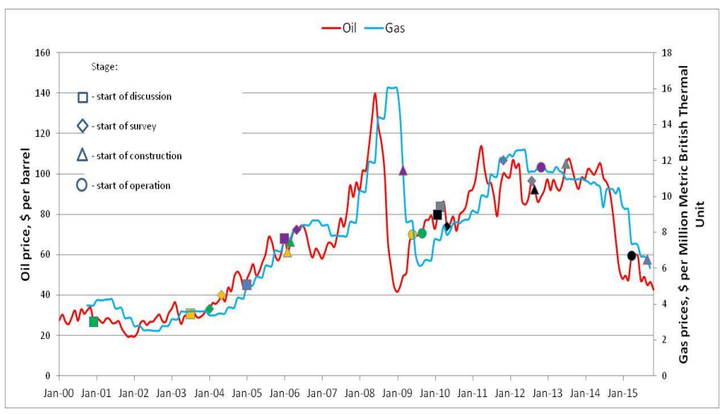


Actuality

Benchmark of Russian pipelines in permafrost → Summary of main tendencies, approaches and developed techniques → Implementation of the best decisions in the Total's Arctic projects



New generation of Russian pipelines : in XXI century more than 35,000 km of pipelines have been set in operation



Pipeline construction boom in Russia since 2000. The different pipelines are marked by different colors: **ESPO, Zapolyrye - Purpe,** Kuyumba - Taishet (expected start of operation - 2016), Vankor - Purpe, Power of Siberia (expected start of operation - 2019), Bovavenkovo - Ukhta

Permafrost challenges for pipeline

Coastal erosion

Uplifting of buried gas pipeline

Icing along pipeline

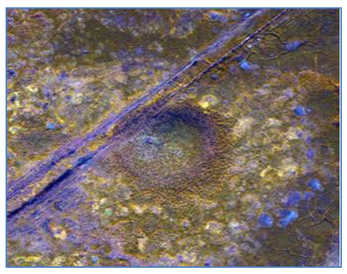
Frost heave of pipeline supports (piles)

Subsidence of pipeline support (piles)

Thawing of ice wedges

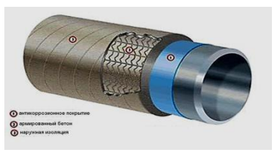
Thermoerosion

Bogging along pipeline

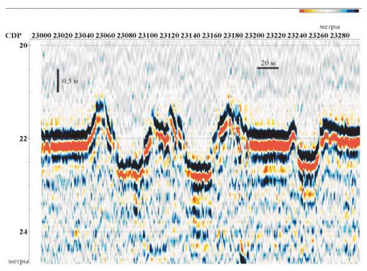


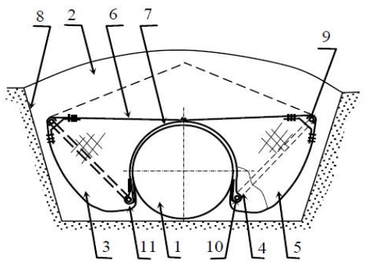
Frost mound (pingo)

Construction of Arctic offshore pipeline (Baydara Bay)



The concrete solidification of offshore pipes (Popov et al., 2013)





The special polymer-container ballasting staff in coastal zone (Shishkin, 2014)

Iceberg exaration (Mironyuk, 2014). Depth is up to 2 m (Ermolov, Pryadilin, 2013)

Reconstruction of oil pipeline in permafrost

Planning

2004-2008 – survey
2006-2009 – construction
2015-16 – reconstruction

Facts

Permafrost warming on 0.1-0.5 C (Smirnov, 2012)
•Height of new frost mounds – 1.0-1.5 m (Vasilchuk et al, 2011);
•Critical pipeline deformation development.

Initial design

•Continues ice-rich permafrost
•820 mm diameter
•0-219 km – pipe-bridge laying
•220-543 km – buried laying
•Artificial ground cooling – the main way of permafrost stabilization

BUT

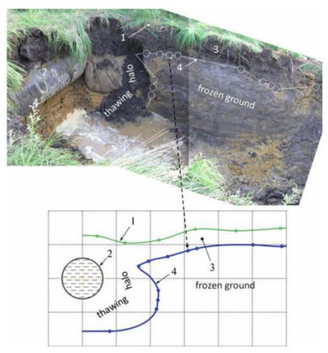
Low efficiently of artificial ground cooling.
In 40% of cases the real temperature is lower than designed.

Reconstruction after 6 years of operation

•2015 - 19,000 ton of new pipe (**19 billion rub**) have been bought for pipeline reconstruction;
•2015 - capital reconstruction of 265-288, 305-325, 330-343 360-383, 405-435 and 507-511 km sections of pipeline (**350 million rub**);
•**Relaying of pipeline on southern section?**
•Additional installation of 3500 thermosyphones on the northern section (**35 million rub**).

Monitoring

Remote non-destructive control (acoustic and magnetic tomography)



THM validation for pipeline (Novikov et al., 2015)

Main tendencies in Russian pipeline practice in permafrost

1. The main pipeline laying out way in Russian permafrost is buried now. The pipe-bridge way with thermal heat pipes have been implemented only for the ice-rich continuous permafrost.
2. The widespread application of buried pipelining leads to development of compensators for pipe couplings.
3. For buried gas pipeline the diversity of ballasting and anchorage staffs are development for providing of pipeline stability and uplifting prevention.
4. The development of pipe insulation technology, include heat insulation and corrosion protection.
5. Decreasing of role of artificial ground cooling by thermosyphons (Vankor – Purpe pipeline – 65,000 thermosyphones, ESPO –only in Pumping Stations).
6. The development of construction technology of water transition of pipeline in permafrost (concrete solidification pipes, micro tunneling).
7. The increasing importance of pipeline strain monitoring at operation stage leads to safety operation
8. The development of regulation-standard base
9. The innovation (techniques, materials, thermoinsulation) applications in design, construction, and operation
10. The active application of THM modeling in pipeline practice at survey and operation stages