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ANALYSIS OF GAS PIPELINE GEOTECHNICAL SYSTEMS INTERACTION WITH THE ENVIRONMENT

SUMMARY. This article shows an interaction between technical and natural environments, resulting in abnormal conditions of gas transportation system. Description is based on experimental data derived during long-term geotechnical monitoring which was performed by the staff of "TyumenNIIgiprogas", LLC. In addition to measuring of soil temperature and frost heave, the analysis of spatial contingency of geosystem with geotechnical conditions has been performed.

The analysis of the first section of the gas-main pipeline allows to describe a joint between types of packing which serves as a relieving zone for water blocked by banking.

The second section of the gas-main pipeline of underground packing type with using of cantledge is regarded as a compensator in the turfed valley depression. Fixation of gas pipeline's body in the frozen mineral sides of turfed area without sufficient deepening in and gas pipeline's shallow entrance into peat caused the increase in the depth of seasonal freezing, formation of permanent snowdrift and pipeline floating to the surface.

KEY WORDS. Gas pipeline, geotechnical system, frost heave, temperature data logger, stability.

The main pipelines at their considerable length in a variety of landscape conditions form a complex combination of geotechnical systems (GTS), of direct and back links in them. The diversity, the scale of landscape contrast conditions, and as a consequence, the structure and links within the GTS determine the sustainability of the transportation system and the environment [1-3].

Objects and methods of research results

The article provides a detailed analysis of the interaction between the two sections of the pipeline with the host medium based on instrumental analysis of the spatial distribution of cryogenic processes, the dynamics of the thermal field and the processes of frost heaving.

Temperature conditions of soils were verified at planned intervals (once every two months), in some wells temperature measurements were taken every day, according to the experience [4] and requirements [5-6] for the work. Temperature measurement in wells was performed by thermistor chains TC-10.10 with measurement record by software and hardware measuring complex "Logger LPC-m», measurement inaccuracy is equal to 0,1°C.

The first test section of the pipeline is laid in permafrost loamy soils of IV lake-alluvial plain [7-8]. The vegetation cover is defined by the next associations: from lichen larch (on well-drained surfaces) to grass-moss-lichen low marshes with thermokarst depressions (boggy slopes). Flow shallows are confined to the peaty valleys of streams with nardly distinguishel watercourses, merging down the slope to form permanent streams.

At sites without permafrost rock, the underground laying method is selected with pipe lining under concrete cantledge weighting. In the flow valleys with permafrost areas, the ground-based lining method is adopted, with sections of aerial crossings over channels. Within the analyzed sector of the main pipeline, the types of lining are changed, with cantledges, weighting the pipeline, are placed above ground level in arched state.

Pipeline installation led to the blocking and redistribution of the flow in two directions: the right one with water discharge at the site where the type of lining is changed from the underground to the surface type (50 m along the axis of line up to the overlap) and the left one, where the discharge of water occurs along the base of the mound (Fig. 1).

Figure 1. The sector of changing the types of gas pipeline: the underground (at the top) and ground (middle part). The arrows indicate the direction of flow, red colour indicates zones of water discharge through MG

To monitor the status of GTS in the area with cantledges denudation, the thermal wellsites (TW) are installed (Fig. 2), outside the zone of thermal gas influence (TW1-56), in the areas of thermal influence with the effects of frost heave (TW1 and TW1-57-58) as well as in the selvage (TW1 and TW1-55-59), outside the spread of soil heaving.

The soil profile outside the thermal effect of the gas pipeline TW1-56 is presented by the unfrozen sandy-loam soils with the depth of seasonal freezing of 0.9-1.0 m. The average temperature of soil in the section is 1,5°C.

Section of the pipeline with denudated cantledges (TW1-57, TW1-58) is located on the thawed ground at the depth of seasonal freezing of 1 m. The average temperature of soil in the section is positive and equals to 0,9°C to 1,0°C.

At the selvage of the wetland (20-30 m from the section with denudated cantledges, TW1-55, TW1-59), the gas pipeline is located in the plastic frozen heaving soils. The average temperature of the frozen soil, which is below the layer of seasonal thawing is from -0,2°C (TW1-55) to 0,4°C (TW1-59), and the depth of seasonal thawing was 2 m. Thus, the area with cantledges rests at the edges on heaving high-temperature frozen soils.

Figure 2. Location of observation thermal wellsites in the area of cantledges denudations (central part of space image)

The analysis of flow direction [9] and the ground temperature during the period of observation shows that there is an unstable state of the thermal regime of soils due to the location of the heaving section in the area of surface water discharge. The value of the gas pipeline heaving according to technical leveling within a five- year period amounted to 70 mm.

The variability of the temperature field in time is accounted for the non-linearity of the reduction reaction of the environment, expressed in the variability of the thermal field in steady conditions of GTS technical core (pipeline) operation.

The second, the test section of the main pipeline of underground installation with cantledges is an expansion joint in the peaty valley-like slide, covered with grass-moss colony, with the width of 130 m, is characterized by the presence of unfrozen peat array of up to 3 m. The morphological features of permafrost heaving are lacking [9-10]. Icy mineral mounds covered with moss-shrub and larch-birch grouths are located only on the slopes to the peaty valley-like depression.

When creating the expansion joint, the top parts of frozen mineral mounds are cut, the edge sections of the expansion joint are on the frozen ground, and the central part is the floated condition with cantledges and impound.

To monitor the GTS in the section of cantledges denudation the TW (Fig. 3) are set, outside the influence of the thermal gas (TW1-40), in the central part of the peaty valley-like depression TW1-39, TW1-41, TW1-42 and TW1-43 as well as on its sides TW1-38, TW1-44, TW1-45 on cut frozen mineral hills.

In TW 1-40 (outside the thermal effect of the pipeline), the average temperature of the soil along the section is 1,7°C. Permafrost rocks are absent, the seasonally frozen layer (SFL) is 1.2 m (Fig. 4).

The cut in the central part of the peaty valley-like depression (TW1-41, 42) and on the section of pipeline with cantledges denudation (TW1-43) to the depth of 3 m is made up of water-saturated silty sands underlain by low-plastic loam soil with the temperature higher than 1°C. TW1-42 uncovered lens of semi-decomposed heavily ice-covered frozen peat up to 3.5 m. While removing from the gas pipeline, the mass of frozen soil is degrading (Fig. 5).

The depth of soil freezing in the pipeline is up to 4 m, in the summer-autumn period the high-temperature frozen ground stays at the depth of 2 to 3 meters at the temperature of about -0,1°C. At 3 m from the pipeline in the TW1-41 frozen soils are not available, while the depth of soil freezing is 1 m.

In the area of cantledges denudation (TW1-43), at the depth interval of 1 to3 m lies ice soil. The average temperature of the frozen soil layer below the seasonal thaw level is minus 0,3°C (Fig. 6).

Landscape position TW1-39 (Fig. 7), description of the cut, as well as the variation of temperature is similar to the previous one (TW1-43).

TW-45 and TW-44 are located at a distance of 0.75 and 1.9 m from the gas pipeline in the selvage of the wetland - instead of loamy icy frozen heaving mounds. Permafrost rocks are spread to the depth of 6 m. The depth of seasonal thawing is 2-2.5 m (Fig. 8 and 9). During the observation period there was an increase in average temperature of permafrost rock from -0.4 to -0,1°C, which indicates the degradation of permafrost.

Analyzing isobathytherms in wells close to the pipeline (TW1-38 TW1-39, TW1-42, TW1-43, TW1-45) and at some distance from it (TW1-41, TW1-40, TW1-44), we can conclude that the depth of freezing depends on the pipeline with impound, i.e. pipeline promotes heat exchange of soil and the atmosphere, increasing the depth of frost penetration and reduces the average ground temperature, which leads to seasonal heaving soils. Observations of deformation showed the buckling of pipeline of 100 to 200 mm (average of 45 mm per year).

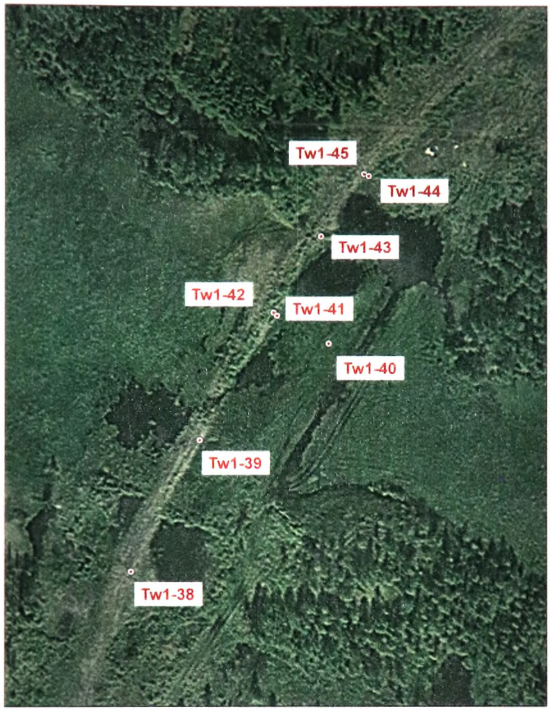

Figure 3. Location of observation thermal wellsites on the site

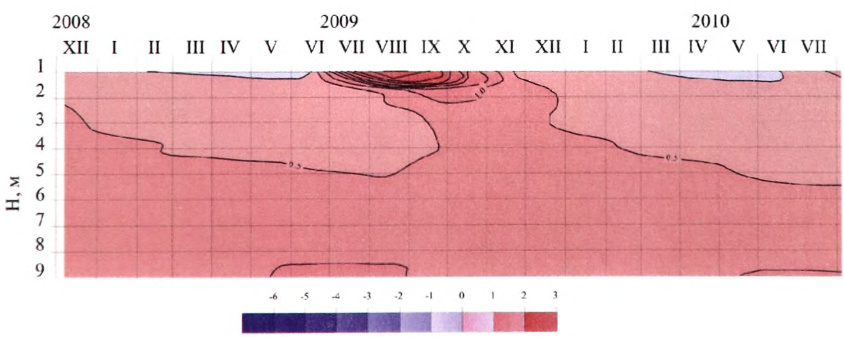

Figure 4. Isobathytherms in the well TW1-40

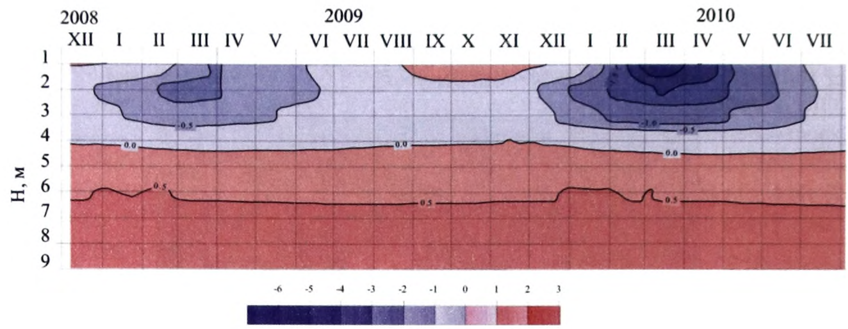

Figure 5. Isobathytherms in the well TW1-42

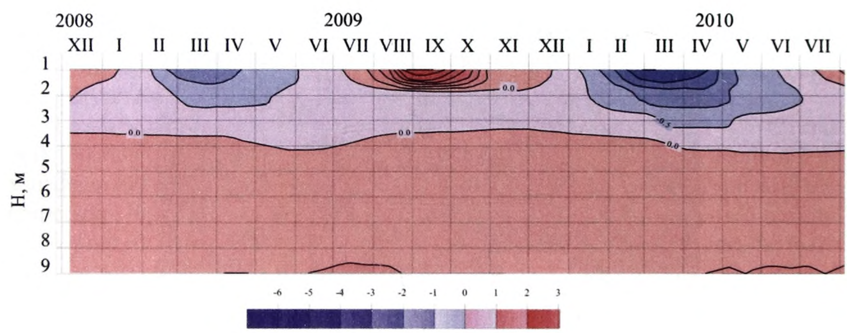

Figure 6. Isobathytherms in the well TW1-43

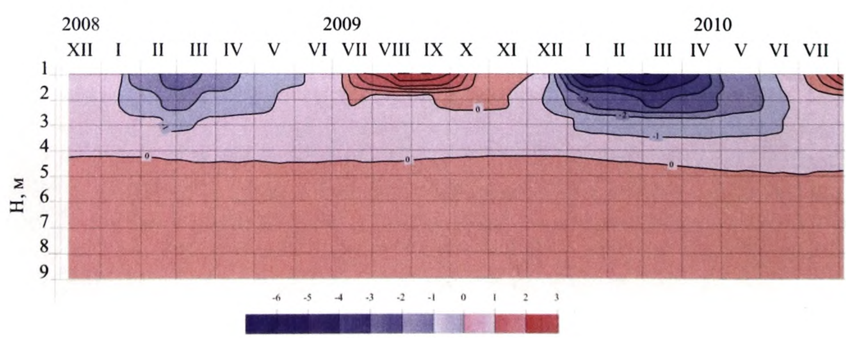

Figure 7. Isobathytherms in the well TW1-39

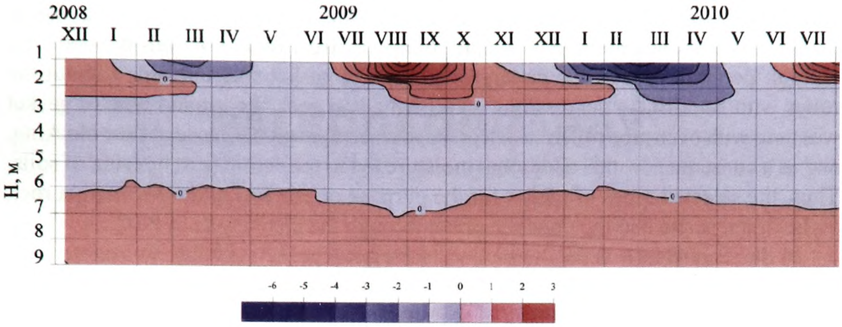

Figure 8. Isobathytherms in the well TW1-44

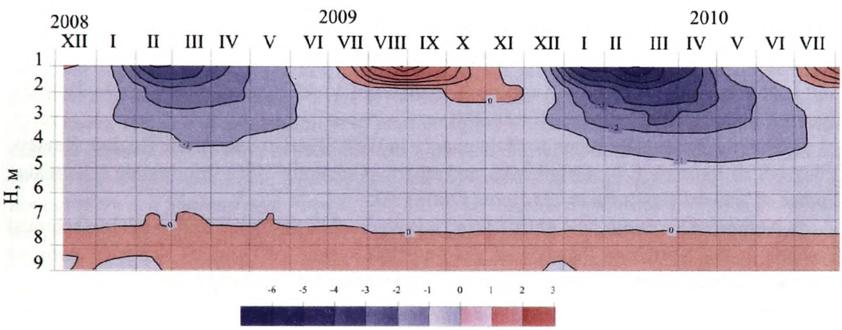

Figure 9. Isobathytherms in the well TW1-45

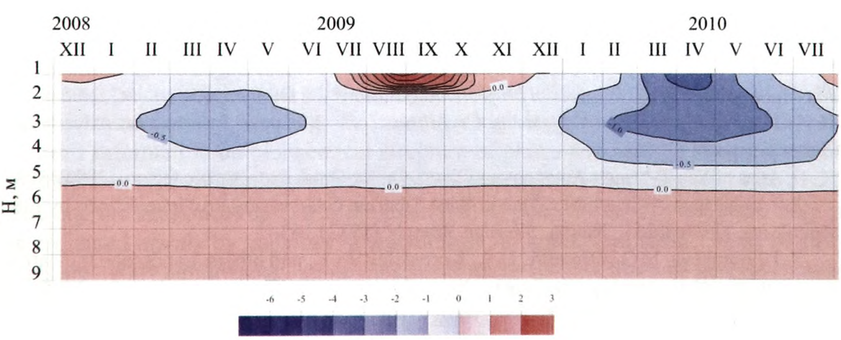

Figure 10. Isobathytherms in the well TW1-38

Conclusion. The division into sections was aimed to adapt the types of gasket to the natural environment, and especially the permafrost rock. For well-drained sites without permafrost rock the underground type of gasket was implied, without the roller with backfill. In depressions with permafrost rock the ground type of gasket was used with over-pipe roller, which in the first section was the cause of flow blocking, and as a consequence, this additional moisture led to the active frost heaving of soils. Thus, the selected types of gasket for the purpose of preserving the permafrost rock at the first test site had the opposite effect through the chain links in PTC.

In the second section the interaction of the gas pipeline with the environment led to its ascent in the peaty valley-like depression above the natural ground level, leading to an increase in seasonal freezing of soils with the formation of a gas pipeline under the frozen ground of different power - the frozen ground permanent snow patch.

The distribution of soil temperature at the depth of the pipeline does not always go steadily. The slow increase in the depth of mineral soils thawing is observed in waterside parts.

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