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REQUIREMENTS FOR LARGE DIAMETER PIPES FOR THE PROJECT "EASTERN SIBERIA – THE PACIFIC OCEAN"

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Abstract

In connection with the development of the "Construction of Eastern Siberia – the Pacific Ocean Pipeline" project VNIIST, fulfilling the task of OAO AK "Transneft", developed the technical norms which regulate the application of large diameter pipes with the higher quality characteristics, which influence oil pipeline operational reliability:

- General technical requirements for large diameter pipes (OTT-08.00-60.30.00-KTH-013-1-04);
- Special technical requirements for high strength pipes with pressure up to 14 MPa (CTT-08.00-60.30.00-KTH-013-1-05);
- Special technical requirements for pipes for Eastern Siberia – the Pacific Ocean Pipeline. (CTT-08.00-60.30.00-KTH-035-1-05).

The technical requirements formulated in the above documents are based on the large preexisting experience in choosing pipes for long distance pipelines. They take into account state-of-the-art for rolling and for pipe production and are designed to insure the working capacity of the oil pipeline in severe emergency and difficult geographical and climatic laying conditions. For construction of the "Eastern Siberia – Pacific Ocean" oil pipeline two categories of pipes are provided.

- I level: Pipes for sections of the oil pipeline with seismicity number up to 8 inclusively;
- II level: Pipes for the sections of the oil pipeline with seismicity number greater than 8 .

Requirements

The new requirements are appreciably different from the requirements referenced in current national (SNiP 2.05.06–85*) and international (API 5L and ISO 3183–3) standards and are focused on base metal and girth weld quality improvement.

Increased and additional requirements for chemical composition and microstructure of base metal. In particular, carbon content (C) is restricted as well as the amount of detrimental impurities (S, P, N). Requirements for chemical composition are listed in Table 1, below.

Table 1. Requirements for chemical composition of base metal

	C	Si	Mn	S	P	Ti	Nb	V	Al	N
I level	0.14	0.16-0.60	1.85	0.011	0.020	0.05	0.02-0.09	0.09	0.02-0.06	0.012
II level	0.09	0.16-0.37	1.65	0.006	0.013	0.05	0.02-0.09	0.09	0.02-0.05	0.009

Microstructure and steel impurities are specified. For this purpose a new Section that was not previously included in the normative documents was added. Non-metallic inclusions were limited. Their presence in steel causes the following:

(a) Lower resistance to fracture initiation and propagation.
(b) Lower plastic deformation capacity steels in the process of pipeline operation;
(c) Lower impact energy.

Intensity of banding of structure and the grain size of skelp are specified. (Table 2) Enumerated requirements to norms for steels in oil pipelines were not specified before in domestic (SNiP 2.05.06-85*) and foreign (API 5L, ISO 3183-3) standards.

Table 2. Requirements for non-metal inclusions content and microstructure of base metal.

	Grain number according to GOST 5639 (index G according to EN 103-71 or ASTM E 112-96).	Banding according to GOST 5640, number.	Non-metallic inclusions according to GOST 1778. (approximate figure of volume ratio V according to ASTM E 1245, %)	
			Average for all fields	Worst field.
I level	>8 (8)	>3	>2.5 (≈0.35)* >2.5 (≈0.30)**	>4.0 (≈0.82)* >4.0 (≈0.71)**
I1 level	>9 (9)	>2	>1.0 (≈0.12)* >2.0 (≈0.19)**	>1.5 (≈0.19)* >2.,5 (≈0.30)**

* - requirements for sulfides
** - requirements for oxides

Restricted requirements for ductility (tough-plastic) characteristics of base metal and welded joints. An obligatory impact elasticity testing of specimens with a sharp cut KCV for welded joints has been added. Impact elasticity of the base metal and weld joints should comply with the requirements of Table 3 and 4.

Table 3. Requirements to impact elasticity for pipes of I level.

Impact elasticity at min. temperature of the oil pipeline wall at temp. of operation, J/cm^2	
Base metal, KCV, J/cm^2	Weld, KCV, J/cm^2
>58.8	>34.3

Table 4. Impact requirements for Level II pipes.

Min temperature of the oil pipeline wall while operation, oC	Testing temperature, oC	Impact elasticity, KCV, J/cm^2		
		Base metal	Middle of welded joint	Weld area
Greater than - 20	- 20	>98	>39	>59
- 20 up to - 40	- 40	>78	>34	>49
Less than - 40	- 60	>59	>29	>39

Steel in pipes in strength class K60 (X70) are characterized by high values of elongation (δ_P = 11,0–13,5 %). The yield point $\sigma_{0,2}$ to tensile strength σ_B limited $\sigma_{0,2}/\sigma_B$ = 0,78–0,90. Nowadays such relationship of strength YS:UTS ratio and other plastic qualities characterizes their greater nonrigid ability and their higher rigidity under seismic loading.

Requirements concerning geometry of pipes based on previous experience of OAO "AK "Transneft" are put into a separate Chapter and restricted**.** This was the first time that out-of-roundness along the pipe body was specified. Pipe ends geometry is also restricted. (Table 5). Pipe should also be manufactured according to higher requirements for geometrical parameters of the weld (reinforcement height and width, outside and inside weld overlap).

Table 5. Requirements for geometry of pipes

Parameter	Requirements of STT-08.00-60.30.00-KTH-035-1-05
Out-of-roundness of pipe bearing face	<1.0 % - t <20 <0.8 % - t ≥20
Out-of-roundness along the whole length of pipe	<2 %
Outside weld reinforcement height, mm	0.5 – 2.5 t ≤10 0.5 – 3.0 t >10
Inside weld reinforcement height, mm	0.5 – 3.0
Overlap of welds, mm	≥1.5 – t ≤10 ≥2.0 – t >10
Weld reinforcement width, mm	≤ 20 – t < 10 ≤ 25 – t = 10-16 ≤ 30 – t > 16

Other Requirements

Other requirements for pipe dimensions are on the same level as the highest requirements of international norms and standards. Requirements for pipe surface quality were specified and restricted. The depth of guide marks and scratches is not more than 0,2 mm. that is stricter than in other norms. Dents with mechanical damage on the surface of metal are not allowed.

Russian plants worked out the technical requirements, taking into account production technology peculiarities for each plant-producer and aimed to fulfill customer requirements. The plants-producers carried out marketing research to check the possibility of purchasing metal of required quality, strength class and wall thickness according to the project.

Russian pipe plants launched the production of Series of Level II pipes with strength class К60 (X70 up to API 5L) and wall thickness up to 25 mm, which correspond to the requirements of СТТ-08.00-60.30.00-КТН-035-1-05.

Laboratory research showed conformity of the pipe metallurgical quality, mechanical properties and geometrical parameters to the revised higher requirements of the normative-technical documentation.

The Central Research Institute for Machine Building (TsNIIMASH) carried out laboratory research related to static and cyclic crack resistance using base metal specimens of said pipes.

Laboratory research on static crack resistance gave high results. They are shown in Table 6 below. Some specimens after testing were not broken. (Figure 1)

Figure 1 – Specimen after testing for static crack resistance.

Table 6 – The results of laboratory testing of base metal specimens for static crack resistance.

Testing temperature, ºC	JC, κJ/m^2	δC, mm
20	750-1200	0.5-1.1
-20	600-1100	0.45-0.65
-40	500-800	0.25-0.65

Crack growth velocity and cycle crack resistance testing is shown according to equation of Paris:

$$V = C \cdot K^{n}, \qquad (1)$$

Characterized by averaged coefficient values for all tested specimens $C = 8.14 \cdot 10^{-12}$ and $n = 2.72$.

VNIIST carried out field testing of crack resistance of the pipes with the aim to determine pipe working ability necessary under difficult operational oil pipeline conditions

Full scale pipe testing (Figure 2) gave high values of critical stress intensity factor K_C=700–870 МПа·м$^{1/2}$ and critical crack opening coefficient δ_C=0.33–0.47mm. of represented pipes' base metal under conditions close to normal operating conditions (pipes as part of an oil pipeline).

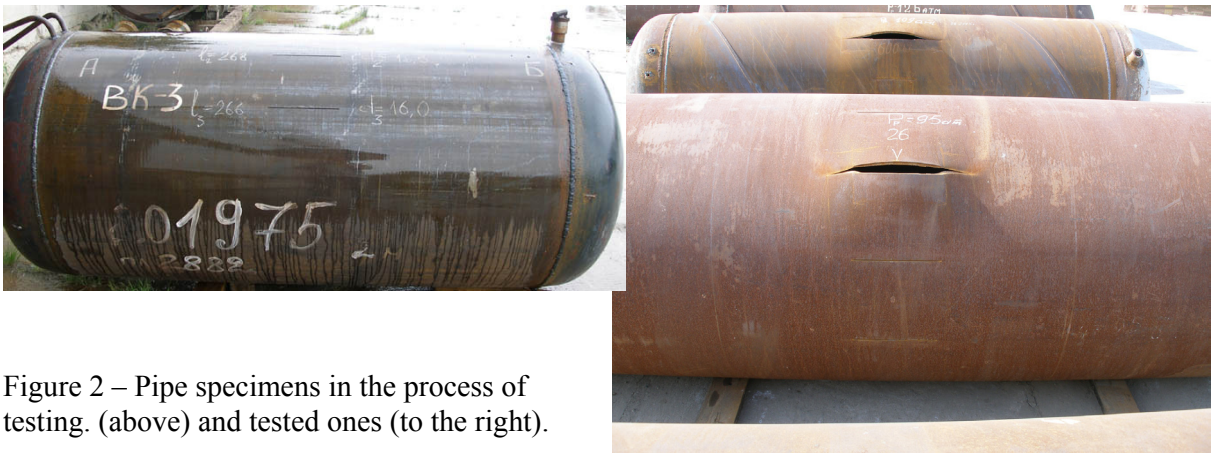

Figure 2 – Pipe specimens in the process of testing. (above) and tested ones (to the right).

SUMMARY

By fulfilling the requirements of OTT-08.00-60.30.00-KTH-013-1-04, CTT-08.00-60.30.00-KTH-013-1-05, CTT-08.00-60.30.00-KTH-035-1-05 we insure higher function ability of the pipe as part of an oil pipeline working in harsh climatic and environmental conditions. (seismicity more than 9 points) Impact resistance at the standard level insures pipe resistance to dynamic fracture initiation and propagation. High values of base metal crack resistance insure the metal's resistance to fracture initiation and propagation under static load.

Research carried out by VNIIST together with NsNIIMASH showed that pipes made according to OTT-08.00-60.30.00-KTH-013-1-04, CTT-08.00-60.30.00-KTH-013-1-05, CTT-08.00-60.30.00-KTH-035-1-05, can satisfy the highest International standards.