ELECTRIC-WELDED STRAIGHT-LINE-SEAM PIPES OF HIGH STRENGTH FOR UNIQUE BUILDING CONSTRUCTIONS.

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Abstract:. *It was examined the developing of Specifications for high durability and large diameter electric welded straight -seam pipes used in unique constructions including that they worked in heavy climate conditions. It was demonstrated that the pipes, made with high cleaned from harmful admixture thick sheets treated by thermo mechanical rolling and accelerated cooling, possess very high cold-resistant, crack-resistant, fire-resistant and high resistant against propagation of fatigued cracks. It was installed that such pipes possess high resistant against mechanical aging and they have high level of parameters defined the resistant against the seismic loadings. In accordance with the results of researches there were developed Specifications with the suitable guarantee provided operational reliability of unique constructions made with electric straight- seam pipes.*

KEY WORDS: *LARGE DIAMETER ELECTRIC WELDED STRAIT-SEAM PIPES, HIGH DURABILITY, HIGH OPERATIONAL FEATURES, UNIQUE CONSTRUCTIONS, HEAVY CLIMATE CONDITIONS.*

Introduction.

The pipes as profiles for building constructions have a number of obvious advantages over structural elements with flat sections (shaped sections, sheets): the pipe structures are lighter-weight (at equal load bearing capacity), work better at compression, have higher resistance to fire and wind effects.

The builders bring particularly high requirements to metal of the structures operated in seismically active regions, especially in those with negative climatic temperatures and severe hydrological conditions. Here, the steel including welded connections should have the high destruction resistance, fracture resistance, uniform elongation and fire resistance as in case of earthquakes a number of fires increases.

This report considers the prospect of the new pipes' application in aseismic construction in severe climatic conditions, where the pipe metal, which is obtained by thermo mechanical rolling with further accelerated cooling, excels by high structure dispersion, high cleanness to detrimental impurities ($S < 0,010\%$, $P \leq 0,015\%$**)**, improved weldability ($C \leq 0,12\%$, the carbon equivalent $C_e \leq 0,43\%$).

Materials.

Currently, pipe plants produce electric-welded straight-line-seam pipes of large diameter 530-1420 mm with wall thickness up to 45 mm for building metal constructions. The pipes of high strength with tensile properties conforming to the requirements of the applicable building codes for steel C390 ($\sigma_{0,2} \geq 390$ N/mm^2;
$\sigma_{\mathbf{B}\text{reaking stregth}} \geq 540$ N/mm^2; $\delta_5 \geq 20\%$) and especially C440 ($\sigma_{0,2} \geq 440$ N/mm^2;
$\sigma_{\mathbf{B}} \geq 590$ N/ mm^2; $\delta_5 \geq 20\%$) are the most interesting for construction use.

For this study we have chosen the pipes typically used in structures with C440 properties with the diameter of 1220 mm and the wall thickness of 34.6 mm. The pipes are made of thick sheets produced at rolling mill 5000 by thermo mechanical rolling with further accelerated cooling, of the chemical composition (Table 1):

Table 1

Op-tion №	Mass fraction of elements, %														
	C	Mn	Si	P	S	Cr	Ni	Cu	V	A1	N	Mo	Ti	Nb	Ca	Cэ
1	0,06	1,73	0,16	0,011	0,001	0,04	0,23	0,23	0,004	0,03	0,004	0,02	0,01	0,04	0,001	0,39
2	0,06	1,63	0,20	0,008	0,001	0,04	0,43	0,22	0,004	0,03	0,004	0,04	0,02	0,04	0,001	0,39

Results and discussions.

The base metal microstructure is a fine mixture of ferrite and bainite bands of lath morphology. The structure of the former austenite consists of elongated "pancake" grains as a result of thermo mechanical rolling with accelerated cooling. Mechanical properties at tension-compression are presented in Table 2

Table 2

Stress conditions	σ 0,01	σ 0,02	σ 0,2	σ 0,5	σ_B	δ_5	δ_P	Ψ
	N/mm^2					%		
Tension	-	-	544	548	601	20,5	5,7	78
The same	-	-	525	527	592	21,0	6,7	79
Compression	504	522	545	-	-	-	-	-

The diagram "σ - $\boldsymbol{\varepsilon}$" has the form without yield plateau, however, $^{\sigma 0.01}/\sigma_{0,2}$ and $^{\sigma 0.2}/\sigma_B \approx 0,9$ like construction steels.

The results of tensile tests at elevated temperatures have showed that at 600°C the criteria of fire resistance for steel ($\sigma_{0,2}$ 600°C /$\sigma_{0,2}$ 20°C $\geq 0,6$) are fully met.

Impact bending tests of the samples with sharp V-shaped notch have shown that within the climatic temperatures the steel has exceptionally high impact strength**:** $KCV^{-75} \geq 300$ J/cm^2 both in the cases of sampling from the surface and sampling from the middle of sectionWhile testing of welded joints it is shown that the metal of weld seams has rather high impact strength: $KCV^{-40} > 150$J/cm^2. When concentrators are on weld line the minimum values occur: these values are big enough for standard sampling $KCV^{-40} > 70$J/cm^2.

At non-uniformity of the properties over the cross section the test results for full-thickness samples are of special interest.

The results of drop weight tear tests (Table 3) indicate high crack extension resistance of the pipe metal: even at -40°C B ≥ 85%.

The Shear area **B**, ***%*** in fracture at ***t,*** °C

Table 3

-20	-30	-40	-50	-60	-70
100;98	85;88	90;85	72;82	54;60	46;52

The high fracture resistance of both the base metal and the welded joint is shown in evaluation of the deformation parameter δ_c by methods of destruction mechanics (Table 4). Also the metal has the high cyclic fracture resistance (Table 5).

Table 4

Crack-tip opening displacement at maximum load $\boldsymbol{\delta_c}$,mm at ***t,*** °C

Sampling location	+20	-20	-40	-60
Base metal	1,22; 0,36	0,77; 1,25	0,64; 1,42	0,30; 0,27
Weld fusion line	1,17; 1,24	1,24; 0,43	0,77; 0,35	0,35; 0,35
Seam centre	0,87;0,73	0,80; 0,70	0,73; 0,66	0,57; 0,10

Table 5

The parameters of cyclic fracture resistance

Parameter evalution' location	Testing temperature	R	Thickness of sample, *mm*	C, *m/cycle* / *MPa√m*	*n*
Base metal	+20	0,2	25	$1{,}82\ 10^{-13}$	4,00
Welded seam	+20	0,2	25	$0{,}93\ 10^{-13}$	4,29
Heat-affected zone of weld	+20	0,2	25	$0{,}51\ 10^{-13}$	4,39

According to the results of the work the Technical Specifications 1381-068- 001 86654-2016 "Steel electric-welded straight-line-seam pipes for unique building constructions" have been developed, where the pipes of high strength C390 and C440 are considered to have the high operating properties: the increased values of impact strength of the base metal and welded joints at -40 and -60°C,the requirements for crack-tip opening displacement (CTOD) of the weld joint metal at -40°C.

In terms of tensile testing for steels the requirements for uniform elongation δ_p =6% and $\sigma_{0,2=}$300 N/mm^2 at 600°C were added.

Conclusion.

According to the new Technical Specifications the pipes can be applied in unique engineering constructions, including those operated in severe climatic conditions and in areas with high seismic activity.

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