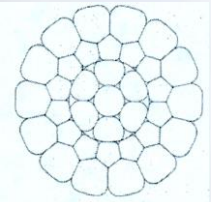
Energoservis Engineering Company

Development of Overhead ground wire, high-strength and high-temperature conductors, OPGW of new generation for overhead power lines

Experience - 18,000 km of transmission lines

79th GM MINSK 2015

HANNOVER MESSE 8 - 12 APRIL 2013



Technical characteristics of Conductors ASHS/ASHT, Ver.I

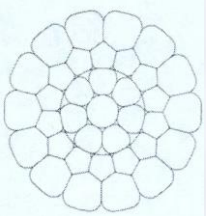
Nominal cross-section мм²	Diameter, мм						Cross-Section aluminum/ Steel, мм²	The weight of 1000 meters of wire, kg			
	Conductor	Steel core	Wires					Steel core	aluminum parts	Conductor without lubrication	with lubrication
			Steel core		aluminum parts						
			Center,1	1-layer, 6	2-layer,14	3-Layer,14					
(128/36)	15,20	7,27	2,70	2,55	1,95	2,80	128,0/36,3	287,2	358,7	645,9	659,5
(133/37)	15,40	7,37	2,75	2,60	2,00	2,85	133,2/37,7	298,5	373,5	672,0	686,0
(139/38)	15,67	7,45	2,80	2,60	2,05	2,90	138,6/38,0	300,1	388,6	688,7	703,2
(159/44)	16,80	8,02	3,00	2,80	2,20	3,10	158,8/44,0	347,5	445,2	792,7	809,4
(162/45)	17,10	8,17	3,05	2,85	2,20	3,15	162,3/45,5	359,9	454,9	814,8	831,0
(168/49)	17,50	8,43	3,15	2,95	2,25	3,20	168,2/48,8	385,4	471,5	856,9	875,0
(174/50)	17,73	8,50	3,15	3,00	2,30	3,25	174,3/50,2	396,5	488,4	884,9	903,5
(190/54)	18,50	8,85	3,30	3,10	2,40	3,40	190,4/53,8	425,3	535,0	960,3	980,5
(197/55)	18,80	8,95	3,35	3,15	2,45	3,45	196,8/55,5	438,9	551,6	990,5	1011,0
(197/56)	18,90	9,00	3,40	3,15	2,45	3,45	196,8/55,8	441,0	551,6	992,6	1013,5
(214/61)	19,60	9,36	3,50	3,30	2,55	3,60	214/60,9	481,3	599,6	1080,9	1103,6
(218/63)	19,82	9,50	3,55	3,35	2,55	3,65	217,9/62,7	495,9	610,8	1106,7	1130,0
(258/73)	21,60	10,30	3,85	3,60	2,80	3,95	257,7/72,7	574,3	722,2	1296,5	1323,7
(277/79)	22,40	10,75	4,00	3,75	2,90	4,10	277,3/78,8	622,6	777,0	1399,6	1429,0
(371/106)	26,00	12,48	4,70	4,35	3,35	4,75	371,4/106,5	841,0	1041,0	1882,0	1921,8

Additional characteristics of Conductors ASHS/ASHT, Ver.I

Nominal cross-section, мм^2	Electrical resistance of 1 km of conductor DC at 20 ° C, Ohm, not more	Tensile strength of conductor, N, not less
(128/36)	0,2250	77067
(133/37)	0,2170	80141
(139/38)	0,2070	81170
(159/44)	0,1810	93198
(162/45)	0,1780	96146
(168/49)	0,1710	102034
(174/50)	0,1655	104886
(190/54)	0,1520	113054
(197/55)	0,1460	116750
(197/56)	0,1460	117147
(214/61)	0,1348	126672
(218/63)	0,1329	130096
(258/73)	0,1116	151533
(277/79)	0,1040	163940
(371/106)	0,0776	220403

The final Elastic modulus: 1,09 x 10^5 N/mm²

Coefficient of linear expansion: 16,7 x 10^{-6} 1/°C



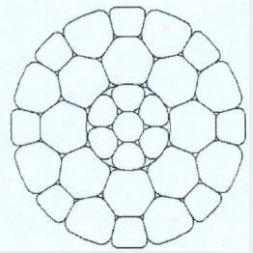
Technical characteristics of Conductors ASHS/ASHT, Ver. II

Nominal cross-section мм²	Diameter, мм						Cross-Section aluminum/ Steel, мм²	The weight of 1000 meters of wire, kg			
	Conductor	Steel core	Wires					Steel core	aluminum parts	Conductor without lubrication	with lubrication
			Steel core		aluminum parts						
			Center,1	1-layer, 6	2-layer,14	3-Layer,14					
(128/37)	15,20	7,27	3,20	2,30	1,95	2,80	128/37,1	293,2	358,7	651,9	665,6
(133/38)	15,40	7,37	3,25	2,35	2,00	2,85	133,2/38,6	305,3	373,5	678,8	693,0
(139/39)	15,67	7,45	3,30	2,35	2,05	2,90	138,6/38,9	307,3	388,5	695,8	710,5
(159/45)	16,80	8,02	3,55	2,55	2,20	3,10	158,8/45,6	360,5	445,1	805,7	822,6
(162/47)	17,10	8,17	3,60	2,60	2,20	3,15	162,3/47,3	373,9	454,9	828,8	846,2
(168/51)	17,50	8,43	3,70	2,70	2,25	3,20	168,2/50,8	401,5	471,5	873,0	891,4
(174/51)	17,73	8,50	3,75	2,70	2,30	3,25	174,3/51,1	403,8	488,4	892,2	911,0
(190/55)	18,50	8,85	3,90	2,80	2,40	3,40	190,4/55,0	435,0	535,0	970,0	990,3
(197/56)	18,80	8,95	3,95	2,85	2,45	3,45	196,8/56,9	449,5	551,6	1001,1	1022,2
(197/57)	18,90	9,00	4,00	2,85	2,45	3,45	196,8/57,2	451,9	551,6	1003,5	1024,5
(214/61)	19,60	9,36	4,15	2,95	2,55	3,60	214/61,3	484,7	599,6	1084,3	1107,0
(218/63)	19,82	9,50	4,20	3,00	2,55	3,65	217,9/63,3	500,2	610,8	1111,0	1134,0
(258/74)	21,60	10,30	4,55	3,25	2,80	3,95	257,7/74,3	587,1	722,2	1309,3	1337,0
(277/81)	22,40	10,75	4,75	3,40	2,90	4,10	277,3/81,2	642,0	777,0	1419,0	1449,0
(371/109)	26,00	12,48	5,50	3,95	3,35	4,75	371,4/109,5	865,2	1041,0	1906,2	1946,0

Additional characteristics of Conductors ASHS/ASHT, Ver. II

Nominal cross-section, мм^2	Electrical resistance of 1 km of conductor DC at 20 ° C, Ohm, not more	Tensile strength of conductor, N, not less
(128/37)	0,2288	79221
(133/38)	0,2170	81461
(139/39)	0,2070	82547
(159/45)	0,1810	95691
(162/47)	0,1780	98824
(168/51)	0,1710	105119
(174/51)	0,1655	10283
(190/55)	0,1520	114897
(197/56)	0,1460	116846
(197/57)	0,1460	119262
(214/61)	0,1348	127332
(218/63)	0,1329	130940
(258/74)	0,1116	153997
(277/81)	0,1040	167655
(371/109)	0,0776	225001

The final Elastic modulus: 1,09 x 10^5 N/mm²
Coefficient of linear expansion: 16,7 x 10^{-6} 1/°C



Technical characteristics of Conductors ASHS/ASHT, Ver. III

Nominal cross-section, мм²	Electrical resistance of 1 km of conductor DC at 20 ° C, Ohm, not more	Tensile strength of conductor, N, not less
(461/64)	0,0625	170507
(477/66)	0,0604	175910
(571/80)	0,0504	211994

Nominal cross-section мм²	Diameter, мм							Cross-Section aluminum/ Steel, мм²	The weight of 1000 meters of wire, kg			
	Conductor	Steel core	Wires						Steel core	aluminum parts	Conductor without lubrication	with lubrication
			Steel core		aluminum parts							
			Center,1	1-layer,6	2-layer, 8	3- layer						
						D1 -8	D2-8					
(461/64)	26,91	9,70	3,65	3,40	5,70	5,15	3,80	461,5/64,9	512,0	1290,0	1802,0	1840,0
(477/66)	27,50	9,85	3,70	3,45	5,80	5,25	3,85	477,6/66,8	526,0	1334,0	1860,0	1900,0
(571/80)	30,00	10,83	4,05	3,80	6,35	5,75	4,20	571,9/80,9	638,0	1598,0	2236,0	2283,0

The final Elastic modulus: 0,88 x 10^5 N/mm²

Coefficient of linear expansion: 16,7 x 10^{-6} 1/°C

Modification of the High strength conductor for replacement on old lines without it reconstruction**

Using this design modification, depending on a problem the replacement conductor provides two options: d_{cond}=const >> S_{AL} - increase *or* S_{AL}=const >> d_{cond} decrease

Rated Core cross section, mm² (standard conductor)	AC Continuous carry, Icc ACHS, t-70°C	Icc ACHT, t-150°C	design parameters high strength conductors**					
			Core cross section, Al/Steel, mm²	Diameter, мм		DC Resistance (20 0C), Ohm/km	Rated Breaking strength, N*	Weight of conductor kg/1000m
				Conductor	steel core, mm			
216/33	718,00	1097,0	216,3/32,9	18,5	6,7	0,1334	89500*	**870**
150/23	563,00	855,0	150,1/22,7	15,40	5,60	0,192	61140	**598**
295/44	879,00	1348,0	294,8/43,9	21,50	7,80	0,098	116800	**1183**
317/47	922,00	1416,0	317,3/47,3	22,30	8,08	0,091	125400	**1267**
389/59	1053,00	1622,0	388,6/58,8	24,75	8,99	0,074	154400	**1558**
403/61	**1071,00**	**1639,0**	**403,4/61,0**	**25,20**	**9,17**	**0,072**	**160380**	**1617**

>While maintaining the diameter (the same as in prior standard conductor) in this design increases throughput by increasing the aluminum part by 15%, thus AC Continuous carry and Throughput increase significantly.

****- If necessary, conductor can be produced as a high temperature (t_{work}=150°C, t_{max}=210°C).**

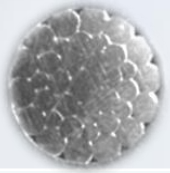
*****- For areas with high wind and sleet loadings**

>Section (conductor) may be different. Presented designed for demands of Russian Grid Company

>Design provides for increase of the filling ratio to 95–97 %, a significant improve of strength and cross-section for the same cable diameter, reduction of aerodynamic load (20-35 %) and icing (25-40%) improves the corrosion resistance. The process itself is more simple, which means substantially cheaper compared to any analogous product, meanwhile performance values obtained are at least the same.

>Tests were carried out in accordance with the regulations of the Russian State Grid Company "Rosseti« (Russian Grids), in the system "wire-fitting".

>Modulus of elasticity – 0,79 * 10^5 N/mm² ASHS/ASHT (0,63 * 10^5 N/mm² Standard conductor)



Technical characteristics of Conductors ANHS, made of aluminum alloy without a core

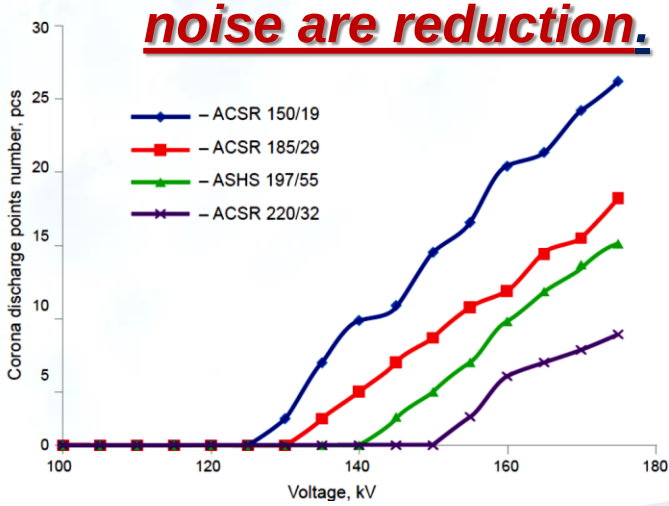
Conductor ANHS	Cross section, mm²	Weight, kg	Diameter of Conductor	Diameters of wires, mm					Rated Breaking strength, daN	R, Ohm/km	AC Continuous carry, Icc ACHS, tc-70°C ta=20°C; Vw=0,6 м/с
ANHS 44,54 6101 T4-290	44,54	125,00	8	1,7	1,2	1,15	0,85	1,45	1559	0,73	241
ANHS 59,06 6101 T4-290	59,06	165,00	9,2	1,9	1,4	1,35	1	1,65	2067	0,55	289
ANHS 69,67 6101 T4-290	69,67	195,00	10	2,1	1,5	1,45	1,1	1,8	2431	0,47	321
ANHS 83,59 6101 T4-290	83,59	233,00	11	2,3	1,65	1,6	1,25	1,95	2894	0,389	360
ANHS 107,97 6101 T4-290	107,97	302,00	12,5	2,6	1,9	1,85	1,4	2,2	3653	0,301	424
ANHS 118,55 6101 T4-290	118,55	331,00	13	2,65	1,95	1,9	1,45	2,35	3964	0,274	455
ANHS 135,88 6101 T4-290	135,88	379,00	14	2,9	2,1	2,05	1,55	2,5	4487	0,239	496
ANHS 157,79 6101 T4-290	157,79	441,00	15	3,05	2,25	2,2	1,7	2,7	5167	0,206	547
ANHS 180,61 6101 T4-290	180,61	504,00	16	3,25	2,4	2,35	1,8	2,9	5758	0,18	600
ANHS 201,59 6101 T4-290	201,59	563,00	17	3,45	2,55	2,5	1,9	3,05	6395	0,161	640
ANHS 240,72 6101 T4-290	240,72	672,00	18,5	3,75	2,8	2,7	2,05	3,35	7253	0,135	724
ANHS 309,35 6101 T4-290	309,35	863	21	4,3	3,15	3,05	2,35	3,8	8684	0,105	853
ANHS 354,29 6101 T4-290	354,29	989	22,5	4,6	3,35	3,3	2,55	4,05	9745	0,092	929

- ***Number of wires in the Conductors*** ***36***
- **Modulus of elasticity E, kN / mm²** **60-65**
- **Coefficient of linear expansion, α*106, К-1** ***23***

Same diameter 18.8 mm ASHS 197/55 conductor by "Metsbytservis", has corona discharge voltage by 5.7% higher than ACSR 185/29

Similar tests were carried out for ASHS 216/33 **Ø18,5 - Ø21,6** ACSR 240/32 have the same corona discharge voltage.

Corona-induced acoustic noise are reduction.



Calculated specific corona losses in good weather (330 kV overhead line with split phase consisting of 2 conductors with 40 cm spacing)

Phase construction (conductor model; conductor radius r_0, cm)	Annual average losses change, %
2 × ACSR 300/39; Ø 24,0 mm	+ 18,52%
2 × ACSR 400/51; Ø 27,5 mm	0,00%
2 × ASHS 317/47; Ø 22,3 mm	–7,41%
2 × ASHS 295/44; Ø 21,5 mm	+ 3,70%

Calculated specific corona losses in good weather (220 kV overhead line)

Phase construction (conductor model; conductor radius r_0, cm)	Annual average losses change, %
ACSR 240/32; Ø 21,6 mm	+ 26,67%
ACSR 300/39; Ø 24,0 mm	0,00%
ACSR 330/43; Ø 25,2 mm	–13,33%
ASHS 317/47; Ø 22,3 mm	–13,33%
ASHS 295/44; Ø 21,5 mm	–6,67%

- **wind loads reduction;**
- **less susceptibility to conductor**
- **galloping and vibrations self-extinction**

Airflow speed v_{AB}, m/s	Wind load acting on the following conductors, N/m					
	ASHS 128/37 (Ø15,2 mm)	ACSR 120/19 (Ø15,2 mm)	ASHS 216/33 (Ø18,5 mm)	ACSR 240/32 (Ø21,6 mm)	ASHS 277/79 (Ø22,4 mm)	ACSR 240/56 (Ø22,5 mm)
25	3,6	4,8	4,9	6,9	5,2	7,0
32	5,9	7,9	7,8	11,4	8,4	11,5
60	20,8	28,5	28,4	41,5	29,8	41,6

Parameters of new conductors ASHS / ASHT in conjunction with the ground wire or OPGW can be extremely effective in the construction of the extended transition.

Conductor	Section Al, mm²	Core, mm²	Weight kg/km	Ø, mm	Breaking load, daN	Continuously per.current, I, A at conductor's temp.		
						70⁰C	90⁰C	150⁰C
ACSR 500/336	490	336	4005	37,5	46664	1172	1413	-
ASHT 520/354	520	354,3	4184	35,32	67000	1179	1422	1981
ASHT 500/240	500	240,72	3239	32,51	47658	1117	1347	1877
TACSR/ACS-521-A20SA	112	409,3	3512	29,7	69884	510	615	856

Application of new cables may allow reduce the height of the end anchor poles go up to 25-30% compared to standard sizes of support masts that will reduce the cost of the entire transition

HIGH-TEMPERATURE STEEL-CORED ALUMINUM CONDUCTORS

In addition to increased strength Experimentally-confirmed operational temperature -150°C, Maximum allowed – 210°C.

The algorithm and the results of tests on Example conductor Ø 18.8 mm, S-197/56.
Determination of the breaking strength in connecting and tension grips –116.1 kN;
Aeolian vibration resistance test – 100 mln. cycles, frequency – 44.3 Hz, loading – 25 % of the breaking force. No breaking was recorded.
Swinging (galloping) resistance test under pulsing load: number of loading cycles – 45,000; loading vibration frequency – 0.06 Hz, load regime – 20-26-20 % of the breaking load. The breaking load after tests – 115.3 kN;
Electric test to find the DC resistance of 1km of the conductor at 20 °C, Ohm, actually within – 0.139
Thermal-cycling resistance test: operational temperature 150 °C, loading regime as related to the breaking load 4 % - 20 % - 70 %, than 4 cycles 20–70 %, and 96 %, marker shift – 0 mm;
Determination of the conductor strength after exposure to the emergency temperature: at 210 °C load of 17 kN (15 % of the breaking load) with subsequent loading up to 112 kN (> 96 %) caused no conductor damage or marker shift;
Electric test to determine the specific resistance of the contact – spiral grip CC-18,8-11(115). Admissible continuous current at 150 °C, air temperature 20 °C, wind speed ≤ 1.2 m/s – 944.8 A

Technical and economic comparison of conductors spent by Russian State Grid Company «Rosseti» in 2016

For a promising use in the development of the network

	Company manufacturer	Conductor	Ø, мм	Weight, kg/км	AC Continuous carry, A	Breaking load, кN	Resistance, Ом/км	Conductors sag at Tmax, м	Cost* EUR/км
Traditionally used CABLES									
1	Standard steel-aluminum conductor	ACSR 240/32	21,6	921	605	72,7	0,121	13,2	2 812 (62%)
2		ACSR 300/39	24,0	1 132	710	89,2	0,098	11,5	4 030 (89%)
3		ACSR 400/51	27,5	1 490	825	115,4	0,075	11,7	4 550 (100%)
Innovative types of CABLES (with improved performance)									
4	Energoservice	ASHT 461/64 high temperature	26,9	1 802	1 668	170,5	0,063	9,3	6 844(150%)
	- " -	ASHT 371/106	26	1 882	1 476	220,4	0,0776	7,8	6000(149%)
	- " -	ASHT 277/79	22,4	1 400	1 199	163,9	0,1040	7,7	4475(111%)
	- " -	ASHS 277/79 ** high-strength	22,4	1 400	862	163,9	0,1040	7,9	3977(98%)
5	Lumpi-Berndorf	TACSR/HACIN 212/49	21	939	861	95,4	0,1283	10,5	20 000 (450%)
6	Lumpi-Berndorf	TACSR/ACS 212/49	21	914	871	95,4	0,1283	11,6	12 000 (270%)
7	J-Power Systems	GTACSR 217/49	20,3	1 015	840	110,7	0,136	9,1	20 000 (450%)
8	Nexans	366-2Z	23,1	1 014	732	116,2	0,092	9,9	27 000 (600%)
9	3M	ACCR 405-T16	20,1	684	1 059	70,0	0,129	8,2	40 000(1 000%)

* -*The Cost of providing estimations for autumn 2015;* **- If the increase in the support load is not desirable, it is suitable to replace the ACSR 300/67 conductor ASHS 317/47, has less weight and heat losses, higher bandwidth compared with the ACSR300/67 with almost equal tensile strength (125 kN) . With the new construction of overhead lines with increasing distance between the supports and the low current loadings on line is possible to use ASHS 277/79, and when it is necessary to significantly increase the capacity of the line - that ASHS 389/59. Conductor ASHS295/44(116 kN) is more suitable for the replacement of AS240/56(98 kN) conductors for overhead lines, where a slight increase in weight and load on the bearing is permissible, with the need to increase bandwidth, while lowering heat loss.

Another attempt of this kind is made in Table

This is a very important task - to identify those niches where the use of new conductors would be most beneficial.

Parameters of the conductors to be compared	ACSR 150/24	ASHS, ASHT 162/47	
	value	value	Change in percent to ACSR
Core cross section, mm^2	24,2	47,3	+90
Al part cross section, mm^2	149	162,3	+8,9
Diameter, mm	17,1	17,1	0,0
Rated Breaking strength, daN	5227,9	9882,4	+89,0
Max current load, A	554	590,5 (822)	+ 6,6 (+ 48,4)
Span length of OHL at one and the same sag, m	280	364	+ 30
Towers on the 10 km of OHL	37	27	- 27
Specific losses of electricity at the same current load (150 A), MWh/km per year	41,7	36,4	- 12,7
Conductor temperature expansion coefficient, 10^{-6} 1/ °C	19,2	16,7	- 13
Conductor elasticity modulus, E*10-3, N/mm2	82,5	88	+ 6,7
Sag at the highest air temperature (+40 °C), m, for the spans: 250 m / 300 m	6,29 9,26	3,32 4,87	- 47,2
Sag at ambient temperature - 5 ° C in the 3rd region of the wind and ice load, m: 250/300	6,66 9,63	4,41 6,04	- 33,8
The electric field of the corona onset at dry weather, kV/cm	34,04	40,0	+17,5
DC Resistance (20 ^{0}C), Ohm/km	0,2039	0,1780	-12,7
Preliminary conductors' relative costs estimation	100 %	110-120 %	

One can see from this pattern that almost all the exploitation parameters of the new conductors important for the OHL designer do exceed greatly than those for ordinary ones. The new conductors they would fit excellent for the new Line to be built in the regions with excessive wind/ice loads or for long River crossings or extended anchor sites . In the case of the new conductors' application at large crossings, it is possible to reduce the height of the terminal anchor supports of the crossing up to 25-30 %, subject to the standardized dimensions of the support Towers; this in turn will lead to considerably lower cost of all the crossing. In addition, with a reduction in height of the support Towers their inductance decreases, correspondingly reduces probability of direct lightning strokes.

The complex of products by LLC Energoservice for high-voltage transmission lines

laureate 1st Prize of the Grid company Rosseti "The best implemented project", is the absolutely unique and innovative the development costs reduction of use and HVL construction costs by using the most cost-efficient technologies. All products are certified and has the experience application.

Design provides for increase of the filling ratio to 92–97 %, a significant improve of strength and cross-section for the same cable diameter, reduction of aerodynamic load (20–35 %) and icing (25–40 %), improves the corrosion resistance.

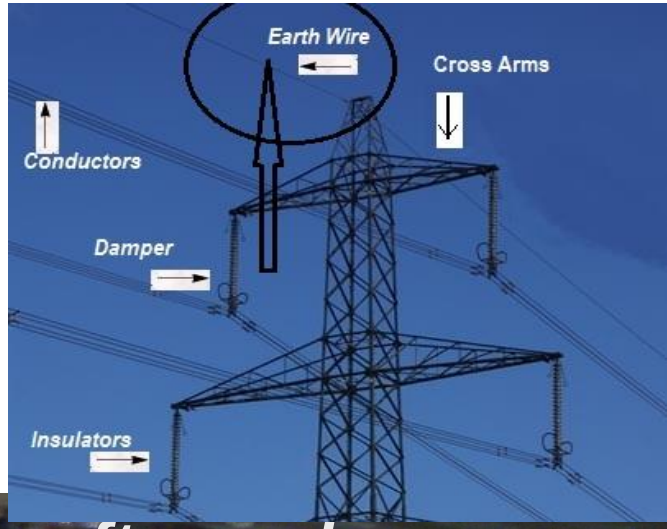
The process itself is more simple, which means substantially cheaper compared to any analogous product, meanwhile performance values obtained are at least the same.

- **High strength steel-aluminum cable** (hereinafter referred to as ASHS, common grades of Al are used). Higher mechanical strength and compact design allows as follows: to use cables of substantially lower diameter and weight for the same HVL span length or to increase the distance between supports (for the same cable cross-section) for at least 20–30 % without changing the HVL transmission capacity, and to increase the ultimate allowable current value at the same maximum allowable temperature. For the same mechanical strength the transmission capacity 15–25 % higher. For identical electromechanical performance values ASHS price is comparable with standard cables.
- **High temperature steel-aluminum cable (ASHT).** The allowable operating temperature of these cables to 210 °C, developed in cooperation with RUSAL, along with design of the cable and fittings allowed for rapid increase (compared to our ASHS cable) of the transmission capacity (up to 100 %), without significant cost rise.
- **Ground wire MZ** as (in operation since 2008, **16,000 km** supplied) – is the only cable, which withstands the complete cycle of successive tests for lightning current effect, aeolian vibration, dancing and for resistance to short circuit current using a single cable sample, which maintains its initial mechanical properties after passing all the exposures..
- **OPGW** retains the properties of MZ. Number of optical fibers in serial production items – 8-96.

Catenary Carrier cable railway - copper products, with the strength of bronze, electrical conductivity of copper, the best aerodynamic performance, standard diameters.

Technical specifications on ***http://w.w.w.energoservise.com***

Our ground (earth) wire and OPGW are indifferent to the lightning discharge all documented values



Experience of 16,000 km of transmission lines

Virtually no damage even after a charge of 147 ampere-second.

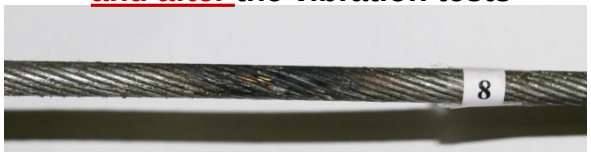
During a vibration/swinging resistance test, the cable got no extra damage; the post-test condition of the cable was satisfactory.
After the test of resistance to direct lightning current, vibration and swinging, the breaking strength of the cable complied with the initial requirements of the specifications.

Results of comparative test for the Technical Council Of Russian Grid Company "Rosseti" (2.04.2013)

Cable 9,2-Г (МЗ)-В-ОЖ-МК-Н-Р **Energoservis**

Cable 9,2-Г (МЗ)-В-ОЖ-Н-Р-1770; **Enterprise Standard 71915393-TU 062-2008 by Energoservis** and Severstal-Metiz, completely and successfully passed the entire test sequence. Cable 2-Г (МЗ)-В-ОЖ-Н-Р-1770; is resistant to lightning strikes with charges over **110 ampere-second**, aeolian vibration and swinging; during the tests the actual braking strength did not reduce and was 103 % of its nominal breaking strength. Grounding cable 9,2-Г (МЗ)-В-ОЖ-Н-Р-1770 by Severstal-Metiz, Volgogradsky branch, is the most reliable and preferred for protection of high-voltage power lines from lightning strikes.

After the lightning discharge and after the vibration tests



Cable ПК-9,2-МЗ-В-ОЖ-Н-МК-Р

Cable ПК-МЗ-В-ОЖ-Н-МК-З-1770; Enterprise Standard 14-173-35 by Mechel failed to pass the test sequence. Cable ПК-МЗ-В-ОЖ-Н-МК-З-1770; TU 14-173-35 by Mechel may be recognized resistant to lightning up to 95 ampere-second; the cable failed to withstand vibration and swinging. Its actual strength during the test reduced to 32.8 kN (55 % of the nominal breaking load). Ground cable ПК-МЗ-В-ОЖ-Н-МК-З-1770; TU 14-173-35 by Mechel cannot be recognized reliable; it is not recommended for protection of high-voltage power lines from lightning strikes.

After the lightning discharge but before the vibration tests

After the lightning discharge and after the vibration tests

Exterior cladding aluminum **Cable** **analogue used in EU**

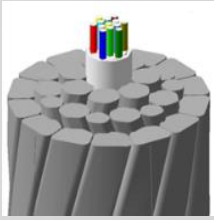
Cable ГТК20-0/50-9,1/60 Enterprise Standard 3500-007-63976268-2011 by EM-Kabel, the city of Saransk, failed to pass the test sequence. Cable ГТК20-0/50-9,1/60 TU 3500-007-63976268-2011 by EM-Kabel, the city of Saransk, cannot be recognized resistant to lightning up to **85 ampere-second**; its actual strength during the test reduced to 32.8 kN (49.6 % of the nominal breaking load). Ground cable ГТК20-0/50-9,1/60 TU 3500-007-63976268-2011 by EM-Kabel, the city of Saransk, is absolutely unreliable and cannot be used to protect high-voltage power lines from lightning.

After lightning discharge but before the vibration tests

After the lightning discharge and after the vibration tests

✓ **Exterior cladding aluminum only enhances the resistance to short circuit currents (it is important only at the end of some lines) decrease all other characteristics of grounding wire**

Optical ground wire



(OPGW, in IEEE standard, optical fiber composite overhead ground wire)

OPGW suspension accessories:

Suspension accessories: **standard** used to connect with central location optical module

Connecting couplings: standard used to connect with a central location optical module, it is required to use the special input complexes having in their designation (melting).

OPGW is produced in cooperation with European optical module.

Description of OPGW tests


SAG

Technischer Bericht Nr. 2014-055

Notwendige Prüfungen eines LWL-Erdseiles zum Nachweis der Funktionsfähigkeit für den deutschen Markt

Auftraggeber: Energolnno GmbH, Alte Jacobstraße 77 CD, 10179 Berlin

Gegenstand: Stahl-Lichtwellenleiter-Erdseil nach Unterlagen der Fa. Energolnno

Verfasser: Dipl.-Ing. Wolfgang Marthen

Datum: Juli-August 2014

SAG GmbH, Leitungsbau, Versuchs- und Technologiezentrum, Pittlerstraße 44, 63225 Langen, Telefon: +49 6103/7600-0, Fax: +49 6103/7600-149

Marthen Unterfinger

Tension resistance test*

Optic fibers deformation tests* **No visible damage of the cable structure elements.**

Compression resistance test* **attenuation gain is within the instrumental error*;**

Lightning currents resistance test – 110 ampere-second*

Rerolling resistance test*

Aeolian vibration test * – no damage of the cable components.

Bending resistance test **Attenuation gain is within the instrumental error*.**

Elongation test (1000 hours)

Galloping Test *No visible damage of the cable structure elements.

Test of resistance to external factors between -40 and +70 °C*.

Waterproof test – 100 %

Short-circuit current resistance test: **The optical attenuation ratio gain is within 0.05 dB/km. The integrity of optical fibers and the minimal breaking strength are preserved.**

*** attenuation ratio growth is within 0.05 dB/km at 1550 nm wave-legth.**

- **Conformity testing requirements of Germany (DIN & IEC), confirmed by SAG Deutschland - Versuchs- und Technologiezentrum**

CARRIER CABLE OF CONTACT NETWORK

Achieved goal: Create a carrier copper (alloys without, only due the design) cable combining a number of features:

- **High Breaking strength (at level of the Bronze)**
- **Larger current load and resistance to overheating**
- **Little temperature-caused extension**
- **Enough conductivity & Better aerodynamic properties**
- **Standard diameters, simple installation & Manufacturable for serial production without increased cost of the final product**

The design reduces power losses by 11.35 % as compared with serial design & by 28.7 % as compared with Bronze cable

Experience of application - the busiest areas of the South-Ural and West Siberian Railway from 2014

IN VIEW OF THIS EXPERIENCE, THE IEC TECHNICAL COMMITTEE (TC-9) HAS ACCEPTED OUR PROPOSAL TO ESTABLISH THE IEC ON THE CARRIER CABLE OF CONTACT NETWORK OF RAILWAYS. THE PROPOSAL WAS SUPPORTED BY GERMANY, SWITZERLAND, ITALY, JAPAN, CHINA (AHG 14).

Basic electromechanical characteristics (confirmed experimentally in the "conductor - fitting" system)

Diameter	Section	Electric resistance	Breaking force
mm	mm²	Ohm/km	kN
10,7	87,7	0,2209	32,944
12,6	124	0,1533	45,73
14	140	0,1383	55,5
15,8	190	0,1008	72,26

In accordance with the task of the Russian Railways, we have developed modifications of plastically deformed suspension cable –

version with a steel core,

zinc- or copper-plated.

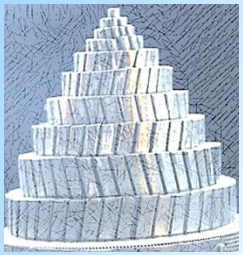
Purpose: use on high-speed Railways

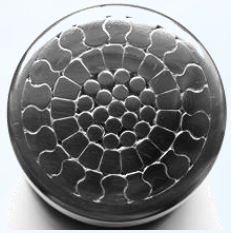
The electrical and mechanical characteristics in the embodiment with steel core

Diameter, mm	Section (Cu) mm²	Breaking force, kN	Specific electric resistance, Ohm/km, at 20 °C, at most
10,7	83,41	39,1	0,235
12,6	119,84	54,6	0,164
14	133,4	72,79	0,145
15,8	182,2	80,4	0,108

The design and technology is protected by Russian patent №161777 (patent priority from 2015.), the production technology of plastically deformed suspension cable - German Patent № DE102014101833. High tensile strength is achieved by using a central wire with increased breaking strength and structure of the cable itself.

Some Our Implemented Projects





RUGRIDS ELECTRO

SUEK

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25 Russian Patents

Deutsches Patent- und Markenar