Energoservis Engineering Company

Best Implemented Project for the Russian State Grid Company "Rosseti® (Russian Grids) in 2014

Products marked on the world's forums

Innovative products for energy infrastructure facilities

Providing simple solutions to complicated problems
Reasons of technology breakdowns of overhead power transmission lines 110–750 kV (ten-year Statistics Join Date)

Accessories: 2.7%
Insulator strings: 29.7%
Ground cables: 13.8%
Pylons: 3.4%
Conductors: 50.3%

Reasons of conductors damage:
1 – cable swinging, vibrations;
2 – thefts;
3 – glaze frost, wind load;
4 – clamp damage;
5 – external effects;
6 – defects of design and installation;
7 – operation defects;
8 – atmospheric overvoltages;
9 – strength loss, corrosion.
Energoservis Engineering Company
Development of Overhead ground wire, high-strength and high-temperature conductors, OPGW of new generation for overhead power lines

European production

Experience - 15,000 km of transmission lines
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, 14,000 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](http://w.w.w.energoservise.com)
For more than a hundred years of conductors’ production for the Power transmission lines, the process has been resting on an axiom-like principle of alternating right-left wires’ lays twist, to reduce the effect of deep fluctuations in conductor torque (and its tendency to twist spontaneously) while highly varieties tension load is applied to the conductor. But how important is this principle for further exploitation of the conductors / ground wires now? The weakening of this “axiom” has become possible on the basis of in-depth study of the "life cycle" of the Overhead Line conductors and ground wires at the present stage. The conductors’ features are estimated there in their common exploitation-addressed way). Presence of swivels during unreeling provides practical absence of the torque moment in conductors rolled along the OHL at mount tension \( \approx 10...15 \% \) of RBS. After the tension is raised up to its working value (around \( 20...25 \% \) of RBS), practically negligible residual torque moment can be found in the conductors, due to their plastic deformation and tough contacts between wires of the structure in the production process. In periods of a higher tension, considerable friction forces in tension/ suspension endpoints of the conductor keep them against excessive rotation. It should be noted that plastic deformation in the multidirectional lay rope may cause damage to the internal layer.(See p.4).
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 and Severstal-Metiz, completely and successfully passed the entire test sequence. Cable 2-Г (МЗ)-В-ОЖ-МК-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-МК-Н-Р-1770 by Severstal-Metiz, Volgogradsky branch, is the most reliable and preferred for protection of high-voltage power lines from lightning strikes.

Cable ПК-9,2-МЗ-В-ОЖ-МК-П

Cable ПК-МЗ-В-ОЖ-МК-3-1770; Enterprise Standard 14-173-35 by Mechel failed to pass the test sequence. Cable ПК-МЗ-В-ОЖ-МК-3-1770; 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-МК-3-1770; TU 14-173-35 by Mechel cannot be recognized reliable; it is not recommended for protection of high-voltage power lines from lightning strikes.

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.

✔ 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

(OGPW, in the IEEE standard, an optical fiber composite overhead ground wire)

It retains the original characteristics and operation of the optical cable after lightning strike over 110 KI

The product keeps on a par with the global analogs and offers highest reliability

Conformity testing requirements of Germany (DIN & IEC), confirmed by SAG Deutschland - Versuchs- und Technologiezentrum
OPGW suspension accessories:
Standard suspension accessories 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).

Description of OPGW tests

- **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-length.
STEEL-CORED ALUMINUM CONDUCTORS for high-voltage overhead power transmission lines

HIGH STRENGTH  HIGH TEMPERATURE

Cheaper technology while maintaining the reliability
Comparison of AS, AERO-Z, ASHS, ASHT conductors a diameter of 22.4

<table>
<thead>
<tr>
<th>Type</th>
<th>Diameter, mm</th>
<th>Breaking force, kg</th>
<th>Weight, Kg/km</th>
<th>Permissible continuous current, A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard AL-Steel 240/56</td>
<td>22.4</td>
<td>98253(100%)</td>
<td>1106(100%)</td>
<td>610(100%)</td>
</tr>
<tr>
<td>AERO-Z 346-2Z</td>
<td>22.4</td>
<td>111320(113%)</td>
<td>958(87%)</td>
<td>852(140%)</td>
</tr>
<tr>
<td>Lumpi -TACSR</td>
<td>22.4</td>
<td>86260(113%)</td>
<td>957(87%)</td>
<td>861(141%)</td>
</tr>
<tr>
<td>J-Power Systems GATACSR</td>
<td>22.4</td>
<td>110000(113%)</td>
<td>1100(100%)</td>
<td>860(140%)</td>
</tr>
<tr>
<td>ASHS 277/79 Energoservis</td>
<td>22.4</td>
<td>163940(167%)</td>
<td>1399(127%)</td>
<td>861(141%)</td>
</tr>
<tr>
<td>ASHS 258/73 Energoservis</td>
<td>21.6</td>
<td>151553(154,2%)</td>
<td>1296,5(117%)</td>
<td>812,72(133%)</td>
</tr>
<tr>
<td>Standard AL-Steel 400/93*</td>
<td>29.1</td>
<td>173715(100%)</td>
<td>1851(100%)</td>
<td>860(100%)</td>
</tr>
<tr>
<td>ASHS 371/106* Energoservis</td>
<td>26,0</td>
<td>225001(122,79%)</td>
<td>1872(113%)</td>
<td>1059,9(123%)</td>
</tr>
<tr>
<td>ASHT 277/79** Energoservis</td>
<td>22.4</td>
<td>163940(167%)</td>
<td>1399(127%)</td>
<td>1199(197%)</td>
</tr>
</tbody>
</table>

Note: The values for Standard AL-Steel 240/56 conductors (serially used now) are assumed as 100%.
* - Comparison AS400 / 93 and ASVP371 / 106; ** - The high temperature cable (ASHT by Energoservis).

\[ \text{ASHS} - t_{\text{work}}=90^\circ\text{C} \quad \text{ASHT} - t_{\text{work}}=150^\circ\text{C} \]

**Advantages:** ASHS and ASHT conductors are more than twice stronger; ASHS conductor’s current is almost as high as AERO-Z’s current; and ASHT conductors offers capacity almost twice higher than AC conductor and 1.5 times higher than AERO-Z conductors of similar diameters. It supposes that the new ASHS and ASHT conductors expand designing of HV power lines and allow dealing with the goals that used to be unpractical or used to require great efforts.

Using OUR conductors may considerably increase the capacity of HV-lines as compared with standard conductors.

The unique technological solutions in the production of our wire allows us to offer a significant reduction in price relative to other wires with the same characteristics!
HIGH-STRENGTH STEEL-CORED ALUMINUM CONDUCTORS

In the absence of constraints associated with the routing of the line, the use of our conductors can lead to a 25-30% capital cost savings in the project due to the smaller number of supports (Span length of OHL at one and the same sag).

High strength steel-aluminum conductor offers high mechanical strength & large section of aluminum part with constant diameter.

By using our conductors is increased Breaking strength and decreased Specific losses of electricity at the same current load, aerodynamic loadings (till 35%) and formation of ice (till 25%), conductor temperature expansion coefficient (15%) only due the design!

The correct definition of the conductors creep has recently become one of the important requirements arising from the Exploitation organizations in Russia, as it turned out that the capacity of many of the overhead Lines may not be fully utilized due to increased, after many years of service, sag of the conductors.

![Graph showing Prognosis of Fatigue behavior for the ASHS, ASHT conductors (shaded area). The test results as a function σ(N) for single-layer (ellipses) and multi-layer (triangles) conductors ACSR are reproduced on the basis of data [7]. N in Megacycles.](image)
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
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.

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

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.
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: $d_{\text{cond}}=\text{const} \Rightarrow S_{\text{AL}}$ - increase or $S_{\text{AL}}=\text{const} \Rightarrow d_{\text{cond}}$ decrease

<table>
<thead>
<tr>
<th>Rated Core cross section, mm² (standard conductor)</th>
<th>design parameters high strength conductors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Core cross section, Al/Steel, mm²</td>
<td>Diameter, mm</td>
<td>DC Resistance (20 0C), Ohm/km</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Conductor, mm</td>
<td>steel core, mm</td>
<td>0,1334</td>
</tr>
<tr>
<td>216/33</td>
<td>18,5</td>
<td>6,7</td>
</tr>
<tr>
<td>300/39</td>
<td>22,3</td>
<td>7,1</td>
</tr>
<tr>
<td>400/51</td>
<td>24,75</td>
<td>7,45</td>
</tr>
<tr>
<td>300/66***</td>
<td>21,5</td>
<td>8,17</td>
</tr>
<tr>
<td>400/93***</td>
<td>25,2</td>
<td>9,50</td>
</tr>
</tbody>
</table>

* - Increase in breaking load with decreasing diameter and still increasing the AC Continuous carry.

> 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 ($t_{\text{work}}=150^\circ\text{C}$, $t_{\text{max}}=210^\circ\text{C}$).

*** - 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 * 10⁵ N/mm² ASHS/ASHT (0,63 * 10⁵ N/mm² Standard conductor)
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

**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.**
Developments are protected by Russian and International patents, which we hope to shall be respected.
Innovative products of Energoservis Ltd.
More 20 years Energoservis’ crew has supplied the market of steel ropes and bare conductors. For many years we have developed, tested and introduced innovative rope products specially for the biggest national companies, such as Norilsk Nickel, Russian Railways, SUEK, ROSSETI Russian Grids etc. Among our facilities are Ostankino TV Tower, deep-earth hoisting, thousands kilometers of power transmission lines, hundreds kilometers Rope guardrails and deck brake systems, and many others. Our production base, manufacturing products that successfully stand competition with European products. All of the projects the company realizes from design, types of special steel (or AL) up to the technology.
We provide to you to cut costs while increasing the reliability of power transmission lines and contact network of railways.

Thank you for your attention!

http://www.energoservise.com