High-Temperature Low Sag (HTLS) conductors for easy Upgrading of Overhead Transmission Lines

J-Power Systems (JPS) is a joint-venture of HITACHI CABLE and SUMITOMO ELECTRIC INDUSTRIES

Hitachi Cable Europe is the sales channel of JPS products in Europe
Advantages of Reconductoring with HTLS conductors

Advantages

- **Increase** the current capacity by **1.6-2.0 times** by using our HTLS conductor which has the **same size** as previous old conductor.
- **No modifications** or reinforcement needed on existing towers.
- Need Re-conductoring only (**low cost and short period**).

Suitable Occasions

- Land Limitation
- Objections from inhabitants to build new O/H Lines
- Short Period Up-rating is required
- Initial Funds are not enough
Up-rating Conductors

**Gap type conductor** (Unique construction)

**G TACSR/GZTACSR**

- Gap Construction
- Thermal Resistant Al-alloy
- Super thermal Resistant Al-alloy

**Invar core conductor** (Unique material)

**ZTA C I R**

- Invar Alloy
- Super Thermal Resistant Al-Alloy
## Thermal Resistant Aluminum alloys (TAL / ZTAL)

<table>
<thead>
<tr>
<th>Allowable temp.</th>
<th>Tensile strength</th>
<th>Conductivity</th>
<th>Current capacity ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>deg C</td>
<td>MPa</td>
<td>%IACS</td>
<td></td>
</tr>
<tr>
<td>1350</td>
<td>90</td>
<td>160</td>
<td>61</td>
</tr>
<tr>
<td>TAL</td>
<td>150</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>ZTAL</td>
<td>210</td>
<td>160</td>
<td>60</td>
</tr>
</tbody>
</table>

Both TAL and ZTAL can be used to produce GAP or INVAR conductors.

**GAP** is offered in 2 versions:
- with TAL (Temp. = 150 C)
- with ZTAL (Temp. = 210 C)

**INVAR** is offered in 2 versions:
- with ZTAL (Temp. = 210 C)
- with XTAL (Temp. = 240 C)*

*XTAL normally has lower conductivity*
Low Sag design concept

Design Concept:

**Gap:** Shift the Knee Point Temperature (KPT) to lower side

**Invar:** very small thermal expansion at temperatures above KPT

KPT is a temperature at which Aluminum layers do not bare any tension due to its thermal expansion in ACSR conductor. So, above KPT the Tension is on the Steel core only.
## HTLS conductors are a Mature Technology

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>• TAL(58%IACS): installed on practical T/L (Japan)</td>
</tr>
<tr>
<td>1970</td>
<td>• TAL(60%IACS): installed on practical T/L (Japan)</td>
</tr>
<tr>
<td>1971</td>
<td>• <strong>Gap</strong> Type: installed on practical T/L (Japan)</td>
</tr>
<tr>
<td>1981</td>
<td>• <strong>Invar</strong> Type (XTACIR): installed on practical T/L (Japan)</td>
</tr>
<tr>
<td>1982</td>
<td>• ZTAL: installed on practical T/L (Japan)</td>
</tr>
<tr>
<td>1984</td>
<td>• ZTACIR: installed on practical T/L (Japan)</td>
</tr>
<tr>
<td><strong>2010</strong></td>
<td><strong>Gap</strong> Type: <strong>supplied roughly 18000 km</strong></td>
</tr>
<tr>
<td></td>
<td>incl. 400kV, 620mm$^2$, no voltage limitation</td>
</tr>
<tr>
<td></td>
<td><strong>Invar</strong> Type: <strong>supplied roughly 6800 km</strong></td>
</tr>
<tr>
<td></td>
<td>incl. 500kV, 610 mm$^2$, no voltage limitation</td>
</tr>
</tbody>
</table>

All relevant technology has been developed by J-Power Systems
Gap need Special Tensioning Method (only Tension Tow.)

- De-stranding & Expose steel
- Steel gripping clamp
- Aluminum gripping clamp
- Woven back
- De-stranded AL-Layers
- AL-CLAMP
- G(Z)TACSR
- INSULATOR ASSY
Gap type conductor: Maintenance

Repair Sleeve: same as ACSR
   in case of damage less than 10% of AL wires

Mid Span joint: same as ACSR
   in case of damage more than 11% of AL wires

➢ Tension load at repaired portion shall have more than 95% tension load of Original conductor

No need for special arrangement for our GAP grease:

Heat Resistant Grease
   After 30+ years usage
   stable characteristic

Test Results from GTASCR 410mm2, installed in 1972 in Japan and tested on 2006
### Gap & Invar Comparison

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Gap Type Conductor</th>
<th>Invar core conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low price</td>
<td>Conventional installation</td>
</tr>
<tr>
<td></td>
<td>Low KPT</td>
<td>(exactly the same as normal ACSR)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantage</th>
<th>Special installation</th>
<th>Higher price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Construction period increases only by approximately 15% or 20%: this data was communicated to us by several Installation Companies)</td>
<td>(Nickel metal price)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High KPT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(If the design temp. of existing T/L is relatively low, Invar conductor is probably not applicable)</td>
</tr>
</tbody>
</table>
Design Example: Existing Conductor & Gap type conductor

Existing Conductor: ACSR 435/55

- Construction: Al 52/3.2mm
  - St 7/3.2mm
- Weight: 1641kg/km
- D.C. resistance: 0.0666 ohm/km

Designed Conductor: Gap GTACSR 448mm²

- Construction: TAl 15/4.8mm
  - TAl 10/ TW
  - Est 7/3.1mm
- Weight: 1687kg/km \( (103) \)
- D.C. resistance: 0.0660 ohm/km \( (99) \)

Equivalence for Comparison with ACSR 435/55 = \( (100) \)
Design Example: Sag-Tension and Ampacity study

Required current capacity: 1250A
- GTACSR 448SQ at 115 deg C: 1250A, (Sag 20.36m)
- ACSR 435/55SQ at 60 deg C: 643A, (Sag 19.83m)

[Current capacity]
- Ambient temp.: 35°C
- Wind velocity: 0.6m/s
- Wind direction: Right angle
- Solar radiation: 895W/m²
- Absorptivity const: 0.5

[Sag - Tension]
- Span: 400m
- Maximum tension: 41701N
- Worst loading condition:
  - -5deg C, 0m/s,
  - 7.7mm Ice
  - Sagging temp: 10 degree C
## Accessories for Gap Type Conductor

<table>
<thead>
<tr>
<th>Conductor type</th>
<th>GTACSR / GZTACSR</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension Clamp</td>
<td>Larger Compression Type</td>
<td>other type, not applicable</td>
</tr>
<tr>
<td>Compression Joint</td>
<td>Larger</td>
<td>Mid-span Joint Repair Sleeve Terminal</td>
</tr>
<tr>
<td>Suspension clamp</td>
<td>Bolted Type</td>
<td>Armor Grip Type, Not applicable</td>
</tr>
<tr>
<td>Damper</td>
<td>Standard</td>
<td>Standard</td>
</tr>
</tbody>
</table>

### Why are the compression fittings larger?
- Low D.C. resistance → Reduce current heating
- Large diameter → Enhance heat radiation
- Temperature of fittings are equivalent to conventional ones!!
HTLS very suitable for Wind Energy

Wind Energy is “unreliable”: sometimes (when there are High Winds) there is the need to have a very big Ampacity available in OH lines, but only for a short period of time (it could be few days in a year).

Energy cannot be stored (at least, in a “cheap” way), so it must be used when it’s produced. For this reason, energy exchange among different Wind Farms (or among other grid areas with other Power Generators) need to be maximised.

For all these reasons, **OH grid capacity needs to be upgraded in presence of Wind Energy production**

By reconductoring a line with our HTLS the TSOs can “reject” a smaller amount of Wind Energy (produced when the Winds are very strong). See next slide.
Building new OHTL should be designed for Maximum Power of 65% of installed Wind Power, thus “rejecting” 1% of Annual Wind Energy produced.

Upgrading Existing Lines with HTLS conductors can be designed for Maximum Power of 75% of installed Wind Power, “rejecting” only 0.3% of Annual Wind Energy produced.

Example: Eastern Germany 2006 (installed Wind Power was 7.6GW)

HTLS conductor is 4 times cheaper than building a new OH line!

Source: EWEC 2009, Marseille (Prof. Jarass et al.)
Confirmations that Upgrading with HTLS is cheap

150 kV, Double-Circuit: need to upgrade 22.8mm2 ACSR line:

Building New Line 31.5mm2 ACSR: 100 K Euro/km
Upgrading with GAP GTACSR 22.8mm2: 30 K Euro/km(*)

Source: ENEL Distribuzione (Italy), 2005

(*) The value of 30 K Euro/km is already taking into account the fact that the higher temperature of service of GAP conductor will produce a higher Joule loss (with respect to standard ACSR). This will bring an additional difference in cost for GAP of about 5 K Euro/km (which is already comprised in the total value 30 K Euro/km)

Using HTLS conductor on this line will increase the Loss only in a negligible way (from 0.5% to 1.0%), compared with the total amount of loss in the overall network (which is typically around 5%-7% in USA). Most of these losses are in Distribution and not in Transmission.
Supply Record/ Gap type conductor (GTACSR, GZTACSR)

Total Installed Length (km)

Year of Installation (started in 1971)

- GAP with ZTAL
- GAP with TAL
Supply Record/ Invar core conductor (ZTACIR, XTACIR)
UK: National Grid

Line: “Canterbury – Kemsley”
Year: 2008
Full refurbishment of 29km of 400kV double circuit with twin GAP conductor and 29 km OPGW
Line diversion for new substation. Driven by new generation connections.

378 km : length of conductor

Line: “Deeside-Daines”
Year: 2003
Full refurbishment of 25km of 400kV double circuit with twin GAP conductor and OPGW

320 km : length of conductor
Line: “Maranola – Minturno”
Year: 2004
Up-rating of line 18.4km (132kV) single circuit with GAP conductor

61 km : length of conductor

Line: “Villanova – Pineto d. Montesilvano”
Year: 2006
Up-rating of line 16.5km (132kV) with INVAR conductor

41 km : length of conductor
Spain: Red Electrica de España

Line: “Atarfe – Caparacena”
Year: 2008
Installation of 220kV double circuit with single GAP conductor

23 km: length of conductor
Conclusions

• JPS’ Low-Sag up-rating conductors (Gap type / Invar type) increase the transmission capacity of existing lines 1.6 / 2.0 times by only re-conductoring (without the need to change or reinforce the existing towers)

• Low-Sag up-rating conductors present big advantages to solve problems of “bottlenecks” in power grid network
Thank You for your attention

Please contact us:

Hitachi Cable
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