Photos on Front Cover, Frontispieces and Rear Cover

Front Cover

+/- 250kV DC-XLPE Cable for Hokkaido-Honshu HVDC Link

Electric Power Development Co. Ltd., and J-Power Systems Corporation cooperatively developed the world’s first extruded cross-linked polyethylene (XLPE) insulated cable for use in HVDC transmission power lines where voltage polarity reversal is expected. In the summer of 2012, the two companies added it to the existing Hokkaido-Honshu DC link owned by the Electric Power Development Co. Ltd., to increase the reliability of this important power link. The cable line came into operation in December 2012.

Two of the photos on the front cover show the installation of submarine cable and the upper left photo illustrates +/-250 kV DC-XLPE submarine cable construction for the Hokkaido-Honshu HVDC link. The cable incorporates optical fiber and is armored with double layers of steel wire. Its unit weight is approximately 48 kg/m in air and approximately 33 kg/m in seawater.

When the operation started in December 2012, the operating voltage (+/-250 kV) of the Hokkaido-Honshu HVDC link was the highest in the world for transmission lines using extruded XLPE insulated cables.

The details of the DC-XLPE cable technology will be reported in the IEEJ Transactions on Power and Energy Vol.134 No.1, to be published in January 2014.

Yoshinao Murata
J-Power Systems Corporation
5-1-1 Hitaka-cho, Hitachi-shi, Ibaraki-ken, 319-1414 Japan

Frontispiece i

In-Grid Demonstration of High Tc Superconducting Cable in Yokohama, Japan

Japan’s first High Tc Superconducting (HTS) cable demonstration project supported by New Energy and Industrial Technology Development Organization is in progress. The target of this project is to operate a 66 kV, 200 MVA HTS cable system for 1 year or more in the real grid to prove system reliability and achieve system control and maintenance methods. The Project is conducted by Tokyo Electric Power Company (TEPCO), Sumitomo Electric Industries, Ltd. (SEI) and Mayekawa mgf. Co. Ltd.

The cable has a structure of three cable cores housed in a cryostat. The cable core consists of Superconducting conductors, a dielectric layers, shielding layers and protection layers. The Superconducting conductor and Superconducting shield are used with HTS wires called as BSCCO wires. Electrical insulation is made of PPLP (Polypropylene Laminated Paper). In HTS shield, the shielding current is induced to cancel the magnetic field generated in the HTS conductor. Vacuumed multi-layer insulation system between the inner and outer corrugated pipes is adopted for the cryostat to decrease heat invasion from the ambience.

HTS cable system was installed at Asahi Substation in TEPCO’s grid, located in Yokohama city. The system has a 240 m HTS cable, a joint, two terminations and a cooling system. One of the terminations is connected to the 66 kV end of a 154 kV/66 kV transformer and the other is connected to a 66 kV bus lines. Liquid Nitrogen is circulated between HTS cable and the cooling system to maintain the cable at around -200 degree Celsius.

After laying the cable and assembling the joint and terminations, several tests were conducted successfully and then the cable was energized in last October, 2012. It has been transmitting electricity to the customer without any interruption or troubles, so far. On the project schedule, it will be operated up to early next year.

The photographs show the HTS cable in the duct, cable structure model, joint, terminations and cooling system.

Takato Masuda
Superconductivity Technology Division
Sumitomo Electric Industries, Ltd.
1-1-3, Shimaya, Konohana-ku, Osaka 554-0024 Japan
In-Grid Demonstration of High Tc Superconducting Cable in Yokohama, Japan

(Provided by NEDO, TEPCO, SEI and Mayekawa.)
Electric Power Development Co. Ltd., and J-Power Systems Corporation cooperatively developed the world’s first extruded cross-linked polyethylene (XLPE) insulated cable for use in HVDC transmission power lines where voltage polarity reversal is expected. In the summer of 2012, the two companies added it to the existing Hokkaido-Honshu DC link owned by the Electric Power Development Co. Ltd., to increase the reliability of this important power link. The cable line came into operation in December 2012.

Two of the photos on the front cover show the installation of submarine cable and the upper left photo illustrates +/-250 kV DC-XLPE submarine cable construction for the Hokkaido-Honshu HVDC link. The cable incorporates optical fiber and is armored with double layers of steel wire. Its unit weight is approximately 48 kg/m in air and approximately 33 kg/m in seawater.

When the operation started in December 2012, the operating voltage (+/-250 kV) of the Hokkaido-Honshu HVDC link was the highest in the world for transmission lines using extruded XLPE insulated cables.

The details of the DC-XLPE cable technology will be reported in the IEEJ Transactions on Power and Energy Vol.134 No.1, to be published in January 2014.

Yoshinao Murata  
J-Power Systems Corporation  
5-1-1 Hitaka-cho, Hitachi-shi,  
Ibaraki-ken, 319-1414 Japan

Japan's first High Tc Superconducting (HTS) cable demonstration project supported by New Energy and Industrial Technology Development Organization is in progress. The target of this project is to operate a 66 kV, 200 MVA HTS cable system for 1 year or more in the real grid to prove system reliability and achieve system control and maintenance methods. The Project is conducted by Tokyo Electric Power Company (TEPCO), Sumitomo Electric Industries, Ltd. (SEI) and Mayekawa mgf. Co. Ltd.

The cable has a structure of three cable cores housed in a cryostat. The cable core consists of Superconducting conductors, a dielectric layers, shielding layers and protection layers. The Superconducting conductor and Superconducting shield are used with HTS wires called as BSCCO wires. Electrical insulation is made of PPLP® (Polypropylene Laminated Paper). In HTS shield, the shielding current is induced to cancel the magnetic field generated in the HTS conductor. Vacuumed multi-layer insulation system between the inner and outer corrugated pipes is adopted for the cryostat to decrease heat invasion from the ambience.

HTS cable system was installed at Asahi Substation in TEPCO’s grid, located in Yokohama city. The system has a 240 m HTS cable, a joint, two terminations and a cooling system. One of the terminations is connected to the 66 kV end of a 154 kV/66 kV transformer and the other is connected to a 66 kV bus lines. Liquid Nitrogen is circulated between HTS cable and the cooling system to maintain the cable at around -200 degree Celsius.

After laying the cable and assembling the joint and terminations, several tests were conducted successfully and then the cable was energized in last October, 2012. It has been transmitting electricity to the customer without any interruption or troubles, so far. On the project schedule, it will be operated up to early next year.

The photographs show the HTS cable in the duct, cable structure model, joint, terminations and cooling system.

Takato Masuda  
Superconductivity Technology Division  
Sumitomo Electric Industries, Ltd.  
1-1-3, Shimaya, Konohana-ku, Osaka 554-0024  
Japan
High-power Testing Facility with State-of-the-art Equipment

Outside of high-power testing facility.

Capacitor bank of adjusting the transient recovery voltage.

(Provided by Hitachi, Ltd. Power Systems Company)
High-power Testing Facility with State-of-the-art Equipment

A major upgrade to the high-power test equipment at Hitachi’s high voltage & high power testing laboratory was undertaken in FY 2011, and the facility has been using its new state-of-the-art equipment to perform breaking and other high-power tests since May 2012. In particular, the all-weather voltage source has been upgraded in order to conduct synthetic breaking tests of high-voltage circuit breakers. The equipment includes a main capacitor bank with a rated voltage of 1,200 kV and total capacitance of 8.3 μF, and a capacitor bank for adjusting the transient recovery voltage with a rated voltage of 1,650 kV and total capacitance of 1.64 μF. These are used for testing of circuit breakers and switchgears from medium-voltage to ultra-high-voltage class transmission systems. In addition to utilizing the latest technologies for high reliability in the design and manufacture of each unit to ensure that if suited its intended purpose, Hitachi also took note of the relevant standards such as JEAG5003 and IEEE 693 for seismic capacity to ensure that the equipment would be capable of withstanding a 0.5-G resonant vibration in the event of an earthquake.

The testing laboratory is certified under the ISO/IEC 17025 standard. It is also a member of the Japan Short-Circuit Testing Committee (JSTC), which in turn is a full member of the Short-Circuit Testing Liaison (STL). This means the facility can provide its customers with an independent and objective testing service for certifying compliance with circuit breaker and other related standards set by standards bodies such as the International Electrotechnical Commission (IEC). The facility is also able to issue certificates for type tests.

Junzo Kida
High Voltage & High Power Testing Laboratory
Hitachi, Ltd., Power Systems Company
Hitachi Works
Address: 1-1-1, Kokubu-cho, 1-chome
Hitachi-shi, Ibaraki-ken
316-8501 Japan

500kV Gas Insulated Bushings with Downsized Porcelain Hollow Core Insulators

The picture shows 500kV Gas insulated bushings with downsized porcelain hollow core insulators for heavy contamination area located in Shin-Haruna substation of TEPCO, which installed by Toshiba corporation. These have been started in service since 2005.

Gas insulated bushings with downsized porcelain hollow core insulators established high seismic performance compared with ordinary bushing. That is to say, for the development of this type of bushing, the improvement of electric field analysis engineering, super high leakage type shed developed for 100kV porcelain hollow core insulator, and high strength porcelain material were adopted. As a result, the design of gas bushings with downsized porcelain hollow core insulators achieved the improvement of seismic characteristics by light weight and high strength porcelain body. The development of this bushing had been completed in 2002. Since then, several power utilities in Japan had started to use them.

Toshiyuki Nakachi
NGK Insulators, LTD.
1155 Tagami, Futaebori, Komaki
485-8566 Japan

Improvement of seismic performance on 500kV Gas insulated bushing with downsized porcelain hollow core insulator

<table>
<thead>
<tr>
<th>Contamination area</th>
<th>Item</th>
<th>(1) Ordinary hollow core insulator</th>
<th>(2) Downsized porcelain hollow core insulator</th>
<th>Improvement ratio of seismic performance (2)/(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L (Low)</td>
<td>Height (m)</td>
<td>5.4</td>
<td>5.2</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>2,200</td>
<td>1,580</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety factor in seismic performance</td>
<td>2.89</td>
<td>3.54</td>
<td></td>
</tr>
<tr>
<td>M (Medium)</td>
<td>Height (m)</td>
<td>6.7</td>
<td>5.2</td>
<td>1.71</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>2,650</td>
<td>1,780</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety factor in seismic performance</td>
<td>1.99</td>
<td>3.40</td>
<td></td>
</tr>
</tbody>
</table>
500kV Gas Insulated Bushings with Downsized Porcelain Hollow Core Insulators (Shin-Haruna Substation of TEPCO)

(Photo: Courtesy of Toshiba Corporation, Provided by NGK Insulators, LTD.)
Frontispiece ii

High-power Testing Facility with State-of-the-art Equipment

A major upgrade to the high-power test equipment at Hitachi’s high voltage & high power testing laboratory was undertaken in FY 2011, and the facility has been using its new state-of-the-art equipment to perform breaking and other high-power tests since May 2012. In particular, the all-weather voltage source has been upgraded in order to conduct synthetic breaking tests of high-voltage circuit breakers. The equipment includes a main capacitor bank with a rated voltage of 1,200 kV and total capacitance of 8.3 μF, and a capacitor bank for adjusting the transient recovery voltage with a rated voltage of 1,650 kV and total capacitance of 1.64 μF. These are used for testing of circuit breakers and switchgears from medium-voltage to ultra-high-voltage class transmission systems. In addition to utilizing the latest technologies for high reliability in the design and manufacture of each unit to ensure that if suited its intended purpose, Hitachi also took note of the relevant standards such as JEAG5003 and IEEE 693 for seismic capacity to ensure that the equipment would be capable of withstanding a 0.5-G resonant vibration in the event of an earthquake.

The testing laboratory is certified under the ISO/IEC 17025 standard. It is also a member of the Japan Short-Circuit Testing Committee (JSTC), which in turn is a full member of the Short-Circuit Testing Liaison (STL). This means the facility can provide its customers with an independent and objective testing service for certifying compliance with circuit breaker and other related standards set by standards bodies such as the International Electrotechnical Commission (IEC). The facility is also able to issue certificates for type tests.

Junzo Kida
High Voltage & High Power Testing Laboratory
Hitachi, Ltd. Power Systems Company
Hitachi Works
Address: 1-1-1, Kokubu-cho, 1-chome
Hitachi-shi, Ibaraki-ken
316-8501 Japan

Frontispiece iii

500kV Gas Insulated Bushings with Downsized Porcelain Hollow Core Insulators

The picture shows 500kV Gas insulated bushings with downsized porcelain hollow core insulators for heavy contamination area located in Shin-Haruna substation of TEPCO, which installed by Toshiba corporation. These have been started in service since 2005.

Gas insulated bushings with downsized porcelain hollow core insulators established high seismic performance compared with ordinary bushing. That is to say, for the development of this type of bushing, the improvement of electric field analysis engineering, super high leakage type shed developed for 100kV porcelain hollow core insulator, and high strength porcelain material were adopted. As a result, the design of gas bushings with downsized porcelain hollow core insulators achieved the improvement of seismic characteristics by light weight and high strength porcelain body. The development of this bushing had been completed in 2002. Since then, several power utilities in Japan had started to use them.

Toshiyuki Nakachi
NGK Insulators, LTD.
1155 Tagami, Futaebori, Komaki
485-8566 Japan

<table>
<thead>
<tr>
<th>Contamination area</th>
<th>Item</th>
<th>(1) Ordinary hollow core insulator</th>
<th>(2) Downsized porcelain hollow core insulator</th>
<th>Improvement ratio of seismic performance (2)/(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L (Low)</td>
<td>Height (m)</td>
<td>5.4</td>
<td>5.2</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>2,200</td>
<td>1,580</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety factor in seismic performance</td>
<td>2.89</td>
<td>3.54</td>
<td></td>
</tr>
<tr>
<td>M (Medium)</td>
<td>Height (m)</td>
<td>6.7</td>
<td>5.2</td>
<td>1.71</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>2,650</td>
<td>1,780</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety factor in seismic performance</td>
<td>1.99</td>
<td>3.40</td>
<td></td>
</tr>
</tbody>
</table>

Improvement of seismic performance on 500kV Gas insulated bushing with downsized porcelain hollow core insulator
<table>
<thead>
<tr>
<th>H (Heavy)</th>
<th>Height (m)</th>
<th>8</th>
<th>6.2</th>
<th>1.64</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>3,200</td>
<td>2,180</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety factor in seismic performance</td>
<td>1.43</td>
<td>2.34</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in table of height and weight show those of hollow core insulator. Safety factor in seismic performance were performed in accordance with JEAG5003 (Three cycle sine wave with resonant frequency).

**Rear Cover**

**Quantum Chemical Calculation Studies on Space Charge Trapping Sites for Polyimide/Kapton**

(a) Chemical structural formula of Kapton.  
(b) The energy band of Kapton which is distributed along the formula chain, such as part A and part B.  
(c) Orbital electron density at HOMO level and one of LUMO level, respectively, which are drawn on the chemical structural formula.  
(d) 3D potential mapping (upper) for the negatively charge which is trapped at the trapping site of LUMO level of part A. 3D potential mapping (lower) for the positively charge which is trapped at the trapping site of HOMO level of part B.

**Prof. Emeritus Tatsuo Takada**  
Tokyo City University  
1-28-1 Tamazutsumi, Setagaya-ku, Tokyo, 158-8557, Japan

**Journals of IEEJ**

A Journal which is edited by the headquarters of the Institute and five transactions which are edited by five technical societies* A to E are monthly published.

Another transaction “IEEJ Transactions on Electrical and Electronic Engineering (TEEE)” is edited in English by the five technical societies and published bimonthly by John Wiley & Sons.

An English journal “IEEJ Journal of Industry Applications” was launched in July 2012. It is edited by the society D and published bimonthly.

Papers in all kinds of journals published by IEEJ can be browsed at [http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index020.html](http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index020.html)

You will be able to directly purchase the full text documents by PDF through the Pay-Per-View System.

Two journals “Electrical Engineering in Japan” and “Electronics and Communications in Japan” are translation of the IEEJ Transactions A, B, C, D and E from Japanese into English both edited and published by John Wiley & Sons (not all articles).

Right: Electronics and Communications in Japan  
Left: Electrical Engineering in Japan  

(*) Five technical societies in IEEJ are as follows:  
A: **Fundamentals and Materials Society** (This magazine is published from EINA Committee under this society.)  
B: Power and Energy Society  
C: Electronics, Information and Systems Society  
D: Industry Applications Society  
E: Sensors and Micromachines Society  
(please visit [http://www.iee.or.jp/index-eng.html](http://www.iee.or.jp/index-eng.html))