**Technical Report**

**Auftraggeber:** Ericsson AB  
**Customer:** Cables & Interconnect  
Källviksvägen 18  
SE 791 29 Falun, Sverige

**Gegenstand:** 20 kV and 30 kV XLPE insulated cables  
**Object:**

**Datum und Zeichen des Auftrages:** Order via e-mail from 2010, November, 5  
**Date and Signation of Order:**

**Untersuchungen:** Impulse voltage test for quality control of the insulation  
**Investigations:**

The measuring results exclusively refer to the examined samples.  
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1. Scope

According the “Richtlinie zur Qualitätsuntersuchung – Prüfung der Stoßspannungsfestigkeit an VPE-isolierten Energiekabeln”, in November 2010 an impulse voltage test for the quality control of the insulation has been carried out on 20 kV and 30 kV samples of XLPE insulated cables, manufactured by ERICSSON Cables & Interconnect (Sweden).

2. Test samples

Type: XLPE cable AXCES 3x95/25 12/20 (24) kV, (Appendix, fig.1and fig. 2) 
5 samples of 20 meters length each are required for the test (No 1 - No 5, see table 1).

Type: XLPE cable AXCES 3x70/25 18/30 (36) kV, (Appendix, fig. 3 and fig. 4) 
5 samples of 21 meters length each are required for the test (No 6 - No 10, see table 2).

3. Test conditions

The voltage grading is controlled via the outer semiconducting layer. The ends of the cable are exposed over a length of 4,5 m resp. 5,0 m each until the semi conductive layer. Only one conductor is connected with high voltage, the remaining two conductors and the screen are connected to ground. The test is carried out with the 3,2 MV impulse voltage generator (curve shape 1,2/50µs) as follows:

The thickness of the insulation of the Swedish cables is 4,5 mm for 20 kV and 5,5 mm for 30 kV (see appendix).
To obtain similar test conditions corresponding to the quality control test for cables manufactured according HD 620, equivalent levels for the withstand voltage V_w had to be defined due to the different geometry of the Swedish cables. Basis to define the scale factors for the equivalent impulse withstand voltage was the electrical field strength on the inner semiconducting layer.

The levels for the withstand voltage V_w for cables manufactured according HD 620 are:

\[ V_{w20} = 600 \text{ kV} \quad \text{... for 20 kV cables} \]
\[ V_{w30} = 800 \text{ kV} \quad \text{... for 30 kV cables} \]

The equivalent levels for the withstand voltage V_{we} for the Swedish cables with reduced thickness of the insulation are:

\[ V_{we20} = 450 \text{ kV} \quad \text{... for 20 kV cables} \]
\[ V_{we30} = 550 \text{ kV} \quad \text{... for 30 kV cables} \]

4. Test results
Table 1 shows the test results of the 20 kV cable samples with the values of the impulse withstand voltage and the breakdown voltage resp. the values of flashover, marked with *).

<table>
<thead>
<tr>
<th>Sample (No)</th>
<th>Impulse withstand voltage (kV)</th>
<th>Breakdown voltage (kV), Flashover voltage (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>625</td>
<td>650 at 1. surge</td>
</tr>
<tr>
<td>2</td>
<td>625</td>
<td>650 at 5. surge</td>
</tr>
<tr>
<td>3</td>
<td>565 *)</td>
<td>590 *) at 1. surge</td>
</tr>
<tr>
<td>4</td>
<td>565 *)</td>
<td>590 *) at 1. surge</td>
</tr>
<tr>
<td>5</td>
<td>565 *)</td>
<td>590 *) at 3. surge</td>
</tr>
</tbody>
</table>

Table 1: Test results, XLPE cable AXCES 3x95/25 12/20 (24) kV

Remark:  
It was not possible to determine the impulse withstand voltage for samples No 3 – No 5. The applied impulse voltage has been limited by flashovers due to the low conductivity of the outer semiconducting layer of these 3 samples. No breakdown in the insulation occurred.

Table 2 shows the test results of the 30 kV cable samples with the values of the impulse withstand voltage and the breakdown voltage.

<table>
<thead>
<tr>
<th>Sample (No.)</th>
<th>Impulse withstand voltage (kV)</th>
<th>Breakdown voltage (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>950</td>
<td>985 at 2. surge</td>
</tr>
<tr>
<td>7</td>
<td>985</td>
<td>1020 at 4. surge</td>
</tr>
<tr>
<td>8</td>
<td>950</td>
<td>985 at 5. surge</td>
</tr>
<tr>
<td>9</td>
<td>985</td>
<td>1020 at 2. surge</td>
</tr>
<tr>
<td>10</td>
<td>850</td>
<td>885 at 2. surge</td>
</tr>
</tbody>
</table>

Table 2: Test results, XLPE cable AXCES 3x70/25 18/30 (36) kV

5. Interpretation of the test results
The test results show, that the values of the impulse withstand voltage for all samples of the 20 kV cable and the 30 kV cable are greater than the equivalent levels of 450 kV resp. 550 kV. Furthermore two samples of the 20 kV cable showed the value of 625 kV for the withstand voltage, and all five samples of the 30 kV cable showed values greater than 800 kV, which additionally fulfill the higher levels for cables manufactured according HD 620 too. Hence the quality of the insulation of the XLPE cables AXCES 3x95/25 12/20 (24) kV and AXCES 3x70/25 18/30 (36) kV is in very good condition.

Graz, November 22nd, 2010

Versuchsanstalt für Hochspannungstechnik Graz GmbH
(Test Institution of High Voltage Engineering)

Managing Director:

(O.Univ.-Prof. Dr. Michael Muhr)

Specialist:

(Ao.Univ.-Prof. DI Dr. Rudolf Woschitz)
APPENDIX
Technical data
AXCES 12/20(24)kV 3x95/25
Product information

Inner conductive layer
Extruded PE

Insulation
XLPE, Triple extruded, dry cured vulcanized.
Nominal thickness: 4,5mm
Diameter over insulation approx: 20,4mm

Outer conductive layer
Extruded PE, easy strippable

Screen
Band of woven copper threads.
Nominal cross sectional area, 25mm²

Tape
PETP-PE tape

Sheath
Black LLD PE
Nominal thickness: 2,8mm
Outer diameter: 49mm
Outer circumscribed circle diameter: 53mm
Weight: 2,2kg/m
Density: 1,25kg/dm³

Embossed
"ERICSSON NT E AXCES 24 kV 3x95/25mm²
(Year of manufacturing YYYY)
+ meter marked"

Application
Self suspending 3-core cable, for use as aerial cable on poles, and in the ground and water.

Fig. 1: Data sheet 20 kV cable
Technical data
AXCES 12/20(24)kV 3x95/25

Electrical
Number of conductors x cross sectional area (mm²) 3x95/25
Rated voltage U0/Un 14/24 kV
Rated current according to IEC 287
<table>
<thead>
<tr>
<th>Temperature</th>
<th>In air 25°C</th>
<th>In the ground 15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum conductor temperature</td>
<td>65°C</td>
<td>200A</td>
</tr>
<tr>
<td>30°C</td>
<td>240A</td>
<td>-</td>
</tr>
<tr>
<td>90°C</td>
<td>240A</td>
<td>-</td>
</tr>
<tr>
<td>as self supporting suspending cable</td>
<td>65°C</td>
<td>200A</td>
</tr>
</tbody>
</table>
Conductor resistance max. at 20°C 0.32Ω/km
Inductance 0.32mH/km
Capacitance 0.25µF/km
Earth fault current,
at 7/12kV 1.6A/km
at 14/24kV 3.3A/km
Max. short circuit current (1 sec.) at 250 °C end conductor temp. 11kA
Max. short circuit current, for the screen 5kA

Installation
Minimum bending radius
| at laying, approx. | 580mm |
| at fixed position, approx. | 350mm |
| Min. temp. at laying approx. | -20°C |

Data for calculation in pole-setting systems (see handbook)
Area 285mm²
Diameter 49mm
q0 Cable weight 2.2kg/m
E0 Elasticty-modulus initial, before ice load 47 000N/mm²
E0a Elasticity-modulus after permanent creep, (after ice load) 61 000N/mm²
Fp Permanent elongation or creep 0.8%
Coefficient of linear expansion per °C 23 x 10⁻⁶
Definitude strain 0°C 55N/mm²
Maximum force on cable in calculations 28kN
Approximate fast break load for cable >70kN
Approximate long term break load for cable >51kN

We reserve the right for alterations due to continual product development and/or changes in standards.

Fig.2: Data sheet 20 kV cable
AXCES 18/30(36)kV 3x70/25

Product information

Inner conductive layer
Extruded PE

Insulation
XLPE, Triple extruded, dry cured vulcanized.
Nominal thickness: 5,5mm
Diameter over insulation approx.: 21,8mm

Outer conductive layer
Extruded PE, easy strippable

Screen
Band of woven copper threads.
Nominal cross sectional area: 25mm²

Tape
PETP-PE tape

Sheath
Black LLD PE
Nominal thickness: 2,6mm
Outer diameter: 52mm
Outer circumscribed circle diameter: 50mm
Weight: 2,1kg/m
Density: 1,2kg/dm³

Embossed
*ERICSSON AB AC3
AXCES 12/20(24)kV 3x70/16 (Year of manufacturing YYYY) + meter marked

Application
Self suspending 3-core cable, for use as aerial cable on poles, and in the ground and water.

Design
IEC 60500-2

Conductor
Aluminum, circular stranded.
Nominal cross sectional area: 70mm².
Diameter, nominal: 9,9mm.
## Technical data

### AXCES 18/30(36)kV 3x70/25

### Electrical

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of conductors x cross sectional area (mm²)</td>
<td>3x70/25</td>
</tr>
<tr>
<td>Rated voltage U0/U1</td>
<td>18/30 kV</td>
</tr>
<tr>
<td>Rated current according to IEC287</td>
<td></td>
</tr>
<tr>
<td>Maximum conductor temperature in air 25°C</td>
<td>160 A</td>
</tr>
<tr>
<td>Maximum conductor temperature in the ground 15°C</td>
<td>190 A</td>
</tr>
<tr>
<td>Resistance max. at 20°C</td>
<td>0,4462/km</td>
</tr>
<tr>
<td>Inductance</td>
<td>0,32 mH/km</td>
</tr>
<tr>
<td>Capacitance</td>
<td>0,19 µF/km</td>
</tr>
<tr>
<td>Earth fault current, at 12/20kV</td>
<td>3,4 A/km</td>
</tr>
<tr>
<td>Earth fault current, at 18/30kV</td>
<td>2,3 A/km</td>
</tr>
<tr>
<td>Max. short circuit current (1 sec.) at 250 °C end conductor temp.</td>
<td>8,0 kA</td>
</tr>
<tr>
<td>Max. short circuit current, for the screen</td>
<td>5,0 kA</td>
</tr>
</tbody>
</table>

### Installation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum bending radius at laying, approx.</td>
<td>560 mm</td>
</tr>
<tr>
<td>Minimum bending radius at fixed position, approx.</td>
<td>350 mm</td>
</tr>
<tr>
<td>Min. temp. at laying approx.</td>
<td>-20 °C</td>
</tr>
</tbody>
</table>

### Data for calculation in pole-setting systems (see handbook)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>210 mm²</td>
</tr>
<tr>
<td>Diameter</td>
<td>52 mm</td>
</tr>
<tr>
<td>Q, Cable weight</td>
<td>2,1 kg/m</td>
</tr>
<tr>
<td>Eₐ, Elasticity-modulus initial, before ice load</td>
<td>55 000 N/mm²</td>
</tr>
<tr>
<td>Eₐ, Elasticity-modulus after permanent creeping, (after ice load)</td>
<td>64 000 N/mm²</td>
</tr>
<tr>
<td>Iₐ, Permanent elongation or creeping</td>
<td>0,7%</td>
</tr>
<tr>
<td>Coefficient of linear expansion per °C</td>
<td>23 x 10⁻⁶</td>
</tr>
<tr>
<td>Definitude strain 0°C</td>
<td>46 N/mm²</td>
</tr>
<tr>
<td>Maximum force on cable in calculations</td>
<td>27 kN</td>
</tr>
<tr>
<td>Approximate fast break load for cable</td>
<td>&gt;57 kN</td>
</tr>
<tr>
<td>Approximate long term break load for cable</td>
<td>&gt;49 kN</td>
</tr>
</tbody>
</table>

We reserve the right for alterations due to continual product development and/or changes in standards.

Fig: 4: Date sheet 30 kV cable