Overhead transmission lines
Conductors

Introduction
These guidelines describe the requirements on steel-, aluminium- (AAC), aluminium conductors steel reinforced (ACSR) and all aluminium alloy (AAAC) conductors for overhead transmission lines and cover design and test. The guidelines intend to guarantee satisfactory performance of conductors during the lifetime of the overhead line and shall be used at purchasing of conductors.
## Revision

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<td>1(A)</td>
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<tr>
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1 References

EN ISO 9001  Quality management systems - Requirements
EN 50182  Conductors for overhead lie-Round wire concentric lay overhead electrical stranded conductors
EN 50189  Conductors for overhead lines – Zinc coated steel wires
EN 50326  Conductors for overhead lines - Characteristics of greases
EN 60889  Hard-drawn aluminium wire for overhead line conductors
EN 61395  Overhead electrical conductors - Creep test procedures for stranded conductors
SS 424 08 05  Hard zinc-coated steel wire for stranded conductors and wire strands for overhead lines - Fe140 wire
SS 424 08 06  Hard zinc-coated steel wire strands for overhead lines - Fe140 wire strands
SS 424 08 11  Aluminium alloy wire for stranded conductors for overhead lines - AlMgSi wire
SS 424 08 12  Aluminium alloy stranded conductors for overhead lines – AlMgSi conductors
SS 424 08 13  Aluminium alloy wire for stranded conductors for overhead lines - Al 59 wire
SS 424 08 14  Aluminium alloy stranded conductors for overhead lines - Al 59 conductors
TR05-07E  Svenska kraftnät Technical guidelines – Joints for conductors
TR05-09E  Svenska kraftnät Technical guidelines – Vibration dampers
2 Scope
These guidelines are applicable to steel, aluminium, steel reinforced aluminium and aluminium alloy conductors for overhead lines and comprise design and testing.

The intention of the specification is to guarantee satisfactory performance of the conductors during the lifetime of the overhead line.

3 Definitions
Technical terms and definitions used in these guidelines:

**Creep**
Permanent elongation under constant stress over a period of time.

4 Requirements

4.1 General
The manufacturer shall have a quality system in accordance with at least EN ISO 9001.

4.1.1 Greasing of conductors
Conductors that shall be installed in severe corrosive industry environment or saline coast environment, for example the West Coast, shall be greased on request of the client.

When greasing of conductors it is requested that they shall be greased in accordance with SS-EN 50182 Annex B, Case 4 figure d). The entire conductor is greased except the outer surface of the wires in the outer layer.

Grease shall meet the requirements in accordance with SS-EN 50326 with type A grease $\theta_1=-20^\circ C$ and $A\theta_2=+180^\circ C$.

4.2 Steel conductors

4.2.1 Descriptions
Conductors consisting of several layers of wires made from hot-dip galvanized steel, see TR05-04E figure 1.

4.2.2 Wire
Wires shall be manufactured from high strength steel in accordance with SS 424 08 05.
4.2.3 Dimensions
Conductors shall have dimensions in accordance with Svk TR05-4E table 1, as in SS 424 08 06.

4.2.4 Design
Conductors shall comply with the requirements in accordance with SS 424 08 06.

4.2.5 Breaking load
Conductors shall comply with the breaking load requirements in accordance with Svk TR05-4E table 1, as in SS 424 08 06.

4.2.6 Resistance
Conductors shall comply with the resistance requirements in accordance with table 1.

4.3 All aluminium conductors (AAC)

4.3.1 Descriptions
Conductors consisting of several layers of wires made from aluminium, see TR05-04E figure 2.

4.3.2 Wire
Wires shall be manufactured in accordance with EN 60889.

4.3.3 Dimensions
Conductors shall have dimensions in accordance with Svk TR05-4E table 2, as in EN 50182.

4.3.4 Design
Conductors shall comply with the requirements in accordance with EN 50182, AL1.

4.3.5 Breaking load
Conductors shall meet the requirements of strength in accordance with Svk TR05-4E table 2, as in EN 50182.

4.3.6 Resistance
Conductors shall meet the requirements of resistance in accordance with Svk TR05-4E table 2, as in EN 50182.

4.4 Aluminium conductors steel reinforced (ACSR)

4.4.1 Descriptions
Conductors having a core consisting of a wire, or several layers of wires, made from hot-dip galvanized steel and with one or several outer layers of wires made from aluminium. See TR05-04E figures 3a and 3b.
4.4.2 Wire
Steel wires shall be manufactured in accordance with EN 50189 Class ST1A.

Aluminium wires shall be manufactured in accordance with EN 60889.

4.4.3 Dimensions
Conductors shall have dimensions in accordance with Svk TR05-4E table 3, as in EN 50182.

4.4.4 Design
Conductors shall meet the requirements in accordance with EN 50182 AL1/ST1A.
A core consisting of only one steel wire shall have no joints.

4.4.5 Breaking load
Conductors shall meet the requirements of strength in accordance with Svk TR05-4E table 3, as in EN 50182.

4.4.6 Resistance
Conductors shall comply with the resistance requirements of table 3.

4.5 AlMgSi, All aluminium alloy conductors, (AAAC)

4.5.1 Descriptions
Conductors consisting of several layers of wires made from AlMgSi, see TR05-04E figure 2.

4.5.2 Wire
Wires shall be manufactured in accordance with SS 424 08 11.

4.5.3 Dimensions
Conductors shall have measurements in accordance with Svk TR05-4E table 4, as in SS 424 08 12.

4.5.4 Design
Conductors shall comply with the requirements of EN 50182.

4.5.5 Breaking load
Conductors shall meet the requirements of strength in accordance with table 4.

4.5.6 Resistance
Conductors shall meet the requirements of resistance in accordance with TR05-4E table 4, as in SS 424 08 12.
4.6 Al59, All aluminium alloy conductor, (AAAC)

4.6.1 Descriptions
Conductors consisting of several layers of wires made from Al 59, see TR05-04E figure 2.

4.6.2 Wire
Wires shall be manufactured in accordance with SS 424 08 13.

4.6.3 Dimensions
Conductors shall have dimensions in accordance with TR05-4E table 5, as in SS 424 08 14.

4.6.4 Design
Conductors shall comply with the requirements of EN 50182.

4.6.5 Breaking load
Conductors shall meet the requirements of strength in accordance with TR05-4E table 5, as in SS 424 08 14.

4.6.6 Resistance
Conductors shall meet the requirements of resistance in accordance with TR05-4E table 5, as in SS 424 08 14.

5 Test program

5.1 Type test
Type test shall be performed in accordance with TR05-04E table 6.

5.2 Sample test
Sample test shall be performed in accordance with TR05-04E table 6 on a minimum of 10% of the drums offered. All wires should be tested.

5.3 Test procedures

5.3.1 Creep
This test shall be performed in accordance with EN 61395 and the parameters shall be in accordance with SS 424 08 14.

- Temperature +23° C
- Test load 40 % RTS
- Duration 1500 h
The creep shall be measured at intervals of time evenly logarithmically distributed over the entire testing time. All readings of temperature, strain and time shall be shown in tabular form. The linear regression shall be calculated for all the measured strain readings. It shall also be calculated for the measured strain readings from 50 hours after start to the end of the test.

When calculating the linear regression, the value $z$ shall be added to every reading such that, at the time $t=87600$ hours (10 years), the creep $\varepsilon$ will be equal for the two regression curves. Calculated values for $k$ and $b$, in addition to the calculated creep from fifty hour to ten years, are to be presented to the client.

The creep shall be calculated according to the formula:

$$\varepsilon = 10^k \cdot t^b$$

where

- $\varepsilon =$ conductor creep during time $t$
- $k =$ point of intersection between the line and the $y$-axis
- $b =$ line slope
- $t =$ time for which creep shall be calculated

In order to compensate for the tensile strength dependency of creep all the including wires should be tested. The mean value for the tensile strength ($R_m$ mean) is calculated and obtained creep value $\varepsilon_k(test)$ is adjusted for by using the formula:

$$\varepsilon_k = \varepsilon_k(test) \times \frac{R_m\text{ mean}}{R_m\text{ min}}$$

6 Delivery

6.1 Documentation

6.1.1 General

All documentation shall be written in English.

Complete documentation according to TR05-04E clauses 6.1.2-6.1.5 shall be available to the client before delivery.
6.1.2 Assembly drawing

Assembly drawing shall show the cross-section of the conductor. On each drawing shall be given:

- Type
- Cross-sectional area and stranding
- Mass per km
- Resistance
- Conductor length per drum

6.1.3 List of material

Description of material for included parts.

6.1.4 Installation instructions

Installation instructions in English with required drawings to prevent handling damage during installation.

6.1.5 Reports

Complete reports, with all measured values reported, from all controls according to TR05-04E clause 5.

6.1.6 Transport and storing

The conductors shall be packed up in such a way that they will not be damaged or fouled at transport, construction and storing.

7 Conductor joints

Detonation joints shall be used for installation of conductors. See also TR05-07E for technical specification.

For new built lines shall the overhead earth wire be installed without joints.

8 Installation

Conductors shall be run-out under tension using pulling line.

After stringing shall the sagging be performed within 24 hours. The total time the conductor is allowed to hang in the stringing blocks before the clipping-in procedure are 72 hours. Vibration dampers in accordance with Svk TR05-09E shall be installed at the clipping-in procedure.
Spacers shall be installed within 120 hours after that the clipping-in has been performed.

Sheaves of running out blocks for the conductor shall have a diameter of at least 15 times the conductor diameter. The groove of the sheave shall be appropriate for the conductor diameter and shall be coated with a material that is gentle to the conductor.

Joints for conductors shall be in accordance with SvK TR05-07E. The conductor ends shall be free from dirt and undamaged when the joint is installed. Conductor adjacent to the joint shall not have protruding wires.
9 Tables

Table 1 Steel conductor (Fe140)

<table>
<thead>
<tr>
<th>Area mm²</th>
<th>Svk Designation</th>
<th>No’s of wires</th>
<th>Diameter Wire mm</th>
<th>Cond. mm</th>
<th>Mass kg/km</th>
<th>Rated strength kN</th>
<th>Calculated resistance ¹) Ω/km</th>
<th>Short circuit current ²) kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>52Fe</td>
<td>7</td>
<td>3.08</td>
<td>9.24</td>
<td>412</td>
<td>71.4</td>
<td>3.705</td>
<td>3.0</td>
</tr>
<tr>
<td>68</td>
<td>68Fe</td>
<td>7</td>
<td>3.52</td>
<td>10.6</td>
<td>538</td>
<td>93.1</td>
<td>2.837</td>
<td>3.9</td>
</tr>
<tr>
<td>89</td>
<td>89Fe</td>
<td>7</td>
<td>4.02</td>
<td>12.1</td>
<td>702</td>
<td>122</td>
<td>2.175</td>
<td>5.1</td>
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<tr>
<td>105</td>
<td>105Fe</td>
<td>7</td>
<td>4.36</td>
<td>13.1</td>
<td>826</td>
<td>143</td>
<td>1.849</td>
<td>6.0</td>
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<tr>
<td>142</td>
<td>142Fe</td>
<td>19</td>
<td>3.08</td>
<td>15.4</td>
<td>1127</td>
<td>194</td>
<td>1.375</td>
<td>8.2</td>
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<tr>
<td>185</td>
<td>185Fe</td>
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<td>3.52</td>
<td>17.6</td>
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<td>253</td>
<td>1.053</td>
<td>10.7</td>
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<td>241Fe</td>
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<td>20.1</td>
<td>1920</td>
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<td>13.9</td>
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<td>284</td>
<td>284Fe</td>
<td>19</td>
<td>4.36</td>
<td>21.8</td>
<td>2258</td>
<td>390</td>
<td>0.6864</td>
<td>16.4</td>
</tr>
</tbody>
</table>

¹) The DC resistance is calculated from the mean value of 192.0 nΩm (9.0 % IACS) for the individual wire.

²) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +30 °C and a final temperature of +300 °C.
### Table 2  All Aluminium Conductor (AAC), (AL1)

<table>
<thead>
<tr>
<th>Designation accord. EN</th>
<th>Svk Designation</th>
<th>Area mm²</th>
<th>No’s of wires</th>
<th>Diameter Wire mm</th>
<th>Cond. mm</th>
<th>Mass kg/km</th>
<th>Rated strength kN</th>
<th>Calculated DC resistance⁴) Ω/km</th>
<th>Short circuit current²) kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>454-AL1</td>
<td>Akleja</td>
<td>454</td>
<td>61</td>
<td>3,08</td>
<td>27,7</td>
<td>1256</td>
<td>74,99</td>
<td>0,06366</td>
<td>43,5</td>
</tr>
<tr>
<td>594-AL1</td>
<td>Hampdån</td>
<td>593</td>
<td>61</td>
<td>3,52</td>
<td>31,7</td>
<td>1641</td>
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<td>774-AL1</td>
<td>Stormhatt</td>
<td>774</td>
<td>61</td>
<td>4,02</td>
<td>36,2</td>
<td>2140</td>
<td>123,9</td>
<td>0,03737</td>
<td>74,2</td>
</tr>
<tr>
<td>911-AL1</td>
<td>Solros</td>
<td>910</td>
<td>61</td>
<td>4,36</td>
<td>39,2</td>
<td>2517</td>
<td>145,7</td>
<td>0,03177</td>
<td>87,3</td>
</tr>
</tbody>
</table>

1) The DC resistance is calculated from the mean value 28.035 mΩm (61.5 % IACS) of the individual wire.

2) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +50 °C and a final temperature of +200 °C.
### Table 3  Aluminium Conductor Steel Reinforced (AL1/ST1A)

<table>
<thead>
<tr>
<th>Svk</th>
<th>Designation according to EN</th>
<th>DC short circuit current (kA)</th>
<th>Short circuit current (kA)</th>
<th>Calculated DC resistance (Ω/km)</th>
<th>Rated strength (kN)</th>
<th>Mass (kg/km)</th>
<th>Diameter Cond. (mm)</th>
<th>Diameter Core Cond. (mm)</th>
<th>No’s of wire Al</th>
<th>Wire Fe (mm)</th>
<th>Wire Al (mm)</th>
<th>Area (mm²)</th>
<th>Designation Phase conductor</th>
<th>Designation Shield conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>402</td>
<td>AL1/52-ST1A</td>
<td>42.2</td>
<td>55.2</td>
<td>71.9</td>
<td>84.5</td>
<td>123.8</td>
<td>33.3</td>
<td>22.0</td>
<td>7</td>
<td>4.38</td>
<td>3.08</td>
<td>454</td>
<td>Condor 402-AL1/52-ST1A</td>
<td>Dotterel 89-AL1/52-ST1A</td>
</tr>
<tr>
<td>525</td>
<td>AL1/68-ST1A</td>
<td>42.2</td>
<td>55.2</td>
<td>71.9</td>
<td>84.5</td>
<td>123.8</td>
<td>33.3</td>
<td>22.0</td>
<td>7</td>
<td>4.38</td>
<td>3.08</td>
<td>525</td>
<td>Curlew 525-AL1/68-ST1A</td>
<td>Alte 122-AL1/89-ST1A</td>
</tr>
<tr>
<td>685</td>
<td>AL1/89-ST1A</td>
<td>42.2</td>
<td>55.2</td>
<td>71.9</td>
<td>84.5</td>
<td>123.8</td>
<td>33.3</td>
<td>22.0</td>
<td>7</td>
<td>4.38</td>
<td>3.08</td>
<td>685</td>
<td>Martin 685-AL1/89-ST1A</td>
<td>122-AL1/89-ST1A</td>
</tr>
<tr>
<td>898</td>
<td>AL1/102-ST1A</td>
<td>42.2</td>
<td>55.2</td>
<td>71.9</td>
<td>84.5</td>
<td>123.8</td>
<td>33.3</td>
<td>22.0</td>
<td>7</td>
<td>4.38</td>
<td>3.08</td>
<td>898</td>
<td>Falcon 898-AL1/102-ST1A</td>
<td>Ymer 116-AL1/68-ST1A</td>
</tr>
</tbody>
</table>

1) The DC resistance is calculated from the mean value 28,264 nΩm (61 % IACS) of the individual wire.
2) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +50 °C and a final temperature of +200 °C.

3) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +30 °C and a final temperature of +200 °C.
Table 4 AlMgSi – Conductor (AL7)

<table>
<thead>
<tr>
<th>Designation accord. EN</th>
<th>Svk Designation</th>
<th>Area mm²</th>
<th>No’s of wire</th>
<th>Diameter Wire mm</th>
<th>Cond. mm</th>
<th>Mass kg/km</th>
<th>Rated strength kN</th>
<th>Calculated DC resistance¹ Ω/km</th>
<th>Short-circuit-current² kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>454-AL7</td>
<td>454AlMgSi</td>
<td>454</td>
<td>61</td>
<td>3,08</td>
<td>27,7</td>
<td>1256</td>
<td>125,0</td>
<td>0,06755</td>
<td>43,2</td>
</tr>
<tr>
<td>594-AL7</td>
<td>593AlMgSi</td>
<td>593</td>
<td>61</td>
<td>3,52</td>
<td>31,7</td>
<td>1641</td>
<td>157,3</td>
<td>0,05172</td>
<td>56,4</td>
</tr>
<tr>
<td>774-AL7</td>
<td>774AlMgSi</td>
<td>774</td>
<td>61</td>
<td>4,02</td>
<td>36,2</td>
<td>2140</td>
<td>197,4</td>
<td>0,03965</td>
<td>73,6</td>
</tr>
<tr>
<td>911-AL7</td>
<td>910AlMgSi</td>
<td>910</td>
<td>61</td>
<td>4,36</td>
<td>39,2</td>
<td>2517</td>
<td>232,2</td>
<td>0,03371</td>
<td>86,6</td>
</tr>
</tbody>
</table>

1) The DC resistance is calculated from the mean value 30,000 nΩm (57.5 % IACS) of the individual wire.

2) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +50 °C and a final temperature of +200 °C.
### Table 5 Al59-Conductors

<table>
<thead>
<tr>
<th>SvK Designation</th>
<th>Area mm²</th>
<th>No’s of wires</th>
<th>Wire Diameter mm</th>
<th>Cond. Diameter mm</th>
<th>Mass kg/km</th>
<th>Rated-strength kN</th>
<th>Calculated DC resistance 1) Ω/km</th>
<th>Short-circuit current 2) kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>454AL59</td>
<td>454</td>
<td>61</td>
<td>3,08</td>
<td>27,7</td>
<td>1250</td>
<td>113,6</td>
<td>0,06532</td>
<td>44,1</td>
</tr>
<tr>
<td>593AL59</td>
<td>593</td>
<td>61</td>
<td>3,52</td>
<td>31,7</td>
<td>1640</td>
<td>142,5</td>
<td>0,05001</td>
<td>57,6</td>
</tr>
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<td>774AL59</td>
<td>774</td>
<td>61</td>
<td>4,02</td>
<td>36,2</td>
<td>2140</td>
<td>178,1</td>
<td>0,03834</td>
<td>75,1</td>
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<td>2510</td>
<td>209,5</td>
<td>0,03260</td>
<td>88,3</td>
</tr>
</tbody>
</table>

1) The DC resistance is calculated from the mean value 29,050 nΩm (59,4 % IACS) of the individual wire.

2) The short circuit current is the calculated effective value with duration of one second at an initial conductor temperature of +50 °C and a final temperature of +200 °C.
### Table 6 Tests for conductors
Sample size in accordance with SS-EN 50182 clause 6.2

<table>
<thead>
<tr>
<th>Type test</th>
<th>Standard /Requirement</th>
<th>Acceptance criteria</th>
</tr>
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<tbody>
<tr>
<td>Conductor</td>
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<tr>
<td>- surface condition</td>
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<tr>
<td>- diameter</td>
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<tr>
<td>- inertness</td>
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<td>x</td>
</tr>
<tr>
<td>- lay ratio dection lay</td>
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<td>x</td>
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<tr>
<td>- number and type of wires</td>
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<tr>
<td>- mass per unit length</td>
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<td>- stress-strain curve</td>
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<tr>
<td>- tensile breaking strength</td>
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<td>- stringing test</td>
<td>(1)</td>
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<td>- creepage test</td>
<td>(3)</td>
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<td>- tensile strength</td>
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<td>- elongation (2)</td>
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<tr>
<td>- tensile strength</td>
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<tr>
<td>- stress at 1 % extension</td>
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<td>x</td>
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<tr>
<td>- elongation or torsion test</td>
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<tr>
<td>- wrapping</td>
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<tr>
<td>- mass of zinc</td>
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<td>- adhesion of zinc coating</td>
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<td>- tensile strength</td>
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<td>- stress at 1 % extension</td>
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<tr>
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<tr>
<td>- drop point</td>
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</table>

(1) By agreement between the client and manufacturer
(2) Elongation test for AL1 is not required
(3) Creepage test is only required for AL59 conductor
10 Figures

Figure 1 Steel conductors

Figure 2 All Aluminium (AAC), All Aluminium Alloy (AAAC) Conductors
Table 3  Aluminium Conductors Steel Reinforced (ACSR)

Figure 3a  Phase conductors

[Diagram showing 54/7 wires and 54/19 wires]

Figure 3b  Overhead earth wire conductors

[Diagram showing 12/7 wires and 32/7 wires]