Overhead transmission lines
Conductors

Introduction
This document in English shall be regarded as a translation of the corresponding guidelines in Swedish. The aim of the translation is to provide support to foreign manufacturers. The wording in Swedish and the interpretation thereof shall govern contract and legal relations between the parties of the purchasing process.

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 inspection. The guidelines intend to guarantee satisfactory performance of conductors during the lifetime of the overhead line and shall be used at purchasing of conductors.
<table>
<thead>
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<th>Change notes</th>
<th>Date</th>
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<td>New template</td>
<td>09 / 07 / 2008</td>
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<td>New template. Chapter numbers changed. Clause 7.1.10 added. Clause 8.2.5 and 10 revised.</td>
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1 References

Note that standards, regulations etc. which are referred to in these guidelines are subject to continuous change and can be withdrawn, revised or replaced. It is the obligation that the contractor immediately will inform the client of such changes.

SS-EN 50182 Round wire concentric lay overhead electrical stranded conductors
SS-EN 50183 Conductors for overhead lines - Aluminium-magnesium-silicon alloy wires
SS-EN 50189 Conductors for overhead lines – Zinc coated steel wires
SS-EN 50326 Conductors for overhead lines - Characteristics of greases
SS-EN 60889 Hard-drawn aluminium wire for overhead line conductors
SS-EN 61395 Overhead electrical conductors - Creep test procedures for stranded conductors
SS-EN 60865-1 Short-circuit currents – Calculation of effects - Part 1: Definitions and calculation methods
IEC/TR 60865-2 Short-circuit currents – Calculation of effects - Part 2: Examples of calculation
SS-EN ISO 9001 Quality management systems - Requirements
SS ISO 5455 Technical drawings – Scales
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
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 Descriptions

4.1 Steel conductors
Conductors consisting of several layers of strands made from hot-dip galvanised steel, see Figures 1a and 1b.

4.2 Aluminium conductors (AAC)
Conductors consisting of several layers of strands made from aluminium, see Figure 2.

4.3 Aluminium conductors steel reinforced (ACSR)
Conductors having a core consisting of a strand, or several layers of strands, made from hot-dip galvanised steel and with one or several outer layers of strands made from aluminium. See Figures 3a and 3b.

4.4 Aluminium alloy conductors (AAAC)
4.4.1 AlMgSi conductors
Conductors consisting of several layers of strands made from AlMgSi, see Figure 2.

4.4.2 Al 59 conductors
Conductors consisting of several layers of strands made from Al 59, see Figure 2.

5 Requirements

5.1 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.

5.2 Steel conductors
5.2.1 Strand
Strands shall be manufactured from high strength steel in accordance with SS 424 08 05.

5.2.2 Dimensions
Conductors shall have dimensions in accordance with SS 424 08 06, see Table 1.
5.2.3 Design
Conductors shall comply with the requirements in accordance with SS 424 08 06.

5.2.4 Breaking load
Conductors shall comply with the breaking load requirements in accordance with SS 424 08 06, see Table 1.

5.2.5 Resistance
Conductors shall comply with the resistance requirements in accordance with Table 1.

5.3 All aluminium conductor (AAC)

5.3.1 Strand
Strands shall be manufactured in accordance with SS-EN 60889.

5.3.2 Dimensions
Conductors shall have dimensions in accordance with SS-EN 50182, see Table 2.

5.3.3 Design
Conductors shall comply with the requirements in accordance with SS-EN 50182, AL1.

5.3.4 Breaking load
Conductors shall meet the requirements of strength in accordance with SS-EN 50182, see Table 2.

5.3.5 Resistance
Conductors shall meet the requirements of resistance in accordance with SS-EN 50182, see Table 2.

5.3.6 Greasing
When greasing of conductors is requested they shall be greased in accordance with SS-EN 50182 Annex B, Case 4, see Figure 4.

Grease shall meet the requirements in accordance with SS-EN 50326.

5.4 Aluminium conductors steel reinforced (ACSR)

5.4.1 Strand
Steel strands shall be manufactured in accordance with SS-EN 50189 Class ST1A.

Aluminium strands shall be manufactured in accordance with SS-EN 60889.

5.4.2 Dimensions
Conductors shall have dimensions in accordance with SS-EN 50182, see Table 3.
5.4.3 Design
Conductors shall meet the requirements in accordance with SS-EN 50182 AL1/ST1A. A core consisting of only one steel strand shall have no joints.

5.4.4 Breaking load
Conductors shall meet the requirements of strength in accordance with SS-EN 50182, see Table 3.

5.4.5 Resistance
Conductors shall comply with the resistance requirements of Table 3.

5.4.6 Greasing
When greasing of the steel core of conductors is requested it shall be greased in accordance with SS-EN 50182 Annex B, Case 1, see Figure 4.

Grease shall meet the requirements in accordance with SS-EN 50326.

5.5 AlMgSi, All aluminium alloy conductor, (AAAC)

5.5.1 Strand
Strands shall be manufactured in accordance with SS 424 08 11

Alternatively shall the strand be in accordance with SS-EN 50183-AL7.

5.5.2 Dimensions
Conductors shall have measurements in accordance with SS 424 08 12, see Table 4A.

Alternatively shall the conductor have dimensions in accordance with SS-EN 50182-AL7, see Table 4B.

5.5.3 Design
Conductors shall comply with the requirements of SS-EN 50182.

5.5.4 Breaking load
Conductors shall meet the requirements of strength in accordance with SS 424 08 12, See Table 4A.

Alternatively shall the conductor meet the requirements for rated strength in accordance with SS-EN 50182-AL7, see Table 4B.

5.5.5 Resistance
Conductors shall meet the requirements of resistance in accordance with SS 424 08 12, See Table 4A.
Alternatively shall the conductor meet the requirements for resistance in accordance with SS-EN 50182-AL7, see Table 4B.

5.5.6 Greasing
When greasing of conductors is requested they shall be greased in accordance with SS-EN 50182 Annex B, Case 4, see Figure 4.

Grease shall meet the requirements in accordance with SS-EN 50326.

5.6 Al 59, All aluminium alloy conductor, (AAAC)

5.6.1 Strand
Strands shall be manufactured in accordance with SS 424 08 13.

5.6.2 Dimensions
Conductors shall have dimensions in accordance with SS 424 08 14, see Table 5.

5.6.3 Design
Conductors shall comply with the requirements of SS-EN 50182.

5.6.4 Breaking load
Conductors shall meet the requirements of strength in accordance with SS 424 08 14, see Table 5.

5.6.5 Resistance
Conductors shall meet the requirements of resistance in accordance with SS 424 08 14, see Table 5.

5.6.6 Greasing
When greasing of conductors is requested they shall be greased in accordance with SS-EN 50182 Annex B, Case 4, see Figure 4.

Grease shall meet the requirements in accordance with SS-EN 50326.

6 Type test

6.1 General
Type tests are to be performed in accordance with SS-EN 50182 as stated in clauses 6.2 – 6.4 below. In addition for conductors made from Al 59 tests in accordance with clause 6.5 shall be performed.
6.2 Joints in strands before stranding
This test shall be performed in accordance with SS-EN 50182.

6.3 Stress – Strain curve
This test shall be performed in accordance with SS-EN 50182. All measurements taken shall be recorded and submitted to the client. Calculated curve of the third degree for the stress respectively strain, connecting the recorded values of stress – strain, including the formulas shall be included.

6.4 Breaking load
This test shall be performed in accordance with SS-EN 50182.

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

\[
\varepsilon = 10^k \times t^b
\]

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

7 Sample test

7.1 General
The sample test shall be performed in accordance with SS-EN 50182.
7.1.1 Tests on zinc coated steel (ST1A to ST6C) for steel conductor and aluminium conductors steel reinforced (ACSR) after stranding

With reference to SS-EN 50182, clause 6.5 "Properties of wires after stranding Table 6". Requirements for measurement of stress at 1% extension after stranding of zinc coated steel (ST1A to ST6C).

- Measurements shall be made on all wires of the conductor.
- Permitted reduction of stress for centre wire 0%.
- Permitted reduction of stress on wires other than the king wire 5%.

7.1.2 Tests on strands before stranding

The tests shall show that strands comply with the requirements of clauses 5.2.1, 5.3.1, 5.4.1, 5.5.1 and 5.6.1.

7.1.3 Cross-sectional area

This test shall be performed in accordance with SS-EN 50182.

7.1.4 Conductor diameter

This test shall be performed in accordance with SS-EN 50182.

7.1.5 Mass per unit length

This test shall be performed in accordance with SS-EN 50182.

7.1.6 Breaking load of strands from conductor

This test shall be performed in accordance with SS-EN 50182.

7.1.7 Surface condition

The test shall be performed in accordance with SS-EN 50182.

7.1.8 Lay ratio and direction of lay

This test shall be performed in accordance with SS-EN 50182.

7.1.9 Grease content

This test shall be performed in accordance with SS-EN 50182.

7.1.10 Tensile breaking strength of conductor

This test shall be performed on a complete steel conductor intended for guy wire in accordance with SS-EN 50182.

For overhead ground wire shall the test be performed on the client’s request.
In due time before the test performance, shall a proposal of the test programme be presented for the client’s acceptance.

8 Delivery

8.1 General
The client shall, according to these guidelines, approve the conductor before delivery. For approval the manufacturer shall show that the conductor conform to the guidelines.

The manufacturer shall provide documentation in accordance with clauses 8.2.1-8.2.5 for approval.

The approval of drawings by the client does not release the manufacturer from his obligation regarding the conductor complying with the guidelines.

All documentation shall be written in Swedish or English.

8.2 Documentation
General requirements for documentation see SvK TR 08E.

8.2.1 Assembly drawing
The assembly drawing shall have an appropriate scale in accordance with SS ISO 5455. On the drawing shall be given:

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

8.2.2 List of material
Description of material for included parts.

8.2.3 Manufacturing process
Description of the manufacturing process

8.2.4 Quality system
Quality system in accordance with SS-EN ISO 9001.
8.2.5 Reports
Reports in accordance with clause 6 Type test and 7 Sample test shall be delivered. The reports shall include all data from the test performance.

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

9 Conductor joints
Detonation joints shall be used for installation of conductors. See also TR 05-07E for technical specification.

10 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 TR 05-09E 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 be rubber lined and have a diameter of at least 15 times the conductor diameter.

Joints for conductors shall be in accordance with SvK TR 05-07E. The conductor ends shall be free from dirt and undamaged when the joint is installed. Conductor adjacent to the joint shall not have protruding strands.
## 11 Tables

### Table 1  Steel Conductor (Fe 140)

<table>
<thead>
<tr>
<th>Designation area</th>
<th>No's of strands</th>
<th>Diameter Strand (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>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>
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<td>2,837</td>
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<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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<td>253</td>
<td>1,053</td>
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<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 strand.

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>Designation area</th>
<th>No’s of strands</th>
<th>Diameter Strand 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>
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</thead>
<tbody>
<tr>
<td>454-AL1</td>
<td>454</td>
<td>61</td>
<td>3,08</td>
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<td>1256</td>
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<td>0,06366</td>
<td>43,5</td>
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<tr>
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<td>593</td>
<td>61</td>
<td>3,52</td>
<td>31,7</td>
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<td>774-AL1</td>
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<td>61</td>
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</table>

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

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>
<thead>
<tr>
<th>Designation according to EN</th>
<th>Designation</th>
<th>No’s of strands</th>
<th>Strand Al mm</th>
<th>Strand Fe mm</th>
<th>Core mm</th>
<th>Cond. mm</th>
<th>Mass kg/km</th>
<th>Rated strength kN</th>
<th>Calculated DC resistance 1) / km</th>
<th>Short circuit current kA</th>
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</thead>
<tbody>
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<td>402-AL1/52-ST1A</td>
<td>454 54 7</td>
<td>3.08</td>
<td>3.08</td>
<td>9.24</td>
<td>27.7</td>
<td>1523</td>
<td>123,8</td>
<td>0.07187</td>
<td>42.2²</td>
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<tr>
<td></td>
<td>525-AL1/68-ST1A</td>
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<td>3.52</td>
<td>3.52</td>
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<td>1989</td>
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<td>685-AL1/89-ST1A</td>
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<td>4.02</td>
<td>12.1</td>
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<td>2594</td>
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<td>71.9²</td>
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<td>Shield conductor</td>
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<td>3.08</td>
<td>3.08</td>
<td>9.24</td>
<td>15.4</td>
<td>658</td>
<td>72.12</td>
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<td>152-AL1/89-ST1A</td>
<td>241 12 7</td>
<td>4.02</td>
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</table>
1) The DC resistance is calculated from the mean value 28,264 nΩm (61 % IACS) of the individual strand.

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 4A  AlMgSi - Conductor

<table>
<thead>
<tr>
<th>Designation area</th>
<th>No's of strands</th>
<th>Diameter Strand mm</th>
<th>Cond. 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>454</td>
<td>61</td>
<td>3,08</td>
<td>27,7</td>
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<td>61</td>
<td>4,02</td>
<td>36,2</td>
<td>2139</td>
<td>197,4</td>
<td>0,03965</td>
<td>73,6</td>
</tr>
<tr>
<td>910</td>
<td>61</td>
<td>4,36</td>
<td>39,2</td>
<td>2516</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 strand.

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 4b  AlMgSi –Conductor (AL7)

<table>
<thead>
<tr>
<th>Designation accord.</th>
<th>Designation area</th>
<th>No’s of strand</th>
<th>Diameter Strand</th>
<th>Cond. mm</th>
<th>Mass kg/km</th>
<th>Rated strength kN</th>
<th>Cal. DC resistance 1) Ω/km</th>
<th>Short-circuit-current 2) kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>454-AL7</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>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>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>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 strand.

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   Al-59 Conductors

<table>
<thead>
<tr>
<th>Designation area</th>
<th>No’s of strands</th>
<th>Diameter Strand (mm)</th>
<th>Cond. (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>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>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>
<tr>
<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>
</tr>
<tr>
<td>910</td>
<td>61</td>
<td>4,36</td>
<td>39,2</td>
<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 strand.

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.
12 Figures

Figure 1 Steel conductors

7 strands

19 strands

Figure 2 All Aluminium (AAC), All Aluminium Alloy (AAAC) conductors

61 strands
Figure 3  Aluminium Conductors Steel Reinforced (ACSR)

12.1.1  Figure 3a  Phase conductors

54/7 strands  54/19 strands

12.1.2  Figure 3b  Shield conductors

12/7 strands  32/7 strands

Figure 4  Conductors, greasing

Case 1  Case 4