Overhead transmission lines
Suspension and support clamps

Introduction
This English text is to be regarded as a translation of the Swedish guideline. The Swedish text and the interpretation thereof shall govern the contract and the legal relations between parties.

These guidelines describe the requirements on suspension and support clamps for use on steel reinforced aluminium conductors and aluminium alloy conductors in accordance with TR 05-04E for overhead transmission lines and cover design and inspection. The guidelines intend to guarantee satisfactory performance of suspension and support clamp during the lifetime of the overhead line and shall be used at purchasing of suspension and support clamp.
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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 which are referred to in these guidelines are subject to continuous change and can be withdrawn, revised or replaced. The contractor shall immediately inform the client of such changes.

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<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>SS 2173</td>
<td>Diameters of spot facings, counter bores and countersinks - Screws and nuts with ISO metric screw treads and tapping screws</td>
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<tr>
<td>SS-EN ISO 887</td>
<td>Plain washers for metric bolts, screws and nuts for general purposes - General plan</td>
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<td>SS-EN ISO 1461</td>
<td>Hot dip galvanized coatings on fabricated iron and steel articles -- Specifications and test methods</td>
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<td>SS-EN ISO 3506-1</td>
<td>Mechanical properties of corrosion-resistant stainless-steel fasteners - Part 1: Bolts, screws and studs</td>
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<td>Metallic materials - Brinell hardness test - Part 1: Test-method</td>
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<td>SS-EN ISO 7089</td>
<td>Plain washers - Normal series - Product grade A</td>
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2 Scope

These guidelines are applicable to suspension and support clamps which shall be used on steel reinforced aluminium and aluminium alloy conductors according to SvK TR 05-04E for overhead lines and comprise design and testing.

The guideline is intended to ensure a satisfactory function of suspension clamps during the lifetime of the overhead line and shall be used at purchase of support and suspension clamps.

3 Definition

Technical terms and definitions used in these guidelines:

**Body**
That part of the suspension clamp that supports the conductor. See Figure 1.

**Corona extinction voltage**
The voltage where no corona is visible when the voltage is reduced from a level with visible corona.

**Conductor supporting groove profile**
Longitudinal curvature of the conductor supporting groove of the body or the keeper. See Figure 1.

**Keeper**
That part of the suspension clamp that clamps the conductor to the body.

**Conductor turning angle**
The angle between the tangents at the conductors’ point of entry into the mouth of the suspension clamp, at each side of the suspension clamp, and the body of the suspension clamp. This angle is the vector sum of the two angles which result from the sag and the line deviation. See Figure 4.

**Axis of oscillation**
Axis around which clamp oscillations take place.

**Straps**

Those parts of the suspension clamp which transfer load from the axis of oscillation to the connection point with the insulator string.

## 4 Description

### 4.1 Suspension clamp

Suspension clamps shall have the axis of oscillation in the plane of the axis of the conductor. They shall be used for both phase conductors and shield wires as well as for straight line and angle supports. Suspension clamps shall be capable of being fitted with counter weights.

### 4.2 Support clamp

Support clamps shall have the axis of oscillation in the plane of the axis of the conductor. They shall be used for shield wires for straight line supports and shall be installed in the supports shield wire bracket.

### 4.3 Counterweight stirrup

Counterweight stirrups shall fit to the accompanying suspension clamp. They shall transfer the load from the counterweight to the body of the suspension clamp. They shall permit 45° of counterweight swing from the vertical plane in both directions. Counterweight stirrups are also to be used with triple bundle conductors. See Figure 3.

## 5 Requirements

### 5.1 General

In new built transmission lines shall the support clamp be installed in the supports shield wire bracket. Adapter is not allowed.

Suspension clamps shall be able to withstand the mechanical stresses which can occur during transport, handling and installation at temperatures as low as -40 °C, in addition to the mechanical stresses which can occur during the lifetime of the overhead line at temperatures from -50 °C to +100 °C.
5.2 Material

5.2.1 Body and keeper
The body and the keeper shall be manufactured from aluminium alloy containing a maximum of 0.10 % Cu. The alloy shall be resistant to inter-crystalline, layer and stress corrosion. Further properties of the alloy shall be:

- Hardness min 75 HBW
- Resistivity max. 60 nΩm at 20 °C

5.2.2 Bolts and nuts
Bolts and nuts shall be made from stainless steel which shall fulfil the requirements of quality A2-80 according to SS-ISO 3506. The mechanical properties shall conform to SS-EN ISO 3506-1 and SS-EN ISO 3506-2. U-bolts are not allowed.

5.2.3 Washers
To provide sufficient resistance to corrosion washers shall be made from stainless steel with a minimum quality equivalent to A2 of SS-EN ISO 3506. The washers shall be in accordance with SS-EN ISO 887 and SS-EN ISO 7089. Washers shall have a minimum hardness of 200 HBW.

5.2.4 Threaded inserts
To provide sufficient resistance to corrosion threaded inserts shall be made from stainless steel with a minimum quality equivalent to A2 of SS-EN ISO 3506. The required mechanical properties shall be equivalent to those given for bolts and nuts in Clause 5.2.2.

5.2.5 Straps
Straps shall be made from hot-dip galvanised steel. The thickness of the zinc coating shall be at least 70 µm and meet the requirements according to SS-EN ISO 1461.

5.3 Design

5.3.1 Clamp
It shall be possible to move clamps along the conductor freely. The trunnion of the clamp may be an integral part of the body. If the trunnion is not an integral part it shall be fixed by mechanical locking to the clamp body.

5.3.2 Conductor supporting groove
The profile of the conductor supporting groove, in the body and the keeper, shall conform to the measurements given in Figure 1 and Table 1. The conductor groove radii in body and keeper shall be adapted to the conductor diameter in question in accordance with SvK TR 05-04E and with maximal groove diameter in accordance to Table 1.
and be free from irregularities and sharp edges. The straight part of the conductor groove (80 mm) may be perpendicular furrowed with a maximum depth of 0.5 mm.

5.3.3 Fatigue damages
Clamps may not cause fatigue damage on the conductor.

5.3.4 Straps
The hole in the strap for the trunnion of the body shall be round and have a suitable size in relation to the trunnion.

5.3.5 Bolts and nuts
Bolts and nuts shall have M12 metric threads with 18 mm width across flats according to SS-ISO 272. Bolts and nuts shall be attached to the tension clamp in such a way that they are impossible to drop accidentally. It shall also be possible to tighten them from the upper side of the clamp.

Bolts shall be long enough to protrude outside the thread of the nut. Counter bores and countersinks shall be made in accordance with SS 2173.

Bolts and nuts shall be locked with two punches or other metallic locking system.

5.3.6 Washers
Washers shall be manufactured in accordance with SS-EN ISO 887 and SS-EN ISO 7089.

5.3.7 Suspension clamps
Suspension clamps shall have a clevis type coupling in accordance with TR 05-12E.

The distance from the axis of oscillation to the axis of the clevis coupling shall be as short as possible.

5.3.8 Support clamps
Support clamps, will be installed on top of crossarms or earth wire peaks. Clamps with brackets shall allow a minimum of 15° vertical movement in both directions without causing contact between the conductor and crossarms or shield wire peaks.

5.3.9 Counterweight stirrups
Counterweight stirrups shall fit to the accompanying suspension clamp. They shall be so designed that the load of the counterweight is transferred to the body of the suspension clamp in accordance with Figure 2. Counterweight stirrups shall be able to swing in line with the direction of the conductor. They shall also permit 45° of counterweight swing from the vertical plane in both directions transverse to the direction of the conductor. The distance (B) between the conductor and the link of the counterweight set
shall be in accordance with Table 1. It shall be possible to install counterweight stirrups after suspension clamps have been installed.

Counterweight stirrups are also to be used with triple bundle conductors with yoke plates. See Figure 3.

5.3.10 Marking
Clamps shall be marked with raised or indented / stamped characters with a minimum height of 3 mm as follows:

- Manufacturer's trademark
- Type or catalogue number
- Conductor diameter
- Bolts and nuts to be marked in accordance with SS-EN ISO 3506.
- Year of manufacture.

5.4 Mechanical requirements

5.4.1 Suspension clamps for earth wire
Suspension clamps shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1 at a conductor turning angle $\alpha$ of 30°. See Figure 4.

Suspension clamps shall, without failure at a conductor turning angle $\alpha$ of 30°, withstand the breaking load given in Table 1. See Figure 4.

Requirements for suspension clamps designed for 45° turning angle, see Appendix A.

5.4.2 Suspension clamps for phase conductor
Suspension clamps shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1 at a conductor turning angle $\alpha$ of 30°. See Figure 4.

Suspension clamps shall, without failure at a conductor turning angle $\alpha$ of 45°, withstand the breaking load given in Table 1. See Figure 4.

Requirements for suspension clamps designed for 45° turning angle, see Appendix A.

5.4.3 Support clamps for earth wire
Support clamps shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1 at a conductor turning angle $\alpha$ of 30°. See Figure 4.
Support clamps shall, without failure, at a conductor turning angle \( \alpha \) of 30\(^\circ\) withstand the breaking load given in Table 1. See Figure 4.

5.4.4 Clamps
Clamps shall, without showing signs of permanent deformation, withstand the tightening torque of the bolts.

5.4.5 Clamping force
The clamp force induced by the bolts shall, for suspension clamps for phase conductors, be at least 112 kN when tightened to a torque of 60 Nm and, for suspension and support clamps for earth wire, be at least 64 kN when tightened to a torque of 37 Nm.

5.4.6 Bolts and threads
Bolts and threads of clamps shall, without rupture, withstand an axial load of 67 kN.

5.4.7 Counterweight stirrups
Counterweight stirrups shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1. See Figure 5.

5.5 Electrical requirements

5.5.1 Fault current
Suspension clamps and support clamps shall withstand the fault current given in Table 1 at a mechanical load of 3 kN. The peak value of the fault current shall be a minimum of 2.3 times its effective value.

5.5.2 Corona
Suspension clamps which will be used for the suspension of phase conductors shall, when fitted to an insulator set, conform to the requirements of SvK TR 05-10E Clause 5-4-4.

5.5.3 Hysteresis losses
Suspension clamps which shall be used for the suspension of phase conductors shall cause no hysteresis losses.

Counterweight stirrups installed on phase conductor suspension clamps shall cause no hysteresis losses.
6 Type test

6.1 General
Unless otherwise agreed upon the type test shall be in accordance with Clauses 6.2-6.10 on three test samples. The test shall be performed in such a way that the method and equipment do not affect the result.

6.2 Dimensions
This test intends to check that the clamp and the counterweight stirrup fulfil the requirements in accordance with Clause 5.3 and that they are also in accordance with the manufacturers' drawing regarding dimensions.

6.3 Thickness of zinc coating
This test shall be performed in accordance with SS-ISO 2178. Each sample shall be subject to, depending on size, 3 to 10 measurements. The points of measurement shall be evenly and randomly distributed over the entire sample surface.

The minimum and average layer thickness requirements in accordance with Clause 5.1.5 shall be fulfilled.

6.4 Hardness
Hardness tests on aluminium shall be in accordance with SS-EN ISO 6506-1.

Measured hardness value shall conform to the requirements of Clause 5.2.1.

6.5 Clamping force
The clamp force shall be measured with one or two load cells located in the conductor supporting groove during a sequence of three installations. The bolts shall be tightened with a torque of 60 Nm at suspension clamps for phase conductors and with 37 Nm for clamps for earth wires.

The measured clamp force shall during all three installations exceed the requirements of Clause 5.4.6.

6.6 Threads
Securing bolts shall be installed in threads to a length equivalent to the minimum length as specified on the workshop drawings. A tensile load of 67 kN shall be applied to the bolt.

Rupture shall not have occurred in the threads and the bolt shall be easily turned by hand.
6.7  Permanent deformation

6.7.1  Suspension and support clamp
The clamp shall be installed on conductors with the required strength and same diameter as the conductor for which the clamp is designed. The securing bolts shall be tightened with a torque of 60 Nm at clamps for phase conductors respectively with 37 Nm at clamps for earth wires.

The clamp shall be installed in a tensile testing machine in such a way that the conductor turning angle \( \alpha \), conforms to Table 1 during the test. See Figure 4. The load shall be increased in steps. The first step shall be 10 % of the specified deformation load. The clamp shall then be unloaded and measurement of the permanent deformation, if any, carried out and recorded. The second step shall be 20 % of the specified deformation load. The clamp shall then be unloaded and measurement of the permanent deformation, if any, carried out and recorded. This procedure shall be continued until 100 % of the specified deformation load is attained.

The load at which permanent deformation is shown shall exceed the load given in Table 1 in accordance with Clauses 5.4.1 and 5.4.2.

6.7.2  Counterweight stirrup
The counterweight stirrup shall be attached to a suspension clamp, or a dummy, in accordance with the installation instructions.

The counterweight stirrup is then to be installed in a tensile testing machine. See Figure 5. The load shall be increased in steps. The first step shall be 10 % of the specified deformation load. The stirrup shall then be unloaded and measurement of the permanent deformation, if any, carried out and recorded. The second step shall be 20 % of the specified deformation load. The stirrup shall then be unloaded and measurement of the permanent deformation, if any, carried out and recorded. This procedure shall be continued until 100 % of the specified deformation load is attained.

The load at which permanent deformation is shown shall exceed the load given in Table 1 in accordance with Clause 5.4.7.

6.8  Breaking load
After the clamp has been tested in accordance with Clause 6.7.1 the load shall be increased until failure occurs in the clamp.

The attained breaking load shall exceed the load given in Table 1 in accordance with Clauses 5.4.1, 5.4.2 and 5.4.3.
6.9  Corona
The intention of this test is to verify the corona extinction voltage in a fully assembled insulator set.

The test shall be performed in accordance with SvK TR 05-10E Clause 6.5.

6.10  Fault current
The intention of this test is to verify that the requirements in Clause 5.5.1 are fulfilled.

Test performed on other product consisting of the same materials and having equal contact surfaces is considered to constitute type test for clamps in accordance with this guidelines.

7  Sample test

7.1  General
Sample tests are carried out by the manufacturer on clamps selected at random from the lot to be supplied.

Test samples shall be supplied by the manufacturer free of charge to the client and shall not be included in the lot to be supplied.

The size of the test samples are indicated in the table below.

<table>
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<tr>
<th>Lot size</th>
<th>Sample size</th>
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<tr>
<td>N ≤ 300</td>
<td>1 to 3 subject to agreement</td>
</tr>
<tr>
<td>300 &lt; N ≤ 2000</td>
<td>4</td>
</tr>
<tr>
<td>2000 &lt; N ≤ 5000</td>
<td>8</td>
</tr>
<tr>
<td>5000 &lt; N ≤ 10000</td>
<td>12</td>
</tr>
</tbody>
</table>

The samples shall be subject to testing in accordance with Clauses 7.2 to 7.6. Clamps which have been submitted for test shall be discarded.

The manufacture shall inform the client when sample tests will be made.
Records from the sample tests shall be filed by the manufacturer and be shown to the client on request. In the case where any component does not comply with the requirements, re-testing shall be performed as below.

If only one clamp or part thereof fails to comply with the sample test requirement, a new sample equal to twice the quantity originally submitted for that test shall be subject to re-testing. The re-testing shall comprise the test or tests in which failure occurred.

If two or more clamps, or parts thereof, fail to comply with any of the sample tests, or if any failure occurs during re-testing, the complete lot shall be considered not to comply with the requirements.

Provided that the cause of the failure can be clearly identified, the manufacturer may sort the lot to eliminate all the clamps with this defect. The sorted lot shall then be resubmitted for sample testing. The number then selected shall be three times the first quantity chosen for the test. The re-testing shall comprise the test or tests in which failure occurred in the original test.

If any clamp, or part thereof of the sorted lot, fails during this re-testing, the complete lot shall be considered as not complying with the requirements.

7.2 Dimensions
The test shall be performed in accordance with Clause 6.2.

7.3 Thickness of zinc coating
The test shall be performed in accordance with Clause 6.3.

7.4 Hardness
The test shall be performed in accordance with Clause 6.4

7.5 Clamping force
The test shall be performed in accordance with Clause 6.5.

7.6 Threads
The test shall be performed in accordance with Clause 6.6.
8 Delivery

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

The manufacturer shall provide documentation in accordance with Clauses 8.2.1 to 8.2.7 inclusive for approval.

The approval of drawings by the client does not release the manufacturer from his obligations regarding the clamp 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 a minimum of two views at an appropriate scale in accordance with SS-ISO 5455. On the drawing shall be given:

- Type and/or catalogue number
- Principal dimensions
- The dimensions of the conductor groove with tolerances
- All marking.
- Weight.
- List of materials.
- Assembly instruction

8.2.2 List of material
Description of material in 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 Installation instructions
Installation instructions shall be written in Swedish or English and include necessary figures.

8.2.6 Fault current
Test report verifying the compliance of the clamp regarding the fault current requirement as given in Clause 5.5.1

8.2.7 Reports
Reports in accordance with Clause 6 Type test report and 7 Sample test report.

8.3 Sample

8.3.1 Clamp
One clamp sample.

8.3.2 Counterweight stirrup
One stirrup sample.

8.4 Transport and storing
The suspension and support clamps shall be packed up in that way that they will not be damaged or fouled at transport, construction and storing.

9 Installation

Installation on the conductor and locking of bolts and nuts shall be performed in accordance with the manufacturers installation instructions.
10 Tables

Table 1 Clamp and stirrup

<table>
<thead>
<tr>
<th>Type</th>
<th>Conductor diameter</th>
<th>Conductor groove profile</th>
<th>Stirrup Deformation load kN</th>
<th>Clamp Deformation load kN</th>
<th>Breaking load kN</th>
<th>Short circuit current kA-1s</th>
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<tr>
<td></td>
<td>mm</td>
<td>D max mm</td>
<td>Rm mm</td>
<td>α Deg</td>
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<td></td>
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<tr>
<td>Suspension clamp for earth wire</td>
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<td></td>
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<tr>
<td>Type H-A</td>
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<td>17,4</td>
<td>225 mm</td>
<td>30</td>
<td>140</td>
<td>4,4</td>
</tr>
<tr>
<td>Type H-B</td>
<td>20,1</td>
<td>22,5</td>
<td>225 mm</td>
<td>30</td>
<td>140</td>
<td>4,4</td>
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<tr>
<td>Type H-C</td>
<td>23,6</td>
<td>25,6</td>
<td>250 mm</td>
<td>30</td>
<td>140</td>
<td>4,4</td>
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<tr>
<td>Suspension clamp for phase conductor</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Type H-D</td>
<td>27,7</td>
<td>30,1</td>
<td>250 mm</td>
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<td>140</td>
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<tr>
<td>Type H-E</td>
<td>31,7</td>
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<td>275 mm</td>
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<td>Type H-F</td>
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<td>Type H-G</td>
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<tr>
<td>Type 3- B</td>
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<td>225 mm</td>
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<tr>
<td>Type 3- C</td>
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<td>250 mm</td>
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</table>
11 Figures

Figure 1 Conductor supporting groove profile, design
Figure 2  Counterweight stirrup, dimensions
Figure 3  Stirrup, application at triple bundle conductors
Figure 4 Clamp, arrangement for test of deformation and breaking loads

Figure 5 Stirrup, arrangement for test of deformation load
The requirements in this informative appendix are for suspension clamps intended for turning angles up to 45°.

12 A.1 Mechanical requirements for 45° turning angle

12 A.1.1 Suspension clamp for earth wire
Suspension clamps shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1 at a conductor turning angle $\alpha$ of 45°. See Figure 4.
Suspension clamps shall, without failure at a conductor turning angle $\alpha$ of 45°, withstand the breaking load given in Table 1. See Figure 4.

12 A.1.2 Suspension clamp for phase conductor
Suspension clamps shall, without showing signs of permanent deformation, withstand the deformation load given in Table 1 at a conductor turning angle $\alpha$ of 45°. See Figure 4.
Suspension clamps shall, without failure at a conductor turning angle $\alpha$ of 45°, withstand the breaking load given in Table 1. See Figure 4.

Table 12.A.1 Clamp and stirrup

<table>
<thead>
<tr>
<th>Type</th>
<th>Conductor diameter D mm</th>
<th>Conductor groove profile Rm mm</th>
<th>Stirrup B mm</th>
<th>Conductor deformation load kN</th>
<th>Suspension clamp deformation load kN</th>
<th>Breaking load kN</th>
<th>Short circuit current kA-1s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension clamp for earth wire</td>
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<tr>
<td>Type H-A</td>
<td>15,4</td>
<td>17,4</td>
<td>225</td>
<td>45</td>
<td>140</td>
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<tr>
<td>Type H-B</td>
<td>20,1</td>
<td>22,5</td>
<td>225</td>
<td>45</td>
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<td>Type H-C</td>
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<td>25,6</td>
<td>250</td>
<td>45</td>
<td>140</td>
<td>54</td>
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<td>Suspension clamp for phase conductor</td>
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<tr>
<td>Type H-D</td>
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<td>30,1</td>
<td>250</td>
<td>45</td>
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<td>34</td>
<td>131</td>
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<td>Type H-E</td>
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<td>45</td>
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<td>74</td>
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<td>45</td>
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<tr>
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<td>42,0</td>
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<td>45</td>
<td>150</td>
<td>114</td>
<td>259</td>
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