Overhead transmission lines
Parallel groove clamps

Introduction
These guidelines describe the requirements on parallel groove clamps with limited tensile strength for steel reinforced aluminium conductors, aluminium conductors and aluminium alloy conductors in accordance with TR05-04E for overhead transmission lines and cover design and test. The guidelines intend to guarantee satisfactory performance of parallel groove clamps during the lifetime of the overhead line and shall be used at purchasing of parallel groove clamps.
<table>
<thead>
<tr>
<th>Notes</th>
<th>Change notes</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(A)</td>
<td>New template</td>
<td>09 / 07 / 2008</td>
</tr>
<tr>
<td>2</td>
<td>New template. Table 4-8 added. Clause 15.7.3. added.</td>
<td>02 / 04 / 2012</td>
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<td>3</td>
<td>Totally reworked.</td>
<td>24 / 01 / 2020</td>
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1 References

SS-EN 9001  Quality management systems - Requirements
IEC 61284  Overhead lines – Requirements and tests for fittings
ISO 3506-1  Mechanical properties of corrosion-resistant stainless-steel fasteners - Part 1: Bolts, screws and studs
ISO 3506-2  Mechanical properties of corrosion-resistant stainless-steel fasteners -- Part 2: Nuts
EBR U303K  Maintenance of transmission lines 0.4 – 420 kV
TR05-04E  Svenska kraftnät Technical Guidelines – Conductors
TR05-16E  Svenska kraftnät Technical guidelines – Resistance measurement of joints

2 Scope

These guidelines describe the requirements on parallel groove clamps with limited tensile strength for steel reinforced aluminium conductors, aluminium conductors and aluminium alloy conductors in accordance with TR05-04E for overhead transmission lines and cover design, testing and installation.

3 Definitions

Technical terms and definitions used in these guidelines.

Body
That part of the parallel groove clamp in which the current is transferred between the conductors attached to the clamp.

Highest voltage for equipment
The highest value of phase-to-phase voltage for which the equipment is designed.
Corona extinction voltage
The voltage where no corona is visible when the voltage is reduced from a level with visible corona.

Fault current
The greatest short duration current which is caused by either a short-circuit (Ik) or an earth fault (3Io).

4 Requirements

4.1 General
Parallel groove 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° to +100° C.

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

4.1.1 Marking
Parallel groove clamps shall be marked with raised or indented/stamped characters with a minimum height of 3 mm as follows:

- Trademark of the manufacturer
- Type or catalogue number
- Conductor diameter (mm)
- Highest system voltage (kV) AC/DC
- Highest system current (A)
- Continuous and short circuit current (A)
- Tightening torque
- Bolts and nuts to be marked in accordance with ISO 3506-1 and ISO 3506-2.
- Year of manufacture
4.2 Description
Device, comprising several parts for jointing two conductors in order to provide electrical contact between two conductors, where the contact is acquired by bolt connection. Parallel groove clamp is intended for low tension forces in the connected conductors.

4.2.1 Parallel groove clamp
Parallel groove clamp to create connection between wrap-over conductors. See TR05-15E figure 1.

4.3 Material

4.3.1 Clamps
Clamps shall be manufactured from aluminium alloy. The alloy, which must not contain more than 0,1 % Cu, shall not be liable to stress, cracking or layer corrosion.

Cast and forged aluminium shall fulfil the requirements relating to tensile strength, hardness and resistivity as specified in TR05-15E table 2.

4.3.2 Bolts, nuts and washer
Bolts and nuts shall be made of stainless steel and fulfil the requirements for A2-80 or A4-80 in accordance with and ISO 3506-1 and ISO 3506-2.

Washers shall be made of stainless steel and, shall have at least the same resistance to corrosion as steel grade A2 in accordance with SS-EN ISO 3506-1, and shall have a hardness of minimum HV 200 at test in accordance with SS-EN ISO 6507-1.

Bolts, nuts and washer should be dry coated in order to reduce the friction coefficient.

4.4 Design

4.4.1 General
Parallel groove clamps shall be designed so that water collection is eliminated. If this is not possible, they shall have drainage holes with a minimum diameter of 6 mm.

Current-carrying parts of the clamps shall be cast or forged in one piece.

Parallel groove clamps intended for connection of parallel stranded conductors shall consist of two current-carrying parts. Bolts shall be positioned between the conductor grooves. The number of bolts shall be as specified in TR05-15E table 1.

4.4.2 Conductor groove
The parallel groove clamps shall have a conductor groove for each conductor.
Each groove shall be adapted to the conductors in accordance with TR05-15E table 2 and TR05-04E in such way that it is possible to install that at any of the conductors with the same external diameter without causing permanent deformation of the parallel groove clamps.

Conductor groove lengths shall be as specified in TR05-15E table 1.

Conductor grooves shall be so designed that they do not reduce the strength of the conductors.

The edges of conductor grooves, G in accordance with TR05-15E figures 3, shall be rounded with a minimum radius of 1 mm.

The ends of conductor grooves, K in accordance with TR05-15E figures 3, shall be rounded, with a minimum radius of 2 mm.

4.4.3 Contact surfaces
Current-carrying contact surfaces of cast aluminium shall be machined and free from casting skin. Current-carrying contact surfaces of forged aluminium need not necessarily be machined. Current-carrying contact surfaces in conductor grooves for stranded conductors shall have a surface smoothness R not less than N8 in accordance with SS-EN ISO 1302. The contact surfaces may be transversely furrowed but the depth of such furrows shall not exceed 1 mm.

Current-carrying contact surfaces in parallel groove clamps, see TR05-15E table 1 and TR05-15E figure 2.

4.4.4 Bolts and nuts
Bolts and nuts should be captive in the clamps, in order to simplify hot line working.

The parallel groove clamps shall be equipped with the number of bolts as specified in TR05-15E table 1. Bolt shall be M12.

The bolts shall be so long that they end outside the nut threads in the installed position.

4.4.5 Washers
Flat washers shall be fitted beneath bolts and nuts which are tightened during installation.

4.5 Mechanical requirements

4.5.1 Tightening torque and joint force
Tightening torques for bolts and nuts shall be at least 75 Nm for M12. Each bolt shall give a joint force of minimum 35 kN.
4.6 Electrical requirement

4.6.1 General
Permanent deformation, cracks or failure shall not occur in current carrying parts due to clashing of conductors at fault current. The clamp surface shall not be treated in order to increase the emission coefficient.

4.6.2 Continuous current
The parallel groove clamp shall be capable to carry the continuous currents in accordance with TR05-15E table 1 without reaching a temperature higher than the conductor with the smallest diameter connected by the parallel groove clamp.

4.6.3 Corona
Parallel groove clamps shall have no visible corona at the test voltage defined by:

$$\text{Test voltage} = \frac{U_m \times 1.1}{\sqrt{3}}$$

Where $U_m$ is 245 kV respectively 420 kV.

4.6.4 Resistance
Parallel groove clamp for phase conductor shall have a resistance (R1) of maximum 55% of the resistance value for the corresponding length of conductor, measured from conductor to conductor in the vicinity of the parallel groove clamp. See TR05-15E figure 4.

5 Test program

5.1 Type test
Type test shall be performed in accordance with TR05-15E table 3 on three test samples.

5.2 Sample test
Sample tests are carried out by the manufacturer on parallel groove 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.
The samples shall be subject to testing in accordance with TR05-15E table 3. Parallel groove 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 clamp 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.

<table>
<thead>
<tr>
<th>Lot size</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<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 TR05-15E table 3. Parallel groove 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.

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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.
6 Delivery

6.1 Documentation

6.1.1 General
All documentation shall be written in English.

Complete documentation according to TR05-15E clauses 6.1.2-6.1.5 shall be available to the client before delivery.

6.1.2 Assembly drawing
The assembly drawing shall have two views at an appropriate scale in. On the drawing shall be given:

- Type and/or catalogue number
- Principal dimensions
- The dimensions after installation
- All marking.
- Weight.
- List of materials.
- Continuous and short circuit current (kA)
- Voltage (kV).

6.1.3 List of material
Description of material in included parts. Preferably described on the assembly drawing.

6.1.4 Installation instructions
Installation instructions shall be written in English and include necessary figures and tightening torque for bolts. Preferably described on the assembly drawing.

6.1.5 Reports
Complete reports, with all measured values reported, from all controls according to TR05-15E clause 5.

6.1.6 Transport and storing
The parallel groove clamps shall be packed up in that way that they will not be damaged or fouled at transport, construction and storing.
7 Installation

7.1 General
The installation shall be in accordance with the installation instruction.

When parallel groove clamp is installed on the conductor in the vicinity of a dead end clamp the distance between the dead end clamp and the parallel groove clamp shall be at least 500 mm.

When parallel groove clamps is installed on the conductor they shall always be installed two in series with a distance of one parallel groove clamp length in between.

7.2 Measurements after installation
After installation the resistance shall be measured. The measurement shall be made in accordance with TR05-16E.
# Tables

Table 1  Parallel groove clamps with two current carrying parts for connection of two parallel conductors

<table>
<thead>
<tr>
<th>Conductor diameter</th>
<th>Current carrying surface A</th>
<th>Conductor diameter</th>
<th>Current carrying surface A</th>
<th>Conductor groove length L</th>
<th>Bolt N</th>
<th>Bolt dim</th>
<th>Continuous current capacity A</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.7</td>
<td>8100</td>
<td>27.7</td>
<td>8100</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1010</td>
</tr>
<tr>
<td>31.7</td>
<td>9800</td>
<td>31.7</td>
<td>9800</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1190</td>
</tr>
<tr>
<td>31.7</td>
<td>9800</td>
<td>27.7</td>
<td>8100</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1010</td>
</tr>
<tr>
<td>36.2</td>
<td>13500</td>
<td>36.2</td>
<td>13500</td>
<td>170</td>
<td>5</td>
<td>M12</td>
<td>1410</td>
</tr>
<tr>
<td>36.2</td>
<td>10800</td>
<td>31.7</td>
<td>9800</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1190</td>
</tr>
<tr>
<td>36.2</td>
<td>10800</td>
<td>27.7</td>
<td>8100</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1010</td>
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<tr>
<td>39.2</td>
<td>15000</td>
<td>39.2</td>
<td>15000</td>
<td>170</td>
<td>5</td>
<td>M12</td>
<td>1540</td>
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<tr>
<td>39.2</td>
<td>15000</td>
<td>36.2</td>
<td>13500</td>
<td>170</td>
<td>5</td>
<td>M12</td>
<td>1410</td>
</tr>
<tr>
<td>39.2</td>
<td>12000</td>
<td>31.7</td>
<td>9800</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1190</td>
</tr>
<tr>
<td>39.2</td>
<td>12000</td>
<td>27.7</td>
<td>8100</td>
<td>140</td>
<td>4</td>
<td>M12</td>
<td>1010</td>
</tr>
</tbody>
</table>
Table 2  Tensile strengths, hardness and resistivity of aluminium for parallel groove clamps

1) Values for machined test pieces manufactured from parallel groove clamp parts.

<table>
<thead>
<tr>
<th></th>
<th>Tensile strength</th>
<th>Hardness</th>
<th>Resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rp 0.2 min. MPa</td>
<td>Rm min. MPa</td>
<td>A5 min. %</td>
</tr>
<tr>
<td>Separate cast test rod</td>
<td>190</td>
<td>230</td>
<td>2</td>
</tr>
<tr>
<td>Cast</td>
<td>180(^1)</td>
<td>200(^1)</td>
<td>1(^1)</td>
</tr>
<tr>
<td>Forged</td>
<td>240</td>
<td>290</td>
<td>5</td>
</tr>
</tbody>
</table>

2) Values for current-carrying parts
### Test program

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test</th>
<th>Sample test</th>
<th>Standard/Requirements</th>
<th>Acceptance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension and material verification</td>
<td>X</td>
<td>X</td>
<td>IEC 61284 clause 7 and 8. Conformity with requirements in TR05-15E clause 4 shall be checked.</td>
<td>IEC 61284 clause 7 and 8</td>
</tr>
<tr>
<td>Clamp bolt tightening test</td>
<td>X 1)</td>
<td></td>
<td>IEC 61284 clause 11.4.5 with the exception that the last step is changed to 120% of recommended installation torque.</td>
<td>IEC 61284 clause 11.4.5</td>
</tr>
<tr>
<td>Bolt joint force test</td>
<td>X 1)</td>
<td></td>
<td>All bolts, nuts and washer in each clamp shall be tested. The supplier shall propose procedure to verify bolt joint force.</td>
<td>TR05-15E clause 4.5.1</td>
</tr>
<tr>
<td>Resistance control</td>
<td>X 1)</td>
<td></td>
<td>IEC 61284 clause 13.4.5</td>
<td>TR05-15E clause 4.6.4</td>
</tr>
<tr>
<td>Heat cycle test</td>
<td>2)</td>
<td></td>
<td>IEC 61284 clause 13 joints class B</td>
<td>IEC 61284 clause 13 joints class B</td>
</tr>
<tr>
<td>Corona and RIV test</td>
<td>X</td>
<td></td>
<td>IEC 61284</td>
<td>TR05-10E clause 4.5.3</td>
</tr>
</tbody>
</table>

1) At every 300 pieces at total order quantities.

2) By agreement between the client and the manufacturer.
9 Figures

Figure 1  Parallel groove clamps with two current carrying parts for connection of parallel conductor

Figure 2  Current carrying contact surfaces in parallel groove clamps with two current-carrying parts
Figure 3  Contact force in parallel groove clamps with two current carrying parts

Figure 4  Measurement of resistance, type test