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Title

Technical requirements Bolted connection clamps

E.ON Energidistribution AB
Technical requirements for

Bolted connection clamps

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1 General

1.1 Scope

These requirements cover the general demands of E.ON Energidistribution AB in respect of bolted connection clamps for current carrying conductors in 40, 50, and 130 kV-facilities.

Clamps of aluminium (Al) are used in stations to connect conductors with other conductors or to connect conductors to apparatus terminals.

Bolted connection clamps are used for overhead transmission lines mainly for interconnecting jumpers in pylons with tension insulator assemblies and for connection of branches to existing overhead lines.

These requirements are a translation to the Swedish requirements D10-0015658. If the content of this document differs from the Swedish version, the Swedish requirements shall prevail.

1.2 Standards

The supplied connector clamps must be designed, manufactured and tested in accordance with the most recent edition of applicable Swedish standards. In the absence of such standards, the European Standard (EN) and IEC publications apply.

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IEC 61284	Overhead Lines - Requirements and Tests for Fittings
SS-EN ISO 3506	Mechanical properties of corrosion-resistant stainless-steel fasteners

In the event of disparities between this technical regulations and the relevant standard, these technical regulations shall apply.

2 Changes relative to previous issue

Any changes in the document are marked with a vertical line in the right-hand margin.

3 Electrical design

The temperature of connector clamps shall be dimensioned to not exceed 80 ºC at the maximum continuous load current of the smallest connected conductor. In the same way, the temperature must not exceed 200 ºC for the impact from short-circuit current. Limit values apply for an ambient temperature of 25 ºC.
The permitted rated short-time current for aluminium connector clamps shall be 95 A/mm^2 related to the smallest connected conductor or max 50 kA (1 s).

Connector clamps shall be designed so that they do not cause radio disturbances.

4 Mechanical design

4.1 Production

Supplied connector clamps shall be ready for use. Clamps with repaired mechanical defects (for example, welding) are not accepted by the client.

Screws that belong to connector clamps shall always be connected to supplied nuts or to threaded parts of the clamp.

Internal threads in parts of clamps shall have a higher strength than the associated screw when screwed in to the minimum length that can occur in practice.
Threads shall be well made with a good surface finish and cleared and lubricated with an appropriate lubricant.

4.2 Material

Connector clamps shall be made of aluminium alloy that satisfies the requirements set out in table 1.

	Min. tensile strength			Min. hardness	Max. resistivity at +20°C
	Rp 0.2 (N/mm2)	Rm (N/mm2)	A (%)		(nΩm)
Cast aluminium	200	240	1	75	50
Wrought aluminium	245	290	8	85	40

Table 1. Requirements for aluminium ally for connector clamps.

Any hot-dip galvanised parts belonging to connector clamps shall be designed with a minimum zinc coating according to the thickness Fe/Zn 115, see Technical requirements for hot-dip galvanizing.

Screws, nuts and washers shall be of stainless steel and satisfy the provisions for quality A2-80 or A4-80 according to ISO 3506. For Al/Cu clamps, another material in the Cu-part's screws can be used, but shall be approved by E.ON Energidistribution.

Tightening torque for stainless steel screws and with that the tensile force brought about in the screw shall at a minimum be:

- for M10 - 45 Nm and 25 kN respectively
- for M12 - 80 Nm and 35 kN respectively

In order to distribute the force, the clamp shall be fitted with a flat washer under the screw head and any nut.

The hardness of the washer shall be at least 300 HB. It shall be well lubricated and must not deform.

5 Functional requirements

5.1 General

The live parts of the clamps shall be cast or forged in one piece. Clamps with keepers shall be equipped with forged keepers with at least 2 screws per keeper. Clamps for connection of two parallel lines shall consists of two live parts. The screws shall be placed between conductor slots.

Connector clamps installed according to the supplier's instruction shall not need to be retightened. Clamps shall be possible to fit without special tools. Mounting of connector clamps should not cause a reduction in the mechanical strength of the connected conductor.

Interconnecting of conductors outside of the substation shall always be designed with double parallel clamps. T-branch clamps can be used within fenced areas.

5.2 Station clamps

5.2.1 Parallel clamps for Al-conductors

Each connection between two conductors shall be designed with two parallel clamps.

5.2.2 T-branch clamps for transitions Al-/Al-conductor and Al-tube/Al-conductor

Minimum number of keepers against a line according to table 2. The smallest cross-section determines the number of keepers.

Conductor 1 Cross section mm^2	Min. number of keepers
157	2
241/234	2
329	2
454	3
593	3
774	3
910	4

Table 2. Minimum number of keepers for conductors

5.2.3 Apparatus connection

Connector clamps shall be designed for the high-voltage outlet on the apparatus designed with cylindrical stud (pin) or plate. Most connections are according to appendix 1.

Connector clamps with a plate shall be possible to connect on both sides to permit termination on an optional side to the high voltage terminal on the apparatus.

Connector clamps shall be easy to fit without special tools. Clamps shall be possible to reuse.

Clamps for apparatus terminals shall be designed so that when fitted they do not reduce the insulation distance.

Fixed connection.

Conductor-Plate

Minimum number of keepers against a conductor according to table 2.

Conductor-Pin

Minimum number of keepers against a conductor shall be according to table 2.

For connection of clamps with a single Al-conductor to cylindric stud with a diameter of 30-60 mm, the number of keepers against the stud shall be at least 2.

For connection of clamps with double parallel Al-conductors, the number of keepers against the pin shall be at least 3.

Flexible connection.

Flexible clamps shall have the smallest possible number of current crossovers.
There must be no mechanical forces in the electrical connections.

Connector clamps for flexible connections of tubes shall be designed so that no load or short circuit currents can be transferred in the mechanical fastening. Arcing may not be formed during short circuit.

The connection angle of the tube should be possible to be at least 15 degrees in all directions.

Connector clamps for flexible connections shall permit a total movement of at least 50 mm in the longitudinal direction of the tube.

The design for flexible connector clamps shall prevent the tube from falling out of the clamp.

5.2.4 Connection clamps Al/Cu

Connector clamps between aluminium and copper shall be designed so that no corrosion occurs between the different materials.

The protective coating that separates the two metals from each other shall be designed with an age-resistant material that can withstand temperatures between -40 ºC and +200 ºC without impacting on the clamp.

5.3 Clamps for transmission lines

When both lines are of the same material, parallel clamps shall be used. If the conductors are of different materials, for example, Cu and Al-alloy, straight bi-metal clamps shall be used where the Cu-conductor is connected at one end and Al-alloy conductor at the other end of the clamp.

5.3.1 Parallel clamps for FeAl-/FeAl-, FeAl-/Al alloy or Al alloy-/Al alloy lines

Clamps shall be forged and consist of two live parts and be equipped with at least two screws. Each connection between two conductors shall be designed with two clamps.

5.3.2 Parallel clamps for Cu-/Cu-conductor

Clamps shall be forged and consist of two live parts and be equipped with at least two screws. Each connection between two conductors shall be designed with two clamps.

5.3.3 Parallel clamps for FeAl-/Cu- or Al alloy/Cu-conductors

Clamps shall be forged and consist of two live parts and be equipped with at least two screws. Clamps shall be mounted with the Cu-conductor under the FeAl- or Al alloy conductor. When the overlying span for branches are Cu-conductors, the connection jumpers shall consist of Cu-conductors and the connection Cu/FeAl or Al alloy shall be made at the underlying span. Each connection shall consist of two clamps.

6 Testing

6.1 Type test

Type tests shall be according to IEC 61284.

Type testing shall, unless otherwise prescribed, be conducted on at least 3 test objects.

Test results may be communicated to the customer prior to ordering.

6.2 Heat cycle test with load current and rated short-time current

Heat cycle tests with load current and short-term current shall be carried out. Tests are performed according to IEC 61284 and with the number of heat cycles N=100.

Test results may be communicated to the customer prior to ordering.

6.3 Resistance measurement

Control of T-branch clamps and simple parallel clamps is carried out according to EBR maintenance publication "Ledningar 0.4-420 kV (U300)", section U303K.
Control of double parallel clamps is carried out according to maintenance instruction D15-0016664, Kontroll av skarvar, spännlinhållare och klämförband.

6.4 Pull test

Connector clamp for fixed connection of Al conductor, shall have a tensile strength for the conductor's fastening in the clamp that is at least 10 kN for connections via 2 keepers, 15 kN for 3 keepers and 20 kN for 4 keepers.

The test shall be conducted at the earliest 24 hours after installation.

6.5 Bending test

Connection clamps for permanent connection or for splicing of Al-tube shall have a mechanical strength that is equal to or greater than the tube's bending strength, see table 3. Connection clamps shall be bend-loaded in the most unfavourable direction.

Al-tube D_y/D_i (mm)	Bending strength (kNm)
100/88	6,6
100/80	9,9
150/136	18,2
150/126	28,2
250/236	53,7
250/226	86,7

Table 3. Calculated bending strength for Al-tube with the yield stress limit 170 N/mm2.

6.6 Fatigue test

Connector clamps for flexible connection shall be loaded with the vertical force between the tube and clamp of 400 N for tubes with Dy= 100 mm and 700 N for tubes with Dy ≥150 mm.

The tube is then subjected to 30,000 movements with ±10 mm in the tube's longitudinal direction and with 30,000 single sided deflections to an angle of 15 degrees.

After the test, no signs of breakage or abnormal wear shall be found on the clamp.

7 Labelling

Connector clamps with associated parts shall be equipped with an age-resistant and durable label with details of manufacturer and possible conductor cross-sections (mm^2) or conductor diameters (mm).

In addition, a connection clamp between different materials shall be labelled with details of both conductor material used, for example, "593 Al – 240 Cu".

8 Documentation

The supplier shall at the time of order promptly send details regarding the connector clamp's installation and connection with requisite tightening torque for screws.

Terminals										
For max current (A)	Cylindrical		Flat							Notes
	diam (mm)	length (mm)	Hole numbers	Sizes (mm) a	b	c	d	e	fig	
Al										
400	30	125	2	75	19	40	14	10	1	
1250	30	125	4	75	17,5	40	14	15	2	
1600	40	125	-	-	-	-	-	-	-	
2500	60	125	-	-	-	-	-	-	-	
3150	-		9	125	22,5	40	14	35	3	4000A when double sided
4000	-		12	125	22,5	40	14	35	4	5000A when double sided
Cu										
1600	30	125	-	-	-	-	-	-	-	
2500	40	125	4	75	17,5	40	14	10	2	
4000	60	125	-	-	-	-	-	-	-	
6300	-	-	4	100	25	50	18	15	2	double sided
8000	-	-	4	125	30	65	18	18	2	double sided

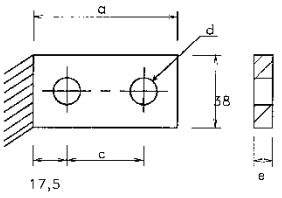


Fig 1

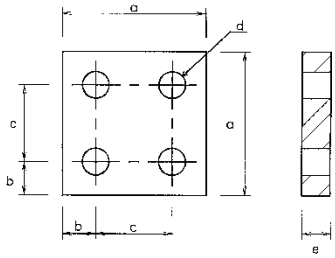
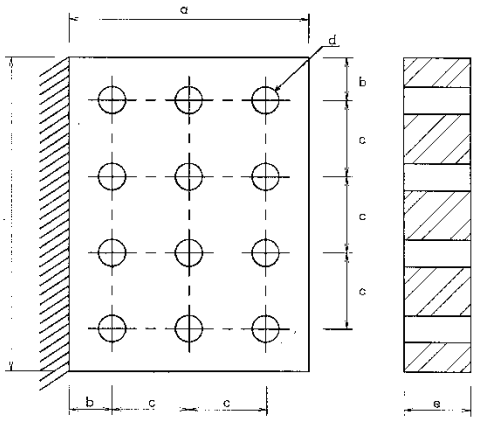


Fig 2



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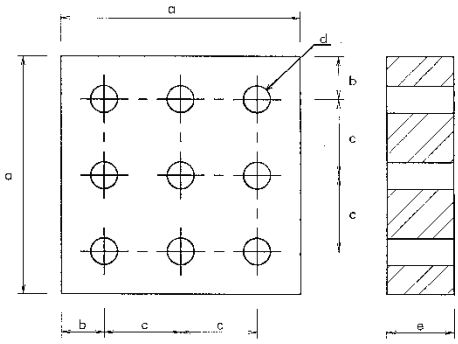

Fig 3