

TE CONNECTIVITY'S (TE) SIMAFLEX CONNECTORS

HIGH VOLTAGE CLAMPS
AND CONNECTORS
FOR SUBSTATION APPLICATIONS

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Introduction

I. Experience The Future With TE's SIMAFLEX Connectors

TE Connectivity's (TE) Simel first generation connectors were created back in 1946. Our primary goal has been the development of power connectors to deliver connectivity solutions for transmission grids over decades; from 10 kV applications up to 1200 kV ultra high voltage substations.

TE continuously invests in development of new solutions for the transmission grid in order to respond to changing market trends.

The Future of Energy Delivery Relies On a Modular Approach

It's clear that utilities around the world face a set of unique challenges. Rising energy demands, aging or nonexistent infrastructure, complex financing and extreme environments mean that "one size fits all" energy solutions are not just impractical: in many cases, they are simply impossible.

By 2040, the global demand for electric energy is expected to increase by 37% (IEA, 2014), but not all demands are equal. For example, China, the world's top energy consumer, has experienced exponential growth since 1980, with energy demand increasing 500%. This has led China to make substantial investments in the transmission and delivery of power. Similarly, India has tripled its energy production over the last two decades.

In many areas, however, expanded capacity hasn't kept pace with the rest of the world. This is especially prevalent in sub-Saharan Africa, where an estimated 620 million people lack access to reliable forms of energy. Conversely, in many parts of the industrialized world, 40% of power plants will need to be replaced by 2040 because transmission lines and substations can no longer handle the electrical loads needed.

If energy demand is going to continue growing at a rapid pace, driving to increase the transfer capacity of transmission infrastructures, how do utilities know they're choosing a connectivity solution that won't be obsolete within the next decade?

To solve this challenge, utilities should employ a modular approach to the future network expansion that allows for a myriad of partners and product solutions that are ideally suited for their particular project and applications.

A utility's engineering partner should be capable of not just meeting today's demands with a list of ready-stocked products – but should also be prepared to anticipate tomorrow's needs with reliable solutions.

This modular approach requires a long-term engineering partner. Before investing in any partnership, utilities should consider the performance of their partner in three key areas:

- Range of products and services
- Depth of industry experience and knowledge
- Global capacity for manufacturing, testing, installation and support

Toward a Universal Solution for Utilities

The first of these areas – products and services – refers to the range of products used to construct new networks and expand existing networks across extra and eventually ultra high voltage levels. High voltage transmission networks have very different demands than high voltage networks, and it's likely that utilities will need to develop solutions for both. By choosing a partner who handles a full range of specifications, utilities can maximize their budgets, and ensure they'll have a single source for installation and design support.

The range of products is a critical need in power delivery and transmission applications, because ageing infrastructure presents numerous challenges. Retrofitting a substation that is 40 to 50 years old could require numerous connectors to fit various equipment simply based on previous upgrades and the age of original equipment. Finding a single partner to handle the sheer number of options and products needed could have a significant impact not only on a project's budget, but also the timeline to completion.

Of equal importance to utilities should be an engineering partner's depth of industry knowledge. This second consideration is critical to a lasting partnership because energy demands and applications are rapidly changing. Possessing a depth of knowledge and history in power transmission allows partners to develop forward-looking solutions. Understanding the next international standard future requirement ensures that solutions offer long-term compliance and reliable performance rather than short term product fixes.

In selecting a partner to develop innovative solutions, utilities should consider their ability to provide global support including design, testing and manufacturing, as well as training and technical support. Companies with a global footprint can be equipped to provide outstanding local support where you need it. Regional manufacturing that can allow products to be delivered to the project site faster, and from shorter distances are a great advantage offered by many global suppliers. Often a regional presence makes it easier for utilities to navigate complicated environmental regulations. Distributed capabilities also make it likely that utilities can receive custom, local installation support and training – which are critical for network reliability and performance. Regardless of a project's size or scope, utilities should seek a partner who can understand and adapt to their unique needs and develop customized solutions that offer proven reliability and meet environmental, structural and network demands.

Connecting the future

Staying ahead of energy demand and anticipating new needs requires an innovative approach. It requires new, adaptable products, vast industry knowledge and partners that understand global needs and can provide local support. Power connectivity solutions for substations will continue to become more modular, and as utilities assess needs, they will favor solutions that adapt to a world that's more connected – and more demanding – than ever before.



II. Description

Applications

The TE's SIMAFLEX extra high voltage range of clamps and connectors is for AC & DC applications up to 550 kV (phase-to-phase voltage).

These products are designed to support and connect Ø15 to Ø58.8 mm overhead aluminium flexible conductors (AAC, AAAC, ACSR...) to Copper or Aluminium Equipment Terminals (Stud, Palm, Tube...).

Benefits

TE's SIMAFLEX connectors range offers multiple technical benefits and customers advantages.

Mass customization concept: from the same connector design, the products can be delivered with 2 or 3 keepers per customer's requirements.

- **Top electrical performances**

The resistance of electrical contacts is at the lowest expected level (below $3\mu\Omega$). This performance level has been achieved by optimization of the involved performances factors such as, machining of the electrical contact surfaces to get a perfect geometry of the contact grooves of the connectors, specific roughness of the machined surfaces to provide efficient metallic contact points, lubricated bolts with high performance wax to get higher contact pressure.

- **High mechanical strength**

Each part has been designed with support of FEM (Finite Element Method) calculation to obtain high strength components.

- **High Quality**

Design to manufacturing method has also been applied to the development of this new range to get high quality casting components.

- **Consistent process**

Components subject to mechanical stress such as mechanical supports and keepers are advantageously die casted.

- **Fit for applications**

The products have been designed to withstand actual mechanical strength required in Extra High Voltage (EHV) substations considering wind and ice loads as well as short circuit fault current up to 80 kA with a peak value at 200 kA.

- **High tensile strength**

The tensile performance of TE's SIMAFLEX connectors has been increased to 15 kN minimum to fit with the increased short circuit requirements up to 80 kA for any future switchyard.

- **Adaptive solution**

The design is adaptive to customer's requirement by offering a 2 or 3 keepers solution from the same connector components and by machining the contact groove at the project conductor size.

- **Digital advantage**

FEM calculation was used to meet EHV design requirements. Simulation and calculation of electrical field of the connectors enabled us to get high Radio Interference Voltage (RIV) and corona performance before confirmation by the test.

Scope of functions

The TE's SIMAFLEX product range includes the following:

- Mechanical supports of flexible conductors on post insulators
- Accessories such as earthing stirrups, spacers
- Conductor(s) to conductor(s) connectors (tee, parallel groove, etc.)
- Terminal connector conductor(s) to terminal equipment (stud and flat palm).
- Transition connectors tube to conductor(s) (tee and parallel connectors).
- Adjustable angular (0° to 90°) connectors to terminal equipment (stud and flat palm).

Power Contacts

The Power of reliability for an extended longevity

The key driver to the power connector's longevity in high voltage infrastructure is the intrinsic performance of the electrical power contact of the bolted connection. The lowest expected electrical contact resistance value is depending on following two physical parameters:

- Resistivity of the connected materials (connector and conductor)
- Metallic contact areas between the contact surfaces through which the current lines carry out the power.

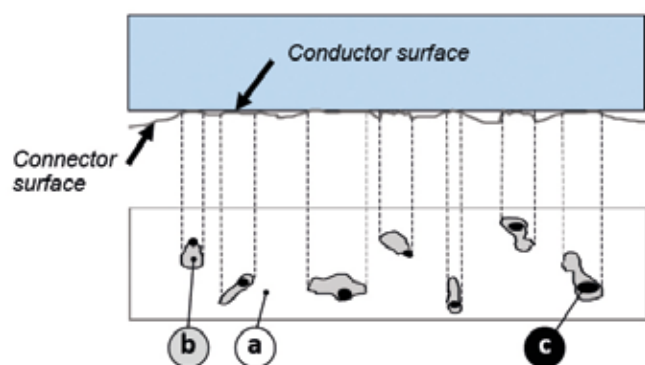


Figure 1

- a) is the area with no contact.
b) is the apparent contact area.
c) is the metallic contact area.

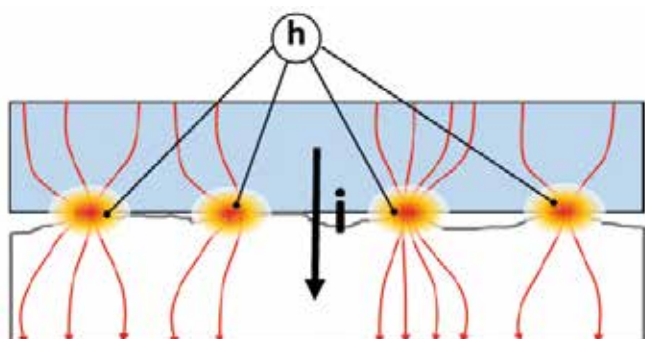


Figure 2

TE's SIMAFLEX connectors offer exceptional performance for an extended lifetime in any service condition.

Opposite Figure 1 is a given model of power connector's contact where the contact areas are randomly distributed as typically met with connector's contacts obtained raw from casting (no machining of the contact areas).

Per Figure 2, only the metallic contact area (c) carry-out the power through the current lines. Depending on the contact areas randomly distributed by the casting process, and insufficient contact pressure, the population of those metallic contact areas is not enough to carry out the current density. They are located in such way that current lines are not consistently distributed across the total contact area ($a + b + c$). Insufficiently or non-uniformly distributed, the metallic contact areas will see important concentration of current flows which have to carry out the current "i". Consequently high current density areas (h) will heat excessively up to melting the contact areas. Then abnormal heating process becomes detrimental to the lifetime of the power contact. This deterioration process is accelerated where flexible bear conductors are involved as the excessive heating generates physical creep of the conductor's wires, driving to lose >80% of the contact pressure machined and the contact pressure dramatically increased.



Figure 3

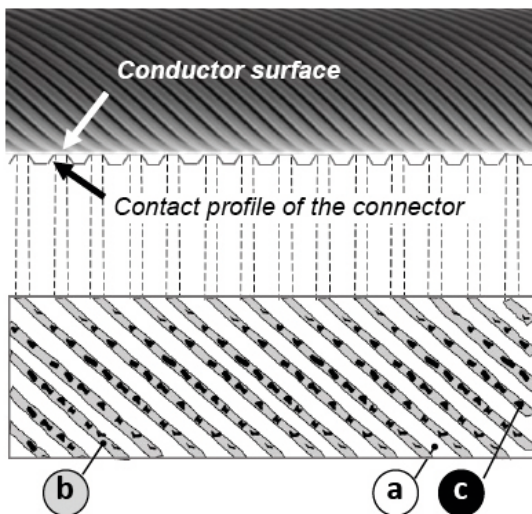


Figure 4

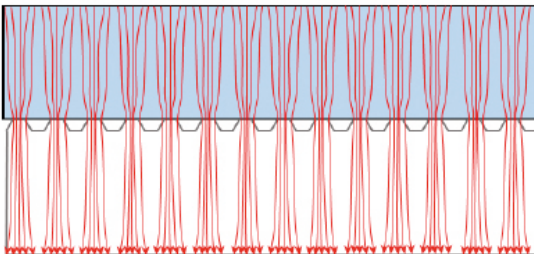


Figure 5

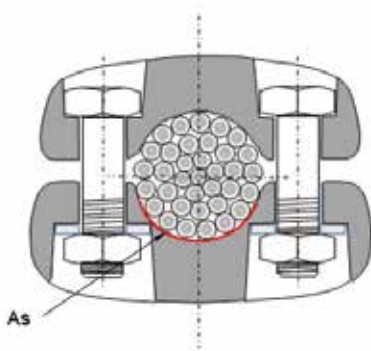


Figure 6

As shown in Figure 3, the cylindrical power contacts of TE's SIMAFLEX connectors are machined with a controlled roughness in order to obtain a regular and managed contact area between the conductor's wires and the connector's surface.

The contact profile of the connector surface (Figure 4) provides multiple contact points with the conductor's wires, uniformly distributed on the length of the contact surface of the connector.

In this model, the managed contact surface *b* is regularly distributed and multiple metallic contact areas *c* are created. Then the current lines are regularly distributed along the contact surface of the connector as shown in Figure 5.

In addition the TE's SIMAFLEX bolted connector is unique in the sense that contact pressure is significantly increased due to its 3 keeper design concept associated to the pre-lubricated bolts by a specific waxing process. Compact design as well as waxed bolts increase significantly the pressure per surface unit in comparison with some conventional bolted connector designs.

High contact pressure ensuring contact longevity

Compare the delivered contact pressure between the TE's SIMAFLEX design and conventional bolted connector design with 4, 3 and 2 keepers (Figures 6 and 7).

A same conductor of diameter "*C*" is connected to a bolted connector having a contact surface "*Cs*".

To simplify the model, we consider the total apparent surface of the connector groove which is basically the length of the contact (*L4*, *L3*, *L2* and *Ls*) by the length of the arc of the connector groove "*As*".

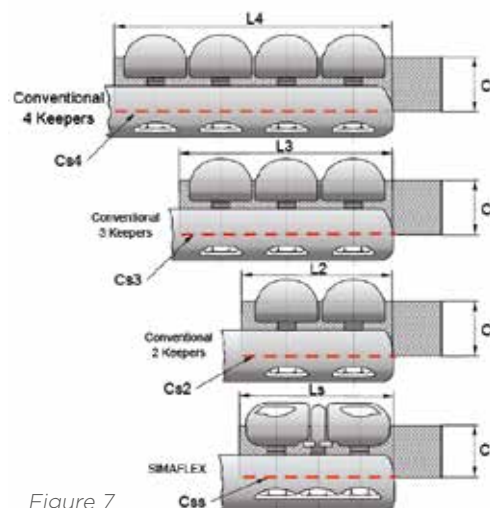


Figure 7

We consider the following data:

Conductor Diameter "D": 42 mm

"As" (Arc of the connector groove): 50 mm

L being the contact length we obtain the apparent contact surface "Cs" with: $Cs = As \times Ls$

- Conventional 4 keepers design with $L4 = 160 \text{ mm} \rightarrow Cs4 = 8000 \text{ mm}^2$
- Conventional 3 keepers design with $L3 = 122 \text{ mm} \rightarrow Cs3 = 6100 \text{ mm}^2$
- Conventional 2 keepers design with $L2 = 84 \text{ mm} \rightarrow Cs2 = 4200 \text{ mm}^2$
- TE's SIMAFLEX connector design with $Ls = 104 \text{ mm} \rightarrow Css = 5200 \text{ mm}^2$

The contact pressure "P" (Figure 8c) is delivered by the bolts as shown in Figure 8b. The majority of the bolted connectors are equipped with stainless steel fasteners for corrosion reasons. In our case study we will consider M10 Bolts to calculate the final pressure per surface unit.

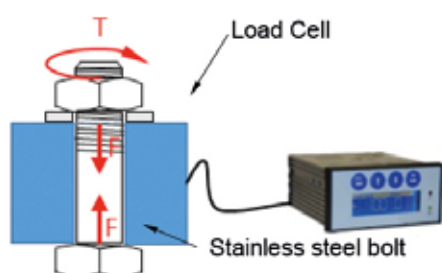


Figure 8a

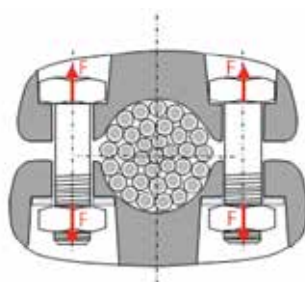


Figure 8b

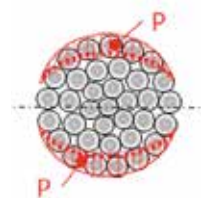


Figure 8c

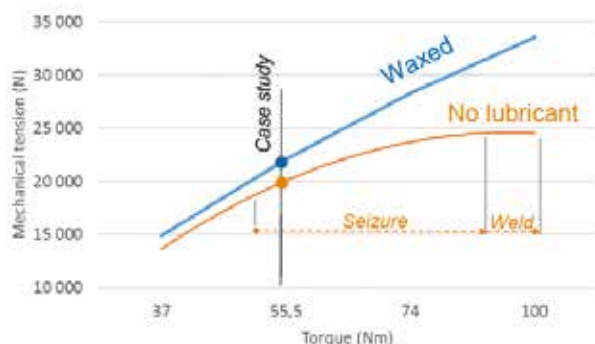


Figure 9

The tensile force provided by the bolts is obtained by testing. A compression load cell (Figure 8a) records the tensile force "F" when gradually applying the torque on the nut from 37 Nm to 100 Nm. Two different bolt arrangements are tested (5 samples of each to be representative):

- A2 grade stainless bolts without any lubricant (conventional connectors).
- A2 grade stainless steel screw with a waxed A4 grade nut (TE's SIMAFLEX connectors).

Conventional connectors are mostly supplied with bolts without any lubricant. The seizure effect of stainless steel bolts is well known. Under high torque, the pressure in the thread (hertz) is such that the friction coefficient becomes very high, inducing a "cold weldment" phenomenon into the fillet. The expected mechanical tension on the bolts is not achieved. Figure 9 graphs the relationship between the applied torque "T" (Nm) and the measured mechanical tensile force "F" in the bolt (N). It shows the benefit of the wax which provides a linear relationship between the torque and the tensile force. In the meantime non-lubricated bolts show fillet seizure from around 50 Nm until the curve becomes flat due to cold weldment of the bolted assembly.

For our case study we will consider the torque value of 55 Nm which is the maximum applicable torque to a non lubricated M10 bolt as seizure effect appears around this value (Figure 9).

The following mechanical tension "F" in the bolts are measured (average of the 5 tested samples for each version):

- Bolts assembly non-lubricated (conventional connectors) → 19312 N/Bolt.
- Waxed bolts assembly (TE's SIMAFLEX) → 22100 N/Bolt.

The below table summarizes the calculation of the Pressure "P" for the 3 given conventional models and the TE's SIMAFLEX 3 keepers design.

Design	N° Bolts	F/Bolt (N)	F Total (N)	Contact area (mm ²)	Pressure P (N/mm ²)
4 Keepers Design	8	19 312	154 496	8 100	19,07
3 Keepers Design	6	19 312	115 872	6 100	19,00
2 Keepers Design	4	19 312	77 248	4 200	18,39
TE's SIMAFLEX Design	6	22 100	132 600	5 200	25,50*

Pressure "P" comparative table

* + 34,2 % pressure

The TE's SIMAFLEX connector's concept is providing more than 30% additional pressure into the electrical contact than other conventional design, which is a remarkable step forward in the bolted technology of the power electrical contact.

An extended lifetime

TE's SIMAFLEX connector concept brings extended lifetime of the products under extreme service conditions thanks to the machined groove and the increase contact pressure. In order to simulate extreme service conditions and reliability of the performance, our connectors are heat cycle tested.

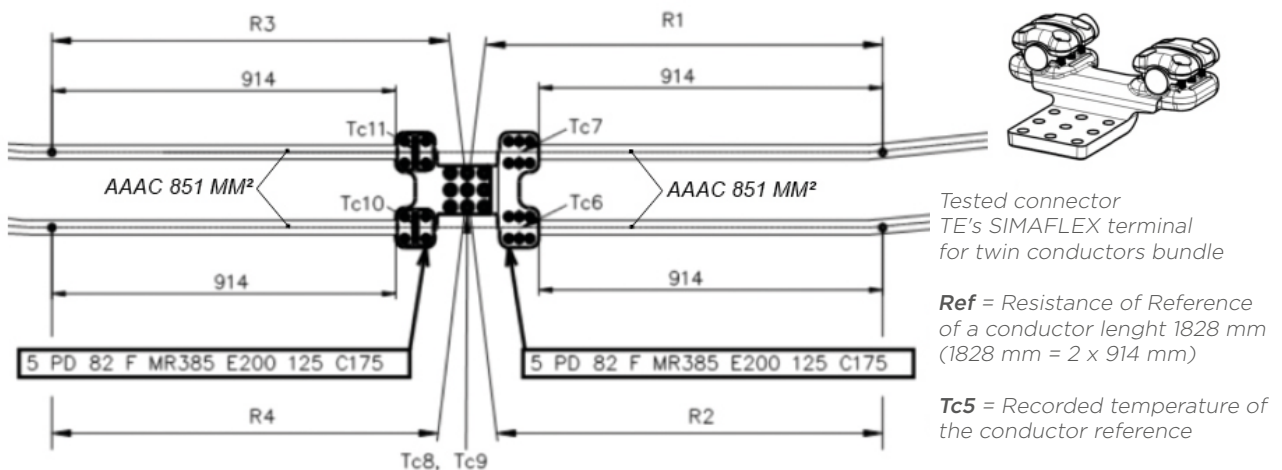


Figure 10

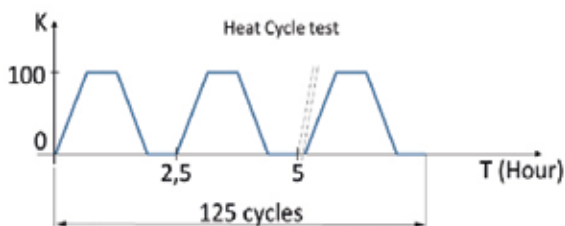


Figure 11

The connectors are tested per the most demanding standards such as the ANSI 119.4 (test loop on Figure 10). The connectors undergo 125 heat cycles. The carried out current is permanently adjusted to ensure 100K temperature rise in the reference conductor before cooling down. The cycles test protocol is shown in Figure 11.

Results:

Electrical resistances as well as temperatures are measured from Cycle 0/1 to Cycle 125 as per the standard requirements. High contact pressure in TE's SIMAFLEX connectors is a key driver for electrical resistances stability as shown in the Figure 12 where absolute deviation of the connector's resistance does not exceed 1.3% (-0.45% to +0.82%) from cycle 25 to cycle 125 as per ANSI 119.4 standard which allows an absolute deviation of 10% ($\pm 5\%$).

Multiple metallic contact areas provide thermal stability to the TE's SIMAFLEX connectors as shown in the Figure 13 where absolute deviation of the temperature rise of the connectors is 3.4K (± 1.7 K) from cycle 25 to cycle 125 as per ANSI 119.4 standard which allows an absolute deviation of 20K (± 10 K).

TE's SIMAFLEX connectors offer reliability and extended longevity under extreme service conditions

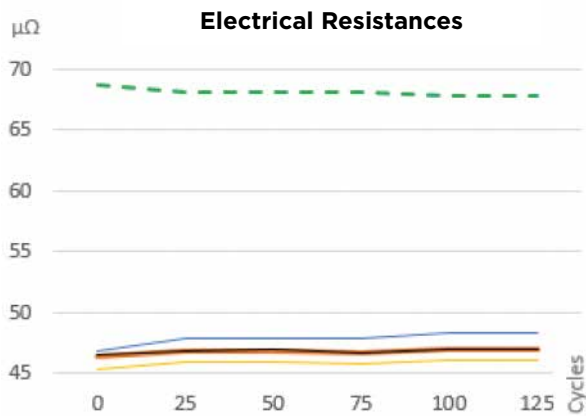


Figure 12

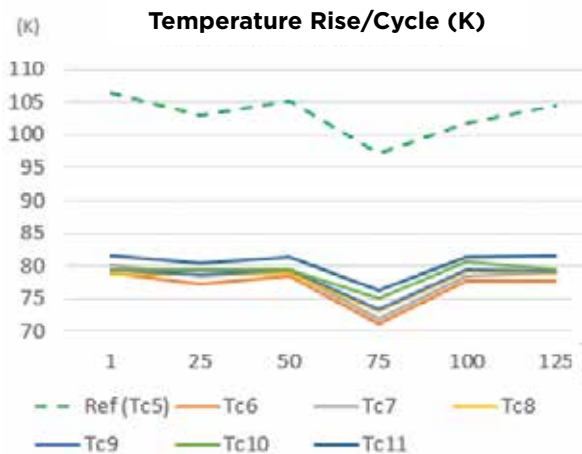


Figure 13

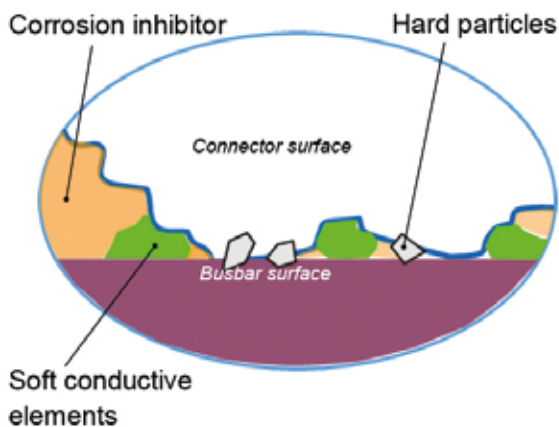


Figure 14

Sustainable under any conditions

In order to keep the metallic contact out of external aggression (ie: moisture, pollution) the overall electrical contact must be kept sealed. Unsealed contact will become inexorably oxidized as it is continuously subjected to temperature changes and environmental constraints.

The opposite figure 14 is a macro view of metallic contacts where the components of the ENERTAL grease are shown. The ENERTAL grease is essential to ensure extended lifetime of the power contact as it's main support is a mineral grease which contains corrosion inhibitor. In addition to its corrosion protection properties, ENERTAL grease also contains soft conductive particles which increase the metallic contact area. Very hard organic particles are also present in the compound in order to create anchorage "micro" points in the contact to improve mechanical tensile strength.

ENERTAL grease is a multifunctional compound which will ensure optimized working conditions to the power contacts and for very long time.



Installation

A detailed installation notice (Instruction Manual ref. EPP-2948) is supplied with our connectors. The manual provides all recommendations and application methods to install our products for optimal performance and an extended lifetime.

The following areas are covered:

- Preparation of the conductors
- Preparation of the connectors
- Tightening torques
- Clamping operations
- Maintenance

The contact surfaces, of our connectors are delivered uncoated but our ENERTAL contact grease is supplied along with our connectors for preparation on site.

III. Material

TE's connector components are cast from normalized ingots to guarantee high alloy quality.

Body and keepers

Sand and die cast silicon aluminium alloy: EN AC-42100 SF and EN AC-42200 KF in accordance with EN 1706 (2010) standard.

Mechanical and physical characteristics

Material	Resistivity at 20° C	Electrical conductivity	R _m (MPa*)	R _{p0.2} (MPa*)	A _{50mm} (%)	Hardness (HBS)
EN AC-42100SF	4 μWcm ² /cm	38 % IACS	140	80	2	50
EN AC-42200KF	4 μWcm ² /cm	38 % IACS	170	90	4	55

* 1MPa = 1N/mm²

R_m = Minimum tensile strength

R_{p0.2} = Minimum elasticity conventional limit

A_{50mm} = Minimum elongation

Material cross - Referencing (designation)

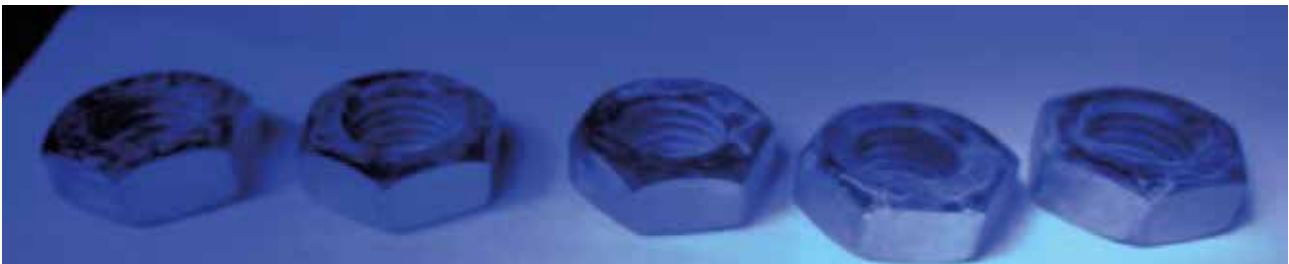
French standard (NF EN 1706)	ASTM standard (ASTM B26/B26M)	DIN standard (DIN 1725.2)	BS standard (BS 1490)
EN AC-42100SF	356	G-ALSi7Mg	LM6M LM25M
EN AC-42200KF			

Fasteners

- H type bolts, ISO thread from M10 to M12.
- Screws, washers of A2 type (A4 on request) and hexagonal nuts of A4 type stainless steel in accordance with international standard ISO 3506.
- Minimum mechanical strength class 70 (minimum breaking stress = 700 MPa).
- U Bolt as the third optional keeper are made of A4-80 stainless steel grade (minimum breaking stress = 800 MPa).

The tightening operation and the tightening torque must be applied in accordance with our Instruction Manual (see 2.5).

Nuts are supplied waxed to improve the contact pressure and avoid any bolt seizure during installation. The wax is applied to the nuts at our factory. It is not visible as the lubricant is transparent. However the coating can be revealed by black light which is the process used to carry-out internal controls (see the picture below).



Note: The fasteners used to install connectors on apparatus terminal palms or pillars are not supplied by default. They can be supplied on request.



ENERTAL bags

ENERTAL contact grease

The ENERTAL contact grease contains zinc dust and a corrosion inhibitor. It protects the metal surfaces against the action of atmospheric oxygen and prevents the formation of oxides which increase contact resistance.

Zinc particles provide a larger contact area to the connectors to improve the electrical properties. ENERTAL grease is delivered in bags in order to facilitate its application and to reduce waste at site.

Physical characteristics:

- Density at 20°C: 1.8 kg/dm³
- Drop point: greater than 190°C
- Penetration at 25°C: 245/10 to 280/10.

IV. Performances - Tests

Electrical performance - HEATING TEST

Since a connector should not cause any particular temperature rise in a power circuit, it must not export additional heating to other components like the conductors or apparatus terminals. Instead it must perform as a conductor end and equipment terminal temperature regulator.

- The connectors have a temperature rise less than or equal to the hottest connected conductor for the same current (ANSI/NEMA CC1, § 2.6 and 3.1 - Publication 2009).
- The temperature rise of the connectors, at an ambient air temperature not exceeding 40°C, is less or equal to 50K (IEC 62271-1, §6.5 and 4.4.2 - Publication 2007).

Electrical performance - HEAT CYCLE TEST

Running on outside circuits the connectors are subjected to many large amplitude thermal shocks (up to 80°C) at a relatively regular frequency (usually 2 shocks per day). This type of thermal stress can bring significant contact damage if the connectors are not well-designed.

For this purpose heat cycling tests are performed according to the ANSI C119.4 standard (2011), paragraphs 3.2 & 6.

It consists of subjecting the circuit (including the connectors to be tested) to a current which heats the conductor to 100K above ambient air temperature, then cooling the conductors to ambient temperature by forced convection. This process is repeated a number of cycles. The products must be thermally and electrically stable to meet the requirements of the standard. In addition, the test current causing the temperature rise is much higher than the maximum current which the connectors are supposed to carry when installed.

Electrical performance - SHORT-CIRCUIT TEST

The connectors are designed to carry the short-circuit current that may flow through the conductors on which it is installed in case of defects in the installation.

This short-circuit current must not cause any damage to the connectors.

Neither burn on the contact surfaces nor welding between the parts must occur during the current overload.

The tests are performed in accordance to paragraph 6.6 of the IEC 62271-1 standard. Typical values of the fault are 40 kA/3s and 80 kA/1s.

Electrical performance - DIELECTRIC HIGH VOLTAGE TESTS

Shapes and design are created to have products for use on phase-to-phase rated voltage up to 550 kV.

Corona effect visual test

Neither positive corona spark nor light are observed on the surface of the products with the naked eye at the nominal voltage (phase-to-ground) equal to $1.1 \times U_r / \sqrt{3}$ (U_r = phase-to-phase rated voltage up to 550 kV).

The tests are performed in accordance with paragraph 6.9.1 of the IEC 62271-1 standard.

Radio Interference Voltage (RIV) test

The maximum RIV level is less than 2500 μ V (68 dB) at $1.1 \times U_r / \sqrt{3}$ (U_r = rated voltage up to 550 kV) with a 300 Ω test circuit impedance. Tests are performed in accordance with paragraph 6.9.1 of the IEC 62271-1 standard.

Mechanical performance - MECHANICAL TESTS

Mechanical performance - PULLOUT TEST

The connectors are designed to withstand the mechanical loads which can be applied to the conductor span. The minimum cantilever strength of conductor span support and/or connector is in accordance with ANSI/NEMA CC1 standard (2009 - §2.7-3.2): an axial load, depending of the conductor cross section, is applied.

No failure or slippage must be observed during the test.

Mechanical performance - CANTILEVER TEST

The mechanical supports and spacers are designed to withstand the mechanical loads which can be applied transversally to the products.

The minimum cantilever strength of supports and/or spacers is in accordance with ANSI/NEMA CC1 standard (2009 - §2.8-3.4): a transverse load of 8896 N is applied.

No failure must be observed after the test.

Mechanical performance - TORQUE STRENGTH TEST

The conductor(s) are assembled in the connector and the bolts tightened uniformly and alternatively incrementally up to 50% over the nominal torque value in accordance with ANSI/NEMA CC1 - 2009, §3.5. (Ref. instruction manual EPP-2948).

V - Applicable Standards

- International standard IEC 62271-1 (2007) for heating, resistance, short-circuit and dielectric tests.
- International standard IEC 273 (1990) for base-plate post-insulator interfaces.
- International standard IEC 518 (1975) for stud interfaces.
- International Special Committee (C.I.S.P.R.) publication n° 16 for R.I.V. tests.
- American standard ANSI/NEMA CC1 (2009) for heating, resistance, tensile, cantilever and torque strength tests.
- American standard ANSI C119.4 (2011) for ageing test on tubular conductor products.
- European standard E.N.C 64-020 (1991) for terminal interface dimensions - palms and studs.
- German standard DIN 46-206 (1989) for terminal interface dimensions.

VI - Services

Through years of international experience and in the interest of our customers, TE Connectivity proposes a wide range of technical support and services.

Fields of expertise

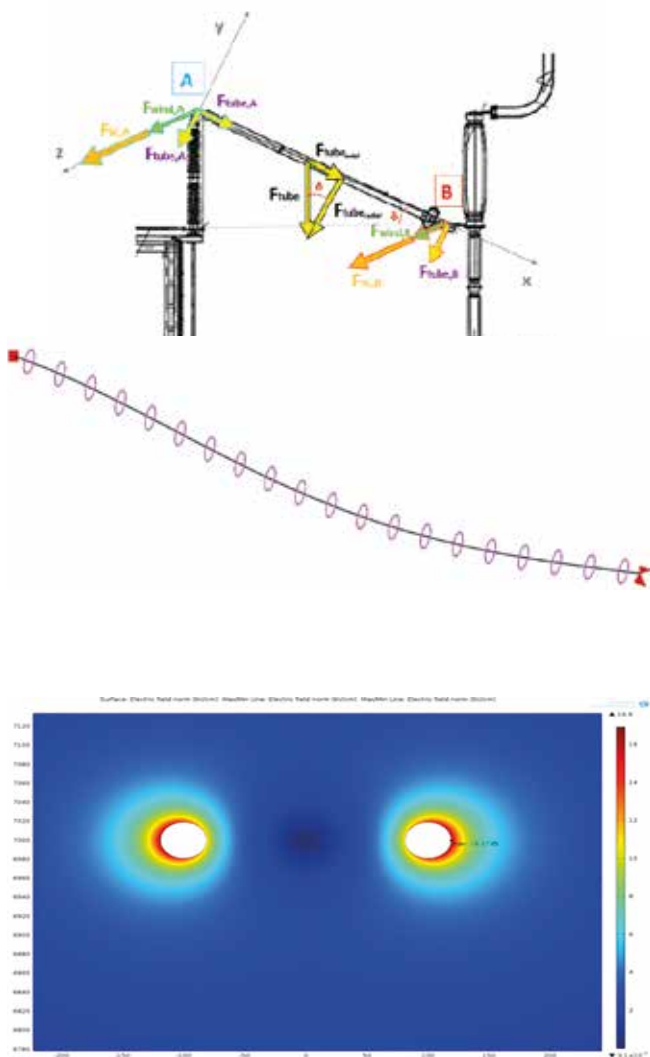
We have acquired extended knowledge of substation applications up to 1200 kV over the last 60 years that can benefit our clients such as:

- Innovative solutions that drive significant savings on projects. Connection point rationalization, reduction of installation cost by avoiding weldments or bending of tubes, original solution for retrofit projects of out of date switchyards.
- Mechanical case studies to propose optimized dimensioning and arrangement of busbar systems.
- Dynamic case studies of bus vibration phenomenon to propose adapted damping solution to critical aeolian applications.
- Electrical field case studies further observed corona phenomenon in Extra and Ultra High Voltage switchyards in order to propose adapted shielding solutions.

For any challenging application in connection systems, TE has a solution.

Calculation

We offer a wide range of calculation support to our customers.



- **Mechanical** calculation of a busbar system by Finite Element Method (FEM). Taking into consideration all external load parameters like short circuit strength, icing of the tubes, and wind pressure, we calculate the strength in the tubular conductor as well as the strength at the connection points in order to estimate the transferred loads to the HV equipment and the adapted size/material grade of the tube.
- **Dynamic calculation** by FEM of a busbar exposed to **aeolian vibrations**. We help our customers collect the most accurate data from the installed busbar system like span length, dimension/material/grade of the tube, and boundary conditions provided from the installed connectors. We run a dynamic calculation to determine the frequencies of the system in order to confirm the critical factors of the studied case. We propose a damping system adapted to the situation and provide all installation recommendations.
- **Electrical field** calculation of a connection environment by FEM. Further, for any observed corona phenomenon, we collect data on your connection and run a calculation to localize the critical discharge areas in order to propose a shielding system adapted to the environment and easy/fast to install.
- Calculation of the **heating** of the conductors. We take into account all environmental data to calculate the expected temperature rise of the conductor(s), taking into consideration its actual physical characteristics as well as its climatic ageing.

Testing laboratory

Our test laboratory, located in France (Gevrey-Chambertin) is COFRAC accredited. This means that our laboratory is considered independent (third party). It is able to demonstrate its competence and independence to carry out specific assessment tasks (i.e. independent test-ing of our products).

Advantages of accreditation

- Proof of technical expertise
- Qualification, training and experience of the lab team
- Equipment properly calibrated and maintained
- Adequate quality assurance procedures
- Appropriate testing procedures
- Traceability of measurements in line with International Standards
- Validity of the test methods
- Accurate recording & reporting procedures
- Suitable testing equipment and facilities

Our testing laboratory offers a wide array of test protocols covered by the accreditation frame (see following tests summary table).

N°	Description of the test	N°	Description of the test	N°	Description of the test
1	Electrical ageing	8	Dielectric strength	15	Electrical ageing under immersion
2	Temperature rise and short-circuit	9	Dry heat	16	Insulation resistance measurement
3	Electrical ageing under mechanical load	10	Mechanical tensile strength	17	Low temperature assembly
4	Climatic ageing	11	Screwing and unscrewing measurement	18	Endurance test for LV accessories
5	Salt bath corrosion	12	Water tightness strength	19	Marking strength
6	Dioxide sulfur corrosion	13	Crimping capabilities	20	Electrical ageing under water pressure
7	Soda corrosion	14	Low temperature mechanical shock	21	Mechanical shock at low temperature

More specifically to high voltage connectors, our laboratory can perform electrical temperature rise tests according to the NEMA, EN and ANSI standards, short circuit tests according to the EN standard, and any mechanical test (tensile, bending, cycle, etc.) according to applicable standards and customer's requirements. We are also equipped to conduct some vibration tests.

Some illustrations of our testing capabilities for high voltage connectors



Temperature rise test up to 10 kA



Cantilever/Bending test up to 5 T/Axis



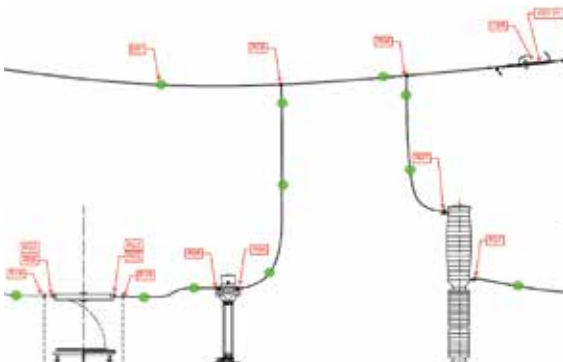
Short-circuit test up to 42 kA/2 Sec



Tensile test up to 70 T



Vibration test



Connectors Bill Of Quantity (BOQ) from switchyard layout

As another service, we offer our customers the definition for the clamps and connectors from the layout of the switchyard.

Item numbers of the proposed products are located on the layout and the final bill of material is provided along with our offer.

Fixing bolts can be also proposed based on the HV equipment that will be installed in the switchyard.

Do not hesitate to ask how we can support you in making your substation project successful.

MCM/KCMIL-AAC-AAAC-ACSR Conductors (Small)

Small (Code Size)		S205	S225	S245	S265	S285	S305	S325
Conductor Range Diameter (mm)		15 to 20.5	20.6 to 22.5	22.6 to 24.5	24.6 to 26.5	26.6 to 28.5	28.6 to 30.5	30.6 to 32.5
Conductor Range Diameter (IN)		.5905 to .8070	.8110 to .8858	.8897 to .9645	.9685 to 1.0433	1.0472 to 1.1220	1.1259 to 1.2007	1.2047 to 1.2795
Conductor	MCM/KCMIL							
ACSR	266.8	•						
AAC	300	•						
AAAC	300	•						
ACSR	300.0	•						
AAAC	312.8	•						
AAC	336.4	•						
ACSR	336.4	•						
AAC	350	•						
AAAC	350	•						
AAAC	394.5	•						
AAC	397.5	•						
ACSR	397.5	•						
ACSR	397.7	•						
AAC	400	•						
AAAC	400	•						
AAC	450	•						
AAAC	450	•						
AAAC	465.4	•						
AAC	477	•						
ACSR	477		•					
AAC	500		•					
AAAC	500		•					
AAC	550		•					
AAAC	550		•					
AAC	556.5		•					
AAAC	559.5		•					
ACSR	556.5		• (osprey)	•				
AAC	600			•				
AAAC	600			•				
ACSR	605			• (Peacock)	•			
AAC	636			•				
ACSR	636			• (Kingbird)	•			
AAC	650			•				
AAAC	650			•				
AAAC	652.2			•				
ACSR	666.6				•			
AAC	700			•				
AAAC	700			•				
AAC	715.5			•				

MCM/KCMIL-AAC-AAAC-ACSR Conductors (Small)

Small (Code Size)		S205	S225	S245	S265	S285	S305	S325
Conductor Range Diameter (mm)		15 to 20.5	20.6 to 22.5	22.6 to 24.5	24.6 to 26.5	26.6 to 28.5	28.6 to 30.5	30.6 to 32.5
Conductor Range Diameter (IN)		.5905 to .8070	.8110 to .8858	.8897 to .9645	.9685 to 1.0433	1.0472 to 1.1220	1.1259 to 1.2007	1.2047 to 1.2795
Conductor	MCM/KCMIL							
ACSR	715.5				• (Crow/Stitt)	•		
AAAC	740.8				•			
AAC	750				•			
AAAC	750				•			
AAC	795				•			
ACSR	795					•	• (Mallard)	
AAC	800				•			
AAAC	800				•			
AAC	850					•		
ACSR	874.5						•	
AAC	900					•		
AAAC	900					•		
ACSR	900						•	
AAC	950					•		
AAC	954						•	
ACSR	954						•	
AAAC	927.2					•		
AAC	1000						•	
AAAC	1000						•	
AAC	1033.5						•	
ACSR	1033.5							•
AAC	1100							•
AAC	1113							•
ACSR	1113							•
AAC	1192.5							
ACSR	1192.5							
AAC	1200							•

MCM/KCMIL-AAC-AAAC-ACSR Conductors (Medium)

Medium (Size Code)		M(R)305	M(R)325	M(R)345	M(R)365	M(R)385	M(R)405	M(R)425
Conductor Range Diameter (mm)		28.6 to 30.5	30.6 to 32.5	32.6 to 34.5	34.6 to 36.5	36.6 to 38.5	38.6 to 40.5	40.6 to 42.5
Conductor Range Diameter (IN)		1.1259 to 1.2007	1.2047 to 1.2795	1.2834 to 1.3582	1.3622 to 1.4370	1.4409 to 1.5157	1.5196 to 1.5944	1.5984 to 1.6732
Conductor	MCM/KCMIL							
ACSR	795	• (Mallard)						
AAC	800							
AAAC	800							
AAC	850							
ACSR	874.5	•						
AAC	900							
AAAC	900							
ACSR	900	•						
AAC	950							
AAC	954	•						
ACSR	954	•						
AAAC	927.2							
AAC	1000	•						
AAAC	1000	•						
AAC	1033.5	•						
ACSR	1033.5		•					
AAC	1100		•					
AAC	1113		•					
ACSR	1113	• (Finch)	•					
AAC	1192.5		•					
ACSR	1192.5			•				
AAC	1200		•					
AAC	1250			•				
AAC	1272			•				
ACSR	1272			•	• (Pheasant)			
AAC	1300			•				
ACSR	1351.5				•			
AAC	1400				•			
AAC	1431				•			
ACSR	1431				•	• (Plover)		
AAC	1500				•			
AAC	1510.5				•			
ACSR	1510.5					•		
AAC	1590					•		
ACSR	1590					•	• (Falcon)	
AAC	1600					•		
AAC	1700					•		
AAC	1750						•	
ACSR	1780							•
AAC	1800						•	
AAC	1900						•	
AAC	2000							•

MCM/KCMIL-AAC-AAAC-ACSR Conductors (Large)

Large (Size Code)		L(R)445	L(R)465	L(R)485	L(R)505	L(R)525	L(R)545	L(R)565	L(R)585	L(R)605	L(R)625
Conductor Range Diameter (mm)		42.6 to 44.5	44.6 to 46.5	46.6 to 48.5	48.6 to 50.5	50.6 to 52.5	52.6 to 54.5	54.6 to 56.5	56.6 to 58.5	58.6 to 60.5	60.6 to 62.5
Conductor Range Diameter (IN)		1.6771 to 1.7519	1.7559 to 1.8307	1.8346 to 1.9094	1.9133 to 1.9881	1.9921 to 2.0669	2.0708 to 2.1456	2.1496 to 2.2244	2.2283 to 2.3031	2.3070 to 2.3818	2.3858 to 2.4606
Cable Type	MCM/KCMIL										
AAC	2250	•									
AAC	2500		•								
AAC	2750			•							
AAC	3000					•					
AAC	3500							•			

METRIC-AAC-AAAC-ACSR Conductors (Small)

Small (Code Size)			S205	S225	S245	S265	S285	S305	S325
Conductor Range Diameter (mm)			15 to 20.5	20.6 to 22.5	22.6 to 24.5	24.6 to 26.5	26.6 to 28.5	28.6 to 30.5	30.6 to 32.5
Conductor Range Diameter (IN)			.5905 to .8070	.8110 to .8858	.8897 to .9645	.9685 to 1.0433	1.0472 to 1.1220	1.1259 to 1.2007	1.2047 to 1.2795
Conductor	Standard	mm ²							
AAAC	ASTM	140	•						
AAC	ASTM	147.1	•						
ACSR	UNE	147.1	•						
ACSR	NFC	147.11	•						
ACSR	NFC	147.11	•						
AAAC	NFC	148	•						
AAAC	DIN	147.11	•						
AAAC	BS	151.1	•						
ACSR	DIN	157.7	•						
AAAC	ASTM	160	•						
ACSR	BS	161.7	•						
ACSR	BS	167.5	•						
ACSR	DIN	173.1	•						
AAAC	ASTM	180	•						
AAAC	BS	180.7	•						
AAAC	NFC	181	•						
AAC	DIN	181.6	•						
ACSR	UNE	181.6	•						
ACSR	NFC	181.62	•						
ACSR	NFC	181.62	•						
AAAC	DIN	181.62	•						
ACSR	BS	194.5	•						
ACSR	BS	194.9	•						
AAAC	ASTM	200	•						
AAAC	BS	211	•						
ACSR	DIN	211.9	•						
ACSR	DIN	213.6	•						
AAAC	BS	222.3	•						
AAAC	ASTM	224	•						
ACSR	BS	226.2	•						
ACSR	NFC	227.82	•						
ACSR	NFC	227.82	•						
AAAC	NFC	228	•						
AAAC(Z)	NFC	261	•						
AAAC	BS	239	•						
AAC	ASTM	242.5	•						
ACSR	DIN	243.2	•						
AAAC	DIN	242.54	•						
AAAC	ASTM	250	•						
ACSR	DIN	260.7		•					
ACSR	BS	261.5		•					
ACSR	DIN	261.6		•					
AAAC	BS	270.8		•					
AAAC	ASTM	280		•					
ACSR	UNE	281.1		•					
ACSR	DIN	282.5		•					
AAAC	NFC	288		•					

METRIC-AAC-AAAC-ACSR Conductors (Small)

Small (Code Size)			S205	S225	S245	S265	S285	S305	S325
Conductor Range Diameter (mm)			15 to 20.5	20.6 to 22.5	22.6 to 24.5	24.6 to 26.5	26.6 to 28.5	28.6 to 30.5	30.6 to 32.5
Conductor Range Diameter (IN)			.5905 to .8070	.8110 to .8858	.8897 to .9645	.9685 to 1.0433	1.0472 to 1.1220	1.1259 to 1.2007	1.2047 to 1.2795
Conductor	Standard	mm ²							
ACSR	NFC	288.35		•					
ACSR	NFC	288.35		•					
ACSR	DIN	297.8		•					
AAAC(Z)	NFC	345.65		•					
ACSR	NFC	297.21		•					
AAC	DIN	299.4		•					
AAAC	DIN	299.43		•					
AAAC	BS	303			•				
AAAC	ASTM	315			•				
ACSR	DIN	344.1			•				
ACSR	DIN	353.7			•				
AAAC	ASTM	355			•				
AAAC	BS	362.1				•			
AAAC	NFC	366				•			
ACSR	DIN	369.1				•			
ACSR	UNE	381				•			
AAAC	ASTM	400				•			
AAC	DIN	400.1				•			
AAAC	DIN	400.14				•			
AAAC(Z)	NFC	455				•			
ACSR	NFC	411.67				•			
AAAC	BS	421.8				•			
ACSR	DIN	420.1					•		
ACSR	DIN	431.5					•		
AAAC	ASTM	450					•		
ACSR	UNE	454.5					•		
AAAC	BS	479.9					•		
ACSR	BS	484.5						•	
ACSR	DIN	488.2						•	
ACSR	DIN	490.6						•	
AAAC	ASTM	500						•	
AAC	DIN	499.8						•	
AAAC	DIN	499.83						•	
ACSR	UNE	517.3						•	
ACSR	DIN	528.2						•	
ACSR	UNE	547.3						•	
ACSR	DIN	553.9							•
ACSR	DIN	555.5							•
AAAC	ASTM	560							•
AAAC	NFC	570							•
AAAC(Z)	NFC	655.92							•
ACSR	DIN	610.7							•
ACSR	DIN	611.2							•
ACSR	NFC	611.76							•
ACSR	DIN	621.3							•
AAAC(Z)	NFC	707							•
AAAC	DIN	626.2							•

METRIC-AAC-AAAC-ACSR Conductors (Medium)

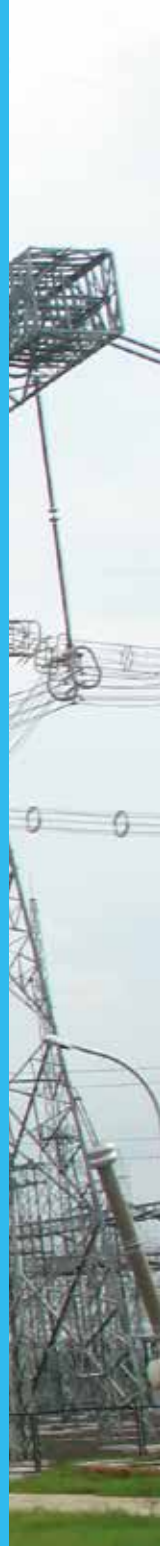
Medium (Size Code)			M(R)305	M(R)325	M(R)345	M(R)365	M(R)385	M(R)405	M(R)425
Conductor Range Diameter (mm)			28.6 to 30.5	30.6 to 32.5	32.6 to 34.5	34.6 to 36.5	36.6 to 38.5	38.6 to 40.5	40.6 to 42.5
Conductor Range Diameter (IN)			1.1259 to 1.2007	1.2047 to 1.2795	1.2834 to 1.3582	1.3622 to 1.4370	1.4409 to 1.5157	1.5196 to 1.5944	1.5984 to 1.6732
Cable Type	Standard	mm ²							
ACSR	BS	484.5	•						
ACSR	DIN	488.2	•						
ACSR	DIN	490.6	•						
AAAC	ASTM	500	•						
AAC	DIN	499.8	•						
AAAC	DIN	499.83	•						
ACSR	UNE	517.3	•						
ACSR	DIN	528.2	•						
ACSR	UNE	547.3	•						
ACSR	DIN	553.9		•					
ACSR	DIN	555.5		•					
AAAC	ASTM	560		•					
AAAC	NFC	570		•					
AAAC(Z)	NFC	655.92		•					
ACSR	DIN	610.7		•					
ACSR	DIN	611.2		•					
ACSR	NFC	611.76		•					
ACSR	DIN	621.3		•					
AAAC(Z)	NFC	707		•					
AAAC	DIN	626.2		•					
AAC	DIN	626.3			•				
AAAC	ASTM	630			•				
ACSR	UNE	636.6			•				
ACSR	DIN	698.8			•				
ACSR	DIN	754.6				•			
AAAC(Z)	NFC	928					•		
AAC	DIN	802.1					•		
AAAC	DIN	802.09					•		
AAAC	NFC	851					•		
ACSR	NFC	865.39					•		
AAC	DIN	999.7						•	
AAAC	DIN	999.71						•	

METRIC-AAC-AAAC-ACSR Conductors (Large)

Large (Size Code)			L(R)445	L(R)465	L(R)485	L(R)505	L(R)525	L(R)545	L(R)565	L(R)585	L(R)605	L(R)625
Conductor Range Diameter (mm)			42.6 to 44.5	44.6 to 46.5	46.6 to 48.5	48.6 to 50.5	50.6 to 52.5	52.6 to 54.5	54.6 to 56.5	56.6 to 58.5	58.6 to 60.5	60.6 to 62.5
Conductor Range Diameter (IN)			1.6771 to 1.7519	1.7559 to 1.8307	.1.8346 to 1.9094	1.9133 to 1.9881	1.9921 to 2.0669	2.0708 to 2.1456	2.1496 to 2.2244	2.2283 to 2.3031	2.3070 to 2.3818	2.3858 to 2.4606
Cable Type	Standard	mm ²										
ACSR	DIN	1090.9	•									
ACSR	NFC	1144	•									
ACSR	NFC	1184.48		•								
ACSR	NFC	1600					•					

NOTE Total cross section (Al+St) considered for ACSR conductors





Chapter I

Clamps & Accessories for Conductors

Conductor(s) Supports.....	28
Earthing Stirrups	30
Spacers	32

Conductor Supports

Single Conductor Support on Post Insulator



FEATURES

- From 60 kV to 330 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible jumper connections
- Flexible bus support

BENEFITS

- Wide conductors range taking
- Adjustable height (on demand)
- Corona free
- Ease installation
- Corrosion resistant

5 CS 84 P_ M_ /M_

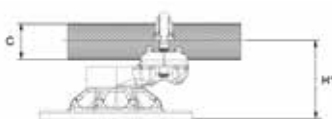
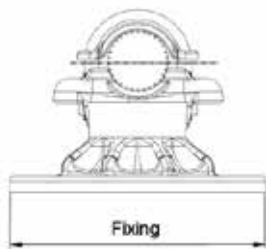
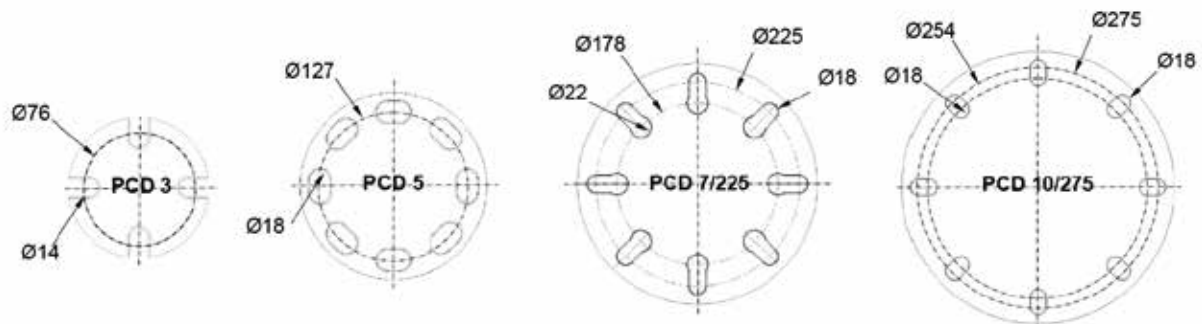
Fixing PCD ← Caliber size ← C mini ← C maxi ← Caliber size

5 CS 84 P3 S205/S325

Support for single conductor (16 to 32 Dia) with PCD 3 fixing

5 CS 84 P5 M345/M425

Support for single conductor (32 to 42.5 Dia) with PCD 5 fixing



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter (C)	C (mm)	15 to 32.5	32.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.2599 to 1.6732	1.6732 to 2.3228
H	(mm)	75	80	80
Fixing	PCD 3	•	•	○
	PCD 5	•	•	•
	PCD 7/225		○	○
	PCD 10/275			

• Standard

○ Option

* H dimension is given for indication as it depends on the conductor's size.

Conductors Supports

Twin Conductors Bundle Supports on Post Insulator



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible jumper connections
- Flexible bus support

BENEFITS

- Adjustable height (on demand)
- Corona free
- Ease installation
- Corrosion resistant

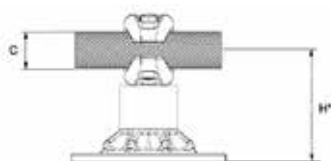
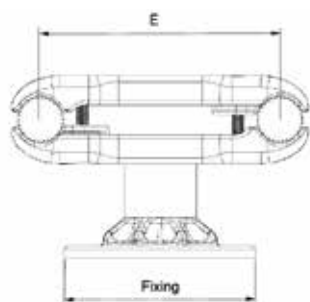
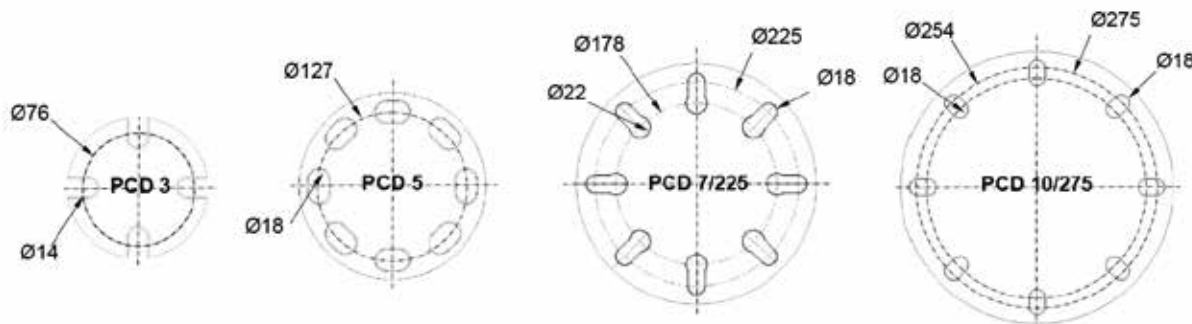
Chapter 1

5 CAE 82 P_M/M_E



5 CAE 82 P5 M320/M425 E200

Support for twin conductors (32 to 42.5 Dia) bundle spacing 200 mm with PCD 5 fixing



Caliber Size	S/M/L	Small				Medium				Large			
Conductor Range Diameter (C)	C (mm)	15 to 32				32.6 to 42.5				42.6 to 59			
	C (Inch)	.6299 to 1.2598				1.2598 to 1.6732				1.6732 to 2.3228			
E	(mm)	100	200	400	450	100	200	400	450	100	200	400	450
H	(mm)	80	115	95	95	80	115	95	95	90	125	105	105
Fixing	PCD 3	•	○	○	○	•	○				•		
	PCD 5	○	○	○	○	•	•	○	○	•	•	○	○
	PCD 7/225					○	○	○	○	○	○	○	○
	PCD 10/275						○	○	○			○	○

- Standard
- Option
- * H dimension is given for indication as it depends on the conductor's size.

Earthing Stirrups (single)

Single Conductor Earthing Stirrup



FEATURES

- From 60 kV to 330 kV
- Up to 63 kA
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connections to equipment
- Earthing connections to HV equipment

BENEFITS

- Wide conductors range taking
- Ease access of the hot stick to earthing rod
- Possibility to change the orientation of the rod
- Corona free
- Ease installation
- Corrosion resistant

5 CAMALT 82 M₁/M₂

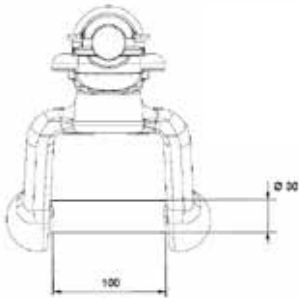
Caliber size ← C mini
← C maxi
← Caliber size

5 CAMALT 82 S205/S325

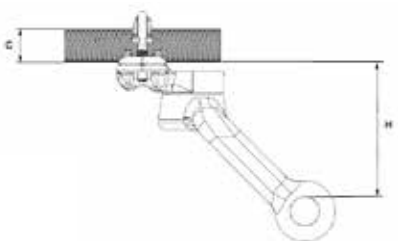
Earthing stirrup for single conductor (16 to 32 Dia)

5 CAMALT 82 P5 M345/M425

Earthing stirrup for single conductor (32 to 42.5 Dia)



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter (C)	C (mm)	15 to 32.5	32.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.2599 to 1.6732	1.6732 to 2.3228
H	(mm)	125	125	127
Standard/Option		•	•	•
				• Standard
				○ Option



Earthing Stirrups (twin)

Twin Conductors Bundle Earthing Stirrup



FEATURES

- From 60 kV to 550 kV
- Up to 80 kA
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connections to equipment
- Earthing connections to HV equipment

BENEFITS

- Wide conductors range taking
- Ease access of the hot stick to earthing rod
- Possibility to change the orientation of the rod
- Corona free
- Ease installation
- Corrosion resistant

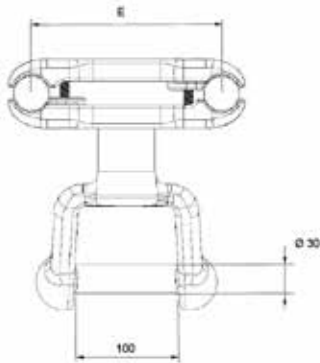
Chapter 1

5 CAMALT 82 F M_—/M_— E_—

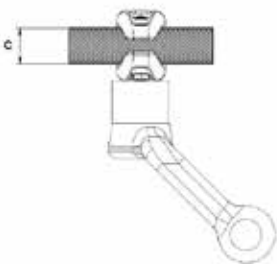


5 CAMALT 82 F M320/M425 E200

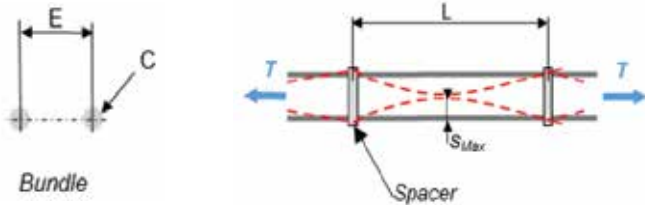
Earthing stirrup for twin conductors (32 to 42.5 Dia) bundle spacing 200 mm



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter (C)	C (mm)	16 to 32	32 to 42.5	42.6 to 59
	C (Inch)	.6299 to 1.2598	1.2598 to 1.6732	1.6732 to 2.3228
E	100 mm	•	•	○
	200 mm	•	•	•
	400 mm	○	○	○
	450 mm	○	○	○
		•	Standard	
		○	Option	



Placement of Spacers



$$s_{Max} < \frac{E - C}{2}$$

$$s_{Max} = \frac{g m L^2}{8 T} \Rightarrow L = \sqrt{\frac{8 s_{Max} T}{g m}}$$

Spacers arrangement is always a question in substation applications. There are 2 conductors bundles configuration to consider:

- Conductors bundle where a mechanical tension is applied to the span. This case is basically corresponding to the flexible busbar.
- Conductors bundle used in the switchyard to make flexible connections between HV equipment.

Flexible busbar

A flexible busbar is mechanically maintained in tension by insulators strings. We consider the conductors span is under mechanical tension around 1% of the nominal breaking load of the conductors which is provided by the adjustment of the sag "Hs" during installation (see below switchyard section).

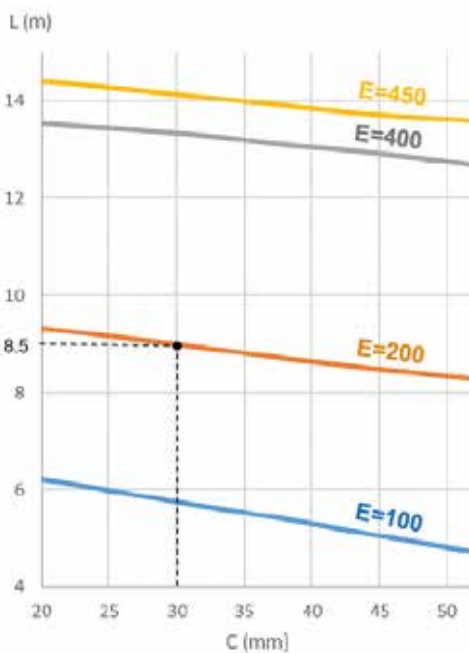
It is recommended to avoid clash between the sub-conductors of the bundle when a short-circuit occurs. The condition for not clashing between the sub-conductors is the following:

- s*: Conductor sag (in m)
- E*: Bundle Spacing (in m)
- C*: Conductor Dia (in m)

Then we determine the optimized distance between the spacers from the equation of the max acceptable sage "sMax" of a subconductor as follow:

- $g = 0.981 \text{ m/s}^2$
- m*: Linear mass of the conductor (in kg/m)
- T*: Mechanical tension (in N)
- L*: Distance between spacers (in m)

Spacers placement (flexible busbar)



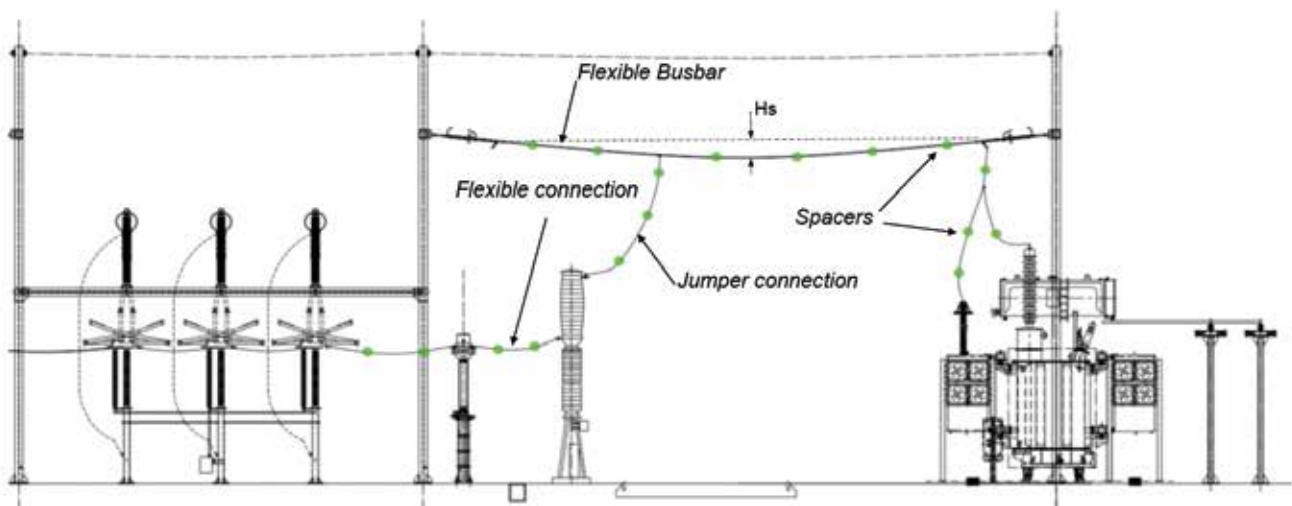
From the above reasoning calculation, we obtain the opposite graph.

The curves from the graph give the recommended distance "L" between each spacer for a given diameter "C" of AAAC conductor and bundle spacings of 100, 200, 400 and 450 mm.

Example: For a flexible busbar made of a twin AAAC Dia 30 conductors bundle spacing 200 mm, we obtain 8.5 m as the recommended distance "L" between 2 spacers.

Spacers placement (flexible connections) Flexible connection to equipment and jumpers

Flexible connection length (m)	2 to 4	5 to 8	9 and above
Recommendation	1 spacer in the middle	2 spacers at 1/3 of the connection length	1 spacer every 3 to 4 m



Spacers

Twin Conductors Bundle Spacers



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible jumper connection
- Flexible bus support
- Flexible connections to equipment

BENEFITS

- Wide conductors range taking
- Corona free
- Ease installation
- Corrosion resistant

5 CAE 82 M_/M_ E_

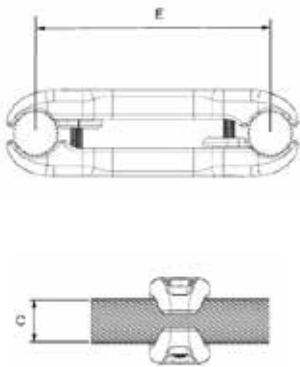


5 CAE 82 F M320/M425 E200

Spacer for twin conductors (32 to 42.5 Dia) bundle spacing 200 mm

5 CAE 82 F S160/MS320 E400

Spacer for twin conductors (16 to 32 Dia) bundle spacing 400 mm



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter (C)	C (mm)	15 to 32	32 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6732 to 2.3228
E	100 mm	•	•	○
	200 mm	•	•	•
	400 mm	○	○	○
	450 mm	○	○	○

- Standard
- Option





Chapter 2 Conductor to Conductor Connectors

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Tee Connectors	42
Adjustable Tee Connectors	44
Parallel Groove Connectors.....	45



Calibers

Calibers' Size and Design

Description

"Caliber" is the clamping part(s) of a connector. There are 3 caliber' sizes within the TE's SIMAFLEX connector range: Small, Medium and Large. With exception of the Small size (2 keepers only) and stud connection side, the Medium and Large sizes offer the possibility to get 2 or 3 keepers from the same connector's design. This innovating solution allows to comply with most of the specifications and/or any customer's requirement. The third keeper is optional but offers performances enhancement of the products as the contact pressure is dramatically increased. The third keeper solution is also offering easier installation especially for large conductor sizes as the "U" bolt is primarily installed to maintain the conductor in place in order to give hand free to the installer for assembling the 2 external keepers.



Small



2 keepers - Size code S

5 ... S ...

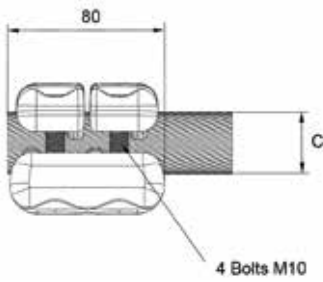
↳ Conductor size code: see table
↳ Caliber size S = Small

S245

Caliber size Small fit for conductor size (O/D) 22.6 to 24.5 mm

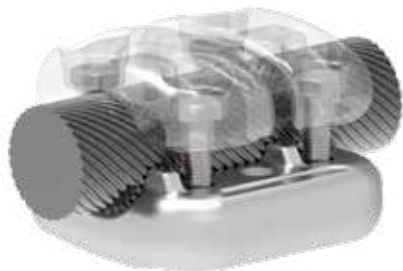
S325

Caliber size Small fit for conductor size (O/D) 30.6 to 32.5 mm

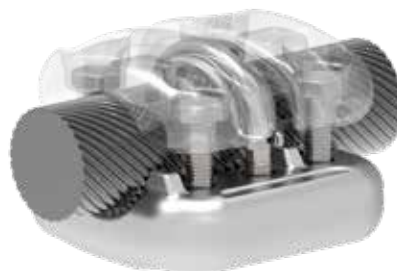


Flexible connection length (m)		Cond size "C" (mm)
2 Keepers	3 Keepers	
Small		
S205	N/A	15 to 20.5
S225	N/A	20.6 to 22.5
S245	N/A	22.6 to 24.5
S265	N/A	24.6 to 26.5
S285	N/A	26.6 to 28.5
S305	N/A	28.6 to 30.5
S325	N/A	30.6 to 32.5

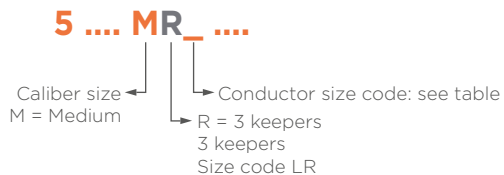
Medium



2 keepers - Size code M

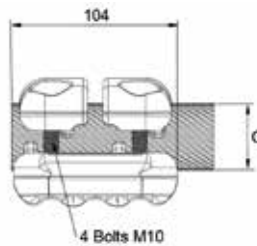


3 keepers - Size code MR



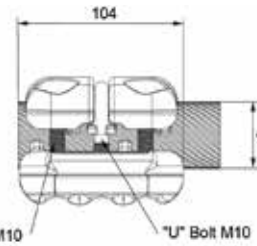
M405
Caliber size Medium with 2 keepers fit for conductor size (O/D) 38.6 to 40.5 mm

MR325
Caliber size Medium with 3 keepers fit for conductor size (O/D) 30.6 to 32.5 mm



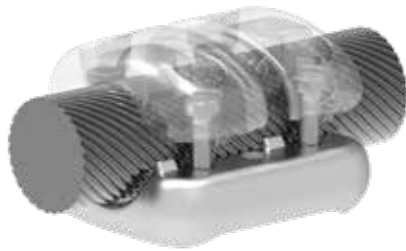
2 keepers - Size code M

Size Code		Cond size "C" (mm)
2 Keepers	3 Keepers	
Medium		
M305	MR305	28.6 to 30.5
M325	MR325	30.6 to 32.5
M345	MR345	32.6 to 34.5
M365	MR365	34.6 to 36.5
M385	MR385	36.6 to 38.5
M405	MR405	38.6 to 40.5
M425	MR425	40.6 to 42.5



3 keepers - Size code MR

Large



2 keepers - Size code L

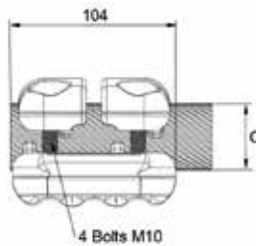


3 keepers - Size code LR

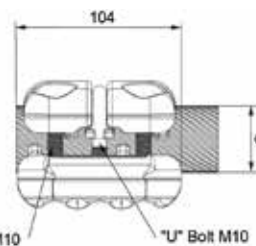


L465
 Caliber size Medium with 2 keepers fit for conductor size (O/D) 44.6 to 46.5 mm

LR565
 Caliber size Medium with 3 keepers fit for conductor size (O/D) 54.6 to 56.5 mm



2 keepers - Size code M



3 keepers - Size code MR

Size Code		Cond size "C" (mm)
2 Keepers	3 Keepers	
Large		
L445	LR445	42.6 to 44.5
L465	LR465	44.6 to 46.5
L485	LR485	46.6 to 48.5
L505	LR505	48.6 to 50.5
L525	LR525	50.6 to 52.5
L545	LR545	52.6 to 54.5
L565	LR565	54.6 to 56.5
L585	LR585	56.6 to 58.5
L605	LR605	58.6 to 60.5

Tee Connectors

Single Jumper Tee Connectors



FEATURES

- From 60 kV to 550 kV
- Up to 80 A/1 sec
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Jumper connections from the incoming overhead line or flexible busbar

BENEFITS

- 2 or 3 keepers versions (for calibers sizes Medium & Large)
- Corrosion resistant

5 CT 82 MR_ MR_

Caliber size
R = 3 keepers (optional)
C1 (main)

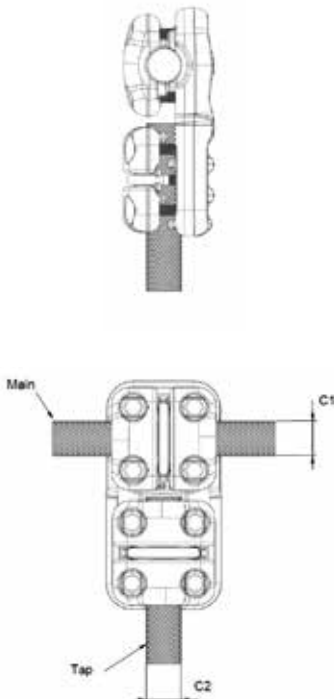
C 2 (tap)
R = 3 keepers (optional)
Caliber size

5 CT 82 M425 M325

Tee connector 2 keepers for main conductor 40.6 to 42.5 Dia and tap conductor 30.6 to 32.5 Dia

5 CT 82 MR325 MR305

Tee connector 3 keepers for main conductor 40.6 to 42.5 Dia and tap conductor 28.6 to 30.5 Dia



		Main Conductor "C1"		
Caliber Size S/M/L		Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
Tap Conductor "C2"	Small			
	15 to 32.5	•	•	○
	.5905 to 1.2795			
	Medium			
	28.6 to 42.5	•	•	•
	1.259 to 1.6732			
Large				
42.6 to 59	○	•	•	
1.6771 to 2.3228				
		•	Standard	
		○	Option	
Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.				

Tee Connectors

Twin Jumper Tee Connectors



FEATURES

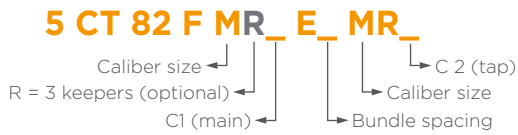
- From 132 kV to 550 kV
- Up to 80 kA/1 sec
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Jumper connections from the incoming overhead line or flexible busbar

BENEFITS

- 2 or 3 keepers versions (for caliber sizes Medium & Large)
- 6 bolts on tap conductor
- Corrosion resistant

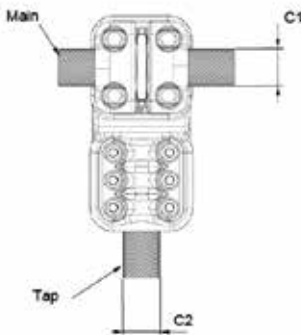
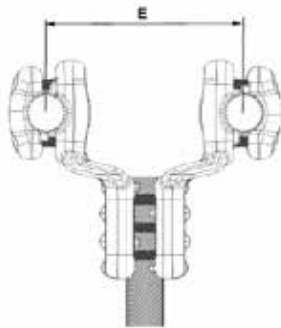


5 CT 82 F S285 E200 MR325

Tee connector for twin conductors bundle Dia 26.6 to 28.5 (2 keepers) spacing 200 mm to single conductor Dia 30.6 to 32.5 mm

5 CT 82 F MR325 E100 MR405

Tee connector with 3 keepers for twin conductors bundle Dia 30.6 to 32.5 spacing 100 mm to single conductor Dia 38.6 to 40.5 mm



		Tap Conductor "C1"		
Caliber Size S/M/L		Small	Medium	Large
Conductor Range Diameter	mm	15 to 32.5	28.6 to 42.5	42.6 to 59
	Inch	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
Tap Conductor "C2"	Small			
	15 to 32.5	•	•	◦
	.5905 to 1.2795			
	Medium			
	28.6 to 42.5	•	•	•
	1.259 to 1.6732			
Large				
42.6 to 59	◦	•	•	
1.6771 to 2.3228				

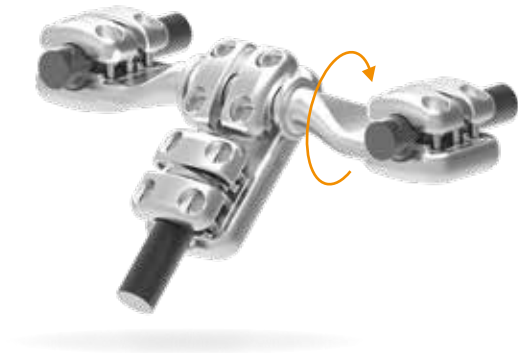
• Standard

◦ Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Adjustable Tee Connectors

Twin Adjustable Jumper Tee Connectors



FEATURES

- From 132 kV to 550 kV
- Up to 80 kA/1 sec
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Jumper connections from the incoming overhead line or flexible busbar

BENEFITS

- Fully adjustable angular between main and tap conductors
- 2 or 3 keepers versions (for caliber sizes Medium & Large)
- 3 keepers (optional) on tap conductor

5 CTA 82 F MR_ E_ MR_

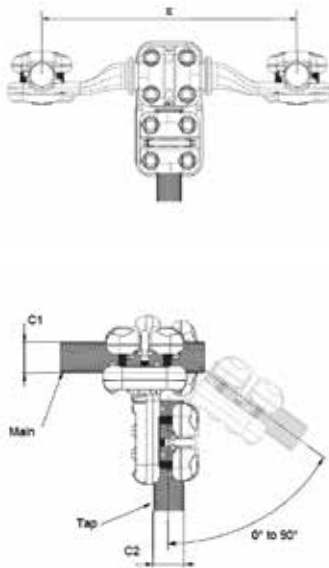


5 CTA 82 F S265 E400 MR325

Adjustable tee connector for twin conductors bundle Dia 24.6 to 26.5 spacing 400 mm to single conductor Dia 30.6 to 32.5 mm

5 CTA 82 F MR325 E450 MR405

Adjustable tee connector with 3 keepers for twin conductors bundle Dia 30.6 to 32.5 spacing 450 mm to single conductor Dia 38.6 to 40.5 mm



		Tap Conductor "C1"					
Caliber Size S/M/L		Small		Medium		Large	
Conductor Range Diameter	mm	15 to 32.5		28.6 to 42.5		42.6 to 59	
	Inch	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
Tap Conductor "C2"	Small						
	15 to 32.5	•	•	•	•	○	○
	.5905 to 1.2795						
	Medium						
	28.6 to 42.5	•	•	•	•	•	•
	1.259 to 1.6732						
Large							
42.6 to 59	○	○	•	•	○	○	
1.6771 to 2.3228							
		<ul style="list-style-type: none"> • Standard ○ Option 					
		Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.					

Parallel Groove Connectors

Parallel Groove Connector



FEATURES

- From 60 kV to 550 kV
- Up to 80 A/1 sec
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection to equipment (VT, SA...) from jumper conductors

BENEFITS

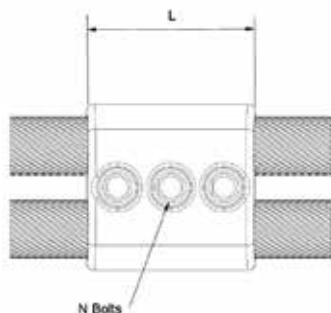
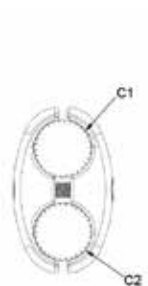
- Designed to carry out current capacity
- Corrosion resistant

5 CU 82 L M

Caliber size (C1) ← → Caliber size (C2)

5 CU 82 M S

Parallel groove connector for main conductor Dia 28.6 to 42.5 to tap conductor Dia 15 to 32.5



		Main Conductor "C1"		
Caliber Size S/M/L		Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
Tap Conductor "C2"	Small	L = 113 N = 3 x M10 Bolts •	L = 113 N = 3 x M10 Bolts ○	
	15 to 32.5			
	.5905 to 1.2795			
	Medium		L = 113 N = 3 x M10 Bolts •	L = 160 N = 4 x M12 Bolts ○
	28.6 to 42.5			
	1.259 to 1.6732			
Large			L = 160 N = 4 x M12 Bolts •	
42.6 to 59				
1.6771 to 2.3228				
		• Standard		
		○ Option		
Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.				





Chapter 3 Terminal Connectors

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Tee Connectors - Conductor(s) to Stud.....	50
Ajustable Connector - Duplex to Stud & Palm	52
Straight Connectors - Conductor(s) to Palm	54
90° Connector - Conductor(s) to Palm.....	56
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Straight Connectors Conductor to Stud

Straight Connectors for Single Conductor to Stud



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to stud terminal equipment

BENEFITS

- High mechanical strength
- Corrosion resistant 2 or 3 keepers version o conductor side
- Can be delivered with a bimetal sleeve (see page 76) for silver, copper or stainless steel material studs

5 CJ 82 MR M

Caliber size
R = 3 keepers (optional)
Conductor (C)

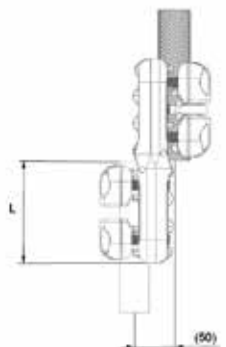
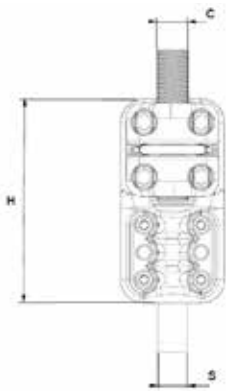
Stud (S)
Caliber size

5 CT 82 M425 M305

Straight connector for Al conductor 40.6 to 42.5 Dia (with 2 keepers) to stud 30 Dia

5 CT 82 LR525 M405

Straight connector for Al conductor 50.6 to 52.5 Dia (with 3 keepers) to stud 40 Dia



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
Stud (S x L)	20 x 80	• H = 165	• H = 187	◦ H = 225
	30 x 80	• H = 165	• H = 187	◦ H = 225
	30 x 104	• H = 187	• H = 209	• H = 249
	40 x 104	• H = 187	• H = 209	• H = 249
	50 x 125	◦ H = 225	• H = 239	• H = 275
	60 x 125	◦ H = 225	• H = 239	• H = 275
		• Standard		
		◦ Option		
Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.				

Straight Connectors Twin Conductors to Stud

Straight Connectors for Twin Conductors Bundle to Stud



FEATURES

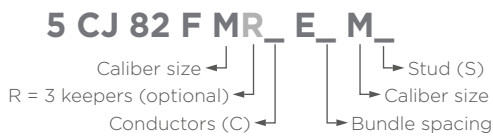
- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to stud terminal equipment

BENEFITS

- High mechanical strength
- Corrosion resistant 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal sleeve (see page 76) for silver, copper or stainless steel material studs



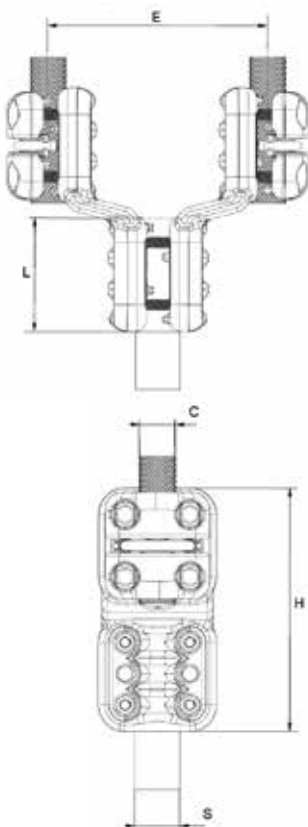
5 CT 82 F S305 E100 M305

Straight connector for twin Al conductor 28.6 to 30.5 Dia (with 2 keepers) spacing 100 mm to stud 30 Dia

5 CT 82 F LR525 E200 M405

Straight connector for twin Al conductor 50.6 to 52.5 Dia (with 3 keepers) spacing 200 mm to stud 40 Dia

Chapter 3



Caliber Size	S/M/L	Small		Medium		Large	
Conductor Range Diameter	C (mm)	15 to 32.5		28.6 to 42.5		42.6 to 59	
	C (Inch)	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
E	(mm)	100	200	100	200	100	200
Stud (S x L)	20 x 80	• H = 165	• H = 177	• H = 187	• H = 200	◦ H = 225	◦ H = 220
	30 x 80	• H = 165	• H = 177	• H = 187	• H = 200	◦ H = 225	◦ H = 220
	30 x 104	• H = 187	• H = 200	• H = 209	• H = 219	• H = 249	• H = 245
	40 x 104	• H = 187	• H = 200	• H = 209	• H = 219	• H = 249	• H = 245
	50 x 125	◦ H = 225	◦ H = 220	• H = 239	• H = 245	• H = 275	• H = 265
	60 x 125	◦ H = 225	◦ H = 220	• H = 239	• H = 245	• H = 275	• H = 265

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Tee Connectors Conductor to Stud

Tee Connectors for Single Conductor to Stud



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to stud terminal equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal sleeve (see page 76) for silver, copper or stainless steel material studs

5 CJ 82 MR M

Caliber size →
R = 3 keepers (optional) →
Conductor (C) →

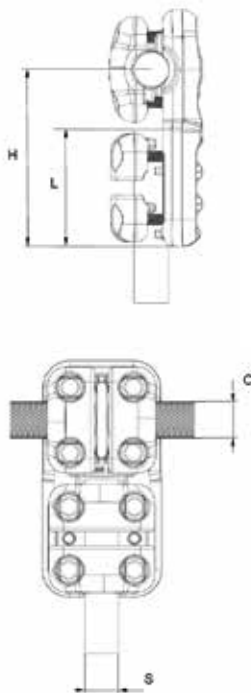
Stud (S) →
Caliber size →

5 CT 82 M425 M305

Tee connector for Al conductor 40.6 to 42.5 Dia (with 2 keepers) to vertical stud 30 Dia

5 CT 82 LR525 M405

Tee connector for Al conductor 50.6 to 52.5 Dia (with 3 keepers) to vertical stud 40 Dia



Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
Stud (S x L)	20 x 80	• H = 130	• H = 135	◦ H = 145
	30 x 80	• H = 130	• H = 135	◦ H = 145
	30 x 104	• H = 152	• H = 157	• H = 172
	40 x 104	• H = 152	• H = 157	• H = 172
	50 x 125	◦ H = 177	• H = 182	• H = 192
	60 x 125	◦ H = 177	• H = 182	• H = 192
		• Standard		
		◦ Option		
Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.				

Tee Connectors Twin Conductors to Stud

Tee Connectors for Twin Conductors Bundle to Stud



FEATURES

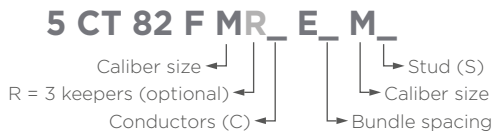
- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Stud terminal equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal sleeve (see page 76) for silver, copper or stainless steel material studs

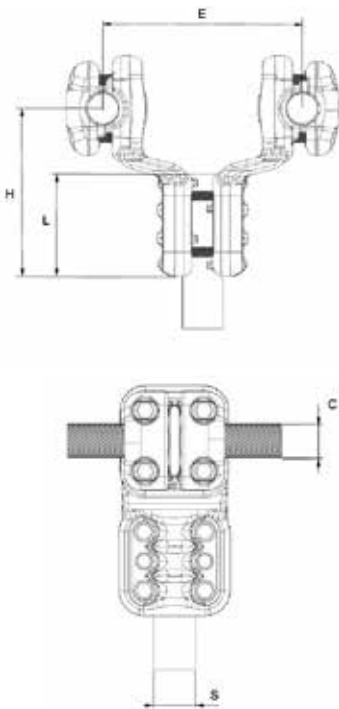


5 CT 82 F M425 E100 M305

Tee connector for twin Al conductors 40.6 to 42.5 Dia (with 2 keepers) spacing 100 mm to vertical stud 30 Dia

5 CT 82 F LR525 E200 M405

Tee connector for twin Al conductors 50.6 to 52.5 Dia (with 3 keepers) spacing 200 mm to vertical stud 40 Dia

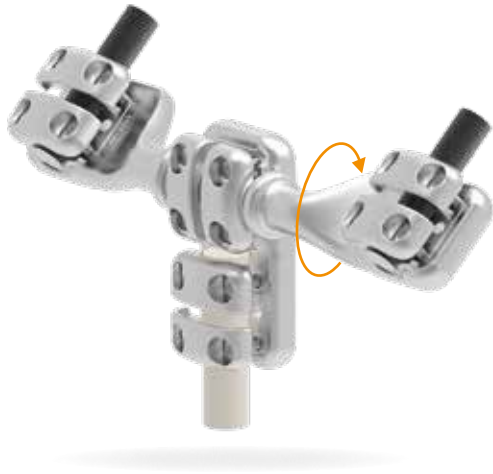


Caliber Size	S/M/L	Small		Medium		Large	
Conductor Range Diameter	C (mm)	15 to 32.5		28.6 to 42.5		42.6 to 59	
	C (Inch)	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
E	(mm)	100	200	100	200	100	200
Stud (S x L)	20 x 80	• H = 137	• H = 137	• H = 143	• H = 143	◦ H = 160	◦ H = 160
	30 x 80	• H = 137	• H = 137	• H = 143	• H = 143	◦ H = 160	◦ H = 160
	30 x 104	• H = 162	• H = 162	• H = 157	• H = 167	• H = 180	• H = 180
	40 x 104	• H = 162	• H = 162	• H = 157	• H = 167	• H = 180	• H = 180
	50 x 125	◦ H = 187	◦ H = 187	• H = 192	• H = 192	• H = 202	• H = 202
	60 x 125	◦ H = 187	◦ H = 187	• H = 192	• H = 192	• H = 202	• H = 202

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Adjustable Connectors for Twin Conductors to Stud

Adjustable Connectors for Twin Conductors to Stud



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

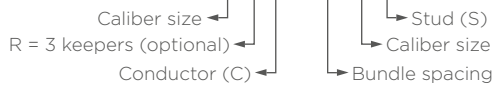
APPLICATIONS

- Connection of Al conductors to stud terminal equipment
- Short flexible connections to HV equipment
- Seismic applications with "wave" flexible connections design

BENEFITS

- Fully adjustable angular between conductors bundle and stud
- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal sleeve (see page 76) for silver, copper or stainless steel stud's material

5 CTA 82 F MR E M

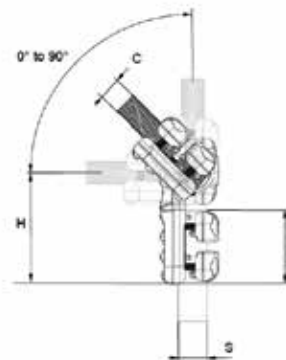
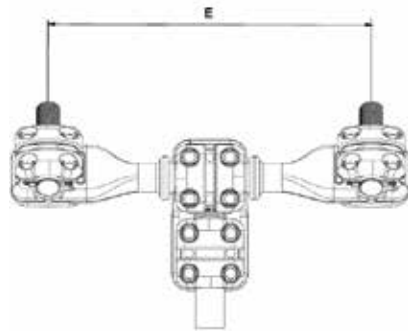


5 CTA 82 F S285 E200 M305

Adjustable connector for twin Al conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 200 mm to stud 30 Dia

5 CTA 82 F MR425 E100 M405

Adjustable connector for twin Al conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 100 mm to stud 40 Dia

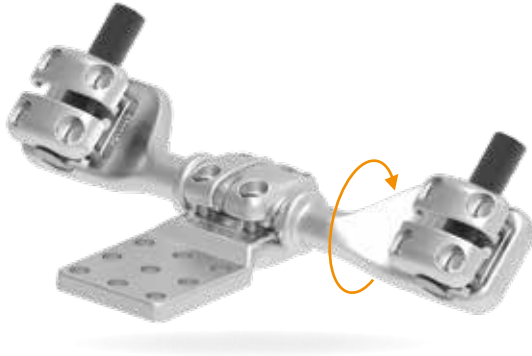


Caliber Size	S/M/L	Small			Medium			Large		
Conductor Range Diameter	C (mm)	15 to 32.5			28.6 to 42.5			42.6 to 59		
	C (Inch)	.5905 to 1.2795			1.259 to 1.6732			1.6771 to 2.3228		
E	(mm)	200	400	450	200	400	450	200	400	450
Stud (S x L)	20 x 80	• H = 130	• H = 130	• H = 130	• H = 135	• H = 135	○ H = 135	○ H = 145	○ H = 145	○ H = 145
	30 x 80	• H = 130	• H = 130	• H = 130	• H = 135	• H = 135	○ H = 135	○ H = 145	○ H = 145	○ H = 145
	30 x 104	• H = 152	• H = 152	• H = 152	• H = 157	• H = 157	○ H = 157	○ H = 167	• H = 172	○ H = 172
	40 x 104	• H = 152	• H = 152	• H = 152	• H = 157	• H = 157	○ H = 157	○ H = 167	• H = 172	○ H = 172
	50 x 125	○ H = 177	○ H = 177	○ H = 177	• H = 182	• H = 182	○ H = 182	○ H = 192	• H = 192	○ H = 192
	60 x 125	○ H = 177	○ H = 177	○ H = 177	• H = 182	• H = 182	○ H = 182	○ H = 192	• H = 192	○ H = 192

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Adjustable Connectors for Twin Conductors to Flat Palm

Adjustable Connectors for Twin Conductors to Flat Terminal



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to stud terminal equipment
- Short flexible connections to HV equipment
- Seismic applications with "wave" flexible connections design

BENEFITS

- Fully adjustable angular between conductors bundle and flat palm
- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 76) for silver, copper or stainless steel terminal's material

5 PDA 82 F MR E X C

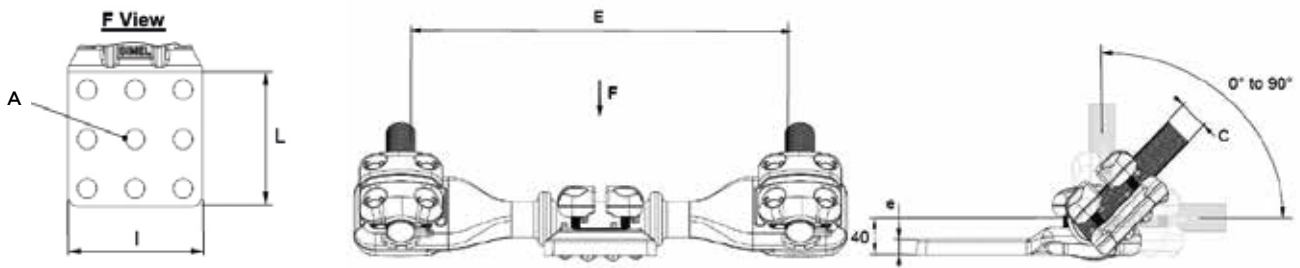
Caliber size
R = 3 keepers (optional)
Conductors (C)
E
Palm size
Bundle spacing
X
Drilling code

5 PDA 82 F S285 E200 100 C290

Adjustable terminal for twin Al conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 200 mm to flat palm 100 x 100 NEMA drilling

5 PDA 82 F MR425 E400 100x200

Adjustable terminal for twin Al conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 400 mm to flat palm 100 x 200 without drilling



A = Drilling of the palm see page 60

Caliber Size	S/M/L	Small			Medium			Large		
		C (mm)	C (Inch)	E	C (mm)	C (Inch)	E	C (mm)	C (Inch)	E
Conductor Range Diameter	C (mm)	15 to 32.5			28.6 to 42.5			42.6 to 59		
	C (Inch)	.5905 to 1.2795			1.259 to 1.6732			1.6771 to 2.3228		
E	(mm)	200	400	450	200	400	450	200	400	450
Stud (S x L)	80 x 80 x 16	•	•	•	•	•	○	○	•	○
	100 x 100 x 16	•	•	•	•	•	○	○	•	○
	125 x 125 x 16	•	•	•	•	•	○	○	•	○
	100 x 200 x 16	•	•	•	•	•	○	○	•	○

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Straight Connectors for Conductor to Flat Palm

Straight Terminal Connectors for Single Conductor to Flat Palm



FEATURES

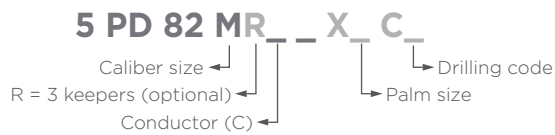
- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to flat terminal equipment
- Flexible connections between equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 76) for silver, copper or stainless steel terminal's material

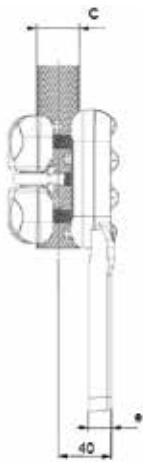


5 PD 82 S265 100 C257

Straight terminal connector for Al conductor 24.6 to 26.5 Dia (with 2 keepers) to flat palm 100 x 100 IEC drilling

5 PD 82 MR425 100x200

Straight terminal connector for Al conductor 40.6 to 42.5 Dia (with 3 keepers) to flat palm 100 x 200 without drilling

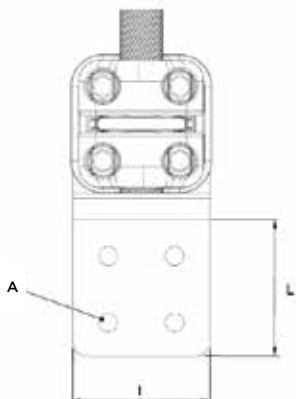


Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
e	(mm)	12	16	16
Palm (L x l)	80 x 80	•	•	•
	100 x 100	•	•	•
	125 x 125	•	•	•
	100 x 200	•	•	•

• Standard

◦ Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



A = Drilling of the palm see page 60

Straight Connectors for Twin Conductors to Flat Palm

Straight Connectors for Twin Conductors to Flat Terminal



FEATURES

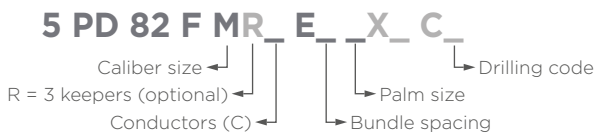
- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of twin Al conductors to flat terminal equipment
- Flexible connections between HV equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 72) for silver, copper or stainless steel terminal's material

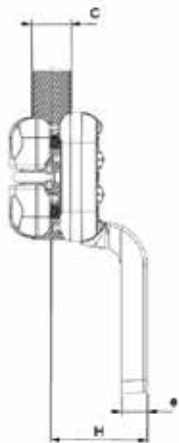


5 PD 82 F S285 E200 100 C290

Straight terminal connector for twin Al conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 200 mm to flat palm 100 x 100 NEMA drilling

5 PD 82 F MR425 E100 100x200

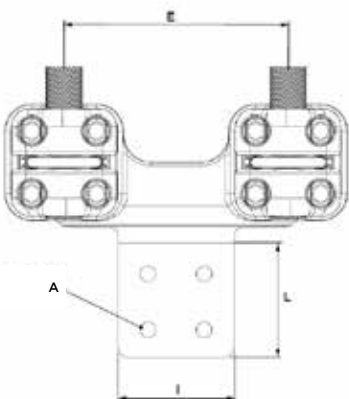
Straight terminal connector for twin Al conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 100 mm to flat palm 100 x 200 without drilling



Caliber Size	S/M/L	Small		Medium		Large	
Conductor Range Diameter	C (mm)	15 to 32.5		28.6 to 42.5		42.6 to 59	
	C (Inch)	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
E	(mm)	100	200	100	200	120	200
H	(mm)	40	80	40	80	40	80
e	(mm)	16		20		25	
Stud (S x L)	80 x 80	•	•	•	•	○	•
	100 x 100	•	•	•	•	○	•
	125 x 125	•	•	•	•	○	•
	100 x 200	•	•	•	•	○	•

- Standard
- Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



A = Drilling of the palm see page 60

90° Connectors for Conductor to Flat Palm

Square Type Terminal Connectors for Single Conductor to Flat Palm



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to flat terminal equipment
- Flexible connections between equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 72) for silver, copper or stainless steel terminal's material

5 PE 82 MR **X** **C**

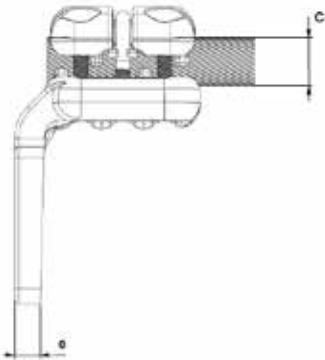
Caliber size
R = 3 keepers (optional)
Conductor (C)
Palm size
Drilling code

5 PE 82 S265 100 C257

90° terminal connector for Al conductor 24.6 to 26.5 Dia (with 2 keepers) to flat palm 100 x 100 IEC drilling

5 PE 82 MR425 100x200

90° terminal connector for Al conductor 40.6 to 42.5 Dia (with 3 keepers) to flat palm 100 x 200 without drilling

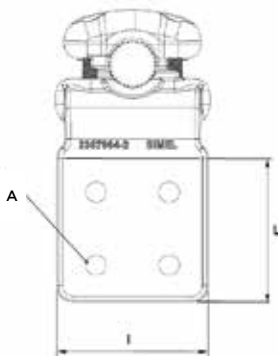


Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
e	(mm)	12	16	16
Palm (L x l)	80 x 80	•	•	•
	100 x 100	•	•	•
	125 x 125	•	•	•
	100 x 200	•	•	•

• Standard

○ Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



A = Drilling of the palm see page 60

90° Connectors for Twin Conductors to Flat Palm

Square Type Connectors for Twin Conductors to Flat Terminal



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of twin Al conductors to flat terminal equipment
- Flexible connections between HV equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 72) for silver, copper or stainless steel terminal's material

5 PE 82 F MR E X C

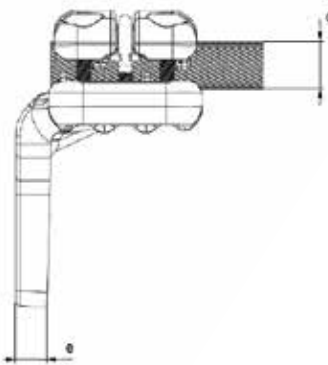
Caliber size
 R = 3 keepers (optional)
 Conductors (C)
 Palm size
 Bundle spacing
 Drilling code

5 PE 82 F S285 E200 100 C290

90° terminal connector for twin Al conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 200 mm to flat palm 100 x 100 NEMA drilling

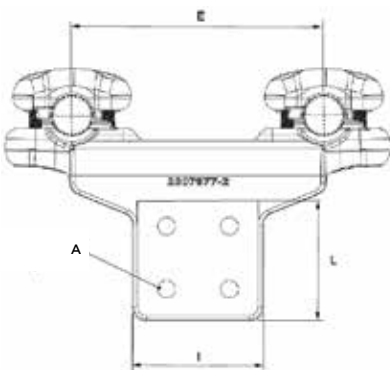
5 PE 82 F MR425 E100 100x200

90° terminal connector for twin Al conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 100 mm to flat palm 100 x 200 without drilling



Caliber Size	S/M/L	Small		Medium		Large	
Conductor Range Diameter	C (mm)	15 to 32.5		28.6 to 42.5		42.6 to 59	
	C (Inch)	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
E	(mm)	100	200	100	200	120	200
e	(mm)	16		20		25	
Palm (L x l)	80 x 80	•	•	•	•	•	•
	100 x 100	•	•	•	•	•	•
	125 x 125	•	•	•	•	•	•
	100 x 200	•	•	•	•	•	•

- Standard
 - o Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



A = Drilling of the palm see page 60

Flag Type Connectors for Conductor to Flat Palm

Flag Type Terminal Connectors for Single Conductor
to Flat Palm



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to flat terminal equipment (ie: SA, CVT)
- Connection for non-supported termination

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 72) for silver, copper or stainless steel terminal's material

5 PF 82 MR X C

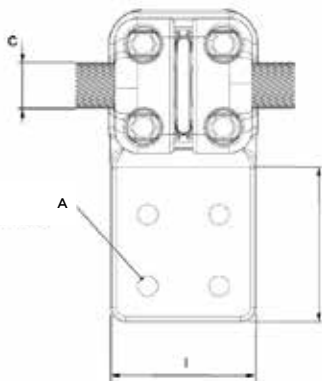
Caliber size
R = 3 keepers (optional)
Conductor (C)
Palm size
Drilling code

5 PF 82 S285 100 C257

Flag type terminal connector for Al conductor 26.6 to 28.5 Dia (with 2 keepers) to flat palm 100 x 100 IEC drilling

5 PE 82 MR425 80

Flag type terminal connector for Al conductor 40.6 to 42.5 Dia (with 3 keepers) to flat palm 80 x 80 without drilling



A = Drilling of the palm see page 60

Caliber Size	S/M/L	Small	Medium	Large
Conductor Range Diameter	C (mm)	15 to 32.5	28.6 to 42.5	42.6 to 59
	C (Inch)	.5905 to 1.2795	1.259 to 1.6732	1.6771 to 2.3228
e	(mm)	12	16	16
Palm (L x I)	80 x 80	•	•	•
	100 x 100	•	•	•
	125 x 125	o	o	o
	100 x 200	o	o	o

• Standard

o Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



Flag Type Connectors for Twin Conductors to Flat Palm

Flag Type Connectors for Twin Conductors to Flat Terminal



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Connection of Al conductors to flat terminal equipment (ie: SA, CVT)
- Connection for non-supported termination

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be delivered with a bimetal plate (see page 72) for silver, copper or stainless steel terminal's material

5 PF 82 F MR E X C

Caliber size
R = 3 keepers (optional)
Conductors (C)
E
Palm size
Bundle spacing
X
Drilling code

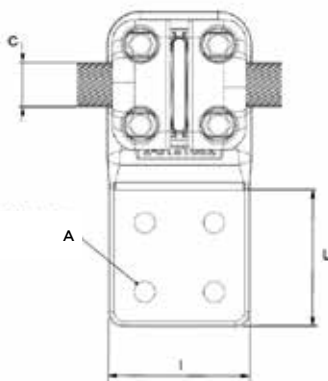
5 PF 82 F S285 E100 100 C290

Flag type terminal connector for twin Al conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 100 mm to flat palm 100 x 100 NEMA drilling

5 PF 82 F MR425 E200 100 C257

Flag type terminal connector for twin Al conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 200 mm to flat palm 100 x 100 IEC drilling

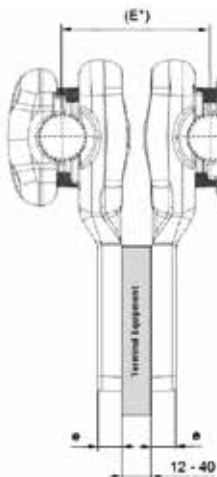
Chapter 3



A = Drilling of the palm see page 60

Caliber Size	S/M/L	Small		Medium		Large	
Conductor Range Diameter	C (mm)	15 to 32.5		28.6 to 42.5		42.6 to 59	
	C (Inch)	.5905 to 1.2795		1.259 to 1.6732		1.6771 to 2.3228	
E*	(mm)	100	200	100	200	120	200
e	(mm)	16		16		16	
Palm (L x I)	80 x 80	•	•	•	•	•	•
	100 x 100	•	•	•	•	•	•
	125 x 125	o	o	o	o	o	o
	100 x 200	o	o	o	o	o	o

- Standard
 - o Option
 - * Spacing (E) is given for indication as it depends on the thickness of the terminal equipment.
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

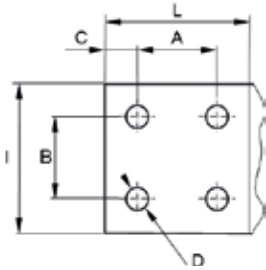


Standard Drillings of Palms

Dimensional Standards of Bolt Holes for Terminal Connectors

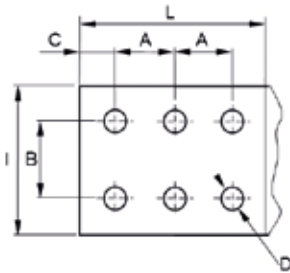
Tee connectors
Bolted fixed tee busbar connectors

4 holes standard palms

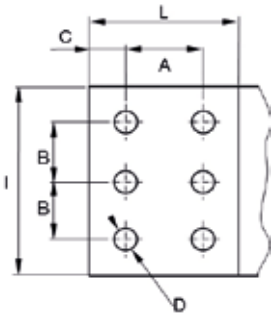


Standard	Drilling code	L (mm)	I (mm)	A (mm)	B (mm)	C (mm)	D (mm)
IEC	C21	80	80	40	40	20	14.5
NEMA	C294	80 (3")	80 (3")	44.4 (1.75")	44.4 (1.75")	15.3 (0.6")	14.3 (0.56")
DIN	C35	80	80	50	50	15	14.5
French	C124 (PL4)	80	80	45	45	16.5	16
IEC	C336	100	100	40	40	30	14.5
NEMA	C290	100 (4")	100 (4")	44.4 (1.75")	44.4 (1.75")	27.8 (1.1")	14.3 (0.56")
DIN	C257	100	100	50	50	25	14.5

6 holes standard palms



Standard	Drilling code	L (mm)	I (mm)	A (mm)	B (mm)	C (mm)	D (mm)
French	R11 (PL6)	125	80	45	45	16.5	16
IEC	R168	125	80	40	40	22.5	14.5

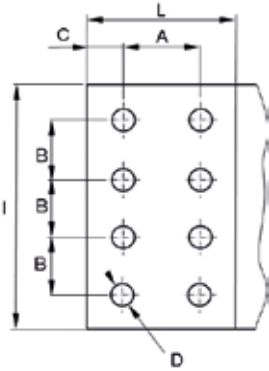


Standard	Drilling Code	L (mm)	I (mm)	A (mm)	B (mm)	C (mm)	D (mm)
IEC	R284	100	125	40	40	30	14.5
NEMA	R285	100 (4")	125 (5")	44.4 (1.75")	44.4 (1.75")	27.8 (1.1")	14.3 (0.56")

Standard Drillings of Palms

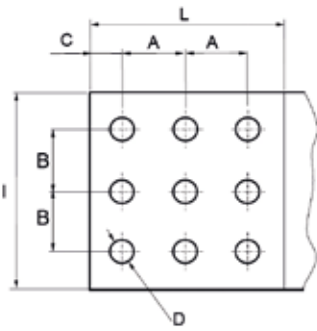
Dimensional Standards of Bolt Holes for Terminal Connectors

8 holes standard palms



Standard	Drilling code	L (mm)	I (mm)	A (mm)	B (mm)	C (mm)	D (mm)
DIN	R90	100	200	50	50	25	14.5

9 holes standard palms



Standard	Drilling code	L (mm)	I (mm)	A (mm)	B (mm)	C (mm)	D (mm)
IEC	C258	125	125	40	40	22.5	14.5
French 1	C41 (PL9)	125	125	45	45	16.5	16
French 2	C292	125	125	45	45	16.5	14

For any other requirement please contact us





Chapter 4

Tube to Conductor(s) Connectors

- Straight Connectors - Tube to Conductor(s) 64
- Tee Connectors - Tube to Conductor(s) 66
- Parallel Connectors - Tube to Conductor(s)..... 68

Straight Connectors Tube to Single Conductor

Straight Connectors for Tubular Busbar to Single Conductor



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

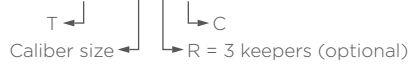
APPLICATIONS

- Flexible connection to rigid busbar

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side

5 MJ 82 T_ MR_

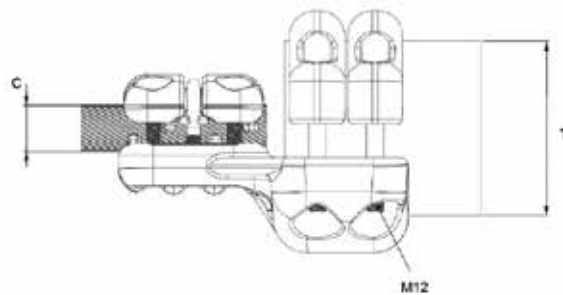


5 MJ 82 T80 S285

Straight connector for Al busbar 80 Dia to conductor 26.6 to 28.5 Dia (with 2 keepers)

5 MJ 82 T120 MR425

Straight connector for Al busbar 120 Dia to conductor 40.6 to 42.5 Dia (with 3 keepers)



Busbar "T"	Metric	80	90	100	120	125	140	150	160	200	220	250				
	IPS	3"	3 1/2"	5"	6"	6"	6"	6"	6"	6"	6"	6"				
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250
Conductor "C"	Small															
	15 to 32.5 (mm)	•	○	○	○	○	•				○	○				
	.5905 to 1.2795 (In)															
	Medium															
	28.6 to 42.5 (mm)	•	○	○	•	○	•	○	○	○	○	○	•	○	○	
	1.259 to 1.6732 (In)															
Large																
42.6 to 59 (mm)	○	○	○	•	○	○										
1.6771 to 2.3228 (In)																

- Standard
- Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Straight Connectors Tube to Twin Conductors

Straight Connectors for Tubular Busbar to Twin Conductors Bundle



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connection to rigid busbar
- Busbar couplers

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side

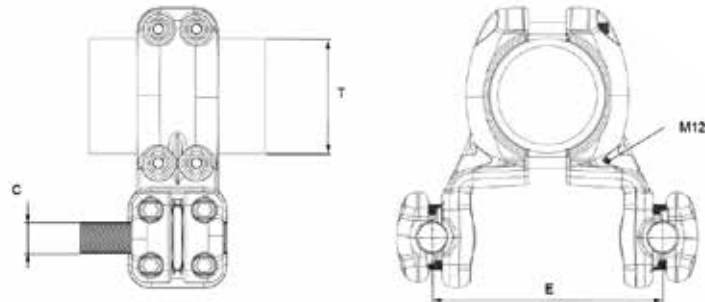
5 MJ 82 A T_ MR_ E_
 T ← Bundle spacing
 Caliber size ← C
 R = 3 keepers (optional) ←

5 MJ 82 A T80 S285 E100

Parallel connector for Al busbar 80 Dia to twin conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 100 mm

5 MJ 82 A T120 MR425 E200

Parallel connector for Al busbar 120 Dia to twin conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 200 mm



Busbar "T"	Metric																
	IPS	80	3"	90	100	3 ^{1/2}	120	125	140	5"	150	160	6"	200	220	250	
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250	
Conductor "C"	Small	E (mm)															
	15 to 32.5 (mm)	100	○		○		○										
	.5905 to 1.2795 (In)	200	○														
	Medium	E (mm)															
	28.6 to 42.5 (mm)	100	●			●		●				○			●		●
	1.259 to 1.6732 (In)	200	●			●		●		○			●		●		●
	Large	E (mm)															
42.6 to 59 (mm)	100						●				○	●					
1.6771 to 2.3228 (In)	200				●		●				○	●		○		○	

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



Possible arrangement for larger spacing

Tee Connectors Tube to Single Conductor

Tee Connectors for Tubular Busbar to Single Conductor



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

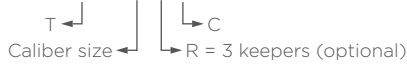
APPLICATIONS

- Flexible connection to rigid busbar
- Jumper connections

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side

5 MT 82 T_ MR_

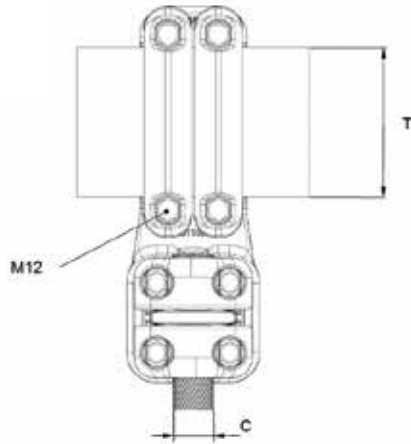


5 MT 82 T80 S285

Tee connector for Al busbar 80 Dia to conductor 26.6 to 28.5 Dia (with 2 keepers)

5 MT 82 T120 MR425

Tee connector for Al busbar 120 Dia to conductor 40.6 to 42.5 Dia (with 3 keepers)



Busbar "T"	Metric	80	90	100	120	125	140	150	160	200	220	250					
	IPS	3"	3 1/2"	4"	5"	5 1/8"	5 1/2"	6"	6 3/8"	8"	9"	10"					
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250	
Conductor "C"	Small																
	15 to 32.5 (mm)	•	○	○	○	○	•				○	○					
	.5905 to 1.2795 (In)																
	Medium																
	28.6 to 42.5 (mm)	•	○	○	•	○	•	○	○	○	○	•	○	○			
	1.259 to 1.6732 (In)																
Large																	
	42.6 to 59 (mm)	○	○	○	•	○	○										
	1.6771 to 2.3228 (In)																

- Standard
- Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Tee Connectors Tube to Twin Conductors

Tee Connectors for Tubular Busbar to Twin Conductors Bundle



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Jumper connection to rigid busbar
- Busbar coupler

BENEFITS

- High mechanical strength and corrosion resistant
- Only one type of connector for coupling two busbars
- 2 or 3 keepers version on conductor side

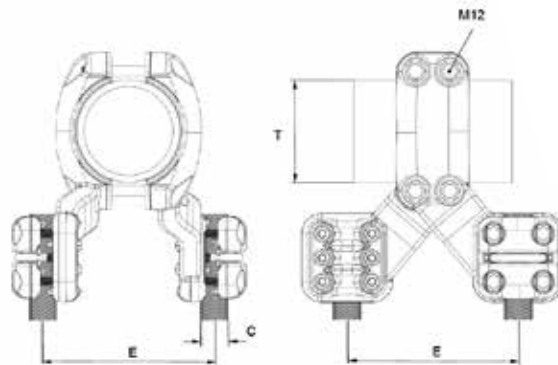
5 MT 82 A T MR E
 T ← Caliber size
 R = 3 keepers (optional) ←
 C ← Bundle spacing

5 MT 82 A T80 S285 E100

Tee connector for Al busbar 80 Dia to twin conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 100 mm

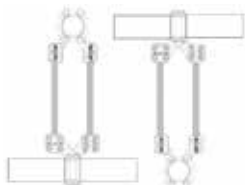
5 MT 82 A T120 MR425 E200

Parallel connector for Al busbar 120 Dia to twin conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 200 mm



Busbar "T"	Metric	80	90	100	120	125	140	150	160	200	220	250				
	IPS	3"	3 1/2"	5"	6"	6"	6"	6"	6"	6"	6"	6"				
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250
Conductor "C"	Small	E (mm)														
	15 to 32.5 (mm)	100	○		○	○										
	.5905 to 1.2795 (In)	200	○													
	Medium	E (mm)														
	28.6 to 42.5 (mm)	100	●		●	●		○			●		●		●	
	1.259 to 1.6732 (In)	200	●		●	●		○		●		●		●		●
Large	E (mm)															
42.6 to 59 (mm)	100				●	●		○	●							
1.6771 to 2.3228 (In)	200				●	●		○	●				○			○

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



Bus coupling arrangement
With one connector type

Parallel Connectors Tube to Single Conductor

Parallel Connectors for Tubular Busbar to Single Conductor



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

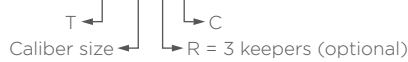
APPLICATIONS

- Flexible derivation from rigid busbar
- Connection to HV equipment

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be used as a straight joint with crossing conductor

5 MU 82 T_ MR_

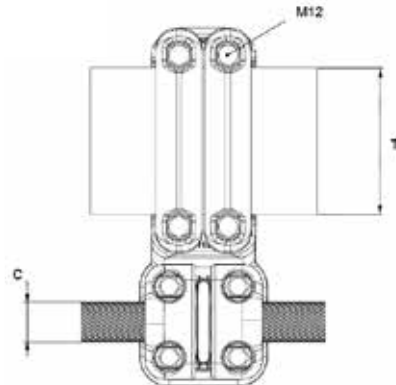


5 MU 82 T80 S285

Parallel connector for Al busbar 80 Dia to conductor 26.6 to 28.5 Dia (with 2 keepers)

5 MU 82 T120 MR425

Parallel connector for Al busbar 120 Dia to conductor 40.6 to 42.5 Dia (with 3 keepers)



Busbar "T"	Metric	80	90	100	120	125	140	150	160	200	220	250				
	IPS	3"			3" ^{1/2}		5"		6"							
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250
Conductor "C"	Small															
	15 to 32.5 (mm)	○			○											
	.5905 to 1.2795 (In)															
	Medium															
	28.6 to 42.5 (mm)	●	○	○	●	○	●	○		●	●		●			●
	1.259 to 1.6732 (In)															
Large																
42.6 to 59 (mm)					○		○									
1.6771 to 2.3228 (In)																

- Standard
- Option

Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.

Parallel Connectors Tube to Twin Conductors

Parallel Connectors for Tubular Busbar to Twin Conductors Bundle



FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connection to rigid busbar
- Busbar couplers

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Can be used as a straight joint with crossing conductors

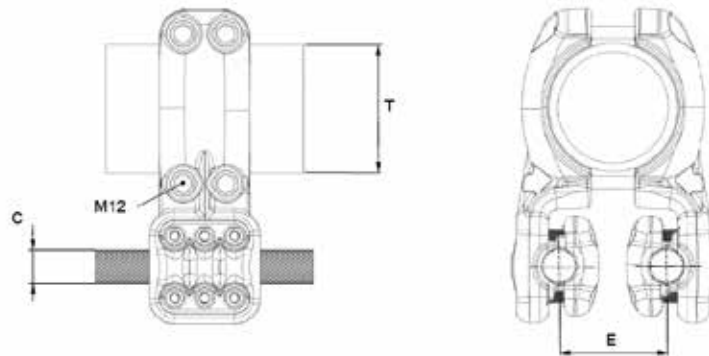
5 MU 82 A T_ MR_ E_
 T → Caliber size
 R = 3 keepers (optional)
 C → Bundle spacing

5 MU 82 A T80 S285 E100

Parallel connector for Al busbar 80 Dia to twin conductors 26.6 to 28.5 Dia (with 2 keepers) spacing 100 mm

5 MU 82 A T120 MR425 E200

Parallel connector for Al busbar 120 Dia to twin conductors 40.6 to 42.5 Dia (with 3 keepers) spacing 200 mm



Busbar "T"	Metric	80	90	100	120	125	140	150	160	200	220	250				
	IPS	3"	3"	3 ^{11/16}	4 1/2"	5"	5 1/2"	6"	6 1/2"	8"	9"	10"				
	T (mm)	80	88.9	90	100	101.6	120	125	140	141.3	150	160	168.2	200	220	250
Conductor "C"	Small	E (mm)														
	15 to 32.5 (mm)	100	○		○	○										
	.5905 to 1.2795 (In)	200	○													
	Medium	E (mm)														
	28.6 to 42.5 (mm)	100	●		●	●		○		●		●		●		●
	1.259 to 1.6732 (In)	200	●		●	●		○		●		●		●		●
	Large	E (mm)														
42.6 to 59 (mm)	100					●		○	●							
1.6771 to 2.3228 (In)	200				●	●		○	●		○		○		○	

- Standard
 - Option
- Conductor size is obtained by machining from Small, Medium and Large in reference to the page 38.



Possible arrangement for larger spacing





Chapter 5 Special Connectors

Special Connectors (Triplex, Quad...).....72

Modular Connectors for Make to Order Projects

TE's SIMAFLEX connector products range is based on a modular concept which allows multiple complex connectivity solutions to Extra and Ultra High Voltage switchyards applications whatever the conductors bundle is designed with twin, triplex or quad conductors configurations.

Angular adjustment of the conductors bundle can be proposed to offer great flexibility during the installation where the conductors bus is rigid and must connect HV equipment on short distances. Adjustable connectors are also recommended to create "wave" design of flexible connections between HV equipment for switchyards submitted to seismic conditions.

The connector's examples here are shown for giving potential capabilities of TE's SIMAFLEX connectors. Please send us your request for quotation that will enable us to propose the products fit for each specific project.

Special Connectors for Twin Triplex and Quad Bundles

Terminal Connectors for Triplex or Quad Conductors Bundles



Adjustable quad terminal connector to vertical stud

FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connections for EHV and UHV applications
- UHV-DC connections for HVDC converters

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Adjustable connections for short connections and anti-seismic
- "Wave design" connections



Triplex straight terminal connector to stud



Adjustable twin tee jumper connector



Quad tee terminal connector to vertical stud

Special Connectors for Twin Triplex and Quad Bundles

Terminal Connectors for Triplex or Quad Conductors Bundles



Quad flag type terminal connector

FEATURES

- From 60 kV to 550 kV
- EN & NEMA compliant
- Aluminium alloy & stainless steel fasteners

APPLICATIONS

- Flexible connections for EHV and UHV applications
- UHV-DC connections for HVDC converters

BENEFITS

- High mechanical strength
- Corrosion resistant
- 2 or 3 keepers version on conductor side
- Adjustable connections for short connections and anti-seismic
- "Wave design" connections



Adjustable quad terminal connector to flat palm



Triplex terminal connector to flat palm



Quad terminal connector to flat palm





Chapter 6 Fasteners

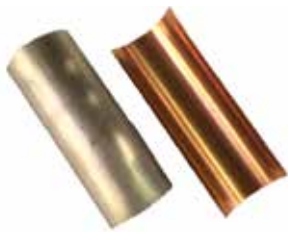
Bimetallic Plates & Sleeves..... 76
Fixing Bolts.....77

Bimetallic Plates & Sleeves

Aluminum-Copper/Bimetallic Strip Plates and Sleeves



Bimetallic plates



Bimetallic sleeves

FEATURES

- From 60 kV to 550 kV
- IEC; NEMA & NF drilling compliant
- Aluminum (99.5%) & copper

APPLICATIONS

- Corrosive atmospheres
- Bimetallic terminal connection
- Recommended for connection of aluminum connector terminal to: Copper/Al - Silver plate/Al - Stainless steel

BENEFITS

- Easy to install
- Cancel galvanic corrosion
- High conductivity material
- Multi drilling standard plates (4 slots)
- Composite material (Al/Co) obtained by roll cladding
- Corrosion resistant

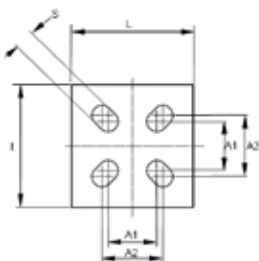
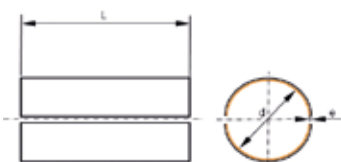


Plate Size (L x l) (mm)	80 x 80	100 x 100	125 x 125
A1	40	40	60
A2	50	50	70
S	16.5	16.5	16.5
e	2	2	2



Stud Dia (d) (mm)	30	40	40	50	60
L	90	90	100	100	100
e	1	1	1	1	1

Fixing Bolts

HDG Steel and Stainless Steel / Kits of Fixing Bolts



FEATURES

- Kits of 4 bolts or screws
- Stainless steel or hot dip galvanized steel
- Metric sizes from M8 to M16

APPLICATIONS

- Terminal connection to high voltage equipments
- Fixing of busbar clamps and connectors to PI

BENEFITS

- Ready to install kits of 4 bolts
- Flat washers and nut included
- Pre-defined lengths to cover any applications (see below table)

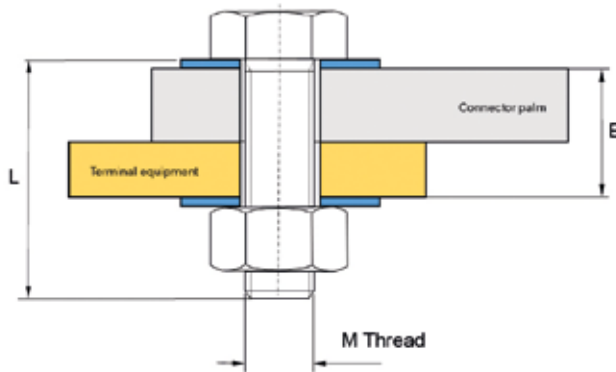


Fig 1
Terminal connector fixing

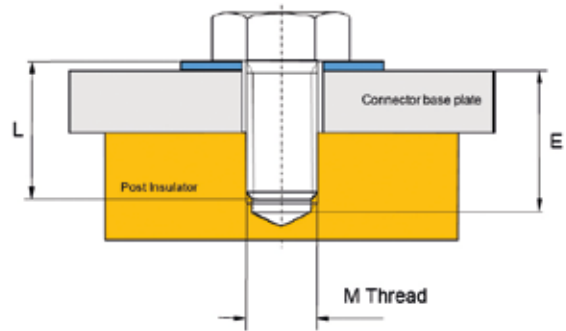


Fig 2
Bus support fixing

Bolt Size	Thread	M8			M10					M12		M14		M16			
	L (mm)	40	50	60	25	40	60	70	80	80	80	60	80	30	60	70	90
Figure	Fig N°	Fig1	Fig1	Fig1	Fig2	Fig1	Fig1	Fig1	Fig1	Fig1	Fig1	Fig1	Fig2	Fig1	Fig1	Fig1	Fig1
E Mini	(mm)	12	16	36	10	12	23	43	53	20	41	16	20	38	38		
E Maxi	(mm)	30	36	46	22	23	43	53	63	41	61	27	38	48	68		
Material	* SS/HDG	SS	SS	SS	HDG	SS	SS	SS	SS	SS	SS	HDG	SS	HDG	SS		

* SS = Stainless Steel bolts
HDG = Hot Dip Galvanized steel bolts

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