General Features

A current carrying clamp can only satisfactorily serve the function that it is designed for, which is the transferral of current flow from one busbar to another, by the optimum design of the contact surface areas coupled with the contact pressure exerted through the clamping covers and their associated clamping systems. Intensive research both in South Africa and in Europe, has resulted in the design of the clamps detailed in this section, such clamps being designed for use at 765kV and capable of carrying current loads in excess of 3 500 amps on a continuous basis. The clamps as shown comply with the requirements of the West German specification number VDE. 0220 and the Eskom (SA) specification number NWS1671. General features of these clamps are:

1. The Compression Tube

The SABS report number 771/8322/R46, "Testing of Line Clamps" clearly shows the best method of making electrical connections to multi-layer aluminium conductor to be the compression technique. In fact, the SABS experiments yielded the following mean percentage increase in voltage drops over the entire aging test carried out on a variety of different current carrying clamps.

Compression Tube	40.80%
Three bolted clamping covers	48.50%
Explosive wedge compression	75.63%
Single bolted clamping cover	182.60%

The compression tube incorporated in bolted compression clamps is specially produced for this application. It is precisely dimensioned in accordance with the "compression efficiency formula" resulting from years of research in Europe. To ensure correct installation, it is indelibly marked with the appropriate conductor size, the crimping die reference number and the required points of compression. It is supplied with an internal coating of the correct compression grease.

2. Bolted Clamping Covers

Although compression tubes should be used for stranded conductor connections wherever possible and bolted joints reserved for attachment is feasible, the nature of the tee clamp necessitates the use of a bolted connection on the "run" conductor. Thus special care must be taken with this clamp half.

On installation, micro-contacts are formed between the clamp body and the conductor. The summated areas of these individual micro-contacts make up the total actual contact area. This area only amounts to between 1% and 5% of the apparent, or overlap, surface. Thus, if the permissible current density is 10 amps/mm^2, this must be interpreted as approximately 0.2 amps/mm^2 of overlap surface.

The quality and life of the connection is determined by the actual contact area formed on installation and the preservation of such contact area. The contact area can reduce with time and one of the prime causes of this is creep of the conductor material - particularly for large diameter conductors with four or more strand layers. The covers fitted to these clamps are made of carefully selected alloys, gravity die cast or drop forged to yield the ideal strength and elasticity characteristics so that a high residual contact pressure is maintained. The number of clamping covers per connection depends on the current loads of the conductors and on whether stranded conductors, tubes or studs are to be connected.

3. The Clamp Body

The clamp body is provided with a large conductor seating area, machine-grooved for penetration of the conductor oxide layers and the creation of increased actual contact area. They further assist in the distribution of the bolt forces over the entire clamp length. Bolts are locked into the clamp body, thus requiring tightening of the nut only.

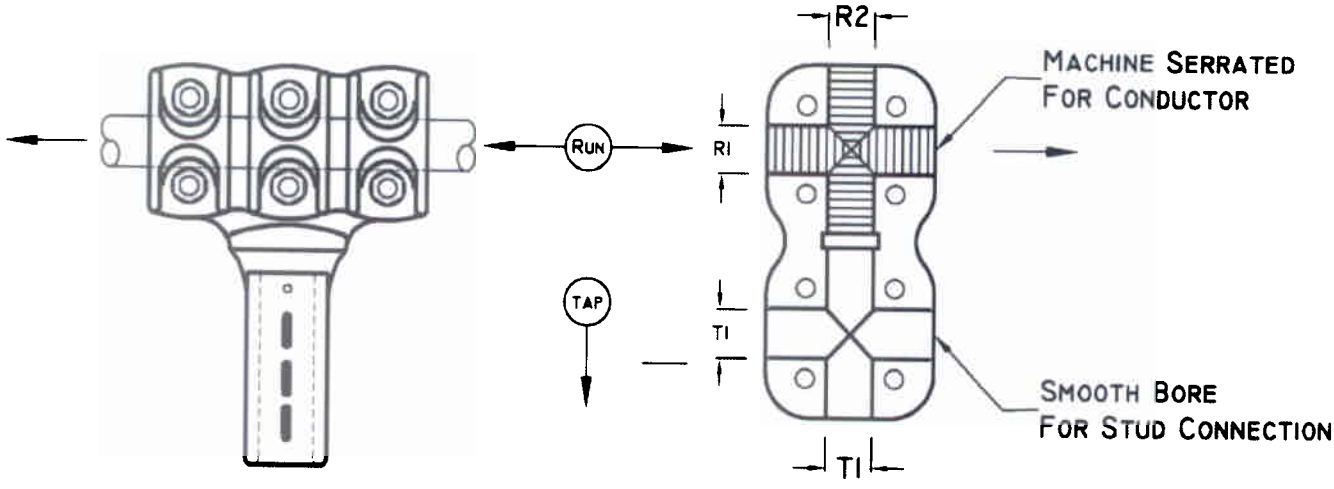
The body is indelibly marked with the clamp type number and conductor size.

4. The Welded Joint

Intensive research into welding techniques, both hand and machine methods, has resulted in joints of high quality. Tests in South African and European laboratories show the connection to be physically, electrically and mechanically sound. On-going quality assurance procedures adopted by McWade Productions guarantee that no problems will arise in this area, or for the unit as a whole.

5. Run And Tap Configuration

International understanding is that the RUN conductor (immaterial whether stranded or tubular conductors) is always in the horizontal plane and that the TAP conductor (whether stranded or tubular conductor) is in the vertical plane - see sketch below.



The K type cross clamp is specifically designed for use with a SOLID EQUIPMENT STUD and STRANDED CONDUCTORS. The K clamp is manufactured in compliance with the Eskom NWS 1671 specification, which specification calls for one half of the clamp having both the horizontal and vertical cross grooves smooth bored to suit 26 or 38mm dia equipment studs - with the other half of the clamp having the horizontal and vertical cross grooves either machined or cast serrated to suit stranded conductors of 16.3, 19.0, 21.0, 26.5 and 38.5mmdia. These are the standard Eskom stud and conductor diameters and the McWade manufactured K clamps are manufactured to suit these stud and conductor sizes where in all instances the stud is normally classified as the tap side of the clamp, immaterial of whether the stud is vertically or horizontally mounted.

Where a standard K clamp is required to be used with either different conductor or stud sizes, the standard K clamp as manufactured requires to be modified to suit these different stud/conductor sizes. It is required that customers specify both the RUN size and the TAP size in each specific case.

6. Preferred South African Substation Conductors

A.) ASCR Conductors to BS.215

Code Name	Reference Area Aluminium/Steel	No. & of ∅ of Wires Aluminium/Steel	Nominal Diameter	Mass per	Current Rating Amps	
	mm^2	mm	mm	kg	70°C	90°C
Wolf	160/40	30/7/2.59	18.13	7.28	371	482
Bear	250/40	30/7/3.35	23.45	1219	504	665

B.) AAC Conductors to BS.215

Code Name	Reference Area	No. and Diameter of Wires	Nominal Diameter	Mass per km	Current Rating Amps	
	mm^2	mm	mm	kg	75°C	90°C
Hornet	150	19/3.25	16.25	433	365	470
Centipede	400	37/3.78	26.46	1150	647	860
Bull	800	61/4.26	38.34	2397	986	1353

NB.: Above current ratings are based on a wind speed of 1.6 kms per hour and at an ambient temperature of 40°C (the 75 and 90°C temperatures in the above table refer to the conductor temperature).

INSTALLATION PROCEDURE

All inter-connector clamps as manufactured by McWade Productions are designed to suit both the electrical transfer current carrying capacity of the stranded/tubular busbar it is to be utilised with and the mechanical strengths associated with the rated short circuit current.

All international manufacturers' inter-connector clamps can only perform to their designed electrical and mechanical functions subject to the correct on-site installation procedures being adhered to which are:

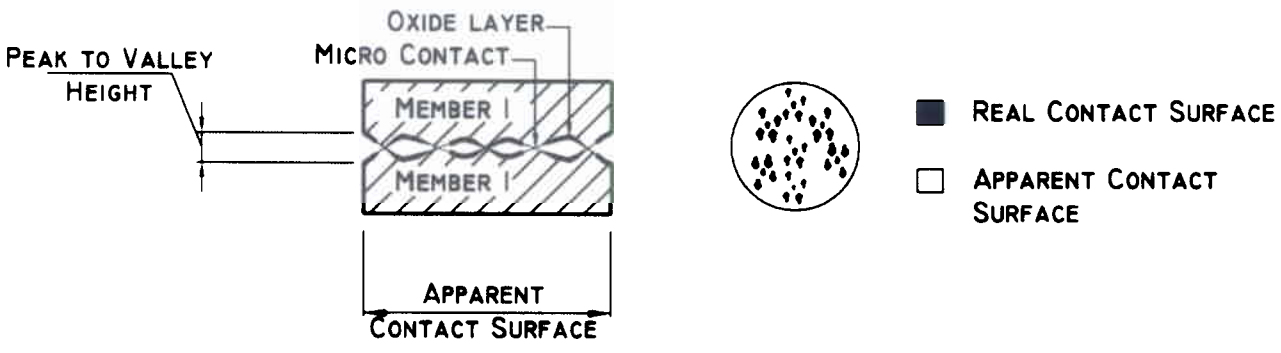
1. Clamp Selection

   The first step is to ensure that the clamp to be utilized is suited to the application in question. McWade clamps are all stamped with both Type Number and Conductor sizes and these can be compared to those specified on the installation drawings. It should be noted that types KC and YC are to be used solely for the compression connection of conductors to equipment terminals. The only time a bolted connection is made to stranded Conductors is in the case of TEE joints or tap-off where the clamp types T, TC or K are utilised.

2. Cleaning Procedure

   All clamps are supplied ex-factory in heavy duty heat-sealed plastic bags and the clamps should only be removed from these plastic bags immediately prior to installation and after correct cleaning and preparation of the installation connection area.

   Aluminium alloys as utilised in stranded or tubular conductors are prone to immediate oxidisation after extrusion. This oxide layer can achieve a maximum thickness of 500 - 1000nm and acts as an insulating medium. The dynamics of an oxidised aluminium connection results in a very high resistance interface and causes thermal instability leading to connection failure. To ensure proper contact between the busbar and clamping contact areas, it is necessary to clean away the layer of aluminium oxide in the contact areas.



Preparation of Contact Surfaces

ALL CONTACT SURFACE AREAS must be strongly brushed with a steel-wire brush alternatively with an aluminium oxide emery cloth grade 80 - 180 and then wiped clean with a dry cloth. Immediately thereafter the contact surfaces of the stranded/tubular busbar and inter-connector clamp are to be greased with a high-melting point non-oxidant grease to a 0.25 - 0.5mm minimum thickness. This greasing process must be immediately followed up with the application of the inter-connector clamp to the respective busbars.

Care should be taken that the contact surfaces, which have been cleaned and greased, are kept free of sand and other foreign matter. In the case of accidental pollution these surfaces shall be cleaned with a suitable solvent and the cleaning and greasing process repeated.

Equipment terminal studs and palms whether of aluminium or plated copper are to be cleaned in accordance with the above procedure.

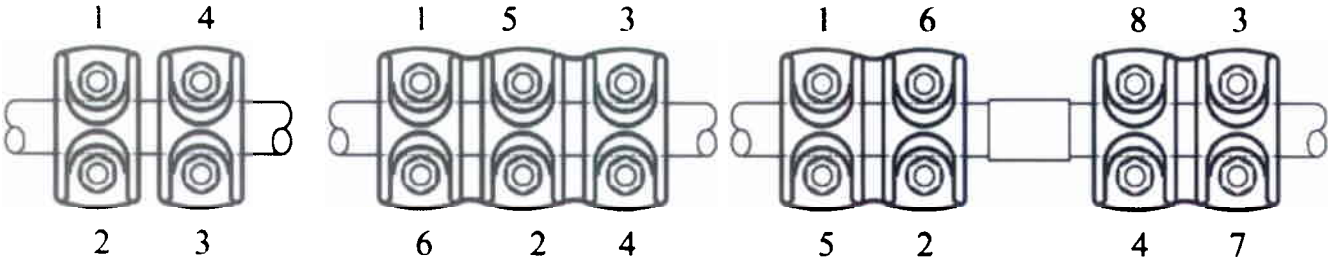
Certain compression compounds contain an aluminium grit and upon compression of the conductor sleeve on conductor, the compressive force drives the grease, containing sharp metalgrit particles, between the conductor strands, at the same time forcing the conductor strands into a semi hexagonal shape, this effect breaking down the oxide film around the inner conductor strands and providing for a point-point contact.

3. Clamp Installation

When installing the inter-connector clamp, ensure that the conductor seating areas match those of the busbar that the clamp is to be fitted to. In cases where the aluminium tubular busbar is slightly beyond the tolerances for diameter and ovality, the clamp can be accurately bedded onto the tube by hammering around the outside of the clamp body shell with a rubber hammer. This can only be done whilst the clamp is clamped onto the tubular basbar and the bolts are to be re-set afterwards with a torque wrench.

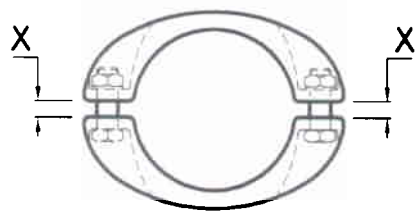
4. Clamping Sequence

Once the caps are correctly positioned, final bolt tightening is to take place according to defined sequences in order to apportion correct stresses to the conductor/tubes as well as the inter-connector bodies.



5. Positioning of the Caps

It is imperative that the clamping covers are tightened down in a parallel sequence so that the gap between the clamp's body and the clamp's cover is equal on both sides.



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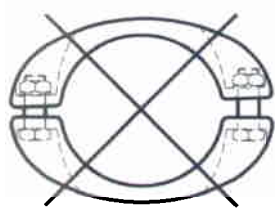
DISTANCE 'X' TO BE EQUAL



INCORRECT

6. Bolt Tightening Torques

All clamps are fitted with bolts, nuts and washers of either:

a) 8.8 grade high tensile steel bolts (HDG),
b) Stainless steel grade A2/A4,
c) Aluminium alloy grade 7075 - P60.

All inter-connector clamps are designed to provide a maximum effective contact surface between the busbar and the inter-connector clamp for the efficient transfer of electrical current. This maximisation of effective contact surfaces can only be achieved by the correct contact pressures of >6N/mm² being applied to the clamp. This can only be achieved by all bolts being tightened with a torque wrench to the required torque as stated below:

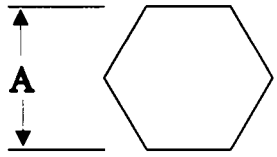
Bolt Thread	Spanner Width	Bolt Tightening Torque (Nm)				
		Steel (HDG)		S/Steel	Bronze	Alum
		5,6	8,8	A2	F60	7075 (p.60)
M8	13	-	15	20	15	10
M10	17	13	26	35	26	21
M12	19	23	45	60	45	36
M14	22	35	60	80	70	55
M16	24	56	75	110	-	70

7. Compression Joints

The conductor size to be compressed must correspond to the conductor diameter stamped on the compression tube. The conductor is to be cleaned as stated above and then cut to the required length. It is inserted into the pre-greased compression tube until the end is firmly against the clamping body stop. Compression is to be undertaken using a suitable 30/45-ton rating power operated compression tool. Compression dies are to be checked to meet with the following sizes:

Hexagon Type Crimped Connections

Conductor Type	Die Ref. No.	Tube O/D (mm)	Die Size (mm)	Dimension "A" (mm)	Die Bite Width
Bull	58	58	49	Max 51 Min 48	25
Centipede	42	42.5	36	Max 37.5 Min 35.2	40



Note: These are the commonly used Conductors in Sub-stations in South Africa. For all other connections, information is available on request.

Dies reference numbers are to be checked to the number stamped on the compression tube. Compression of the tube and conductor should commence from the conductor end towards the clamp body and compression must be effected over the compression marks detailed on the tube.

Compression tools are to automatically bypass on complete compression and under no circumstances should the die pressure be released before bypass is reached. After full compression the die numbers 42 or 58 will be imprinted onto the tube and serve to indicate both satisfactory and complete compression.

Compression tools are to be treated strictly in accordance with the operating instructions supplied. A light film of pure white Vaseline should be applied to the compression die faces after every 5 - 10 compressions in order to extend die life and facilitate die slide over the compression tube surface. Any compression die flashes should be removed with a file.

Upon completion of the clamp installation and checking that all bolts are correctly torqued surplus grease should be wiped away.