TECHNICAL REPORT
McWade Electrical Inter-connector Clamps

Installation Procedure

All inter-connector clamps as manufactured by McWade Electrical 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 an 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.

6. Bolt Tightening Torques

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

a) 8.8 grade high tensile steel bolts (HDG and/or MoS^2 galvanised),
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 $>6N/mm^2$ 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:

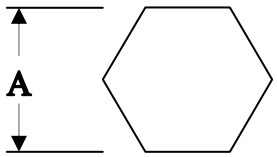
Bolt Thread	Spanner Width	Bolt Tightening Torque (Nm)				
		Steel (HDG)		S/Steel	Bronze	Alum
		5,6	8,8	A2	F60	7075 (p.60)
M8	13	-	15	20	15	10
M10	17	13	26	35	26	21
M12	19	23	45	60	45	36
M14	22	35	60	80	70	55
M16	24	56	75	110	-	70

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



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.

8. Installation of Expansion Tubular Busbar Inter-connector

When installing full or half expansion inter-connector clamps care must be taken for the allowance of the thermal expansion of the relevant basbar tube, be it aluminium or copper. An estimate of the expansion of various tubes due to thermal expansion at various temperature changes is given in the table below:

I. Calculation of Thermal Expansion in Aluminium Tubes in mm

Length of Pipe in Meter	Temperature Difference △T. in ℃									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
2.5	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
5.0	1.2	2.4	3.6	3.0	6.0	7.2	8.4	9.6	10.8	12.0
10	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0
20	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2	48.0
30	7.2	14.4	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0
40	9.6	19.2	28.8	38.4	48.0	57.6	67.2	76.8	86.4	96.0
50	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0

a) Temperature Co-efficient of Linear expansion (temp. range -20° + 200°C

Aluminium: 23×10^{-6} (0,000023 per centigrade degree)

II. Calculation of Thermal Expansion in Copper Tubes in mm

Length of Pipe in Meter	Temperature Difference △T. in ℃									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
2.5	0.42	0.85	1.3	1.7	2.2	2.6	3.0	3.4	3.9	4.4
5.0	0.85	1.7	2.6	3.4	4.3	5.2	6.0	6.8	7.7	8.6
10	1.7	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.3	17.0
20	3.4	6.8	10.2	13.6	17.0	20.4	23.8	27.2	30.6	34.0
30	5.1	10.2	15.3	20.4	25.8	30.6	35.7	40.8	46.2	51.6
40	6.8	13.6	20.4	27.2	34.0	40.8	47.6	54.4	61.2	68.0
50	8.5	17.0	25.5	34.0	42.5	51.0	59.5	68.0	76.5	85.0

b) Temperature Co-efficient of Linear expansion (temp. range -20° + 200°C

Copper: 17×10^{-6} (0,000017 per centigrade degree)

Example of the Calculation of Thermal Busbar Expansion

Aluminium basbar tube, length = 10m

Temperature difference t = Max. Op. Temperature – Min. Op. Temperature
= (+80°C) – (-20°C)
t = 100°C
Assembly temperature = +20°C

For complete expansion length refer to table – 24.0mm.

Temperature difference between the final temperature (+80°C) and the assembly temperature (+20°C) is therefore 60°C. Referring to the above table, the corresponding expansion difference will be 14,4mm. The clamp must therefore be mounted in such a way that a shift of at least 14,4mm in the direction of the clamp centre is guaranteed. A shift in the opposite direction in accordance with the temperature difference of (+20°C) assembly temperature and (+20°C) being the lowest final temperature - 40°C. Referring to the above tables, this value is given as 9.6mm.

9. Tube Operations

Aluminium tubular busbars are subject to wind-generated vibration and oscillation. Because of the low self-damping of tubular busbars very slight excitation forces will suffice to excite the tubes to vibrations amplitudes of the order of the tube diameter, when there is a resilience of the excitation force with a natural frequency of the tube. These high amplitudes produce additional dynamic stresses inside all structural parts and it is often necessary to dampen this tube oscillation by the insertion of AAC conductor into the busbar. The increased self damping provided by the insertion of damping conductor delays the onset of resilience build-up and this limits the maximum amplitudes created by a given excitation force.

As a rule it is normally sufficient to insert one conductor into a tube, but in order to increase the safety and to maintain maximum damping effect it is advisable to insert two conductors into the tube (one at each end running for 2/3 of the tube length). The following table shows recommended damping conductor sizes. A drain hole of 10mm diameter should be drilled at bottom centre point of tubes to facilitate drainage of condensate moisture.

Recommended Damping Cables		
Tube-Ø mm	**Al-cable mm**	**Permissible spacing between supports without damping cables m (nominal values)**
63	120	3.0
80	150	3.5
100	240	4.5
120	300	5.5
160	500	7.5
200	625	9.5
250	625	12.0