

## **Guide to Low Voltage Busbar Trunking Systems Verified to BS EN 61439-6**



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**Companies involved in the preparation of this Guide**



### **Acknowledgements**

BEAMA would like to thank IEC and BSI for allowing references to their standards;  
Health and Safety Executive (HSE) for reference to their documents.

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# Guide to Low Voltage Busbar Trunking Systems Verified to BS EN 61439-6

## Introduction

BEAMA is the long established and respected trade association for the electrotechnical sector. The association has a strong track record in the development and implementation of standards to promote safety and product performance for the benefit of manufacturers and their customers.

The object for this guide is to provide an easily understood document, aiding interpretation of the requirements to which Busbar Trunking Systems are designed and how they should be safely installed and used in service.

Principally, these requirements are detailed in BS EN 61439-6:2012 and for a more thorough understanding this guide should be read in conjunction with this standard.

*Note: BS EN 61439-6 is in line with EN 61439-6:2012 and IEC 61439-6:2012. References to the BS EN in this guide apply equally to the EN and IEC standards.*

The guide seeks to provide an understanding of the standard, accompanied by some typical examples as foreseen for the general products available from BEAMA Installation member Companies.

Certain additional information has been included regarding:

- Use
- Application
- Installation
- Site testing
- Safe working with busbar trunking systems.

It is the intention of BEAMA Installation to review this guide periodically, to reflect changes in related specifications, product standards and working practices.

In addition to the above standards there are a number of other standards applicable for the design, installation and use of Busbar Trunking Systems, detailed in Appendix A:

This Guide has been produced by BEAMA's Engineered Systems Product Group (ESPG). The ESPG comprises major UK manufacturing companies in this field and has its own officers, technical and other committees, all operating under the guidance and authority of BEAMA, supported by specialist central services for guidance on European Single Market, Quality Assurance, Legal and Health & Safety matters.

The management of technical issues relating to ESPG products is further sub-divided and delegated to two Technical Committees. Low Voltage Switchboard Technical Committee (LVSWBTC) and Busduct Technical Committee (BDTC).

BDTC was responsible for the preparation of this guide.

Details of other BEAMA Guides can be found on the BEAMA website [www.beama.org.uk](http://www.beama.org.uk)

# Useful Definitions

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## **Busbar Trunking System [BTS]:**

An enclosed electrical distribution system comprising solid conductors separated by insulating materials.

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**Busbar Trunking Unit [BTU]:** A unit of a BTS such as a straight length, angle (elbow), tee piece etc.

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**Distribution Busbar Trunking:** Busbar trunking having tap-off outlets on one or more faces.

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**Feeder Busbar Trunking:** Busbar trunking with no tap-off outlets.

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**Angle [elbow] Unit:** Busbar trunking, which enables the system to change direction.

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**End Feed Unit [feeder BTU]:** Busbar trunking unit as an incoming unit to permit connection of supply cables.

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**Make-up Piece:** A custom-engineered trunking unit to complete a trunking system (made to measure).

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## **Busbar Trunking Expansion Unit [thermal expansion BTU]:**

A busbar trunking unit permitting axial movement of the busbar conductors due to the differing coefficients of expansion of differing materials.

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## **Busbar Trunking Building Expansion Unit [BTU for building movements]:**

A busbar trunking unit permitting enclosure and conductor movement to compensate for structural displacement.

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## **Busbar Trunking Phase Transposition Unit [phase transposition BTU]:**

A busbar trunking unit which changes the relative positions of the phase conductors within the enclosure to balance inductive reactance or to facilitate connection between items of fixed equipment.

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## **Busbar Trunking Adapter (reducer) Unit [adapter BTU]:**

A busbar trunking unit for connecting two elements of the same system but of a different type or current rating.

*Note it is necessary to ensure overcurrent protection is provided for the reduced rating*

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## **Busbar Trunking Fire Barrier [fire barrier BTU]:**

A busbar trunking unit intended to prevent the propagation of fire through a wall or floor, for a specified time.

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## **Tap-Off Outlet:**

A location on a busbar trunking unit, which permits the connection of external loads to the busbar system via the appropriate tap-off unit.

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## **Tap-Off Unit:**

An outgoing unit for tapping off power from a busbar trunking system. (see section I.3).

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## **Flanged-end (flange):**

A connection unit for terminating a trunking system at a switchboard or transformer.

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# I. Use and Application

Modern electrical installations are placing increasing demands on all products of the electrical equipment manufacturer.

Products must have:

- Reliable service life
- Adaptability to new requirements
- Low installation costs
- Low maintenance costs
- Inherent safety features
- Minimal purchase cost
- Energy efficiency
- Safe recycling

In today's market one of the most important elements is cost effectiveness. In an electrical installation, one area where savings can be made and provide the features listed above is in the use of busbar trunking systems.

Busbar trunking installations can be categorised into two basic types: Distribution and Feeder.

## I.1 Distribution Trunking Run

This is the most common use of busbar trunking and is applied to distribute power over a predetermined area. Busbar trunking can be run vertically or horizontally, or a combination of both.

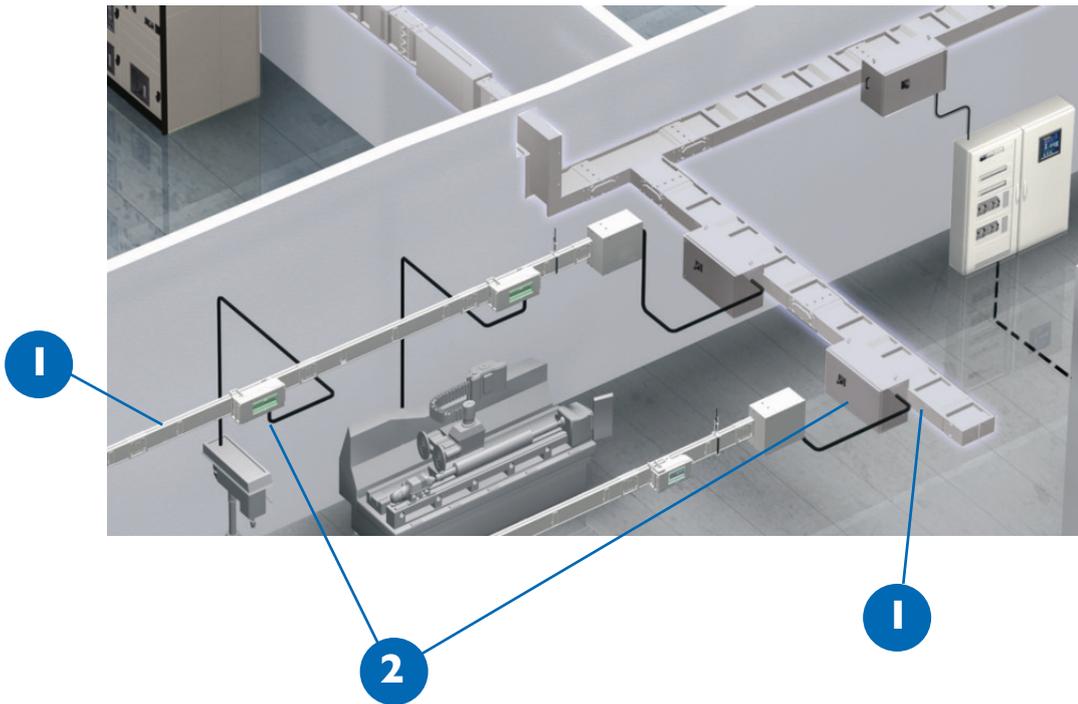
Typical applications would be:

- Supply to large numbers of light fittings
- Power distribution around factories and offices
- Rising main in office blocks or apartment blocks to supply distribution boards serving individual floors or other busbar systems serving individual floors.

Power is taken from busbar trunking by the use of tap off units which connect at defined positions along the busbar trunking, and allow power to be taken from the system, usually via a suitable overcurrent protective device.

Advantages over cable:

- The contractor can achieve savings with respect to material i.e. cable trays and multiple fixings and also labour costs associated with multiple runs of cable.
- Reduced installation time since busbar trunking requires less fixings per metre run than cable.
- Multiple tap-off outlets allow flexibility to accommodate changes in power requirements subsequent to the initial installation (subject to the rating of the busbar trunking).
- Repositioning of distribution outlets is simpler.
- System is easily extendable.
- Engineered product with proven performance.
- Verified to recognised international and national standards.
- Aesthetically pleasing in areas of high visibility.



**Figure 1:**  
Typical distribution  
busbar layout

**Key:**  
1 Busbar trunking system  
2 Tap-off unit

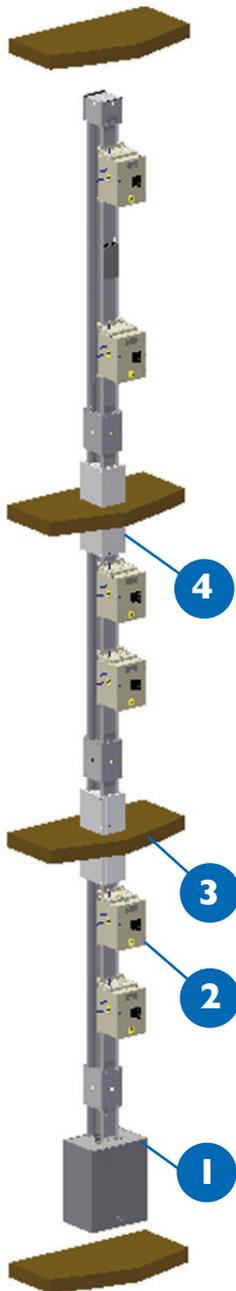
## 1.2 Feeder Trunking Run

Used for the interconnection between switchboards or switchboard and transformer, busbar trunking systems are more economical to use, particularly for the higher current ratings, where multiple single core cables would be used to achieve the current rating and compliance with voltage drop requirements.

The advantages over cable are:

- Greater mechanical strength over long runs with minimal fixings resulting in shorter installation times.
- Replaces multiple runs of cable with their associated supporting metalwork.
- Easier to install compared to multiples of large cables with all of the associated handling problems.
- Less termination space required in switchboards.
- Verified short-circuit fault ratings including joints.
- Takes up less overall space, bends and offsets can be installed in a much smaller area than the equivalent cable space.
- Cable jointer not required.
- Busbar trunking systems may be dismantled and re-used in other areas.
- Busbar trunking systems provide a better resistance to the spread of fire.
- Voltage drop in the majority of cases is lower than the equivalent cable arrangement.

**Figure 2:**  
Typical Busbar  
Riser Application



**Key:**

- 1 End feed unit
- 2 tap-off units
- 3 Floor
- 4 External fire barrier

## 1.3 Tap-off Units

Tap-off units are of two types, either plug-in or fixed. Plug-in units are designed to be accommodated at tap-off outlets at intervals along the distribution busbar trunking.

Fixed tap-off outlets are engineered and positioned during manufacture to suit the specified installation.

The tap-off unit usually contains the device providing overcurrent protection to the outgoing circuit terminated at the unit to distribute power to the required load. For example:

- a) HRC fuses to BS EN 60269-1 (BS88)
- b) Miniature Circuit Breakers to BS EN 60898
- c) Moulded Case Circuit Breakers to BS EN 60947-2
- d) RCBO devices to BS EN 61009-1

*Note 1 HRC fuses may be incorporated into fuse combination units to BS EN 60947-3.*

*Note 2 The degree of enclosure protection of the tap-off unit is defined by BS EN 60529.*

### 1.3.1 Plug-in Distribution Boards

Plug-in distribution boards are designed for use where space is limited. This solution removes the requirement for a tap-off unit, a separate distribution board, cable containment and interconnecting cable. They are designed to be accommodated at tap-off outlets at intervals along a distribution busbar trunking system.

A plug-in distribution board may contain an incoming device and is designed to accommodate outgoing devices, primarily for low voltage distribution. For example:

Incoming device typically:

- Moulded Case Circuit Breakers to BS EN 60947-2
- HRC fuses to BS EN 60269-1

Outgoing devices typically:

- a) Miniature Circuit Breakers to BS EN 60898
- b) RCBO devices to BS EN 61009-1
- c) RCCB devices to BS EN 61008-1
- d) HRC fuses to BS EN 60269-1

### 1.3.2 Protection Device Substitution

Tap-off units and feeder units are verified with specific devices (e.g. MCCBs, MCBs) installed; these devices are more often than not from the same manufacturer as the BTS. Verification will have been undertaken, by the manufacturer, to BS EN 61439-6 or BS EN 60439-2<sup>1</sup>. Replacement or substitution with devices of another manufacturer without the necessary verification of performance should not occur.

**Substituting devices not verified by the BTS manufacturer invalidates any testing/verification and warranty.**

Although devices from different manufacturers may appear similar, the technical performance, dimensions, and terminations are not necessarily compatible. Contact the BTS manufacturer in the first instance for advice.

<sup>1</sup> BS EN 60439-2 has been replaced by BS EN 61439-6.

### 1.3.3 Safety Features

Each tap-off unit includes the necessary safety features for systems and personnel protection, as follows:

- Plug-in units are arranged to be non-reversible to ensure that they can only be connected to give the correct phase rotation.
- Plug-in units are arranged to connect the protective circuit before the live conductors during installation and disconnect the protective circuit after the live conductors, while being removed.
- Where units are provided with a switch disconnect or circuit-breaker these are capable of being locked in the OFF position.
- Covers permitting access to live parts can only be removed by the use of a tool and will have any internally exposed live parts shielded to a minimum of IP2X or IPXXB in accordance with BS EN 60529 (finger-proof).
- Outgoing connection is achieved by cable terminations in the unit or by socket outlets to BS EN 60309-2 or BS 1363.

### 1.4 Fire Barrier BTU

This is a busbar trunking unit (BTU) designed to prevent the propagation of fire and limit the propagation of heat through building divisions (walls and floors), for a specified time under fire conditions.

Internally the trunking may or may not require fire-stop measures according to the construction; where they are required these will generally be factory-fitted by the manufacturer and positioned according to a schematic drawing for the installation.

Compact or sandwich-type trunking does not require internal fire-barriers, as suitability as a fire-barrier is inherent in the design. However in all cases verification of the performance of the trunking under fire conditions needs to be provided by the manufacturer.

*It is not the responsibility of the trunking manufacturer to provide the specification or detail the rating or construction of the fire barrier external to the trunking. The following information is provided for guidance, and the method used should be agreed with the trunking manufacturer.*

The sealing external to the busbar trunking (with or without an internal fire barrier) will need to conform to applicable building regulations. This will require filling the aperture around the busbar trunking, as specified by the manufacturer, with material to maintain the same fire proofing as the wall or floor.

Careful consideration needs to be given to the access required to complete the fire barrier. It may be necessary to install sections of fire barrier at the stage of installation of the trunking if access afterwards is impossible e.g. trunking runs in close proximity.

## 1.5 Protective Earth Conductor Sizes

The protective earth connection(s) external to the busbar trunking system shall conform to Section 543-1 of BS 7671:2008 (2011).

## 1.6 Low-Noise Earth Systems

A low-noise earth, commonly referred to as a 'clean earth', is typically specified when electronic apparatus supplied from the system is sensitive to spurious voltages arising on the system earth. This is particularly true with IT equipment, found in all commercial premises these days, where data processing functions can be corrupted.

The low-noise earth is provided by a conductor separated from the protective earth (PE) and from all extraneous earth paths throughout the distribution system.

Many busbar trunking systems provide a 'clean earth' conductor in addition to the three phase conductors plus neutral, using the case or an external conductor as PE.

Tap-off units must be specified as 'clean earth' for the circuits concerned since the separation of the earths must be maintained and an additional termination will be provided for the load circuit 'clean earth' conductor.

Sizing of the 'clean earth' conductor is not specified in BS 7671:2008 (2011) but the usual practice is to calculate the size in the same way as for the protective earth conductor.

## 1.7 Neutral Sizes/Harmonics

The designer of the electrical network specifies the size of the neutral conductor depending upon the network loading. Typically this tends to be a neutral conductor the same size as the phase conductors (i.e. 100% neutral). As a minimum a 50% neutral may be specified.

*BS 7671:2008 (2011) states "If the total harmonic distortion due to third harmonic currents or multiples of the third harmonic is greater than 15% of the fundamental line current the neutral conductor shall not be smaller than the line conductors"*

With the increase of non-linear (almost anything electronic) single phase loads connected to a network, for example electronic ballasts in lighting fittings, or switchmode power supplies (the type found in personal computers and servers) the total harmonic distortion is increased.

### 1.7.1 Neutral Conductor Sizing for Commercial Loads

It has been established using typical waveforms for switch-mode power supplies that the third harmonic is approximately 70% of the fundamental. If it is assumed that the loading of the three phases is balanced with similar load characteristics, the rms phase and neutral currents can be approximated as follows:

$$I_{phase} = \sqrt{(I_1^2 + I_3^2)} = \sqrt{(1.0^2 + 0.7^2)} = 1.22$$

$$I_{neutral} = (I_3 + I_3 + I_3) = (0.7 + 0.7 + 0.7) = 2.1$$

$$I_{neutral} / I_{phase} = 2.1 / 1.22 = 1.73 \text{ [ See Guidance Note 1 section 6.3 of BS 7671:2008 (2011) ]}$$

The neutral current in this case will be 173% of the rms phase current magnitude. The conclusion from this calculation is that the neutral conductors in circuits supplying totally electronic single-phase loads should have almost twice the capacity of the phase conductors.

The above represents the worst case condition, in practice the proportion of electronic loading to total loading must be established to allow correct sizing of the neutral. This factor must also be taken into account in the case of existing installations that are being refurbished, extended or a change of use occurs affecting the network loading.

### 1.7.2 Implications of High Harmonic Currents

The effects of harmonic currents on electrical conductors are:

- a) Increased temperature caused by higher RMS currents in the phases of a system than is necessary to transfer the active power.
- b) Increase in effective resistance of the conductors caused by ‘skin-effect’ whereby higher frequencies reduce the effective cross-sectional area.
- c) Third-harmonic currents in a three-phase system add in the neutral, regardless of whether the phase currents are balanced.
- d) Neutral currents due to harmonic distortion will generate voltage distortion and neutral–earth potentials.

The presence of triplen harmonics (multiples of the third) depends on the application involved and can be present in low and high current BTS. Therefore, it is necessary to obtain data and/or carry out a study on each non-linear load to determine the level of harmonic distortion.

A simple way to deal with this issue of additional heat in the conductors is to use a larger neutral conductor. This applies to the whole of the busbar system including affected tap-off units and associated protective devices with a neutral pole. Busbar trunking manufacturers may provide “oversized” devices in order to accommodate the high neutral current, or use parallel connected devices to meet the specification. The extra heat produced in the conductors within the BTS may lead to the need for temperature de-rating factors to be applied to the standard designs of BTS. Typical de-rating figures that may need to be applied are as in the Table 1.

Abnormal temperature rise may occur in the conductors because of harmonic currents flowing in the phases and the summing of the triplen harmonics in the neutral. Therefore as an alternative the manufacturer may provide a BTS specifically designed for a given level of harmonic distortion without the need for de-rating, sometimes known as a ‘Harmonic-rated BTS’.

Neutral current due to harmonics	Rating factor	
	100% neutral	200% neutral
50% $I_n$	0.96	0.98
100% $I_n$	0.87	0.93
150% $I_n$	-	0.85

**Table 1:**  
Harmonic  
rating factor

#### Example

A TP&N BTS rated at 2000 A is found to be carrying a neutral current of 1000 A (50 %  $I_n$ ) due to the presence of harmonics in the load current. If the BTS has a 100 % neutral fitted the system is rated as  $0.96 \times 2000 \text{ A} = 1920 \text{ A}$ .

### 1.7.3 Harmonic filters

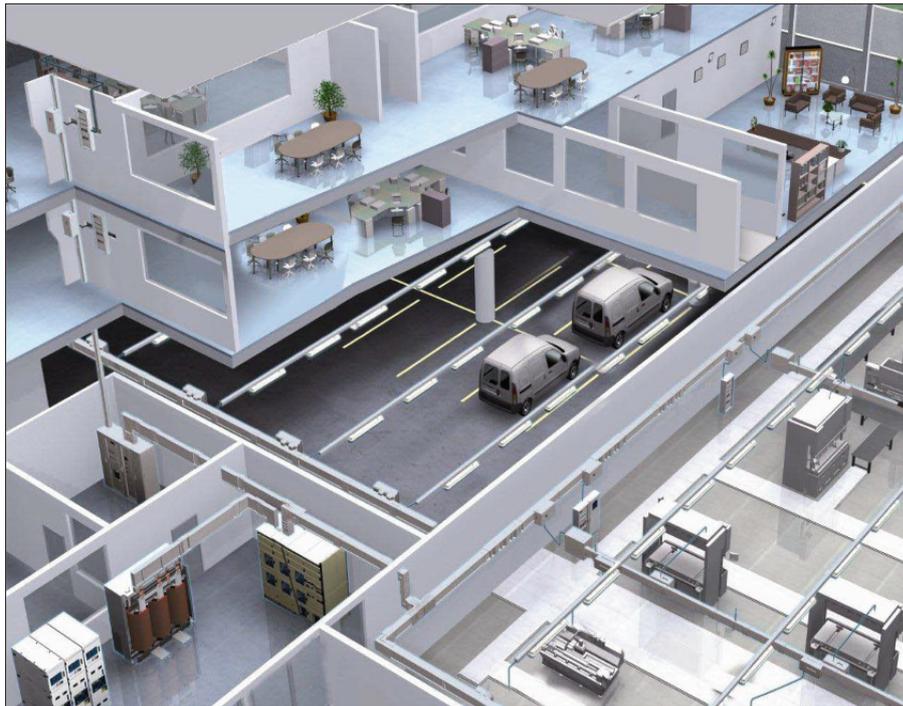
In the overall design of the installation, equipment may be considered that will remove the harmonics from the neutral. Typically, this may be 'active harmonic filters', connected at the load (source of distortion) that will then allow the use and connection of standard (100% rated) equipment and compliance with BS 7671. See IEE Guidance Note 1; Section 6.3 – neutral conductors.

## 1.8 Typical areas of Application

**Table 2:**  
*Typical areas  
of Application*

Offices	Shopping Centres
Apartments	Factories
Schools	Electrical Generation
Hotels	Petrochemical Industries
Hospitals	Oil & Gas Platforms
Photovoltaic installations	Wind farms
Data centres	Automotive manufacture

**Figure 3:**  
*Typical busbar  
trunking  
applications*



## 2. Technical Specifications

### 2.1 Performance under Short-Circuit Conditions

Busbar trunking systems to BS EN 61439-6 are designed to withstand the effects of short-circuit currents resulting from a fault at any load point in the system, e.g. at a tap-off outlet or at the end of a busbar trunking run.

The short-circuit current rating for busbar trunking, for a particular installation, should match the prospective fault current available at the feeder unit. There is no advantage in specifying a higher figure for short-circuit rating.

#### 2.1.1 Rating under Short-Circuit Conditions

The withstand ability will be expressed in one or more of the following ways:

- a) rated short-time withstand current and corresponding time.
- b) rated peak withstand current.
- c) rated conditional short-circuit current when protected by one or more short-circuit protective device(s) (SCPD(s)).

These ratings are explained in more detail:

##### a) Rated short-time withstand rating ( $I_{cw}$ )

This is an expression of the value of rms current that the system can withstand for a specified period of time without being adversely affected such as to prevent further service. Typically the period of time associated with a short-circuit fault current will be 1 or 3 seconds, however other time periods may be applicable.

The rated value of current may be anywhere from about 10 kA up to 50 kA or more according to the construction and thermal rating of the system.

##### b) Rated peak current withstand current ( $I_{pk}$ )

This defines the peak current, occurring virtually instantaneously, that the system can withstand, this being the value that exerts the maximum stress on the supporting insulation.

In an a.c. system rated in terms of short-time withstand current, the peak current rating must be at least equal to the peak current produced by the natural asymmetry occurring at the initiation of a fault current in an inductive circuit. This peak is dependent on the power-factor of the circuit under fault conditions and can exceed the value of the steady state fault current by a factor of up to 2.2 times.

##### c) Rated conditional short-circuit current ( $I_{cc}$ )

Short-circuit protective devices (SCPDs) are commonly current-limiting devices; that is they are able to respond to a fault current within the first few milliseconds and prevent the current rising to its prospective peak value. This applies to HRC fuses and most circuit breakers in the instantaneous tripping mode. Advantage is taken of these current limiting properties in the rating of busbar trunking for high prospective fault levels. The condition is that the specified SCPD (fuse or circuit breaker) is installed upstream of the trunking.

Each of the ratings above takes into account the two major effects of a fault current, these being heat and electromagnetic forces. The heating effect needs to be limited to avoid damage to supporting insulation. The electromagnetic effect produces forces between the busbars, which stress the supporting mechanical structure, including vibrational forces on a.c. The only satisfactory way to establish the quoted ratings is by means of verification to the British Standard.

### 2.1.2 Verification

Busbar trunking systems are verified in accordance with BS EN 61439-6 to establish one or more of the short-circuit withstand ratings defined above. In the case of a short-time current test a current is applied such as to achieve the let-through energy and peak current corresponding to the rated value. In the case of a conditional rating test with a specified SCPD, the test is conducted with the full prospective current value at the busbar trunking feeder unit and not less than 105% rated voltage, since the SCPD (fuse or circuit-breaker) will be voltage dependent in terms of let through energy.

### 2.1.3 Application

It is necessary for the system designer to determine the prospective fault current at every relevant point in the installation by calculation, measurement or based on information provided, e.g. by the supply authority. The method for this is well established, in general terms being the source voltage divided by the circuit impedance to each point. The designer will then select protective devices at each point where a circuit change occurs, e.g. between a feeder and a distribution run of a lower current rating. The device selected must operate within the limits of the busbar trunking short-circuit withstand rating. The time delay settings of any circuit-breaker must be within the specified short time quoted for the prospective fault current. Any SCPD used against a conditional short-circuit rating must have energy limitation not exceeding that of the quoted SCPD. For preference the SCPD recommended by the trunking manufacturer should be used.

## 2.2 Voltage Drop

The requirements for voltage drop in an installation are given in BS 7671:2008 (2011) Regulation 525. For busbar trunking systems the method of calculating voltage drop is given in BS EN 61439-6 from which the following guidance notes have been prepared.

### 2.2.1 Voltage Drop Values

- Figures for voltage drop for busbar trunking systems are given in the manufacturers' literature.
- Figures are usually expressed in mV/A/m or mV/A/100 metres, for various power factors, allowing a simple calculation for a given length of run.
- Figures are usually given as line-to-line voltage drop for a 3 phase balanced load.
- Figures take into account resistance of joints, temperature of conductors and assumes the system is fully loaded.

### 2.2.2 Voltage Drop Calculation from Basic Data

BS EN 61439-6 requires the manufacturer to provide the following data for the purposes of calculation, where necessary:

- $R_{20}$  – the mean ohmic resistance of the system, unloaded and at 20°C, per metre per phase.
- $X$  – the mean reactance of the system, per metre per phase.
- $R$  – the mean ohmic resistance when loaded at rated current and at an ambient temperature of 35°C, per metre per phase.

In general the voltage drop figures provided by the manufacturer are used directly to establish the total voltage drop on a given system; however this will give a pessimistic result in the majority of cases.

Where a more precise calculation is required (e.g. for a very long run or where the voltage level is more critical) advantage may be taken of the basic data to obtain a more exact figure.

### 2.2.2.1 Resistance

The actual current is usually lower than the rated current and hence the resistance of the conductors will be lower due to the reduced operating temperature.

$$R_x = R_{20} [1 + 0.004(T_c - 20)] \text{ ohms/metre and } T_c \text{ is approximately } T_a + T_r$$

where  $R_x$  is the actual conductor resistance.

$T_a$  is the ambient temperature

$T_r$  is the full load temperature rise in Kelvin (obtained from the manufacturer)

### 2.2.2.2 Power Factor

The load power factor will influence the voltage drop according to the resistance and reactance of the busbar trunking itself.

The voltage drop line-to-line ( $\Delta v$ ) is calculated as follows:

$$\Delta v = \sqrt{3} \cdot I (R \cos \phi + X \sin \phi) \text{ volts/metre}$$

Where:

$I$  is the load current and  $R_x$  is the actual conductor resistance ( $\Omega/m$ )

$X$  is the conductor reactance ( $\Omega/m$ )

*Note: For BTS rated below 100A the reactance  $X$  is deemed to be negligible.*

$\cos \phi$  is the load power factor (PF)

$\sin \phi = \sin [\cos^{-1} (\text{PF})]$

### 2.2.2.3 Distributed load

Where the load is tapped off the busbar trunking along its length this should also be taken into account by calculating the voltage drop for each section.

As a rule of thumb the full load voltage drop may be divided by 2 to give the approximate voltage drop at the end of a system with distributed load.

### 2.2.2.4 Frequency

The manufacturers' data will generally give reactance ( $X$ ) at 50Hz for mains supply in the UK. At any other frequency the reactance should be re-calculated as follows:-

$$X_f = X \cdot f / 50$$

where  $X_f$  is the reactance at frequency  $f$  in Hz

## 2.3 Electromagnetic Fields (EMF)

Any electrical conductor carrying current will generate a magnetic field. This effect is of importance in some applications to ensure safety of personnel and trouble-free operation of equipment installed in the vicinity.

BS EN 61439-6 provides a method of test to establish the field strength surrounding a busbar trunking system to enable the determination of distances for safe levels of exposure. This test is not mandatory and is not a condition of compliance with standard.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) publishes guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields in the frequency range from DC up to 300GHz.

Busbar trunking systems (BTS) are better suited for power distribution than cables when a low magnetic induction is required, as the BTS construction facilitates the optimum arrangement of conductors to keep magnetic interference to a minimum. In many cases the conductors of a busbar trunking system are totally shielded by the equipotential metal casing of the system. In the case of sandwich-type construction the conductors are closely packed together and the induced magnetic fields cancel one another to a large extent, resulting in an extremely low external magnetic field. The material of the conductors in a BTS (e.g. copper or aluminium) has negligible effect on the magnetic field.

Often, less attention is paid to EMF when installing cables. As a result, neither the distance between the conductors nor the sequence of the conductors is considered, which results in high magnetic fields compared to the equivalent BTS.

## 3. Aluminium or Copper as Conductor Material

These two materials are both physically and economically viable for use as conductors in power busbar trunking systems (BTS). Some manufacturers of BTS offer a product with copper busbars and others offer a product with aluminium conductors. Increasingly major UK manufacturers are offering both products, leaving the choice to the customer.

Historically the choice of busbar material by the manufacturer has been based on the expectations of the local market. Traditionally, in the UK copper conductors have predominated both for BTS and cable. In other markets, the USA and mainland Europe for example, aluminium has had the greater role. The decisions leading to the choice of material would have been influenced by the availability of the raw material and its cost, rather by the physical properties of the respective materials.

Another factor would have been the ratio between the use of cable and the use of BTS in the market. In the UK, it can be shown that BTS has increased its share of the market relative to cable, to some extent due the increasing amounts of power required in buildings, in particular for automated industrial units and high-rise commercial centres.

Some of the factors affecting the choice of busbar material are subject to change, in particular the cost of raw material, and the facts needed to allow an informed choice are summarised below.

### 3.1 Performance

The performance of a busbar trunking system (BTS) using either aluminium or copper busbars will be the same for any given specification. Performance is dictated by compliance with the current national standard BS EN 61439-6 which is identical with international standards EN 61439-6 and IEC 61439-6. The performance requirements consist of:

- Dielectric properties (power frequency and impulse voltage withstand)
- Fire resistance (where applicable)
- Impedance characteristics (R, X, Z)
- Ingress protection (IP rating)
- Mechanical strength, crush resistance
- Short-circuit withstand
- Temperature rise
- Thermal cycling (tap-off units)
- Voltage drop characteristics

### 3.2 Physical Properties

Aluminium has a lower density than copper and copper has a higher conductivity. The effect of these differences on busbar trunking unit (BTU) design is explained, taking high-power, low-impedance BTS (also known as 'compact' or 'sandwich-type') as the basis:-

### 3.3 Weight

The lower density of the material means aluminium busbar BTS will be lighter for a given current rating. The lower density is offset to some extent since the lower conductivity of aluminium means that the size of the busbars will be greater than copper for a given current rating. The busbar weight is only a proportion of the total weight of a BTU which includes the case, which may be of aluminium or steel, plus the insulation and jointing means. However it can be shown that, on average, a BTU with aluminium busbars will be 30% lighter than a BTU of the same current rating with copper busbars.

### 3.4 Dimensions

Size does matter sometimes! To accommodate the larger busbar sizes needed with aluminium, the overall dimensions of the BTS are generally greater than for copper busbar BTS. Typically the overall cross-sectional area (c.s.a) of a straight-length BTU with aluminium busbars will be 10 – 20% greater than a length of the same current rated BTU with copper busbars. The exception to this is when a step-change occurs between a single-bar construction and a double-bar construction, usually at around 2500 A. In this case the difference in size will be in the order of 70%.

*Note that the size of the conductors in the busbar trunking is designed to meet the performance characteristics of the standard. It is not necessary or helpful for conductor sizes to appear in the user specification.*

### 3.5 Voltage-drop

The voltage-drop along a BTS run is dependent on the current flowing and the impedance (resistance and reactance) of the busbars. The data published by the manufacturer for voltage drop is based on worst-case conditions i.e. with the BTS at a temperature resulting from full-load current and an ambient temperature of 35°C.

Due to the higher conductivity of copper, offset to some extent by the larger busbar c.s.a in aluminium, the voltage-drop per unit length with copper busbars will be on average some 25% lower than with aluminium of the same current rating.

### 3.6 Power-loss

A few years ago this might not even have been a consideration, but now it may enter into the equation, since it will be a factor, however small, in the overall operating efficiency of an installation. Power-loss figures can be made available from the data taken during BTS performance testing. Since power-loss is largely proportional to the electrical resistance of the busbars it will be typically 25% lower with copper busbar BTS than with aluminium busbar BTS of the same current rating. This however needs to be put in perspective; for example, an 800 A 3-phase trunking run can transmit up to 500 kW of load power; the power loss in 50 m of the trunking is in the order of 8 kW i.e. 98.4 % transmission efficiency.

# 4. Installation and Site Testing

## 4.1 Transportation and Storage

The conditions should be no worse than the normal service conditions as BS EN61439-6, with particular regard to temperature and humidity.

As typically the electrical connections are not protected (IP00) until installation is complete, the components must be protected from dust/water and condensation/corrosive materials, such protection may not be provided by manufacturer's packaging.

Suitable handling equipment should be used, appropriate to the weight and size of the busbar trunking.

## 4.2 Inspection/Test before installation

All components should be checked for mechanical damage and be subjected to an insulation resistance test before installation.

## 4.3 Installation

Busbar systems must be fixed to the building in accordance with manufacturer's instructions.

## 4.4 Jointing

The joint contact surfaces must be clean and particular care taken with alignment while the connections are made – best practice must be employed when making electrical connections. Since the current carrying capacity is dependent on contact pressure the torque settings specified by the manufacturer must be used.

## 4.5 Inspection/Test after installation

The correct time to make the Initial Verification/Inspection to BS 7671, and any additional requirements from manufacturers' instructions, is during installation and not as a preliminary to commissioning.

To check that the installation has been made correctly, and to provide records for comparison during maintenance, the following are particularly relevant to busbar trunking:

### 4.5.1 Insulation Resistance

BS 7671:2008 (2011) requires the insulation resistance of a complete system to be checked, and sets minimum values. The measured value not only depends on the quality of the insulation and length of the busbar system, but can also be affected by for example, ingress of moisture.

*Note that dielectric (flash) tests will have been made on each unit in the factory using the voltage specified in the Standard BS EN 61439-6. It is not advisable to repeat this on an installed busbar trunking system due to the safety hazards from high voltages (2200V 50 Hz is typical). If the client requires such a test then a risk assessment must be carried out in consultation with the manufacturer. Such a test may not be practical due to the capacitive leakage at the a.c. test voltage, exceeding the capability of the test equipment. An alternative is the use of a d.c. voltage.*

*It is essential to discharge the stored energy in the capacitance following such a test.*

### 4.5.2 External Surface Temperature

One method of monitoring performance of busbar trunking is to take a temperature profile during commissioning under typical load conditions. Periodically repeat checks of the temperature profile are then made for comparison.

*Note: A typical temperature rise on the external surface of up to 55 K may be expected at full load current.*

## 4.6 Installation Certification & Reporting

Required by Chapter 63 of BS 7671:2008 (2011) and Code 28 of BS 6423.

### 4.6.1 As part of Commissioning

An Electrical Installation Certificate to be signed by the Client's Consulting Engineer as the designer, electrical contractor as the constructor, and electrical contractor as the tester. Advice and recommendations on the results may be requested from the manufacturer(s).

### 4.6.2 As part of Maintenance

Periodic Inspection Report to be signed by the electrical contractor as the tester. Advice and recommendations on the results may be requested from the manufacturer(s).

## 4.7 Safe Working with Busbar Trunking Systems

First and foremost within the UK, the requirements of The Electricity At Work Regulations 1989, **must** be complied with; Regulation 14 is particularly pertinent and requires:

*"No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless:*

- a) it is unreasonable in all the circumstances for it to be dead; and*
- b) it is reasonable in all the circumstances for him to be at work on or near it while it is live; and*
- c) suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury."*

Regulation 4(4) in particular also applies to the provision and use of protective equipment. Effectively this means that, where live working is being contemplated, a risk assessment and judgement must be made for every situation by the *Duty Holder*\*. This must take account of all relevant factors, some of which include:

- the effectiveness of isolating equipment,

Correctly secured isolation of the supply is the most effective safety precaution against electric shock and inadvertent short-circuits during work on the equipment.

- the task to be performed,
- the skill level of the personnel carrying out the work,
- use of correct tools, instruments and other work equipment,
- use of warning signs, etc.

Manufacturers cannot give all-embracing assurances for safe working with the system live. This can only be determined on a case by case basis depending on the work to be done.

For further reference see HSE publication 'Electricity at Work – Safe Working Practices HS(G) 85.

**\*Duty Holder:** *The term used within the Electricity At Work Regulations 1989 to refer to the person appointed to be responsible for the electrical equipment, systems and conductors and any work or activities being carried out on or near electrical equipment. The Duty Holder must be competent and may be the employer, an employee, or a self-employed person.*

# Appendix A

In addition to the above standards the following are applicable for the design, installation and use of Busbar Trunking Systems:

## **BS EN 61439-1:2011**

Low Voltage Switchgear and Controlgear Assemblies: Part 1: General Rules

## **BS 7671:2008 (2011)**

Requirements for Electrical Installations (IET Wiring Regulations 17th Edition).

## **BS 6423:1983**

Code of practice for Maintenance of Electrical Switchgear and Controlgear up to and including 1000V.

## **BS EN 60529:1992**

Specification for Degrees of Protection provided by Enclosures (IP Code).

## **European Directives**

Busbar trunking systems come within the scope of 2006/95/EC Low Voltage Directive, and UK Low Voltage Electrical Equipment (Safety) Regulations 1994.

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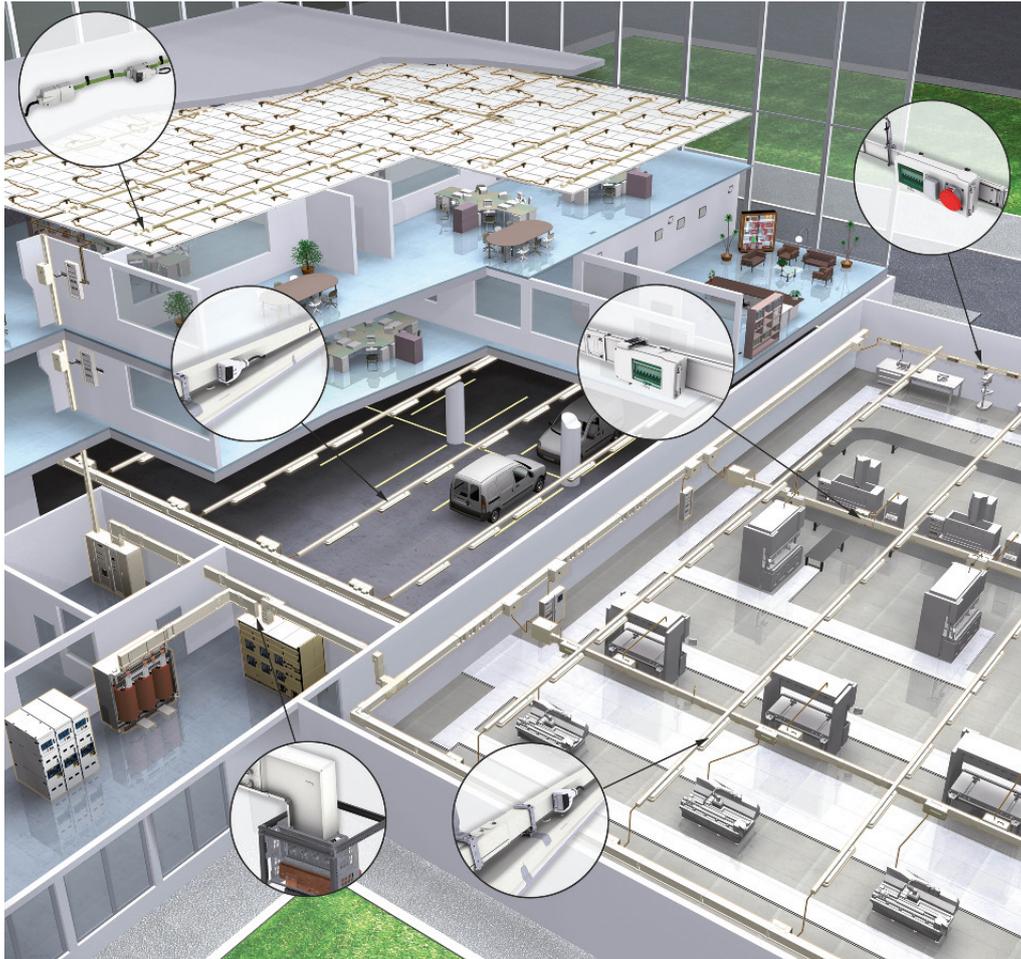
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