Questions relating to the requirements for supplementary equipotential bonding are frequently asked; a very common one is where should it be installed. This article looks at the requirements for supplementary equipotential bonding in BS 7671:2008, where supplementary equipotential bonding should be installed and offers help on the process of evaluation.

TERMINOLOGY
Firstly, it is important that the terminology is correct. Earthing and bonding are two different concepts yet the terms are often used together. Once we have established that “earth-bonding”* is a nonsensical expression and should never be used, we can look at the requirements of supplementary equipotential bonding in BS 7671:2008.

*Earthing and bonding are two separate concepts.

Main protective bonding conductor Used to connect extraneous-conductive-parts, such as a metallic water pipe, to the main earthing terminal.

Supplementary equipotential bonding conductors Used to supplement to fault protection by maintaining various exposed conductive-parts and extraneous-conductive-parts at substantially the same potential, such as the connection of all exposed-conductive-parts and extraneous-conductive-parts that can be touched by livestock in an agricultural installation.

HISTORY
The change from the 14th to the 15th Edition of the IEE Wiring Regulations in 1981 created a big upheaval in the electrical installation industry as many new concepts were introduced and many existing practices were expanded or enhanced - one of those being supplementary equipotential bonding. To a great extent, the 15th Edition was based on CENELEC harmonised documents (HDs) (more so now with the introduction of the 17th Edition).

HD 384.4.41 was the basis for Chapter 41 of the 15th Edition - Protection against electric shock, which had requirements for supplementary equipotential bonding in Regulation 413-7, reproduced here:

413-7 Within the zone formed by the main equipotential bonding, local supplementary equipotential bonding connections shall be made to metal parts, to maintain the equipotential zone, where those parts -
(i) are extraneous conductive parts, and
(ii) are simultaneously accessible with exposed conductive parts or other extraneous conductive parts, and
(iii) are not electrically connected to the main equipotential bonding by permanent and reliable metal-to-metal joints of negligible impedance.

NOTE - Where local equipotential bonding is provided in accordance with Regulation 413-7, metalwork which may be required to be bonded includes baths and exposed metal pipes, sinks, taps, tanks, and radiators and, where practicable, accessible structural metalwork.
Those far reaching changes, issued on 31st March 1981, are still being felt today with designers and specifiers still implementing the requirements for supplementary equipotential bonding from the 15th Edition. Much of the confusion can be attributed to the note of Regulation 413-7 which required the bonding of all metallic items, essentially, those within the designated equipotential zone. This led to the installation of supplementary equipotential bonding of general metallic items such as baths, ceiling grids, hand rails, kitchen sinks, radiators, pipework at boilers, etc. Thankfully, we have moved on from this general concept.

THE REQUIREMENTS FOR SUPPLEMENTARY EQUIPOTENTIAL BONDING

We’ll look at the requirements for supplementary equipotential bonding then at instances where it would be required.

Initially, the scene is set by Regulation 410.3.7 which requires that if the conditions of a protective measure cannot be met, supplementary provisions shall be applied to achieve the same degree of safety.

What a protective measure?

There are four protective measures generally permitted by BS 7671:2008, given in Regulation 410.3.3:

(i) Automatic disconnection of supply (Section 411)
(ii) Double or reinforced insulation (Section 412)
(iii) Electrical separation for the supply to one item of current-using equipment (Section 413)
(iv) Extra-low voltage (SELV and PELV) (Section 414).

A note at the end of this Regulation acknowledges that, in electrical installations, the most commonly used protective measure is automatic disconnection of supply.

DISCONNECTION TIMES

Regulation 411.3.2.6 states that where automatic disconnection cannot be achieved in the required time, supplementary equipotential bonding shall be provided.

In this instance, if disconnection will not occur in the required 0.4 s, for example, supplementary equipotential bonding is used to hold various exposed-conductive-parts and extraneous-conductive-parts at substantially the same potential to limit the risk of a dangerous electric shock - this clears the confusion created by Regulation 413-7 of the 15th Edition.

Do bear in mind that supplementary equipotential bonding need not be physically carried out by the installation of single-core green-and-yellow conductors in every instance. There may be a situation where, for example, two simultaneously accessible metallic parts are in reliable contact and the resistance between the two parts is sufficiently low.
Where doubt exists regarding the effectiveness of supplementary equipotential bonding, Regulation 415.2.2 requires that the resistance, R, between simultaneously accessible exposed-conductive-parts and extraneous-conductive-parts fulfils the following condition:

In a.c. systems \( R \leq 50 \text{ V} \frac{I_a}{I}\)

Where:
- \( I_a \) is the operating current in amperes of either:
  - the protective device for RCDs, \( I_A \).
  - overcurrent devices, the current causing automatic operation in 5 s.

**Example 1**

Let's take the scenario that the protective device is an RCD rated at 30 mA:

\[
R \leq 50 \text{ V} \frac{I_a}{160}
\]

\[
R \leq 0.31 \text{ } \Omega
\]

Therefore, a maximum resistance of 0.31 \( \Omega \) will ensure there is sufficient current to operate the circuit breaker within five seconds.

**Example 2**

Let's take the scenario that the protective device is a BS EN 60898 Type B circuit-breaker, rated at 32 A. First we must establish the current causing operation of the circuit-breaker by referring to the correct time/current characteristics graph in Appendix 3 of BS 7671.

Therefore, looking at fig. 1 (extract from fig.3.4 of BS 7671:2008), we can establish that the current causing operation of the circuit breaker is 160 A.

\[
R \leq 50 \text{ V} \frac{I_a}{160}
\]

\[
R \leq 0.31 \text{ } \Omega
\]

Therefore, a maximum resistance of 0.31 \( \Omega \) will ensure there is sufficient current to operate the circuit breaker within five seconds.

**Working Standards**

The installation of supplementary equipotential bonding does not mean that a lower standard of work is permitted, nor the requirements for fault protection or the need to disconnect the supply for other reasons, such as protection against fire, thermal stresses in equipment, etc., can be omitted.

**Sizing of Supplementary Equipotential Conductors**

BS 7671:2008 has requirements for the sizing of supplementary equipotential bonding conductors in Regulation 544.2, the table shown overleaf, fig. 2, will aid with the choice of conductor.

**Where Supplementary Equipotential Bonding is Required**

Ultimately, responsibility is with the designer of the installation, who is a competent person, fully aware of the installation conditions and will use their skill and engineering
judgement to design the installation accordingly.

Where supplementary equipotential bonding is required, it may involve the entire installation, a part of the installation, an item of equipment or a location, etc. Where supplementary equipotential bonding is installed, it should include all simultaneously accessible exposed-conductive-parts of fixed equipment and all extraneous-conductive-parts.

**Exposed-conductive-part**
Conductive part of equipment which can be touched and which is not normally live but which can become live when basic insulation fails.

An example of an exposed-conductive-part is the metallic outer case of an electrical class I appliance, designed to be connected to the means of earthing at all times of operation.

**Extraneous-conductive-part**
A conductive part liable to introduce a potential, generally Earth potential, and not forming part of the electrical installation.

An example of an extraneous-conductive-part is a metallic water pipe which is buried in the ground and subsequently enters a building.

To generalise, as stated earlier, supplementary equipotential bonding is required where a disconnection time cannot be met or where a Special Installation or Location, i.e. those in Part 7 of BS 7671:2008, has an increased risk of electric shock. The following Sections of Part 7 directly reference supplementary equipotential bonding - note that other measures will be necessary to meet the requirements of BS 7671:2008.

**Section 701 - Locations containing a Bath or Shower**
Section 701 now has a relaxed requirement for supplementary equipotential bonding when the following three conditions of Regulation 701.415.2 are met:

(i) All final circuits of the location comply with the requirements for automatic disconnection

(ii) All final circuits of the location have additional protection by means of a 30 mA RCD

(iii) All extraneous-conductive-parts of the location are effectively connected to the protective equipotential bonding.

**Section 702 - Swimming Pools and Other Basins**
Supplementary equipotential bonding will connect all extraneous-conductive-parts in zones 0, 1 and 2 to the protective conductors of exposed-conductive-parts of equipment situated in these zones, in Regulation 702.411.3.3.

Regulation 702.522.21 requires that in zones 0, 1 and 2, any metallic sheath or metallic covering of a wiring system shall be connected to the supplementary equipotential bonding. The note at the end of this Regulation states that cables should preferably be installed in conduits made of insulating material. This is a relaxation from the 16th Edition as Regulation 602-06-01 states that in zones A and B, a surface wiring system shall not employ metallic conduit or metallic trunking or an exposed metallic cable sheath or an exposed earthing or bonding conductor.

Regulation 702.55.1 permits the installation of an electric heating unit embedded in the floor, provided that it incorporates an earthed metallic sheath, is covered by an embedded earthed metallic grid and connected to the supplementary...
equipotential bonding of the location (other requirements are also necessary).

Section 705 - Agricultural and Horticultural Premises
Supplementary equipotential bonding is required to connect all exposed-conductive-parts and extraneous-conductive-parts that can be touched by livestock, the metal grid laid in the floor, concrete reinforcement in general or reinforcement of cellars for liquid manure (other requirements are also necessary), in Regulation 705.415.2.1.

Regulation 705.544.2 requires that supplementary equipotential bonding conductors are protected against mechanical damage and corrosion and chosen to avoid electrolytic effects, with examples given as:

(i) Hot-dip galvanized steel strip with dimensions of at least 30 mm × 3 mm
(ii) Hot-dip galvanized round steel of at least 8 mm diameter
(iii) Copper conductor having a minimum cross-sectional area of 4 mm²

Other suitable materials may be used.

Section 706 - Conducting Locations with Restricted Movement
In a conducting location with restricted movement, Regulation 706.410.3.10 requires that a supply to fixed equipment shall incorporate supplementary equipotential bonding is used to connect exposed-conductive-parts of fixed equipment and the conductive parts of the location where automatic disconnection of the supply is the protective measure. Part e) of this Regulation requires that where the protective measure is PELV, equipotential bonding is provided between all exposed-conductive-parts, all extraneous-conductive-parts inside the conducting location with restricted movement, and the connection of the PELV system to Earth.

CONCLUSION
To summarise, supplementary equipotential bonding is required where a disconnection time cannot be met or where a Special Installation or Location, i.e. those in Part 7 of BS 7671:2008, has an increased risk of electric shock. Confusion created by Regulation 413-7 of the 15th Edition of the IEE Wiring Regulations, which effectively required supplementary equipotential bonding to reduce the risks of sparking due to the build-up of static electricity, for example. In such installations, the requirements of BS 7671 will be supplemented by the requirements or recommendations of other British Standards or by the requirements of the person ordering the work.

FURTHER INFORMATION
- BS 7671:2008 Requirements for Electrical Installations, IEE Wiring Regulations, Seventeenth Edition
- Guidance Note 3 - Inspection and Testing
- PD CLC/TR 50404:2003 Electrostatics — Code of practice for the avoidance of hazards due to static electricity
- BS EN 60079 Electrical apparatus for explosive gas atmospheres (suite of standards)
- BS EN 60079–14:2003 Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)

Thanks to Richard Rennie of Yorkshire Water for the image used.