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To bond or not to bond: domestic swimming pools

With the summer sun warming our skin and tempting us into plans for weekends spent poolside, Paul Harris BEng (Hons) CEng FIHEEM MIEE MCIBSE, of Harris Associates Ltd, looks at whether or not to bond domestic swimming pools – a question that is often put to the wet leisure industry trade associations.

Please note: in this article, earth (with no capital) refers to the earth of the electrical system, whereas Earth (with a capital) refers to the general conductive mass of the earth.

When it comes to domestic swimming pools, the question of whether to bond is a very good one and is put to the wet leisure industry trade associations, such as SPATA (Swimming Pool and Allied Trades Association), all the time. The first initial answer is: “it depends ...”.
In reality, when met with this response, it is not from a person vying for a fee, it generally does depend on the circumstances. The circumstances surrounding the installation of a swimming pool in the UK vary considerably; the main considerations are:

- where is the pool to be located?
- what type of pool construction is employed?
- What are the earthing arrangements of the electricity supply entering your premises?
- where are you locating the electrical equipment relative to the pool?

Additional risks around swimming pools

The increased risk associated with swimming pools is that of electric shock due to:

- a reduction of body resistance (because a person is wet);
- the possibility that a person is in contact with earth potential; and
- in outdoor installations, the risk of contact with the general conductive mass of the earth, which may be at a slightly different potential than the earth of the electrical system.

Due to these additional risks, requirements for safety above and beyond the general requirements placed by BS 7671 apply to basins of swimming pools, paddling pools and their surrounding zones. The additional requirements are detailed in Section 702 of BS 7671.

Reasons to bond

Traditionally, swimming pools have been located in sports complexes and, sometimes, as part of an indoor ‘extension’ to the house. In these instances there is no question as to whether to bond due to the requirements of Section 411 and Chapter 54 of BS 7671, as these require exposed- and extraneous-conductive-parts to be bonded in accordance with the requirements of regulation group 411.3 of BS 7671.

Image produced with permission from Portrait Pools & Enclosures

Where the installation is outside the house, either in a raised or a sunken pool, there is a change in circumstances and external influences to the system. In these circumstances, additional considerations need to be made and the type of earthing arrangement for the incoming supply has a significant effect on the installation design.

The main type of earthing arrangement that used to be supplied to domestic premises was TN-S, however, since the 1970s the majority of installations are provided with a TN-C-S (PME) earthing arrangement, with a relatively small number of TT supplies being provided to typically rural areas.

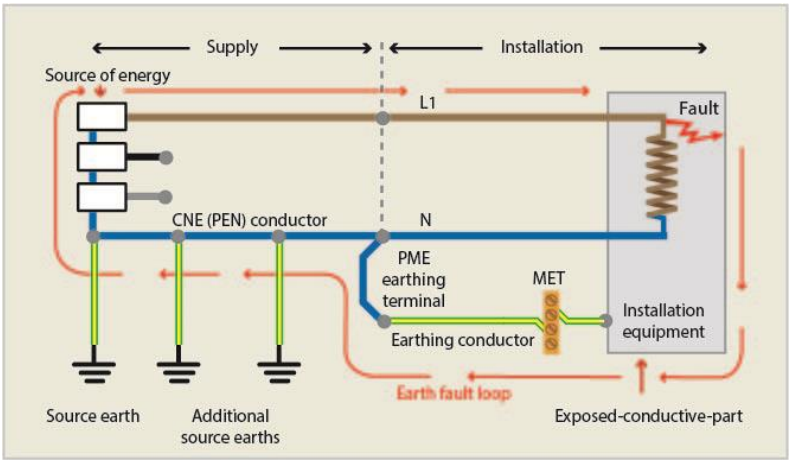
TT systems have a number of challenges with respect to RCDs, but TN-C-S arrangements provide the greatest number of challenges when dealing with swimming pools in the domestic environment.

How do you know what type of supply is provided?

Generally, this information should be available at the meter position as a label would state ‘PME terminal’. Where this is not the case, the electrical designer/installer should examine the equipment to establish the earthing arrangement. It may be possible to obtain the information from the distributor of electricity as they may have it on record but alterations could have occurred in the intervening years, so, it is always advisable for the designer/installer to establish the earthing arrangement on site. For further information, see the IET’s On-Site Guide to BS 761:2008(2011), figures 2.1 (i)-(iii).

Protective Multiple Earthing

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended) permit the Distribution Network Operator (DNO) to combine neutral and protective functions in a single conductor provided that, in addition to the neutral to earth connection at the supply transformer, there are one or more other connections with Earth. The supply neutral may then be used to connect circuit protective conductors of the customer's installation with earth if the customer's installation meets the requirements of BS 7671.



Protective Multiple Earthing (PME) has been almost universally adopted by DNOs in the UK as an effective and reliable method of providing their customers with an earth connection. This supply system arrangement is described in BS 7671 as TN-C-S.

Whilst a PME terminal provides an effective and reliable facility for the majority of installations, under certain supply system fault conditions (external to the installation) a potential can develop between the conductive parts connected to the PME earth terminal and the general conductive mass of Earth. The potential difference between true Earth and the PME earth terminal is of importance when:

- body contact resistance is low (little clothing, damp/wet conditions); and/or
- there is relatively good contact with true Earth.

The local DNO may therefore decide not to provide a PME earthing terminal for an installation such as that of a swimming pool, etc.

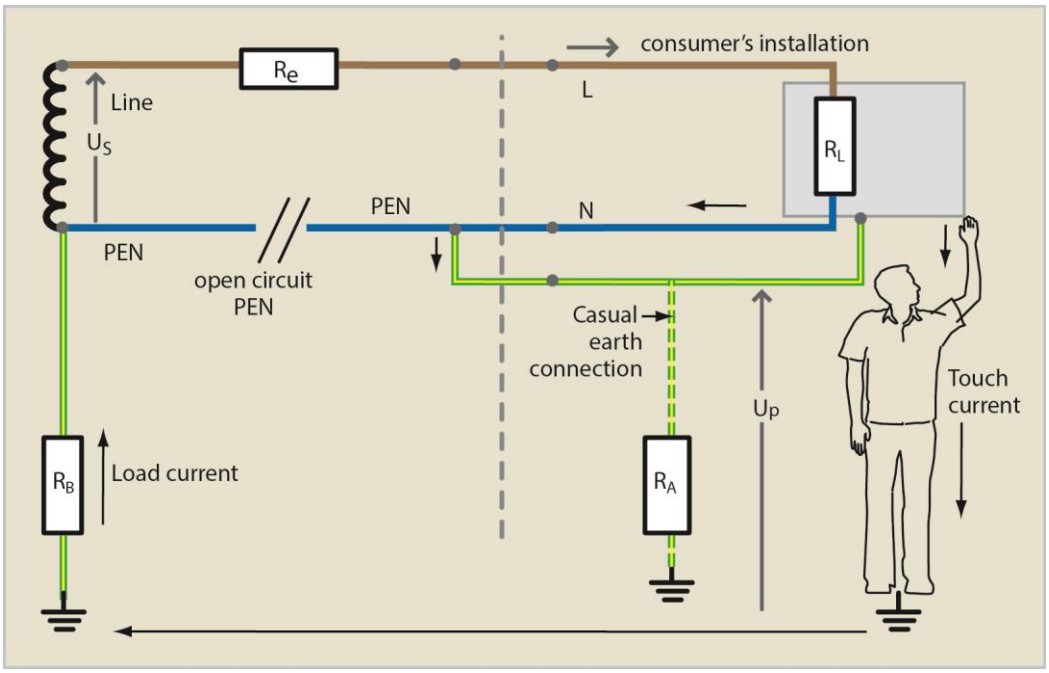
As far as BS 7671 is concerned, it does not preclude the use for an installation that includes a swimming pool but recommends that an earth mat or earth electrode of suitably low resistance, for example, 20 ohms or less, be installed and connected to the equipotential bonding.

This has two benefits.

Reducing risk of electric shock

Firstly, should a discontinuity occur in the DNO supply PEN conductor (under very exceptional circumstances), all metalwork will rise to approximately 230 V with respect to true Earth, which will in itself mean that there could be a lethal touch voltage present between the exposed-conductive parts, extraneous-conductive-parts and true Earth. In an indoor environment, this is normally adequately dealt with by the protective bonding arrangements. In an outdoor environment, there is much more likelihood that a person will come into contact with the earth of the electrical system earth, i.e. the metalwork connected to the protective bonding system and true Earth. This separate earth mat or earth electrode will help to minimise the potential difference between the two.

The diagram below assumes that there is no casual connection to true Earth in the house through protective bonding. This is, of course, a pessimistic view that all other services are isolated from earth. The additional earth electrode(s) provided outside will therefore have the effect of minimising the touch voltage in the installation. This will be further reduced if the structure of the pool forms an earth electrode itself. However, the thought of the pool structure forming the earth electrode is uncomfortable.

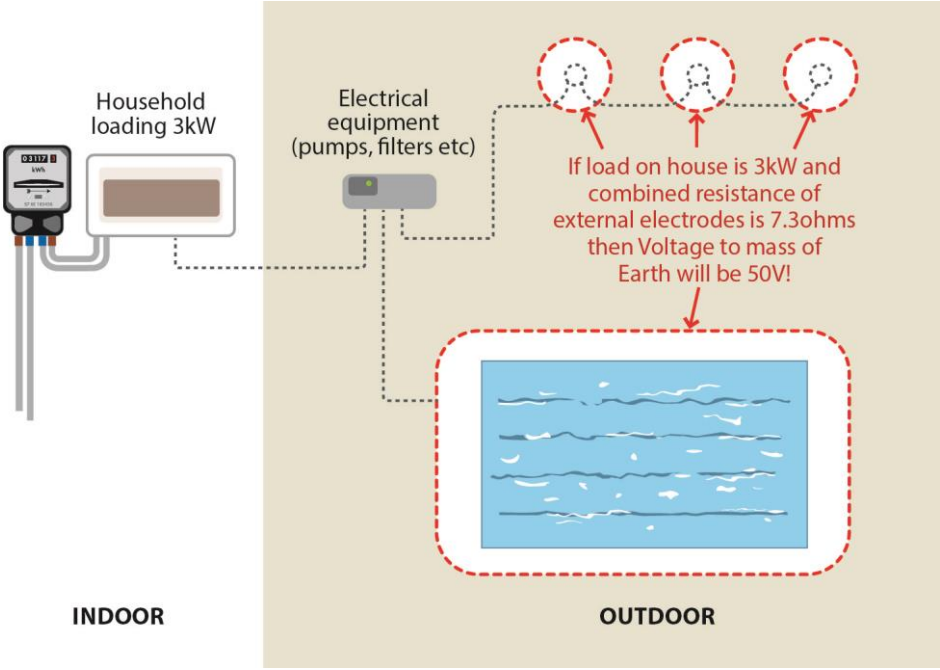


The touch voltage will be determined by the load connected within the installation and the value of the earth electrodes and any casual connections to earth that is provided by the bonded services.

Using the formula:

$$R_A = R_L \times \frac{V_p}{(V_s - V_p)}$$

Load (kW)	R_L (ohms)	R_A (ohms)		
		Vp= 25V	Vp = 50 V	V_p = 100 V
7	7.6	0.92	2.1	5.8
3	17.6	2.14	4.9	13.5
2	26.4	3.21	7.3	20.3
1	52.9	6.45	14.6	40.6



Above diagram indicating an installation with no casual connection to earth

As the table above demonstrates, to reduce the voltage to a significantly low value requires a considerable earth electrode. In the above example with the pool and additional earth electrodes, for an earth electrode resistance of 20 ohms, to restrict the value of touch voltage to a 'safe voltage' of 50 V a.c. the connected load on the system would need to be 0.73 kW.

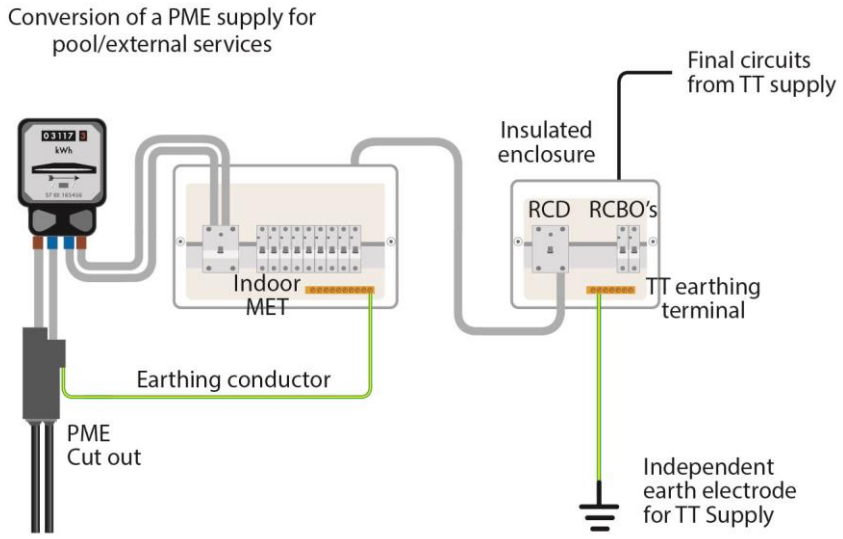
'Tingles'

Secondly, under normal operating conditions, it is possible, due to small differences in potential between the earth of the electrical system and true Earth, for a small voltage to be present. This is usually due to the voltage drop in the PEN conductor creating the difference in potential. This difference is detectable, for instance, by a wet person touching a handrail and coming into contact with true Earth. This perceived electric shock is minimised by installing the additional earth mat or earth electrodes as recommended by BS 7671, however, the most effective method of removing this risk is to provide a TT earthing arrangement and completely isolate the pool's metalwork and any pipework from the PME supply.

Customer derived TT Supplies

Often, the DNO will refuse to provide a means of earthing to a property in a rural area; commonly, where an overhead supply is the means of distributing electricity in that area. Where this occurs, the electrical installer will install an earth electrode as the means of earthing for the consumer's electrical installation. However, where PME supplies are available, it is usual to find where PME is not compatible with the proposed installation, i.e. petrol stations or remote sports pavilions with showers, that a number of these supplies have been converted to a TT earthing arrangement.

As far as swimming pools are concerned, this does not mean that the earthing arrangement for the whole house has to be changed; it simply means that, for the external supply and associated services, a TT earthing arrangement should be formed for those services. This would involve providing a supply to an insulated enclosure in which an RCD or an RCBO is installed. A separate earthing conductor and earth electrode is required, which provides the TT earthing arrangement.



Once the TT arrangement has been formed with the appropriate earth electrode it is necessary to ensure that this system and any of the pool extraneous-conductive-parts are not connected to the PME earthing system by any 'casual' connection, as this would only serve to create problems.

Once the TT system has been constructed, the relevant information should be supplied to the owners along with suitable and appropriate labelling. It is important to prevent future confusion or ‘contamination’ of the TT earthing arrangement by persons at a later date that may connect the external system to the household protective conductors in order to improve test results, etc.

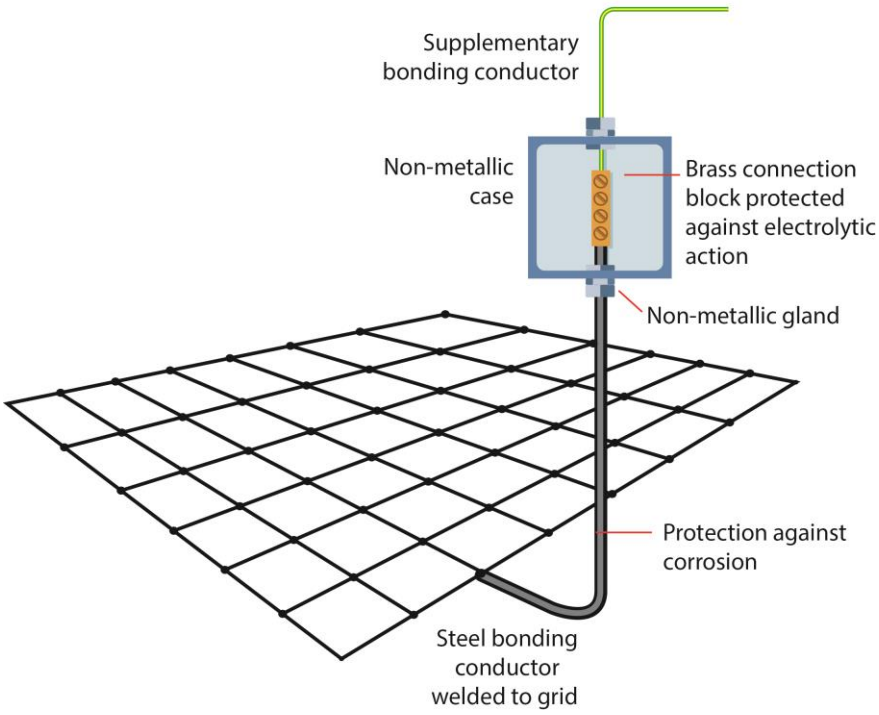
Where a TT system has been installed it is still essential to prevent a difference in potential between exposed-conductive-parts and extraneous-conductive-parts, however, this time any protective bonding that is carried out should be connected to the main earthing terminal for the TT arrangement.

Is welding necessary?

A concern that is raised by the trade is if the concrete reinforcing needs to be bonded, does a welder need to be brought in to weld the mesh together?

This is unnecessary as BS 7671 does not require reinforcing mesh to be welded. What is required is a reliable connection between mesh grids and the point at which any conductor is connected. The confusion is possibly due to a requirement in Energy Networks Association Engineering Recommendation G12/3 calling for a metallic grid to be installed in remote installations served by a PME supply.

What is required is that electrical continuity is maintained by welding or clamps.



What happens in other standards?

Reviewing the requirements for the provision of earth electrodes using the building reinforcing in BS EN 62305-2:2012 *Protection against lightning. Risk management*, it is clear that the lightning protection standards consider electrical continuity to be achieved where there is an overlap in the mesh by 20 x the diameter of the reinforcing bar and the reinforcing mesh is bound together by wire or proprietary clamps. As a result, whilst welding is ideal, there are other methods of ensuring the continuity of the reinforcing bar.

Conclusion

In conclusion to the question of whether or not to bond, the answer should be yes, but take into account the impact of what you are bonding.

Where a PME earthing arrangement is in place, is the protective bonding going to bring about further problems in terms of potential risk relating to discontinuity (failure) of the neutral conductor and the no-fault situation, which is the potential for perceived shocks (tingles from a perfectly normal PME supply). Whilst an electric shock is our concern and should be a 'never' event, the potential for 'tingles' experienced from a perfectly healthy PME supply system with correct protective bonding in place is cause for concern – and, as far as customer relationships are concerned, probably quite damaging!

Where the property is supplied by a PME earthing arrangement, the person responsible for the design should be aware of all the above factors and consider other approaches. This would usually be to provide a TT supply to the pool and outside services with the appropriate documentation and labelling to ensure that there is no 'contamination' of the TT earthing arrangement.