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Earth Bonding

by Paul Cook of the Institute of Electrical Engineers

You do not have to earth plastic pipes

Plastic pipes make for a safer electrical installation and reduce the need for earthing. Festooning an installation that has been plumbed in plastic pipe with green and yellow earth wire is not necessary and of likely to reduce the level of electrical safety of the property, not increase it.

Everyone knows that water and electricity do not mix, that the risk of electric shock is greater when there is water around. They know that the risk and severity of an electric shock is increased as a result of the presence of water. This may be the reason for the concern that water in plastic pipes may conduct electricity and that bonding is required. Because of this, the IEE commissioned the Electrical Research Association to carry out measurements of the electrical conductivity of water in plastic pipes.

The ERA tests confirm that tap water in a plastic pipe is a poor conductor of electricity. One metre of 15mm diameter of plastic pipe filled with tap water from Leatherhead where the ERA are based, has resistance of 100,000 Ohms. This one metre of 15mm pipe will restrict currents to less than fatal values and of course in practice, there would be many metres of pipe between metal items of plumbing equipment and earth.

The resistance of water varies around the country, it is reduced by impurities, not all of which are harmful. The additives put into water of central heating systems to reduce corrosion make the most difference, as can be seen from the table below.

	Resistance - Ohms
15mm diameter, tap water	115,000
20mm diameter, tap water	65,000
15mm diameter, tap water with double dose of inhibitor at 60 deg. C	20,200

So why do wet hands and immersion in a bath increase the risk of electric shock?

The human body plus clothes, particularly shoes has an impedance of about 3,000 Ohms - see next table. At 230 volts this will result in a current of about 153mA (153 thousandths of an amp). This is not nice, but is unlikely to kill you. If there are no shoes and hands are wet, the impedance falls to 500 Ohms and the current at 230 volts is 460mA. This is getting decidedly unpleasant. Immersion of the body in a bath, in effect halves the impedance of the body and current at 230 volts would be then 1,000 mA. This is dangerous, and can kill.

Situation	Body Impedance	Current at 230 V
Dry with shoes	3000 + Ohms	76 mA
Dry	1500 Ohms	153 mA
Wet	500 Ohms	460 mA
Body 1/2 immersed	250 Ohms	920 mA

Horny dry hands and feet are quite good insulation. However, if the hands are wet, salts and contaminants improve the contact and reduce the resistance of the skin. Dry skin has a high resistance, wet skin has a relatively low resistance.

The other reason why bathrooms and such places are relatively risky electrically, is the presence of earthed metal. Should you be unfortunate enough to touch the live parts of broken equipment and nothing else except say a well insulated floor, there would be little result. Electrical jointers and fitters regularly work live under such controlled conditions. However if you touch a live part and an earthed metal pipe, then you get a very dangerous electric shock.

An earthy environment where there are lots of metal pipes is potentially less safe than an earth free environment. We can now start to see why plastic pipe installations are going to lead to safer installations. For a start, there is not all that earthed metal around.

The bonding requirements for plastic piped and metal pipes installations is described below.

At the Service Position - Main Bonding

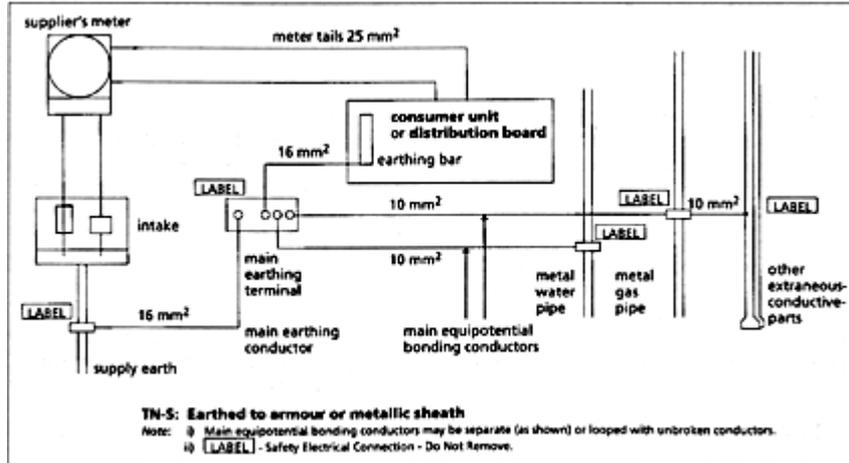
In each electrical installation, main equipotential bonding conductors (earthing wires) are required to connect to the main earthing terminal for the installation of the following:

•	metal water service pipes
•	metal gas installation pipes
•	other metal service pipes and ducting
•	metal central heating and air conditioning systems
•	exposed metal structural parts of the building
•	lightning protection systems

It is important to note that the reference above is always to metal pipes. If the pipes are made of plastic, they do not need to be main bonded.

If the incoming pipes are made of plastic, but the pipes within the electrical installation are made of metal, the main bonding must be carried out. The bonding being applied on the customer side of any meter, main stopcock or insulating insert and of course to the metal pipes of the installation.

The connections of the bonding wired to the pipes has to be made with a proper clamp to BS 951 complete with the label "SAFETY OF ELECTRICAL CONNECTION - DO NOT REMOVE."



If the incoming services are made of plastic and the pipework within the building is of plastic then no main bonding is required. If some of the services are of metal and some are plastic, then those that are of metal must be main bonded.

In the bathroom - Supplementary Binding

Supplementary or additional equipotential bonding (earthing) is required in locations of increased shock risk. In domestic premises the locations identified as having this increased shock risk are rooms containing a bath or shower (bathrooms) and if you are lucky to have one, in the areas surrounding swimming pools.

Please note, there is no specific requirement to carry out supplementary bonding in domestic kitchens, wash rooms and lavatories as they do not have a bath or shower. That is not to say that supplementary bonding in a kitchen or wash room is wrong (it would be wrong for plastic pipes!) but it is not necessary.

For plastic pipe installation within a bathroom the plastic pipes do not require supplementary bonding and metal fittings attached to these plastic pipes also would not require supplementary bonding.

It seems to be the practice of some builders to effect all the plumbing in plastic except for those bits of the pipework that are visible. These short lengths of metal pipework supplied by plastic pipes or metal taps connected to plastic pipes, metal baths supplied by plastic pipes and with a plastic waste do not require supplementary bonding.

However, electrical equipment still does require to be supplementary bonded and if an electric shower, or radiant heater is fitted, they will require to be supplementary bonded as usual.

This requirement does not apply to class II or all insulated equipment where no metal work that is likely to become alive in the event of a fault, is accessible. However, it is recommended that supplementary bonds are run to the earth terminals of all electrical equipment accessories e.g. flex outlets, or the equipment itself, as class II equipment may be replaced by class I during the life of the installation.

Figure 1 shows the supplementary bonding in a bathroom where the house is plumbed with metal pipes and figure 2 shows the supplementary bonding required in a bathroom where the pipework is plastic.

Metal radiators supplied by plastic pipes should not be supplementary bonded. It is safer not to supplementary bond them. Locations generally are safer if the location is earth free as discussed earlier.

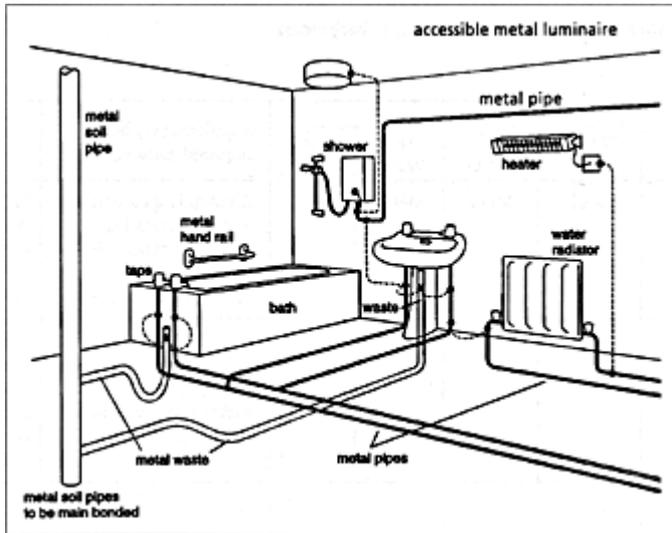


Figure1: Supplementary bonding in a bathroom - metal pipe installation

Notes:

1. All simultaneously accessible metal (class I) equipment (e.g. electrical heaters and showers), central heating pipes, hot and cold water and waste pipes require supplementary bonding in or close to the bathroom.
2. Metal baths not connected to a metal building structure do not require supplementary bonding if all metal pipe connected to them has been connected.
3. Connections to pipes to be made with BS 951 clamps (complete with "Safety Electrical Connection" label).

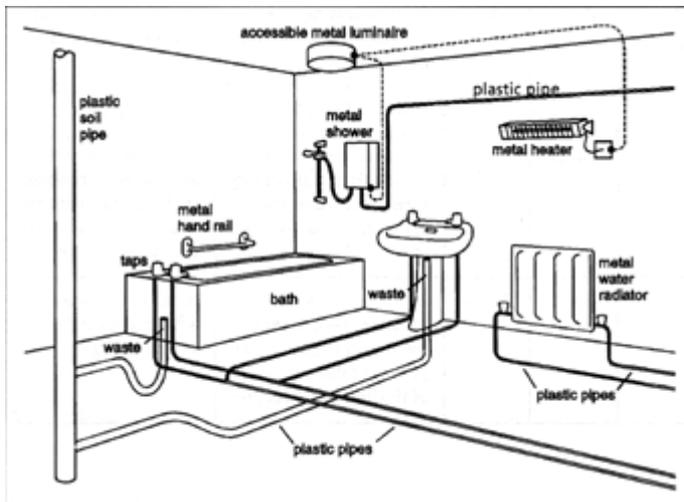


Figure1: Supplementary bonding in a bathroom - plastic pipe installation

Notes

1. Metal (class I) items of equipment (e.g. electrical heaters and showers) require supplementary bonding if simultaneously accessible. Supplementary bonds to be connected to the protective conductors of each circuit at the accessory point.
2. Supplementary bonding of short lengths of copper pipe (less than 0.5m in length) installed where the pipes are visible, is not necessary.

There are many possible combinations of metal and plastic pipe arrangements in a bathroom. To try and answer questions regarding the supplementary bonding required in a number of permutations of copper and plastic pipe, table A has been prepared.

Pipework Material				Supplementary bond required between	Comments	
	Waste Pipes	Cold Water	Hot Water			Central Heating
1	Metal	Metal	Metal	Metal	All metal pipes, earth terminals of class I equipment, and accessible exposed-conductive parts of the building structure	Metal pipes can be used as bonding conductors if joints are metal to metal and electrically continuous
2	Plastic	Plastic	Plastic	Plastic	Earth terminals of class I equipment and accessible exposed-conductive parts of the building structure	Bonding of metal taps, metal radiators or metal baths is not required unless the bath is connected to the metallic building structure
3	Plastic	Plastic	Metal	Metal	Hot water pipes, central heating pipes, earth terminals of class I equipment and accessible exposed-conductive parts of the building structure	A bond is not required to the taps, nor metal baths unless connected to the metallic building structure
4	Plastic	Plastic	Plastic	Metal	Central heating pipes, the earth terminals of class I equipment and access to exposed-conductive-parts of the building structure	Bonding of metal water taps is not required, nor metal baths unless connected to the metallic building structure
5	Plastic	Metal	Metal	Metal	All metal pipes, earth terminals of class I equipment, and accessible exposed-conductive parts of the building structure	Metal pipes themselves can be used as bonding conductors if joints are metal to metal and electrically continuous
6	Plastic	Metal	Metal	Plastic	All metal pipes, earth terminals of class I equipment, and accessible exposed-conductive parts of the building structure	Metal central heating radiator does not require bonding

Notes:	
1. Supplementary Bonding is carried out to the earth terminal of equipment within the bathroom with exposed-conductive part. A supplementary bond is not run back to the main earth	3. Metal baths are supplied by metal pipes do not require supplementary bonding if all the pipes are bonded and there is no other connection of the bath to earth
2. Metal window frames are not required to be supplementary bonded unless they are electrically connected to the metallic structure of the building	4. All bonding connections must be accessible and labeled "Safety Electrical Connection - Do Not Remove".