MEDICOS SIN FRONTERAS

ELECTRICAL SAFETY GUIDELINE

GUIDELINE

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Grounding contributes for the safety of electrical installations, which in principle should respect the following principles in order to guarantee the safety of personnel, infrastructure and equipment:

- Be well organized and the electrical equipment must be in good working condition (electrical outlets, switches, etc.)
- Have a good ground
-

Have electrical protection devices in place, and specially a residual current device (RCD) protection verified monthly

CHAPTER 1: THE ELECTRICAL INSTALLATION

1.1-The components of a good installation

The following components are found in a good electrical installation :

- Wires
- Connection boxes, terminal connectors and conduit
- Electrical outlets
- Lights and light switches

All these items allow the utilization of electricity at no danger for the user, diminishing the possibility of direct or indirect contact between the user and the electrical current, and that way preventing a probable electrocution.

1.2-Wires

Wires are used to transport electricity, which are considered active elements in the electrical liaisons.

There are two types of wires, the insulated wires and the cables.

- **Insulated wires :**
  They are made of a conducting core and an insulating cover. The core is usually in copper. It can be solid copper (solid wire) or made by multiple copper strands (flexible wire).

- **Cables:**
  The cables are made by grouping insulated wires under a secondary protection layer. The secondary protection layer can be in rubber, PVC or other materials depending on the application.

In France the standard imposes a colour code for wires in an installation. This code must be followed when there is no standard in place in the country.

- Phases : Red, black, brown or all other colours except blue and green/yellow
- Neutral : Blue
- Ground : Green/yellow

If the country has a colour code, the national colour code should be respected.

1.3-Installation of wires

Wires can be installed apparent on the wall's surface or embedded in the wall. In our missions, we prefer installation apparent on the wall if renovating a structure. In this case we can choose between direct fixation on the walls, wires in a plastic conduit or wires in a moulding. Of these options we recommend the first two.

- **ATTENTION – MSF RECOMMENDATION:**

Some rules to follow for the installation depending on the chosen method:

Direct fixation on the wall:

- **Cables to use : U 1000 R2V , FR-N 05 VV-U, A05 VV-F**
- **Bending radius :**
    - **Non armed cable : 8 times its diameter**
- **Fixation with cable holders in plastic adapted to the cable's diameter :**
    - **1 meter between each vertical fixation**
    - **0.45 meters between each horizontal fixation**
- **Avoid direct fixation of coiled wires or flat cables.**
- **A sheath must be used when going through walls**

Fixation in a plastic conduit :

- **Cables to use : H 07V-U, R or K, U 1000 R2V**
- **Respect the rule of 1/3 : the total cross section of the wires must not be bigger than 1/3 of the internal cross section of the conduit.**
- **Fixing accessories must be adapted to the conduit diameter :**
    - **0.8 meters between each fixing point.**

1.4-Relationship of power and wire's cross section

Wire's capacity is determined by its cross section. Each cross section has a maximum amperage, hence a maximum capacity of power to transport :

Wire capacities and protection			
Power to transport (in Watts)	Wire cross section copper (in mm²)	Tripping curent of circuit protection device	
		Miniature Circuit Breaker	Fuse
2000	1,5	10	-
4250	2,5	16	16 (3500 W)
5500	4	25	20
7250	6	32	25

The maximum power corresponds to a maximum intensity that the wire can withstand without deteriorating. It is for this reason that the wire is protected with a thermo-magnetic miniature circuit breaker (MCB) with a tripping current corresponding to the maximum intensity that the cable can withstand.

It must be noted that cable sizing depends also on the distance to transport power. In order to prevent a significant voltage drop, the cable cross section should be adapted to the distance to cover. The tables shown below make the correlation between the power to transport and the maximum distance in order to have an acceptable voltage drop. The tables shown are 1 for single phase and the other for three phase power.

Table for copper wire, 220 V Single Phase, cos φ = 1

Power in kW	Intensity in A	Wire cross-section in mm²							
		2	**2,5**	**4**	**6**	**10**	**16**	**25**	**35**
0,5	2,3	100	165	265	395				
1	4,6	50	84	135	200	335	530		
1,5	6,8	33	57	90	130	225	355	565	
2	9	25	43	68	100	170	265	430	595
2,5	11,5	20	34	54	80	135	210	340	470
3	13,5	17	29	45	66	110	180	285	395
3,5	16	14	24	39	56	96	155	245	335
4	18		21	34	49	84	135	210	295
4,5	20		19	30	44	75	120	190	260
5	23			27	39	68	105	170	235
6	27			23	32	56	90	140	195
7	32				28	48	76	120	170
8	36					42	67	105	145
9	41					38	60	94	130
10	45					34	54	84	120
12	55						45	70	98
14	64						38	60	84
16	73							53	74
18	82							47	65
20	91								59
25	114								
30	136								
35	159		Overheating limit						
40	182								
45	205								
50	227								
60	273								
70	318								

Table for copper wire, 380 V Three Phase, cos φ = 0,8

Power in kW	Intensity in A	Wire cross-section in mm²								
		2	**2,5**	**4**	**6**	**10**	**16**	**25**	**35**	**50**
2,5	5	190	325	510	745					
3	6	160	270	420	620					
3,5	7	135	230	365	540	895				
4	8	120	200	320	470	785				
4,5	9	105	180	285	420	700				
5	10	96	165	255	375	630	970			
6	12	79	135	210	315	525	810			
7	14	68	115	180	270	455	700			
8	16	60	105	160	240	400	610	940		
9	18	51	92	145	215	355	550	850		
10	19		84	130	190	320	500	780		
12	23		69	110	160	265	415	640	880	
14	27			94	140	230	355	550	750	
16	31			81	120	200	315	485	655	860
18	35				110	180	280	430	580	770
20	38				98	160	255	390	520	690
25	48					130	205	315	420	555
30	57						170	260	355	465
35	67						145	225	300	400
40	76							195	260	350
45	86							175	235	310
50	95							160	215	285
60	114								180	235
70	133		Overheating limit							200
80	152									
90	171									
100	190									
120	228									
140	266									
160	304									
180	342									

Note: the lengths are expressed in meters.

1.5-The conduits

Conduits protect wires when these are installed on the wall's surface. They have different characteristics such as water tightness, mechanical resistance (shocks) and they do not propagate fire.

- **ATTENTION – MSF RECOMMENDATION:**

Conduits must be used when with insulated wires. Cables can be installed without conduit. The following conduits are recommended :

Indoors:

- **IRL 3321 – insulating, rigid and smooth**

- **ICTA 3422 – insulating and flexible**

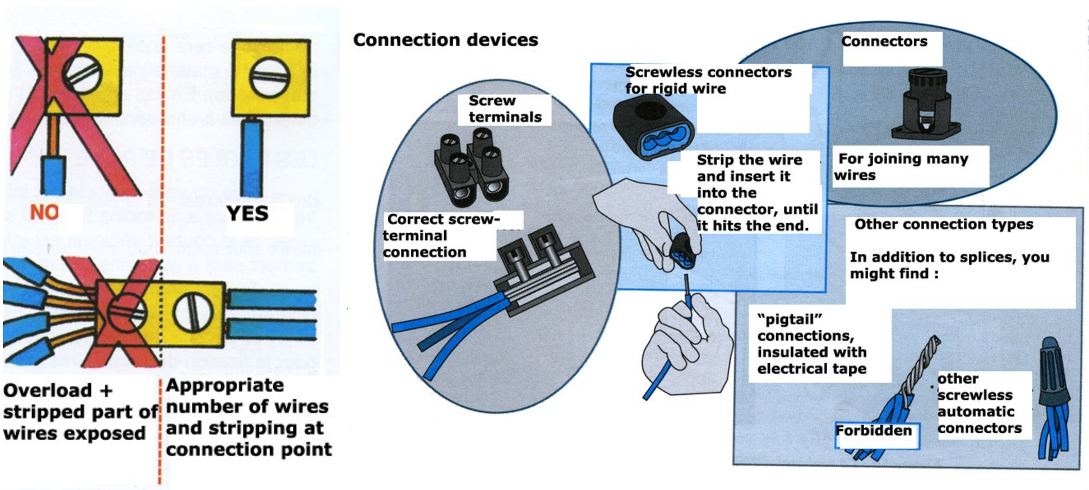
Outdoors:

- **TPC – insulating, flexible, double wall, smooth interior and rigged exterior**

1.6-Connections

In order to have a reliable connection, wires must be connected with the use of connection terminals such as dominoes, screwed or screw less connection terminals and these must be made in a junction box.

The following illustration shows how to make a proper connection :

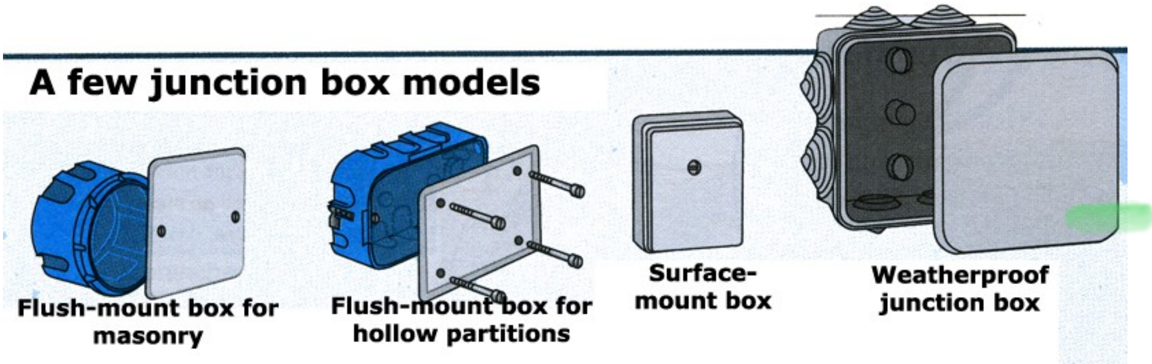


In the case of the dominoes, a double connection is more reliable, so it should be used when possible.

- **WARNING** do not shave off the wire's core (for solid wire) or cut any copper strands (for flexible wire), because the wire's cross section will decrease and it will not have its original power transport capacity. The electrical installation's reliability and safety (fire risk) depend on the quality of connections.

1.7- Junction boxes

Junction boxes are destined to house wire connections for circuit distribution or liaisons. Junction boxes can be installed on the wall's surface or embedded in the wall. In the boxes, all connections must be made by using connection terminals. Junction boxes must be used wherever there are wire connections and their cover should remain accessible for future maintenance.



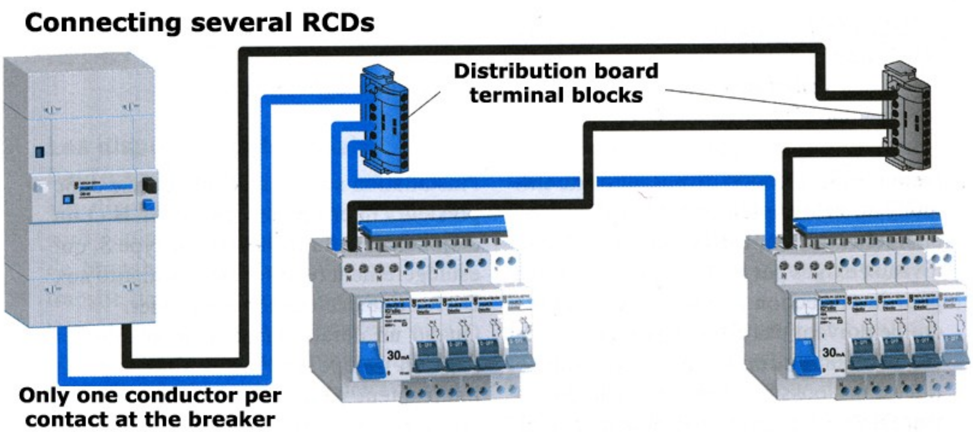
- **ATTENTION – MSF RECOMMENDATION:**

For our installations, all wire junctions must be made at the aid of terminal connections, such as dominoes, and must be in junction boxes (waterproof for outdoor applications).

1.8-Protection devices connections

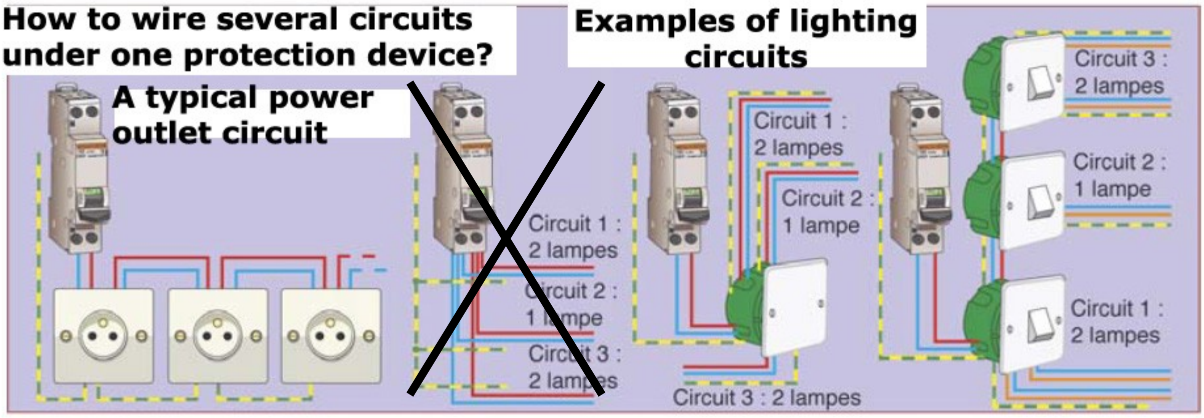
<u>Connections between the main circuit breaker and residual current devices</u>

Use terminal blocks to connect several residual current protection devices under the main circuit breaker, since there should never be more than one conductor per connector at the main breaker.



Connections of several wires of a circuit to its protection

MCBs are meant to receive one wire per terminal. Therefore, to connect several wires of the same circuit to its protection, a junction box must be used as illustrated below:



To Avoid

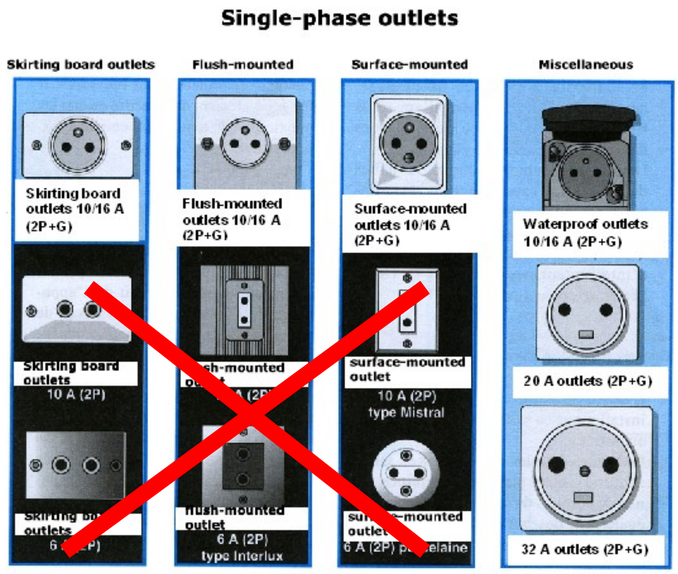
1.9-Distribution circuits

Electrical outlet circuits

Electrical outlets are meant to supply power to appliances with or without grounding connection.

For single phase networks, electrical outlets used are usually 2 poles (2P) or 2 poles plus ground (2P+G). See the examples in the illustration below:

OUTLETS WITHOUT GROUND ARE FORBIDDEN

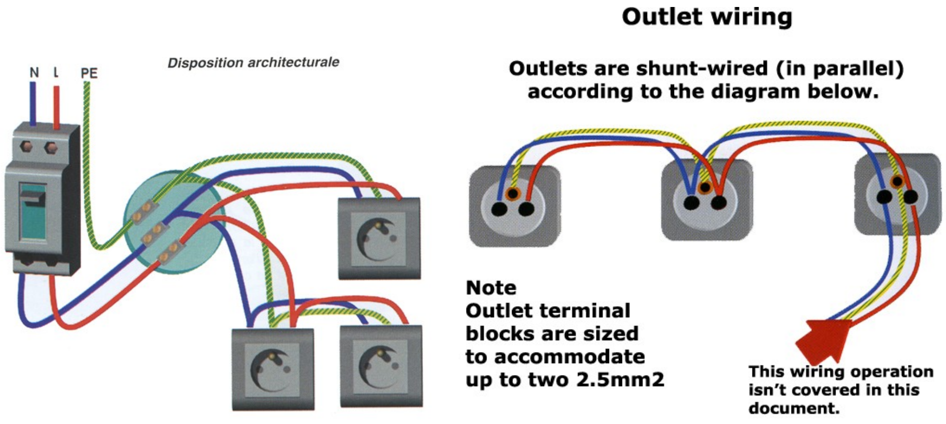


6, 10, 16, 20, and 32A represent the maximum allowable current in amperes;
P indicates the number of poles
G Indicates the presence of a ground contact
Only outlets on a blue background meet current standards; the other models are obsolete.

For our missions it is mandatory to use outlets with a ground contact, therefore 16A (2P+G), 20A (2P+G), and 32A (2P+G), depending on the appliance's power demand.

- **WARNING: There is a wide variety of old outlets and they are rarely equipped with a ground contact. These outlets do not respect the actual security criteria.**

16 amp outlets are connected in parallel, according to the diagram shown below. These can be interconnected by using a junction box or by shunting from one outlet to the next.



The maximum number of 16A outlets per circuit is limited to 8 single outlets and power must be supplied with 2.5 mm² wires.

Electrical outlets of 20 and 32A supply power to specific circuits. One circuit must be dedicated to one outlet maximum. Power must be supplied in 4 mm² for the 20A outlets and 6 mm² for the 32A outlets.

- **ATTENTION – MSF RECOMMENDATION:**

For electrical outlet circuits the following table must be respected:

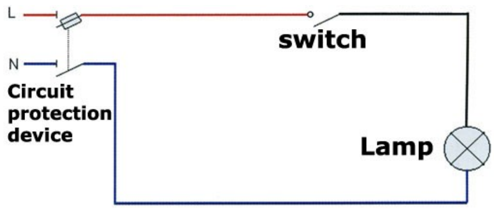
Number of utilisation points by type of circuit				
Type of circuit	Maximum number of points	Wire cross section copper (in mm²)	Tripping curent of circuit protection device	
			Miniature Circuit Breaker	Fuse
Electrical outlet circuits 16 A	8	2,5	16	10
Electrical outlet circuit 20 A	1	4	20	20
Electrical outlet circuit 32 A	1	6	32	32

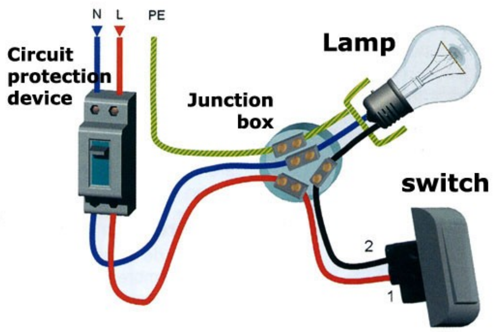
1.10 - Lighting circuits

The one-way lighting circuit

The one-way lighting circuit is the simplest set-up. There is only one control – the switch – which cuts the circuit's phase. The neutral and the earth connect directly to the light fitting.

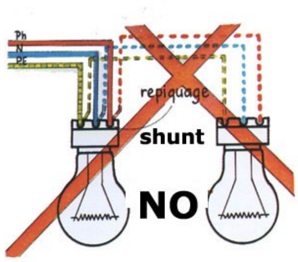
Care should be taken to make sure that the wire from the switch to the light fixture is a different colour than the inlet phase—orange, for example. We call this the "load wire."

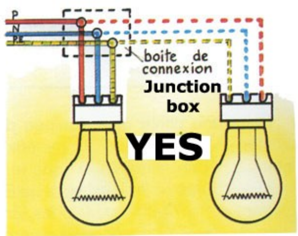


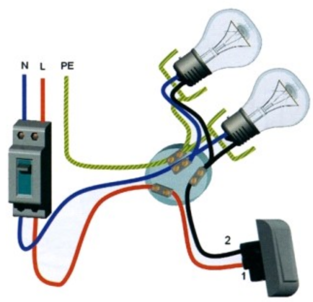


- **WARNING : The ground wire is mandatory in all lighting circuits, even if the some light fixtures do not have a ground connection point.**

Several lighting points can be governed by the same switch by connecting them by the means of a junction box and not by shunting at the light socket:







Power for lighting circuits must be supplied with 1.5 mm² cross section wires. Lighting circuits must have a maximum of 8 points of utilization.

- **ATTENTION – MSF RECOMMENDATION:**

For lighting circuits the following table must be respected:

Number of utilisation points by type of circuit				
Type of circuit	Maximum number of points	Wire cross section copper (in mm²)	Tripping curent of circuit protection device	
			Miniature Circuit Breaker	Fuse
Lighting circuits	8	1,5	10	6

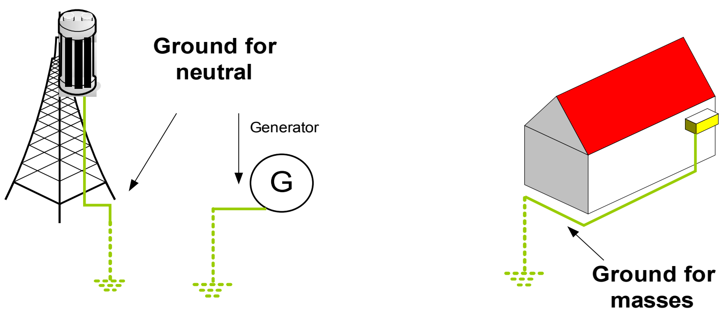
- **ATTENTION – MSF RECOMMENDATION:**

For all outdoor applications, all electrical accessories (outlets, lighting, switches and junction boxes) must be weatherproof.

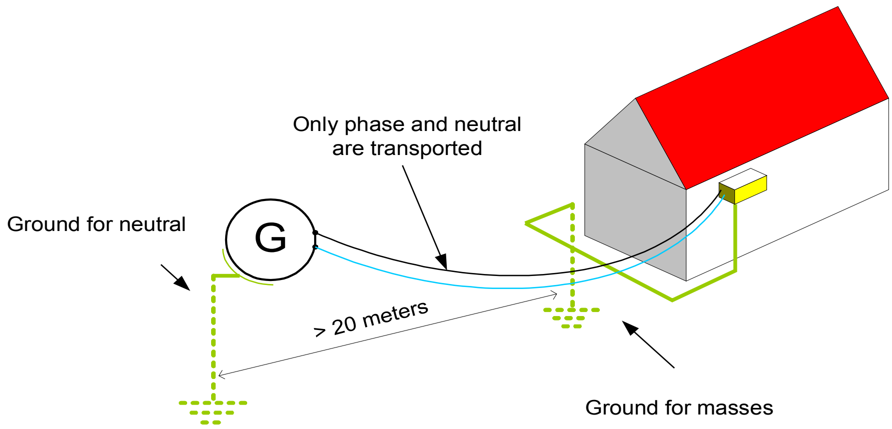
CHAPTER 2 : GROUNDING

2.1-Types of grounding in an electrical installation

There are two types of grounds, the ground for the neutral (for the generators or the power company transformer), and the ground for the masses (for the metallic parts on site).

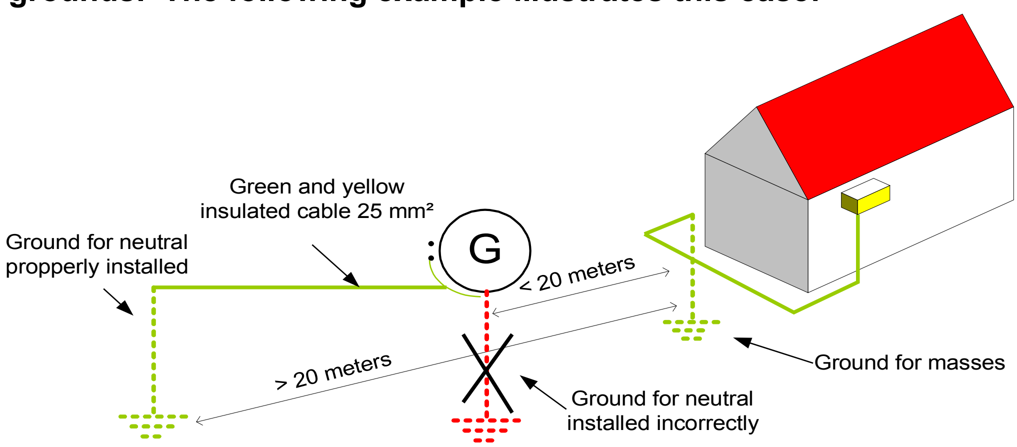


A distance of 20 meters (minimum) should be respected between the ground for the neutral and the ground for the masses. The ground for the neutral must never be connected to the ground for the masses.



ATTENTION – MSF RECOMMENDATION:

If the generator is located at less than 20 meters from the ground for masses, it will be the ground for the neutral which will be displaced using an isolated 25 mm² conductor in order to respect the 20 meters separation between the two grounds. The following example illustrates this case:



2.2-The ground for neutral

The ground of the neutral is used for the generators and/or for the transformer of the power supplier.

For the generator

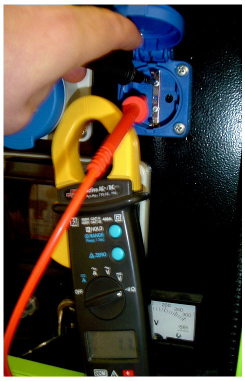
In the case of the generator, the metal housing of the generator is connected to a grounding peg in order to create the ground for the neutral. After grounding the housing, it is compulsory to verify that the liaison between the neutral and the ground has been established by testing the continuity between the neutral and the ground at the generator's outlet.

How to do it:

1. **Disconnect all loads and turn the generator off.**
2. **Make sure that the breaker is on the ON position.**
3. **Measure the continuity between the ground and the neutral at the generator's outlet. There should be continuity and the resistance should be close to zero.**

Ground/N 0.3 Ω

Phase/N 1 Ω



Phase/Ground 1,1 Ω

***NOTE:* If this test is performed between the phase and the neutral, it will be seen that there is also continuity between both, but with a higher resistance (due to the generator's coil).**

For the transformer

In the case of the transformer, it is the power supply company who creates the ground of the neutral. It is therefore needed to contact the supplier to verify if the neutral of the supply network is grounded.

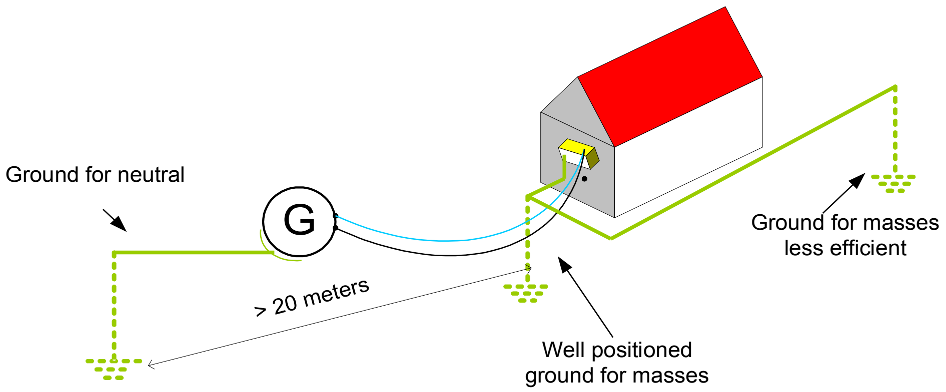
- **ATTENTION – MSF RECOMMENDATION:**

  If the neutral of the generator or the transformer are not grounded, stop using the source and contact your supervisor for technical advise.

2.3-Ground for masses

The ground for the masses is the grounding in the building (in electrical outlets, lighting, metal housings, metal parts of the building, etc.), It is always present where there is a phase and the neutral, and it bonds all metal parts on site to create the equipotential bonding (piping, frames, etc).

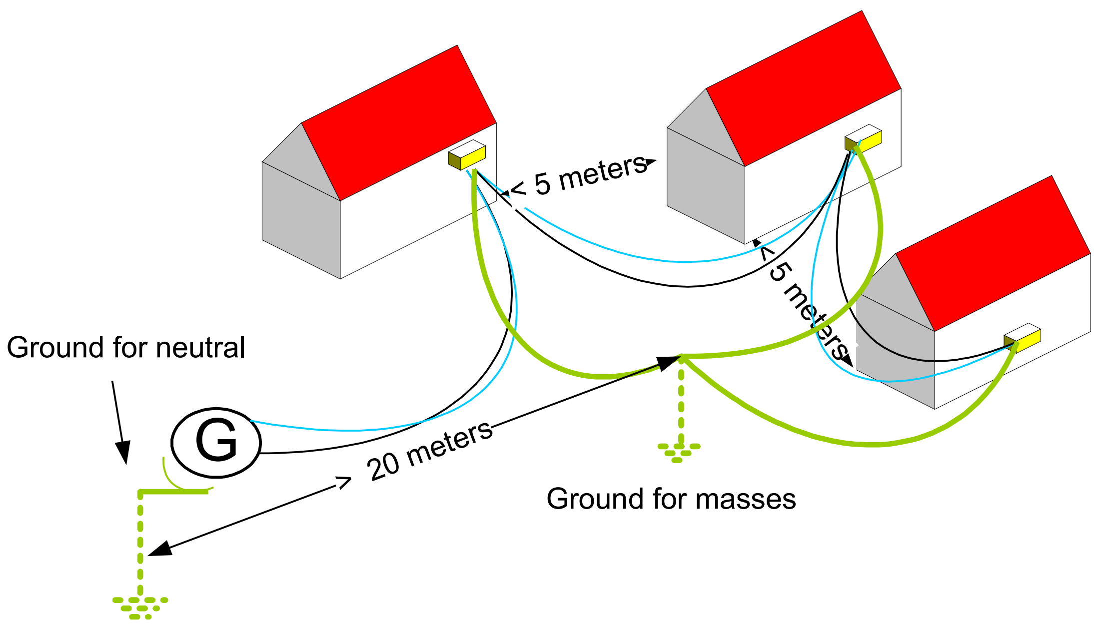
The ground for the masses should be as close as possible to the distribution board and the structure to protect. If possible, it should also be oriented towards the ground for the neutral.



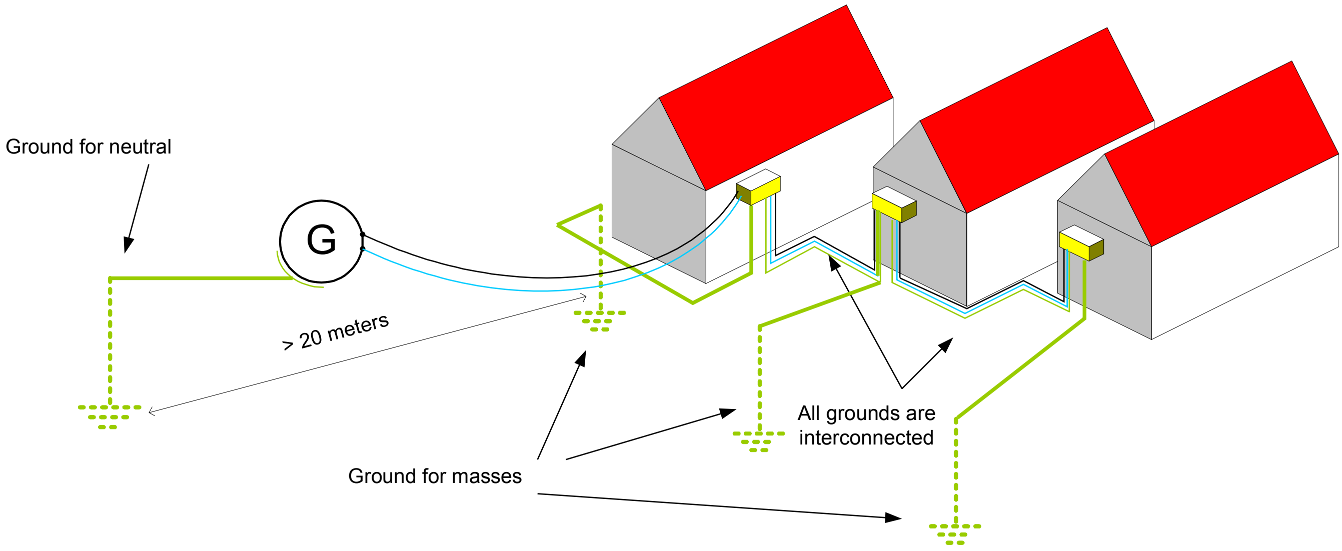
- **ATTENTION – MSF RECOMMENDATION:**
  If there are several buildings with sub-distribution boards, <u>all "grounds for masses" must always be interconnected.</u>

Following, two examples of how to install the ground for the masses and to interconnect them between each other:

1. Install the grounding peg in a central point and share it between the buildings.



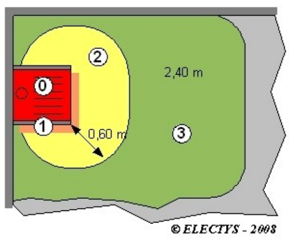
2. Install a ground for each building and its distribution board. All grounds for masses should be interconnected.



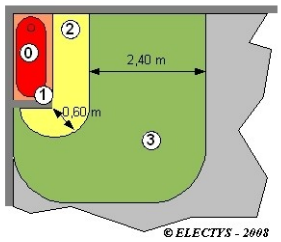
2.4-Rules to respect when installing the ground for the masses in the building

1. Humid Areas

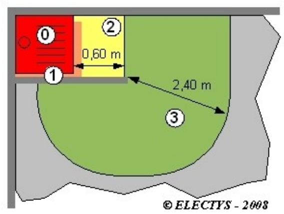
Zones are ranked differently, depending on their risk level. The following examples can be applied to all humid areas such as bathrooms, sterilisation rooms, or laundry rooms.



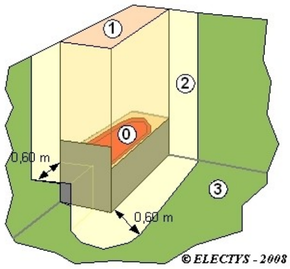
Cabine de douche



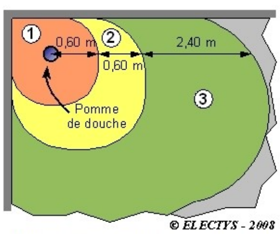
Baignoire ou douche fixe



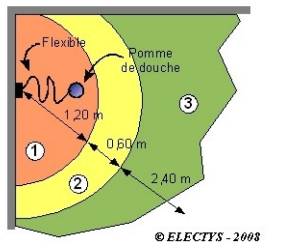
Douche avec paroi débordante



Paroi n'atteignant pas le plafond



Douche sans receveur et pomme de douche fixe



Douche sans receveur et pomme de douche avec un flexible

- **ATTENTION – MSF RECOMMENDATION:**

In our missions, it is better to follow the following recommendations:

Zones 0,1, and 2: no electrical outlet, lighting or equipment must be installed.

Zone 3: all electrical appliances and exposed metal parts must be grounded.

<u>**CHAPTER 3: EQUIPOTENTIAL BONDING**</u>

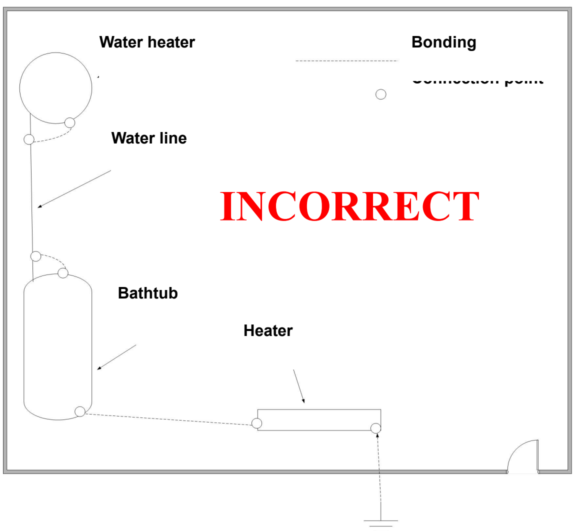
Equipotential bonding links all exposed metal parts of the building in order to assure that they are at the same potential (a difference in potential creates a voltage which could be dangerous).

An example of an equipotential bonding in a metallic pipe in a bathroom can be seen in the following picture:

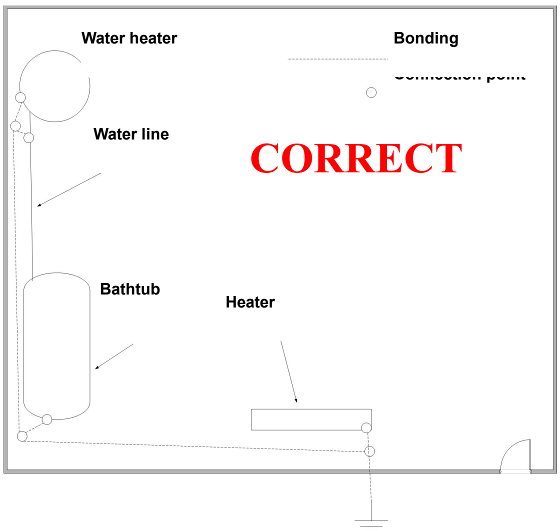
- Bonding must be made with a wire of 2.5 mm².
- Paint or corrosion must be removed before bonding

- **ATTENTION – MSF RECOMMENDATION: the continuity of the grounding must not be assured by foreign elements, in order to prevent discontinuity by mistake. Refer to the following illustration:**

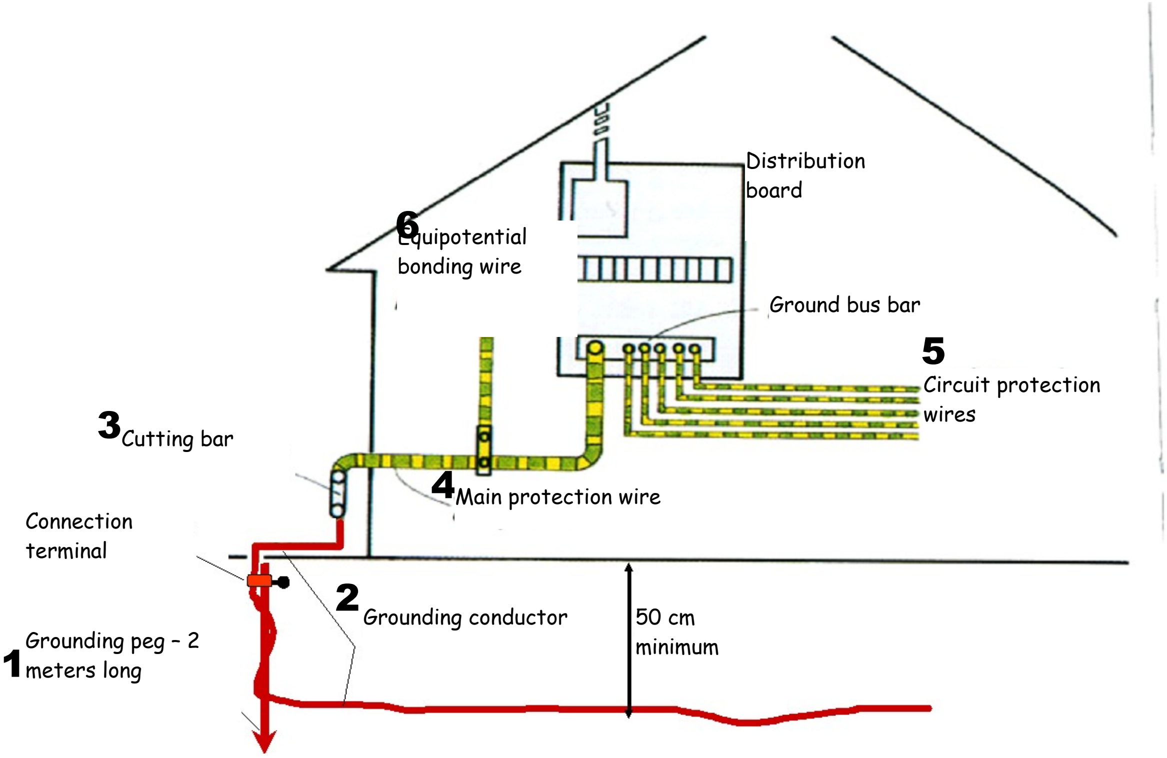
In this figure, the continuity is assured by elements foreign to the bonding circuit, which is incorrect.



In this case, the grounding is assured by and only by the bonding circuit, which is correct.



3.1-Wires ires used for the grounding network of an installation



1. **The grounding peg**
   The peg is buried, which in turn makes contact with the ground. The peg must be 25 mm in diameter and 2 meters long. It must be in copper or steel with a copper layer. Its total length should be in contact with the soil and buried vertically.
2. **The grounding conductor**
   It increases the surface area in contact with the ground, and it connects the grounding peg to the cutting bar. Its cross section must be minimum 25 mm² in bare copper and 10 meters long.
3. **The cutting bar**
   It makes the connection between the grounding peg and the building's grounding network. It is used to isolate the grounding peg from the building's installation, in order to be able to measure resistance values.
4. **The main protection wire**
   It makes the connection between the cutting bar and the distribution board. Its cross section must be minimum 16 mm² of green/yellow insulated wire.
5. **The circuit protection wires**
   They are also green/yellow insulated wires. They go from the ground distribution bus bar, in the distribution board, to all electrical outlets, lighting fixtures, and equipment. Its cross-section must be equal to the cross-section of the active wires (phase and neutral). Example: A circuit for a sterilizer with a 4 mm² wire must have a circuit protection wire in 4 mm².
6. **The equipotential bonding wires**
   They are also in green/yellow insulated wire, and they bond all metallic parts of the building. For a metal water feeding line a 6mm² green/yellow wires must be used. For a metal gas feeding line the cross section of the bonding wire

must be the same as for the power feeding line. For all other metallic parts (exposed metal piping, window sills, etc…), a 2.5 mm² must be used.

<u>NOTE:</u> If there is a grounding circuit protection wire that is used for several circuits, its cross section must be the size of the biggest phase carrying conductor.

3.2-How to install the grounding kit ?

The kit was conceived to install the ground with a peg, and it is composed by the following items:

- ✓ 2 grounding pegs 1 meter long and 25 mm diameter, which can be assembled to get 1 peg 2 meters long.
- ✓ 1 cutting bar
- ✓ 5 meters of green-yellow conductor to connect the disconnecting bar to the distribution board – **the main protection wire**
- ✓ 10 meters of copper cable of 25 mm² diameter to connect the peg to the disconnecting bar – **the grounding conductor**
- ✓ 1 terminal connector for the peg

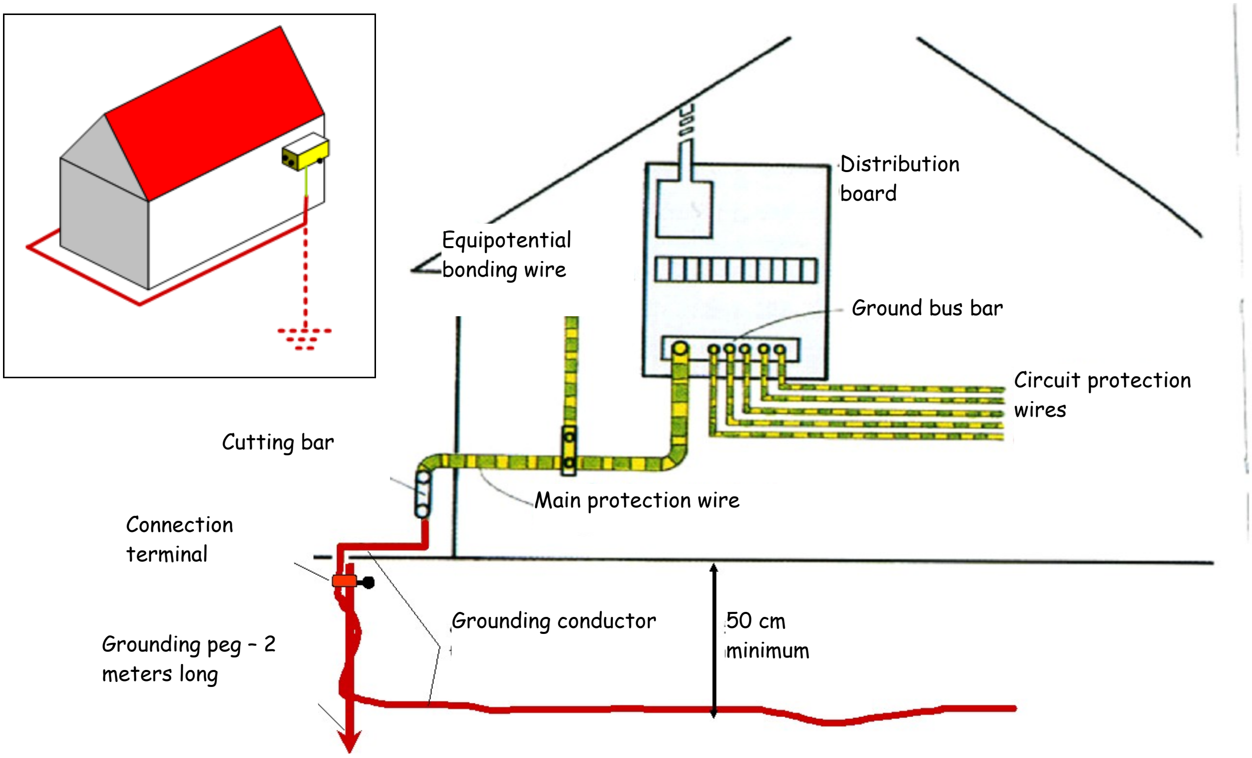
<u>Items to foresee other than those provided in the kit:</u>

1. Anti-corrosion protection: electrical insulating tape to protect the connection.
2. Shock cover: allows the inspection of the connection and verify if it has not suffered from mechanical shock.

3.3- Ground for Masses

To install the ground for masses follow the following procedure:

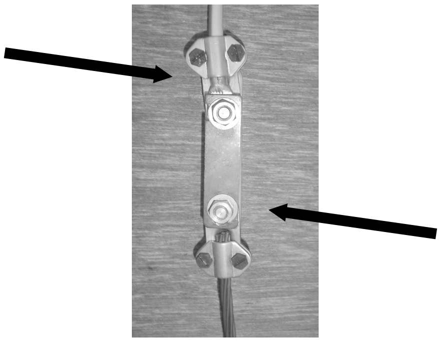
3.3.1-Soft terrains



1. Drive the peg vertically into the ground **maximum 3 meters from distribution board** and at a minimum of 20 meters from the ground for the neutral (ref. document Grounding).
   In order to protect the assembly system of the peg, make sure to use the bolt furnished when driving the peg into the ground.
2. Dig a 10 meter long and 0.50 meters deep trench, beginning from the position of the grounding peg and following the buildings contour.
3. Lay the bare copper cable horizontally in the trench.
4. Connect the grounding peg to the ground cutting bar with the grounding conductor using the terminal connection provided. Do not cut the bare copper cable, just pass it through the terminal connection in order to make a good contact with the peg. Leave enough cable length to allow fixing the ground cutting bar on the wall.

5. Fix the ground cutting bar and connect it to the ground distribution bus bar in the distribution board with the main protection wire.

Main Protection Wire
16 mm² wire with green/yellow insulation



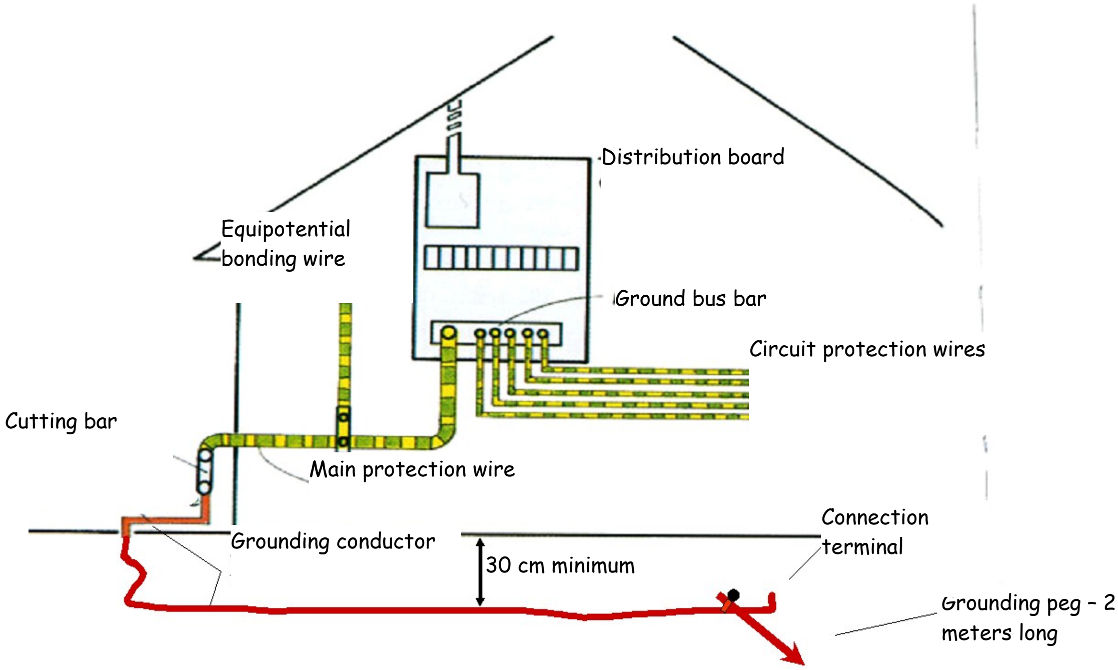
Grounding Conductor
25 mm² bare copper wire

6. Verify the continuity of all connections with the tester. With 15 meters of wire the continuity between the ground bus bar and all the connection points (the two connections of the cutting bar and at the peg terminal).
7. The connection point of the grounding peg and the grounding conductor must be protected against corrosion. To do this, cover the connection point with insulating tape.

8. Fill back the trench with the soil, and install the shock cover to protect the connection point of the peg and the grounding conductor (example: a plastic bucket or the bottom part of a plastic bottle).

<u>NOTE :</u> The grounding peg should be driven into ground that is sheltered from drying and frost. Sinking the grounding peg into a pond or running water is prohibited.

3.3.2-Rocky terrains (in case the ground is too hard to drive the grounding peg vertically)



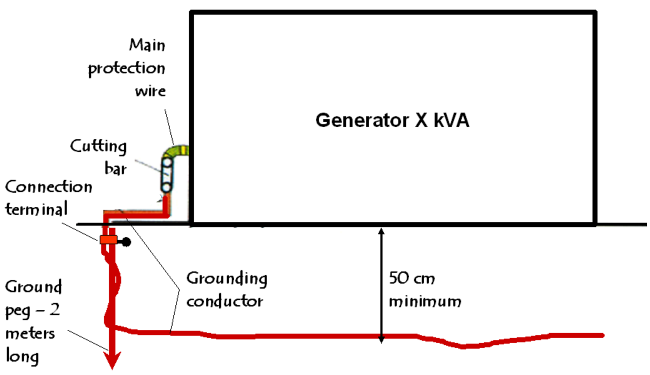
1. Dig a 12 meter long at a minimum **depth of 0.30 meter** (the deeper the better).
2. Lay the grounding conductor in the trench and connect the grounding peg at the end of the wire. **Drive the grounding peg as vertical as possible** into the ground. _One can also dig a hole with a crowbar to put the peg in and cover it with soil. In order to protect the assembly system of the peg, make sure to use the bolt furnished when driving the peg into the ground._
3. Connect the other end of the grounding conductor to the cutting bar.
4. Follow the same procedure as for soft terrains (points 5 to 8).

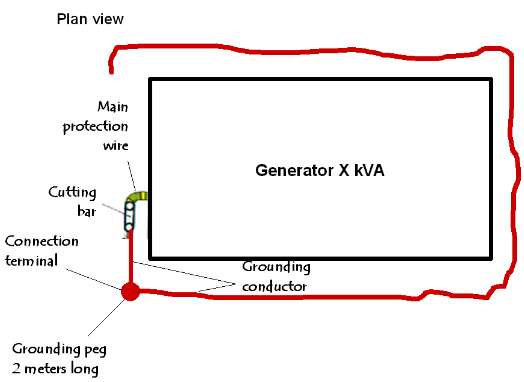
NOTE :** **The trench technique must be used only and only if the ground is too hard to drive the grounding peg vertically (rocky ground), this system is less efficient than the vertical peg system.

3.4-Ground for the Neutral

To install the ground for the neutral follow the following procedure:

3.4.1- Soft terrains





1. Drive the peg vertically into the ground next to the generator shelter and at a minimum of 20 meters from the ground for masses (ref. document Grounding). *In order to protect the assembly system of the peg, make sure to use the bolt furnished when driving the peg into the ground.*
2. Dig a 10 meter long and 0.50 meters deep trench, beginning from the position of the grounding peg and following the buildings contour.
3. Lay the bare copper cable horizontally in the trench.
4. Connect the grounding peg to the ground cutting bar with the grounding conductor using the terminal connection provided. Do not cut the bare copper cable, just pass it through the terminal connection in order to make a good contact with the peg. Leave enough cable length to allow fixing the ground cutting bar on the wall (see figure 4 for ground for masses).
5. Fix the ground cutting bar to the wall and connect it to the generator's housing with the main protection wire (see figure 5 for ground for masses).
6. Verify the continuity of all connections with the tester. With 15 meters of wire the continuity between the generator's housing and all the connection points (the two connections of the cutting bar and at the peg terminal).
7. Follow the same procedure as for the ground for masses (points 7 and 8).

3.4.2- Rocky terrains (in case the ground is too hard to drive the grounding peg vertically)

1. Dig a 12 meter long at a minimum **depth of 0.30 meter** (the deeper the better).
2. Lay the grounding conductor in the trench and connect the grounding peg at the end of the wire. **Drive the grounding peg as vertical as possible** into the ground. *One can also dig a hole with a crowbar to put the peg in and cover it with soil. In order to protect the assembly system of the peg, make sure to use the bolt furnished when driving the peg into the ground.*
3. Connect the other end of the grounding conductor to the cutting bar.
4. Follow the same procedure as for soft terrains (points 5 to 8).

CHAPTER 4: PROTECTION DEVICES

There are two main protection devices in an electrical installation, the circuit protection devices and the devices for personnel protection. In this document, the devices for circuit protection and those destined for personnel protection are differentiated.

4.1-Circuit protection

Circuit protection against overload and short-circuits can be assured by two different types of products:

- the miniature circuit breaker (thermo-magnetic)
- the fused circuit breaker

Both types of protection are activated as defaults occur in the circuits.

a. The miniature circuit breaker (MCB)

The miniature circuit breaker known as MCB has a thermo-magnetic mechanism to protect the circuits by cutting the power supply instantaneously when a fault is present (phase and neutral).

More expensive than the fuse, it is faster, more reliable, safer and it does not need to be replaced after every electrical fault.

Whenever an overload or short-circuit incident occurs on the circuit, the MCB trips and the lever is lowered, which allows an immediate visual identification of the circuit in fault.

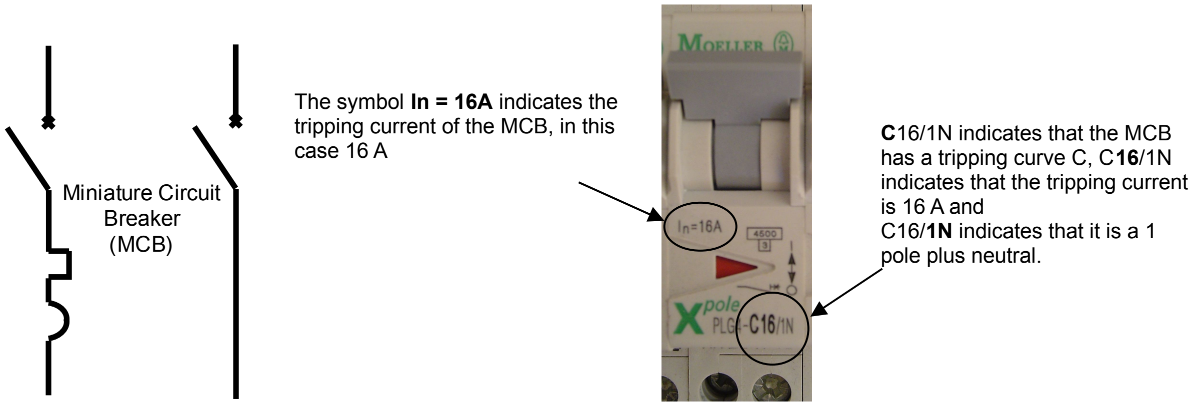
After eliminating the fault, the circuit can be re-established by simply activating the MCB's lever.
MCBs can have different pole numbers (single pole, "1 pole plus neutral", two pole, three pole or four pole). The number of poles indicates the number of wires that will be protected by the thermo-magnetic device. The single pole, "1 pole plus neutral" and the two pole MCBs are used for single phase circuits. It is important to note that the "1 pole plus neutral" MCB protects only the phase, but when desactivated, it cuts both, the phase and the neutral.

The thee and four pole MCBs are used for three phase circuits. The difference between the two is that the additional pole in the fourth pole cuts the neutral in the three phase circuit.

In addition, the MCBs can have different tripping curves. The most common curves are B, C and D. Depending on the tripping curve, the MCB will interrupt the supply faster (for a curve B) or slower (for a curve D). For general applications curve C MCBs are used, leaving curves B and D for specific applications.

Following, an example of the symbol for the MCB and how to identify the characteristics of the device:

Symbol of the MCB



b. <u>The fused circuit breaker</u>

It's the most simple circuit protection device. The fused circuit breaker works with a fuse cartridge, most commonly called fuse.

Whenever an overload or a short circuit is detected, the fuse melts, cutting in this way the supply. However, the neutral remains connected. In order to completely disconnect the circuit, the circuit breaker must be manually opened.

In order to re-establish the power supply, a new fuse has to be installed. The diameter and the length of the fuse depend on the fused circuit breaker. Once the fuse melts it must be changed for another one of the same rating in order for it to regain its protecting role. That means that there must be an available stock close by.

- **ATTENTION – MSF RECOMMANDATION:**
  For MSF electrical installations, we prefer to use thermo-magnetic miniature circuit breakers instead of fuses. The MCB must be "1 pole plus neutral" and with a C tripping curve.

The sizing of the circuit protection is done based on the cross-section of the circuit's wire. It should be noted that the wire must be sized based on the foreseen power demand on the circuit.

As a general rule, one can use the following table to size the circuit protections in a residential electrical installation:

Number of utilisation points by type of circuit				
Type of circuit	Maximum number of points	Wire cross section copper (in mm²)	Tripping curent of circuit protection device	
			Miniature Circuit Breaker	Fuse
Lighting circuits	8	1,5	10	6
Electrical outlet circuits 16 A	8	2,5	16	10
Specific circuits with electrical outlet (washing machine, electrical oven, dishwasher, freezer, dryer)	1	2,5	20	16
Electrical range, single phase	1	6	32	32
Electrical range, three phase	1	2,5	20	16
VMC, VMR	1	1,5	2	Interdit
Non-instantaneous water heater (cumulus)	1	2,5	20	16
Other circuits, including distribution boards	-	1,5	10	6
	-	2,5	16	16
	-	4	25	20
	-	6	32	32
Other circuits based on the circuit's power	2 000 W	1,5	10	-
	4 250 W	2,5	16	16 (3500 W)
	5 500 W	4	25	20
	7 250 W	6	32	25

NOTE: For the same wire cross-section and application, the MCB's rating is higher than the one for the fuse. This difference is due to the fact that the fuse has only a thermal component, which reacts slowly to the default. The magnetic component in addition to the thermal component of the MCB makes the device more precise, which allows a higher tripping current, but keeping the safety level to a maximum.

4.2- Personnel protection

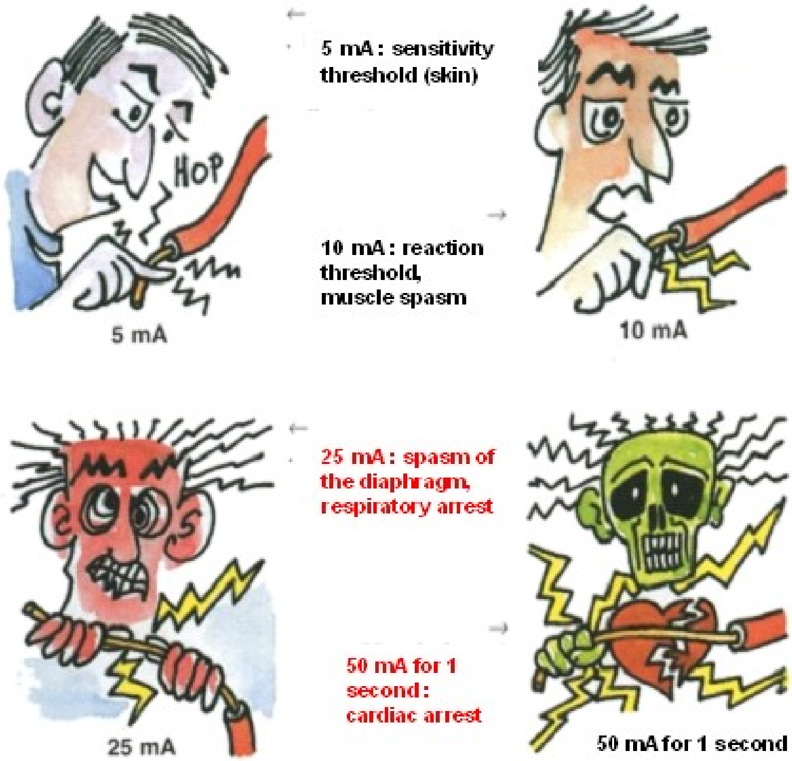
Personnel protection is assured by using residual current devices.

Residual current devices detect default currents leaking by the grounding or other ways (like electrocution).

Residual current devices react based on the difference of intensity of the phase and the neutral. This intensity difference is, in fact, the current leaking from the system. If this current cannot be evacuated by the ground, the first person which will touch the equipment with the fault will be electrified. **That is why it is mandatory to combine the residual current protection devices with a good ground** (ref. document Grounding)

Residual current devises exist in different sensitivities (500 mA, 300 mA, 30 mA et 10 mA). In general, devices with leakage tripping current of 500 mA and 300 mA are destined for the protection of the entire electrical installation. These are usually installed with the main circuit breaker of the installation.

High sensitivity residual current devices, 30 mA and 10 mA are used for the protection of one or more distribution circuits and they are installed directly upstream of consumption points. The maximum sensitivity of the residual current devices protecting all final consumption points must 30 mA, because as illustrated in the figure below, the effect of an electrification with a current of 50 mA can cause death.



Residual current devises are also categorised by the type of current that they can detect:

- Residual current devices type AC are used for the detection of leaks in alternating current. The symbol indicating type AC devices is 
- Residual current devices type A are used for the detection of leaks in alernating and direct current. The symbol indicating type A devices is 

- **ATTENTION – MSF RECOMMANDATION:**

For our applications in MSF, we use the type AC because the equipment currently used in our missions do not have big direct current components.

Residual current devices can be **residual current circuit breaker (RCCB)** or **residual circuit breaker with overload protection (RCBO).**

a. The Residual Current Circuit Breaker (RCCB)

The RCCB is a device which detects the intensity difference between the phase and the neutral.

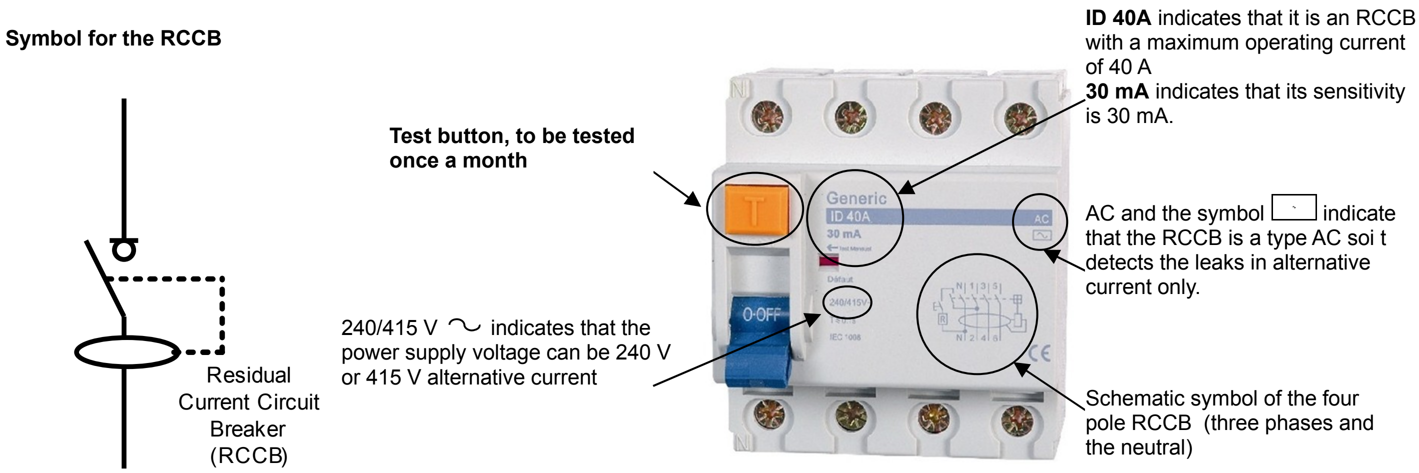
As described before, the sensitivity of the residual current device is rated in milliamperes (10 mA, 30 mA, 300 mA or 500 mA).

- RCCBs rated at 300 or 500 mA must be used for the general protection of the electrical installation.
- RCCBs rated at 10 or 30 mA must be used to protect one or more distribution circuits.

In the nomenclature of the RCCB, the rating given in amperes (16 A, 32 A, 40 A, 63 A….) indicates the maximum operating current (the maximum current at which the device can cut the power supply). In other words, it is the maximum current that it will be able to interrupt without suffering a deterioration (either producing sparks, burning or melting).

- **ATTENTION: RCCBs are personnel protection devices, but they must always be coupled with circuit protection devices (MCBs or fuses).**

Following, the schematic symbol and an example of how to identify the RCCB:



b. <u>The Residual Current Circuit Breaker with Overload protection (RCBO)</u>

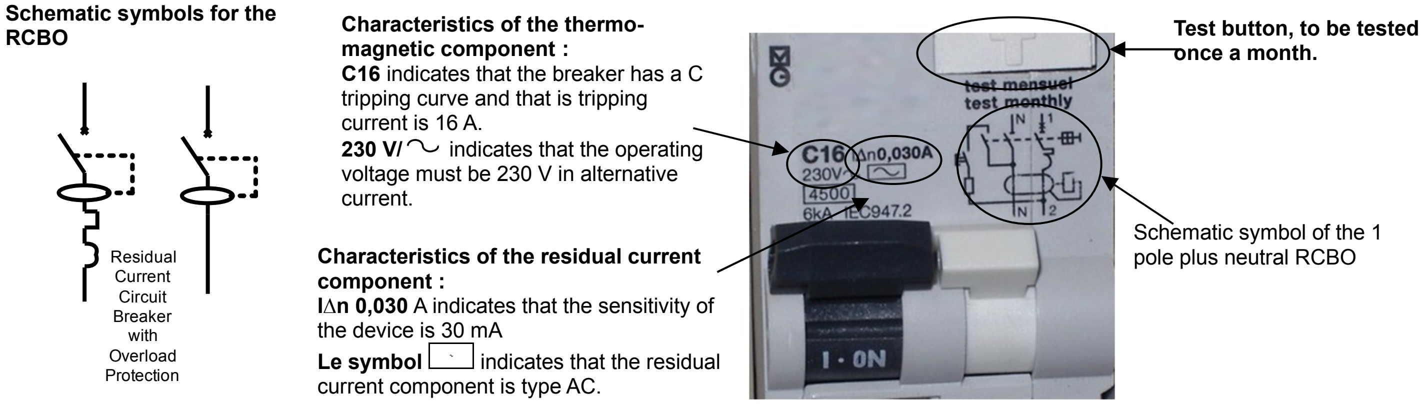
The residual current device can be combined with an MCB in one protection device, in this case the device is called a residual current circuit breaker with overload protection. This device provides protection for the circuits with the thermo-magnetic component and at the same time it provides personnel protection with its residual current detection component.

The characteristics of the residual current detection component in the RCBO are the same as in the RCCB. Likewise, the thermo-magnetic component protection for the circuits are the same as for the MCB.

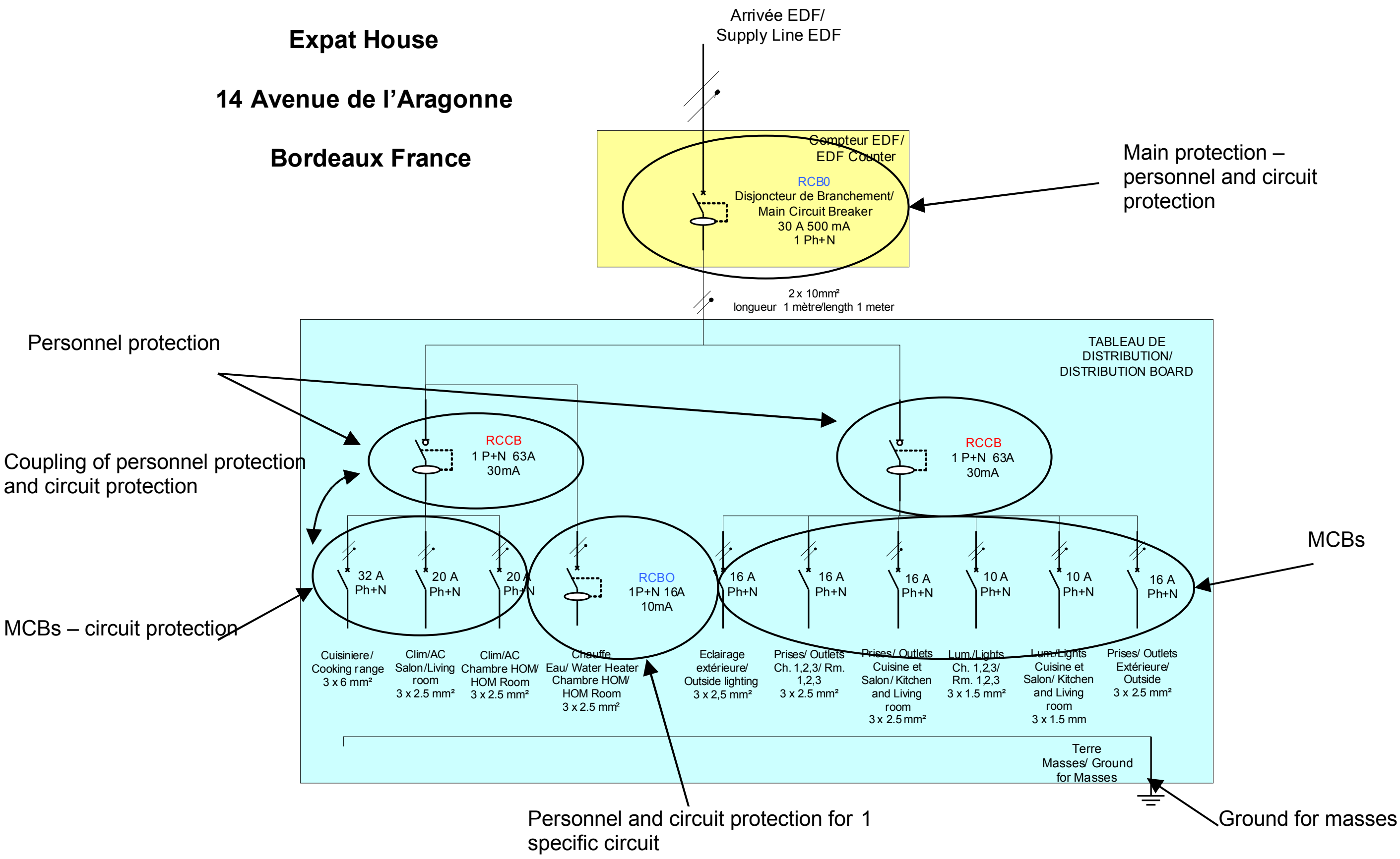
It should be noted that in this case, the rating in amperes for the device is the tripping current of the breaker (once the current passing through the device surpasses this value, the breaker will trip, and will not suffer any damages).

The RCBO is usually installed as a main circuit breaker protecting the entire installation or in distribution boards to protect specific equipments.

Following, the schematic symbol for the RCBO and an example of how to identify the RCBO:



Following, an example of a single wire diagram following the recommendations described above:



- **ATTENTION – MSF RECOMMANDATION:**

For MSF installations, we use the 500 mA RCBO as main circuit breaker for the entire electrical installation and in the distribution board the residual current device (either RCCB or RCBO) which protects the circuits going to the consumers must be 30 mA maximum and type AC. For non-instantaneous water heaters the protection must have a leakage tripping current of 10 mA.

- **ATTENTION! DO NOT FORGET: All residual current devices have a test button, and the device must be tested once a month. Residual current devices are tested under voltage.**

I. *Where and how to install the protection devices? The Distribution Board*

The distribution board is installed in a board which size is proportional to the number of circuits of the electrical installation.

The ground will also be connected to this board. Additional space should be foreseen for eventual expansion, remodelling or addition of electrical consumers to the electrical network.

c. Location of the distribution board

The distribution board should be accessible. However, as all components will be apparent, as well as all conduits, the distribution board must be installed in a dry place.

The distribution board must be installed away from the reach of children and above head level in order to protect the face if a breaker is rearmed when a default is still present.

Nevertheless, it must also be close to the main circuit breaker to which it will be connected. The board must be installed in such way that the ground for masses at a maximum distance of 3 meters.

- **ATTENTION – MSF RECOMMANDATION:**

In order to guarantee the quality of electrical protection devices, these must be bought at the main supply center, MSF Logistic. In case of difficult import procedures or emergencies contact your logistic supervisor for local purchase.