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ELECTRICAL SAFETY IN THE USE OF PORTABLE POWER TOOLS

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d'outils électriques portatifs

Electrical Safety in the Use of Portable Power Tools

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Electrical Safety in the Use of Portable Power Tools

1.0 INTRODUCTION

This publication is intended for band maintenance and construction supervisors on day labour projects. Its purpose is to promote awareness of the dangers of electrical shock from portable power tools that are wrongly used or improperly maintained. Safety devices and maintenance procedures to encourage safe operation are described.

2.0 ELECTRIC CURRENT AND ITS EFFECT ON THE HUMAN BODY

In order to understand electric shock, you must grasp the basic concepts: current, voltage and resistance. They can be illustrated by comparing electrical flow in a circuit with water flowing through a pipe.

Current can be compared to the total volume of water flowing past a certain point in a given unit of time. The basic unit of electric current is the ampere. The ampere, however, is rather too large a unit to consider current flow and its effects on the human body. A more suitable measurement is the milliampere (.001 ampere). (See Table 1)

Voltage can be compared to water pressure in a pipe. Electrical pressure is expressed in volts. Voltage levels are listed below:

a. extra low voltage is any voltage up to and including 30 volts;

b. low voltage is any voltage from 31 to 750 volts inclusive; and

c. high voltage is any voltage above 750 volts.

Frequency of an electric current indicates that it is an alternating current (AC). Frequency is expressed in hertz (Hz) or cycles per second. To understand this, lets consider that the current flow follows a wave shape similar to that produced when a pebble is dropped into a pool, except in this case the wave travels back and forth in the conductor (wire). 1 cycle of the wave is shown below. A 60 Hz AC wave goes through 60 such cycles in a second and its frequency is therefore 60 Hz or 60 cycles per second. This is the ordinary household type current. The 10 000 Hz may be referred to as light frequency type current and is not likely to be encountered in normal use, it is tabulated for comparative purposes.

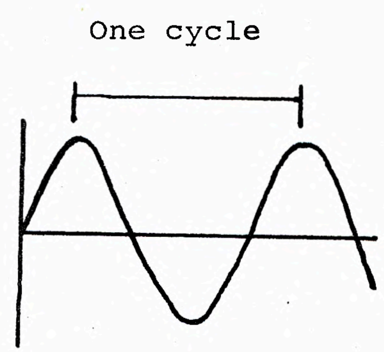


Table 1

EFFECTS OF ELECTRIC CURRENT ON THE HUMAN BODY

Effect	Current in Milliamperes					
	Direct current		Frequency 60 Hz		10,000 Hz	
	Men	Women	Men	Women	Men	Women
Perception threshold	5	4	1	0.7	12	8
Shock - not painful, muscular control not lost	9	6	2	1.5	17	11
Shock - painful, muscular control not lost	62	41	9	6	55	37
Shock - painful, let-go threshold	76	51	16	10	75	50
Shock - painful and severe, muscular contractions, breathing difficult	90	60	23	15	94	63
Shock - possible ventricular fibrillation effect from 3-second shocks*	500	500	100	100		

*a condition in which the heart fibres act haphazardly, instead of in unison, causing loss of heart pumping action and blood circulation.

Resistance is the condition that retards flow, like an obstruction in a water pipe. Electrical resistance is measured in ohms.

Electric shock occurs when current flows through a person in contact with an energized circuit (see Table 1). It is estimated that a 60 cycle/sec. (60 Hz) alternating current (ordinary household type) of 100 milliamperes may be fatal if it passes through the vital organs; 16 milliamperes is considered the average current at which a person can let go of a hand-held object.

A current of 100 milliamperes may readily be encountered on contact with the ordinary light and power circuits of 120 or 240 volts.

Our skin is the first line of resistance against the flow of current. A sharp decrease in skin resistance occurs if the skin is moist (Table 2). Once the skin resistance is broken down, current readily flows through blood and body tissues.

Skin resistance decreases rapidly as voltage is increased. High voltage AC 60 Hz current causes violent muscular contractions, often so severe that the person is thrown clear of the circuit.

Low voltage causes muscular contractions of a less violent nature which may prevent the person in contact from getting free from the circuit. This, coupled with a lack of knowledge and careless habits, particularly at the 120/240 volt level, can lead to disregard of the hazard involved.

TABLE 2

HUMAN RESISTANCE TO ELECTRICAL CURRENT

Body Area	Resistance (ohms)
Dry Skin	10,000 to 60,000
Wet skin	1,000
Internal body-hand to foot	400 to 600
Ear to ear	(about) 100

Fatality or injury from electric shock may result from the following effects of current on the body:

a. The chest muscles may contract and interfere with breathing. Asphyxiation can occur if exposure is prolonged.

b. The nerve centre that controls breathing may be temporarily paralysed. This condition often continues after the victim has been freed from the circuit.

c. The heart rhythm may change causing the heart to pump irregularly and blood circulation to slow down or stop. The heart cannot recover from this condition on its own, and without medical attention, death follows.

d. Muscles contract on contact with large current flow; the heart may resume its normal rhythm when the victim is removed from the circuit.

e. The heat from heavy current flow may cause haemorrhaging, and tissue, nerve and muscle damage.

In general, the longer the exposure to current flow, the more serious the result.

3.0 FUNCTION AND METHOD OF PROPER GROUNDING

The main hazard from the use of electrically powered tools is electric shock, which may give rise to flash burns, cause a fall, or, if severe enough, kill. How severe the shock is will depend on the amount of current, which is the ratio of the system voltage and the resistance of the current path.

A tool with defective insulation might allow leakage current to flow through the metal case through the operator to the ground. The use of an effective ground connection will protect the operator by providing an alternative path for the current to flow to ground.

Portable tools are normally grounded with a separate green insulated equipment grounding conductor. This is included in the portable cord connecting the metal parts of the tool with the plug and terminates in the 'U' ground pin of the standard two-pole three-wire grounding plug. This feature is mandatory for CSA certified tools with exposed metal parts, except for double-insulated tools which are discussed in 4.1 (see Figure 1).

A continuous ground connection is made at the plug by means of a matching two-pole three-wire grounding receptacle where the tool is plugged in and energized. This receptacle is connected to the service ground of the power supply (see Figure 2).

Receptacle ground connections should be checked as described in section 5.0 to ensure that the ground conductor is continuous and not broken.

<u>CAUTION</u>

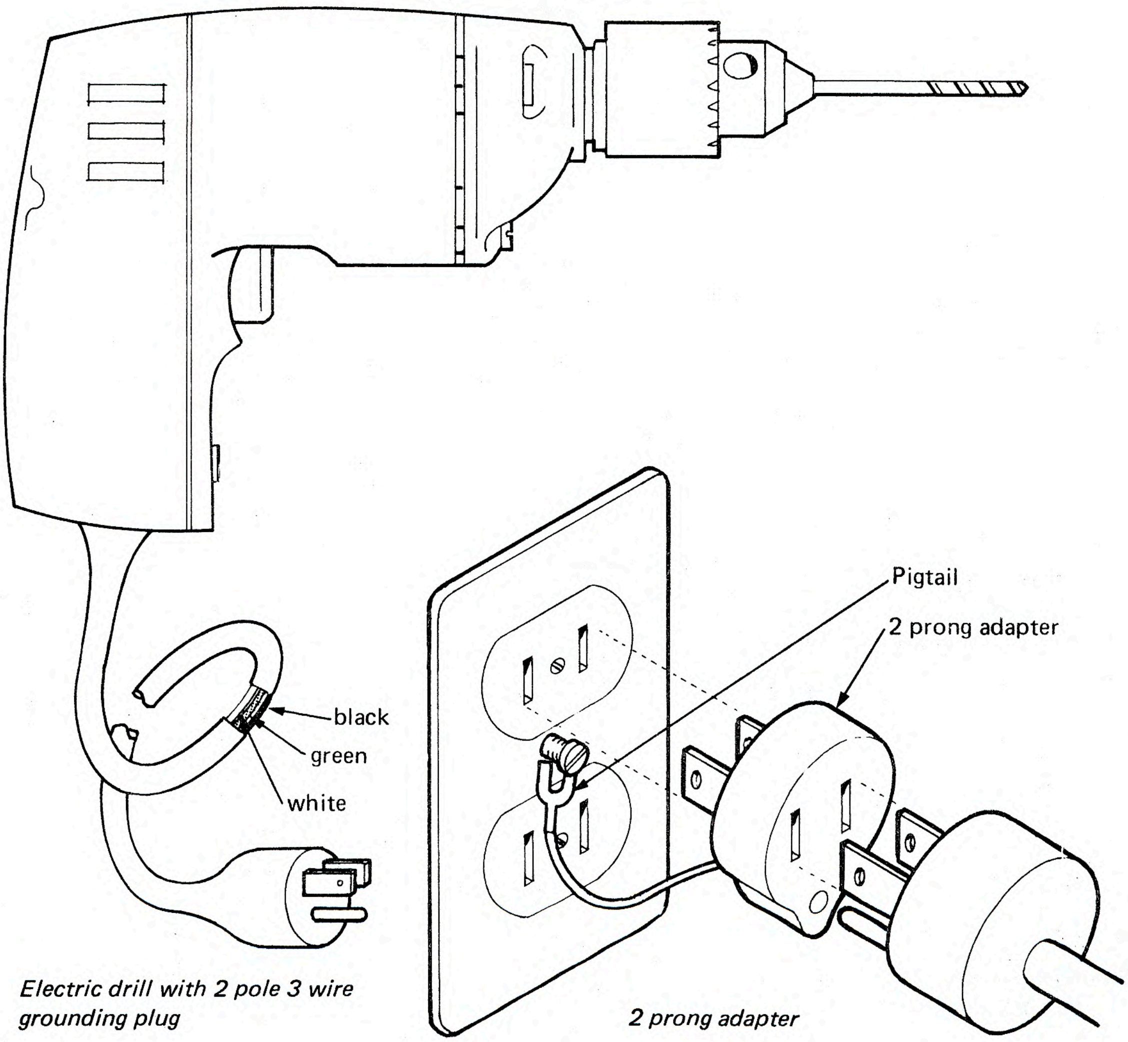
1. Do not use a metal encased tool with a non-grounding, two-pole, two-wire plug.

2. Do not remove the 'U' ground pin from the standard two-pole, three-wire, grounding plug to fit it into the older two-blade, two-wire, non-grounding receptacle.

In neither case will the tool be properly grounded. Use an adapter, but ensure that the outlet box is grounded (see Figure 2).

3. Only ground the white insulated (neutral) circuit conductor at the service equipment ground, unless special permission has been obtained from the inspection authority.

4. Do not connect the white insulated circuit (neutral) conductor to both the silver-coloured terminal screw and the green equipment grounding screw of a receptacle. If the white neutral circuit conductor is interrupted between the receptacle and the service ground point, the metal case of the



Electric drill with 2 pole 3 wire grounding plug

2 prong adapter

Note: The two prong adapter is grounded only if the pigtail isconnected to a properly grounded outlet box. Inspect outlet box to ensure that bare ground wire is included and connected to box.

Fig. 1 Equipment Grounding

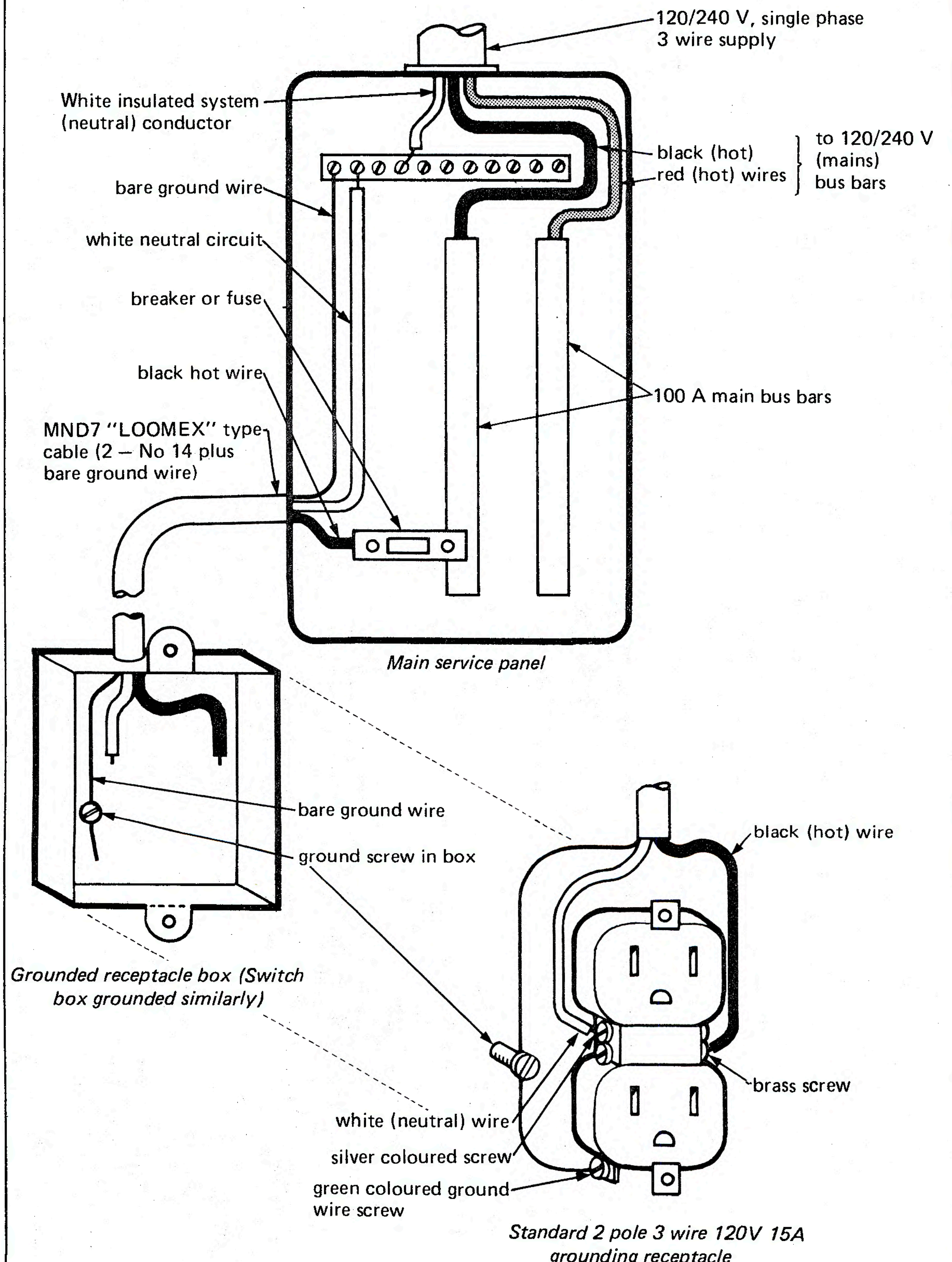


Fig. 2 System Grounding

equipment plugged into this receptacle will then be energized at full line voltage (120 V). This occurs because the green grounding conductor in the line cord connects the case and plug, causing a very hazardous situation.

4.0 SAFETY FEATURES AND AUXILIARY DEVICES

4.1 Double-insulated Tools

Tools and appliances are available with a protective double insulation system and their labels either state "double-insulated" or have a symbol of two squares, one inside the other.

Double-insulated tools provide protection equal to the conventional grounded tools, without the need for the third wire grounding conductor in the cable.

They are particularly useful on old non-polarized non-grounded receptacles, which would otherwise require adaptors to ensure grounding of tools (see Figure 1).

Double-insulated tools should not be immersed in water or used in areas of extreme moisture as this may reduce the effect of the double insulation.

4.2 Ground Fault Circuit Interrupters (GFCIs)

Use ground fault circuit interrupters (GFCIs) in addition to grounding the metal case of portable electric tools as an extra safeguard. This is particularly important where the condition of the tool and the continuity of the receptacle system ground are questionable.

A GFCI of the type which may be used with tools is defined in Appendix B Article 68-006 of the Canadian Electrical Code: "Its prime function is to provide protection against hazardous electric shock from leakage current flowing to ground from defective circuits or equipment".

Under the Canadian Electrical Code, it is mandatory to use a GFCI on electrical power and lighting circuits installed in and around swimming pools and for receptacles mounted on the exterior of houses. It is usually installed in the lighting panelboard, occupying a standard 2-pole, 15 amp breaker space. The GFCI may be installed in its own separate enclosure, and is also available as a portable device with a number of built-in receptacles for tools or other portable equipment. A built-in test switch and instructions are provided on the device so the user can check it is in proper working order. It is recommended that the test be performed once a day before plugging in and using portable tools.

5.0 MAINTENANCE

The following checks should be part of an inspection and maintenance plan:

1. Check cords periodically for worn or broken insulation and replace or repair as necessary.

2. When replacing defective plugs, use the heavy duty type that clamps to the cord to avoid excessive strain on the electrical connections.

3. If terminal screws or connectors on plugs are not made of moulded rubber, cover them with proper insulation such as a slotted plastic or mica disc which fits through the three-prong plug.

4. Train users not to jerk cords, and to protect them from abuse from sharp objects, heat, oil, and solvents or anything else that might soften and damage the insulation.

5. For tools that must be grounded, use extension cords of the three-wire grounding type. Ground continuity should be checked periodically with a ground continuity checker. A volt-ohm meter set to the lowest resistance scale can be used to indicate zero ohms between the tool case and the plug 'U' ground connector. Zero ohms indicates a proper grounding connection. A reading other than zero ohms

indicates either a poor grounding connection or, if the meter needle points to the opposite end of the scale at infinity (symbol), the ground conductor is open or broken.

6. Good insulation has a very high resistance to current flow, in the order of 1,000,000 or more ohms. Faulty insulation has a much lower value and complete breakdown could give zero ohms. Faulty insulation, unlike broken external wiring, is not usually visible. There is therefore a need for frequent inspection and maintenance. The condition of the insulation should be checked by using a 500 volt insulation resistance checker -- commonly known as a 'megger' -- to give a direct reading of insulation resistance when connected between the metal case and each insulated load of the plug successively. A reading of less than 100,000 ohms should be considered unsatisfactory.

7. If in doubt, before using, check the ground continuity of the receptacle and circuit where the tool is to be used. This is especially important if the circuit has not been used before. A receptacle tester such as Hubbell No. 5200 can be used. When plugged into a single phase 120 V, 2-pole, 3-wire receptacle, it will indicate the following:

- correct wiring,
- reversed polarity,
- open ground wire (black or red insulated wire),
- open neutral wire,
- open hot wire,
- hot and ground wires reversed,
- hot wire on neutral terminal, and
- hot terminal unwired.

6.0 INSPECTION CHECK-LIST

1. General Use

a. Check that tools are well maintained. Indicate what has been done, and the dates.

b. Check that tools are placed where they are unlikely to fall.

2. <u>Insulation</u>

Check insulation resistance preferably before or after each use. Hard usage and detriorated external wiring are indicators that internal insulation may be deteriorating as well. Keep a log of insulation checks to help predict insulation failure.

3. <u>Cords</u>

a. Ensure that insulation and plugs are in good condition after each use.

b. Ensure that cords are protected and routed away from vehicle paths.

4. <u>Grounding</u>

a. Ensure that ground wiring is in good operating condition. Check it periodically with a continuity meter, especially after hard usage, and when cord connection deterioration is apparent.

b. Ensure that three-wire plug-extension cords are used on three-wire grounding type tools.

5. <u>Receptacles</u>

Ensure that the receptacle circuit ground is in good operating condition. Check on first using the receptacle, and periodically from then on.

7.0 REFERENCES

<u>Canadian Electrical Code. Part I</u>, Current Edition, "Section 10 Grounding".

National Safety Council, 1977. <u>Accident Prevention Manual</u>, 7th edition.