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NEW ZEALAND ELECTRICAL CODE OF PRACTICE

for

EARTHING AND EQUIPOTENTIAL BONDING

of

LOW VOLTAGE ELECTRICAL INSTALLATIONS

Issued by the Office of
The Chief Electrical Inspector,
Energy and Resources Division, Ministry of Commerce
Wellington, New Zealand

THE ELECTRICITY ACT 1992

APPROVAL OF THE ELECTRICAL CODE OF PRACTICE

FOR

EARTHING AND EQUIPOTENTIAL BONDING

OF

LOW VOLTAGE ELECTRICAL INSTALLATIONS

Pursuant to Section 36 of the Electricity Act 1992 ("the Act")

On the 11th day of October 1994, the Secretary of Commerce issued the Electrical Code of Practice for Earthing of Low Voltage Fittings and Fixed Wired Appliances (NZECP 25:1994 ("the Code")).

On the 20th day of October 1994, pursuant to section 38(2)(a) of the Electricity Act 1992, the Secretary published in the *Gazette* a notice of intention to apply to me for approval of the Code, and there has been consultations with such persons (or their representatives) as will be affected by the Code and they have had the opportunity to consider possible effects and comment on those effects.

I have through my officials considered the comments concerning those effects and where necessary amendments were made to the Code, including to the title.

Therefore, pursuant to section 38 of the Electricity Act 1992, I, Douglas Lorimer Kidd, Minister of Energy, have this day approved the Electrical Code of Practice for Earthing and Equipotential Bonding of Low Voltage Electrical Installations 1995 (NZECP25:1995), which Code shall come into force on the 1st day of August 1995.

Dated this 13th day of June 1995.

Douglas Lorimer Kidd
Minister of Energy

COMMITTEE REPRESENTATION

This Code of Practice was prepared by the Ministry of Commerce, Chief Electrical Inspector's Office with reference to the following organisations:

Electrical Consultants
Electrical Supply Engineers' Association of NZ
New Zealand Electrical Institute
Electrical Contractors' Association of NZ Inc
Electrical Engineers
MEN Working Group
Central Inspectors Association
Electrical Polytech Tutor
Communication & Energy Workers Union.

REVIEW

This Code of Practice will be revised as occasions arise.

Suggestions for improvements of this Code are welcome. Send all comments in writing to : -

The Chief Electrical Inspector's Office
Ministry of Commerce
PO Box 1473
WELLINGTON

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INTRODUCTION

This Code of Practice is intended to provide safe methods for earthing and equipotential bonding of low voltage electrical installations.

Where electrical installation wiring is terminated in or passes through a metal enclosure, or supplies a Class 1 appliance, an earth connection is made to the outer protective metal. This connects the outer protective metal to the general mass of earth and to other metallic fittings in close proximity. If an active conductor comes into contact with the earthed outer protective metal the voltage to the general mass of earth or to other earthed metallic fittings should not exceed 50V, and the resulting large current flow will be sufficient to positively operate the protective fitting.

Earthing is the connection of metallic fittings to the general mass of earth. The earth fault current flow is dependent on the total resistance of the earthing system. The resistance is dependent on:

- (a) Earthing conductor size and length;
- (b) Connections forming part of the earthing system;
- (c) Ground resistance of the general mass of earth; and
- (d) The resistance of the supply network including the transformer earthing.

The lower the resistance value of the earthing circuit, the higher the protective current flow and the faster the protective fitting will operate, thus reducing the risk of electric shock and/or fire.

Equipotential bonding involves the connection of metallic parts (that are not part of the electrical installation) to the general mass of the earth.

EARTHING AND EQUIPOTENTIAL BONDING OF LOW VOLTAGE ELECTRICAL INSTALLATIONS

SECTION 1

SCOPE, APPLICATION, INTERPRETATION, GLOSSARY, NUMBERING AND GENERAL

1.1 SCOPE

1.1.1 This Code sets requirements for earthing of low voltage (LV) electrical installations as a means of protection against electric shock and/or fire in the case of a fault (thus, references to electrical installations in this Code are to low voltage electrical installations).

1.1.2 This Code also sets requirements for the equipotential bonding of metallic parts not directly associated with the electrical installation.

1.2 APPLICATION

1.2.1 This Code sets minimum obligations for earthing and bonding of low voltage electrical installations. Please note that electrical installations in the following areas, or of the following kinds, also have other Codes that apply to them:

- (a) Caravans and caravan park areas (see NZECP 1);
- (b) Damp situations (see NZECP 2);
- (c) Supply by generating systems not exceeding low voltage (see NZECP 4);
- (d) Medical locations and associated areas (see NZECP 12);
- (e) Electric security fences (see NZECP 21.2);
- (f) Hazardous areas (see NZECP 24);
- (g) Boat marinas and pleasure vessels (see NZECP 29);
- (h) Mineral insulated cables (see NZECP 33);
- (i) High voltage power systems (see NZECP 35);
- (j) Distributions systems (see NZECP 35);
- (k) High voltage installations on consumers' premises (see NZECP 35);
- (l) Single wire earth return systems (see NZECP 41);
- (j) Electrical wiring work in domestic premises (see NZECP 51).

1.3 INTERPRETATION

In this Code, unless the context otherwise requires:

1.3.1 Earth continuity conductor - means a conductor connecting any part of an earth continuity busbar to fittings required to be earthed.

1.3.2 Earthed - means effectively connected to the general mass of the earth.

1.3.3 Earth electrode - means a metal rod or rods, or other conducting objects, providing an effective connection to the general mass of earth.

1.3.4 Earthing lead - means a conductor connecting any part of an earth electrode to

the earth continuity busbar.

- 1.3.5 Earthing system - means all conductors, electrodes, clamps or other connections used to provide an electrical path to earth.
- 1.3.6 Equipotential bonding - means the electrical connection of exposed metal parts so that they are at substantially the same voltage.
- 1.3.7 Equipotential bonding conductor - means a conductor connecting any exposed metal.
- 1.3.8 Equipotential bonding lead - means a conductor connecting any equipotential bonded metal to an earth electrode or earth continuity busbar.
- 1.3.9 Protection against direct contact - means the protection of persons against dangers that may arise from contact with live parts of fittings or fixed wired appliances.
- 1.3.10 Protection against indirect contact - means the protection of persons against dangers that may arise from contact with exposed conductive parts which may become live under fault conditions.
- 1.3.11 Protective fitting - means a fitting that interrupts the flow of electricity to a circuit or part of a circuit under adverse conditions of overload, short circuit or leakage to earth (i.e. fuse or circuit-breaker).
- 1.3.12 Reinforced-insulation - means a single insulation system applied to live parts, which provides a degree of protection against electric shock and is equivalent to double insulation.
- 1.3.13 Safety extra-low voltage or SELV - means extra-low voltage in a circuit that is isolated from the electricity supply mains by means such as a safety isolating transformer.

1.4 GLOSSARY OF ABBREVIATIONS USED IN THIS CODE

A	Amperes
a.c.	Alternating current
d.c.	Direct current
HRC	High rupturing capacity
m	Metres
MEN	Multiple earthed neutral
mm	Millimetres
MIMS	Mineral insulated metal sheathed
mm ²	Square millimetres
NZECP	New Zealand Electrical Code of Practice
V	Volts

1.5 NUMBERING SYSTEM OF THIS CODE

- 1.5.1 Sections are numbered from 1 - 4.
- 1.5.2 Subsections are numbered by one full stop between two numbers (e.g. 1.4).
- 1.5.3 Clauses are numbered by two full stops between three numbers (e.g. 4.2.1).
- 1.5.4 Subclauses are numbered by three full stops between four numbers (e.g. 2.1.7.1).
- 1.5.5 Paragraphs contain numbering punctuated by one or more full stops together with a parenthesised letter.
- 1.5.6 Subparagraphs are represented by lower case roman numerals enclosed in parenthesis following paragraphs.
- 1.5.7 Unless otherwise specified, references in this Code to sections, subsections, clauses, subclauses, paragraphs, subparagraphs, or Tables are references to those of this Code.

SECTION 2

EARTHING REQUIREMENTS

2.1 GENERAL

- 2.1.1 Electrical installations shall have an earthing system as a means of protection against electric shock and fire caused by overload, earth leakage, and short circuit currents.
- 2.1.1.1 The switchboard electrically closest to the point of supply for an electrical installation shall be a MEN switchboard.
- 2.1.2 The earthing system for an electrical installation shall consist of:
- (a) An earth electrode; and
 - (b) An earthing lead; and
 - (c) An earth continuity busbar for the connection of the earthing lead and earth continuity conductors; and
 - (d) A removable link between the earth continuity busbar and the supply neutral; and
 - (e) Circuit earth continuity conductors.
- 2.1.3 The earthing lead shall run from the earth electrode to the earth continuity busbar on the first MEN switchboard.
- 2.1.4 Accessible metal forming part of fittings or fixed wired appliances shall be earthed.
- 2.1.5 The design, selection, and installation of the earthing system shall be such as will ensure:
- (a) Correct operation of protective fittings;
 - (b) Earth fault currents can be carried safely, having regard to thermal, thermomechanical, and electromechanical stresses;
 - (c) Adequate mechanical protection.
- 2.1.6 The maximum acceptable values for earth fault loop impedance shall be as set out in Table 1.
- 2.1.6.1 For protective fittings in series, the value of the earth loop impedance to the furthest point of any final subcircuit need only be that value required to operate the protective fitting of that final subcircuit.

TABLE 1

Maximum Earth Fault Loop Impedance Values

Protective Fitting Rating (amperes)	Semi Enclosed Fuses (ohms)	Curcuit Breakers and HRC Fuses (ohms)
5	15	31
10	7.8	15
16	4.8	9.6
20	3.8	7.8
27	2.8	5.7
32	2.4	4.8
63	1.3	2.4
80	1.0	1.9
100	0.8	1.5
125	0.6	1.2

2.2 FITTINGS AND FIXED WIRED APPLIANCES

- 2.2.1 Except as provided for in subclause 2.2.1.1 earthing shall be provided for:
- (a) Fixed wired appliances designed to be earthed;
 - (b) Metallic switchboards (including cases, surrounds, and enclosures), metallic wiring enclosures, boxes, and fittings associated with a wiring system;
 - (c) The earthing contact of every socket-outlet except where the socket-outlet is supplied from an isolating transformer;
 - (d) Metallic fittings in contact with structural metalwork, or in contact with conductive building materials;
 - (e) Metallic sheathing or armouring, or metallic sheathing or braiding of a cable or flexible cord;
 - (f) Metallic standards, brackets, and stay wires; and
 - (g) Any metallic supports for standard low voltage aerial conductors within 2.5 m of the ground, floor, platform, or other structure on which a person may be expected to stand.

- 2.2.1.1 The following fittings are not required to be earthed provided they are isolated in a manner that ensures they are not liable to come into contact with live parts, or with earth or earthed metal:
- (a) Short isolated lengths of metal used for mechanical protection of sheathed wiring;
 - (b) Flush mounting metal outlet boxes, if screened by non-conducting material;
 - (c) Metal clips for fixing cables;
 - (d) Lamp caps;
 - (e) Small parts isolated by insulating material (e.g. nameplates);
 - (f) Metal chains for the suspension of lighting fittings;
 - (g) The metallic sheathing or braiding of a cable or flexible cord where specifically designed, and used, as a neutral.

2.2.2 The earth continuity conductor of any subcircuit shall not be used to earth any other circuit.

2.2.3 Double insulated fittings and double insulated fixed wired appliances shall not be earthed.

2.3 EARTH ELECTRODES

2.3.1 Earth electrodes and their connections shall be located so that they are not subjected to mechanical damage or corrosion.

2.3.2 Earth electrodes shall be sized no smaller than the earthing lead unless the reduction in size is supported by specific calculation.

2.3.3 Aluminium or aluminium alloys shall not be used for earth electrodes.

2.3.4 Pipes used for other services shall not be used to form, or be a part of, an earth electrode.

2.3.5 Rod earth electrodes shall be either:

- (a) Non-ferrous rods of not less than 12 mm diameter; or
- (b) Non-ferrous coated steel rods of not less than 12 mm diameter; or
- (c) Stainless steel coated steel rods of not less than 12 mm diameter; or
- (d) Galvanised steel rods of not less than 16 mm diameter; or
- (e) Galvanised iron pipes of not less than 20 mm diameter.

2.3.5.1 Rod earth electrodes shall be driven to a vertical depth of at least 1.8 metres.

2.3.6 Strip earth electrodes shall be one of the following types:

- (a) 7.5 m of 7 mm diameter copper rod; or
- (b) 7.5 m of 25 mm by 1.6 mm section copper strip; or
- (c) 7.5 m of 15 mm internal diameter galvanised iron pipe; or

- (d) 7.5 m of 15 mm internal diameter copper pipe; or
- (e) 7.5 m of 35 mm² bare copper conductor; or
- (f) 15 m of 16 mm² bare copper conductor.

2.3.6.1 Strip earth electrodes shall be buried at a depth of not less than 500 mm below ground level.

2.3.7 Structural earth electrodes shall consist of reinforcing steel and/or structural steel embedded in concrete that is in direct contact with the general mass of earth. A suitable means of connecting the earthing lead to the steelwork shall be provided.

2.4 EARTHING LEAD CONNECTIONS

2.4.1 Earthing leads shall be connected to the earth electrode by a suitable corrosion-resistant connection.

2.4.2 Earthing lead terminations shall be readily accessible.

2.4.3 All earthing lead connections shall:

- (a) Be mechanically sound; and
- (b) Be protected against mechanical damage, corrosion, and any vibration likely to occur; and
- (c) Not impose any appreciable mechanical strain on the component fittings of the connection; and
- (d) Not cause any mechanical damage to the conductor or associated fittings.

2.5 IDENTIFICATION OF EARTHING LEAD

2.5.1 The earthing lead shall be labelled in the manner provided for in subclause 2.5.1.1 at the electrode and at the switchboard so that it is identified as the earthing lead.

2.5.1.1 The manner of labelling for earthing leads of the kind referred to in clause 2.5.1 shall be by way of permanent fitment at the connection point and legibly marked with the words "**EARTHING LEAD - DO NOT DISCONNECT**" or "**EARTHING CONDUCTOR - DO NOT DISCONNECT**", with each letter of those words having a minimum height of 4 mm.

2.6 SINGLE ELECTRICAL INSTALLATION

Where a single electrical installation is supplied from its own substation transformer then the electrical installation main earth continuity busbar shall be directly connected to the substation main earth busbar.

2.7 MATERIALS FOR EARTHING CONDUCTORS

2.7.1 Earthing leads shall be made of high conductivity copper.

2.7.2 Earth continuity conductors shall be made of:

- (a) high conductivity copper; or
- (b) high conductivity aluminium.

2.8 SUBMAIN AND SUBCIRCUIT EARTH CONTINUITY CONDUCTORS

Submain and subcircuit earth continuity conductors shall be directly connected to the earth continuity busbar at the switchboard from which the submain or subcircuit is supplied.

2.9 INSULATION OF EARTHING LEADS AND EARTH CONTINUITY CONDUCTORS

2.9.1 Subject to clause 2.9.2, conductors used for earthing shall be insulated with thermoplastic or elastomer insulation, or covering with an insulating sleeve fitted on the conductor insulation.

2.9.1.1 The colour of the insulation or sleeving shall be green or green with a yellow stripe.

2.9.2 Clause 2.9.1 shall not apply to the following conductors:

- (a) Aerial conductors:
- (b) Flat braided conductors:
- (c) Busbars:
- (d) Sheaths of MIMS cable:
- (e) Catenary wires:
- (f) Metallic wiring enclosures:
- (g) Copper earthing conductors buried directly in the ground or in an underground enclosure:
- (h) Metallic screens or armouring of cables:
- (i) Separate copper earthing conductors that cannot come into contact with any other conductor.

2.10 SIZE OF EARTHING LEADS AND EARTH CONTINUITY CONDUCTORS

2.10.1 The size of earthing leads and earth continuity conductors shall be such that:

- (a) Earth fault currents are carried by the conductor for a period of time that ensures that any protective fitting operates without danger to persons and property from the risk of electric shock and/or fire; and

- (b) Adequate protection is provided against:
 - (i) The possible effects of mechanical damage; and
 - (ii) Corrosion, where there is a likelihood that corrosion would occur at the point of installation.

- 2.10.2 Subject to clause 2.10.4, the minimum size of an earthing lead shall be determined from Table 2.

- 2.10.3 Subject to subclause 2.10.3.1 and clause 2.10.4, the minimum size of an earth continuity conductor, that is not contained in a composite cable, shall be determined from Table 3.

- 2.10.3.1 The use of Table 3 in the situations outlined in the following paragraphs, shall be as provided for in those paragraphs:
 - (a) Where, in a multiphase electricity supply, the active conductors are of different sizes, the minimum size of the earth continuity conductor shall be determined from the size of the largest active conductor to be protected:
 - (b) Where the active comprises a number of conductors, connected in parallel, the minimum size of the earth continuity conductor shall be determined from the summation of the sizes of the individual conductors forming the largest active to be protected.

- 2.10.4 Where-
 - (a) The nominal size of the active conductor is greater than 120 mm²; or
 - (b) Accurate information is available on-
 - (i) The value of the prospective fault current at the MEN switchboard; and
 - (ii) The operating time of the protective fitting; and
 - (iii) The characteristics of the conductors and insulation-then, as an alternative to using Table 2 to determine the minimum size of the earthing lead, or Table 3 to determine the minimum size of the earth continuity conductor, the minimum size may be determined by calculation.

TABLE 2**MINIMUM SIZE OF AN EARTHING LEAD**

Nominal Size of Active Conductor mm ²	Minimum Nominal Size of Earthing Lead mm ²
4 or smaller	4
6	4
10	6
16	6
25	10
35	16
50	25
70	35
95	50
120	70

Note: for sizes above 120 mm² clause 2.10.4 applies.

TABLE 3

**MINIMUM SIZE OF THE EARTH CONTINUITY
CONDUCTORS NOT CONTAINED IN A COMPOSITE CABLE**

1	2	3	4
Nominal Size of Active Conductor	Nominal Size of Copper Earthing Conductor		Nominal Size of Aluminium Earthing Conductor
Copper or Aluminium mm ²	With Copper Active Conductors mm ²	With Aluminium Active Conductors mm ²	With Aluminium Active Conductors mm ²
1	1.5	-	-
1.5	1.5	-	-
2.5	2.5	-	-
4	2.5	-	-
6	2.5	2.5	-
10	4	2.5	-
16	6	4	6
25	6	6	6
35	10	6	10
50	16	10	16
70	25	10	25
95	25	16	25
120	35	25	35

Note: for sizes above 120 mm² clause 2.10.4 applies.

SECTION 3

INSTALLATION OF EARTHING LEADS AND EARTH CONTINUITY CONDUCTORS

3.1 GENERAL

- 3.1.1 All earthing leads and earth continuity conductors, and other forms of earthing, shall be installed in a manner which provides adequate protection against likely mechanical damage, chemical, and electrolytic deterioration.
- 3.1.2 Earthing leads and earth continuity conductors shall be prevented from becoming displaced, damaged, or cut, by means of one or more of the following methods (appropriate to the point of installation):
- (a) Fixing by means of clamps, clips, saddles, clouts, or similar fixings that do not either pass between the strands of the conductor or damage the conductor in any way:
 - (b) Guarding by metallic barriers or other suitable robust material:
 - (c) Installation in a wiring enclosure.
- 3.1.3 Earthing leads and earth continuity conductors, and any associated fixings, shall be protected from corrosion. Corrosion is likely to occur where moisture is present, and where dissimilar metals have been used that come into contact with each other.
- 3.1.4 All joints, terminations, fittings, and fixtures in locations exposed to the weather shall be constructed of, or protected by, corrosion-resistant material.
- 3.1.5 Where aluminium earth continuity conductors are used, they shall be installed in dry and protected situations.
- 3.1.6 In order to maintain electrical continuity, joints and terminations in earthing conductors, and other forms of earthing, shall be mechanically and electrically sound.
- 3.1.7 The connection of earth continuity conductors to an earthing terminal shall be made in a manner that will prevent spreading or cutting of the individual conductor strands and shall be suitable for the cable type.
- 3.1.7.1 Subject to subclause 3.1.7.2, the use of any of the following methods shall be deemed to be compliance with clause 3.1.7:
- (a) Crimped ferrules:
 - (b) Tunnel-type cable connections incorporating pressure plates:
 - (c) Tunnel-type cable connections incorporating clamping screws with spherical ends:
 - (d) Stud terminals:
 - (e) Non-spreading fittings:

- (f) Bi-metal crimp lugs:
- (g) Aluminium crimp lugs used with joint tensioning spring washers.

3.1.7.2 Where aluminium conductors are being connected, the methods specified in paragraphs (f) and (g) of subclause 3.1.7.1 shall be the only methods where compliance with clause 3.1.7 is deemed.

SECTION 4

EQUIPOTENTIAL BONDING

4.1 GENERAL

- 4.1.1 Equipotential bonding shall be used for metallic parts not directly associated with the electrical installation but which may become alive as the result of a fault.
- 4.1.2 Equipotential bonding arrangements are intended to minimise the risk associated with the occurrence of voltage differences between the accessible metallic parts of fittings and fixed wired appliances, and other accessible metal.
- 4.1.2.1 Subject to subsection 4.4, the accessible metal fittings requiring equipotential bonding shall include those of:
- (a) Water pipes:
 - (b) Sewage ducts or pipes:
 - (c) Gas reticulation pipes:
 - (d) Sink bench tops:
 - (e) Shower trays:
 - (f) Urinals:
 - (g) Exposed structural steel work.

4.2 INSTALLATION

- 4.2.1 Fittings used for equipotential bonding purposes (clamps etc) shall be made of non ferrous material compatible with the metal being bonded.
- 4.2.2 Conductors used for equipotential bonding shall either be of the stranded type having basic insulation, or be of a strap type.
- 4.2.3 Insulation on the conductors shall be coloured green or green with a yellow stripe.
- 4.2.4 Terminations and joints of equipotential bonding conductors shall be of a size and type appropriate to the component fittings with which they are associated.
- 4.2.5 All equipotential bonding connections shall:
- (a) Be mechanically and electrically sound; and
 - (b) Be protected against mechanical damage, corrosion and any vibration, likely to occur; and
 - (c) Not impose any appreciable mechanical strain on the component fittings of the connection; and
 - (d) Not cause any mechanical damage to the cable conductor and associated fittings.

4.3 EQUIPOTENTIAL BONDING CONDUCTORS

- 4.3.1 Equipotential bonding conductors shall connect all the following (if they are present and provided they are made of metal):
- (a) Incoming water pipes:
 - (b) Gas pipes (not being pipes provided with cathodic corrosion protection):
 - (c) Other pipe services and ducting:
 - (d) Exposed metallic parts of the building structure.
- 4.3.2 Metallic parts that have equipotential bonding shall be earthed by an equipotential bonding lead run to either the earth electrode or the earth continuity busbar.
- 4.3.3 Where the equipotential bonding lead is run to the earth electrode the termination shall be separate to that of the earthing lead.
- 4.3.4 The equipotential bonding connections to services such as gas pipes (not being pipes provided with cathodic corrosion protection) or water pipes shall be made as near as practicable to the point of entry of those services into the building or structure containing the fittings being earthed.
- 4.3.5 The size of any equipotential bonding conductors shall be not less than half that of the earthing lead, and in no case shall they be smaller than 4 mm².

4.4 EQUIPOTENTIAL BONDING EXEMPTIONS

- 4.4.1 Equipotential bonding is not required where it can be shown that there is complete segregation between any piece of accessible metal and the electrical system.
- 4.4.1.1 The following are not required to be bonded provided they are isolated in a manner (i.e. by non-metallic service pipes) that ensures they are not otherwise in contact with earth or earthed metal:
- (a) Metal taps:
 - (b) Metal baths, shower trays, metal sinks or metallic urinals:
 - (c) Gang nail plates where no electrical cable is in contact with the plate.

4.5 TEMPORARY EQUIPOTENTIAL BONDING FOR MAINTENANCE

Before any metallic service pipe (part of which is buried) is cut or uncoupled, the following precautions shall be taken to reduce the risk of electric shock:

- (a) The pipe shall be cleaned to bare metal where the clamps are to be connected; and
- (b) A bridging conductor fitted with suitable clamps shall be connected across the intended gap. A conductor of 10 mm² is suitable for this purpose; and
- (c) The bridging conductor shall not be broken or removed until all work on the pipe is completed.

APPENDIX 1

TESTING

A.1 GENERAL

Testing of the earthing arrangements can be separated into two types:

- (a) Testing the effectiveness of the earthing arrangements as a whole (earth fault loop):
- (b) Testing the resistance of the actual earth electrode.

A.2 TESTING THE EARTH FAULT LOOP IMPEDANCE

A.2.1 In testing the effectiveness of the earthing arrangements as a whole, the use of an instrument to measure earth fault loop is necessary.

A.2.1.1 Subject to the inclusion of the additional fittings specified in subclause A.2.1.2 in relation to the MEN system, the earth fault loop comprises:

- (a) The line conductor from the point of fault back to the supply transformer;
- (b) The path through the transformer winding;
- (c) The earthed neutral point of the transformer;
- (d) The path from the earthed neutral point of the transformer to the earthing lead; and
- (e) The earthing lead and the earth continuity conductor back to the point of the fault.

A.2.1.2 In the MEN system, part of the earth fault loop specified in subclause A.2.1.1 includes the neutral of:

- (a) the main cable; and
- (b) the submain (if any); and
- (c) the supply system; and
- (d) the service line in parallel with the path through earth.

A.2.1.3 The method used for testing the earth fault loop may:

- (a) Show the loop impedance in ohms; or
- (b) Give a direct indication of the maximum permissible setting of the protective fitting, or an indication of whether the protective fitting of a given rating will operate satisfactorily under fault conditions.

A.2.1.4 Where the MEN system is concerned, the tests referred to in subclause A.2.1.3 may be carried out by an instrument which determines the amount of current flowing when a known resistance (usually of the order of 10 ohms) is connected between phase and the earth electrode.

A.2.2 Subject to clause A.2.3, where a measurement of the kind referred to in subsection A.3 is made, the effective value shall be the measured value, subject to any necessary correction for the impedance of supply transformers, etc.

A.2.3 On an a.c. system operating at less than 10 amps a.c., or on a system with rapidly reversed d.c., the measured value shall be doubled, and after so doubling, the value measured at the consumer's earth terminal shall be subtracted.

A.3 MEASUREMENT OF RESISTANCE OF AN EARTH ELECTRODE

A.3.1 The measurement of the resistance of an earth electrode to the general mass of earth shall be in accordance with the steps outlined in subclauses A.3.1.1, A.3.1.2 and A.3.1.3.

A.3.1.1 To measure the resistance of an earth electrode to the general mass of earth (see Figure 1 at Page 22), a steady alternating current shall be passed between:

- (a) The earth electrode (E); and
- (b) An auxiliary earth electrode (E1) (which may be a metal spike driven into the ground) that is placed at such a distance from the earth electrode that-
 - (i) The resistance areas of the two electrodes do not overlap; or
 - (ii) Where overlap cannot be prevented, the two electrodes are as far apart as possible.

A.3.1.2 A second auxiliary earth electrode (E2) (which may be a metal spike driven into the ground) shall then be inserted half way between E and E1. The voltage drop (V) between E and E2 shall then be measured. The resistance of the earth shall then be calculated in accordance with the following formula:

$$V \text{ divided by } A$$

where-

- V** is the voltage between E and E2
- A** is the current between E and E1.

A.3.1.3 In order to ascertain whether the distance between E and E1 is large enough for accurate results, readings of the following two kinds shall be taken in accordance with subclause A.3.1.2:

- (a) With E1 six metres nearer to E; and
- (b) With E1 six metres farther from E.

If the above results are substantially similar, the mean of the those readings shall be acceptable as the measurement of the resistance of E. If those readings are not substantially similar E1 shall be moved farther from E and the tests repeated.

FIGURE 1

**MEASURING THE RESISTANCE OF AN EARTH ELECTRODE TO THE
GENERAL MASS OF EARTH**