

# Insulation Inspection and Testing

ESM-11-01

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ARTC Network Wide

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1.2	24 May 2021	Various	Updated to align with ESD-09-01 Signalling Power Supply

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## Table of Contents

<b>Table of Contents .....</b>	<b>2</b>
<b>1 Introduction.....</b>	<b>4</b>
1.1 Purpose .....	4
1.2 Scope .....	4
1.3 Document Owner .....	4
1.4 Responsibilities .....	4
1.5 Reference Documents .....	4
1.6 Definitions.....	5
<b>2 Inspection and Testing Rationale .....</b>	<b>7</b>
2.1 Concept.....	7
2.2 New and Altered Work .....	7
<b>3 Testing Considerations .....</b>	<b>8</b>
3.1 Test Equipment .....	8
3.2 Earth for Test.....	8
3.3 Inspection .....	8
3.4 Testing of ELDs.....	9
3.5 Test Frequencies .....	10
3.6 Testing Complete Circuits .....	11
3.7 Signal Equipment Enclosures .....	11
3.8 Insulation Resistance Test Frequencies .....	12
<b>Test Frequencies: In-Service for 20 years or more .....</b>	<b>12</b>
<b>4 Method of Testing.....</b>	<b>17</b>
4.1 Signalling Circuits: Internal.....	17
4.2 Signalling Circuits: External Cables and Wires .....	18
4.3 Earth Leak or Insulation Defect – Actions Resulting.....	18
4.3.1 <i>Caused by Degradation</i> .....	18
4.3.2 <i>Caused by an Event</i> .....	18
<b>5 Testing Specific Signalling Cables, Wiring and Equipment .....</b>	<b>19</b>
5.1 Power Supply Busbars.....	19
5.2 External Power Supply Cables.....	19
5.3 Non-Vital Wiring and Equipment.....	19
5.4 Arrestors.....	20

5.5 Surge Protection Testing Track Circuit Cables .....20

5.6 Microprocessor Modules .....20

**6 Values of Insulation Resistance .....21**

6.1 Results Below 1 Megohm .....21

**7 Recording and Configuration Management .....22**

**8 Appendix A – Applicable Test Forms.....23**

## 1 Introduction

### 1.1 Purpose

The purpose of maintenance insulation inspection and testing of wires and cables is to check for defects or progressive degradation of the insulation of cables and wires and to determine the requirement for their repair or renewal.

Insulation defects could potentially result in irregularities and/or wrong side failures due to current leakage cutting out one or more of the control elements of a circuit or compromise the safety of personnel working making unintentional contact with live parts of the system by permitting the flow of touch currents at hazardous levels.

### 1.2 Scope

This standard cover inspection and insulation testing of wires and cables associated with signalling systems and equipment to determine asset condition or identify insulation defects.

### 1.3 Document Owner

The General Manager Technical Standards is the Document Owner. For any query, initial contact to be made at [standards@artc.com.au](mailto:standards@artc.com.au).

### 1.4 Responsibilities

Signal technicians are responsible for:

- routine inspection of visible wiring, termination and equipment for signs of potential electrical leakage paths and for insulation damage or deterioration due to vermin or mechanical damage.
- earth leakage testing (including ELD's) and recording busbar voltage leak to earth test results, and earth leakage detector tests, on the appropriate form (refer Appendix A), provided for the purpose and kept in the equipment enclosure/location.
- bringing to the attention of the Signal Maintenance Engineer any abnormal earth leakage reading and the value of all insulation resistance which is less than the minimum required or is showing signs of deterioration, as well as any visual or other evidence indicating abnormal deterioration or damage of insulation. A defect is to be raised in accordance with EGP-10-01 Asset Maintenance Works Management.

Should the results of inspection or tests of insulation indicate that further special action or testing is required, the Signal Maintenance Engineer shall direct accordingly. The Signal Maintenance Engineer shall decide under which conditions the wiring or cabling shall remain in use.

The Signal Work Group Leader shall direct and control the insulation test programme, the defect repair programme and cable renewal programme.

### 1.5 Reference Documents

The following documents support this standard:

- ESM-00-07 Calibration of Tools and Instruments for Signalling Applications
- ESA-11-01 Cables for Railway Signalling Applications – General Requirements

- ESC-11-01 Construction of Cable Route and Associated Civil Works
- ESC-21-03 Inspection and Testing of Signalling – Inspection and Testing Principles
- Technical Maintenance Plans and Associated Service Schedules for Enclosures and Aerial Line Wire Routes
- ESM-00-10 Testing and Certifying Equipment Worked on or Altered During Maintenance
- ESM-00-20 Like for Like Renewals
- SMP 12 Repair/Replacement of Signalling Wires
- ESM-00-03 Signalling Irregularities and Wrong Side Failures

The following forms support this standard:

- ESM1101F-01 TC 2(a) Cable Insulation Test Certificate
- ESM1101F-02 TC 2(b) Cable Insulation Test Certificate
- ESM1101F-03 TC 2(c) Cable Insulation Test Certificate
- ESM1101F-04 Insulation Test Record – Signalling Circuits
- ESM1101F-05 Power Supply History Card
- ESM1101F-06 Emergency Power Supply (Standby Generator) History Card.

The forms are available on the ARTC Engineering Extranet.

The following Work Instructions support this standard:

- ESI-11-10 Earth Leakage Detector Routine Testing
- ESI-11-11 Surge Protection Testing
- ESI-11-12 Testing Microprocessor Signals Equipment.

## 1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Earth Leakage Detector (ELD)	A device for indicating electrical current leakage from a normally isolated circuit to earth.
Event	A random incident that may or may not have been predicted to occur for which there is no effective failure finding or preventative maintenance task to manage the risk, e.g. be a cable being dug up by a backhoe.  As the timing of an events is unpredictable the best method of managing the risk of failure is to continually monitor or design out the vulnerability (if cost justified) or develop a procedure e.g. "dial before you dig".
Metal Oxide Varistor (MOV)	An electronic device used to protect sensitive components by shunting current caused by high voltage surges. MOVs typically

Term or acronym	Description
	degrade and become less effective from repeated exposure to surges.
Earth Leakage Detector (ELD)	A device that monitors an isolated power supply to indicate the occurrence of an earth fault on either leg of the supply bus. ELD sensitivity is set to detect a fault condition at a level less than that which would result in both an electrical and functional safety hazard this being defined as earth leakage current of such a magnitude that could hold a vital signalling relay in the energised position, or that could result in physiological harm. i.e. > 30mA.
Residual Current Device (RCD)	<p>A device that disconnects a circuit whenever it detects that the current is not balanced between the energised conductor and the return neutral conductor.</p> <p>NOTE: Must only be installed for "MEN" circuits. ELD's are provided for circuits on signalling power supplies (isolated from earth in compliance with the IT system of protection).</p>
Tail cables	Cables which are connected directly to trackside operating apparatus (e.g. release switches, annett locks, signals, points, train detection equipment, level crossing lights and booms, and such like) or to mechanical interlocking machines (lever rotary contacts, catchrod contacts, circuit controllers, electric locks, annett locks).
Main cables	A multi-core cable run between equipment enclosures (locations).
Power cables	A cable that transmits the terminal power supply between equipment enclosures (locations).
Double Switched	A circuit that has its end function cut by its functional control in the active & common or positive & negative legs e.g. the yellow signal light is cut in both legs by its HR relay contacts.
Single Switched	A circuit that has its end function cut by its functional control in the one leg of the circuit e.g. the positive leg only with the negative leg being connected directly to the bus.

## 2 Inspection and Testing Rationale

### 2.1 Concept

Insulation inspections and tests are performed to detect the presence of individual earths on conductors, degradation in the insulation of electrical circuits from earth and degradation in the insulation of electrical conductors from one another in multicore cables. This is particularly important for single switched circuits that are not an output of a CBI's or do not have back proving of relay and operating contacts.

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*NOTE: Outputs of CBI's are disconnected if it is detected in the wrong state.*

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Leakage to earth significant enough to affect the safe and reliable operation of circuits, can occur through two individual earth faults or through the cumulative effects of a number of less significant earth faults - each less significant leakage path to earth adding up in parallel to give a significant total. Circuits with cabling or wiring that are not double insulated PVC are particularly susceptible to this risk.

The aim is to detect and rectify each single earth fault before a second earth fault develops.

Earth leakage detectors, voltage leak to earth tests, and insulation test instruments assist in detecting leakage to earth.

### 2.2 New and Altered Work

Poor installation practice, leading to electrical contact between wires, between cores and between wires and framework may cause immediate or latent faults.

Testing, either prior to commissioning or as a matter of routine maintenance, is no substitute for good installation practice and thorough supervision and management of the installation process.

New and altered work shall be supervised accordingly and shall be completely insulation tested and the results recorded before the installation is brought into use. Where defects are raised as part of a defect walkout, these are to be actioned and completed within a specified timeframe by the Project Owner and accepted by the Infrastructure Manager. Where all the defects are not actioned at the time of handover, then all equipment within that area should have insulation testing undertaken at a frequency decided by Signal Maintenance Engineer until all defects are rectified.

#### References

ESA-11-01 Cables for Railway Signalling Applications – General Requirements – section 14

ESC-11-01 Construction of Cable Route and Associated Civil Works – section 14

ESC-21-03 Inspection and Testing of Signalling – Inspection and Testing Principles

ESM-00-20 Like for Like Renewals

SMP 12 Repair/Replacement of Signalling Wires

ESM-00-07 Calibration of Tools and Instruments for Signalling Applications

## 3 Testing Considerations

### 3.1 Test Equipment

All test instruments used shall comply to the requirements of ESM-00-07.

Where the working voltage does not exceed 250v between the conductors and earth or between the conductors, a 500v insulation test instrument shall be used. In other cases, a 1000v test instrument is required.

The 500v test instruments have a current rating of less than three (3) milliamps and may be used safely on connected DC circuits.

All test equipment shall be checked frequently to ensure that it functions correctly. In particular, the user shall ensure that the operation of the test equipment will not falsely operate the circuit or equipment being tested. Faulty equipment shall be repaired before being used for further testing.

### 3.2 Earth for Test

Perform a check to prove that a satisfactory test earth is obtained before insulation testing commences.

Identify a suitable earthed object close to the location, but not connected to the test earth or earth mat – this may be a steel fence or troughing support post, or a screwdriver pressed into ground that is not completely dry. Check that the insulation tester indicates a zero resistance between the intended test earth and the earthed object.

The actual value of the location earth mat/earth electrode resistance to earth shall be measured using an approved earth testing instrument in accordance with the Technical Maintenance plan and to verify earth effectiveness and prior to each insulation test. The value of earth resistance should be not greater than 5 ohms for main relay rooms and 10 ohms for isolated locations. The measured value shall be recorded on the power supply test sheets.

Where these earth resistance values cannot be obtained with standard earthing arrangements, investigations shall be carried out to determine the cause and repair. If the defect cannot be rectified or the cause cannot be determined, then the circumstances are to be referred to the Signal Maintenance Engineer for a determination.

### 3.3 Inspection

Visual inspections assist in detecting degradation of insulation.

Before-testing of cables and wires, visually examine wires, cables and cable routes for damage and deterioration of insulation as far as it is practical, particularly at points where there could be a possibility of disturbance which might cause chafing or mechanical damage to take place.

Replacement equipment shall be inspected to ensure it is in good order and condition before being placed in service.

At all times when maintaining equipment, signalling personnel shall inspect as far as practical the condition of cable and wire insulation and the condition of insulating material and components comprising the equipment being maintained.



Inspect for evidence of:

- abrasion or other damage to the insulation,
- ingress of moisture into cables or across insulating surfaces,
- build-up of metal filings, dirt and grit across insulating surfaces,
- distortion or movement of components affecting the clearance between metallic conductor parts,
- terminal lugs or wire strands coming into contact with frames,
- breakdown of surge arrestors,
- line wires coming into contact with trees,
- deposits caused by rotary contact wear and/or arcing,
- the securing glands and mechanical protection for conduits.

Major forms of wire and/or cable insulation deterioration that may be encountered are described below.

- Hardening of the insulation. In extreme occurrences the insulation may crumble and fall away thereby exposing bare copper. This has been known to occur on old VIR insulated cables.
- Softening of the inner core to a liquid, in some neoprene or synthetic rubber insulated cables. In extreme situations, the outer core can split allowing the liquid to ooze out. Neoprene and other synthetic rubber insulations have a recorded history of extreme degradation as described here. DIOPE plasticiser loss, usually in nylon-jacketed PVC wiring, is recognisable as clear oily fluid collecting at the termination ends of individual conductors. Loss of plasticiser results in no measurable loss of insulation integrity.

If either is evident, the Signal Maintenance Engineer shall be immediately notified. Further work in the location is to be managed under the defect management process.

### **3.4 Testing of ELDs**

#### **a. ELDs**

Proof of operation of the ELD shall be tested as part of the routine maintenance of the applicable power supply.

This is detailed in work instruction ESI-11-10 Earth Leakage Detector Routine Testing.

Test each ELD in accordance with the requirements of the Technical Maintenance Plan to prove it is working correctly.

The preferred method for testing ELDs is by using the integral test facility ("Test button") provided in each unit. Testing in this way proves that the ELD is functioning correctly, at the specified sensitivity, and also proves the effectiveness of the ELD detection and test earths and their connections.

Perform each test for a period not less than the operating time delay of the ELD, typically 5 seconds.

The ELD should operate for each test; if it does not, the ELD shall be declared defective, discarded and replaced.

Record the results of the tests on form ESM1101F-05.

An acceptable alternate method of test is by application of an external test resistance between each busbar and earth. The value of the test resistance shall be not less than the values shown in Table 01 below, for the applicable busbar operating voltage.

Busbar voltage (nominal)	12 DC	24 DC	50 DC	120 AC	415 AC
ELD sensitivity (kohm)	15	15	40	40	100

Table 01 – ELD sensitivities for testing

The design of the test resistance must be done that eliminates the risk of the tester making simultaneous contact with the busbar and earth. The entire test resistance lead and test contacts shall be effectively insulated, and the test contact to earth should be a clip type, to allow testing to be done using one hand only.

### 3.5 Test Frequencies

The tests applicable to the various wiring and cable type and circuit configurations for installations with over 20 years' service are detailed in section 3.9 *Insulation Resistance Test Frequencies*.

Routine maintenance testing of insulation resistance is not required for

- 1 All internal circuits continuously monitored by an ELD
- 2 All external PVC cables for double switched circuits with ELD's monitoring their power supply.

If no ELD is provided then earth leakage tests are to be performed in accordance with the requirements in Section 3.9 *Insulation Resistance Test Frequencies*, or as varied in the approved Technical Maintenance Plan's service schedule for non-ELD installations.

Tests specified in this standard should be carried out after flooding events which required equipment to be cleaned of mud and debris.

#### a. Cables or wires with unsatisfactory insulation values

If cable or wire insulation values are close to the minimum expected or the unsatisfactory values specified, and if they cannot be replaced promptly, then it is to be recorded in as a defect in WMS and the risks managed until replaced.

In addition, where an earth leak is detected due to degradation of the wires/cables, expand the testing to include a wide sample of cables of similar vintage in the region – see section 6.

#### b. Non-Vital Circuits

Non-vital wiring and/or equipment connected to non-vital busbars shall have the busbar voltage leak to earth tests carried out as per the TMP and Service Schedule for the Location/Power Supply.

#### c. Surge Protection

Requirements for testing of surge protection are detailed in ARTC work instruction ESI-11-11 *Surge protection testing*

### **3.6 Testing Complete Circuits**

Regular insulation testing of each external circuit complete end to end is not necessary as a general rule.

Should there be reason to believe that the integrity of circuits may be diminished because of undiscovered insulation defects then the Maintenance Signal Engineer shall include complete end-to-end circuit insulation testing as required.

### **3.7 Signal Equipment Enclosures**

For the purpose of this standard, signal locations shall include relay rooms, signal boxes, level crossing huts, walk-in enclosures, equipment location cases and cupboards.

## 3.8 Insulation Resistance Test Frequencies

### Test Frequencies: In-Service for 20 years or more

	Insulation Type	ELD Fitted	Double Switched in Circuit (D/S)	INSULATION TEST WORKING CONDUCTORS	Test Frequency (years)
<b>INTERNAL CABLES/WIRES</b>	PVC	ELD	D/S	NIL	-
	PVC	ELD	NOT D/S	NIL	-
	PVC	NO ELD	D/S	ALL	
	PVC	NO ELD	NOT D/S	ALL	4
	NON PVC	ELD	D/S	NIL	-
	NON PVC	ELD	NOT D/S	NIL	-
	NON PVC	NO ELD	D/S	ALL	4
	NON PVC	NO ELD	NOT D/S	ALL	2 (safety critical)

*Note: Wherever cables are visible they are to be regularly examined. If there are any indicators that cable insulation is deteriorating or defective, then more extensive insulation testing than shown above is required.*

	Insulation Type	ELD Fitted	Double Switched in Circuit (D/S)	INSULATION TEST		Test Frequency (years)
				Spare Conductors*2*1	Conductors Working	
<b>EXTERNAL MAIN CABLES/WIRES</b>	PVC	ELD	D/S	ALL	ALL	ON EVENT
	PVC	ELD	NOT D/S	ALL	MIN 2	4
				ALL	ALL	ON EVENT
	PVC	NO ELD	D/S	ALL	MIN 2	4
				ALL	ALL	ON EVENT
	PVC	NO ELD	NOT D/S	ALL	ALL	4 (safety critical)
				ALL	ALL	ON EVENT
	NON PVC	ELD	D/S	ALL	MIN 3	4 or ON EVENT
				ALL	ALL	ON EVENT
	NON PVC	ELD	NOT D/S	ALL	MIN 3	2 (safety critical)
				ALL	ALL	ON EVENT
	NON PVC	NO ELD	D/S	ALL	MIN 3	2
				ALL	ALL	ON EVENT
	NON PVC	NO ELD	NOT D/S	ALL	ALL	2 or ON EVENT (safety critical)

*Note: \*1 F/CC Carry out function tests of external contacts of operating apparatus to verify no core to core insulation breakdown. Core to core insulation tests of all working conductors in the multicore cable may be used instead but not if more than one wire at a time has to be disconnected from its terminal in the apparatus. The links at the location end are to be opened.*

*Wherever cables are visible they are to be regularly examined. If there are any indicators that cable insulation is deteriorating or defective then more extensive insulation testing than shown above is required*

*Where an earth leak is detected do insulation testing to identify the cause of the defect. If due to degradation of the wires/cables, implement insulation testing to include a wide sample of cables of similar vintage in the region – see 4.3.1*

*If there is an earth leak on a busbar, then all that insulation testing can do is (1) confirm that there is an earth leak on the busbar or (2) with each circuit on the busbar isolated in turn, identify which circuit on the busbar has the earth leak. Further isolation of that circuit into shorted segments is needed, to enable isolation of the fault down to a single conductor. Other test technique will be required to determine the specific location of the fault.*

*On EVENT – see 4.3.2*

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	Insulation Type	ELD Fitted	Double Switched in Circuit (D/S)	INSULATION TEST		Test Frequency (years)
				Spare Conductors*2	Conductors Working	
<b>EXTERNAL POWER CABLES</b>	PVC	ELD/RCD	-	-	ALL	ON EVENT
	PVC	NO ELD	-	-	ALL	4
	NON PVC	ELD/RCD	-	-	ALL	ON EVENT
	NON PVC	NO ELD	-	-	ALL	2 or ON EVENT (safety critical)
	NON PVC	ELD	D/S or CBI/SSI	ALL	MIN 3	2
				-	ALL	ON EVENT
	NON PVC	ELD	NOT D/S	ALL	MIN 3	2
				-	ALL	ON EVENT
	NON PVC	NO ELD	D/S	ALL	MIN 3	2
	NON PVC	NO ELD	NOT D/S	-	ALL	ON EVENT
<b>EXTERNAL TRACK FEED CABLES</b>	NON PVC	Track Circuit Tail	DC, AC, HVI & Coded Track circuits ONLY	-	All	4
				-	ALL	ON EVENT
	NON PVC	Track Circuit Tail	A/F, overlay, predictor Track circuits ONLY	-	All	ON EVENT

*Note: \*2 Include test of spare conductors to one another. Also test spare and working conductors to metal casing/frame of operating apparatus, and in multicore cables. Wherever cables are visible they are to be regularly examined. If there are any indicators that cable insulation is deteriorating, or defective then more extensive insulation testing is required.*

Test Frequencies: In-Service for 20 years or more

*Where an earth leak is detected do insulation testing to identify the cause of the defect. If due to degradation of the wires/cables, implement insulation testing to include a wide sample of cables of similar vintage in the region – see 4.3.1*

*On EVENT – see 4.3.2*

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## 4 Method of Testing

Tests should be carried out only after the circuit to be tested has been completely isolated from its power supply at both ends.

Electronic (solid state) based equipment such as CBIs, rectifiers, power supplies, diodes or transistors, electronic time limit or electronic flashing relays, solid state modules, surge protection equipment, etc., shall be disconnected before testing to avoid damage from the insulation test meter voltage.

For internal wiring and cabling of signal locations, the internal circuits should be tested complete with all relay contacts closed and disconnected at outgoing cable links. Where this is not possible, the internal circuit shall be tested throughout over individual parts that can be closed.

The insulation of each circuit should then be tested to earth using the same earth to which the metal of relay racks or location cupboards are connected (where these are earthed), after the effectiveness of the earth connection has been proven as described in section 3.2 *Earth for Test*.

If there are less spares than the minimum requirement in a multicore cable and working conductors are required to be disconnected, select from the outer layer of cores and record core numbers. Where some working conductors in the cable are connected directly through to busbars that are monitored by earth leakage detectors, and some are not, then those that are not shall be selected in preference. Where applicable the working conductors of single wire routes shall be similarly selected.

Cables with metallic screen sheaths or bare conductor drain wires earthed via lightning arrestors shall have the arrestors disconnected at both ends during tests.

The external cables and wires being tested shall be disconnected at the cable links from the internal equipment and wiring. For tail cables, the testing should be done without disconnecting the operating apparatus.

Record results on forms referred to in Appendix A. Each sheet shall only be compiled by one individual signalling person. If an alternate signalling person undertakes part of the work, then these results shall be recorded on a separate copy of the record sheet.

The process of insulation testing shall be as per the test instrument manufacturer's instructions. All safety requirements shall be complied with.

All test results shall be recorded on the appropriate forms - see Appendix A for links to the forms associated the forms associated with this standard.

### 4.1 Signalling Circuits: Internal

#### a. Power Supply Busbar Voltage to Earth

Where power supply busbars are not fitted with earth leakage detectors then, on each maintenance visit, the busbar voltage to earth for each leg shall be tested, with the fixed test equipment, where provided, or otherwise with a digital multimeter such as a Fluke meter, fitted with a 20k ohm shunt.

NOTE: Under no circumstances is an ammeter to be connected between any busbar and earth.

All busbar voltage leak to earth test readings shall be recorded in an appropriate record book or on record cards provided for the purpose, and a check shall be made for any deviation from previous readings. Record results on ESM1101F-05.

Where either leg (i.e. B/BX or N/NX) voltage to earth reading exceeds 60 per cent of the busbar voltage, or where the summation of both legs (i.e. B/BX and N/NX) exceeds 80 per cent of the bus bar voltage then further investigation is required.

#### **b. Internal Wiring – Circuits with Earth Leakage Detectors**

No maintenance insulation testing of internal wiring is required where earth leakage detectors continuously monitor supply busbars that feed the internal wiring or if the circuits are double switched.

#### **c. Internal Wiring – Circuits without Earth Leakage Detectors**

Where internal wiring is more than 20 years old and fed from power supply busbars without earth leakage detection, then the internal wiring shall be insulation tested to earth and to frame as per section 3.8.

Internal circuits over 20 years old with non-PVC wiring are to be tested as specified in section 3.8. The results are to be recorded on ESM1101F-04.

#### **d. Outputs from CBI**

Output circuits from CBIs are not required to be insulation tested where the CBI disconnects the output if it is detected in the wrong state.

#### **e. Wiring to Mechanical or Power Interlocking Frames**

Circuit wiring to mechanical or power interlocking frames or to annett locks or safeworking instruments in signal boxes is to be treated as stipulated for tail cables.

## **4.2 Signalling Circuits: External Cables and Wires**

The external main and local tail cables and wires which connect relay rooms, walk-in-enclosures and control equipment location cupboards and cases to one another and/or to vital signalling operating apparatus shall be tested, as listed in section 3.9 *Insulation Resistance Test Frequencies*.

Record results on forms referred to in Appendix A. Each sheet shall only be compiled by one individual signalling personnel. If an alternate signalling person undertakes part of the work, then these results shall be recorded on a separate copy of the record sheet.

## **4.3 Earth Leak or Insulation Defect – Actions Resulting**

### **4.3.1 Caused by Degradation**

Where an earth leak or insulation defect is detected due to degradation of the wires/cables, expand the testing to include a wide sample of cables of similar vintage in the region.

### **4.3.2 Caused by an Event**

Where an earth leak is detected due to an event expand the testing to include all wires/cables in the trench or equipment enclosure.

Events include:

- Flooding of equipment
- Ground movement in the vicinity of cables – land slip, rock fall, subsidence, etc.
- Mechanical damage to cable

- Earth leakage detected
- Where it is suspected the cables may be damaged by a power or lightning surge

## 5 Testing Specific Signalling Cables, Wiring and Equipment

All test results shall be recorded on the appropriate forms - see Appendix A. All faults are to be investigated and resolved and recorded as a defect in the management system.

Test requirements are summarised in tabulated in section 3.8.

### 5.1 Power Supply Busbars

Periodic maintenance testing – Ref TMP and Service Schedules for Enclosures:

If an ELD is fitted, then check if a fault is indicated also test the ELD unit for each busbar.

If no ELD is fitted then the busbar voltage to earth for each leg shall be tested, with the fixed test equipment, where provided, or otherwise with a digital multimeter such as a Fluke meter fitted with a 20k ohm shunt.

Where either leg (i.e. B/BX or N/NX) voltage to earth reading exceeds 60 per cent of the busbar voltage, or where the summation of both legs (i.e. B/BX and N/NX) exceeds 80 per cent of the bus bar voltage, then further investigation is required.

A result exceeding these values indicates an earth leakage less than 50k ohm.

**Exception:** level crossing supplies where the summation of the BX and NX 120 may be less than 10vac.

### 5.2 External Power Supply Cables

The conductors of signalling power cables and wires are not required to be tested where the supply busbars are connected to earth leakage detectors or where residual current devices are fitted.

Cables with metallic screen sheaths earthed via lightning arrestors shall have the arrestors disconnected during tests.

Signalling power cables and wires are to be insulation tested each conductor to earth and to each other.

When the power cables and wires are being insulation tested, they are to be disconnected from the supply and from the equipment, including disconnection from surge protection equipment.

RCDs are only fitted on 240v MEN supplies (generally authority supplies) and are not subject to routine insulation resistance tests.

Insulation testing of 120v AC power supply mains that only feed isolating transformers for SSI Trackside Functional Modules is not required.

Record results on ESM1101F-02.

### 5.3 Non-Vital Wiring and Equipment

Non-vital wiring and/or equipment connected to non-vital busbars shall have the busbar voltage leak to earth tests carried out and the tests results shall be recorded. Record results on ESM1101F-05.

## 5.4 Arrestors

Arrestors or varistors to earth shall be tested using an ohm-meter or arrestor tester to ensure they are open circuit. Where arrestors are found to have operated, then the whole of the cable shall be tested as per the requirements of section 4.

Similarly, breakdown tests of arrestors or varistors are also required.

This is detailed in work instruction ESI-11-11 Surge Protection Testing.

## 5.5 Surge Protection Testing Track Circuit Cables

Track circuit leads from the location to the bootleg riser, trackside disconnection point, bond, or tuning unit, shall be disconnected at each end and each conductor insulation tested to earth and where applicable, metallic screen sheath to earth. Record results on ESM1101F-02.

Risk management measures must be taken to ensure the polarity is not reversed when reconnecting 50hz AC, DC and impulse track circuits.

## 5.6 Microprocessor Modules

Insulation Testing is not required for circuits or tail cables connecting to computer based interlocking equipment. This includes Microlok lamp driver or output cards, Westrace MkI VLOM or VROM or HIMA F series CBI and I/O modules. These are protected by self-checking in the module.

This is detailed in work instruction ESI-11-12 Testing Microprocessor Signals Equipment.

## 6 Values of Insulation Resistance

For installations up to 20 years old values between infinity and **40 megohms** insulation resistance to earth (up to 1km in length), irrespective of the type or length of cable, internal or external should be **expected** for signalling cables which are free of apparatus, i.e., links disconnected.

Values better than **5 megohms** insulation resistance to earth should be **expected** for local tail cables tested with the cable disconnected at the location but connected at the trackside apparatus.

Values below **5 but above 1 megohm** insulation resistance to earth for complete signalling circuits are considered **unsatisfactory** and should be recorded as a defect and investigated – see 5.3.1.

### 6.1 Results Below 1 Megohm

Values below 1 megohm insulation resistance to earth for complete signalling circuits are considered **defective** and must be investigated and resolved. Appropriate risk assessment and management measures are to be introduced until the defect is rectified. Single switched circuits are a high priority defect and must be resolved urgently and appropriate risk management measures are to be introduced (including consideration of booking the equipment out of use) until the defect is rectified or otherwise protected. Defects in a single core of a cable may be remedied by utilising a spare wire/cable core. However, this is to be a temporary measure only as a defective core indicates a potential breakdown of the whole cable.

When no obvious cause can be found and remedied for cables and wires that produce test results of a value less than the minimum expected values specified above, or less than the unsatisfactory values specified above, the details shall be reported immediately to the Maintenance Supervisor and escalated as appropriate.

In the case of single switched circuits; If cable or wire insulation values are close to the **unsatisfactory** values specified, and if they cannot be replaced promptly, the non-tested cores in the cable are also to be tested and the whole of that cable or wire is to be retested at double switched or CBI output 6 monthly and single switched 3 monthly intervals until replaced.

Any vital signalling circuit with a conductor with an insulation resistance to earth value of **200,000** ohms or less is considered **failed** and shall be disconnected and booked out of use except where written authority is obtained from ARTC Standards, to retain the circuit in service under nominated conditions.

Appropriate risk management measures may include changing circuits on defective cores to non-defective cores, temporary rewiring/re-cabling, insulation taping of defective sections, protective measures against disturbance, frequent insulation testing to monitor degradation, and monitoring busbar voltage to earth readings or installing earth leakage detectors.

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*NOTE: Where a circuit is double switched the risk is less than with single switched circuit.*

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## **7 Recording and Configuration Management**

All test certificates shall be uniquely identified with a certificate number in the appropriate section of the respective form. This number shall be issued by the Signal Engineer or Signal Maintenance Manager (as appropriate) for the corridor section. Where certificates are created as part of a project the Tester in Charge shall allocate the unique certificate number.

The signal cables can have a service life up to 40 years and the gradual deterioration of the cable as represented by the test values needs to be available for comparison. The test certificates are to be retained as records for the life of the cable. The Signal Engineer or Signal Maintenance Manager (as appropriate) for the corridor section is to manage for the scanning and electronic retention of the test certificates. This responsibility includes ensuring test certificate availability for future engineering managers of the assets.

## **8 Appendix A – Applicable Test Forms**

Test certificate forms are controlled documents. Copies of the form/s listed below shall be downloaded from ARTC website or extranet, when needed for use:

- ESM1101F-01 TC 2(a) Cable Insulation Test Certificate
- ESM1101F-02 TC 2(b) Cable Insulation Test Certificate
- ESM11-01F-03 TC 2(c) Cable Insulation Test Certificate
- ESM1101F-04 Insulation Test Record – Signalling Circuits
- ESM1101F-05 Power Supply History Card
- ESM1101F-06 Emergency Power Supply (Standby Generator) History Card