UGL REGIONAL LINX

INSPECTION & TESTING PROCEDURES

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CRN SC 010

LINKING COMMUNITIES. CONNECTING CUSTOMERS.

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Document Control

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1.1	03/12/2021	UGLRL Operational Standards Template applied
2.0	17/12/2021	First approved and issued UGLRL version
3.0	25/01/2022	Issued for publish to intranet and webpage

Summary of changes made from previous version

Section	Summary of change
All	This document is based on the previous rail infrastructure maintainer (RIM). Full revision history is available on request from UGLRL.

1 Introduction

1.1 General

This Specification is part of a suite of inspection and testing of new and altered works requirements as nominated in Clause 1.3 Applicable documents.

This Specification sets out the requirements of the inspection and testing procedures for certifying new and altered signalling works and the standard procedures and practices for carrying out and recording inspection and testing.

1.2 Definitions

Signalling definitions are contained in the "Signal Engineering Standard CRN SD 032 Glossary of Signalling Terms. Additionally, the definitions from Specification CRN SC 008 Plans, Programs, Documentation and Packages apply to this Specification.

1.3 Applicable Documents

This Specification shall be read in conjunction with the CRN System Safety Manual and associated frameworks, standards, Specifications and elements.

This Specification shall be read in conjunction with companion CRN Infrastructure Engineering Specifications - Signalling:

- Specification CRN SC 007 Roles, Responsibilities and Authorities,
- Specification CRN SC 008 Plans, Programs, Documentation and Packages,
- Specification CRN SC 009 Inspection and Testing Principles,
- Specification CRN SC 011 Typical Inspections and Tests For Signalling Apparatus,
- Specification CRN SC 013 Interface Requirements and Procedures for Alterations,
- Specification CRN SC 012 Standard Forms,
- CRN SC 006 Signalling Documentation and Drawings,
- CRN SC 017 Computer Based Interlocking,
- Signalling Maintenance Procedures Manual CRN SP 000,
- Signal Engineering Standard CRN SD 032 Glossary of Signalling Terms.

This Specification shall be read in conjunction with CRN Infrastructure Engineering Specifications – Signalling for Equipment and Construction:

- As published on the Engineering pages of the CRN Intranet and internet
- Training and Competency Procedures as follows:
- Personnel training, licensing and logbook documents.
- Signal Engineering Instructions and Guidelines:
- As issued from time to time and published on the Engineering pages of the CRN Intranet and internet.

2 Insulation Testing

2.1 General

The aim of insulation testing is to ensure that electrical circuits are adequately insulated from one another and from earths so that circuit functions are not liable to incorrect energisation by electrical leakage currents.

Circuit electric leakage paths to earth can be detected by the use of earth leakage detectors, voltage tests to earth, and insulation test instruments. Visual inspections also assist in detecting damage or deterioration of insulation.

Deterioration in the insulation of circuits from earth or from one another may occur due to ageing, cracking, abrasion or other damage to the insulation, entry of moisture into cables or across insulating surfaces, build-up of dirt and grit etc. on or across insulating surfaces, distortion or movement of components affecting the clearance between metallic conductor parts, terminal lugs or wire strands shifting into contact with frames, breakdown of surge arresters, line wires coming into contact with trees, deposits caused by rotary contact wear etc.

Perform Insulation Testing to determine the following:

- Insulation resistance to earth of electrical equipment, wire conductors, cable cores, and cable sheaths,
- Insulation resistance between cable cores,
- Insulation resistance between each cable core and the cable sheath.

2.1.1 Megger Test Instrument

The insulation testing of all wiring and equipment associated with signalling installations must be carried out prior to bringing into use any new work and thereafter at regular intervals with a type approved 'Megger' type tester with a voltage output of 500 volts D.C. and a current output of no more than 3 milli-amps. This can be of the hand generator type or the electronic version. The instrument shall be type approved.

2.1.2 Regularly Test Instrument and Earth

Test the instrument to ensure correct operation and voltage and current output before commencing the tests and at regular intervals.

Test the test earth immediately prior to performing a series of tests and immediately after the last of the series of tests. Retest if disturbed at any time.

Where a combined bell tester/insulation tester is approved regularly test the insulation tester to ensure it detects an insulation resistance to earth below the stipulated value.

2.1.3 Insulation Test Conditions

Insulation testing involving external wiring / equipment should be carried out in wet / damp conditions wherever practical

Record weather conditions at time of test and enter on test certificate.

2.1.4 Insulation Tests: Circuits

When insulation testing circuits, it is desirable to test the complete circuit as a single test. Refer to Paragraph 2.3.

In approved cases, insulation testing of circuit internal wiring may be done at the same time as the bell continuity test, one wire at a time, using an approved combined bell continuity/insulation tester.

When performed in conjunction with bell continuity tests, any insulation to earth defects in plug-in relays and some other equipment will not be detected as these are removed for the bell continuity tests.

Similarly any insulation breakdown to the equipment case or to frame, but not earth, will not be detected.

This needs to be covered by other means, eg. earth leakage detection tests on busbars during circuit function tests, individual equipment insulation tests, equipment acceptance tests, or a later test of the complete circuit.

Testing of a complete circuit, with all other circuits connected and working, has the added advantage of possibly detecting an insulation breakdown directly between circuits and not via earth.

2.1.5 Lightning Protection Devices

Prior to testing, all lightning protection devices must be removed or disconnected to avoid incorrect or misleading readings.

2.1.6 Removal of Solid State Devices

To avoid damage from the 500-volt output of the 'Megger' all solid state devices (electronic timers, flashing relays, rectifiers etc.) must be disconnected or removed prior to testing.

2.1.7 Rotary Contacts

When testing circuits containing rotary contacts or other contacts with bridging segments, the test must be made with the contact closed to ensure that the segment or bridging piece is in circuit. Faults have occurred where the screw holding the segment to a wooden contact roller has been short-circuited to frame.

2.1.8 Equipment Case Earths

Point mechanisms may be mounted on timbers and insulated from the rails and therefore isolated from earth. All circuits passing through the point machine must therefore be tested to the case of the mechanism as well as to earth.

Circuits through level crossing barrier mechanisms, releasing switches, etc. must be similarly tested.

2.1.9 Transformers

When testing circuits containing transformers the primary and secondary wiring must be individually insulation tested.

2.2 Insulation Testing of Cables

2.2.1 General

Cables are to be tested when terminated at both ends; it being of equal importance that the terminal is free of earth fault, as is the cable.

In a section of open aerial wires, the cable connecting the locations to the aerial at each end of the section, together with the aerials themselves may be treated as a continuous cable.

Similarly, a series of power cables connecting several successive locations, may be switched (or linked) through in each location, and the continuity and insulation tests performed as if the cables were one. On new or altered work the polarity shall be proved separately at each location.

Minimum cable insulation values for new cables shall be 60 Megohm/km conductor to earth, 5 Megohm/km sheath to earth and 60 Megohm/km conductor to conductor.

Any failure to attain minimum values for new cables shall be regarded as a fault condition.

Insulation resistance values for cables have been specified at 20C. The measured value of insulation resistance is temperature dependent, and, if the measured value is taken at a different temperature, it must be corrected to 20C. Temperature correction factors for common insulating materials are tabulated in Specification CRN SE 035 Cables for Railway Signalling Applications - General Requirements.

The tests shall be carried out in the following order:

- Verify sheath arrestors correctly installed and remove prior to tests,
- Verify correct cable conductor size and cable insulation has been installed,

- Prove integrity of "Test Earth",
- Test continuity of each conductor being insulation tested,
- Test Insulation between each conductor and all other conductors in the cable and the cable sheath,
- Test Insulation between each conductor to earth,
- Test Insulation between sheath to earth,
- Check correct polarity of all power cable.

2.2.2 Continuity Test Cable

Continuity must be checked before Insulation Testing to ensure that the correct wire or cable is being tested, has been correctly terminated and to validate the results of the Insulation Tests, since, if the continuity is not complete, then the insulation tests results will not be correct.

When continuity tests are made on multi-core cables, ensure that each cable core is connected to the correct termination by connecting cable core No. 1 sequentially to every other cable conductor at one end and similarly the continuity tester at the other end.

A low voltage continuity tester is preferable to utilising the Megger insulation tester for continuity testing, as high resistances may not be detected by the Megger insulation tester.

All details of tests are to be noted on the appropriate cable insulation test sheets and signed by the person conducting the testing.

2.2.3 Conductor Insulation Testing

2.2.3.1 Single Series of Tests

With proper preparation, all insulation resistance measurements on a multi-core cable can be completed in a single series of tests:

- Ensure that the cable is terminated at both ends, on standard disconnect terminals, and that all links are open at both ends,
- Connect the earth terminal of the megger tester to a suitable Test Earth,
- At the end of the cable nearest the Test Earth, connect all conductor cores together on the cable side of the termination links with, for example, a 'daisy-chain' of 4mm plugs looped together,
- Prove the continuity of the daisy-chain by checking that each plug meggers short-circuit to the No.1 plug,
- Alternatively the following tests may be carried out as individual tests for each conductor core, without linking the cores.

2.2.3.2 Individual Tests

2.2.3.2.1 Prove integrity of Test Earth

Connect the insulation tester, one leg to the test earth, the other leg to one conductor, or to the conductors linked together.

At the remote end of the cable, apply a second earth to the same conductor or conductors.

Prove the test earth by observing a low resistance whenever the remote earth is applied.

Remove the remote earth.

2.2.3.2.2 Insulation Test, Conductor to Earth

Measure the insulation resistance between all conductors linked together and the test earth. If the measured value is too low, megger from each conductor individually to the test earth, to identify any faulty conductor or terminal. Record the value. This should be 100 Megohm or at least 60 Megohm/km for a cable longer than 500 metres.

2.2.3.2.3 Insulation Test, Conductor to Sheath

Measure the insulation resistance between all conductors linked together and the metallic screen (sheath). If the measured value is too low, megger from each conductor individually to the sheath, to identify any faulty conductor. Record the value. This should be 100 Megohm or at least 60 Megohm/km for a cable longer than 500 metres.

2.2.3.2.4 Insulation Test, Sheath to Earth

Measure the insulation resistance between the cable sheath and the test earth. Record the value. This should be greater than 10 Megohms, or at least 5 Megohm/km for a cable longer than 500 metres.

2.2.3.2.5 Insulation Test between Conductors

Insulate each conductor in turn from the daisy chain, and measure the insulation resistance between it and all the other conductors linked together. Record the resistance value obtained. This should be greater than 100 Megohm, or at least 60 Megohm/km for a cable longer than 500 metres.

2.3 Insulation Testing of Complete Circuits

When testing, it is desirable to test the complete circuit in a single test. As an example, the following procedure would be adopted:

- Test the 'Megger' - when the handle is turned (or the button pushed on an electronic megger) with both leads together a zero reading should be obtained. When the Megger is operated with the leads separated an infinity reading should be obtained. Check the battery condition on electronic types,
- Connect one lead of the Megger to a suitable known earth. The earth should be tested by connecting the other lead to another earth and operating the Megger and obtaining a zero reading. The second earth could be obtained by using a screwdriver pushed into the ground,
- Carry out necessary Network Rules and Procedures and Signalling Maintenance Procedures before interfering with the signalling,
- Check that circuit is completely closed and that all parallel paths are closed,
- Remove the fuse and disconnect the negative/common from the bus bar,
- Test by immediately connecting the Megger lead to the active/positive end of the circuit, operating the Megger and noting the reading,
- As a check to ensure that the circuit is still complete, tap the negative/common onto a suitable earth connection while operating the Megger. A zero reading will be obtained,
- Insulation test between the signal arm contacts and wiring and the signal arm case, between the relay wiring and the relay racks, between points wiring and the points mechanism case, between release switch wiring and the release switch case etc,
- If the test reading is below the minimum requirement then the circuit must be broken up and each individual wire tested until the defect is located. To simplify the testing the circuit could first be broken up into internal and external components. When the defective part of the circuit has been found it is then only a matter of breaking up that part of the circuit,
- Similarly, if it is not practical to close the complete circuit for testing, then the circuit shall be wholly tested in separate parts.

2.4 Testing Busbar Voltage Leak to Earth

A busbar voltage test to earth consists of measuring the voltage from each leg of a supply bus, individually, to earth. Comparison of the result obtained with the nominal bus voltage gives an indication of whether any leakage exists, and on which leg of the bus (positive or negative, active or common) it is.

In each case, a significant reading obtained on one leg indicates an earth leakage fault on the opposite leg. The magnitude of the voltage reading, referred to the bus voltage, indicates the degree of the earth leakage fault.

The accuracy of the equivalent earth leakage indicated by the test for each leg of the supply busbar relies on the other leg being at a high resistance to earth.

The measurement must be carried out with the earth test voltmeters built into normal relay room switchboards, or by using a Fluke multimeter with a 100 k-ohm test shunt in parallel with its input terminals. These provide a suitable reference resistance against which any earth leakage is compared.

The use of a Fluke meter directly, without the 100 k-ohm test shunt, will lead to misleading results due to the extremely high input impedance of the Fluke meter.

The test is also misleading if both legs of the busbar have a lower resistance to earth than the meter resistance.

The test will only indicate a leak to earth in circuit wiring and equipment that, at the time of the test, is closed through to the busbar.

If there were no the discrete earth leakage points, voltage leak to earth readings would depend on the amount and distribution of circuit wiring connected to each busbar, with alternating current circuits also reflecting capacitive coupling to earth.

Busbar voltage leak to earth tests are most useful where readings are taken and recorded regularly and any significant change investigated. Maintenance publications stipulate required testing frequencies.

2.5 Localisation of Earth Leakage Faults

When an earth leakage fault on a busbar is detected isolate the circuits on the bus in turn, until the fault clears, in order to find the faulty circuit. Then further isolate sections of the faulty circuit to find the faulty component.

This method is time consuming, and involves serious disruptions to working circuits that are in perfectly good order.

An alternative method involves the use of an approved earth 'locater'. (VIGIDI) This injects a low frequency signal between the faulty bus and earth without disruption of the working equipment. A current clip ring, tuned to the injected frequency, is then used to track the injected fault current from the bus to the earth fault point, without any circuit, even the faulty one, being disconnected.

2.5.1 Busbar Voltage Leak To Earth Measurements

CONVERSION OF MEASURED VOLTAGE TO EQUIVALENT LEAKAGE RESISTANCE

(a) Values using Fluke meter with 100k-ohm shunt

LEAKAGE VOLTS		% LEAKAGE VOLTS	RESISTANCE (KOHM)
120V BUS	50V BUS		
0.12	0.05	0.1	19980
1.2	0.5	1	1980
2.4	1	2	980
3.6	1.5	3	647

6	2.5	5	380
12	5	10	180
24	10	20	80
42	17.5	35	37
60	25	50	20
72	30	60	13
84	35	70	8.6
96	40	80	5.0
108	45	90	2.2
118.8	49.5	99	0.23

(b) Values using 120 volt A.C Switchboard meter (1k ohm per volts; meter resistance 130k ohm)

LEAKAGE VOLTS		% LEAKAGE VOLTS	RESISTANCE (KOHM)
120V BUS	50V BUS		
0.12	-	0.1	130000
1.2	-	1	13000
2.4	-	2	6000
3.6	-	3	4000
6	-	5	2000
12	-	10	1170
24	-	2-	520
42	-	35	240
60	-	50	130
72	-	60	90
84	-	70	60
96	-	80	30
108	-	90	10

c) Values using 50 volt D.C. Switchboard meter (2k ohm per volt; meter resistance 140k ohm)

LEAKAGE VOLTS		% LEAKAGE VOLTS	RESISTANCE (KOHM)
120V BUS	50V BUS		
-	0.05	0.1	140000
-	0.5	1	14000
-	1	2	7000
-	1.5	3	5000
-	2.5	5	3000
-	5	10	1260
-	10	20	560
-	17.5	35	260
-	25	50	140
-	30	60	90
-	35	70	60
-	40	80	40
-	45	90	20
-	47	94	9

2.6 Testing Earth Leakage Detectors

Earth Leakage Detectors are fitted with a push button to provide a test to earth connection.

To test the operation of the Earth Leakage Detector itself, a resistance of value equal to the sensitivity setting of the ELD can be temporarily connected between the supply busbar and the test earth, first one leg then the other. The resistance value for a ML ELD is 40k ohms.

2.7 Power Supply Isolation Test

Isolation between power supplies is checked by measuring for zero voltage between power supply busbars using a 20k ohm per volt moving coil voltmeter or a Fluke digital multimeter with a 100k ohm shunt. This is carried out separately for each busbar normal and emergency supply with the other busbars connected in each case alternatively to their normal supply and, where applicable, to their emergency supply.

With the power supply disconnected, the busbar isolation to earth is checked using an ohmmeter.

3 Bell Continuity Test

3.1 General

A bell continuity and correspondence test is carried out on each installed wire from termination point to termination point in accordance with the circuit-wiring diagram.

The bell continuity test will not necessarily prove that the wiring takes the path shown nor prove the absence of any incorrect intermediate connections that might provide a false feed or bridge out a function, Therefore a Wire Count and a Null Count must also be carried out to reveal any wiring anomalies. Otherwise hand tracing of each wire would be needed to verify internal wiring.

3.2 Bell Continuity Test Procedure

Before a bell continuity test is conducted all wiring is to be terminated and all contacts, fuses, links, etc are to be opened to ensure no alternative paths exist. All plug-in relay connectors are to be locked into their relay base positions.

In the case of shelf type relays that do not have detachable tops, removal of the relay is not practical and the bell continuity test is carried out with the relays de-energised for front contacts and energised for back contacts to ensure that each end of the wire under test is open circuit.

The seals of shelf type relays must not be broken nor the relay case opened.

The shelf type relays would be de-energised with all fuses and links removed. To energise a shelf relay for a bell continuity test of wiring to a back contact of that relay, a temporary false feed may be used directly across the relay coil terminals provided that the relay and all circuits through the relay are disconnected and out of use. Refer to Clause 6.1.4 of this Specification "False feeds". Alternatively the wire may be temporarily removed from the terminal but the disconnection; test and reconnection of the wire shall be done as single, uninterrupted activity.

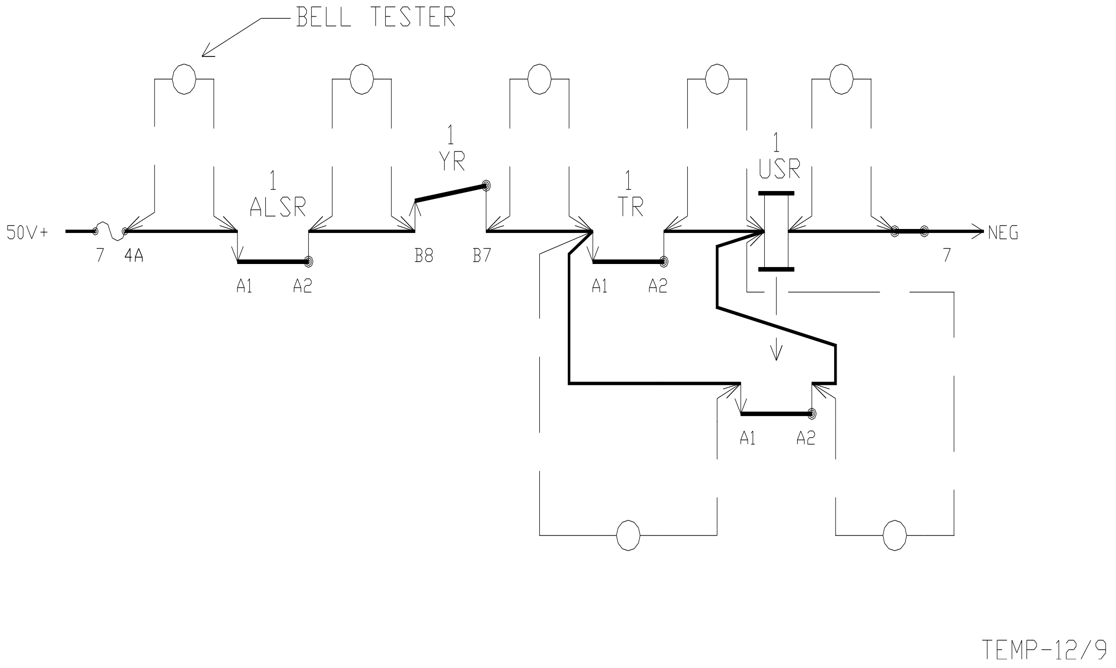
The bell tester shall be a low voltage audible alarm that shall sound when the bell tester leads are connected across a short circuit wire. The bell tester shall have its own independent power supply. A high resistance or open circuit between the terminated ends of the wire under test shall prevent the alarm sounding.

- Place the bell continuity tester leads onto the terminal studs of equipment or into the wire entry side of plug-in relay bases etc, thus enabling the wire count to be made at the same time as the continuity test.
- Start at a logical point eg, the fuse end of a circuit. Place the first lead of the bell continuity tester at that terminal point. The second lead is to be placed on the terminal at the other end of the wire being tested. An output from the bell continuity tester indicates wire continuity between the two terminals. Where the circuit extends with 2 wires on each termination point, the test

may be conducted staying on the first single wire and moving one probe through the series chain to the single termination at the end.

- Proceed systematically, bell continuity testing each individual wire through the circuit, including all parallel paths, until the entire circuit or part circuit has been tested, while also counting the wires on each individual terminal and contact point.
- The method of indicating on the circuit wiring diagrams that the tests have been successfully carried out is shown in Specification CRN SC 008 Plans, Programs, Documentation and Packages" Clause 3.12.

3.3 Example of Bell Continuity Test



- To bell continuity test the circuit above:
- Remove fuse and negative link pin,
- Remove all plug in relays,
- De-energise shelf relays to open front contacts, energise shelf relays to open back contacts,
- Place one leg of bell set on fuse terminal 7 and other leg on A1 of 1 ALSR. Bell sound indicates continuity of circuit,
- Proceed systematically through the circuit, bell continuity testing each wire between its connection points, until the continuity of all wires is tested,
- Count wires on each individual terminal and contact point, as each wire is continuity tested.

NOTE: In plug-in relay installations - bell testing shall be carried out from rear of the relay base.

4 Wire Count and Null Count

The Wire Count is generally carried out at the same time as the bell continuity test by the same person who is inserting the lead of the bell continuity tester. It may be carried out as a separate exercise.

Examine the apparatus and the corresponding circuit wiring diagram and analysis sheets:

- Verify the number of conductors terminated at a particular point is as shown on the circuit wiring diagrams

  - There should normally be no more than two wires attached to any single termination point in the case of a plug in relay and one wire in the case of a clamp type terminal,
  - The wire count shall include verification of all conductors connecting to a terminal, whether wires, busbars, links or other strapping. Rail mounted fuses should be closely checked to verify the presence or absence of common connections,
- Verify the wiring identification labels correctly identify the termination point of the wire,
- Check terminations and crimps are correctly made, wires are not trapped under adjacent terminals and spade type crimps are correctly locked into plug boards or terminal blocks,
- Prior to proceeding with the next test the person who is marking up the circuit books is to complete a documentation check to cross relate the circuit to the information contained in the documentation (contact analysis/fuse/terminal analysis etc.),
- Once it has been verified that the circuits and analysis documentation are correct and in agreement then testing may proceed,
- The method of indicating on the wiring diagrams and analysis sheets that the tests have been successfully carried out is shown in Specification CRN SC 008 Plans, Programs, Documentation and Packages Cause 3.12.

When internal parts of a circuit are tested separately from the external part of a circuit the wire count on both sides of the external cable termination link shall be performed by every person who tests the circuit either side of the cable termination link. That is, by the persons doing circuit testing of the internal wiring, by persons doing circuit testing of the external wiring, and by persons doing through circuit tests.

The wire count on both sides of the external cable termination link shall be recorded on the circuit diagram in the standard manner by the person conducting the circuit testing of the internal wiring and verified by the person conducting the through testing in accordance with Clause 7.2 iii).

The person responsible for testing the circuit shall check all wires in vital signalling circuits to be shown as wire counted on the testing copy of the circuit diagram.

When wire counting, all conductors connecting to a terminal shall be checked including bridging, busbars and links.

Wire counts, bell continuity tests, and insulation tests shall include the external wiring run to signal head LED terminals, to point machine terminals, , to releasing switch terminals, to electric lock terminals, to level crossing mechanism terminals, to highway and boom lights terminals and to all operating mechanisms and contact terminals of operating mechanisms.

Wire counts, bell continuity testing and insulation testing of the internal wiring within equipment mechanisms may be carried out in pre-site tests and factory acceptance tests. Certificates are required.

- The Null Count is carried out after the Bell Continuity Test and Wire Count has verified the wiring connecting to the respective terminals.
- The documentation to be used shall be the relevant completed analysis sheets that were checked / marked up from the documentation check.
- Examine relay bases, other operating equipment terminal assemblies, and fuse and terminal racks and the corresponding analysis sheets:
- Verify that there is no conductor connecting to terminals shown as spare in the contact/fuse/terminal analysis sheets in the circuit book,
- Verify that there are no contacts/fuses/terminals shown in use in the circuit book analysis sheets that are spare and without connected wires,

- On the analysis sheets mark the spare contact, fuse or terminal with a tick to indicate the test is successfully completed.

In conjunction with the Bell Continuity Test and the Wire Count, the Null Count, if carried out over the whole installation, provides assurance that there are no 'rogue' connections in the circuits. Null Counts on portion of the equipment in a circuit control area will provide less assurance.

5 Circuit Function Tests

5.1 General

The Circuit Function Test is supplementary to the Bell Test and Wire Count and is performed to verify that the fuses, links and controlling devices are effective in controlling the circuit function.

Circuit Function Tests involve energisation of the circuit then energising or de-energising (or removing and replacing) in turn each control device and observing the de-energisation of the circuit function. Specific control contacts are not individually proved.

The fuses and links are also disconnected and reconnected and the circuit function observed.

Part circuits in separate locations can be separately function tested using a voltmeter and a Through Circuit Function Test performed when the parts are interconnected over external cables.

With parallel paths, there can be several combinations of the minimum number of contact closures needed to close the circuit, as well as several combinations of the minimum number of contact openings needed to open the circuit. Rather than test every such combination it is sufficient, in conjunction with a Wire Count, to function test the controls in each and every series path with all other parallel paths open.

The Circuit Function Test will not, in itself, prove that a specific contact is actually in the circuit, particularly if the controlling device has a second contact in another position in the circuit (double switching) or if the controlling device also switches another device that opens the circuit function under test.

A Bell Continuity Test and a Wire Count are therefore also necessary to prove compliance with the circuit wiring diagrams.

Even so, these tests will not necessarily prove that the control device contacts are the correct type (back, front, normal, reverse etc) and will not necessarily prove that they are not shorted out or qualified irregularly.

This additional verification shall be achieved by separately testing that the specific control contacts are electrically opened and closed by operation of the control device and by inspection that they are the correct types. Eg, plug-in relays tested in a relay test panel and checked against the contact analysis sheets. This is called a Contact Proving Test.

Instead of a Circuit Function Test and separate Contact Proving Test, a Circuit Strap and Function Test can be used to prove that the specific contacts of control devices are effective in controlling the circuit function in accordance with the circuit wiring diagram.

Circuit Function tests, inclusive of Circuit Strap and Function tests, will not prove that series contacts are wired in the correct sequence or the correct way around (point-armature). The bell continuity test is necessary for this.

The Circuit Function Test Procedure is the same as for the Circuit Strap and Function Test, except that the specific control contacts are not proved by strapping or manual disconnection.

5.2 Circuit Function Test Procedure

i) Connect a voltmeter across the end function, or the terminals of any outgoing "part circuit".
ii) Test with other circuits energised to provide a high probability of detecting the presence of any false voltages in the circuit under test.

iii) Apply voltage to the ends of the circuit either by inserting the relevant fuses and links or by applying a fused false feed of the correct voltage to the terminals of an incoming "part circuit". The person conducting and certifying the tests shall keep records of any such false feed applied.

Note: If part of a circuit that does not include the circuit function, is being circuit function tested then a through circuit test is also required to prove that "part circuit" is in the circuit of the function concerned.

i) Make the circuit operative by energising or de-energising relevant relays and other control devices to close the complete circuit over the specific contacts involved. This may involve temporary false feeds to the control relays and these must be recorded and strictly controlled.

ii) Open and close in turn each fuse, link and control contact verifying the operation of the circuit under test by observation of the voltmeter and, except for outgoing part circuits, the end function.

iii) De-energise (or energise for back contacts) the respective controlling device to open the control contact and check that the end function de-energises and the voltmeter reading drops to zero.

iv) Where controls are wired in parallel, each and every series path through the complete circuit shall be selected in turn and the contacts in that path tested with all alternative paths broken. In each case the controlling contact, fuse or link on either side of the parallel path shall be broken and proved. Parallel paths may emanate from fuses, links or looping.

The texts of Paragraph 6.1.3 "Disconnection of Wires" and Paragraph 6.1.4 "False Feeds" also apply to Circuit Function Tests.

6 Circuit Strap And Function Test

The Circuit Strap and Function Test is the same as the Circuit Function Test except that it is extended to individually prove the specific contact of the control device is effective in the circuit.

The strap and function test of a circuit assumes that the contacts and terminals shown are the only ones in the circuit; it verifies the wiring arrangements of these contacts by:

- Closing each full series path in turn through the circuit with all other contacts open, to energise the function proving that none of the open contacts are in that series path.
- Opening each contact in turn in the series path to de-energise the function proving that the contact being opened is in the circuit and not in parallel with any other closed contact in that series path.

If each and every other contact in the location were open during the strap and function test of a circuit, or part of a circuit, than the tests would also verify that no other contacts were in series within the circuit path being tested.

If each and every other contact in the location were closed during the strap and function test of a circuit, or part of a circuit, then the tests would also verify that no other contacts were in parallel with any contacts within the circuit path being tested.

The procedure sets out the preferred method of opening and closing each specific control contact during function testing to the circuit wiring diagrams.

Where earth leakage detectors are available connect a temporary audible alarm for the duration of the tests.

6.1 Circuit Strap and Function Test Procedure

6.1.1 Procedure

- Carry out Network Rules and Procedures and Signalling Maintenance Procedures and ensue that any and all trackside apparatus affected by the tests are disconnected and booked out of use,
- Connect a voltmeter across the end function, or the terminals of any outgoing "part circuit",
- Test with other circuits energised to provide a high probability of detecting the presence of any false voltages in the circuit under test,
- Apply voltage to the ends of the circuit either by inserting the relevant fuses and links or by applying a fused false feed of the correct voltage to the terminals of an incoming "part circuit". Records of any such false feed applied shall be kept by the person conducting and certifying the tests.

Note: If part of a circuit, that does not include the circuit function, is being strap and function tested then a through circuit test is also required to prove that "part circuit" is in the circuit of the function concerned.

- Make the circuit operative by energising or de-energising relevant relays and other control devices to close the complete circuit over the specific contacts involved. This may involve temporary false feeds to control relays and these must be recorded and strictly controlled;
- Open and close in turn each fuse, link and control contact verifying the operation of the circuit under test by observation of the voltmeter and, except for outgoing part circuits, the end function;
  - De-energise (or energise for back contacts) the respective controlling device to open the control contact and check that the end function de-energises and the voltmeter reading drops to zero;
  - Bridge the specific control contact with a test strap to test the presence of that specific contact in the circuit by observing the end function re-energise and the voltmeter reading register the correct voltage.
- Where controls are wired in parallel, each and every series path through the complete circuit shall be selected in turn and the contacts in that path tested with all alternative paths broken. In each case the controlling contact, fuse or link in series on each side of the parallel path shall be broken and proved.
  - Parallel paths may emanate from fuses, links or looping.

6.1.2 Manually Opening Contacts

The seals of relays shall not be broken on site nor shall contact fingers be broken by inserting an insulation piece eg, strip of paper, cardboard or a person’s finger, within the relay case.

In the case of accessible individual contacts (eg. rotary contacts, etc) the tests may be done by manually breaking the specific contact (eg. separating the contact finger from the band) during the strap and function test.

Care must be taken to ensure that this action does not damage, introduce dirt or grease, or upset the adjustment of the contact.

If this method of opening the contact is used it must be also be proved that the control device when operated will electrically open and close the specific contact.

6.1.3 Disconnection of Wires

After certification bell continuity tests and wire counts, wires shall not be removed from contact terminals for function testing except as absolutely necessary.

In such a case the removal, test and reconnection must be done one terminal at a time by the person conducting and certifying the tests.

Wires shall be correctly labelled with the terminal number etc. before removal.

6.1.4 False Feeds

Where temporary false feeds have been applied to carry out this testing they shall be removed at the conclusion of the test and signed for on the record of false feeds applied (see Paragraph 6.1.1 v) by the person conducting and certifying the tests. Temporary wiring shall be distinctively coloured and labelled. Only registered test straps are permitted on site.

When testing near working circuits, strict care must be taken to ensure that any false feed cannot accidentally or inadvertently be applied to affect the working circuits.

Where practical and relevant, additional security can be obtained using a false feed isolated from any signalling supply in use through a separate transformer or transformer rectifier unit.

6.1.5 Test Straps

- Must be no less than 450mm long
- Must have brightly coloured insulation, preferably orange
- Must be numbered in sets
- Must be kept in a locked box. The person conducting and certifying the tests must ensure the safe custody of this box
- Must be counted and recorded before the start and at the end of each days testing work to ensure that no straps have been inadvertently left in position.

6.1.6 Plug-in Relays

With plug-in relays, if the relays are removed and straps placed in the relay base from the front to bridge the control contact terminals, the circuit can be closed to energise the end function.

If the straps are opened and closed in turn to correspondingly open and close the circuit function then the contact terminals can be proved to be in circuit. (Proof of the contact terminals would have been covered by the circuit bell continuity test.)

This test with straps in the front of the relay base is NOT a proper circuit strap and function test, as the contact type (back or front) is not proved and it will not detect any internally missing, wrong or short-circuited contact.

The plug-in relay must therefore also be tested in a relay test panel to prove that it electrically operates the contacts and that the specific contact concerned is the right type. (Contact Proving Test)

Contact Proving Tests of plug-in relays also involve an inspection of the relay for any signs of damage, foreign matter or defective operation. A signed and dated sticker affixed to the relay case shall signify that the relay has been proved in the relay test panel.

6.2 Example of Circuit Strap and Function Testing

Referring to the worked examples at the end of this Clause, the circuits, have three logic paths and would be strap and function tested in the following manner. A wire count must also be done.

- Carry out the necessary Network Rules and Procedures and Signalling Maintenance Procedures.
- Ensure that the approach stick relay and all relays in the circuit are energised (except 71u CONTROL) and that 71 and 84 signals are at stop so that all contacts and links in all paths of the circuit are closed.

- Use a Voltmeter to observe the correct operating voltage across the approach stick relay when energised and zero voltage when de-energised.
- Remove and replace No.7 fuse three times noting the approach stick relay energise and de-energise accordingly. Check that it is the correct busbar supply.
- Disconnect and reconnect No.7 common wire at the busbar three times noting the approach stick relay energises and de-energises accordingly. Check that it is the correct busbar supply.

ALL PATHS CLOSED

- Open and close No.2 contact on 84u banner signal three times noting the approach stick relay de-energise and energise accordingly. If it is not possible to open No.2 contact only on 84u signal, open all contacts and use a bridge to strap No.2 contact.
- Open and close link terminal LC1 three times noting the approach stick relay energise and de-energise accordingly.
- Energise 71u Control relay and bridge No.2 back contact three times noting the approach stick relay energises and de-energises accordingly. De-energise 71u control relay.

PATH 1 CLOSED

- De-energise 54 and 55 Normal Detector relays and open the stick finger contact (No.1) of the approach stick relay by disconnecting the wire on the point or armature terminal. Path No.1 is now closed and all other contacts in paths No.2 and No.3 are fully opened.
- De-energise M11.65A INDG relay and bridge No. 10 contact three times noting the approach stick relay energise and de-energise accordingly. Re-energise M11.65A INDG relay.
- Follow the same procedure in turn for the following contacts in path No.1, S11.70A INDG (No.7), S11.65A INDG (No.4), and S11.65B INDG (No.4).

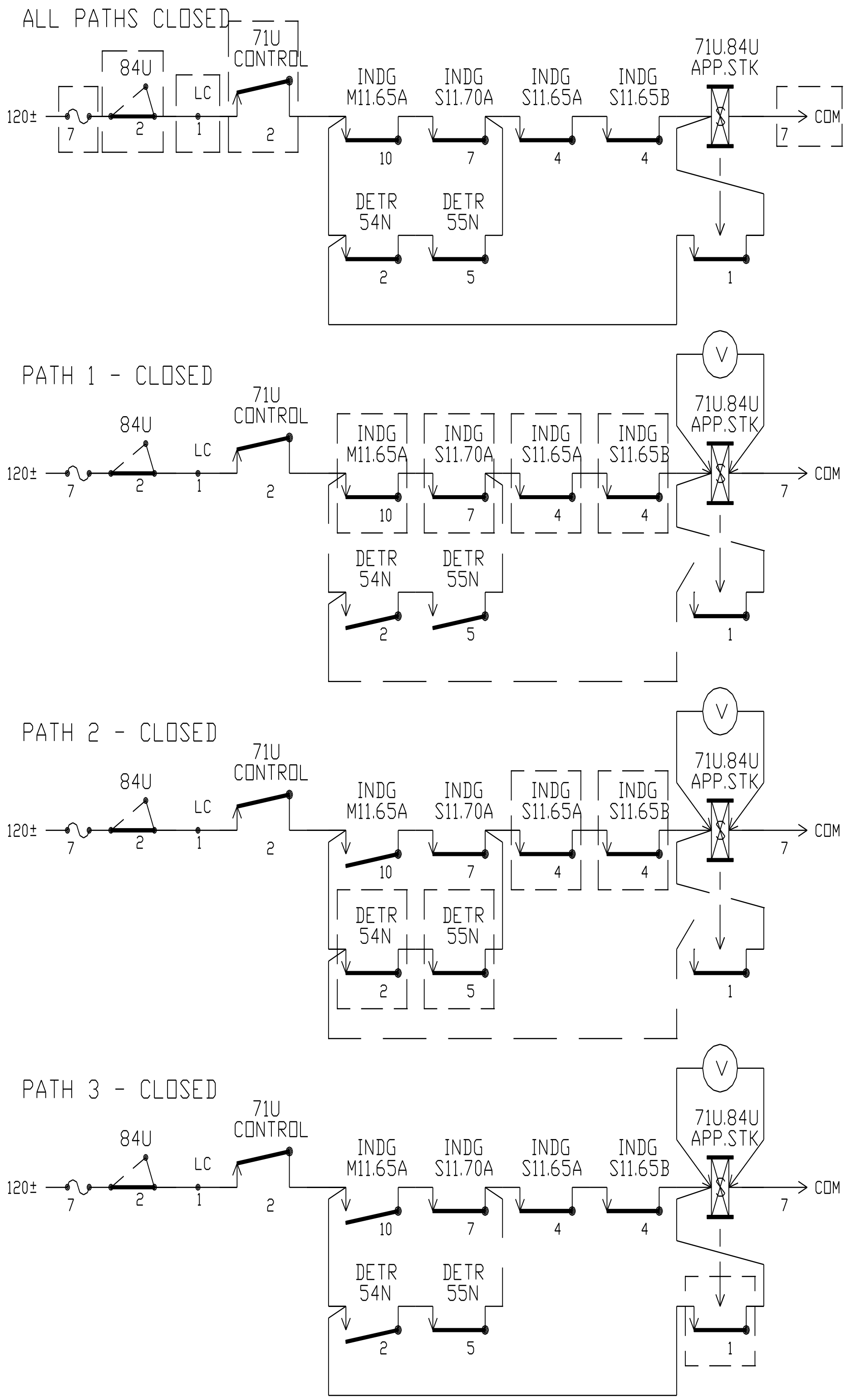
PATH 2 CLOSED

- De-energise M11.65A INDG relay, leave the approach stick finger opened. Energise 55 Normal Detector relay leaving 54 Normal Detector relay de-energised.
- Test path No.2 by bridging No.2 contact on 54 Normal Detector relay three times noting the approach stick relay energise and de-energise accordingly. Re-energise 54 Normal Detector relay.
- Follow the same procedure in turn for the following contacts in path No.2, 55 Normal Detector (No.5), S11.65A INDG (No.4), S11.65B INDG (No.4).

PATH 3 CLOSED

- De-energise 54 Normal Detector relay, leave M11.65A INDG relay also de-energised to open paths No.1 and No.2. In path No.3 reconnect the wire that had been disconnected from No.1 stick finger contact of the approach stick relay.
- Test path No.3 by bridging across No.1 stick finger contact noting the approach stick relay energise. Remove and replace the fuse to de-energise the approach stick relay and repeat test.
- Energise M11.65A INDG relay and 54 Normal Detector relay.

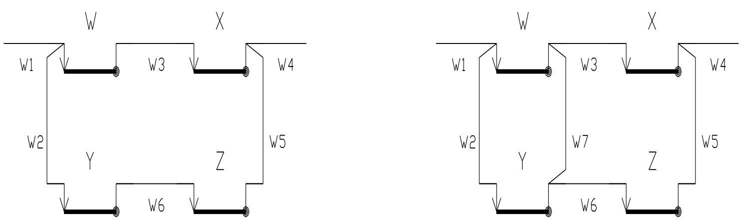
TESTING PROCEDURE EXAMPLE
CIRCUIT STRAP AND FUNCTION TEST



NOTE: IN THIS EXAMPLE, AS CONTACTS 84U (2) AND 71U CONTROL (2) ARE STRAP AND FUNCTION TESTED WITH ALL OTHER CONTACTS CLOSED, IT IS NOT NECESSARY TO RETEST THEM WHEN PATHS 1, 2 AND 3 ARE INDIVIDUALLY STRAP AND FUNCTION TESTED; IN MOST CASES IT IS DIFFICULT TO ENSURE ALL THE OTHER CIRCUIT CONTACTS ARE CLOSED AND THE MORE COMMON APPROACH IS TO REPEAT THE STRAP AND FUNCTION TEST OF 84U (2) AND 71U CONTROL (2) IN EACH SERIES PATH.

CIRCUIT STRAP & FUNCTION TESTING

CONFIGURATION A CONFIGURATION B



TEST	W	X	Y	Z	OUTPUT
1	OPEN	CLOSED	OPEN	CLOSED	A&B OPEN
2	CLOSED	OPEN	CLOSED	OPEN	A&B OPEN
3	OPEN	CLOSED	CLOSED	OPEN	A OPEN /B CLOSED
4	CLOSED	OPEN	OPEN	CLOSED	A OPEN /B CLOSED
5	CLOSED	CLOSED	OPEN	OPEN	A&B CLOSED
6	OPEN	OPEN	CLOSED	CLOSED	A&B CLOSED

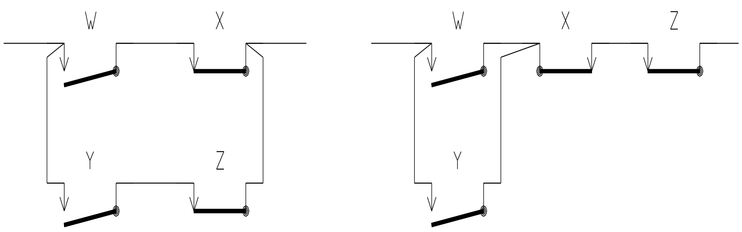
Circuit strap and function tests 1 to 6 prove the contact switching in Configurations A and B. A wire count and null count in conjunction with the six tests will prove the physical circuit wiring.

Tests 3 and 4 are necessary to prove the the presence of wire W7 in Configuration B and the absence of wire W7 in Configuration A (or the absence of an equivalent leakage path).

Tests 5 and 6 with the parallel path open at all contacts,are necessary in conjunction with tests 1,2,3 and 4 otherwise a continuity test is also needed for certification to the wiring diagram.

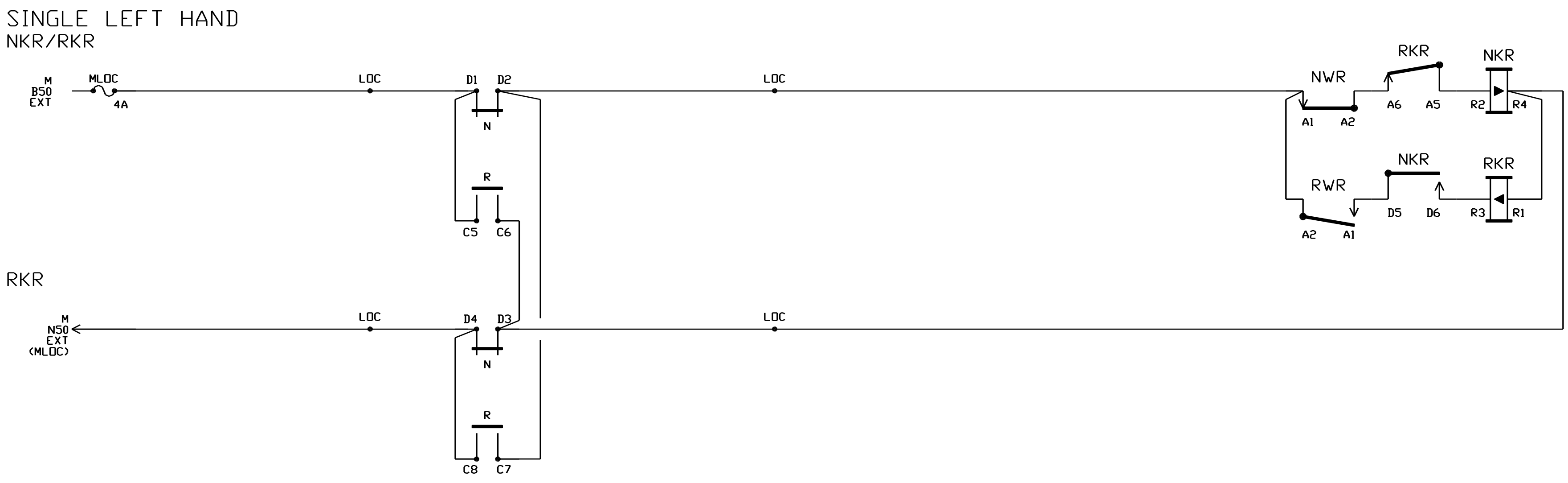
For example consider the following where tests 5 and 6 are not carried out.

CONFIGURATION C CONFIGURATION D



In Configuration C if X is closed and W only is opened to break the top path while circuit testing the bottom path Y - Z, and if Z is closed and Y only is opened to break the bottom path while circuit testing the top path W - X, then, even with a wire count, these tests would not discriminate between Configurations C and D. A bell continuity test is also necessary.

CIRCUIT STRAP AND FUNCTION TEST



The following illustrates the necessity to function test actual contacts.

The detector relays in the above circuit are de-energised under normal operation when the respective contactor de-energises.

Under the normal sequence of operation, it is therefore not possible to verify that, for example, the NKR relay drop proving contact D6-D5 is not shorted out internally in the relay.

Similarly, under the normal sequence of operation it is also not possible to verify that, for example, one (or both) of the point normal contacts D1-D2 (and/or D3-D4) is not shorted out internally and thus ineffective in open circuiting the NKR relay even if the points do not properly close against the stockrail.

If the NKR relay is removed for circuit testing and the terminals D6-D5 bridged with a strap to close then open the circuit, a defective internal short or weld of the contact would not be revealed.

Similarly, if the points detector contacts were not in place for the circuit testing and the contact terminals bridged with a strap to close then open the circuit, a defective internal short or weld of the contact would not be revealed.

A proper Circuit Strap and Function Test is necessary to reveal the internal contact defects or otherwise a separate Contact Proving test is necessary to supplement the circuit function test.

7 Through Function Tests

7.1 General

Through function tests are carried out to prove correct correspondence where circuits extend between locations.

The Through Circuit Function Test is carried out on circuits that operate between locations to prove:

- The end function operates as intended through the complete circuit when the correct voltage of the correct polarity is applied to the ends of the circuit,
- The circuit internal wiring has been correctly connected to the respective external cables where both have been separately continuity tested, wire counted and insulation tested,
- De-energisation of and zero residual voltage across the circuit function when the circuit is opened in turn at the fuse, each link and at each intermediate relay. The test is performed with as many other circuits energised as practical to provide a high probability of detecting the presence of any false voltages in the circuit,
- All repeat, indicating and intermediate relays correspond and operate correctly,
- Diagram indicators, repeaters and detectors respond correctly.

Through Function Tests of the System are also carried out to prove correspondence from the operator's control to operation of the trackside apparatus and from the operation of the trackside apparatus back to the operator's indicator panel.

7.2 Through Circuit Function Test Procedure

After circuits internal to locations and the external interconnecting cables have been separately tested, a through test shall be carried out on complete circuits, ie circuits that operate between separate locations.

Where earth leakage detectors are available, temporarily connect an audible alarm for the duration of the tests.

This test shall operate and verify the equipment and complete circuit from end to end in a functional manner and shall be carried out for both control and indication circuits as follows:

- Energise the circuit to pick up the final control relay and any intermediate relays,
- At all the locations involved, disconnect and replace in turn the feed fuse and every link in the circuit, including at the power supply busbar, observing that all relays in the circuit and all indications respond in each case by correctly changing status,
- Verify the wire count at the fuse and on each side of disconnection links and record on the circuit diagrams,
- For polarised circuits the test shall be carried out for each polarity,
- Place a meter across the relay coils and observe correct working voltages. Investigate any non zero voltage when the circuit is opened,
- Where circuits are in cascade (such as cut sections for AC traction immunisation or for volt-drop purposes) the intermediate relay circuits must also be similarly tested, the final relay under test being observed to respond,
- For FDM and TDM systems, prove that each output corresponds with its relevant input,
- Where possible and relevant, carry out tests for each through circuit as a single operation from the point of control to the point of operation and from the point of operation to the point of indication,

- The method of indicating on the circuit diagrams that the through circuit test has been successfully completed at each fuse and disconnection link is shown in Specification CRN SC 008 Plans, Programs, Documentation and Packages Clause 3.12.

7.3 Through Function Test

A Through Function Test of the system shall ensure that when there is a control operated at the control centre it is correctly relayed throughout the system and operates the trackside apparatus, and when there is an indication from the trackside apparatus that it is correctly relayed throughout the system to the control centre. Each relay in the chain and each indication shall be observed to change status in correct correspondence.

Each relay in a chain shall be removed and replaced and the affected relays and indications observed to correctly change status from energised to de-energised to energised.

8 Points Correspondence Test – including Out of Correspondance Test

(a) It is important that proper planning is carried out before proceeding with the correspondence / out of correspondence test to check that all paths in the detector circuit are tested to ensure any error in the point mechanism and detector, caused by incorrect design or installation is identified by the test.

(b) Ensure all Network Rules and Procedures and Signalling Safeworking precautions have been carried out then close all out going terminals to the point mechanisms, check to see that the relevant fuses are inserted, the points isolation switch is turned on, the machines are operable and all ends of the points are unclipped,

(c) After ascertaining that no personnel are working on any of the points mechanisms or sets of points, check the points detector indicator lights show either normal or reverse, and place the controlling lever/key for the points to the detected position,

(d) Change the position of the points (assuming the points are lying in the normal position) to reverse and back to normal again three times. Pause each time to check that the points are detected in their new position before operating the control lever/key again,

(e) Ask the nominated signalling person in the field to describe, geographically which set of points they are standing at and what identification number is marked on the sleepers adjacent to the points mechanism. Then ask the person what the lie of the points is by describing which switch is closed and which switch is open looking in at the "toe" of the points. Check this information by reference to the Track Plan and the points detector indicator,

(f) Taking each mechanism in turn, first open circuit each detector contact in turn three times for each position (Normal and Reverse) of the points and check that the respective points detector indicator reflects these actions. With sealed contacts, ensure the respective points detector indicator energises and de-energises whenever each sealed contact device in circuit changes state (ie: circuit function test),

(g) Prove that the (lock) indication contacts on Nippon machines inhibit the points detection by hand winding the lock to the disengaged position without moving the points. It will be necessary to temporarily bridge the ESML contacts with a strap while this test is carried out,

(h) Prove that the ESML contacts inhibit the points detection and the points power operation for each position of the points when the ESML handle is removed from its box. Check that the Crank Handle fits into each of the mechanisms to that it relates and that it open circuits the safety cut out switch to disconnect the motor,

(i) Prove that removal of each of the isolating relays inhibits the points detection and the points power operation for each position of the points,

(j) Operate each end of the points onto an obstruction placed between the open switch and stock rail to check the operation and time of the points timer to cut off each mechanism,

(k) On double or multiple ended sets of points an out of correspondence test shall be included. Inhibit one end of the set of points from operating and check that detection is not obtained.

(l) For the purpose of an out of correspondence test, points shall be inhibited by means of electrical or pneumatic isolation that prevent its operation. For electric points, remove the relevant motor operating fuse or link/terminal pin in either the active or common leg of the motor operating circuit or operate the point hand crank cut-out.

(m) Where an out of correspondence test is being performed, the test shall be carried out for each and every possible combination of normal and reverse. Refer to Table 1 and Table 2.

Exception 1: On CBI installations where separate inputs for each end of points detection are used, then the "field" requirement of an out of correspondence test may be omitted (out of correspondence testing must still be considered during the data-design testing phase).

Exception 2: At combined point ends where all the switches are mechanically connected together by stretcher rods ensuring all the switches operate in unison, and where they are driven by the same motor, then these can be treated as a single end for the purpose of Out of Correspondence Testing. For example: a compound point arrangement - where the A/B end is mechanically connected and operated by the same motor.

(n) The successful completion of each of the tests shall be recorded and signed for in a Work Instruction or Design Integrity Test Plan by the team leader who conducts the test.

The following combination applies for two point ends (new installations):

Lever Position	"A" end	"B" end	
N	N	N	Correspondence test
N	R	N	Out of Correspondence test
N	N	R	Out of Correspondence test
N	R	R	Out of Correspondence test
R	R	R	Correspondence test
R	N	R	Out of Correspondence test
R	R	N	Out of Correspondence test
R	N	N	Out of Correspondence test

Table 1 - Two Point Ends

The following combination applies for three point ends:

Lever Position	"A" end	"B" end	"C" end	
N	N	N	N	Correspondence test
N	R	N	N	Out of Correspondence test
N	N	R	N	Out of Correspondence test
N	N	N	R	Out of Correspondence test
N	R	R	N	Out of Correspondence test
N	R	N	R	Out of Correspondence test
N	N	R	R	Out of Correspondence test
N	R	R	R	Out of Correspondence test
R	R	R	R	Correspondence test
R	N	R	R	Out of Correspondence test
R	R	N	R	Out of Correspondence test
R	R	R	N	Out of Correspondence test
R	N	N	R	Out of Correspondence test
R	N	R	N	Out of Correspondence test
R	R	N	N	Out of Correspondence test
R	N	N	N	Out of Correspondence test

Table 2 - Three Points Ends

9 Aspect Sequence Test

9.1 General

Aspect Sequence Testing shall check that signal lamps, and signal repeaters at control stations, assume the correct colours for various operational sequences and failure conditions.

The aspect sequence testing shall be performed in accordance with Track Plans that provide details of potential routes through the area of track under test, and with any special Aspect Sequence Charts drawn up specifically for the purpose of carrying out this test.

The Engineer conducting the testing shall locate observers at signal locations and a competent officer at the operation control. The Testing engineer shall direct the Aspect test by Radio etc., by having the control centre officer set specified routes and by having the signal observers report the colour aspect of relevant signal lamps. The Test engineer shall judge the correctness of the responses by reference to the Track Plans and Aspect Sequence Charts.

Lamp Failure conditions shall be simulated.

The Testing engineer must maintain tight control of the communications and ensure that there is no confusion caused by other radios.

The communications must also be conducted in accordance with pre-established Question and Answer formats. Noise and talk within the test control centre shall be kept to a minimum while the tests are in progress and the aspect reports in the centre should be on a separate loud speaker.

9.2 Aspect Sequence Test Procedure

The aspect test is carried out from the control console/signal box by the Testing engineer whilst the field test team observe the aspects/indications exhibited to the driver. During the aspect test the diagram signal repeater shall be observed for correct indications.

The field test team shall be positioned so that each signal in the full aspect sequence can be observed and reported back to the control console/signal box for each test in the sequence.

The method of reporting aspects from the field shall be in a vertical manner from the top aspect downwards e.g.

"Signal Number **** Red over Red over small Green ", in the case of a double light type of signal.

or

"Signal Number **** Red over Red marker over small Green ", in the case of a single light signal.

The Test engineer shall repeat the signal indication report back to the field and obtain acknowledgment prior to marking the test form.

The use of the words Stop, Caution, Clear, etc is not permissible.

The reporting of stencil type route indicators shall also include the positional relationship of the indication to the signal.

The reporting of position light and dwarf colour light type of shunting signals shall include the positional relationship of the indications.

The description of turn out indicators in single light indication areas shall include the number of lamps alight and the direction of inclination.

For each route under test, the exit signal must be cleared to each possible aspect for all routes. The entrance and exit signals and any repeater or co-acting signals must be continually observed to ensure that only the correct aspect sequence is displayed.

Where the entrance signal is located at a junction all exit signals must be cleared to each possible aspect from which a sequence can be derived.

In single light areas remove the illuminated yellow or green lamp of the signal under test and check that the signal in rear can show no higher aspect than yellow. Check that the lamp proving circuits function correctly and lamp failure is given at the indicator device.

By using a test lamp (ie one that has had the main filament deactivated) observe that the changeover relay in the signal head operates correctly and that a filament fail indication is given at the control point.

Check that, at night there are no confusing reflections of signals off structures, e.g. Stainless steel cases.

Tests are to be made to prove correct operation of associated equipment e.g. Guard's Indicators, Warning lights.

In automatic signal sections the aspect sequence test is to include the verification that each track circuit up to the clearance point replaces the signal to its most restrictive aspect when occupied. With the signal at clear each track circuit shall be shunted then cleared and the automatic signal observed to change from green to red to green aspects accordingly.

The successful completion of each of the tests shall be recorded and signed for as nominated in Specification CRN SC 008 **Plans, Programs, Documentation and Packages** Clause 3.13.

10 Mechanical Interlocking Test

On each occasion that work is carried out on interlocking frames a mechanical interlocking test shall be carried out on all interlocking associated with locking that has been disturbed in addition to testing the alterations.

The interlocking tests shall ensure that all interlocking between conflicting signals, points, etc is in accordance with the Locking Tables and Locking Diagrams, and shall encompass procedures that test the relevant locks, releases, conditions, and their respective converses.

On new works and major alterations the testing of mechanical interlocking frames should be carried out as a design integrity test working from the track layout plan with an assistant marking off the tests on the locking table. Test engineers must be suitably licensed by being in possession of the appropriate Interlocking Certificate issued by the Chief Engineer Signals.

Where the Testing engineer is assisted by other personnel pulling the levers, they shall be closely supervised to ensure the correct lever has been tried or moved.

The Test engineer shall also check:

- Lever name plates are correctly inscribed and fitted,
- Inscriptions and wards on all Annett keys, lock faces, etc are correct,
- Annett keys are held captive in Annett locks until releasing arrangements are satisfied,
- Annett keys correctly release external locks and are held captive in those locks when the apparatus is operated,
- Mechanical detectors/selectors operate and interlock equipment correctly,
- Emergency switch machine locks operate and interlock apparatus correctly,
- Bolt locks, bracket locks operate and interlock apparatus correctly,
- Cranks, channel iron rodding and signal wire routes are correctly installed and operate correctly,
- Mechanical points, signals and MPIs respond correctly,
- Locking covers secured in place prior to interlocking test,
- Redundant locking and keys made inoperative and recovered,
- The Inspection and Testing shall be documented on the respective design document/s and a Signalling Form SF S4.304A/B Mechanical / Relay Interlocking Test Certificate.

11 Design Integrity Test / Function Test to Control Table

11.1 General

This testing is carried out after circuit testing and the null counting has been completed and certified.

A Function Test to the Control Tables is a function test of the installed interlocking and controls against the prepared design as set out in the control tables. Operational train movements are set up using the passage of trains, or specially arranged light engines, or by progressively dropping track circuits to simulate a train. The test engineer works from the control tables and marks off each successful test.

A Design Integrity Test is a function test of the design to signalling principles and practices. It covers all the operational train movements and all the interlocking and controls that should be listed in the control tables; the integrity test should reveal any deficiency in the control tables.

The design integrity test engineer is a suitably experienced and knowledgeable person who works to the track plan and the operational requirements while an assistant separately marks off each successful test on the control tables.

The Design Integrity Test is exactly the same as the Function Test to the Control Tables except that the test engineer does not reference the control tables.

The engineer performing a design integrity test must initiate each test without referring to the control table. The test proposed should be announced to the assistant so that there is a clear understanding of what is being tested. Once each function has been tested, the engineer assisting must mark off the control table.

The assisting engineer marking off the control table must satisfy himself/herself that the function test carried out by the engineer performing the design integrity test is exactly what is written in the control table.

11.1.1 Function Testing works where Control Tables are not Provided

For simple new works or alterations where a control table does not exist a design integrity test is required to verify that, with train movements, the signalling operates safely to fundamental signalling principles and practices. In these simple cases, the Commissioning engineer generally conducts the design integrity test. . In more complex cases an authorised signal design engineer who is suitably licensed, experienced and competent carries out the design integrity test.

Testing shall be checked off to an approved / independently checked Design Integrity Test Plan.

11.1.2 Function Testing to follow Sign Off of Design Checking

The extent of function testing outlined herein is based on the knowledge that the design has been carried out to tried and proven standard circuit constructions (or data constructions) etc. and has been independently checked in detail. The breadth and depth of testing would need to be greater for untried or unproven design.

Function testing verifies that the interlocking, control and releasing are as specified in the control tables but is difficult to prove that there is no rogue qualification of locking or of controls and this aspect relies on the independent checking of designs to proven Standards and the physical inspection and testing of the installation of the designs.

11.1.3 Function Testing for Operational Purposes

The function testing procedures described herein are directed at verifying the safety of the signalling system in meeting the operating requirements.

The design integrity test engineer should include additional operational tests to check the functionality of the design for all required train movements, including parallel and closely following movements involving more than one train, and to check that no movements are unintentionally locked out or unable to be released, particularly those involving long trains. These operational tests are not described herein.

11.2 Marking and Signing off the Control Table

Coloured highlighter pens and indelible pens are to be used for marking off the test copy of the Control Tables.

Where there are to be multiple function test engineers, each is to be allocated a different colour at the outset of a testing program.

Each test engineer’s name is to be printed in a unique designated colour on the front sheet of the Control Tables.

As each function is tested, the test engineer is to colour in with the highlighter the locked function to record that it has been satisfactorily tested, thus:

445 L (807 W 466 R or 474B R or 819 R) * Highlight when satisfactorily tested.

When the detection is tested for points that are "set and locked and detected", then the locked function (already highlighted to designate that it has been tested as "set and locked") is to be marked with an oblique stroke, using an indelible pen in the test engineer’s colour, to designate that it has been tested as "detected" thus:

(807 W 466 R or 474B R or 819 R)

Additional oblique strokes may be needed for some cases.

Each page of the control table is to be signed off by the test engineer/s conducting tests on that page, using their designated colour.

All sign offs are to be dated.

When the function test to control table/design integrity test is completed, the senior signal design engineer must ensure that each and every function has been recorded as tested and each page has been signed off.

The Senior signal design engineer is to initial each page and sign off the front page of the control tables to attest that all tests have been satisfactorily completed and that no tests have been missed.

The Engineer in charge of the function testing is to complete, sign and date the SF S4.304C certificate.

The signed off test copy of the control tables is to be stored with the signed off test copies of the circuit books and signalling plans.

11.3 Temporary Test Panel to Simulate the Operation of Trackside Apparatus

Function testing to the control table is normally carried out from the signaller's control console/diagrams that may comprise keyboards, levers, switches/keys or pushbutton controls.

For works of a minor nature the function testing will normally be conducted with the external equipment connected to the relay room, the simulation of train movements being effected by test personnel disconnecting and reconnecting links, etc. As this activity is likely to be conducted under ATP (As Traffic Permits) conditions, close cooperation with the appropriate network operations representative must be observed and the safe passage of trains throughout the work area is of paramount importance at all times. Signals and points under test are to be booked out of use and are only to be operated for testing when it is guaranteed that no trains could be affected. The Network Rules and Procedures and Signalling Maintenance Procedures must be followed.

With major new works, ie, new Interlockings, the function testing will normally be done as a simulation process (MISS for Microlok). Before the new controls are connected to the external functions such as signalsand points, they may be "turned around" onto incoming indications on the cable terminating links, to simulate the operation of the external equipment by using a temporary test panel with switches wired up for the purpose. These simulated indications shall provide correspondence of track indications, point indications, signal and route indications, etc.

The circuit design for the temporary test panel shall be checked and approved by the Signal Design Office.

Where the controls are "turned around" it should be noted that the final control equipment should be operated wherever possible, signal HR relays, point N&R contactors etc;

- The actual indication circuits should be used for the returning indications,
-
- Local cables to the external apparatus must be securely open-circuited.

The procedures to be adopted when using temporary wiring such as the wiring used for "turn around" functions are described in CRN SC 013 under temporary stagework wiring. The installation, testing and removal shall be documented in testing copies of the stagework design provided for that purpose.

When function testing is carried out by simulating the operation of the trackside apparatus then correspondence testing is required when the apparatus is connected.

Aspect sequence tests are part of Design integrity testing/function testing to Control tables, but, as the higher aspects are not individually indicated to the operating panel, these tests are normally carried out also at this later stage, with persons observing the actual signal indications on site.

11.4 Testing from a Control Console/Indicator Diagram

Testing from a control console/indicator diagram relies on observing the correct diagram indications in response to controls initiated by the test engineer. The test engineer must be alert to any irregular indications on the console or diagram while the testing in progress.

Correspondence must first be proved between each of the signals controls and indications and the respective trackside function.

Where verification of locking relies on the absence of a change to the status in response to a test from the control console then the test should be applied at least twice to minimise the possibility of a lack of response due to faulty manipulation or a momentary failure of the non-vital equipment to properly register the control or indication.

Operate keys and buttons slowly and deliberately and, when operating point keys, pause in the centre position for a sufficient time to allow the point free relays to be energised.

It is important for test engineers to ensure that for any specific locking being tested there is no other condition in effect that would cause locking of the function under test, including any non-vital locking. For example, when testing route holding, ensure that there is no approach locking also being applied.

The locking of points by another function may be verified to be in effect by observing, with the points key in the centre position, that the points free light becomes extinguished and by attempting, without success, to set the points by operating the points key to the opposite position to that in which the points are lying.

The locking of signal routes by another function may be verified to be in effect by attempting, without success, to set the route and clear the signal.

The test engineer is to test that each specific element of locking is applied when it should be and is released when all the releasing conditions are satisfied (and not when only some of the release conditions are satisfied).

The test engineer is to be alert for any indication of locking additional to that shown in the control tables (as this could mask the lack of other locking), and for any conditions that could allow premature or false release of interlocking or false clearance of signals.

The test engineer is also to be watchful for any condition that incorrectly puts signals back to stop, even momentarily.

The test engineer should also be watchful for any track circuit direct locking that should only be applied after a signal has been reversed (approach locking, route holding) or for a given direction of train movements.

Points, and Ground Frame releases, are operated individually and checked for the existence of:

- Direct track locking,
- Locking by signal route,
- Route holding,
- Any other forms of locking,
- Non storage requirements.

Controlled signal routes are cleared in turn and checked against the control tables for:

- Point setting, locking and detection,

- Interlocking with other signal routes,
- Track circuit control of the aspect including the lever stick feature,
- Inhibition of the signal lever stick feature when auto working has been selected,
- Points sequencing and availability to ensure a new safe overlap is available to an already set and cleared signal when setting a route that changes an already set and established overlap. A check shall be made that previously clear aspects do not have their status changed as overlap swinging is taking place,
- Aspect sequence (as part of the simulation testing in SSI but as part of the testing on commissioning for relay based Interlockings).

Approach locking is checked for all conditions, ie. Initiation (when cleared or comprehensive), normal release path (passage of train) and timed release path.

In testing large relay installations it may be arranged to "time down" the release timer to approximately 15 seconds to aid the progress of the testing. The process of checking the time release on each of the approach locking relays, in turn, is done towards the end of the function testing phase and the temporary straps used to achieve this are removed and certified as being removed by the Test engineer.

Checks are made on route holding and sectional release. It is desirable to simulate the worst case situation with the route being held by one track occupied only and never more than two occupied at any one time by the simulated movement of a train.

When checking the release of opposing route holding and the release of overlap points holding, first prove the holding is effective and that it is held until a simulated movement of a train fulfils the release condition. When checking timed releases firstly ensure that the release functions with only the timing track occupied and then repeat the test with all the route holding track circuits occupied.

This ensures the release will function in the case of a long train occupying more than one-track circuit at a time.

As in the case of the approach locking timers it may be arranged to "time down" the release timer relay to approximately 15 seconds provided the process of time checking and certification that these straps have been removed is as stated above.

It is essential that all conditional locking and converses be checked.

Further checks are carried out to satisfy any special conditions of the control tables for example: intermediate shunt signals, over riding, automatic route normalising. When testing automatic normalising check that it is inhibited when auto working has been selected.

11.5 Control Table Function Tests

The procedures for control table function testing is as follows:

- Operate all points individually and verify track circuit, point to point, and any other dead locking controls, together with the non-storage feature,
- Operate all ground frame and similar releases individually and verify track circuit, ground frame to point/ground frame and any other dead locking controls together with the non storage feature where the ground frame is in a controlled signal area,
- For each controlled signal route in turn :
  - In turn, release each ground frame that conflicts with the route and verify that the route cannot be set. Conversely with the route set prove that all ground frames are locked,
  - In turn, set and lock each set of points in the route and its overlaps to conflict with the route and verify that the route cannot be set and the points do not move. Conversely with the route set prove that all points are locked,

  - Set all points in conflict and return point keys to the centre position then set the route and verify that points move to the required position as the route sets,
  - Ensure that signal clears under correct conditions eg. approach control and/or main aspect lamp proving where applicable,
  - Verify track circuit, signal replacement, point and ground frame detection, lamp of signal ahead and other direct controls,
  - Verify the lever stick feature and suppression of this feature for auto working where this is provided and operated,
  - Verify the approach locking, and approach releasing by the operation of the relevant track circuits and by the relevant time delay,
  - Verify the controls required for automatic route normalisation of routes, where applicable,
  - Verify the route holding and sectional route releasing of points in the route:
- By the sequential operation of the track circuits to simulate a train passing through the route and by operating the relevant point/ground frame keys ensure that the points/ground frames are locked until they are sectionally released by the rear of the train reaching the clearance point. The relevant point/ground frame keys must be turned from the centre to the conflicting position as each track circuit is operated.
  - Verify the route holding and release of directly opposing signals:
- Set each directly opposing route in turn and check that as each track circuit is operated the locking of signals is not released until the simulated movement of a train through the route has fulfilled the release conditions.
  - When carrying out tests on signal routes containing swinging overlaps ensure that each overlap sets in accordance with the lie of the facing points in the overlap when that is available or otherwise to an alternative available overlap:
- Verify that all overlap controls and route locking and releasing are in accordance with the control tables for each possible position of the overlap and during swinging,
- Verify that the overlap can be swung by setting all relevant other routes and by operating the facing point key(s), and verify all controls required for moving from one position to another,
- Verify signals are not put to stop when overlap points are swinging.
  - Ensure for all overlaps, the overlap is maintained ahead of a train in the route until correct release conditions apply.
  - Verify automatic setting of overlap facing points to an unoccupied overlap is prevented when the points key is not in the centre position.
  - When carrying out tests on signal routes containing preferred overlaps verify that any special controls on setting or swinging the overlap are observed.
  - When carrying out tests on signal routes containing intermediate shunt signals verify all the special requirements for setting up the route, clearing, replacing and re-clearing the signals, and releasing the route.
  - Verify the interlocking, controls and indications for signal routes with level crossing protection.
  - Verify the conditions for automatic normalisation of points, where applicable.
- For each automatic and semi-automatic signal verify all controls including the operation of replacement facilities from the control panel where applicable.
- Verify the controls for repeating signals, indicator signals and guards 'right away' indicators.

- Verify the controls for level crossing protection.
- For all signals with route indicators, verify that the correct route indication is displayed for each route.
- Verify correct aspect sequence.
- Verify any blocking controls for signals, tracks, or points.

12 Inspection & Testing - Communication Protocol

Persons conducting inspections and tests with other personnel must ensure:

- That all persons communicating inspection or testing messages use agreed terms and pre-established question and answer formats that are unambiguous and clearly understood by those involved,
- The status of Contacts should be referred to as 'front' or 'back', 'open' or 'closed',
- The status of Relays should be referred to as 'up' or 'down', or 'energised' or 'de-energised',
- The status of Points should be referred to as 'left hand switch closed', 'right hand switch closed' looking in from the toe of the points,
- The status of Signals should be referred to as the colour of the lights displayed from the top down,
- The status of Track Circuits should be referred to as 'clear', or 'occupied',
- That the identity of persons communicating inspection and testing messages is clearly established on each occasion,
- That results are not recorded until after clear confirmation is received (do not anticipate),
- That testing telecommunications channels are dedicated where practical, and are tightly controlled without confusion from other radio channels,
- That noise and disturbances at the inspection and test control centre are kept to a minimum,
- That requests for information are not phrased in a leading manner and the responses repeat the identification details with the result. For example:
- Ask non – leading question:
- Q. What relay is located in grid position C2B11?
- A. Relay 77ATPR is located in grid position C2B11
- Q. How many wires are there on A2 terminal, 77ATPR relay?
- A. Two wires on A2 terminal, 77ATPR relay.
- Do not ask leading question:
- Q. Are there two wires on A2 terminal 77ATPR relay
- A. Yes