Discipline
Engineering Standard – NSW

Category
Signalling

Title
Typical Inspections and Tests for Signalling Apparatus – Procedures for Alterations

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Document Control

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		Refer to Reference Number	H Olsen	M Owens	Refer to minutes of meeting 12/08/04

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About This Standard

This Specification sets out the requirements for the implementation of an effective system for verification and assurance of the safety integrity of the signalling system, and for verification and assurance of the compliance to specification of the new and/or altered signalling system when commissioned.

Document History

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List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1	01/09/2004		▪ Reformatting to ARTC Standard
1.2	14/03/2005	Disclaimer	▪ Minor editorial change ▪ Footer reformatted
	13/08/2010	ALL	Superseded by ESC-21-03

Contents

1. General Requirements For Alterations, Renewals And Repairs

1.1 Modifications, Renewals and Repairs

Where vital signalling equipment and/or circuits are modified, renewed or repaired there may be a risk that the signalling could be altered to function incorrectly and it is necessary to ensure that the changes are tested and certified to function correctly and to conform with the approved designs.

The testing necessary will need to cover the risk involved and this risk shall be minimised by strict adherence to alteration precautions and procedures.

1.2 Authority for Alterations to Existing Installation

The Signal Design Authority for approving design alterations to existing installations (in accordance with documented ARTC standards) shall be a person granted such authorisation by the ARTC General Manager ISP or nominated Signalling representative or by an authorising agent representing ARTC as determined by the ARTC GM ISP or nominated Signalling representative. Design alterations to an existing system shall not be carried out without that authority. Unless otherwise approved, the authority for changes shall be in the form of approved design documentation.

Alterations include the following:

i) Alterations to electrical or mechanical configuration eg., circuit wiring.

ii) Changing items of equipment to a different type, make, or model.

Any difficulty with the issued alterations is to be referred to the Signal Design Authority for clarification and direction. Modifications to issued design alterations shall be approved by the Signal Design Authority and formerly issued before alteration to working circuits.

Field staff shall ensure that all copies of issued design alterations are promptly corrected and updated with modifications and they shall keep each copy properly bound, secure and in good condition.

Where an alteration which does not affect the principle of a working circuit is necessary in emergencies and it is not practical to obtain authority from the Signal Design Authority, viz under failure conditions to change from a defective relay contact or defective cable core to a spare relay contact or spare cable core, the Signal Design Authority shall be advised of the change in writing promptly and without delay and written acknowledgment obtained from the Signal Design Authority that the information has been received.

1.3 Approval to Commence Alterations

Authorised alterations also require the approval of the local maintenance Signal Engineer before the alteration work can commence.

1.4 Performance and Liaison

Where alterations are not carried out by staff under the direction of the local Signal Engineer, there must be a full liaison between the installation staff and the local maintenance Signal Engineer and maintenance staff.

1.5 Detailed Site Assessment (Site Integrity Agreement)

Prior to any significant alteration, addition, or renewal of wiring, or a relay change programme, being commenced, a detailed site assessment of the condition of the location and the ability of the existing wiring and equipment to withstand disturbance is be carried out by the Project Engineer, Construction, the Commissioning Engineer and the local maintenance Signal Engineer.

1.6 Precautions to be Agreed

All precautions to minimise disturbance to the existing equipment and damage to buried cables are to be agreed by the Commissioning Engineer and the local maintenance Signal Engineers and are to be documented.

The Project Engineer, Construction, the local maintenance Signal Engineer and the Commissioning Engineer are to agree on the condition of the location and of the equipment installed. They are to agree on preparatory work needed, precautions to be adopted, and on the method of working that will ensure the existing signalling system is not endangered by the project work, particularly where the wire insulation or equipment may be old or fragile, where labelling is not adequate, where the accuracy of the circuit book is not certain or any other vulnerable situation. Details of insulation records are to be noted.

Prior to work commencing they are to ensure that the location is in a clean and tidy condition, that there are no loose wires or connections, that any unterminated wires are cut back and covered, and that there are not pieces of wire, bits of metal, loose washers or other extraneous objects etc., in the location. The Project Engineer, Construction, the maintenance Signal Engineer and the Commissioning Engineer shall agree on who will carry out the preparatory work required to remove any potential hazards.

The agreement for each inspected location shall be written down as part of the scope of works and signed by the Project Engineer, Construction, the local maintenance Signal Engineer and the Commissioning Engineer before the maintenance Signal Engineer authorises work to commence in the location.

Once project work starts in a location the project team become accountable for conditions that arise resulting partly or wholly from their work; from that

time, district staff are not to carry out any work in the location that interferes with the equipment or wiring, except in emergency or as agreed between the Project Engineer, Construction, the Commissioning Engineer and the local maintenance Signal Engineer. Details of such work are to be recorded.

The project staff shall work within the agreement and will be accountable for ensuring that the existing signalling system is not endangered by work in the location.

The documented safeguards are to be approved by the local maintenance Signal Engineer.

1.7 Inspection, Testing and Certification of Alterations

Inspection, testing and certification of design alterations of existing vital signalling shall be based on the inspection, testing and certification principles and procedures applying to New and Altered Works.

2. Instructions When Working Near Or Altering Existing Signalling

Below are instructions that shall be followed when involved in alterations to existing circuits or when working near existing circuits.

2.1 Isolation from Working Circuits

Wires and equipment, de-commissioned from use, or not yet commissioned into use shall not be connected at any point to working signalling circuits or power supplies and must be secured against and insulated from any possible metallic contact with working circuits.

2.2 Mixing of Old and New Circuits

If new wiring is to tap into old circuits, the new wiring shall not be connected into the existing working circuit before commissioning the new wiring into use.

2.3 Loose Wires or Crimps

Loose wires with exposed conductors or with exposed crimps or lugs etc shall not be left unterminated near working circuits or equipment. They shall be clearly labelled and have their ends secured and insulated to prevent contact with one another or with any other equipment.

2.4 Connection or Disconnection from Vital Circuits

For new work and alterations, wires or equipment shall only be connected into or disconnected from vital signalling circuits when the affected signalling apparatus is disconnected and formally booked out of use.

2.5 Interference with Working Circuits, Security of Signalling Locations

All precautions shall be taken to ensure that working circuits cannot be mistakenly interfered with, accidentally damaged, or shorted out by tools, loose relay nuts, washers, bits of wire, etc.

All vital equipment and locations shall be fitted with locks and be locked when unattended.

Before closing up equipment or locations, persons shall check that everything is in order and properly connected and that nothing has been left loose, foul of standard clearances, or in a potentially unsafe condition.

Only persons who are properly instructed and who are approved by the Commissioning Engineer and the local maintenance Signal Engineer are

permitted to work without close supervision by suitably qualified and authorised staff in equipment locations and relay rooms.

Only persons who are suitably qualified and authorised, or closely supervised by a suitably qualified and authorised person, are permitted to interfere with signalling working circuits or equipment.

2.6 Wiring Not In Use

In working locations any wiring or equipment which is not in use for signalling shall be distinctively evident as such and shall be clearly and adequately labelled accordingly. It shall be kept isolated from any power supply except as necessary under supervised use.

2.7 Tagging of Wiring at Termination Points

At the termination point where new wiring is to be connected to working circuits, or where old wiring is to be disconnected from working circuits, the wire shall be fitted with a tag clearly identifying the circuit and terminal to which it applies and the terminal to which it runs; the other end of any such wire it is to be similarly tagged.

2.8 Labelling of Stagework

Wiring to be commissioned or de-commissioned in stages shall be clearly labelled as to what stage it is to be commissioned or de-commissioned. On changeover, the stage labelling shall be removed, the correct labelling applied and the arrangements made obviously permanent.

2.9 Temporary Wiring

2.9.1 Stagework

Temporary stagework wiring is to be of a distinctive colour with a different colour for each stage.

2.9.2 Testing

Temporary wiring for testing purposes is to be of a distinctive type and colour.

2.9.3 Colours

Document the distinguishing colours for temporary wiring and display the document in the location concerned.

2.9.4 Control and Removal of Temporary Wiring

The use of temporary wiring must be strictly controlled; it must be removed as soon as it has served its purpose and prior to through testing.

2.10 Spare Wires

Spare wires in equipment locations shall be properly terminated on spare terminals on termination racks; spare wires within trackside apparatus shall have the ends insulated, if there are no spare terminals available.

2.11 Equipment Not in Use

Equipment not in use and disconnected from the interlocking shall be securely open circuited and labelled accordingly.

It shall not be sufficient to only remove a fuse or open a link or remove a signal lamp etc ie, situations where someone could mistakenly insert a fuse or connect a link or insert a lamp etc and cause a potentially unsafe situation. The equipment shall be securely open circuited in two places where practical, and measures applied to prevent accidental or mistaken connection at both places.

2.12 Insulating the Wire and Equipment Not in Use

Where insulation of unconnected wiring or equipment out of use is required, a secure method shall be used.

Insulating tape or adhesive devices shall not be reused, new insulating tape etc., is required on each occasion. Approved closed and pre-insulated connectors properly crimped to wires shall be used where applicable.

Adhesive insulating tape should not be used directly on prepared conductor ends or on terminal lugs or pins etc, that are intended to be brought into use subsequently, as the adhesive may cause unreliable contact resistance.

Check that the insulation method and application is effective.

2.13 Test Equipment

Approved test equipment only shall be connected to signalling circuits and equipment.

Test lamps shall not be used as they may provide a significant leakage path for circuit currents.

Test equipment shall be subject to calibration checks taken and recorded at appropriate intervals.

Electrical test instruments shall have insulated prods, etc.

2.14 Use of Spares or Re-use of Existing Equipment

Use of spares or reuse of redundant or existing equipment in new and altered works shall require the agreement of the local maintenance Signal Engineer.

All spares, redundant or existing wires, cable cores, contacts or other items of equipment which are to be utilised in new circuits or in altered parts of existing circuits must first be inspected and tested to ensure that:

- they are spare without any connection at any point with other conductors, contacts, power supplies, or other equipment,
- their condition complies with the required standard,
- they are properly insulated without any leak or potential leak of current to or from earth or other circuits.

Special attention must be paid to ensure that terminals are not connected together by jumper bars or other strapping.

The results of the wire count, bell continuity test and insulation tests of the new circuit or altered parts of existing circuits, inclusive of the spare or reused items, shall be recorded and certified.

2.15 Interfacing of New and Existing Work

Where new or altered work is to interface with existing vital signalling, the Project Engineer, Construction and the Commissioning Engineer shall together satisfy themselves of the accuracy of existing signalling plans and circuit diagrams to the as-built situation, in consultation with the local maintenance Signal Engineer. If there is reasonable cause to doubt that they are accurate then the existing arrangements, which are to be altered to connect with the new arrangements, shall be tested and certified.

3. Modifications To Existing Circuits

When modifications to circuits are carried out the utmost care is necessary to ensure that the altered circuit is in accordance with the design, taking particular precaution to ensure that separate circuits are not wrongly interconnected, to ensure that existing terminals or contacts in the circuit are not wrongly removed and to ensure that existing terminals or contacts in the circuit are not wrongly qualified.

The risk is increased if the existing circuit is not in accordance with the circuit design diagrams, eg., contacts not in the circuit order shown; contacts connected with the point and armature opposite to that shown; different contacts, fuses or links to the numbers shown; etc.

Discrepancies could have come about because of original wiring errors; transfer from defective contacts or cable cores without written advice; incorrect testing of new or altered work; drawing errors in the design office; certified copies not forwarded or not received; or maintenance copies not updated; etc.

The risk is also increased if persons involved do not identify the contacts or terminals correctly. Persons involved must be competent in this regard and the work independently checked.

A completely new circuit would be fully bell continuity tested, wire counted and operationally function tested, to the control tables.

In comparison, an altered circuit could be fully bell continuity tested only if it were practical to remove all relays and equipment items and open all links in the location; additionally a wire count and operational function test to the control table would be required.

Alternatively the complete circuit could be strap and function tested throughout after the alterations, in conjunction with the wire count and operational function test to the control tables.

This alternative may also be difficult and the following procedures are to be followed as a minimum.

3.1 Existing Circuit to be Checked and Labelled before Alteration

Check the design of the whole of the circuit to be altered, not just the portion to be modified.

Correlation check and verify that part of the existing circuit affected by the alteration to ensure that it is wired exactly in accordance with the circuit diagrams.

The Tester in Charge and the Commissioning Engineer, in consultation with the local maintenance Signal Engineer, shall determine the extent of correlation checking required.

Further to the precautions detailed in the following Paragraph 3.2, carry out a wire count to the existing circuit wiring diagram on every contact, fuse and link in the signalling circuit to be modified.

The wire count shall be performed unless otherwise determined by the Tester in Charge and the Commissioning Engineer, in consultation with the local maintenance Signal Engineer or with other accountable senior experienced signalling engineers.

Refer any discrepancies to the Signal Design Authority before the modifications are made.

Based on the nature of the discrepancy the Tester in Charge, the Commissioning Engineer and the local maintenance Signal Engineer shall determine the necessity for more extensive and more detailed correlation checking.

3.2 Precautions when Modifying portion of a Circuit

Precautions shall be taken when modifying portion of an existing circuit to ensure that the respective portion of the existing circuit is exactly as shown in the drawings and that no terminals or contacts will be incorrectly removed or qualified by the alteration.

Assurance can be achieved by any one of the following.

i. Hand Trace the wiring and Wire Count the terminals of the portion to be qualified or replaced inclusive to one clear series contact, fuse or link on each side **OR**

ii. Bell Continuity Test the wiring of the portion to be qualified or replaced inclusive to one clear series contact, fuse or link on each side, with each and every fuse, busbar terminal, link and contact throughout the complete circuit opened. Also Wire Count each and every terminal in the complete circuit **OR**

iii. Circuit Strap and Function Test and Wire Count the complete circuit after the alteration has been carried out

NOTE: A "clear series contact, fuse or link" shall mean the first unaltered contact, fuse or link connected by unaltered wiring to each side of the alteration, and which is in series with the alteration.

The condition of the wiring insulation shall be examined before being disturbed by hand tracing.

iv. As an additional precaution;

Record the number of wires on each and every terminal on the top or base of every relay and equipment item where there will be a wiring alteration. Compare the null count with the circuit book analysis sheet. After the modification, check the wiring on these items against this record.

3.3 Label points of connection, disconnection

Identify the wires of the existing circuit which are to be disconnected (hand trace where practical otherwise bell continuity test as above) and fit each end with a secure label, clearly identifying the terminal to which it is connected, the terminal to which it runs, the circuit concerned, and clearly marked as to its future status.

Identify each and every wire which will become redundant in the altered circuit (hand trace where practical otherwise bell continuity test) and fit each end with a secure label clearly identifying the terminal to which it is connected, the terminal to which it runs, the circuit concerned and clearly marked as to its future status.

Identify the existing wiring to one clear series contact, fuse or link on each side of the alteration (hand trace where practical otherwise bell continuity test) and fit each end with a secure label, clearly identifying the terminal to which it is connected, the terminal to which it runs, and the circuit concerned.

Identify each new wire end with a secure label clearly identifying the existing terminal to which it will connect, the terminal from which it runs, the circuit concerned and clearly marked as to its future status.

3.4 Build up New Circuitry

Build up the new circuitry.

Wire count, bell continuity test, insulation test and certify accordingly and secure against interference.

The new circuitry may be strap and function tested at this stage using a voltmeter.

3.5 Changeover

Conduct the changeover and observe each wire correctly removed from and/or connected to its terminal.

Where assistance is required to observe each wire changeover, select suitably qualified, competent signalling supervisors who can identify terminals correctly but not persons who did the actual preparation work they are required to verify.

3.6 Redundant Wiring to be Removed

On changeover, disconnect each and every redundant wire at both ends, cut cleanly off and collect the terminal lugs/exposed wires and turn back and tape the ends (with labels still intact.)

Remove redundant wiring from the wire runways etc., where practical before commissioning; removal of internal redundant wiring by tracing it throughout provides a further check that there are no intermediate terminations or

contacts (not shown in that circuit order in the circuit diagrams) which might otherwise be inadvertently removed from circuit.

3.7 Testing the Altered Circuit

The altered circuit comprises the new work, the contact, fuse or link at the point of connection and all parallel paths to the new work.

When alterations to the circuit are complete, perform the following:

i. a Wire Count and Null Count over the circuit alterations and on the top or base of all relays and equipment items that were to have wires connected or disconnected. (Compare against the alteration circuit diagrams and against the wire and null count recorded in accordance with Paragraph 3.2)

ii. a Circuit Strap and Function Test over the alterations inclusive of the series contact, fuse or link adjacent to each side of the alteration

iii. an apparatus function test to check trackside apparatus operation, adjustment and correspondence to indications and controls, if these are altered by the modifications

iv. a function test to control tables of vital interlocking or controls, if these are altered by the modifications

v. an operational test to check that the principal functions affected by the alteration are working.

An accountable, senior, experienced signalling test engineer may approve deletion of the circuit strap and function test if the existing wiring is verified by hand tracing and an apparatus function test and function test to the control tables is to be performed in conjunction with the wire and null count. This engineer shall analyse the situation and satisfy himself/herself that all testing requirements to prove safety are covered.

Details of the inspection and testing procedures for alterations to existing circuits are to be stipulated in the Detailed Inspection and Test Plan for New and Altered Works.

3.8 Certainty of Circuit Status

If there is no certainty that the existing circuit is as shown in the circuit diagrams or if there is no certainty that tested new wiring etc., was fully secured against interference, intentional or inadvertent, then the inspection, testing and certification is to extend to the whole of the circuit containing the alterations.

3.9 Procedures for Modifications to Existing Circuits

The following summary of the procedure is based on tracing the affected portion of the existing circuit rather than the alternative of strap and function testing the complete circuit after the modification. However the majority of the steps apply to both methods.

3.9.1 Designers to check and approve the design of the whole of the circuit which is altered, (not just the modified portion).

3.9.2 Wire count the complete circuit to be altered, against the circuit diagrams. (Unless otherwise approved).

3.9.3 Record the number of wires on each and every terminal on the top, base or terminal assembly of every relay and equipment item where there will be a wiring change.

Compare the null count with the circuit book analysis sheets.

3.9.4 At points of connection, trace and verify the existing wires connected to both sides of the existing contact, fuse or link at each point of connection of the alteration.

At points of disconnection, trace and verify the existing wires connected to the terminal that is the point of disconnection.

Verify the wire count at both ends of these existing wires. Label wires at ends next to points of connection and points of disconnection.

3.9.5 Further trace and verify to the circuit diagrams the existing wiring from contacts, fuses or links looped to each terminal which is a point of connection/ of the alteration. Verify wire count at both ends of these existing wires.

Steps 3.9.4 & 3.9.5 shall include tracing existing wires from the point of connection to one series contact, fuse or link clear of the alteration and where applicable, to adjacent contacts in parallel with the contact at the point of connection.

3.9.6 Trace and verify to the circuit diagrams each and every existing wire that will become redundant in the altered circuit. Verify wire count at both ends of these existing wires. Label wires at both ends

3.9.7 Trace and wire count to the circuit diagrams the circuit paths in parallel with the new circuit work.

3.9.8 Wire count, bell test, insulation test and strap and function test all contacts, fuses and links in the new circuit work.

3.9.9 Changeover to new circuitry.

3.9.10 Disconnect, cut back and remove each and every redundant wire, tracing it throughout.

3.9.11 Strap and function test the existing contact, fuse or link at each point of connection/disconnection. (If this contact, fuse of link is in parallel with the alteration then all the contacts, fuses and links in the alteration shall be open and any other parallel path shall also be opened for this test).

3.9.12 Strap and function test the series contact, fuse or link, adjacent to

each side of the new work (with all the contacts, fuses and links in the new work closed and with paths parallel to the alteration open). (In some cases this may be the existing contact, fuse or link at the point of connection covered in Step 3.9.11 above).

At points of disconnection, strap and function test the adjacent contact, fuse or link, if connected to and in series with the terminal at the point of disconnection.

3.9.13 Perform a wire count and null count over the circuit alterations and on the top, base or terminal assembly of all relays or equipment items that were to have wires connected or disconnected.

Compare against the alteration circuit diagrams and the wire and null count recorded in accordance with Step 3.9.3 above.

3.9.14 Perform an apparatus function test to check trackside apparatus operation, adjustment and correspondence to indications and controls, if these are altered by the modifications.

3.9.15 Perform a function test to control tables of vital interlocking or controls, if these are altered by the modifications.

3.9.16 Perform an operational test to check that the principal functions affected by the alteration are working.

3.9.17 Where both active and common legs (or positive and negative legs) of power supply or circuit wiring are affected, or where power supply components are affected, check to ensure polarity has not been reversed.

Note: The point of connection/disconnection is the existing terminal to which a new wire connects or from which an existing wire is disconnected.

Note: Where tracing is not practical a strap and function test is required of all contacts, fuses and links in the modified circuit which are connected to the ends of wires that were to be traced in the above procedure. Tracing of wires connecting to the terminal that is a point of connection/disconnection is still required as is tracing of all wires that become redundant.

Note: The above procedure may contain some redundancy and any departure must be given proper consideration by accountable, senior experienced signalling testers and the procedures to be followed shall be documented and approved prior to the work.

Note: If the evidence is that the existing circuit wiring diagrams are accurate and the local maintenance Signal Engineer and the Commissioning Engineer are so satisfied after proper investigation, then the above procedures may be unduly onerous where there are multiple paths in parallel with the alteration and/or where these paths are particularly long. In such cases consideration could be given to limiting the tracing of existing wires in Step 3.95 (T5) from the point of connection to adjacent contacts in just two parallel

paths, and to limiting Step 3.9.7 (T7) to a wire count of the contacts and links in the paths parallel to the alteration, deleting the requirement for hand tracing. Function tests would still be required.

Conversely, if there is any lack of confidence in the information or there is scope for error in the process then test engineers shall give due consideration to more comprehensive testing than covered by the above procedure. Refer to Paragraph 3.10. 'Modifications on a Large Scale'.

REFER TO ILLUSTRATIONS ON THE FOLLOWING PAGES

3.10 Modifications on a Large Scale

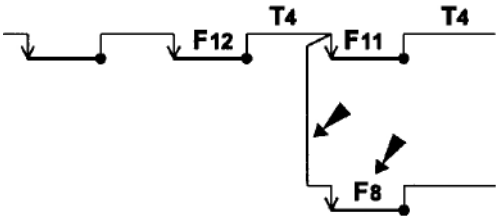
Where there are many and/or complex modifications to existing circuits the Tester in Charge and the Commissioning Engineer shall analyse the potential for error using risk analysis techniques similar to failure (error) mode effect and criticality analysis, task analysis, fault tree analysis.

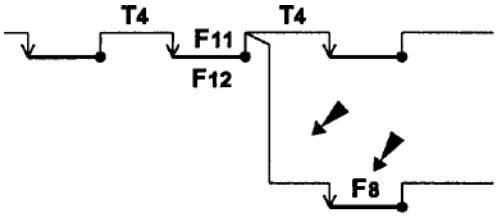
The probability of human error in performing multiple tasks increases with the number of repetitions and is influenced by the rigour and application of the testing methods, by the testers' experience, alertness, awareness of the potential sources or error, sense of accountability, state of fitness and whether the environment is favourable or adverse to the chances of an error free process.

The Tester in Charge and the Commissioning Engineer shall consult with the local maintenance Signal Engineer or with other accountable, senior experienced signalling testers on the breadth, depth and detail of the inspection and testing required to ensure the integrity of the modified installation and these determinations shall be fully documented. Step by step procedures for critical activities shall also be fully documented and communicated to all staff concerned in the testing. These detailed procedures are to be included in the Inspection and Test Plan.

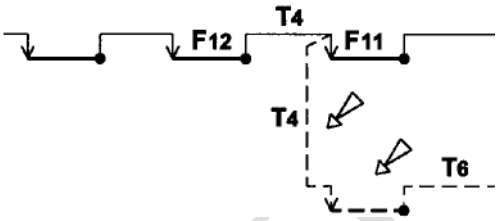
ILLUSTRATIONS OF EXISTING WIRES TO BE TRACED AND CONTACTS (FUSES OR LINKS) TO BE STRAP AND FUNCTION TESTED IN ACCORDANCE WITH THE "PROCEDURES FOR MODIFICATIONS TO EXISTING CIRCUITS".

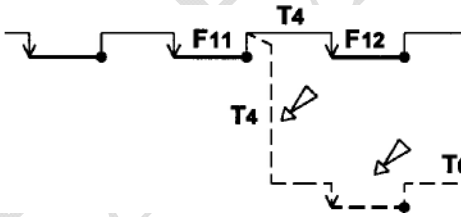
POINTS OF CONNECTION





POINTS OF DISCONNECTION





IN SOME CASES A TERMINAL MAY BE BOTH A POINT OF CONNECTION AND A POINT OF DISCONNECTION AND THE REQUIREMENTS FOR BOTH APPLY.

T4, T6 - TRACE AND WIRE COUNT EXISTING WIRES TO BE REMOVED.

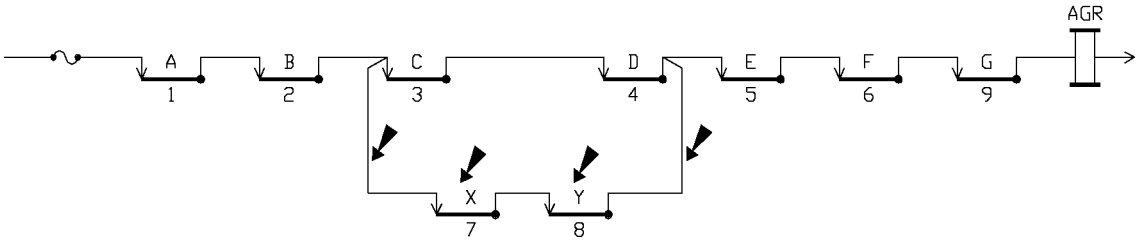
F11 - STRAP AND FUNCTION TEST CONTACT AT THE POINT OF CONNECTION/DISC

F12 - STRAP AND FUNCTION TEST ADJACENT CONTACT IN SERIES WITH THE NEW WORK

IN A ONE THER, WHERE NO CONTACTS (FUSES OR LINKS) ARE ADDI CUIT, EN, PROVIDED THE WIRES ARE CORRECTLY IDENTIFIED AND IT IS SHE THEY ARE CONTINUOUS BETWEEN THE TWO TERMINALS WHICH ARE THE POINTS OF CO ION/DISCONNECTION, THE NEED FOR FURTHER TRACING OF THE CIRCUIT IS UNNECESSARY.

ILLUSTRATIONS OF EXISTING WIRES TO BE TRACED AND CONTACTS (FUSES OR LINKS) TO BE STRAP AND FUNCTION TESTED IN ACCORDANCE WITH THE "PROCEDURES FOR MODIFICATIONS TO EXISTING CIRCUITS".

TESTING CIRCUIT MODIFICATIONS (EXAMPLE)



1. RECORD THE NUMBER OF WIRES ON EACH AND EVERY TERMINAL OF RELAYS C, D, X AND Y INCLUDING SPARE TERMINALS.

2. IDENTIFY THE EXISTING WIRE ON CONTACT C3 POINT TERMINAL AND PROVE IT GOES TO CONTACT B2 ARMATURE TERMINAL. VERIFY WIRE COUNT BOTH ENDS. LABEL WIRE WITH TAG BOTH ENDS.

3. IDENTIFY THE EXISTING WIRE ON THE ARMATURE TERMINAL OF CONTACT C3 AND PROVE IT GOES TO THE POINT TERMINAL OF CONTACT D4. VERIFY WIRE COUNT BOTH ENDS. LABEL WIRE WITH TAG BOTH ENDS.

4. IDENTIFY THE EXISTING WIRE ON THE ARMATURE TERMINAL OF CONTACT D4 AND PROVE IT GOES TO THE POINT TERMINAL OF CONTACT E5. VERIFY WIRE COUNT BOTH ENDS. LABEL WIRE WITH TAGS BOTH ENDS.

5. BUILD UP PATH X-Y, RUN WIRES TO VICINITY OF CONTACTS C3 & D4, TEMPORARILY INSULATE ENDS. LABEL WIRES WITH TAGS.

6. BELL TEST, WIRE COUNT, INSULATION TEST AND CHECK TAGS FOR COMPLETE PATH X-Y.

7. CARRY OUT SAFEWORKING PROCEDURES INCLUDING DISCONNECTING APPARATUS CONTROLLED BY AGR RELAY. CONNECT WIRE FROM CONTACT X7 POINT TERMINAL TO CONTACT C3 POINT TERMINAL. CONNECT WIRE FROM CONTACT Y8 ARMATURE TERMINAL TO CONTACT D4 ARMATURE TERMINAL.

8. WIRE COUNT AND CHECK TAG LABELS ON C3 AND D4 TERMINALS.

9. CHECK THE NUMBER OF WIRES ON EACH AND EVERY TERMINAL OF RELAYS C, D, X AND Y AND COMPARE WITH THE PRE-ALTERATION RECORD, ADJUSTED BY THE ALTERATION.

10. WITH X AND Y RELAYS DE-ENERGISED, CHECK RELAY AGR ENERGISED. STRAP AND FUNCTION TEST CONTACTS C3 AND D4 IN AGR RELAY CIRCUIT.

11. RE-ENERGISE X AND Y RELAYS, DE-ENERGISE C AND D RELAYS, CHECK RELAY AGR ENER
STRAP AND FUNCTION TEST IN TURN THE CONTACTS IN THE SERIES

IF IT CAN BE
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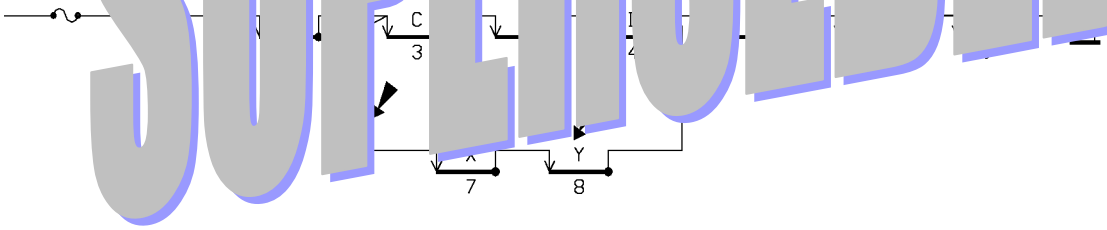
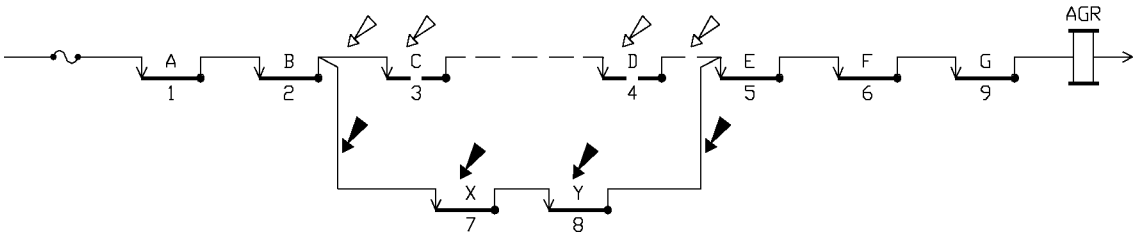


NOTE: THE CERTIFYING TEST ENGINEER SHOULD PERSONALLY SEE THE ACTUAL CONNECTION OF THE NEW WIRES INTO THE CIRCUIT. THE CERTIFIED DIAGRAMS SHALL BE MARKED TO SHOW ONLY THE ACTUAL CONTACTS, WIRES, ETC. INSPECTED AND TESTED.

TESTING CIRCUIT MODIFICATIONS (EXAMPLE)



1. RECORD THE NUMBER OF WIRES ON EACH AND EVERY TERMINAL OF RELAYS B, C, D, E, X AND Y INCLUDING SPARE TERMINALS.

2. IDENTIFY WIRE ON CONTACT TERMINAL B2 ARMATURE AND HAND TRACE WIRE TO CONTACT TERMINAL C3 POINT. VERIFY WIRE COUNT BOTH ENDS. LABEL AND TAG WIRE BOTH ENDS FOR REMOVAL. IDENTIFY WIRE ON B2 POINT, TRACE TO A1 ARMATURE. VERIFY WIRE COUNT BOTH ENDS. LABEL WIRE BOTH ENDS.

3. IDENTIFY WIRE ON THE ARMATURE OF CONTACT C3 AND HAND TRACE IT TO THE POINT OF CONTACT D4. VERIFY WIRE COUNT BOTH ENDS. LABEL AND TAG WIRE BOTH ENDS FOR REMOVAL.

4. IDENTIFIY THE WIRE ON THE POINT OF CONTACT E5 AND HAND TRACE IT TO THE ARMATURE OF CONTACT D4. VERIFY WIRE COUNT BOTH ENDS. LABEL AND TAG WIRE BOTH ENDS FOR REMOVAL. IDENTIFY WIRE ON E5 ARMATURE, TRACE TO F6 POINT. VERIFY WIRE COUNT BOTH ENDS. LABEL WIRE BOTH ENDS.

5. BUILD UP PATH X-Y, RUN WIRES TO VICINITY OF CONTACTS B2 & E5, TEMPORARILY INSULATE ENDS. LABEL WIRES WITH TAGS.

6. BELL TEST, WIRE COUNT, INSULATION TEST AND CHECK TAGS FOR PATH X-Y.

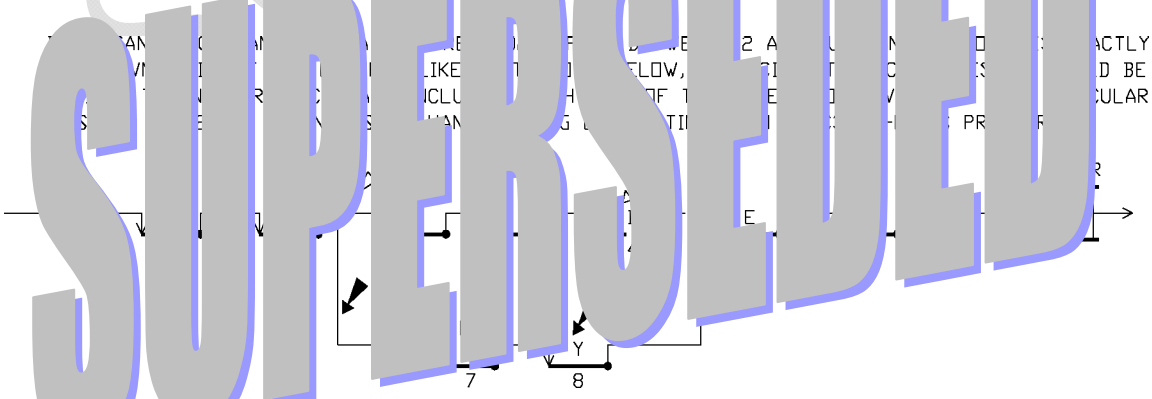
7. CARRY OUT SAFEWORKING PROCEDURES INCLUDING DISCONNECTING APPARATUS CONTROLLED BY AGR RELAY. REMOVE WIRE FROM CONTACT TERMINAL B2 ARMATURE, CUTTING THE WIRE TERMINAL OFF AND INSULATING THE END. CONNECT WIRE FROM CONTACT X7 POINT TERMINAL TO CONTACT B2 ARMATURE TERMINAL. REMOVE WIRE FROM CONTACT TERMINAL E5 POINT, CUTTING THE TERMINAL OFF AND INSULATING THE END. CONNECT WIRE FROM CONTACT Y8 ARMATURE TERMINAL TO CONTACT E5 POINT TERMINAL.

8. SIMILARLY REMOVE WIRES FROM CONTACT TERMINALS C3 POINT, C3 ARMATURE, D4 POINT AND D4 ARMATURE. REMOVE THIS REDUNDANT WIRING FROM THE RACKS.

9. WIRE COUNT AND CHECK TAG LABELS ON B2 ARMATURE AND E5 POINT TERMINALS.

10. CHECK THE NUMBER OF WIRES ON EACH AND EVERY TERMINAL OF RELAYS B, C, D, E, X AN
COMPARE WITH THE PRE-ALTERATION RECORD, ADJUSTED BY THE ALTERATIONS.

11. ENERGISE ALL RELAYS IN THE MODIFIED CIRCUIT TO
TURN ALL THE CONTACTS IN THE CI



NOTE: THE CERTIFYING TEST ENGINEER SHOULD PERSONALLY SEE THE ACTUAL CONNECTION OF THE NEW WIRES INTO THE CIRCUIT AND THE DISCONNECTION OF THE OLD WIRES FROM THE CIRCUIT. THE CERTIFIED DIAGRAMS SHALL BE MARKED TO SHOW ONLY THE ACTUAL WIRES AND CONTACTS ETC. INSPECTED AND TESTED.