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Discipline

Engineering Standard – NSW

Category

Signalling

Title

Guidelines for Irregularity Inspection and Testing to Determine Cause

Reference Number

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Document Control

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About This Standard

This Standard defines the Guidelines to be followed when conducting Inspections and Tests to determine cause following a report of an irregular operation or wrongside failure of signalling equipment.

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

Content

1 IRREGULARITY INVESTIGATION TO DETERMINE CAUSE

1.1 Investigation of Irregularities to Determine Cause

The requirements in relation to the investigation and reporting of accidents and irregularities are covered in maintenance procedures SMP 02 and SMP 04.

The purpose of this document is to provide guidelines for investigating signal engineers in the determination of whether there has been a signalling irregularity and if so its technical cause, through inspection and testing of the signalling apparatus. It is not to be considered a definitive or comprehensive procedure.

It is difficult to prescribe particular inspections and tests for irregularity investigations as circumstances can vary greatly and reports may range from anonymous, vague recollections, to specific allegations, to cases where the irregularity occurrence is obvious.

Whatever the case, the investigating engineer is accountable for certifying that the signalling involved is safe by signing the equipment back into use.

Investigating engineers must therefore satisfy themselves that the correct cause has been conclusively identified and rectified or that the integrity of the signalling has been verified.

There is the further requirement that the investigating engineer and management determine and correct any deficiency in the signalling or in the management control systems including deficiencies in staff competency, supervision, and control procedures.

1.2 Securing the Evidence

As with other failures, irregularities may be intermittent or only be evident under a certain set of circumstances which may have changed by the time signal investigation staff are in attendance.

In some incidents, an irregularity may be alleged but not be independently substantiated, or following an accident the integrity of the signalling may need to be verified and proven not to have been a contributing factor.

It is imperative that the cause of an irregularity be identified and corrected so that trains can resume normal signalled operations with the guaranteed safety provided by the system.

Attention to the protection of the site from further risk and to anyone seriously injured is the first priority. Restoration of the service to minimise disruption will be necessary in most cases although the signalling concerned will be taken out of service. It is usually not practical to isolate and hold captured all factors that might be involved in the incident.

However, it is necessary that the incident circumstances and the signalling concerned be kept as undisturbed as possible until relevant symptoms are noted and inspections and tests are conducted by authorised persons.

Where tests necessarily require the equipment to be interfered with or disturbed, then the investigating signal engineer shall arrange to carry out these tests after carrying out other nondisturbing inspections and tests that may determine the cause or reduce the possibilities by elimination.

Photographs may by useful and all observations, measurements and witness reports should be recorded in writing.

1.3 History of the Apparatus Involved

An examination of the failure, maintenance and operating history of the apparatus concerned may provide useful evidence

It may be that a defect has been present for some time and has only come to attention under the circumstances of the irregularity incident

For an irregularity to occur after a previous history of correct operation then something must have changed, such as,

- a set of operating conditions occur for which deficient signalling design or incorrect installation does not provide protection
- degradation or catastrophic change occurs in the physical properties of materials or equipment on which the fail-safe operation of vital circuits and equipment are dependent
- a false feed occurs from one circuit to another
- a current leakage path falsely qualifies part of the correct selection path in a circuit
- detection or indicating equipment becomes out of adjustment
- foreign matter interferes with correct train detection
- foreign matter or lack of lubrication obstructs gravity return or spring return devices
- worn or defective bearings or linkages obstruct gravity return or spring return devices or cause lost motion in drive mechanisms or in detection mechanisms
- worn, loose, bent or fractured mechanical interlocking defeats locking
- a complete interruption of power supply to protection systems occurs
- time limit release devices shorten from the time interval stipulated
- interference from personnel alters adjustment, correspondence
- damage occurs affecting the integrity of the equipment in the operating environment

1.4 Investigation Strategy

The investigating signal engineer will need to gather the evidence and study the circumstances and details of the alleged irregular incident, accident or derailment.

The investigating signal engineer will need to devise a strategy and plan for investigating the cause. This could change as evidence unfolds or as suspect items are eliminated.

The investigating signal engineer may need to,

Analyse:	whether the evidence allows the cause to be localised to the trackside apparatus itself or the controls to, or indications from, the trackside apparatus.
Identify:	all the related circuits and equipment items that control and operate the trackside apparatus and provide indications of its operation.
Inspect and Test:	those circuits and equipment items to check that they are installed and operate correctly to the specifications, design drawings and to the interlocking and control tables.
Deduce:	what omission, interference or other deviation factor could have caused irregular operation of the apparatus or the related circuits and equipment items.
Ascertain:	whether those factors are or could have been present at the time of the incident using appropriate inspection and tests together with analysis of witness reports, event recorders and other clues.
Attempt:	to reproduce the alleged irregularity.

The Investigating signal engineers should develop familiarity with structured analysis methods such as Kepner-Tregoe Problem Analysis techniques and Fault Tree Analysis techniques which could be helpful. Essentially they will need to understand the respective signalling system, its components and the operating environment.

Investigating signal engineers are to seek expert advice and assistance if they are not satisfied that their inspections and tests have successfully determined the true cause or verified the integrity of the signalling.

2 Inspections and Tests

The investigation will involve similar inspections and tests as used in the commissioning of new and altered works and in general maintenance. eg. general apparatus inspection, circuit testing, apparatus function testing and system function testing.

Similarly, the investigation will seek to verify conformance with the designs, compliance with installation standards and correct adjustment, correspondence, interlocking and control of the trackside apparatus concerned.

The investigating signal engineer is to be conversant with the procedures and typical inspections and tests described in the Specification SCP 12.

The inspections and tests would generally start with a close, critical examination of the operating equipment involved, particularly of the mechanical operation of mechanisms such as relays, looking for signs of damage, interference or irregular behaviour.

Electrical wiring and terminations, and mechanical linkages and connections would be similarly inspected.

Depending on the situation, the investigation might next move to function tests (to the control tables) of the interlocking and controls between the items of trackside apparatus involved, correspondence and adjustment tests of those items, and then delve more deeply into the individual elements of the controls and indications.

Look first, and only when satisfied, proceed to function test, insulation test, circuit test etc.

When a defect is found that conclusively accounts for the problem, and the investigating engineer considers that multiple causes would not exist, then further testing need not be performed.

Depending on the incident the inspection and tests could typically involve the following.

a) Inspection of the **aspects** of signals, including level crossing signals.

   Inspection of the **positions** of points, facing point locks, points detectors, semaphore signal arms, level crossing booms, trainstops, releasing switches, operating levers and keys, rotary controllers, relays, etc.

   Inspection and tests that the mechanisms operate freely and correctly.

b) Mechanical Interlocking inspections and tests including
   interlocking frames

   trackside equipment eg. bolt locks, selectors, train bars, facing point lockbars, keys and

   locks eg. E.S.M.L., annett keys and locks,

c) Electro-mechanical Interlocking inspection and tests including

   electric lever locks

   electric releasing switches,

d) Electrical Interlocking and Control tests including

   route to route interlocking (signal to signal, signal to points, points to points)
   indication locking (correspondence of signal/trainstop with signal normal indication relays and correspondence of points switch and lock positions with points detection relays).

   track control of signals, trainstops and points points detection control of signals and points approach locking of signals and points route holding of points and opposing signals release of approach locking, route holding
   proving features such as track sticks, back contacts,

Function testing of signal control circuits is typically performed as follows:

1. Clear signal,
2. Observe signal clear
3. Drop first track (lever stick),
4. Observe signal/trainstop return to stop
5. Pick up first track
6. Observe signal/trainstop held at stop
7. Reclear signal
8. Observe signal/trainstop clear
9. Drop second track
10. Observe signal/trainstop return to stop
11. Pick up second track
12. Observe signal/trainstop reclear
13. Repeat 9-12 for subsequent tracks up to clearance points
14. Obstruct interlocked points with gauge
15. Observe signal/trainstop can't clear
16. Remove gauge, allow switch to close
17. Observe signal/trainstop clear.

Function testing of approach locking is typically performed as follows.

1. Clear and replace signal to check it is not approach locked
2. Clear signal
3. Drop first approach track
4. Cancel signal
5. Observe approach locking is held
6. Drop second track
7. Pick first track
8. Observe approach locking is held
9. Repeat 6-8 for subsequent tracks.

Function testing of route holding is typically performed as follows:

1. Operate and restore points, to check they are free.
2. Clear signal
3. Observe points locked
4. Drop first track past signal
5. Normalise signal
6. Observe points still locked
7. Drop second track
8. Pick first track
9. Observe points still locked
10. Repeat 7-9 for subsequent tracks up to points clearance.

e) Train Detection tests

track circuits (see attached guidelines)

blockjoint clearance positions

trains, wheel/surface, light vehicles

rail surface

f) Electrical Insulation/Isolation inspections and tests

1. Inspect cable insulation, cable entries, cable clamps, cable troughing, cable joints for signs of damage/deterioration of insulation, water entry, burning,
2. Inspect cable terminations, crimps, connections for signs of bare metal, wire strands, looseness, arcing, burning,
3. Inspect insulating surfaces for signs of electrical tracking, water, burning, arcing, metallic dust etc.
4. Inspect contacts for signs of sustained arcing, sticking, welding etc., and for adequate air gap, proper adjustment, proper clearances.
5. Close circuit, operate function and check for correct voltage across function.

Open circuit by removing fuse and check function de-energises and voltage across function goes to zero (if ac circuit in multicore cable check induced voltage is well below de-energise voltage).

Repeat test but open circuit by removing negative/common terminal instead of fuse.

Maintain other circuits closed and operating normally during tests to detect any leakage current present.

6. Check earth leakage detectors
7. Check busbar voltages to earth using voltage-to-earth meters or Fluke meter with 20K ohm shunt. Compare with records.
8. Check power supplies are isolated from one another
9. Megger test the circuit to earth and to equipment racks, equipment cases, and cable sheaths where these are insulated from earth.
10. Megger test multicore cables core to core, core to sheath, core to earth, sheath to earth.

Should the investigating engineer require further megger testing directly between circuits or directly across open contacts, the method of testing needs to be carefully considered as to the disconnection of semi-conductor devices, including power supply units, and the use of temporary bridging around open contacts or around semi-conductor devices removed for the test. The use of temporary bridging must be strictly controlled by the investigating engineer and bridges must be recorded and recovered immediately after each application.

11. Hand trace and examine the circuit wiring. If this could disturb suspect wiring it should be the last test of the circuit or if a number of circuits are to be tested all other tests of all relevant circuits should be performed before the wiring is disturbed.

Note: In the case of internal circuits in a main relay room fitted with earth leakage detection, it may not be necessary to initially insulation test each circuit individually, providing the earth leakage detection is operating correctly, and proved to be so by the application of a test earth on each busbar and observing the earth leakage detector drop out.

Circuit Test to the Wiring Diagrams

Check equipment for correct type, correct indexing, pin coding etc.

Close circuit, operate function and check for correct voltage across the function, including correct polarity where relevant.

Open and close each fuse, contact and link in turn noting the function deenergise and the voltage reduce to zero

Wire count the complete circuit (s). Null count the terminals on equipment items in the circuit.

Prove contacts are in correct adjustment and operate in correspondence with their operating mechanisms.

Security Inspections location locks

signalling equipment locks

h) Signal Inspections

If the irregularity involves the passing of a signal at stop or allegedly at clear the investigating engineer should inspect the signal sighting and check the following, among other things,

sighting distance; focus; lamp filament; lamp voltage; lens condition; lens colour; lampcase lock; lampcase seal from external light; lampcase internal finish in matt black; possibility of confusion with background lighting; possibility of vegetation, structures or vehicles on other lines affecting line of sight; possibility of confusion with other signals or reading through; possibility of reflected phantom indication; possibility of indication being "washed out" with bright incident light; possibility of power supply interruption etc.

If needed the signal should be observed from the same type of train travelling at the same time of day under the same weather conditions etc.

3 Function Testing Observations

Function testing is testing in which the function is operated through its controls to check that it achieves its specified purpose and includes testing that it will not operate from a safe position if any of the required controls are incorrect or missing.

Investigating signal engineers should ensure that their observations cover all levels of the operation that they need to check when function testing, viz the trackside apparatus, the local controls and indications, intermediate controls and indications, the central controls and indications and the operator's control console and indicator diagram.

There are a number of levels at which signal equipment may be observed to operate/not operate, for example, in the case of a signal,

signal aspects

signal UCR relay

signal HR/DR relays

signal repeater on diagram

There are a number of levels at which controls may be opened and closed in order to observe the operation/non-operation of signalling equipment, for example, in the case of a track circuits,

track circuit rail shunt track circuit relay.

track circuit relay contact.

If, for example, a signal repeater is observed to correctly change status when a track relay circuit fuse is removed, this would not in itself include proof that the signal repeater is in correspondence with the signal control relays or the signal aspects, and would not in itself include proof that the specific track circuit relay contact concerned would put the signal to stop when a train occupied the track circuit.

Investigating signal engineers are to be aware that through correspondence tests may need to be completed in addition to the interlocking and control function tests (at a particular level) between elements which control or indicate the operation of the trackside apparatus.

4 EXAMPLES OF SOME TESTS FOR PARTICULAR IRREGULARITY INCIDENTS

4.1 Interlocked Signal alleged Falsely at Clear or at Less Restrictive aspect.

4.1.1 Interlocking Test

All functions interlocked with the signal (as shown on the Locking Table) are to be proved to be so locked by performing interlocking tests with those functions.

4.1.2 Function Test

The signal is to be proved to correctly return to stop when each controlling track circuit and point detector function is de-energised.

The signal is to be proved to be correctly approach locked. The first approach track to the signal is to be dropped and the signal returned to stop. Then each approach track is to be dropped in turn up to the signal to ensure the approach locking is not released. The approach locking time limit release is also to be checked.

Lamp proving is to be proved to be effective.

The track stick circuit is to be proved to be effective, also any trainstop VCSR circuit.

Aspect sequence is to be checked.

4.1.3 Insulation Testing

The signal light operating circuit and all control and indication circuits for the signal are to be considered for insulation resistance testing.

These include RUR, UCR, LSpR, HR, HDR, DR and ALSR circuits or their equivalents (Relay Interlocking - Reverse relay, NI relay, Control, Caution, Medium, Clear, Approach stick etc; Electromechanical Interlocking - N lock, NI lock, LPR, Control etc;) and related repeat relays.

Also included are the signal repeater circuit, and the track stick circuit.

All operating, control, and indication circuits for an associated trainstop are also to be considered.

The controls within the above circuits may also need to be considered for insulation testing eg., detector relays, track relays etc.

4.1.4 Track Shunt Tests

Each track circuit in the approach locking and track control of the signal is to be shunt tested. The track relays and all their track repeat relays are to be observed to correctly operate for these tests, to prove correspondence. As all these relays are unproved, close examination of their operation is required.

4.1.5 Circuit Testing

Where further testing is required, the circuits considered for insulation testing may need to be considered for circuit strap and function testing, wire counting, and bell continuity testing or hand tracing.

4.2 Automatic Signal alleged Falsely at Clear or at Less Restrictive aspect.

4.2.1 Interlocking Test

Not applicable

4.2.2 Function Test

Each track circuit (and any other function) is to be proved to return the signal to stop. Lamp proving is to be proved to be effective

The track stick circuit is to be proved to be effective, also any trainstop VCSR circuit. Aspect sequence is to be checked.

4.2.3 Insulation Testing

The signal light operating circuit and all control and indicating circuits for the signal are to be considered for insulation resistance testing.

These include:-

LSpR, HR, HDR, DR, circuits or their equivalents.

Also included is the track stick circuit.

All operating, control and indication circuits for an associated trainstop are also to be considered.

The controls within the above circuits may also need to be considered for insulation testing eg. track relays, release switch normal relays etc.

4.2.4 Track Shunt Tests

Each track circuit in the signal route is to be shunt tested and the track relay and any repeat relays are to be observed to operate correctly and in correspondence.

4.2.5 Circuit Testing

Where further testing is required, the circuits considered for insulation testing may need to be considered for circuit strap and function testing, wire counting, and bell continuity testing or hand tracing.

4.3 Points Run Through, or Operated in Front of Train

4.3.1 Interlocking Test

All functions interlocked with the points (as shown on the locking table) are to be proved to be so locked by performing interlocking tests with those functions.

4.3.2 Function Test

Each track circuit that dead locks the points shall be proved to do so.

Where there is route holding between protecting signals and the points, this route holding is to be tested by clearing the signal and dropping the first track circuit and then restoring the signal. Each track up to the points should then be dropped in turn to ensure the route locking is effective.

Any timed release of route locking is to be checked to be functioning correctly.

4.3.3 Insulation Testing

All points operating, control, and indication circuits are to be considered for insulation resistance testing.

These include NLR/RLR, NWR/RWR, NKR/RKR, NWKR/RWKR, NLKPR/RLKPR, NWAR, RWAR, WZR, WJR, IR and point motor operating circuits, or the equivalents in other interlockings (Relay Interlocking - Normal and Reverse Relays, Lock Relays, Contactors, Route Sticks etc. Electromechanical Interlocking-LPR's, Contactors, N & R locks, NI - RI locks, etc).

4.3.4 Track Shunt Tests

All local track circuits, and all route holding tracks from a protecting signal to the points are to be shunt tested. The track relays and the track repeat relays are to be observed to correctly operate for these tests, to prove correspondence. As all these relays are unproved, close observation of their operation is required.

4.3.5 Circuit Testing

Where further testing is required, the circuits considered for insulation testing may need to be considered for circuit strap and function testing, wire counting, and bell continuity testing or hand tracing.

5 GUIDELINES FOR TESTING OF TRACK CIRCUITS IN IRREGULARITY INVESTIGATIONS

5.1 Introduction

When a signalling irregularity is reported, it is critical that the testing which follows be completed as quickly as possible, at the same time ensuring that it is sufficiently detailed and comprehensive to identify any possible cause.

The use of a comprehensive checklist as an 'aide-memoire' can ensure that all necessary testing is completed, with minimum wasted effort and time.

This guideline recommends a general series of steps to be followed in investigating an incident believed to involve the false indication of a track circuit as 'clear', while occupied by a train.

Prior to these activities being undertaken, preliminary investigations will have established that there is substantial evidence that an irregularity has in fact occurred, and that it may involve the irregular operation of one or more track circuits.

The procedure's purpose is to check in a logical manner, for anomalies in all parts and operating characteristics of a track circuit.

CAUTION

Where the incident leading to the investigation is of a serious nature, take care to avoid, as far as possible without compromising safety, making any change which might be considered to alter conditions material to any subsequent investigation.

5.2 Possible Causes

5.2.1 Recent History, Background

Has there been any work carried out recently which might affect the signalling system, or give rise to unusual indications in the course of the work?

Check the recent history of the area concerned, for all activities which might affect the operation of the signalling system. Activities could include routine maintenance, repairs, installation, trackwork etc.

5.2.2 Manipulation

Was the relay held in the energised position by manipulation?

Check the location for signs of entry, the relay for broken seals or other signs of manipulation. Were any persons noticed in or about the relay location at the time of the incident?

If 'yes', record the details, and continue the tests.

5.2.3 Relay Fault

Is there any mechanical defect in the relay which could cause it to remain in an energised position, or for one or more contacts to remain closed with the relay de-energised?

Do a close visual inspection of the relay.

If an obvious fault is found (for instance, relay still being held up with zero volts applied), have it verified, then try to determine the cause of the mechanical fault without disturbing the relay. If it is not possible to accurately determine the cause of the fault, record all that can be seen, then gently remove the relay, taking the utmost care to retain the faulty condition. Return the relay for a full workshop examination and repair. Replace with a new relay, then carry out a normal comprehensive track circuit test, as done when a relay is replaced in routine maintenance.

If an apparent fault is found, record the details, then continue with this procedure, to identify any other possible cause.

If no definite cause is subsequently found, replace the relay as a precautionary measure, and return the relay for a full workshop examination and repair.

5.2.4 Circuit Error

Is the track circuit, including bonding, wired correctly?

Check that the track circuit is wired according to the circuit book and track insulation plans, and that the drawings themselves are correct.

If an error is found in one or both, record the details, then continue with this procedure, to identify any other possible cause.

After completing the other inspections and tests, make the necessary corrections and then carry out a full test of the track circuit's operation.

5.2.5 Circuit Fault

Is there a fault in the track circuit wiring?

Megger test all track circuit wiring; include tests on relay and feed cables, from each core to earth and to adjacent track circuits' relay and feed cables .

If any faults are found, record the details, and whether they could result in false energisation of the relay. Continue with this procedure, to identify any other possible cause.

After completing the other inspections and tests, return and correct the fault and then carry out a full test of the track circuit's operation.

5.2.6 Adjustment/Sensitivity

Are any track circuit fuses open circuit?

If open-circuit, examine the fuse wire to determine the nature of the failure. Record the details. Retain the defective fuse, and fit a replacement unit.

Is the track circuit incorrectly adjusted, resulting in reduced sensitivity to shunts?

Check all operating voltages. Measure the drop shunt resistance value of the track circuit, at all extremities and at several points evenly spaced along the track circuit. Note the relay control voltage when shunted, for each shunting point.

If any values are out of specified range, record them, and continue the tests.

After completing the other inspections and tests, return and adjust track circuit levels and then carry out a full test of the track circuit's operation.

5.2.7 False Energisation

5.2.7.1 Extraneous feeds

Is the track relay being energised by current from an external source?

Check polarity reversal to adjacent tracks (on DC, 50Hz and J/S tracks). If any error is found, record the details,

After completing the other inspections and tests, and before final retesting, return and correct any phasing error that was found.

Switch off track feed (O/C fuse to feed set or to feed transformer primary) and check that the residual voltage on the track relay is zero or near zero (less than 0.02 volts for double-element AC relay, or a higher voltage but at adjacent track circuit frequency on jointless track circuit).

On an AC track circuit, also remove the local fuse and check that local and control coil voltages are completely zero.

If the relay residual voltage is not zero, then the track relay is subject to current from an external source which must be identified and corrected.

Check external connections to rails; note particularly the condition of any spark gaps, and record the position of any that are short-circuited. Use a Clancy meter to locate any point where current is entering or leaving the track circuit. Individually clear and replace any extraneous connections found, checking the track relay input each time.

On jointless track, check attenuation of tuned loops between the suspect track and adjacent tracks operating at the same frequency.

In single rail track circuits areas a level of stray signalling current could be expected in the traction rail. Stray current shall not be permitted to cause a residual voltage of greater than 30 percent of the drop away value of the track relay.

On D.C. tracks any residual voltage due to track battery effect must be less then thirty percent of the drop away voltage of the track relay.

5.2.7.2 Circulating Currents in AC and Audio Frequency Track Circuits

Is there a stray circulating current, able to affect the operation of the relay?

Using an Induction meter, measure the currents in opposite rails of the track circuit and the current between the track circuits (eg. in the impedance bond neutral connections on double rail A.C. track circuits or in the traction rail opposite the signalling rail blockjoint in single rail track circuits).

If rail currents are unequal, this indicates the presence of stray alternating current in the rails (In single rail track circuit areas the Clancy meter reading will include traction harmonics in the traction rail and this could account for differences between the signalling rail and the traction rail currents). The source may be the suspect track circuit itself.

Disconnect the power supply to the track feed. Measure the rail currents and the current between the track circuits. Restore the track feed power supply connection.

If these currents dropped to zero, the track circuit itself is the source of the circulating current.

This indicates the presence of a resistance (impedance) unbalance in the track circuit, which can render it prone to false energisation by a stray current. The unbalance may be caused by one or more high resistance rail or bond connections, high resistance mechanical joints, broken rails, defective insulated blockjoints, defective impedance bonds or low resistance leakage paths to earth.

Examine the track carefully for open-circuit or high-resistance connections or bonds. High resistance rail connections can be checked by measuring the track circuit voltage drop between the rail connection cable and the head of the rail. Good connections for AC and audio frequency track circuits measure less than a few millivolts AC; any connection that measures more than 10 millivolts, or significantly more than the connections adjacent to it, should be regarded as suspect.

For a conclusive test of rails and impedance bond connections on a double rail track circuit, measure simultaneously the traction currents in both sets of sideleads with high current D.C. tongmeters; the degree to which traction current is unequally shared indicates the amount of resistance unbalance in the track circuit. Individual checking of each side lead in both sets further determines the equality of the connections.

If the source of the circulating current is external, the current between the track circuits will be unchanged when the feed power supply is disconnected and, in balanced double rail track circuits, the rail currents will each equal about half of the neutral current.

Trace the circulating current to its source, and correct the fault that causes it. On any balanced double rail track circuit in the path of the circulating current, the neutral current will be equal to the difference in the currents in the two rails.

5.2.8 Fail to Shunt

If all tests to this stage have identified no cause for the irregular operation of the track, check for conditions leading to a failure of a train or track vehicle to shunt the track.

Was the train involved in the irregularity of short length, and/or consist of very light vehicles? If the train was one or more light engines only, were they electric or diesel powered?

If it was a light rail vehicle, was it one that had been authorised to work under track block operating conditions, was it travelling at speed?

Inspect the rails of the track circuit, and in particular the rail contact surfaces and surroundings.

Do the wheels appear to adequately clean the rail or do they track only on a narrow width of the rail head.

Is the suspect track circuit itself very short?

Is it infrequently used, or are there long periods without traffic over the track?

Does the rail show signs of recent corrosion on its contact surfaces?

Are there signs of gross contamination on or immediately adjacent to the rail?

These checks may indicate a combination of conditions in which it is likely that all or part of the train could have failed to shunt the track circuit due to the presence of an insulating layer on the rail and/or wheel contact surfaces.

If all other factors have already been eliminated as possible causes, then the final check is to monitor the operation of the track circuit under track and train conditions which reproduce as closely as possible those which existed at the time of the reported irregularity.

Operate the train over the track while monitoring the input to the track relay. If the input reaches values close to, or exceeding, that required to energise the relay, then rail-wheel contact problems may be inferred. If the input stays at very low values while the train is present, then no conclusion can be drawn.

5.3 Rectification

At this stage, when all tests have been completed, check that all temporary disconnections, etc, have been restored. Make arrangements to rectify any faults found in the course of the investigation, which might lead to the irregular operation of a track circuit. Before making any such changes, be certain that the fault is fully documented, photographed, and independently witnessed if necessary.

If no cause has been found for a serious irregularity, obtain approval before making adjustments or rectifying faults which may be considered possible causes or contributory factors.

5.4 Conclusion

If a track circuit irregularity has taken place, then by the conclusion of these tests there should be one or more factors that have been identified as definite or probable causes.

In the case where no factors have been identified, then 'no cause found' is the only conclusion that can be reached. Either the report was based on an error in observation or interpretation, or it was due to some fleeting condition of which no sign remains. The remaining course of action available is to monitor the operation of the track circuit for a period, in an effort to capture any transient condition.

5.5 Track Circuit Investigation Checklist

1. Irregularity still on?

Check reports of any witnesses to incident

Decide - possible irregularity (Y/N) Decide

- suspect circuits (Y/N)

suspect track (Y/N)

2. Signs of interference

with location of equipment?

with trackside equipment?

Reports of persons near equipment?

3. Signs of defect that could hold relay, now or recently? Signs of relay contacts failing to open, now/recently? Relay replaced?

4. Circuit design correct?

Circuit wiring and bonding correct to circuit book and track insulation plan?

Condition of wiring - possible intermittent faults?

5. Megger tests to earth/other cables and wiring correct?

6. Operating voltages etc within accepted limits and consistent with history card? Track drop shunt within specifications?

7. Relay has 'zero' residual voltage with feed power supply removed?

Phasing to adjacent tracks correct?

Blockjoints and bonding OK?

Spark gaps in good conditions (V greater than 5.0v)? No other rail connections

Rail currents balanced and no sudden increase/decrease? Tuned loop rejection value greater than 10?

Are rail currents unequal?

Do currents drop to zero with feed power supply removed? Check all bonds and sidelead connections OK

Does difference in rail currents equal bond neutral current?

Trace circulating current to source, and correct

8. Check for train failing to shunt -

Train short

light weight

authorised for track-block operation Train

speed over trainlength prior to incident

powering or coasting?

diesel or electric traction?

Rail contact surfaces clean and polished?

signs of recent oxide film?

signs of heavy contamination?

signs of contaminates at foot of rail?

Track circuit short length?

6 IRREGULARITIES AND WRONG SIDE FAILURES: TYPES, FACTORS AND DEFECTS

6.1 Irregularity Type

Irregularities which do not result in false proceed or false release.

False proceed signal indication, train ahead.

False proceed signal indication, conflicting route.

False proceed signal indication, points not correctly set and secured.

False warning signal indication, less restrictive.

False line clear indication, block instrument.

Second staff issue, electric train staff instrument.

Facing points released with train present, loss of approach/route holding locking.

Facing points opening with train present, defective points equipment. Ground frame irregularly released, train approaching.

Trainstop falsely clear.

Level Crossing protection inoperative.

6.2 Factors

Track Circuit Not Detecting Train out of adjustment

track relay defective

stray/induced currents

contaminated rail surfaces, light rail vehicles

defective, damaged track circuit equipment

open circuit parallel bonds

incorrect polarity reversal, short circuit blockjoint

Circuit Wiring and Contacts Incorrect/Ineffective

Incorrect

faulty design

faulty installation

Ineffective

coupled/induced currents

leakage currents, defective insulation/is olation

contacts not switching

contacts out of adjustment Relay

falsely energised

electrically held

contacts welded

mechanically held

magnetically held (residual magnetism)

timing short

Points Detection Incorrect/Ineffective

out of adjustment

worn

damaged

Signal Lights falsely illuminated, obscure

illumination by external light

lamps burnt out

lights out of focus

loss of power supply

view obstructed

signal out of position

lens broken

Level Crossing Protection Power Supply Failure

defective/exhausted battery

open circuit fuses, wires, high resistance terminations

long term loss of ac supply

switched off

defective battery charger

Mechanisms & Mechanical Equipment

worn

damaged

out of adjustment

obstructed, seized

out of position

lost motion

Mechanical Lockbars, Trainbars, Clearance Bars, Ineffective

worn

damaged

out of position

Electric Locks Ineffective

electrically held

mechanically held contact

out of adjustment

Electric Train Staff Instrument Defective

Block Instrument Defective

Trainstop Defective

out of gauge

damaged

obstructed

Mechanical Interlocking Defective

6.3 Defect type

6.3.1 Mechanical Defect

Component/assembly dislocated, deformed, damaged, degraded (physical properties), disintegrated, fractured, fatigued, flooded, obstructed, tight, loose, stuck, corroded, worn, welded, overheated, vibration affected,

Equipment out of adjustment, tolerances exceeded,

Faulty equipment design, manufacture, installation, maintenance,

6.3.2 Optical Defect

Signal lens illuminated by external light

Lens broken

Lens colour change

6.3.3 Electrical Defect

Circuit incorrectly designed

Circuit incorrectly wired

Isolated conducting parts moving into contact

Leakage currents tracking across contaminated/wet insulating surfaces

Leakage currents tracking through defective insulation directly between circuits

Leakage currents to earth through defective arrestors, metallic connections, defective insulation

Electromagnetic induction/capacitive coupling between alternating current circuits.

Direct current arcing across switching contacts

Residual magnetism in magnetic cores

Circuit adjustment incorrect

Contact adjustment incorrect

Contacts welded, struck

Contaminated rail and/or wheel surfaces preventing correct shunting of track circuits, light rail vehicles.

Interfering harmonics in track circuits from chopper trains, defective substation supplies, parallel H. V. powerlines,

Battery effect on D.C. track circuits

High resistances resulting in circulating currents through connected functions, track circuits etc.

Insulated blockjoint failure and track circuit polarities not reversed.

Open circuit parallel bonds in a track circuit

Loss of power supply to Level Xing lights (open circuit fuse, exhausted/defective battery, defective battery charger, high resistance/broken connections/wires).

Faulty equipment design, manufacture, installation

Variation in properties of timing circuit components

6.3.4 Damage

Due to power surges, lightning, fire, flood etc

Due to construction, maintenance activity,

Due to accidents

Vandalism

Sabotage

6.3.5 Personnel Defect

Design checking deficient

Inspection and testing incorrectly performed

Emergency releases incorrectly given

Work wrongly performed, procedures not followed, substandard

Signal lens door left open allowing external light to illuminate lens.

Level crossing test switch left turned on, or emergency switch left turned off.

Accidental damage, interference

6.3.6 Management Defect

Faulty or deficient standards

Faulty or deficient procedures

Faulty or deficient training, accreditation

Faulty or deficient supervision, quality control