

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

Guidance Note

Methodology for the demonstration of Compatibility with Lineside Equipment.

Endorsement and Authorisation

Endorsed by:



P. Mann, Strategy Engineer (Signals)

Authorised by:



S Hailes, Head of Signal Engineering

Accepted for issue by:



M McManus, National Standards Manager

This document is the property of Network Rail. It shall not be reproduced in whole or part nor disclosed to a third party without the written permission of Network Rail.
© Copyright 2008 Network Rail.

Uncontrolled copy once printed from its electronic source.

Published and Issued by Network Rail, 40 Melton Street, London NW1 2EE.

Network Rail



Documents

Document Sharing Hub

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

Issue record

Issue	Date	Comments
Issue 1	Feb 2003	New Document
Issue 2	Aug 2008	Updated to reflect Phase 2A / Engineering reorganisation responsibility change, no technical changes.

Disclaimer

In issuing this document for its stated purpose, Network Rail makes no warranties, express or implied, that compliance with all or any documents it issues is sufficient on its own to ensure safe systems of work or operation. Users are reminded of their own duties under health and safety legislation.

Supply

Copies of documents are available electronically, within Network Rail's organisation. Hard copies of this document may be available to Network Rail people on request to the relevant controlled publication distributor and to other organisations from IHS (Technical Indexes Ltd) tel: 01344 328039.

Copyright Network Rail

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

Contents

1. Introduction	5
1.1 Purpose	5
1.2 Scope	5
2 Source of Documents	6
2.2. Previous Safety Case Documentation	6
2.3 Other Standards	7
2.3. Other Documents	7
3. Description of Equipment	7
3.1. Signalling Equipment	7
3.1.1. Control Panels	7
3.1.2. Signals	9
3.1.3. Point Motors and Actuators	10
3.1.4. Point Detection Circuits	11
3.1.5. Line Circuits	11
3.1.6. Automatic Warning System (AWS)	11
3.1.7. Signalling Cables	12
3.1.8. Ground Frame Release and Detection Systems	13
3.1.9. Emergency Signalling Power Supplies	13
3.1.10. Track Circuit Assister Interference Detector (TCAID)	13
3.1.11. Automatic Train Protection (ATP) Systems	14
3.1.12. European Rail Traffic Management System (ERTMS)	15
3.1.13. Level Crossings	15
3.1.14. Train Operated Warning System (TOWS)	17
3.1.15. Treadles - Mechanical and Electrical	18
3.1.16. Train Stops: Actuators and Detection	18
3.1.17. Train Describer Systems	19
3.1.18. Tripcock Testers	19
3.1.19. Train Running Away Alarm	19
3.2. Other Systems	19
3.2.1. Closed Circuit TV Systems	19
3.2.2. Hot Axle Box Detector (HABD)	20
3.2.3. Automatic Vehicle Identification (AVI)	21
3.2.4. Transponders	21
3.2.5. Station Information Video Systems (SIVS)	22

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

3.2.6. Public Address System (PA)	22
3.2.7. Station Clocks	23
3.2.8. Fire Alarm Systems	23
3.2.9. Wheel Impact and Load Detectors (WILD/Wheelchex)	23
3.2.10. Business Data Systems	23
3.2.11. Third Party Systems	24
3.2.12. Automatic Power Control (APC) Magnets	24
3.2.13. Traction Supervisory Pilots/SCADA Systems	24
3.2.14. Panchex System	24
3.2.15. Uninterruptible Power Supplies (UPS)	25
4. Infrastructure Assumptions	25
5. Susceptibility Analysis and Methodology for Demonstration of Compatibility	25
5.1. Signalling Systems	26
5.2. Other Systems	35

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

1. Introduction

The traction package for a modern electric traction unit will probably use IGBT or other solid state devices as switching elements to produce a variable frequency, variable voltage supply to three phase induction motors. It is possible, therefore, to generate frequencies other than 50 Hz or d.c. in the traction return current. These frequencies could cause maloperation of signalling and other equipment vital to the safety of the railway or important in railway operation.

This Guidance Note describes a number of items of equipment and systems that could be affected by interference currents, in both d.c. and a.c. electrified areas. These items have been determined as part of previous studies (for example, Ref. 7) augmented by information obtained from Network Rail Signals & Telecoms Maintenance Engineer, Racal Telecomms and other parties. Each item is examined in the light of:

- how its functionality may be affected by the train;
- what the consequences would be;
- the proposed methodology to demonstrate traction system compatibility with the lineside equipment;
- any other influencing factors.

1.1 Purpose

The purpose of this Guidance Note is to provide a methodology to demonstrate compatibility with lineside equipment installed on the a.c. and d.c. electrified railway on Network Rail controlled infrastructure. This is achieved by specifying criteria/standards against which theoretical calculations or test results for new rolling stock should be compared to enable a safety case to be made.

1.2 Scope

This Guidance Note is concerned with interference to fixed systems only (i.e. not trainborne) and concentrates on those that are safety critical or safety related; though systems of commercial significance are also considered. The items are arranged into broad groups according to the functions performed by them although this grouping is not precise as there are many areas of overlap. The following systems are specifically excluded as they form the subjects of separate Network Rail Company standards:

System	Network Rail Company Standard
Interlockings	NR/GN/SIG/50013
Reed FDM Systems	NR/GN/SIG/50015
Axle Counters	NR/GN/SIG/50011

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

Train Protection and Warning System (TPWS)	NR/GN/SIG/50012
Telecommunication systems	NR/GN/TEL/50016

Note that this report includes only systems found on Network Rail controlled infrastructure. Equipment specific to other infrastructure is excluded.

2 Source of Documents

2.1 Railway Group And Network Rail Company Standards

1. "Guidance Note [GK/RT0061](#) - Shunter's Release, Ground Frames, Switch Panels, Gate Boxes and Shunting Frames", Railtrack, Issue I, November 1996.
2. "Guidance Note for EMC between the Railway and its Neighbourhood" GM/RC1500, Railtrack, Issue I, December 1994
3. Network Rail Company Standard [NR/L2/SIG/11762](#) - "Track Circuit Assister Interference Detector", Issue I, December 2000.
4. Network Rail Company Standard [NR/GN/ELP/27010](#) - "Compatibility between Electric Trains and Electrification Systems", Issue, December 2005.
5. Network Rail Company Standard [NR/GN/SIG/50013](#) - "Methodology for the Demonstration of Compatibility with Interlockings" Issue 1, February 2003.
6. Network Rail Company Standard [NR/SP/TEL/50016](#) - "Methodology for the Demonstration of Compatibility with Telecommunications Systems". Issue 3 April 2003

2.2. Previous Safety Case Documentation

8. "Juniper EE&CS safety Case: EE&CS Systems List for all Electrified Routes" AEA Technology Rail Ref. PRJ-SCSEQUN)-RP-I, Issue I, June 1997.
9. "Juniper Project - Electric Traction Interference: Non Track Circuit Systems" AEA Technology Rail Ref. PRJ-SCSEQUN)-RP-16, Issue 2, September 1998.
11. "Compatibility of Class 357 Electrical Systems with Miscellaneous Systems on LTS Routes", ADtranz Ref. 3EER300000-1 179, Issue D, July 2000.
12. "Class 365/5 Trains: A.C. Full Service EE&CS EMC Safety Case Assessment-Module 3 Other Signalling Systems", AEA Technology Rail Ref. PRJ-SCSE(ELAC)-SA-18, Issue 2, April 1997.
13. "Class 92 Locomotive EMC safety Assessment Volume 8-Miscellaneous Signalling Equipment", AEA Technology Rail Ref. 120-dr0442, Issue b0, May 1999.
14. "Class 92 Locomotive EMC Safety Assessment Volume 11 -Miscellaneous Equipment

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

on 750 V D.C. Railway", AEA Technology Rail Ref. 120-dr0077, Issue d0, October 1997.

15. "EE&CS Compatibility and Safety Requirements for Class 334 Trains. Hazard Analysis and Engineering Guidance", Alstom Traction, 10109.1205, Rev A, June 1999.

2.3 Other Standards

16. BS EN 50121: Railway applications. Electromagnetic compatibility, 2000
17. "Cab Secure Radio", BR Specification BR1845.
18. "VHF Band Three Radio for the National Radio Network incorporating the Train Overlay System", BR Specification 1609, Issue 2, August 1987.

2.3. Other Documents

19. "Railway Safety Principles and Guidance, Part 2, Section E: Guidance on Level Crossings", Health and Safety Executive, 1996.
20. Statutory Instrument 1992 No 2372 "Electromagnetic Compatibility", The Electromagnetic Compatibility Regulations 1992.
21. "50 Hz Single Phase A.C. Electrification: Immunisation of Signalling and Telecommunications Systems against Electrical Interference", British Railways Board, BR 13422, November 1980.

3. Description of Equipment

This section gives a brief description of the items covered in this Guidance Note. The items are arranged into broad groups according to the functions performed by them although this grouping is not precise, as there are many areas of overlap. Requirements for compatibility are given in section 5.

3.1. Signalling Equipment

3.1.1. Control Panels

3.1.1.1. Lever Frame with Block Bells/ Instruments

In certain areas, though rarely on electrified lines, signals and points are worked mechanically from small signal boxes by levers through wires and rodding (or in some cases, electromechanically). Interlocking of points and signals may be achieved mechanically, electrically (through conventional d.c. relay circuits) or by a combination of both. Operation of trains and communication with adjacent signal boxes uses block telegraph instruments and bells which are essentially low voltage d.c. electromagnetic devices communicating via open wire pole routes or buried cables.

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

3.1.1.2. Entrance-Exit (NX) Panels

An NX panel depicts the area of control on a "mimic diagram" (panel) within the control centre. The panel shows the status of routes (not set/set/occupied) using coloured lamps inset along the depiction of the line of route, the state of signals (on/off), the identity of trains (train description) and other information. The signaller sets routes by operating illuminated push buttons corresponding to the entrance and exit of the route either on the panel itself, or on a separate console. Facilities are also provided for individual operation of points, emergency replacement of automatic signals, operation of remote level crossings, release of ground frames etc.

The panel may be local to or remote from the interlocking. Communication between the panel and the interlocking may be hard wired, using conventional 50V d.c. relay circuitry or it may use multiplexing in which the status of the controls is encoded into a serial data stream using, for example, the RS 422 interface standard for transmission to the interlocking. Similarly, serial data from the interlocking is decoded into individual circuits for driving the lamps and indicators. Multiplexing is always used in Solid State Interlocking (SSI) installations and may be used in Route Relay Interlocking (RRI) installations (ref. 7). The RS 422 standard provides a degree of error protection by use of redundancy, start/stop/parity bits.

3.1.1.3. Integrated Electronic Control Centre (IECC)

The IECC is an electronic signalling control system, operated from desk-like workstations, which provides all the facilities required for the control and monitoring of a substantial area of railway.

A signaller's workstation holds four or five monitor screens providing a detailed display of the railway, train describer maps, alarms and information messages. Control is exercised either through a trackerball and push button set, or through a keyboard.

The IECC also provides:

- a train describer, with communication links to other train describer systems;
- automatic route setting;
- technician facilities for monitoring and diagnosing faults.

An IECC is composed of a number of sub-systems, depending upon the size and complexity of the scheme it serves. Each subsystem is connected to one or both of two communications networks; the Signalling Network, which handles time-critical railway control data, and the Information Network, which handles less critical information traffic. The two networks and almost all the subsystems are duplicated for availability, using an active/standby configuration. Nearly all the software is standardised, the characteristics of each scheme being stored as data.

The IECC signalling network communicates directly with one or more SSIs using multiplexed serial data. For communication with relay interlockings, a Relay Interlocking Interface subsystem converts serial data into the Westinghouse S2 protocol for communication to the interlocking via time division multiplex links and serial to parallel conversion (ref. 7).

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

IECC equipment is housed within the Control Centre building in the equipment room and operating floor and protected against EMI by normal industrial standards of earthing and shielding. Recent versions of equipment are tested for EMI susceptibility in accordance with the requirements of EN50121 part 4

3.1.2. Signals

In most installations the lamp used is a type SL35, with main and auxiliary filaments each rated at 12 V, 24W but under run at 10.8 V to prolong life. Lamps are illuminated through 110 V a.c. feeds using a tail cable to transformers in the signal head. Certain types of signals use 110V a.c. 35 W long life single filament lamps as detailed below. Signals using arrays of LED light sources are currently being introduced into service (at present these are confined to Position Light Signals).

3.1.2.1. Multiple aspect (plus flashing) colour light signals

Multiple aspect signals are typically constructed with a vertical array of lamp units inside a signal head. Each unit has a double filament lamp displaying its aspect through a focused lens arrangement with coloured filter, but no reflector. Relays in the signal head effect the changeover from main to auxiliary filament and produce a filament failure alarm. Total failure of a lamp (other than the second yellow of a double yellow aspect) is detected by a relay or, in the case of SSI, in the Trackside Functional Module in the location and will restore the stop signal in rear to danger.

3.1.2.2. Position Light Junction Indicators (PLJI)

The PLJI is provided at junction signals with a speed of 40 mph or more on the fastest diverging route, to give an indication of route. This is by a line of five lunar white lamps for each diverging route. In modern installations these are SL35 but with only one filament in use. The lamps are driven by 110 V: 12 V transformers in the signal head, one transformer for each diverging route and a separate transformer for the pivot lamp. A lamp proving relay, or a function in the TFM, in the location, will prove that 3 out of 5 lamps, are alight before permitting the main signal to show a proceed aspect for a diverging route.

3.1.2.3. Position Light Signal

Position light signals are employed either to provide subsidiary aspects on main signals or as independent shunt signals, usually mounted at ground level and known as Position Light Ground Signals (PLGS). The subsidiary signal is mounted adjacent to the signal head of a main running signal. Two lunar white lights at 45° provide a 'Shunt' or 'Call-on' aspect when illuminated.

A PLGS, usually ground mounted has three lamps providing a horizontal lunar white and red aspect for stop and two lunar white lights at 45° for proceed. A recent variant provides four light sources; two horizontal red lights for stop and two white lights at 45° for proceed.

A similar signal with two horizontal red lights is used as a limit of shunt marker. An illuminated board stating "LIMIT OF SHUNT" (LOS) is also used. All position light signals use 110 V a.c. 35W long life single filament lamps or LED sources.

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

3.1.2.4. Banner Repeater Signal

The Banner Repeater is used for repeating the aspect of main signals where the sighting distance is inadequate. It displays a black band on a white background, horizontal for signal at danger or light out, inclined at 45° for a proceed aspect and the light on.

The aspect is obtained by extinguishing a combination of white lights supplied by optical fibre from separate "off" and "on" halogen lamps or by electromagnetic displacement of an arm against an illuminated white background with the arm proved in the signal aspect in the rear.

3.1.2.5. Multi Lamp Route Indicator (MLRI)

An MLRI will provide indication(s) of route(s) at a junction signal for speeds of 40 mph or less. A letter or figure is provided on a 7x5 or 7x7 light array, sometimes duplicated for two character displays. Lamps can be wired in parallel groups or optical fibre can be used. Where a reduction of speed of more than 10 mph relative to the fastest route is required, then illumination of sufficient lamps to provide a recognisable letter or figure is required.

3.1.2.6. Stencil Route Indicator, CD, RA and Signal OFF Indicators

Stencil route indicators provide a letter or number indication for the route(s) of a position light signal. They generally incorporate 110 V a.c. lamps behind the stencil, of the indication to be displayed. Modern indicators employ fibre optics for light transmission. Similar indicators are used for Right Away (RA), Close Doors (CD) and Signal Off indicators at station platforms. The supply voltage is 110 V a.c., 35W.

3.1.2.7. Signal Passed at Danger (SPAD) Indicator

SPAD Indicators are installed a few metres beyond a stop signal to indicate to the driver that the train has passed the stop signal at danger. A SPAD Indicator resembles a conventional 3 aspect signal but has a blue, rather than black, backboard. Normally (i.e. when indicating proceed), no lamps are illuminated. When indicating stop, the top and bottom lamps display flashing red. The centre lamp displays steady red.

3.1.3. Point Motors and Actuators

Conventional point machines are driven by series wound d.c. motors fitted with snubber circuitry (low resistance shunt) to bring the motor rapidly to rest at the end of the movement. In a.c. electrified areas, to prevent false operation due to stray traction current, a permanent magnet may be used instead of a field winding.

In a clamplock machine, the motor operates a hydraulic compressor rather than moving the switch rail directly. D.C. operated solenoid valves are used to operate the points via hydraulic pressure.

In pneumatically operated points, the motor operates a pneumatic compressor rather than moving the switch rail directly. D.C. operated solenoid valves are used to operate the points via pneumatic pressure.

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

3.1.4. Point Detection Circuits

Points are detected in their correct position (normal or reverse) and locked by the mechanical operation of electrical contacts. To maximise immunity to traction current interference, these contacts may be fed from supplies at various frequencies as listed below:

d.c.	non electrified lines, a.c. electrified lines
50 Hz	d.c. electrified lines
83.33Hz	dual (d.c. and a.c.) electrified lines
audio reed	d.c. and a.c. electrified lines
pseudo-random binary sequence	SSI installations

3.1.5. Line Circuits

D.C. line circuits are used in a.c. electrified and non-electrified areas. The receiving unit for d.c. line circuits is a d.c. relay. A d.c. supply is switched on or off and the relay at the receiving end will either energise or de-energise accordingly. In a.c. electrified areas the d.c. relays are immune to a.c. therefore EMI in the form of a.c. will not cause them to operate falsely. Line circuits in 25 kV 50 Hz traction areas are almost invariably fed at 50 Volt d.c., and have a contact of the controlling relays in both the outward and return conductors (double cut). If the complete circuit is required to exceed 2 km, a repeater is used at 2 km so as to limit the length of exposure of the conductors to induced interference. Relay coil resistances are dependent on type and manufacturer, but are typically about 1000 SZ, so that the line circuit power is of the order of 3 W.

The immunisation of this equipment was primarily designed to protect it from false operation by 50 Hz currents present in the traction system. This immunity will provide protection against interference from other frequencies, for example mains harmonics as a result of waveform distortion due to traction operation.

3.1.6. Automatic Warning System (AWS)

AWS is an aid to the driver which uses trackside and trainborne equipment to draw attention, by audible warnings in the cab, to the approach to certain restrictive signals, signs, level crossings and speed restrictions. The brakes are applied automatically if an AWS warning is not acknowledged within a certain time. A visual reminder is presented to the driver after acknowledgement of the warning and retained until the next set of AWS track equipment is encountered.

The track equipment consists of magnets, mounted centrally between the rails such that their magnetic fields can be detected by the AWS trainborne equipment of any train which passes over them. There are two basic forms of such magnets: a permanent magnet which has its South pole uppermost, and an electromagnet which, when energised, has its North pole uppermost. An electromagnet is always associated with a signal, and is energised only if that signal is displaying the "clear" aspect. High strength magnets are used on d.c. electrified lines in conjunction with reduced sensitivity receivers (to give greater immunity from false operation due to traction current). Permanent magnets fitted with suppressor coils may be used on bi-directional lines to prevent an AWS warning on a train travelling in opposition to the signalled direction.

Copyright Network Rail

Ref:	NR/GN/SIG/50014
Issue:	2
Date:	26 August 2008
Compliance date:	N/A

The trainborne equipment consists of a bistable reed receiver which responds to the fields produced by the magnet, relay logic circuitry (electronic circuitry in the case of trains fitted with TPWS), warning horn, audible clear indicator (bell), electromechanical reminder device ("sunflower") and an interface with the braking system. A standard receiver shall respond to a flux density of 3.1 mT or greater. It shall not respond to a flux density of 1.5 mT or less. A reduced sensitivity receiver shall respond to a flux density of 5.0 mT or greater. It shall not respond to a flux density of 3.5mT or less.

In operation, the permanent magnet (South pole) initiates the warning process within the trainborne equipment. If an electromagnet (North pole) is detected within a short time delay, the equipment sounds the bell and cancels the warning process. Otherwise the horn sounds. The driver is required to acknowledge this warning, after which a visual reminder is given in the cab by the "sunflower" indicator. Failure to acknowledge within a given time, leads to an automatic application of the train brakes. Definitive information on AWS is given ref. I

Maximum permitted levels of flux density that may be generated by rail vehicles at rail level are given in section 5. I.

3.1.7. Signalling Cables

The types of cable to be used in signalling installations are defined in the Signalling Installation Handbook. C2 type multicore cable 2, 4, 7, 10, 12 or 16 cores is commonly used to supply signalling equipment at 110 V a.c.. 50 V d.c. line circuits are commonly provided by type B2 cable of section 0.75 mm², 1.5 mm² or 2.5 mm² with 4, 7, 10, 12, 19, 27, 37 or 48 cores. A version of 12 core cable is available containing twisted pairs.

To avoid danger and prevent damage to cables and equipment, circuit length is limited to 2 km in a.c. electrified areas such that longitudinal induced voltage does not exceed 60 V rms on full traction load or 430 V rms under fault conditions (from CCITT directive on telephone circuits reproduced in reference 20). More detailed curves giving maximum permitted induced voltage against exposure time are given in British Standard BS7354.

Tail cables commonly use C2 type 50/0.25mm multicore cable having 2, 4, 7, 10, 12 or 16 cores or single core type C I . A maximum length of 200 m applies in a.c. electrified areas.

An SSI Trackside Data Link (TDL) consists of an individual screened twisted pair copper cable having a nominal impedance of 100 ohms to specification BR 1932, the equipment at each location being connected to it in parallel via Data Link Modules (DLMs). The TDL is limited in length to 10 km (where data links run parallel to a.c. electrified lines, isolating transformers are inserted at 2 km intervals).

SSI messages incorporate a number of features to reduce their susceptibility to traction interference:

- the signal levels are much higher than would be permitted over conventional shared telecommunications circuits (4.5V ± 0.25V at the transmitter); as a consequence they have a high signal-to-noise ratio and are relatively immune to interference from traction sources;
- the SSI messages are represented by complex signals which cannot conceivably be replicated by any known form of traction system;
- two levels of coding are employed and these provide a very secure means of distinguishing between data signals and noise, and of detecting messages which have been corrupted;