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Guidance Note

SIGTAN 012 Cables and Wiring used for Signalling Systems

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

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1. PURPOSE

This Guidance Note provides information relating to cables and wiring insulation, both degradation that has been encountered on Network Rail Signalling Infrastructure and testing methods. It also contains relevant technical information and the historical background. Some notes on inspection techniques, alterations to affected wiring and some miscellaneous cable problems are included in the appendices. The purpose of insulation testing is to detect the deterioration or failure of the insulation of wires, cables and other circuit components. Testing may be by continuous monitoring or by regular testing depending on the required level of integrity.

2. SCOPE

This Guidance Note mainly covers railway signalling wires and cables with copper conductors. The conductors in wires and cables with natural rubber insulation are tinned and surrounded by an external layer of polychloroprene. The colours mentioned are those most commonly found, but some types are available in other colours. Known problems with cables of other types are mentioned. Except where specially mentioned, references to cables may be taken as also applying to wires (i.e. single insulated conductors without an overall sheath). Testing methods are also included. The requirement to test insulation applies to cables, wires and circuit components carrying signalling circuits. This includes cables, interlockings, apparatus cases and lineside signalling equipment.

3. REFERENCES

3.1 British Railways Board Specifications

BR 872 Railway Signalling Cables
BR 972 Railway Signalling Cables

3.2 British Standard Specifications

BS 6360 Conductors in Insulated Cables and Cords
BS 6899 Rubber Insulation and Sheath of Electric Cables

3.3 Network Rail Line Standards

NR/L2/SIG/11221 Signal Works Testing Handbook
NR/L3/SIG/11231 Signal Maintenance Testing Handbook
NR/L2/SIG/11655 Management of Signalling Wire and Cable Insulation Degradation
NR/GN/SIG/19030 Signalling Equipment Technical Advice Notice (SIGTAN030)
Earth Testing of Bus-Bars
NR/L2/SIG/00005 Railway Signalling Cable
NR/L3/SIG/10663 Signalling Maintenance Specifications (Part C - Tests EL21 & EL31)

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3.4. Technical Investigation Reports

No. 1921	Report on the National Cable Survey 1994
No. 90018	Recognising Deterioration in the Quality of Insulation on Cables and Wires Manufactured to BR Specification 872 prior to 1986
No. 90028	Defective Insulation on BR 872 Type A1 Wire
No. 90053	Investigation into Reasons for Core-to-core Short Circuits on BR 872 (1986) Type B2 Cable
No. 91507	Perceived Wiring Installation Problems
No. 92542	Various Cable Faults
No. 93551	Signalling Cable and Geographical Set Wiring Deterioration

4. ABBREVIATIONS

COSHH	control of substances hazardous to health
EPR	ethylene propylene rubber
PCP	polychloroprene (also known as neoprene)
PVC	polyvinyl chloride
QRA	quantified risk assessment
uPVC	unplasticised polyvinyl chloride
SIGTAN	Signalling Equipment Technical Advice Notice
TI	technical investigation
VIR	vulcanised india rubber (also known as isoprene or natural rubber)

5. DEFINITIONS

5.1. Signalling Circuit

A control system circuit carrying information used for the operation of the railway signalling system, electrification control or associated with the safe movement of trains.

It includes:

any portion of the circuit in operational telecommunications cables which is not coded or is susceptible to corruption by earth or cable degradation.

It excludes:

any portion of the circuit carried in telecommunications transmission systems such as FDM or PCM.

otherwise protected signalling circuits, not susceptible to corruption by earth or cable degradation

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5.2 Operational Telecommunications Cable

A telecommunications cable associated with the signalling system or specifically provided for the direct operation of the railway.

6. PERSONAL SAFETY

All appropriate safety precautions shall be observed when undertaking the work covered by this document.

Substances leaking from degraded cables and wiring do not normally present a hazard to health provided they are not swallowed or allowed to come into contact with the skin. Impermeable gloves and overalls should be worn when dealing with a leaking substance and should be disposed of correctly at the end of each shift. A local instruction including a COSHH assessment may be in operation for work of this nature, and will highlight the precautions that shall be taken to control any health and safety concerns.

This document does not address general personal safety measures. Local instructions including a COSHH assessment may be in operation and these will highlight those measures which shall be taken to control any Health and Safety concerns.

7. BR 872 CABLES (PRE-1986)

7.1.General

Railway signalling cables have traditionally consisted of tinned copper conductors insulated and sheathed with various rubber compositions. During the 1970's and 1980's, there were a number of reports of serious decomposition of the rubber insulation. Although a number of the failures were traced to chemical contamination and thermal degradation, by far the most frequent

mechanism was the degradation of the rubber compound in immediate contact with the copper conductor. This implied that the conductor tinning, intended to serve as a barrier between the two, was ineffective.

Two types of premature insulation degradation were observed: **wet degradation**, in which the inner rubber insulation is transformed into a sticky liquid that seeps out of the cable ends, leaving the PCP sleeve loose, and **dry degradation**, in which the inner rubber loses its elastic properties, becomes hard and brittle, and crumbles when handled.

7.2 Cable Sampling Exercise

In the late 1980's, the incidence of cable degradation as reported was felt to be increasing at a rate that warranted further investigation. In an attempt to target the type of cable that was most prone to degradation, a major sampling exercise was undertaken in 1989. The rubber formulation was analysed, the extent of copper

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migration tested against the limits laid down in the manufacturing specification, and the thickness and variability of tinning measured by electron microscopy. The findings of the exercise were as follows.

1. No significant chemical differences could be detected between the insulants used by the different manufacturers, these being isoprene with some addition of butadiene styrene.
2. BICC cables manufactured between 1974 and 1981 were in universally good condition despite the fact that the BS 6360 tinning test indicated copper migration close to, and in some cases exceeding, the permitted maximum.
3. AEI cables manufactured in the 1970's were all degrading.
4. Pirelli cables supplied between 1981 and 1984 were universally degrading, showing an insulation resistance worse than that of the BICC equivalent cables, despite being some five years younger. The results of the tinning test in accordance with BS 6360 revealed copper migration to an extent that often exceeded the permitted maximum, although the margin was hardly sufficient to explain the scale of the electrical and physical differences between the Pirelli and other manufacturers cables.

One manufacturer whose cable did not feature in the 1989 sampling exercise was Sterling Greengate. However, in response to a number of reports of defective cables in 1992, Sterling Greengate cables became the subject of an investigation in due course (see TI Report 92542). These cables were manufactured in 1985 and were in accordance with BR 872 (1970). All the samples exhibited degradation of the isoprene rubber inner insulation.

Note: if the cable cannot be identified from the outer sheath, the information can be found on the manufacturer's identification tape that runs through the centre of each cable. Various cable types were reported during this investigation, i.e. 4-core 50/0.25 mm, 2-core 50/0.25 mm and 2-core 7/0.67 mm.

7.3. Mechanisms of Degradation

Degradation of rubber, which in its degraded state is variously described as perished, cracked, crazed or weathered, can normally be attributed to attack by atmospheric ozone, oxygen and ultraviolet light, which break down the polymer chains. These effects can be accelerated by heat. Copper ions are known to act as a catalyst in this process, causing significant acceleration of decomposition. One of the functions of conductor tinning in BR 872 cables has been to provide a barrier to prevent copper ions from migrating into the isoprene insulation, although it is unlikely that either British Rail or the cable industry realised its crucial importance at the time.

The degradation exhibited by the cables investigated in 1989 was traced to the reduction in the thickness of the tin-plating of the conductors, this being the result of a change in the manufacturing process; traditional hot dip methods had been

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replaced by an electro-tinning process. It was also observed that, at least in some of the affected samples, the tin conductor plating had completely corroded away, suggesting that the chemical by-products of de-composition are themselves corrosive to the tin plating, thereby accelerating the process even further.

Isoprene rubbers are known to degrade over time by chemical action, the differing formulations of rubber, filler and undisclosed (secret) additives from individual manufacturers having differing physical, electrical and degrading characteristics. Experience since BR 872 was published indicates that the BS 6360 tinning test pass criteria are not sufficiently stringent to achieve a 20 - 30 year service life with isoprene-based insulation material.

There is no doubt that the effects of degradation are mitigated to a significant extent by the continued presence of a PCP outer cover. Although its insulation performance is not so good, owing to slight porosity and water absorption, it nevertheless provides an electrical barrier for the cable.

7.4. Locating and Recognising Degradation within BR 872 Signalling Cable

Degradation is confined to the inner blue or green insulation of BR 872 cables manufactured before 1986. Post-1986 cable cores are one-part insulated (black) and are therefore noticeably smaller in overall diameter for a given number of cores. Some single cores are two-part insulated with a white inner and a black outer, while others are one-part insulated (black).

Degradation is accelerated by heat; therefore cables situated in hot relay rooms are more likely to be affected than those in cold location cases. At any given relay room or location case, cable cores exposed to localised hot spots, e.g. those running above convector wall heaters or above power transformers, etc., will tend to have more advanced degradation.

7.5. PCP (rubber-covered) Stranded Wire (black)

This is used for free wiring in relay interlockings and lineside location cases. Wires that are in good condition are flexible and feel cool to the touch. Older wiring of this type has a number of modes of degradation.

One of these is hardening of the wire, characterised by a general stiffness of the wiring trees. Individual wires can be heard to crack when slightly flexed; this is because the inner insulation has hardened, and when disturbed it becomes a powder. Relay rooms that date from the early 1980's, and were known by the late 1980's to have wire hardening, have been observed to be no worse by the late 1990's provided the heat source that caused the initial damage was removed. Such wires are dry to the touch and do not feel colder than the surroundings. Provided the outer sheath is still intact and is not showing signs of splitting, these wires are considered capable of giving a further 10 years service, but they shall be regularly examined in accordance with [NR/L2/SIG/11655](#). If the outer sheath is showing annular (concentric) cracks, the wire will need to be renewed with some urgency, since it is likely that the insulation will come off and expose the conductor if it is disturbed any more.