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INSTITUTION OF RAILWAY SIGNAL ENGINEERS
MINOR RAILWAYS SECTION

GUIDELINE ON

SIGNALLING AND TELECOMMUNICATIONS CABLES FOR USE ON MINOR RAILWAYS

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Anyone who wishes to contribute additional items or correct / amend any of the entries or wants further information may contact the IRSE Minor Railways Section Guideline co-ordinator at mrsdc@irse.org or via the IRSE Headquarters.

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1 INTRODUCTION

This document provides information on the provision and management of the cables that can be used for signalling and telecommunications systems on Minor Railways.

This document is a basic guide on the essentials.

This is not intended to be a definitive document on how to install, test and maintain cables but to disseminate information on best practice.

The IRSE Minor Railways Section has used its best endeavours to ensure that the contents of this document are factually and technically correct and that it is suitable for its stated purpose. The IRSE Minor Railways Section will not accept liability for any incidents arising from its use.

Any railway seeking to follow the guidelines in this document should ensure that it is suitable for their particular railway concern. Duty holders are reminded that they must be satisfied that they are doing all that is needed under health and safety duties to control risks. Compliance with this guideline issued by the IRSE is not mandatory as it is intended merely to provide advice.

2 DEFINITIONS

The following is a list of the definitions, a fuller description may be found in subsequent sections. Readers should also refer to the glossary document issued by the IRSE

Double cut circuit	A circuit that uses two conductors and the circuit includes switch contacts in both the feed and return legs to de-energise the circuit. Requires multiple insulation failures to give a potentially unsafe condition.
Earth return circuit	A circuit that only has switching contacts in the feed and uses the earth as a return. Normally used in mechanical signalling areas. An earth fault will normally result in a safe condition, and insulation failure will give a potentially unsafe condition.
Single cut circuit	A circuit that only has switching contacts in the feed of the cable and often has a return that is shared with another circuit. Normally only used for indications but can be used in vital signalling circuits. Requires two earth faults or a single insulation failure to give a potential unsafe condition.
Quad	Four wires laid up to form two balanced pairs using opposites for pairs
PE	Polyethylene
PVC	Poly Vinyl Chloride
PJ	Petroleum Jelly
LSZH	Low Smoke Zero Halogen

3 SAFETY CONSIDERATIONS

When working with cable, as in all workplaces, ensure that you have a safe system of work before you start.

Cable is normally delivered on large drums, so care is required when handling these. The use of mechanical devices (such as road rail machines) should be used to lift and unload heavy cable reels.

When unloading cable from trailers or trains the cable drums should be supported on a proper jig designed for the purpose. This can consist of jacks that are a fixed the correct distance apart with a support for a pole that is run through the middle of a drum or for smaller drums, a drum roller.

When unreeling cables from a train or trailer, the movement should be made at walking pace. Personnel should avoid travelling on the train or trailer when in motion unless suitable arrangements are in place to prevent personnel falling off.

4 CABLES AND WIRES

4.1 Cable Types

4.1.1 Whilst many different kinds of cables can be used for signalling and telecommunications purposes on Minor Railways, it is important that they should be fit for purpose. This means that they should be rated to carry the voltages, currents and frequencies that need to run through them. They should also be robust enough to withstand the physical conditions to which they are subjected during laying and the environmental conditions they must endure during their working life.

4.1.2 Telecommunication cables are always made up and terminated in pairs. The cable construction is designed to optimise the electrical performance of the circuit carried in the cable, by minimising interference between pairs. Increased performance is provided when the pairs in the cable are arranged in quads, this where the two pairs are wound together with the wires of the pairs opposite each other. Quad cables were used for trunk circuits over long distances between major centres and were the main cable type installed by British Rail for many years. These perform well with four wire circuits when the circuit should be allocated to an individual quad, all circuits should always be connected to an individual pair. Quad cables are now replaced with twin cables designed to have lower crosstalk.

4.1.3 Signalling cables tend to be cored cables, and each core is normally numbered rather than colour coded. The cable conductors can be solid or stranded in construction. Signalling cables are normally terminated with a crimp or boot lace ferrule. Cables with solid conductors are not normally terminated with crimp terminals, but usually by forming the wire into an eyelet. Paired cables can be used for signalling circuits, and it is good practice to allocate the circuits per pair if practicable, especially if voice frequency circuits are running through the cable.

4.2 Telecommunications Cables

Different types of cable are available dependant on their application and location. Cables for external use are generally insulated and sheathed with PE and are often provided with steel wire armouring and a further black PE over sheath. Cables for indoor use normally have a white or cream sheath and are PVC insulated and sheathed. Different types are available for building wiring and equipment (often referred to as ‘Switchboard cable’). Latterly much use is made of wiring systems using standardised four pair cable radiating from a patch panel to sockets near the applications. This is often referred to as ‘Structured Wiring’.

4.2.1 External cables

These are usually insulated with solid or foamed polyethylene (PE) and sheathed with black PE. Cables can be filled with petroleum jelly (PJ), and/or have an aluminium moisture barrier. When a drain wire is included it can be used as a screen. These cables are sheathed in PE then are optionally overlaid with steel wire armouring and an outer PVC outer sheath. The PJ filling and aluminium/PE-copolymer moisture barrier resists the penetration of water and water vapour.

Cable cores are twisted up into pairs and made up into a cable or unit by gently twisting to give a helical long ways lay. The pairs at one end therefore have a clockwise rotation – this end is often designated as the A or red end, the cable often being marked with red tape at the A end and green at the B. Cables should be laid so that the A end is always at the same end so that adjacent cables each have the same direction of lay.

The readily available unit twin cable to CW 1128 specification is made up of groups of 5 or 10 pairs (depending on cable size), the groups of cable pairs are called units and are laid up together to form a cable of the required size. Each unit is identified by a coloured coded polyester tape.

Details of commonly used cables are shown in the Appendix 3.

4.2.2 Aerial Cables

When slung between poles, cables normally have an integral suspension wire is included in a figure of eight configuration under a single sheath. Aerial cables are fixed to poles and buildings using purpose made clamps. When erecting the cable it is first fixed at alternate poles then at the centre point a number of twists are made before clamping the cable to the pole. This helps support the cable and reduces wind vibration.

For local ‘drops’ to buildings or trackside equipment Drop Wire is used. This is a self-supporting cable erected using purpose made spiral clamps. Drop wire is made in a variety of sizes, from one to 4 pair.

4.2.3 Fibre cables

Fibre cables require specialist equipment for jointing and testing and are best left to a specialist.

4.2.4 Internal Cables

4.2.4.1 Internal Distribution Cable

These cables are insulated with PVC and sheathed with Black, Cream, White or Grey PVC. A version of this cable is also available with a black sheath which is intended when the internal cabling system is extended outside and between buildings. LSZH version is also available. These cables are intended for IDC termination. A 1.38 mm single earth wire is included in cables having 10 or more pairs.

Intermediate jointing is not normally recommended; and all terminations should be in boxes or on MDFs.

4.2.4.2 Switchboard Cable

These cables are intended for use interconnecting telecommunications equipment and are insulated and sheathed with PVC, they are available with pairs or triples.

4.2.4.3 Structured Wiring

Structured wiring makes use of 4-pair cables arranged individually in a star formation to link a central patch panel (or panels) with multiple user sockets presented throughout a building, or equipment location. Such installations are called Local Area Networks and they are primary intended for data distribution, but they can also be used for telephony. The 4-pair cabling is classified according to its performance/bandwidth – Category 5 Enhanced (Cat.5e) and Category 6 (Cat.6) cables are in common usage.

Connections on the patch panel are made using patch cords.

4.2.4.4 Loading

Cables by their construction are capacitive which causes signal loss at voice frequencies through attenuation. On long audio circuits this effect can be mitigated by introducing inductance into the circuit. To do this continually throughout the length of the cable would mean wrapping the cable core, or the pair, in a layer of soft iron foil somewhat similar to the construction of a transformer or inductor, this is the process of Loading.

Continuous loading is clearly impractical so the method adopted is to install an inductor across pairs as required, usually though not always, in a suitable cable joint. Fairly obviously this is called Joint Loading.

The method used is to fit an 88mH inductor at strictly 2000M intervals throughout the length of the cable, the end treatment is important so at each end a 44mH inductor is fitted at 1000M from each end, odd lengths of cable have to be carefully calculated. The effect is designed to enhance the normal audio speech band, but attenuation at higher frequencies is greatly increased and therefore loaded pairs cannot be used for circuits carrying wide band circuits for analogue or digital carrier or other pair capacity increasing systems.

The presence of loading coils needs to be taken into consideration whilst testing.

4.3 Signalling Cables

The signalling cables used on the National Rail Network are graded, dependent upon their application. They can be purchased from a variety of manufacturers and stockists who will be able to supply cable to the latest Network Rail specification, currently NR/PS/SIG/00005. Cables to this specification are manufactured with 650V insulation between cores and 1100V between any core and earth.

4.3.1 Type A cable is normally only suitable for use in equipment rooms.
A1 is single insulated single core cable and is used for wiring between relays and terminal blocks when the route is totally contained within trunking. Not normally subject to insulation testing.
A2 is insulated and sheathed single core cable is used where there is a harsh environment such as locking rooms and traditional shelf type relay racks where there is no cable trunking. Not normally subject to insulation testing.
A3 is an insulated and sheathed multicore cable version of type A2. It is for internal use where the external insulation is not robust enough to withstand moisture or the effects of sunlight.

4.3.2 Type B cable is insulated and sheathed suitable for use externally where cables are run in cable ducting (including troughing), such as between equipment cases.
The insulation is more robust than the type A3 cable. B1 cable is available in single core and B2 is manufactured in 2 to 48 cores with many different conductor sizes.

4.3.3 Type C cable is suitable for use when laid on the surface. These single and multicore heavy duty cables have flexible stranded conductors and are designed for use between apparatus cases and line-side equipment, and are often referred to as tail cables.

4.4 Pole Routes

In the UK poles are usually made of wood, though in some countries old rail is popular.

Wires are supported on ceramic or composition insulators, generally to BS16, mounted on pre-drilled wooden arms with a steel spindle bolted to the arm and fixed to the insulator with a special slow thread. Red insulators are used where vital signalling circuits or 110V power are carried via the pole route and they are normally carried on opposite ends of the same arm.

The wires can be of copper or steel, although copper clad steel wire is popular in the US. Insulated wire reduces contact faults. Wires are terminated at the end of the line with the joint between open wire conductor and lead-in cable located in a removable recessed top of the terminal insulator. Wires are tied in to each insulator along the line of route. Inter circuit crosstalk is reduced by transposing (reversing) the wires at fixed intervals to a pre-determined pattern.

Poles are fitted with side stays to resist off centre pulls caused by curvature or the line route. Longitudinal stays are provided at regular intervals to resist pull on the wires in the event of heavy snowfall or damage.

Purpose designed clamps are bolted through the top of a pole for fixing aerial cable or drop wire.

4.5 Installation methods

4.5.1 Planning

Before installing a new cable, the type of cable, the conductor size, the sheath, the route, jointing, termination methods and location, all need determination before work can start. On minor railways where reuse and recycling are the norm, understanding the cable on hand is a must. Conductor size is determined by looking at the type and length of circuits to be carried by the cable. As an example, conventional telephone circuits will work to a 500 ohm loop but modern electronic telephone systems may not; or a 50V signalling circuit may need a higher feed voltage once the loop resistance gets greater than 250 ohms. Ideally the number of pairs / cable cores will be based on an estimate of the total known demand over the section of line but this is not always possible when using donated cable.

If the cable is to be fitted with loading joints, careful measurement and planning to ensure that the inductance is spread evenly down the cable.

The type of cable route, aerial, trough, duct or direct bury burial influences the sheath requirements and the need for protection against damage. It could be better to plan for two smaller cables if it is a long pull or to keep telecommunications circuits free from crosstalk. Cable should be laid with the clockwise ends all facing in the same direction, it is a good plan to standardise the direction.

The route needs measuring, terminations identified and the boxes, main distribution frames or other terminations specified together with the type and quantity of the termination devices.

4.5.2 Cable installation

Ideally cables should be installed in some form of ducting to protect them from damage, theft and vandalism. It is good practice to keep cables and cable runs neat and tidy. Not only is this more pleasing to the eye, but it also helps create a safer working environment and could prevent the cables from being damaged.

When cables are buried they should be marked on the surface every 50M to indicate their location. Ideally as they are buried a marker tape should be installed just above the cable to assist in locating the cable in the future. Marker tape can include a metallic marker to assist location when used with non-metallic cables.

Where cables pass under the railway or roads, they should ideally be contained within in ducts at least 600mm below the bottom of the sleepers or roadway. Alternatively they can be run in either hollow sleepers (if affordable) or trunking between the sleepers that is clearly marked, or attached to the top of sleepers.

Cables should not be subject to bending more than between 10 and 20 times the outer diameter of the cable to prevent undue stress on the cores and the outer insulation material. Often with Telecommunications cables it is impossible to bend them too tightly due to the screen and outer insulation materials. Signalling cables are more likely to be stressed in this situation.

If there are a lot of cables in the route it is a good idea to ensure that each cable is labelled regularly, particularly when they adjoin or cross another railway company's infrastructure or they carry high voltage. Labels should indicate where the cable runs from and to, the size and the cable name. If the voltages carried in the cable exceed 50V, the maximum voltage that the cable carries should be marked on the labelling.

4.5.3 Moisture Barriers

When cables are run into equipment housings, where possible, they should be fitted with a moisture barrier. A moisture barrier is made up from a heat shrink sleeve and thermal insulation material. When the heat shrink sleeve is heated up the thermal insulation material melts and forms a seal at the top of the cable.

A moisture barrier also has a secondary function with jelly filled cables, where it prevents the jelly leaking out and causing cable cores to deteriorate due to the effect of the jelly material coming into contact with non PE insulation material.

4.5.4 Termination of cables in equipment housings

Crimps should only be used on cables where the cable cores are stranded and require to be terminated on binding posts. If staff are unfamiliar with the installation of solid conductors on binding posts then crimps may be used but they can present a potential failure point.

Most of the modern termination methods are designed to accept un-crimped wires, particularly DIN Rail mounted terminal blocks. The termination method used should have similar insulation properties as that of the cable being terminated and should be capable of carrying the voltage and current required.

Any electrical work including termination should take into consideration the requirements of the Electricity at Work Act. Exposed terminals should be insulated from accidental contact if they are carrying nominal voltages above 50VAC / 120VDC. Any bare termination with voltage above these limits should be accessible only when the supply has been isolated.

Terminations for telecommunications cables are usually made using screw down, Insulation Displacement Connectors (IDC), or other proprietary devices in test boxes or equipment cabinets. When terminating cables in buildings full flexibility of access to the cable pairs should be provided through the installation of a Main Distribution Frame (MDF) or purpose designed termination box with jumpering facilities. This MDF or box normally forms the boundary between external and internal cables and would usually employ IDC terminations.

Where cables pass through a bulkhead of any description (walls, case sides, bottoms etc) the cable must be properly glanded to prevent chafing. Where cables are run in buildings and the compartmentation of any room is breached by the hole made for the cable, any aperture remaining after the fitting of the gland must be blocked with an approriate fire stopping material.

Where cables enter any equipment housing they should be sufficiently restrained by the use of cable clamps to prevent the cable being accidentally pulled and stress being applied to the individual cable cores and terminations.

4.5.5 Jointing of cables

Signalling, power distribution and some telecommunication cables are normally jointed by use of through butt crimps and the use of a heat shrink sleeve.

Where the cable is of a specialist Telecommunications type such as a PJ cable, the jointing of the cable conductors is usually effected using specialist PJ filled crimps, such as Scotchlok 8A crimps, contained in a purpose made enclosure which will need access through its life, so should be installed on a pole, enlarged trough or an accessible cable pit.

Joints in cables create a potential failure point and should be avoided whenever possible. Increasingly the jointing of cables is only now done to effect repairs caused by the difficulty in locating failure points. Cables can now be delivered in longer lengths than the traditional 500M drums.

5 TESTING

When any cable is first brought into use it should be continuity and insulation tested. If new circuits are added to existing cables then it is acceptable just to test the spare cores in the cable. Should the insulation resistance values show that the cable is in poor condition (values less than 1MΩ) then consideration should be given to testing the whole cable.

Maintenance testing can depend on the type of circuits that are being carried by the cable concerned. If the cable carries earth return circuits (typically used in mechanical signalling areas) then the cable should be subjected to regular insulation testing. If the cables carry signalling circuits that are fed from earth free supplies, then regular bus-bar testing will monitor the insulation resistance of the circuits in the cable.

It is important when carrying out the testing that a suitable possession has been taken of the signalling or telecommunications circuits if the testing involves a disconnection of the circuits.

Before starting testing the tester should ensure that both ends of the cable have been isolated from working circuits, as the testing could apply a false feed to working circuits and an incorrect reading could be obtained.

If the cable is to be tested as part of a maintenance regime it is strongly recommended that both continuity and insulation testing should be carried out. The continuity test should always be carried out before insulation testing.

It has become acceptable practice not to test cables feeding track circuit rail connections as the failure mode for the cables will either be an open circuit or a short circuit. In either case the track circuit will fail. If there is a cross in the cable then it will show itself during the testing of the track circuit. If track circuits cables have more than two conductors and are used between the equipment and a disconnection box then these cables should be tested.

5.1 Continuity Testing

A continuity test proves that the cable core is intact throughout its length, and has the same identification at either end. To prove continuity an assistant is required at the far end of the cable to apply a loop. The tester should measure the resistance between the cores under test once a loop has been applied. If more than two cores are to be tested then one core should be used as a common. Once the testing has been completed another core should then be used as a common to prove that the original common core is not of high resistance. Two core cables should be tested to ensure that “core 1” is core 1, this can be achieved by using a battery at the far end and measuring the voltage for polarity, or earthing one core and testing for that earth.

The tester should check that the recorded values are suitable for the type of cable that is in use. Typical values are included in Appendix 1.

5.2 Insulation testing

Cables should be tested for electrical resistance between each core and between each core and earth or screen when fitted. The cable should be tested with an insulation tester, which effectively feeds a voltage down the cable and then measures the current drawn to calculate the resistance.

The actual value of the voltage used for the test will depend on the type of cable. Generally most cables these days have an insulation voltage value marked on them. It will also depend on the maximum value of the voltage in use in the cable. It is important to remember that the higher the voltage the more likely that the insulation will break down.

Testing of cables should be undertaken with the cable terminated at both ends. Care should be exercised where black 2BA or 0BA blocks are used, as it known that after time (and in particular if the blocks are in a damp location) that the insulation resistance of this style of terminal blocks can break down and can give misleading results. If there are poor results with both core to core and core to earth readings and they are terminated on black blocks, the cable cores should be removed and then retested to prove whether it is the cable or the termination block that is faulty.

Imperial signalling cables are normally tested to 250V, whereas most metric cables (signalling and telecommunications cables) are tested to 1000V. A check should be made against the specification of cable in use to determine the testing voltage that should be used.

To carry out an insulation test between the cores of a cable, the insulation tester should be attached to the core under test and then each other core in the cable in turn. If the cable has more than 12 cores, it is worth using a “Spider” to connect all the cores together and then just test the core under test to the “spider”. A “Spider” is a lead that has a number of crocodile clips connected together that can be connected to the insulation tester.

To carry out an insulation test between a core and earth, the insulation tester is connected between the core under test and a suitable earth. If there is no suitable earth then putting a screw driver into the ground can make a temporary earth, but when using this method always use hand pressure only to ensure that you do not spike any buried services. It is good practice when using either method to prove the earth by getting an assistant to earth the core at the far end of the cable then test to ensure that the reading is zero ohms at both the start and end of the test.

5.3 Crosstalk testing

Any signal detected on a cable pair which is picked up from other pairs on the cable, or an external source such as parallel cables, is referred to as Crosstalk and is cause by capacitance, inductance or conductive coupling between one pair and any other.

In structured cabling crosstalk can be experienced when using unshielded cable, which is bunched or laid up together on a common trunking or otherwise running in parallel.

The main crosstalk effects experienced are Near End Crosstalk (usually called NEXT) and Far End Crosstalk (usually called FEXT). Cables are designed to minimise crosstalk by variation in the twists and lay of the cable pairs but faulty installation such as crossed pairs can make crosstalk worse.

Crosstalk testing at its simplest level requires listening on the cable pairs whilst speech or a 1 KHz tone is present on adjacent pairs.

Full technical testing is carried out at voice frequencies, this requires specialist test gear to generate a controlled voice frequency tone, which can be measured on other pairs in the cable. Test gear such as a Transmission Measuring Set (TMS) and knowledge on how to use it and to interpret the results. This is best left to the experts.

5.4 Commissioning

The accepted minimum level of insulation resistance for new line side signalling cables is 50MΩ. For new signalling tail cables this reading is 30MΩ.

For Telecommunication cables, the minimum level for new cables is 1500MΩ.

5.5 Maintenance

The acceptable minimum level of insulation resistance for existing signalling cables is 1MΩ (for Telecommunication cables it is 50MΩ, core to core, and 10MΩ core to earth), although this can be relaxed by risk assessment. Any risk assessment should take into consideration the type of circuits that are in use in the cable, particularly the impedance of any circuit (i.e. whether it employs circuits that need a low current to cause the equipment to operate, typically those circuits that operate at 10-15mA) and if the cable carries single cut or earth return circuits.

If a cable carries only double cut circuits then regular insulation testing can be replaced by regular bus-bar testing. Any faults that are detected can then be investigated and acted upon. When using this method it is important that as many of the circuits as possible should be energised when the tests are undertaken. The fitment of earth leakage detectors on the signalling supplies is another good method of monitoring the insulation resistance and this has the added bonus of giving continuous monitoring. It is important that any faults are acted upon. To a certain degree, if the cable carries single cut circuits, then bus-bar or earth leakage detectors can be a useful tool in monitoring the condition of the cable but this should not be the only test method used.

6 MAINTENANCE REQUIREMENTS

From October 1st 2010 maintenance on Minor Railways is subject to the ROGS requirements. This places a duty on a railway undertaking to ensure that it has a plan in place for the inspection, testing, repair, modification and maintenance of its assets including cables. This plan, and records of work undertaken, should be kept on file as evidence in the event of an incident.

6.1 Maintenance Standards

The frequency of maintenance will be different for each railway, based on the following factors, but this list is not exhaustive:

- The type of cable used
- The location that the cable is installed (i.e. surface laid, buried or in ducting)
- The type of circuits that are in use.

6.2 Maintenance Intervals

These will depend on the particular requirements of the railway concerned. The older the cable or if the cable is either buried or surface laid the more likely that it will deteriorate. Standard railway cables are normally good for 25 years if installed in the appropriate manner.

Should the insulation resistance values start to fall over time then the testing frequency should be adjusted accordingly and the cable should be monitored to reduce the likelihood of any failure causing an unsafe condition.

6.3 Maintenance Records

It is recommended that every test or replacement is recorded in a logbook, record card or database. Generally the following items are recorded:

- Identity of the asset.
- The date of installation of the asset.
- The type of cable
- The date of manufacture (if known).
- The number and location of joints present.
- Date of the test.
- Who undertook the test (Competence management)
- The instrumentation used to carry out the test (in case of instrumentation failure giving incorrect results).
- Condition of the equipment.
- Any repairs undertaken
- Any modifications or alterations made

6.3.1 Development of Maintenance Plan

The use of the detailed maintenance records will enable the development of a maintenance plan, which will make the best use of the available staff or volunteers.

6.4 Failure Modes

Obviously all failures associated with cables cannot be document here, but a number of the common failure modes are listed below as a guide. This list is not intended to be exhaustive.

6.4.1 Insulation material failures

It has been found that signalling cable can fail with either wet or dry insulation degradation. Normally the only course of action is to replace the cable throughout. However if it can be proved that it is only the tail of the cable where it enters the cupboard / termination point that has failed, this alone can be renewed. It is recommended that the cable should then be tested more frequently until it is proven that it is not causing any problems.

A wet insulation failure is where the insulation around a cable core becomes tacky or liquefied. This can be accelerated by the over use of terminal protection products that can come into contact with the insulation material. Normally this only occurs where solid conductors are used and it will over time cause a core to core failure.

Dry cable degradation will show itself with brittle insulation that cracks or breaks to the touch

6.4.2 Insulation resistance failures

If the insulation resistance to earth deteriorates on the higher numbered cores of a multicore cable, this is normally an indication that the outer insulation and sheath has failed, and it could also lead to a core to core cable failure. The cable should be investigated to try to locate the damage. There are meters on the market such as Wheatstone bridge style measuring instruments that can be used to locate the cable failure.

If the cable has poor insulation resistance core to core it can indicate that the cable has got damp in a joint, or that the insulation material is breaking down.

6.4.3 Continuity resistance failures

These are normally located at a joint or where the cable is terminated. Occasionally it will occur if the cable is spiked or has suffered other physical damage. These failures can have secondary indicators such as low insulation resistance to earth. Failure of a joint or within a moisture barrier will not normally result in a low insulation resistance to earth.

It has been found in the past that when a cable outer sheath is stripped back it is possible to nick through the core insulation and for this not to be seen. Over time the effects of moisture can cause the cable to deteriorate and corrode the conductor to the point where it will fail with high resistance or open circuit.

6.4.4 Sheath Damage

Rodent or physical damage in unfilled telecommunications cables will result in eventual water penetration down the length of cable and into any joints which will lead to low insulation faults, PJ filled cable prevents water penetration but corrosion at the point of damage can still cause low insulation or earth faults due to the presence of standing dc on PABX and CB circuits.

7 REFERENCES

Railway Signalling & Communications, The St Margret's Press, London for pole route construction

British Transport Commission Code of Practice for Pole Line Construction for Signalling and Telecommunications Circuits

RSSB Railway Group Standards see www.rgsonline.co.uk

RSPGs and RSPs Issued by the Office of Rail Regulation see www.rail-reg.gov.uk

- Railway safety principles and guidance Part 1 (1996) (HSE 1996)
- Railway Safety Publication 4; Safety critical tasks - Clarification of ROGS regulations requirements
- Railway Safety Publication 5; Guidance on minor railways

Department for Transport

Railways and Other Guided Transport Systems (Safety) Regulations 2006; Statutory Instrument No 2006/599.

8 APPENDICES

1 Typical Values for loop resistance cables.

2 Telecommunication core Colour codes

3 Schedule of Common Cable Types.

APPENDIX 1 – TYPICAL VALUES FOR CABLE LOOP RESISTANCE

Signalling Cables

Size Strand/size	Nominal cross section area	Resistance (Ω/KM)	Size Strand/size	Nominal cross section area	Resistance (Ω/KM)
1/0.85mm	0.6mm	33.2	9/0.12”	0.001”	25.6
9/0.30mm	0.65mm	31.7	1/0.036”	0.001”	24.97
-	0.75mm	24.8	1/0.044”	0.0015”	16.71
1/1.13mm	1.0mm	18.2	16/0.012”	0.0018”	14.45
16/0.30mm	1.15mm	17.8	3/0.029”	0.002”	13.08
-	1.5mm	12.2	1/0.064”	0.003”	7.90
1/1.53mm	1.85mm	9.96	3/0.036”	0.003”	8.41
50/0.25mm	2.45mm	8.21	7/0.029”	0.0045”	5.59
7/0.67mm	2.5mm	7.56	7/0.036	0.007”	3.59
1/1.78mm	2.5mm	7.56	7/0.044	0.01”	2.41
7/0.85mm	4.0mm	4.70	7/0.052”	0.0145”	1.72
7/1.04mm	6.0mm	3.11	7/0.064”	0.0225”	1.14
7/1.35mm	10.0mm	1.84	19/0.044”	0.03”	0.89
7/1.70mm	16.0mm	1.16	19/0.052”	0.04”	0.64
7/2.14mm	25.0mm	0.73	19/0.064”	0.06”	0.42
19/1.53mm	35.0mm	0.53	19/0.083”	0.1”	0.25
19/2.14mm	70.0mm	0.27	37/0.072”	0.15	0.17
19/2.52mm	95.0mm	0.20	37/0.083”	0.2”	0.13
37/2.03mm	120.0mm	0.15	37/0.103	0.3”	0.08
37/2.25mm	150.0mm	0.13			

Telecoms Cables

Size	Nominal cross section area	Resistance (Ω/KM)
1	0.63mm	58
1	0.9mm	27.5
1	1.27mm	13.75

Aluminum Power Cables

Size	Nominal cross section area	Resistance (Ω/KM)
1	16	1.89
1	25	1.20
1	35	0.87
1	50	0.65
1	70	0.44
1	95	0.33

APPENDIX 2 – TELECOMMUNICATION CABLE COLOUR CODE

The colour codes for most telecommunications cables are now to BS/EN standards, but in the UK they tend to follow BT specifications for insulation colours. The cable pairs are identified with a uniform sequence of colours generally following the format:

BLUE-ORANGE-GREEN-BROWN-GREY-RED-BLACK-YELLOW-VIOLET-PINK.

The way in which these colours are used varies with the type and size of the cable, so the specification, manufacturers or stockholders information should be consulted before starting work. There is a convention that base or solid colours are described in upper case characters whilst printed rings or secondary colours are in lower case. Larger cables use identical groups of pairs or UNITS with 10 or 20 pairs wrapped with a polyester binder tape, itself to a particular colour code to determine the order of termination.

CW 1128 Cable – External PE insulated and sheathed Unit Twin cable. This cable type uses solid colour insulation. Thus:

Pair No	a-wire	b-wire	Unit No	Binder colour	Pair No	a-wire	b-wire	Unit No	Binder colour
1	White	Blue	1	Blue	6	Red	Blue	6	White
2	White	Orange	2	Orange	7	Red	Orange	7	Red
3	White	Green	3	Green	8	Red	Green	8	Black
4	White	Brown	4	Brown	9	Red	Brown	9	Yellow
5	White	Grey	5	Grey	10	Red	Grey	10	Violet

Note that many cables have a quad formation for the first two pairs which form the centre core for the cable construction. Although most new work will use pair cables as these are readily available from stockholders, many existing cables are of quad construction. This practice has its roots arising from the early air spaced paper cables used for trunk inter exchange and were extensively used by previous railway administrations. Two pair trackside cable is often formed of a single quad thus the colour code is of pairs 1 and 2.

Colour Scheme for BR 884 Cable – Star Quad PE insulated and Sheathed

Position of Quad in core or layer	Insulation Colour				Layer Whipping Colours	
	A	B	C	D	Centre/Even	Odd
1st (Marker)	Orange	White	Green	Black	White / Orange	Black / Orange
2nd, 4th, etc	Red	Grey	Blue	Brown	White	Black
3rd, 5th, etc	Orange	White	Green	Black	White	Black
Last (Reference)	Red	Grey	Blue	Brown	White / Orange	Black / Orange

The quads are laid up layer over layer so to count pairs it is necessary to fan out the quads and identify the first and last pair in each layer, ensuring the remaining quads stay in place. A few carefully placed ties will keep each layer intact for fanning.

Internal PVC cables to CW 1308 use a two colour system having a solid base colour with a second ring or spiral printed on. Base colours shown in upper case whilst the second colour is shown in lower-case.

Pair No	a-wire	b-wire	Pair No	a-wire	b-wire
1	WHITE/blue	BLUE/white	6	RED/blue	BLUE/red
2	WHITE/orange	ORANGE/white	7	RED/orange	ORANGE/red
3	WHITE/green	GREEN/white	8	RED/green	GREEN/red
4	WHITE/brown	BROWN/white	9	RED/brown	BROWN/red
5	WHITE/grey	GREY/white	10	RED/grey	GREY/red

Larger cables use the unit system with coloured marker tapes

Switchboard cables to CW 1293 uses a solid colour code which caters for layer construction up to 120 pairs of colour combinations. Larger cable sizes use the unit principle for making cables up to 320 pairs. When there is a third wire included with each pair to form a triple, this wire is coloured turquoise in all cases.

APPENDIX 3 - SCHEDULE OF COMMON TELECOMMUNICATIONS CABLE TYPES

Cable designation	Sizes	Insulation Material	Sheath		Description	Application
	Pairs		Material	Colour		
CW 1044	single	PVC	N/A	Cream	Functional Earth	PBX Earth
CW 1109	1	PVC	N/A	Blue/Yellow etc	Jumper Wire	Cross connection with IDC blocks
CW 1128	2; 3; 5; 10; 20; 30; 50; 100	PE	PE	Black	PJ filled Twin Cable	External distribution trackside etc
CW 1179		PE	PE	Black	Moisture barrier/ screen	Add to standard cable core code
CW 1198		PE	PE	Black	Steel Wire Armour	Add to standard cable core code
CW 1236		Foamed PE	PE	Black	PJ & Screen	Trunk & quality circuits
CW 1252		Foamed PE	PE	Black	Steel Wire Self support	Add to standard cable core
CW 1293	Up to 320	PVC	PVC	Cream & other colours	Switchboard Cable in pairs & triples	Equipment wiring
CW 1308	2, 3, 4, 6, 10, 12, 20 ,25, 30, 40, 50, 80, 100, 120, 150, 160, 320	PVC	PVC	White/ Cream	Internal	Internal building distribution
CW 1308		LSHF	LSHF		Internal	Closed spaces
CW 1308B		PVC	PVC	Black	External	External inter building wiring
CW 1317	1	Cross linked PVC	PVC	Blue/Yellow etc	Jumper wire	For use in external cabinets
CW 1326		Foamed PE	PE	Black	Lower crosstalk	
CW 1378	2	PVC	PE	Black	Drop Wire 10	Aerial drops and routes
CW 1406	1	PE	PE	Black	Drop Wire 12	Aerial drops and routes
CW 1411	2	PE	PE	Black	Drop Wire 10B	Aerial drops and routes
CW 1417	4	PE	PE	Black	Drop Wire 14	Aerial drops and routes
CW 1423	1, 2, 3, 4 & 5	Cross linked PVC	PE	Blue/yellow etc	Jumper Wire	Cross connection on MDFs etc
CW 1600	As CW1308	LSZH	LSZH	Cream & other colours	Similar to CW1308 but with screen and drain wire	Low smoke and fumes if burning