

Installation of Equipment Racks and Termination of Cables and Wiring

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1.0	29 June 2023	First issue as TS 05166. Version renumbered to 1.0 in line with new designation.

Preface

This document is a first revision as TS 05166 and supersedes SPG 0707 *Installation of Equipment Racks and Termination of Cables and Wiring*, version 1.5.

This standard sets out requirements for the installation of equipment racks and termination of cables and wiring for signalling and control systems.

Changes from previous version include the following:

- inclusion of the CRA
- addition of ETCS equipment
- updates to referencing to other documents and drawings.

For projects in the MRA this document should be read in conjunction with TS 05164.

For projects in the CRA this document should be read in conjunction with TS 01263.

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1 Scope

This standard sets out the requirements for the installation of equipment racks, equipment cubicles and termination of cables and wiring for signalling and control systems.

This document complements TS 05165 and specifies the requirements for the installation of signal equipment in buildings and installation of equipment racks and cubicles.

Reliable connections and terminations are important to long term reliability of signalling and control system installations. This standard details the type of signalling fuses, terminal blocks and signalling cable terminations required.

Other sections of the standard detail how the wiring to trackside equipment, power supplies and temporary wiring and ETCS equipment is to be installed.

To aid ongoing maintenance of the installed signalling and control systems equipment there are requirements for appropriate labelling for the rail environment.

2 Application

This document applies to TfNSW signalling and control system heavy rail assets in the MRA and CRA.

This standard is intended for use by designers, equipment suppliers, installers, maintainers and TAOs.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards

EN 61140 *Protection against electric shock – Common aspects for installations and equipment*

Australian standards

AS 2700 *Colour standards for general purposes*

AS/NZS 2373 *Electric cables – Twisted pair for control and protection circuits*

AS/NZS 3000 *Electrical installations “Wiring Rules”*

AS 4506 *Metal finishing – Thermoset powder coatings*

Transport for NSW standards

TS 00026 (T MU EN 00005 ST) *Ambient Environmental Conditions*

TS 05164 (SPG 0705) *Construction of Cable Routes and Signalling Civil Works*

TS 05165 (SPG 0706) *Installation of Trackside Equipment*

TS 05167 (SPG 0708) *Small Buildings and Location Cases*

TS 05258 (T HR SC 01000 SP) *Common Signals and Control Systems Equipment Requirements*

TS 05268 (SPG 1010) *Cables for Railway Signalling Applications – General Requirements*

TS 05269 (SPG 1011) *Cables for Railway Signalling Applications – Multi Core Signalling Cables*

TS 05270 (SPG 1012) *Cables for Railway Signalling Applications – Single and Twin Conductor Cables*

TS 05271 (SPG 1014) *Cables for Railway Signalling Applications – Traction Return Bonding and Track Connection Cables*

TS 05272 (SPG 1015) *Cables for Railway Signalling Applications – High Frequency Screened Track Circuit Cables*

TS 05273 (SPG 1016) *Cables for Railway Signalling Applications – Fire Safe High Frequency Screened Track Circuit Cables*

TS 05274 (SPG 1017) *Cables for Railway Signalling Applications – Fire Safe Multi-conductor Cables*

TS 05275 (SPG 1018) *Cables for Railway Signalling Applications – Fire Safe Single and Twin Conductor Power Cables*

TS 05276 (SPG 1019) *Cables for Railway Signalling Applications – Fire Rated Twin Conductor Power Cables for Emergency Services*

TS 05287 (SPG 1062) *Supply and Installation of Cable Jointing Material for the Jointing and Repair of PVC and Power Cable*

TS 05288 (SPG 1066) *Solderless Terminals and Cable Lugs for Signalling Applications*

TS 05300 (SPG 1571) *Specification Light Signals*

TS 06178 (T MU MD 00005 GU) *Type Approval of Products*

UGL Regional Linx standards

Note: UGL Regional Linx standards are available on the UGL Regional Linx website.

TS 01257 (CRN SC 014) *Type Approval Requirements for Signalling Systems and Equipment*

TS 01263 (CRN SC 021) *Cable Routes and Associated Civil Works*

TS 01313 (CRN SE 006) *Connectors for Signalling Interface*

TS 01327 (CRN SE 022) *Solderless Terminals and Cable Lugs for Signalling Applications*

TS 01330 (CRN SE 029) *Supply & Installation of Cable Jointing Material for the Jointing and Repair of PVC & Power Cable*

TS 01331 (CRN SE 033) *Solderless Terminals Screw & Spring Clamp Terminal Blocks*

TS 01333:1.0 (CRN SE 035) *Cables for Railway Signalling Applications*

TS 01334 (CRN SE 036) *Lights – Signals*

Transport for NSW drawings

TS 05204.04 (M05-504) *ETCS Trackside Junction Box Assembly Details*

TS 05204.05 (M05-505) *ETCS Trackside Junction Box Post Wall Mount Fabrication Details*

TS 05204.06 (M05-506) *ETCS Trackside Junction Box Post In-ground Fabrication Details*

TS 05204.10 (M05-510) *ETCS Trackside Above Ground Junction Box Installation Diagram*

TS 05204.11 (M05-511) *ETCS Trackside Junction Box Cable Termination Details*

TS 05204.16 (M05-516) *Alstom LEU Vital Plug Coupler Assembly Diagram*

TS 05204.20 (M05-520) *Alstom ATP Power Cable 24V DC Assembly Diagram*

TS 05204.21 (M05-521) *ATP Alstom LEU Retrofit to Existing Full Height Cabinet – General Layout*

TS 05204.22 (M05-522) *LEU Power Supply Cable 120V AC – Assembly Diagram*

TS 05204.23 (M05-523) *ATP LEU Location Label – Manufacturing Detail*

TS 05204.28 (M05-528) *Alstom ATP LEU Annexe Cabinet Mounting Plate – General Layout*

TS 05204.29 (M05-529) *Alstom ATP LEU Full Height Cabinet – General Layout*

TS 05204.30 (M05-530) *Alstom ATP LEU Components List – General Layout Wall Mount*

TS 05204.31 (M05-531) *ATP Terminals and Resistor Components & Assembly*

TS 05204.32 (M05-532) *Alstom LEU Cabinets Main Earthing Arrangements*

TS 05204.33 (M05-533) *Alstom LEU Ethernet Cable – Type K Assembly Diagram*

TS 05204.36 (M05-536) *ATP LEU Double Skin Annexe Cabinet – Installation Arrangement*

TS 05204.38 (M05-538) *ATP Alstom LEU Annexe Cabinet Type C – Tail Cable Termination Details*

TS 05204.42 (M05-542) *Alstom Balise Cable at LEU 90° – Type A & B Assembly Diagram*

TS 05204.43 (M05-543) *Alstom LEU 90° Ethernet Cable – Type J Assembly Diagram*

TS 05204.49 (M05-549) *ATP – LEU ID Plate Manufacturing Detail*

TS 05204.52 (M05-552) *Alstom Balise Plug Coupler – Type D Assembly Diagram*

TS 05204.57 (M05-557) *ATP Alstom LEU Full Height Cabinet Type C – Tail Cable Termination Details*

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document.

COTS commercial off the shelf

CRA country rail area; that part of the NSW rail network not within the metropolitan rail area
(Source *Transport Administration Act 1988*)

DIN Deutsche Institut für Normung; German acronym with translated to German Institute of Standards

DIN rail Deutsche Institut für Normung; English translation German Institute of Standards.

There are two major types of DIN rail in use by the MRA and CRA, top hat section and G section. The top hat section DIN rail has two different sizes of top hat section, 35 x 7.5mm or 35 x 15mm

EOL emergency operation lock

ESML emergency switch machine lock

ETCS European train control system

ID identification

LEU lineside equipment unit (part of ETCS equipment)

MRA metropolitan rail area; the rail freight network and the rail passenger network within the metropolitan rail area bounded by Newcastle (in the north), Richmond (in the northwest), Bowenfels (in the west), Macarthur (in the southwest) and Bomaderry (in the south), and all connection lines and sidings within these areas, but excluding private sidings.

non-vital signalling equipment and circuits are considered non vital (not a safety application) where failure to function correctly would not cause an unsafe outcome of the signalling system. Non-vital equipment and circuits do not affect the safe operation of the signalling system.

PVC polyvinyl chloride

Q relay is a signal relay based upon British Rail 930 series specifications for a rail signal relay. Q relays have been used by MRA and CRN for many years and are available from multiple suppliers with different contact arrangements and functions.

TAO Technically Assured

type approval Transport for NSW process used by RIMs in the MRA and CRA where rail signalling products are assessed for application on the rail network. The TfNSW process for type approval is detailed in TS 06178. The CRN process for type approval is TS 01257.

vital signalling equipment and circuits are considered vital (a safety application) where failure to function correctly could cause an unsafe outcome either directly or together with another signalling equipment or circuit failure. Vital signalling equipment is equipment whose safe

operation is fundamental to the safe operation of the signalling system. Equipment for use in this mode should have been designed to ensure that it will not fail in an unsafe manner. This may well involve designing it in such a way that should it fail it will fail in a predetermined state which does not lead to an unsafe situation.

5 Quality

Quality of materials and workmanship should minimise the necessity for regular preventative maintenance tasks to retain the performance, reliability and safety of the equipment racks and terminated cables and wiring over its minimum 40 year lifetime in the installed rail network.

6 Environmental conditions

Signalling equipment, equipment racks, cable terminations, wiring and conduits are exposed to the ambient environmental conditions described in TS 00026.

Strong winds up to 160 km/h are experienced in the railway network, including tunnels and cuttings.

In addition to the environmental conditions described in TS 00026 railway specific signalling equipment is subject to pollution in tunnel environments, vibration and UV exposure.

All signalling equipment racks, cable terminations, wiring and conduits shall be installed in accordance with the environmental conditions requirements of TS 05258.

Trackside equipment installed in the danger zone of the rail corridor where there is an overhead traction system (mainly in the MRA) shall comply with requirements for class II electrical equipment as described in EN 61140. This is part of the risk control measures for electrical traction faults. Class II equipment is double insulated and does not require earthing for electrical safety.

7 Finishing of metal surfaces

The steel metalwork used for relay racks, equipment racks, housings, cabinets, plinths and bases shall be finished in B44 light grey blue as defined in AS 2700. The finish shall be chip and scratch resistant. All steel metalwork shall be finished in powder coating in accordance with AS 4506 with an atmospheric classification category of category B as defined in AS 4506 which requires a 40 um coating thickness. Powder coated products shall be supplied with test certificates showing the coating thickness, cure test and adhesion test. When ordering powder coated products the purchasing information requirements in appendix A of AS 4506 should be used.

Bolts, nuts and other fastenings shall be have corrosion protection, for example, zinc plating or made of stainless steel. Steel cable trays shall be provided with a finish which will provide equivalent life.

Metal cable trays and ducts shall have no sharp edges or corners.

Bolts and nuts shall be stainless steel where part of a bolt or nut is external to a location case and exposed to outside weathering.

No other surface treatment is necessary where steel metalwork is galvanised or provided with equivalent metallic protection.

No additional surface protection is required for aluminium and stainless steel.

8 Alterations within existing equipment locations

When installing new signalling equipment such as signal interlockings, axle counters, ETCS equipment and communications equipment, it is preferable to use a new equipment location or equipment cupboard to ensure performance, reliability, life cycle costs and full standards compliance are achieved.

If new signalling equipment is to be installed in an existing equipment refer to TS 05165.

9 Installation of internal equipment

Equipment racks, equipment cubicles, switchboards, cable and wiring terminations and other equipment shall be located to make most effective use of the available floor space and to provide unobstructed maintenance access.

The minimum clearance between equipment racks, equipment cubicles, cupboards, wall mount panels and other obstructions and so on with all equipment mounted shall be as follows:

- 800 mm between one end of a rack or cubicle and any other fixed object (one end may be against a wall or other rack if there is no need for access at that end)
- 900 mm at the rear of any rack or cubicle which requires rear access
- 900 mm at the side of any rack or cubicle which requires side access
- 900 mm at the front of any rack or cubicle
- 1200 mm between racks or cubicles which require front and rear access to allow sufficient maintenance access so that the rear of one rack or cubicle and the rear or front of the next rack or cubicle in front can be accessed simultaneously.
- 750 mm in front of any roll or slide out drawer or tray when extended.

Equipment projecting into walk spaces shall be free of sharp edges and protrusions.

Ventilation slots or ventilation panels on equipment racks, cubicles or cupboards shall not be blocked or obstructed.

The lowest point of any cable trays which passes over access ways or corridors between racks or other equipment shall be no less than 2100 mm above floor level.

All equipment shall be mounted, fastened and braced, if necessary, to ensure that there is no possibility of collapse or distortion under any normal operating condition including the possibility of staff bumping into or falling against the equipment.

9.1 Equipment racks and switchboards

Equipment racks, cubicles and switchboards shall not exceed 2000 mm in height.

Switchboards shall have 1000 mm clearance from all faces that need to be accessed in accordance with AS/NZS 3000.

9.2 Equipment mounting

In external locations and open equipment racks, or in areas where water could possibly enter the equipment room or location, to ensure physical protection from maintenance staff bumping or accidentally kicking equipment or excess water flooding the location floor all equipment shall be mounted higher than 300 mm above floor level. In office and control centre equipment locations or within cubicles where water entry is highly unlikely and the equipment has appropriate covers (is not an open equipment rack) then equipment may be mounted within 100 mm above floor level .

Equipment shall not be mounted higher than 1800 mm from the base of the equipment case to the floor level.

Any sensitive equipment likely to be affected by vibration shall be housed on racks or in cubicles mounted on vibration isolating footings.

Heat producing equipment shall be arranged so that rising heat will not affect the operation of, or cause damage to, any equipment mounted above or adjacent to it.

Enclosed racks or equipment cubicles shall be provided with access panels wherever necessary to provide maintenance direct access to the equipment mounted therein and the cables or wiring terminated to that equipment.

All items of equipment shall be easily accessible for inspection and easily removable for maintenance or replacement without the need to disconnect or remove other items or units of equipment on the rack or in the cubicle.

Where duplicate units of equipment are provided, for example, dual power supplies, each unit of the duplicated equipment shall be packaged and mounted separately so that a defective unit can be removed and replaced without affecting the operation of the serviceable unit.

Wiring shall be arranged so that when a defective unit is being repaired or replaced it is not necessary to disconnect or disturb the wiring to other equipment on the rack or in the cubicle.

Vital signalling equipment shall not be intermingled with non-vital signalling equipment.

However, both vital and non-vital signalling equipment may be fitted to the one rack or within the

one cubicle provided the vital signalling equipment is clearly separated from the non-vital signalling equipment.

10 Termination

Soldering is not a preferred means of terminating signalling conductors, vital or non-vital, except on the coil connections of large plug-in relays (for example Westinghouse VT1, BL1B, BT1B).

10.1 Fuse holders and terminal blocks

In the MRA, fuse holders and terminal blocks used within buildings and location cases shall comply with TS 05258.

In the CRA, fuse holders and terminal blocks used within buildings and location cases shall comply with TS 01331.

RIMs managing the MRA and CRA both have signalling type approval registers which list fuse holders and terminal blocks used for vital signalling connections (used to control any functional safety related failure modes) which have been type approved. Contact the AMB for details of type approved products.

TS 05258 contains a COTS equipment framework which details how TAOs in the MRA can be delegated type approval assessment.

10.2 Plug connectors

Plug connectors in the MRA shall comply with TS 05258.

Plug connectors in the CRA shall comply with TS 01313.

Where plug connectors are used for equipment located outside of buildings or where vibration could affect reliability, they shall have a means of locking the plug and socket securely together.

Where it is possible to accidentally plug a cable into another piece of equipment and make a wrong electrical connection an engineered solution shall be used to prevent accidentally placing the incorrect plug into a socket. Possible solutions could include one or more of the following:

- mechanical keying of plugs and sockets
- selecting different wire connection pins within a plug
- equipment layout design ensuring that the plug on the end of a cable cannot reach a wrong socket.

10.3 Spacing of terminals

10.3.1 DIN rail mounted fuses, terminals and equipment

The surface tracking distance between the metal parts of adjacent terminal blocks shall be at least 6.5 mm.

Vertical DIN rails (top hat section or G rail section) used for mounting fuses, terminals, signalling equipment shall be spaced to ensure adequate clearance to install equipment and connect wiring without encroaching upon adjacent equipment.

Spacing between DIN rails should be of sufficient spacing to allow access to the mounted equipment and terminals mounted on the DIN rail. DIN rail spacing shall ensure adequate space to install and replace equipment and re-connect wiring. The signalling design will detail these requirements.

Vertical DIN rails shall be sufficiently rigid to carry the mounted equipment loads without deforming due to flexing of the DIN rail.

Vertical DIN rails longer than 1000 mm shall be 35 mm x 15 mm top hat section or G section to provide sufficient support and rigidity for the mounted fuses, terminals and equipment.

10.3.2 Stud type terminals

Stud type terminals shall have studs spaced at no less than 20 mm centres unless an insulating barrier at least one third the height of the terminal stud is provided between adjacent pairs of terminals, in which case the spacing may be reduced to 16 mm.

Stud type terminals shall be of a type in which the stud is captive in the current bar (or base where a separate link is used) or there is a captive nut into which the stud or bolt is screwed. Terminals in which a thread is tapped into the current bar for a free bolt shall not be used, unless the current bar thickness is at least 60% of the stud diameter.

Pre-insulated crimp lugs used on stud type terminals shall be arranged so they cannot touch or rest on other exposed terminals or on other lugs even if they become loose or bent. Separate lock nuts shall be fitted to stud terminals except where self-locking nuts, such as Nyloc nuts, are used.

10.4 Crimp lugs and ferrules

Crimp lugs, crimp pins and bootlace ferrules shall comply with TS 05288 in installations in the MRA and TS 01327 for installations in the CRA.

Application of lugs, pins and ferrules shall be in accordance with TS 05288 in the MRA and TS 01327 in the CRA using the correct manufacturer recommended manual ratchet or hydraulic crimp tools.

Wires with a single strand 1.5 mm diameter or more or multistrands (minimum 7 strands) each of 0.85 mm diameter or more may be terminated directly into screw clamp or spring clamp terminal blocks or fuse holders, without crimp lugs or ferrules.

10.5 Fuse holders

Fuse holders and associated components, which are type approved for use are in the signals type approval registers in the MRA and CRA.

10.6 Terminal blocks

Incoming and outgoing vital cables in equipment relay rooms and equipment location cases shall be terminated on type approved test/disconnect terminal blocks. Refer to signals type approval registers in the MRA and CRA.

Cables and wires to neutral busbars shall be terminated on type approved test or disconnect terminal blocks.

Terminal blocks for inter rack wiring shall be type approved feed through blocks of appropriate size for the cable to be terminated.

Q relay base terminations shall be compatible with the Q relay base.

Up to two wires may be terminated in a screw clamp type terminal block provided that flat blade type crimp lugs are used. Only one wire shall be terminated in a spring clamp terminal unless the terminal is specifically manufactured to accept more than one wire.

Two wires may be terminated in a double bootlace ferrule or a double crimp lug designed for two wires.

10.7 Plug coupling

Components or sub-assemblies of electrical signalling equipment, which can be removed for repair or maintenance purposes without removing the item of equipment, shall be fitted with plug couplers.

10.8 Cable crimps and crimp tool details

Crimping tools with defective ratchets shall not be used.

Crimping tools shall have a guard which controls the location and orientation of the crimp lug. Only when crimping in-line sleeves may the guard be removed.

Once each week, or after each 40 hours of work, the following procedure shall be carried out:

1. Check the operation of the crimping tool.
2. Record the crimping tool serial number.

3. Make three sample crimps.
4. Check visually for any unusual deformations and such and test pull each sample crimp with a spring balance, to a force of 9kg. If there is any movement between wire and crimp lug, the tool is defective.
5. Label each sample with crimp tool number, date, name of supervisor approving and forward to signal commissioning engineer for the project.

Test samples of Q relay base crimp terminals shall be made with the following:

- the wire in the left-hand side of the crimp only
- the wire in the right-hand side of the crimp only
- the wire in both the left and right hand sides of the crimp.

Any crimping tool found to be defective shall be withheld for rectification. In the event that a defective tool is found, then all work carried out by that tool between time of discovery and its last pass check shall be visually inspected and, where SFAIRP random pull tested, and the work rectified as necessary.

Multi-head crimp tools shall not be used. Crimp tools shall only be used on the specific lugs and pins for which they have been designed.

Crimp lugs, crimp pins and bootlace ferrules and their applications for use in the MRA are listed in TS 05288.

Crimp lugs, crimp pins and bootlace ferrules and their applications for use in the CRA are listed in TS 01327.

10.9 Heat shrink sleeves

Plastic heat-shrinking sleeves shall be colour coded with red for feed cables (for example, BX120, B50 designations from the circuit) and black for return cables (for example, NX120, N50 designations from the circuit). White sleeves shall be used for circuits or cables which may be subject to change of polarity or have no defined polarity.

11 Termination and wiring of equipment

11.1 Termination of signalling cables in signalling enclosures

All signalling cables shall be terminated in accordance with the requirements of the applicable signalling design and signalling circuit diagrams.

No less than 100 mm slack shall be left on the ends of all cable cores to provide for two re-terminations in the event of wires breaking at the point of connection.

The copper sheath around cables shall be clamped with an adjustable ring clip at the base of the cable termination rack. The sheath of each cable shall be isolated from other cables. The sheath shall be connected separately to a lightning arrestor using a minimum conductor size of 7 x 0.85 mm (4 mm sq) green/yellow earth wire.

The incoming and outgoing cables shall be securely clamped in position at the base of the termination rack to prevent loading on individual cores where terminated.

All spare conductors shall be terminated in core number sequence. All cable penetrations to enclosures shall be sealed.

11.2 Wiring and cabling of trackside equipment

All trackside equipment shall be wired in accordance with the signal design, signal circuit diagrams, standard installation diagrams and the track circuit bonding plans, as applicable.

All vital signalling cables in the MRA shall be in accordance with the following:

- TS 05268
- TS 05269
- TS 05270
- TS 05258
- TS 05271
- TS 05272
- TS 05273
- TS 05274
- TS 05275
- TS 05276

All vital signalling cables in the CRA shall be in accordance with TS 01333.

All cables and wires shall be installed so that they are fixed clear of all moving parts or surfaces which may cause mechanical damage to the cables or wires.

All cores of multicore cables including spares shall be terminated. Where no spare terminals are available, spare cores shall be capped with crimped insulated end caps.

Sheath connections, where applicable, shall be made utilising a hose clamp with the sheath area re-insulated using heat shrink tubing or self-vulcanising tape

Connection of cables to the rail shall be via welded studs or direct web welding.

11.2.1 Signals – post and gantry mounted

The multi-core cable to the signal shall be terminated on the terminals in the base of the signal post or a gantry junction box or boxes, as applicable.

A multi-core cable with the same conductor size, conductor insulation and sheath as required by TS 05269 in the MRA and TS 01333 in the CRA but without metallic screen or outer sheath, shall be installed between the terminals in the signal base or gantry junction box and those in the signal head.

Flexible conduit with conduit terminators shall be provided to carry wiring between the signal post and any external equipment (subsidiary lamp cases, half pilot staff boxes and so on) which is mounted on the signal post.

Terminals in both the signal base and signal lamp cases, including subsidiary lamp cases, shall be numbered in accordance with TS 05300 in the MRA and TS 01334 in the CRA.

Multi-core cables in accordance with TS 05269 in the MRA and TS 01333 in the CRA shall be used for circuits which emanate from the terminals in the base of the signal post or gantry junction box and connect to equipment which is not attached to the signal post or gantry.

11.2.2 Trainstops

Train stops are only used in the MRA and shall be installed in accordance with TS 05165.

Train stops are normally located at signal positions and may be fed from the multi-core cables terminated in the base of the signal post or gantry junction box. Where this applies a further multicore cable shall be installed between the signal post terminations or gantry junction box and the train stop terminals.

Where a train stop is installed separately from a signal, the cables to the train stop shall be run from the location case indicated on the circuit diagrams.

11.2.3 Point machines

Cable sizes and wiring of points machines shall be in accordance with the signalling design circuit diagrams.

11.2.4 Electro-pneumatic points mechanisms

Electro-pneumatic points mechanisms are only used in the MRA.

Where there is no adjacent location case, a cable termination box shall be provided adjacent to electro-pneumatic points. This will be specified in the signal design.

11.2.5 Releasing switches and ground frame operated points

The signalling multi-core cable to the releasing switch shall be terminated on terminals in the base of the releasing switch mounting post.

Multi-core cables from the terminals in the base of the releasing switch to any associated points detector shall be in accordance with TS 05269 in the MRA and TS 01333 in the CRA. The multi-core cables shall be installed in heavy duty, orange flexible PVC conduit laid on the ballast. If the length of the cable exceeds four metres it shall be buried in accordance with TS 05164 in the MRA and TS 01263 in the CRA.

A multi-core cable with the same conductor size, conductor insulation and sheath in accordance with TS 05269 in the MRA or TS 01333 in the CRA but without metallic screen or outer sheath, shall be installed between the terminals in the post base and those in the releasing switch.

11.2.6 Guards indicators

Cables or wiring to guards indicators shall be protected by rigid or flexible conduit where the cable is not within the post on which the indicator is mounted. The cable or wire shall be in accordance with TS 05269 and TS 05270 in the MRA and TS 01333 in the CRA.

The type of conduit used and the selected location shall be designed to be unobtrusive where it is necessary to fix the conduit to a station building.

Exposed conduits or cable ducts that are accessible to the public shall be made of steel to minimise damage and vandalism. The conduits and cable ducts shall be made as unobtrusive as possible and painted to blend with the supporting station structure and environment.

11.2.7 Emergency switch machine locks and emergency operation locks)

Wiring to the ESML or EOL shall be treated as being internal to the relay room where ESMLs or EOLs are mounted on relay room walls., Wiring shall be in accordance with TS 05269 in the MRA and TS 01333 in the CRA where mounted on separate posts located in the vicinity of the points.

11.2.8 Telephones

Flexible conduit with conduit terminators shall be provided to carry telephone cables between signal posts (or similar) and telephones.

Telephone cables to telephones shall be run within the mounting post and terminated directly on the telephone where mounted in separate posts.

11.2.9 ETCS balise cable at lineside equipment unit

Refer to M05-542 for balise cable at LEU assembly details.

11.2.10 Balise cable to balise

Refer to M05-510, M05-511, M05-538 and M05-557 for cable termination details.

11.2.11 Balise tail cable

The balise tail cable shall be laid between the ETCS trackside junction box and the balise.

Refer to TS 05165 for balise tail cable mounting requirements.

To minimise the risk of electric shock between the earth connection and a traction rail where the balise tail cable is pluggable at a controlled balise the following requirements apply:

- the tail cable plug shall be fully insulated
- when the cable has been unplugged, any exposed pins or sockets of a disconnected plug shall be shrouded
- where the plug can be dismantled, any direct earthed conductive portions shall be insulated.

Refer to M05-552 for balise tail cable assembly details.

Where practicable, the installation arrangement for the balise tail cable should be designed to minimise damage to the ETCS trackside junction box should the tail cable be caught up in track machinery or a rail vehicle.

Refer to M05-504, M05-505 and M05-506 for fabrication details. Refer to M05-510 for general installation details.

11.3 ETCS lineside equipment unit equipment

Where practicable, LEU and associated equipment shall be as follows:

- mounted inside existing signalling enclosures
- installed in an enclosure designed for signalling equipment in accordance with TS 05167
- mounted at the interlocking/control relay output location
- placed outside the danger zone.

Retrofit of LEU equipment into an existing standard size signalling cabinet shall be in accordance with M05-521.

Installation of LEU equipment into an annexe cabinet shall comply with M05-528.

Installation of LEU equipment into a standard size signalling cabinet shall comply with M05-529.

Installation of LEU equipment on wall mounted ETCS panels or plates shall comply with M05-530.

12 Wiring of internal equipment

12.1 General

All internal wiring shall be supported in cable tray, trunking or similar.

Protection shall be provided at corners of cable trays and so on. Wiring shall be of sufficient length so as not to be under tension around corners or at terminals. Where wires pass through holes in cable trays or trunking, the holes shall be fitted with grommets or bushes to ensure wire and cable insulation is not damaged.

Wiring to relay bases, terminal blocks and fuse blocks shall be neatly formed and arranged to provide ease of access to individual terminals and to relay bases.

Vital and non-vital wiring shall be kept separate as far as practicable.

12.2 Internal wire for safety applications

Internal wire for signalling safety applications has historically been called vital.

Internal wire with PVC insulation and a nylon jacket with 7 x 0.4 copper conductor is used in the MRA and CRA. Teflon, or similar, insulated wires in accordance with TS 05258 has been used with computer based interlockings.

Equivalent products may be considered for type approval.

Wiring for signalling safety applications shall comply with TS 05258 in the MRA and TS 01333 in the CRA.

All safety application wiring using 7 x 0.4 mm copper conductor shall be terminated using crimp pins, bootlace ferrules or crimp lugs.

12.3 General application cable and wire

Historically general application cable and wire, as specified in TS 05258, has been called 'non-vital wiring'.

In the MRA any general application cable or wire (non-vital) which is within the same cable tray or trunking as safety application (vital) wiring shall use the same type of internal wire for safety applications (7 x 0.4 mm) or cable and wire meeting the requirements of TS 05258.

In the CRA any general application cable or wire (non-vital) which is within the same cable tray or trunking as safety application (vital) wiring shall be either 7 x 0.4 mm wire in accordance with TS 01333 or cable and wire in accordance with TS 05258.

Where single core wires are used on equipment racks, the conductor shall be no less than 0.9 mm in diameter.

Inter-rack general application wiring shall be carried out using multi-pair communication cables with conductor sizes of no less than 0.60 mm in diameter.

Wire used for general application wiring purposes shall be in accordance with TS 05258.

Equipment specific multi pair cable and wire is approved for use with the particular equipment as part of the type approval of the equipment.

General application cable and wiring shall be terminated either on appropriately sized screw clamp, tension clamp or insulation displacement terminals.

12.4 Wiring of power supplies

Power cables shall be in accordance with TS 05270 in the MRA and TS 01333 in the CRA.

Power conductors for internal use inside cubicles, equipment locations shall be in accordance with TS 05258.

12.5 ETCS wiring to LEU

Signalling inputs wired to LEUs are considered safety applications and shall be wired according to safety application requirements in accordance with TS 05258.

Black nylon jacketed PVC internal vital signalling wire, consistent with existing wiring and compliant with TS 05258 shall be used between the interlocking equipment and the LEU assembly interface terminals.

All safety critical wire terminated to DIN style plug connectors shall be of black Teflon (or similar) insulated wire compliant with TS 05258.

LEUs shall be installed so that when removing and replacing a faulty LEU, individual wires interfaced to the signalling interlocking system will not need to be disconnected.

Where practicable, new LEU enclosures shall be installed in close proximity to existing signalling enclosures so that wiring between is protected to the same level as the existing enclosure. This is to minimise the need for double cut LEU input circuits.

Where safety critical wiring for LEU inputs are not double cut and there is a need to run wiring between signalling location enclosures, the wiring shall be as follows:

- where practicable, be run between enclosures at the same height as existing horizontal vital wiring ducting within the location enclosure
- not be routed below ground
- be run between adjacent enclosures in galvanised steel pipe with an inner PVC conduit or similar approved means of robust protection

- be protected from sharp edges at all interfaces such as between cabinets, trunking, conduits and the like.

Sleeving fitted to panel wiring for the purpose of providing additional mechanical protection (for example, solid state interlocking (SSI) red retaining wires) shall be continuous and fitted the length of the wire up to the wire identification ferrule at the termination point.

Refer to M05-532 and M05-538 for earthing details of LEU equipment.

Balise trunk cable surge arrestors and earthing shall be fitted in the vicinity of the LEU location.

Where ETCS equipment is mounted inside a walk-in location, the balise trunk cable surge arrestors and earthing are to be located at the base of the existing racks where practicable.

13 Temporary wiring and stage work

Temporary wiring and stage work wiring shall be terminated using crimp lugs and crimp pins.

Temporary cables and internal wiring shall not be coloured black, red, blue or green.

Wire for stage work wiring shall be yellow. If black is the only wire available it shall be fitted with a coloured sleeve at each end of the cable or wire for a distance of no less than 150 mm.

The conductor cross sectional area in temporary cable shall be at least equivalent to 7 x 0.5 mm but the cable used may in accordance with AS/NZS 2373. Internal wiring shall be of at least equivalent conductor size to 7 x 0.4 mm .

Where the work involves multiple commissioning works, the colour of internal temporary wiring should either be different or carry different coloured sleeves for each commissioning.

Temporary wiring shall be carried out to the same standard of workmanship as the final wiring and shall be kept separate, as far as possible, from final wiring for ease of removal.

All wiring disconnected for stage work or other purposes shall be insulated and secured to prevent its contact with working circuits.

Limited in line crimp joints may be made in temporary or stage work wiring subject to ensuring insulation and isolation requirements are maintained. In line crimps shall be covered with heat shrink sleeves extending over the wiring installation.

14 Jointing of signalling cables

All signalling and power cables shall be jointed with materials in accordance with TS 05287 in the MRA and TS 01330 in the CRA.

14.1 Inspection

Cable joints of signalling cable shall not be covered or backfilled until the joint has been inspected, tested and approved on the insulation test plan by the inspection and testing authorised TAO.

15 Jointing communications cables (for signalling)

The requirements in Section 15 apply only to jointing communications cable used for signalling supervisory control and data acquisition (SCADA), telemetry or maintenance voice communications. It does not apply to communications cables used for voice or data transmission, including optic fibre cables.

All joints shall be enclosed in a re-enterable enclosure. Non re-enterable techniques shall not be used.

When jointing communications cables a purpose designed joint enclosure shall be used.

There shall be no snaking and deformation of the cables in the vicinity of the joints. The joints in the cable shall be in the same axis as the cable run. Joints shall be placed so that they are readily accessible.

The protective jelly coating (if present) around the pairs of conductors in the cable should, not be removed when jointing the cable. If small portions of the jelly coating have to be removed, the installer shall use a soft, dry cloth. De-greaser or similar substance shall not be used.

Before commencing to crimp any jointing devices the joint installer shall test each crimping tool by completing 3 crimps and testing the resulting crimp in the appropriate gauge. Any tool that produces an incorrect crimp shall be taken out of service. Defective crimping tools shall not be used.

Each crimped joint shall be visually inspected by the jointer. Any crimps which are physically damaged, having protruding wires or where wires are missing shall be redone using a new connector.

After the jointing of each unit has been completed, its unit binder tape shall be wrapped and tied around the unit to distinguish it from other units.

The metallic screens of the cables shall be electrically continuous throughout all joints.

Each completed joint shall be tested and the original certified record shall be submitted to the inspection and testing authorised TAO.

16 Labelling

All labelling shall be in English and be produced by machine type setting.

Labels shall be attached in a permanent manner, except those related to temporary work and stage work where paper labels may be used.

High voltage equipment shall be conspicuously labelled in accordance with the relevant Australian standards, and work health and safety legislation and regulations.

Labels for any item of equipment which may need to be removed for repair or replacement shall be attached to its rack or housing so that the label shall remain in place when the item of equipment which it identifies is removed.

Labels, except those for high voltage equipment, shall be white or yellow with black inscriptions.

16.1 Equipment and rack labels

Only Traffolyte (or similar) type engraved labels and laser etched labels shall be used. Dyno brand (or similar) labels shall not be used.

The size of labels and the size of lettering shall permit reading at a minimum distance of 750 mm. (suggested size of lettering should be greater than 8 mm)

16.2 Wires and cables to fuses and terminals

Labels shall be installed on all wires and on individual cores of all cables using bead or sleeve type labels coloured white with black inscriptions. The labels shall indicate the terminals to which the wires or cable cores are to be connected. The labels shall be placed on the wires or cable cores before the crimps are fitted and the wires or cables terminated.

16.3 Fuses, terminals and busbars

Fuse blocks and terminal blocks shall be labelled in numerical sequence.

Numbering shall be from top to bottom or left to right, as applicable, commencing with number one.

Busbars shall be clearly labelled (for example, BX120, NX120, B50, N50 and so on) Each wire shall be labelled to identify the circuit which it feeds.

16.4 Plug-in relays

All relay positions shall be labelled front and back.

Wires to the bases of Q relays shall be labelled with bead type labels which shall indicate the column and wire positions to which the wires are to be connected (for example, A1, A2, B1, B2

and so on where A and B denotes the column and the numbers denote the wire positions in the columns).

The bead type labels on wires to the Q relay bases shall be colour coded for the different column positions as shown in Table 2:

Table 1 – Colour coding

Column	Bead colour	Inscriptive colour
A	Red	White
B	Yellow	Black
C	Green	White
D	Blue	White

The wires to the Q relay coils (R1, R2, R3 and R4) shall be labelled with white beads with black inscriptions.

The labels on wires to all general relays shall be white with black inscriptions.

16.5 Circuit breakers

Circuit breaker labels shall display the identification, voltage and rating of the circuit breakers.

16.6 ETCS equipment

Identification labels and serial numbers of equipment shall be visible when installed without disconnection or removal of equipment.

Each LEU module shall be fitted with a unique ID plate to be located adjacent to the LEU module position. Refer to M05-549 for details.

A location ID plate shall be fixed on the outside of each cabinet or above each mounting panel dedicated to housing or mounting of LEUs and associated equipment. Refer to M05-523 for details.

Refer to M05-521, M05-528, M05-529, M05-530, M05-531 and M05-536 for ETCS equipment labelling requirements.

Refer to M05-516, M05-520, M05-522, M05-533, M05-538, M05-542, M05-543, M05-557 for typical ETCS cable labelling requirements.

The ETCS balise trunk cable shall be labelled at the point where it leaves the LEU location, that is, at the trunk cable surge arrestor location.

16.7 Miscellaneous internal equipment

All internal equipment not already provided for in Sections 16 to 16.5 shall be labelled with a description outlining its function.

16.8 Trackside and track-mounted equipment

All trackside and track-mounted equipment shall be clearly labelled using a product which is suitable for labelling outdoor equipment in the railway environment.

Identification labels fitted to trackside and track mounted equipment shall be engraved or laser cut so that the label inscription is still legible even if the label is spray painted.

Labels on trackside and track-mounted equipment shall be white or silver with black inscriptions.

The ends of all cables and wires to terminations on trackside equipment shall be labelled using bead type labels, coloured white with black inscriptions.

On double rail impulse track circuits, the wiring to impedance bond terminals shall be identified by the number of the transmitter or receiver terminal to which each is connected.

16.9 Temporary work and stage work

All temporary work and stage work shall be clearly identified. Temporary type labels may be used (including paper labels), provided they are sufficiently durable for the application and anticipated duration of the work and are securely fixed in position.

The colour coding of temporary labels shall not be identical to that for permanent labels.

16.10 Partially commissioned and de-commissioned work

Where new cables, wires and equipment are being commissioned progressively during the progress of the work and old equipment is being progressively de-commissioned, equipment shall be clearly labelled either in use or not in use. In addition, power supply switches shall be clearly labelled 'working circuits – do not switch off'.