

# Installation of Equipment Racks and Termination of Cables and Wiring

ESC-07-04

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SMS

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1.1	12 Jul 19	1.3, 1.7, 2.1, 3.4.2, 3.5.1,	Update to include bond pin requirements. Other updates include rebranded document template, correction of typo's,

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		11.2	Amend Figure 2 to reflect current practice.
		12	Deleted as not applicable.

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## **1 General**

### **1.1 Scope**

The Standard Specification sets out the requirements for the jointing of cables, terminating and wiring of Signalling equipment and installation of equipment racks in buildings and location cases.

This specification describes the requirements for:

- Installation of equipment in buildings.
- Installation of equipment racks and cubicles.
- Types and Installation of Signalling fuse and terminal blocks.
- Termination of Signalling cables.
- Wiring of trackside equipment.
- Wiring of internal equipment.
- Wiring of power supplies.
- Temporary wiring and stage work.
- Jointing of cables.
- Labelling.

Except as otherwise noted in the Particular Specification, all items of equipment and all materials required for installation shall be supplied and installed by the Contractor as part of any Contract.

This Specification shall be read in conjunction with all other relevant Signalling Standard Specifications referenced within this document and the Particular Specification.

### **1.2 Safety**

The Contractor shall at all times ensure the safety of employees, not cause danger, delay, obstruction or stoppage to railway traffic and not interfere with the business of ARTC or its Operators.

The Contractor shall ensure that all staff working on the Contract including sub-contractors staff are appropriately accredited for work on or about Rail corridors in accordance with ARTC network Operational and Safe working requirements.

### **1.3 Work Health and Safety**

The Contractors and sub-contractors, if any, shall comply with the relevant safety legislation of the Work Health and Safety Act.

### **1.4 Drawings**

The documentation and drawings to be used in the execution of the works shall be the relevant approved Contractors drawings plus any other drawings nominated in this Specification and those of the Particular Specification.

### **1.5 Definitions**

In this document, the following definitions of items shall apply:

Term or acronym	Description
ARTC	Australian Rail Track Corporation Ltd.
Contractor	A person, company or authority nominated by ARTC or ARTC's Primary Contractor to manage a specific contract.
ARTC's Representative	A person, company or authority nominated by ARTC to make engineering determinations on ARTC's behalf.
Main Cables	Any cables that are run from a cable termination point in one building or location case, to a cable termination point in another building or location case.
Local Cables	All other cables.
Internal Cables	Any cables that are wholly contained within a building or location case.
External Cables	Any cables that run outside a building or location case.
Hypalon	Synthetic rubber sheathing material, R-90-BP or equivalent.

## 1.6 Quality of Work

The standard of materials and workmanship shall ensure that the installed equipment, cabling, wiring and equipment racking is fit for purpose over the lifetime of the asset, in its physical and operational environment, in terms of Safety, Reliability and Maintainability.

Quality of materials and workmanship shall also ensure that the necessity for regular preventative maintenance tasks to retain the safety, reliability and useability of the asset over its lifetime is minimized.

## 1.7 Submissions for Approval

Where alternatives or new equipment types are proposed, the matter shall be submitted by the Contractor with documented justification in writing, in accordance with ARTC Engineering Procedure EGP-21-01 New Equipment and System Approval.

## 1.8 Referenced Documents

The following standards and documents are referenced in this specification:

### 1.8.1 Australian Standards

AS 2700	Colour Standards
AS 1394	Round Steel Wire for Ropes
AS 2373.1	Multi-core Control Cables
AS 1125	Conductors in Insulated Electric cables and flexible cords
AS 5000	Electric Cables – Polymeric insulated for voltages up to and including 0.6/1KV
AS/ACIF S009	Installation Requirements for Customer Cabling
AS/ANZ 3000	Electrical Installations

### 1.8.2 ARTC Specifications

ESA-11-01	Cables for Railway Signalling Applications – General Requirements
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ESC-07-03	Small Buildings, Location Cases, Terminal Cases & General Purpose Cases
ESC-09-02	Lightning and Surge Protection Requirements
ESC-07-01	Installation of Trackside Equipment
ESC-11-01	Construction of Cable Route & Associated Civil Works

### **1.8.3 Drawings**

N/A

## **1.9 Special Conditions**

When working in the vicinity of or adjacent to overhead electrified Special Conditions shall apply.

# **2 Installation of Equipment in Buildings**

## **2.1 General**

Racks and other equipment shall be located to make most effective use of the available floor space and to provide unobstructed maintenance access.

Approximately 20% of the available space shall remain unused for the future installation of additional equipment, in new housings provided as part of the contract.

The minimum clearance between racks, cubicles, cupboards etc shall be consistent with work health and safety requirements and as minimum, the following clearances shall be applied:

- Between one end of a rack 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) 800mm.
- At the rear of any rack that requires rear access 900mm.
- At the front of any rack 900mm.
- Between racks that require front and rear access 1200mm.

The lowest point of any cable trays which pass over access ways or corridors between racks or other equipment shall be not less than 2.1m 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.

## **2.2 Equipment Racks and Cubicles**

### **2.2.1 Equipment Racks**

Except where otherwise specified or approved,

### **2.2.2 Equipment Mounting**

No equipment shall be mounted less than 300mm from the floor.

Wherever possible equipment should not be mounted more than 1800mm above floor level.

Any sensitive equipment likely to be affected by vibration shall be housed on racks or in cubicles mounted on vibration isolating footings or shall itself be mounted on vibration isolators within the rack or cubicle.

Heat producing equipment shall be arranged so that rising heat shall not affect the operation of or 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 access to the equipment mounted therein and the cables or wiring terminated to that equipment.

All items of equipment shall be 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, such as 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 also 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.

Vital signalling equipment and circuits are those where failure to function correctly could cause an unsafe outcome either directly or together with another signalling equipment or circuit failure. Vital equipment and circuits affect safety.

Signalling and train control equipment and circuits are considered non-vital where failure to function correctly would not cause an unsafe outcome. Non-vital equipment and circuits do not affect safety.

Telecommunications equipment shall be mounted on separate racks from Signalling equipment.

### **2.2.3 Painting/Finish of Metal Surfaces**

Steel metalwork within relay rooms, buildings and location cases including relay racks, equipment racks and housings, cabinets, plinths and bases shall be finished to AS 2700 using a robust finish which will resist chipping and scratching and provide corrosion protection to the steelwork for a period of at least 20 years. Colour to be as agreed with ARTC's Representative.

Bolts, nuts and other fastenings shall be provided with corrosion protection such as zinc plating and cable trays, if steel, shall be galvanised or provided with a finish that will provide equivalent life. Where part of a bolt or nut is external to a location case, the bolt or nut or both shall be stainless steel.

Appropriate mechanisms such as insulating washers and bushes shall be used when joining dissimilar metals to avoid the potential for cathodic corrosion.

Where steelwork is galvanised or provided with equivalent metallic protection no other surface treatment is necessary. Similarly, no additional surface protection is required for aluminium and stainless steel.

If powder coating, baked enamel or lacquered finishes are used, the metal shall be surface cleaned, primed, undercoated and finished strictly in accordance with the paint manufacturer's recommendations.

### **3 Termination**

#### **3.1 General**

Soldering shall not be used as a means of terminating interconnecting equipment Signalling conductors, vital or non-vital, except on the coil and finger contact connections of large plug-in relays (e.g. Westinghouse VT1, BL1B, BT1B).

#### **3.2 Fuse Holders and Terminal Blocks**

Fuse holders and terminal blocks used within buildings and location cases shall be DIN rail mounted screw clamp type (stud type for some earthing and larger cables) or, in listed applications only, spring clamp type.

The maximum internal resistance connection to connection for any fuse holder or terminal block shall be not more than 5 milliohms.

Wire wrap terminals for single strand conductors of appropriate sizes are acceptable only in non-vital applications.

Fuse holders and terminal blocks listed in Section 10 are considered suitable for use on Signalling applications. Other similar fuse and terminal blocks may be acceptable but will require submission in accordance with Section 1.7 before use.

Incoming/outgoing vital cables in relay rooms and location cases shall be terminated on approved test/disconnect terminal blocks.

Cables and wires to neutral bus bars shall be terminated on approved test/disconnect terminal blocks.

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

BR930 series relay base terminations shall be as specified in British Rail specification BR930.

It is permissible to terminate up to two (2) wires 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.

#### **3.3 Plug Connectors**

Plug connectors, both wire to wire and wire to circuit board edge, shall have gold plated (flushed) contacts and, where used for equipment located outside of buildings or where vibration could be a factor, shall have a means of locking the plug and socket securely together.

#### **3.4 Spacing of Terminals**

##### **3.4.1 DIN Rail Mounted Terminals**

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

Rows of fuses and/or terminals shall be spaced at not less than 150 mm centres except where otherwise approved.

### 3.4.2 Stud Type Terminals

Stud type terminals shall have studs spaced at not less than 20mm centres unless an insulating barrier at least 1/3 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 are not acceptable unless the current bar thickness is at least 60% of the stud diameter.

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

## 3.5 Crimp Lugs and Ferrules

### 3.5.1 General Description

This Specification shall be read in conjunction with AS 3100 (Approval & test specification-general requirements for electrical equipment), and the appropriate provisions shall apply to the construction of the terminals and the insulation and/or safeguarding of parts that normally carry current.

Where wires are subject to vibration, stranded wires shall be used between such apparatus and the nearest junction free of vibration.

Stranded conductors shall be fitted with Utilux "Supergrip" type crimp lugs or equivalent.

- Cable Lugs shall be supplied consistent with 3 essential types, i.e.
- Non-insulated type including bimetal lugs.
- Insulated type.
- Bootlace ferrules (Non Vital only).

Terminal/cable lugs shall be capable of being applied to the conductor with "over centre" or barrel type crimping tools, to provide mechanical security and electrical performance, as required. Crimping tools must provide for full crimping cycle before permitting the crimping jaws to return to the original open position.

Reasonable length of barrel shall be provided on the lug for crimping process.

The current carrying portions of terminals shall be of Copper or suitable Copper alloy.

All conducting materials shall be coated with tin, nickel, or silver plating or equivalent, to prevent corrosion.

Cadmium and zinc shall not be used.

### 3.5.2 Non-Insulated Cable Lugs

All non-insulated cable lugs shall be consistent with the requirements laid down by the Manufacturer for the cable/conductor to which they will be applied.

### 3.5.3 Insulated Cable Lugs

All terminals/cable lugs of the insulated type shall have the outer surface of the wire barrel covered with insulation. The insulation shall extend over the wire barrel to a point not more than 5mm from the assembly of binding post (terminal mount), nut and washer for cable lugs on stranded wire/cable of 0.5 sq.mm to 4 sq.mm cross sectional area and not more than 11mm on stranded wire/cable of 4 sq.mm to 14 sq.mm cross sectional area.

The conductor insulation shall be supported and gripped where practicable along the wire barrel shaft to prevent the insulation slipping or being removed in either the crimped or un-crimped state. In addition, the lug shall be of the double gripped type, which incorporates a separate inner conductive sleeve to grip and support the insulation. This sleeve is provided between the insulation and wire barrel without protruding past the barrel and hindering the terminal mounting arrangement.

The insulation material shall be non-corrosive, resistant to abrasion and fungi, shall not support combustion, and shall be capable of being crimped at temperatures of 0°C to 50°C without altering its characteristics.

The standard colour code adopted by ARTC is as indicated in Table 1.

### 3.5.4 Bootlace Ferrules

Thin sheet Copper sleeve fitted with an insulated cone to assist entry of wire strands and provide some support to the shaped system.

The insulation on the ferrules shall be colour coded to identify the proper cross sectional area of the wire size that it should be used with. The standard colour code adopted by ARTC is as indicated in Table 2.

Twin pre-insulated sleeves shall also be in accordance with this colour standard.

Crimping tools used with bootlace ferrules shall form a flat square uniform rectangular cross sectional area.

### 3.5.5 Identification and Marking

Each cable lug shall be properly identified for conductor size range and manufacture's identification and insulating sleeve shall be of the following colour for proper identification of conductor size range:

**Table 1.0 Colour code & preparation of wire for Pre-Insulated Cable Lugs**

Cross Section (mm <sup>2</sup> )	COLOUR of Insulated Terminals	Strip Length in-line splice	Strip Length
0.5 – 1.65	Red	4 – 5 mm	7 – 8 mm
1.0 – 2.60	Blue	5 – 6 mm	7 – 8 mm
2.5 – 6.00	Yellow	6 – 7 mm	7 – 8 mm

**Table 2.0 Colour code for Bootlace Ferrules**

NOMINAL CROSS SECTION (mm <sup>2</sup> )	AWG	INSULATION COLOUR
0.25	24	Light Yellow
0.34	22	Light Green
0.50	20	White
0.75	18	Blue
1.00	18	Red
1.50	16	Black
2.50	14	Grey
4.00	12	Orange
6.00	10	Green
10.00	8	Brown
16.00	6	White

### 3.6 Plug Coupling

As far as practical 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.

### 3.7 Cable Crimps and Crimp Tool Details

Crimping tools from which the guard, which controls the location and orientation of the crimp lug in the tool, has been removed shall not be used except when crimping in-line sleeves.

- No crimping tool with a defective ratchet shall be used.
- All crimping tools shall be individually numbered.

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

- Check the operation of the crimping tool
- Record the crimping tool serial number
- Make three sample crimps
- Check visually for any unusual deformations, etc. 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.
- Label each sample with crimp tool number, date, name of supervisor approving the test and forward to Tester in Charge for safe keeping and be retained until the end of the defects liability period.

Test samples of BR930 relay base crimps shall be made with:

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

The visual checks and sample labelling indicated above should also be applied to these BR930 relay base crimps.

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 practical, random pull tested and the work rectified as necessary.

Except for modified tools, with red and yellow dies, multi-head crimp tools are not approved for use. Crimp tools shall only be used on the specific lugs and pins for which they have been designed.

### **3.8 Heat Shrink Sleeves**

Plastic heat-shrinking sleeves shall be colour coded with red for feed cables (BX120, B50 etc.) and black for return cables (NX120, N50 etc.). White sleeves shall be used for circuits that may be subject to change of polarity after installation during setting up, such as the track circuit connections to bootleg risers etc.

### **3.9 Track Circuit Connections**

“Burndy” type B25M6 crimp lugs or similar shall be used for the connection of both Copper and Steel Hypalon track connection cables in bootleg risers and for connection of the Copper Hypalon to the rail.

## **4 Termination and Wiring of Equipment**

### **4.1 Termination of Signalling Cables in Relay Rooms & Location Cases**

All Signalling cables shall be terminated in accordance with the requirements of the relevant circuit diagrams.

The cables shall be terminated using terminal blocks and crimp lugs, pins or ferrules, where applicable, in accordance with the provisions of Section 3.

No less than 100mm 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 incoming/outgoing cables shall be securely clamped in position at the base of the termination rack to prevent loading on individual cores where terminated.

All cable cores shall be terminated in core number sequence, left to right, top to bottom inclusive of spares.

### **4.2 Wiring of Trackside Equipment**

#### **4.2.1 General**

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

Signalling cables and wires shall be terminated, where applicable, using terminals and crimping tools in accordance with the provisions of Clause 3. The exception to this being stainless steel and copper Hypalon track connections which shall be in accordance with Procedures 1 and 2 of Appendix A.

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

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

#### 4.2.2 Track Circuits

The track circuit trackside equipment shall be installed on mounting posts in accordance with ESC-07-01 Installation of Trackside Equipment.

As a minimum all track connection cables shall be connected via bootleg risers (BLR) mounted trackside.

Where high voltage impulse and audio frequency trackside equipment boxes can be installed within three (3) metres of the rail, surface mounted track connecting cables may be run directly to the track from the trackside equipment boxes in accordance with ESC-07-01 Installation of Trackside Equipment.

The cables from the trackside equipment boxes or bootleg risers to rail shall be, either stainless steel or copper Hypalon cables and in all cases be duplicated.

The choice of stainless steel or copper Hypalon cable will depend on cable lengths, resistance considerations and the particular track circuit manufacturers recommendations.

The cable shall be secured to the rail foot using a suitable proprietary strain relief clip, at a point not more than 300mm from the rail connection.

Stainless steel and copper Hypalon cables shall not be fixed or attached to the sleepers. They shall be tied together with non metallic UV stabilised PVC cable ties at not greater than 600mm intervals to form a single unit and be laid directly on the ballast.

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*Note: Hypalon insulated cables shall never be direct buried.*

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Connections to rails for the different types and sizes of cable shall be:

- Stainless Steel Hypalon: - Connected to rails by means of grooved channel pins installed as detailed in Procedure 1 of Appendix A.
- Copper Hypalon: - Connected to rails by means of stainless steel tapered bolt, "star" washer, spring washer and nyloc nut as detailed in Procedure 2 Appendix A. (**Note:** All components to be stainless steel).

#### 4.2.3 Pin Brazing: - Connected to rail by means of brazing silver. The connection as detailed in Procedure 3 Appendix A. Rail Bonds, V & K Crossing Bonds

In general, all bonds shall be duplicated and kept as short as possible.

Parallel and short series bonds (less than 8m) shall be surface mounted. Long series bonds (greater than 8m) shall be buried in accordance with the provisions of ESC-11-01 Construction of Cable Route and Associated Civil Works.

Hypalon covered bonding cables shall be laid as detailed in Section 4.2.2. Other bonding cables, except those around rail joints and within V crossings, shall be installed in heavy duty, orange coloured flexible UV stabilised PVC conduit laid on the ballast.

Rail joints in non electrified areas shall be bonded using steel Hypalon, copper Hypalon or 7/1.40 steel signal wire as appropriate for the type of track circuit in use.

The connections to the rails shall be made using the procedures outlined in Appendix A. as applicable to the type of cable required.

#### **4.2.4 Signals – Mast and Gantry Mounted**

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

A Signalling multi-core cable with at least the same conductor size and conductor insulation 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 mast and any external equipment (e.g. lamp cases, half pilot staff boxes etc) on any non top of mast mounted equipment.

Terminals in both the signal base and signal lamp cases, including subsidiary lamp cases, shall be numbered from top to bottom left to right, including spaces and commencing at one (1).

Multi-core cables shall be used for circuits that emanate from the terminals in the base of the signal mast or gantry junction box and connect to equipment which is not attached to the signal mast or gantry.

#### **4.2.5 Electric Point Machines**

Local power and multi-core cables to points machines and associated equipment shall be installed in heavy duty, orange flexible PVC conduit laid on the ballast, except where the length of the cable exceeds 4 metres when it shall be buried in accordance with the requirements for buried cable route in ESC-11-01 Construction of Cable Route and Associated Civil Works.

Cable sizes and wiring shall be in accordance with the circuit diagrams.

Flexible conduits shall be securely fixed to the points machine cable entry and to the cable entries of associated equipment and shall be sealed with a neutral cure sealant after cable termination to prevent moisture entry.

#### **4.2.6 Electro-Pneumatic Points Machine**

Where there is no adjacent location case, a cable termination box shall be provided adjacent to electro-pneumatic points.

Local multi-core cables from the location case or termination box to control valve, detector, motor and, where applicable, facing point lock and indication box shall be installed in individual heavy duty orange PVC conduits laid on the ballast.

Conduits shall be securely fastened to the cable terminators provided on each piece of equipment.

#### **4.2.7 Releasing Switches, Outlying Point Locks and Ground Frame Operated Points**

The Signalling multi-core cable shall be terminated on terminals in the base or in the equipment as appropriate.

Multi-core cables from the terminals in the base of the releasing switch to any associated points detector shall be installed in heavy duty, orange flexible PVC conduit laid on the ballast except where the length of the cable exceeds 4 metres when it shall be buried in accordance with the requirements of ESC-11-01 Construction of Cables Routes and Associated Civil Works.



A multi-core cable with the same conductor size and conductor insulation shall be installed between the terminals in the mast base and those in the releasing switch.

#### **4.2.8 Guard Indicators**

Cables or wiring to guards indicators shall be protected by rigid and/or flexible conduit where the cable is not within the mast on which the indicator is mounted.

Where it is necessary to fix the conduit to a station building, the type of conduit used and the selected location shall be designed to be as unobtrusive as possible.

#### **4.2.9 Traffic Huts**

The cables to traffic huts shall be brought to a single termination point within the hut then distributed to equipment within or on the hut. This shall include the call light circuits, and the lighting circuits for the traffic hut internal lighting.

#### **4.2.10 Emergency Switch (Point) Machine Lock (ESML), Emergency Operated Lock (EOL)**

Where ESMLs or EOLs are mounted on relay room walls, location cases or equipment housings, the wiring to the ESML or EOL shall be treated as being internal to the relay room. Where mounted on separate posts located in the vicinity of the points wiring shall be a multi-core cable with at least the same conductor size and insulation similar to that of releasing switches.

#### **4.2.11 Telephones**

Flexible conduit with conduit terminators shall be provided to carry the telephone cable between the signal mast (or similar) and the telephone which is mounted on or adjacent to the signal mast.

The telephone cable to the telephone, where mounted on a separate mast, shall be run within the mast and terminated directly on the telephone.

## **5 Wiring of Internal Equipment**

### **5.1 General**

All internal wiring shall be adequately supported in cable tray, trunking or similar and be of sufficient length so as not to be under tension around corners or at terminals.

Where wires pass through holes in cable tray or trunking, the holes shall be fitted with grommets or bushes.

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 practical.

### **5.2 Vital Wiring**

All internal vital Signalling wiring shall be single core 32/0.20mm annealed copper conductor except where the Signalling Design requires otherwise.

All internal wiring shall be terminated using Utilux "Supergrip" type or equivalent crimp lugs, crimp pins or bootlace ferrules, as applicable.

The insulation shall be PVC-V75 coloured "black" PVC/Nylon to AS 1125 and AS 5000.

### 5.3 Non-Vital Wiring

Non-vital wiring that is within the same cable tray or trunking as vital wiring, shall be either 32/0.20mm or multi-pair communications cable of 0.64mm minimum conductor size to Telstra Specifications.

Inter-rack non-vital wiring shall be carried out using multipair communication cable with conductor sizes of not less than 0.64mm in diameter manufactured to Telstra Specifications.

Non vital wiring shall be terminated either on appropriately sized screw or spring clamp terminals or on wire wrap terminals.

### 5.4 Wiring of Power Supplies

Power cables shall be manufactured to the requirements of the ARA Specification "Cables for Railway Signalling Applications – General Requirements".

The actual conductor size shall be determined by power calculations and included in the Signalling Design.

The insulation shall be in accordance with AS 5000 and ARA Specification "Cables for Railway Signalling Applications – General Requirements".

## 6 Temporary Wiring and Stage-Work

Temporary wiring and stage-work wiring shall be terminated the same as for permanent wiring.

Temporary cables and internal wiring shall be carried out in a distinctive colour other than black, red, blue or green. Alternatively, if black they shall be fitted with a coloured sleeve or tagging at each end of the cable or wire.

The conductor cross sectional area in temporary cable; shall be at least equivalent to the internal wiring conductor size of 32/0.20mm.

Where the work involves multiple commissioning's, the colour of internal temporary wiring should either be different or carry different coloured sleeves for each stage of 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 in a manner that prevents its contact with any other working circuits.

**Note** that in line crimp joints shall **not** be made in temporary or stage-work wiring.

## 7 Jointing of Signalling Cables

### 7.1 General

This section applies to multicore Signalling cables.

The closure system for jointing Signalling cable shall be Raychem XAGA 530, or direct technical equivalent.

This closure system is to be used in conjunction with Raychem RSS joint filling compound and Raychem heat shrink jointing and repair sleeves, or technical equivalents.

Conductors shall be joined by approved Manufacturers procedure (i.e. standard crimp sleeves and crimping tool).

## 7.2 Inspection

Cable joints of Signalling cable shall not be covered or backfilled until the joint has been appropriately inspected and tested. Each completed joint shall be tested and certified by the Contractor. The record of tests shall be part of the installation testing process.

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*Note: In buried cable routes, the joint shall be buried directly in the ground. Otherwise the joint shall remain in the ground level trough or above ground trough. There shall be no snaking and deformation of the cables in the vicinity of the joints. The joints in the cable shall be placed in the trench or trough and shall be in the same axis as the main cable run. Joints shall be so placed that they are readily accessible.*

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## 8 Jointing Communications Cable

### 8.1 General

This section applies only to copper conductor communications cables that are used in hard wired non-vital Signalling applications.

The jointing system for jointing communications cable of up to but excluding 50 pairs, shall be KRONE PSI Type or equivalent.

Communications cables of 50 pairs or more shall be KRONE PSI Type 2A or equivalent.

Copper conductors of cables with diameters up to and including 0.9mm shall be jointed using the crimp technique employing AMP Picabond mini two-wire crimps or equivalent.

For cables with conductors larger than 0.9mm, 3M 'Scotch-locks' or equivalent shall be used.

Tooling to be employed for the AMP Picabond crimps shall be the AMP semi-automatic type MA12 machine or similar.

Cable joints of Signalling cable shall not be covered or backfilled until the joint has been appropriately inspected and tested. Each completed joint shall be tested and the original certified record of tests shall be submitted to ARTC's representative as part of the installation testing process.

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*Note: In buried cable routes, the joint shall be buried directly in the ground.*

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Otherwise the joint shall remain in the ground level trough or above ground trough. There shall be no snaking and deformation of the cables in the vicinity of the joints. The joints in the cable shall be placed in the trench or trough and shall be in the same axis as the main cable run. Joints shall be so placed that they are readily accessible.

### 8.2 Optical Fibre

All Fibre installations shall be in accordance with:

- Australian Standard AS/ACIF S009 – Installation Requirements for Customer Cabling.
- Australian / New Zealand Standard AS/ANZ 3000 – Electrical Installations.

All fibre jointing shall be carried out using the fusion type jointing method.

Where a joint is installed, a loop of at least fifteen (15) metres of cable from each direction is required to allow for future jointing, or for existing joints to be removed from the pit and worked on in a portable shelter or vehicle.

Coiling of the fibre cable shall be carried out in accordance with the manufacturer's specifications relative to bending radius.

Joint enclosures in pits shall be secured to the side of the pit in such a manner that ensures 'zero' strain on the cables.

## **9 Labelling**

### **9.1 General**

All labelling shall be in English and be produced by some form of machine type setting. Hand-written labels are not acceptable.

The size of labels and the size of lettering thereon shall permit reading with average eyesight in the prevailing light conditions at a minimum distance of 750mm.

Labels shall be made of durable and permanent material and be attached in a permanent manner, except that for temporary work and stage-work paper labels may be used. The format and quality of these temporary labels shall be acceptable to ARTC's Representative.

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

High voltage equipment shall be conspicuously labelled in accordance with the relevant Australian Standards and Work Health and Safety regulations and shall generally be red background with white inscriptions.

Rack labels, except those for high voltage equipment, shall generally be white or yellow background with black inscriptions.

### **9.2 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.

"Snap On" type labels shall not be used except where re-labelling existing wiring.

### **9.3 Fuses, Terminals and Busbars**

Fuse blocks and terminal blocks shall be labelled in numerical sequence with proprietary labels.

Numbering shall be from top to bottom or left to right, as applicable, commencing with number 1.

Bus bars shall be clearly labelled (e.g. BX120, NX120, B50, N50, etc.)

A laminated Terminal and Fuse analysis sheet shall be affixed to the inside of location case doors. In relay rooms and equipment housings this sheet shall be affixed adjacent to the Termination and Fuse racks.

### **9.4 Plug-In Relays – Vital**

All relay positions on the equipment rack shall be labelled both, front and back.

Wires to the bases of BR930 series relays shall be labelled with bead type labels which shall indicate the column and wire positions to which the wires are to be connected (e.g. A1, A2, B1, B2 etc. 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 BR930 series relay bases shall be colour coded for the different column positions as follows:

Column	Bead Colour	Inscription Colour
A	Red	White
B	Yellow	Black
C	Green	White
D	Blue	White

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

## 9.5 Circuit Breakers

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

## 9.6 Miscellaneous Internal Equipment

All internal equipment not already provided for above shall be labelled with an appropriate description of its function.

## 9.7 Trackside Equipment

All trackside equipment installed under the Contract shall be clearly labelled using a metal label that is suitable for outdoor use.

Labels shall be robust in construction, weather proof, fade free and securely fixed in position.

Labels should be white or silver inscription on a black or contrasting background.

All cable cores and wires to terminations on trackside equipment shall be labelled using appropriate bead type labels coloured white with black inscriptions.

All cables shall be labelled both ends by means of cable labelling ferrules.

## 9.8 Temporary Work and Stage-Work

All temporary work and stage-work shall be clearly identified. Temporary type labels will be acceptable provided they are sufficiently durable for the application and anticipated duration of the work and that they are securely fixed in position.

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

## 9.9 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 "In Use" and "Not in Use" shall be clearly labelled, as applicable. In addition, power supply switches shall be conspicuously labelled "Working Circuits - Do Not Switch Off".

## 10 Screw and Spring Clamp Terminal Blocks and Fuse Holders

### 10.1 General

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

The following types of screw and spring clamp terminal blocks and fuse holders are considered suitable for use on Signalling applications and details of construction do not need to be presented for further approval unless there is a change in design or materials.

Other types of terminal blocks and fuse holder may be acceptable but shall be required to be submitted in a manner consistent Section 1.7

No terminal block or fuse holder shall be used where the wiring to be terminated or the maximum applied voltage or the current is outside the manufacturer's rating for that particular terminal block or fuse holder.

All terminals shall be supported by appropriate hardware as specified by the manufacturers e.g. end plates, end stops etc.

### 10.2 Feed Through Terminals

#### KLIPPON

Terminal Type	Cat No	Rail	Comments
AKZ4	029432	TS	May not be used for terminating external cables
SAK2.5	027962	TS32	May not be used for terminating external cables
SAK2.5/35	038046	TS35	May not be used for terminating external cables
SAK 4	012832	TS32	General purpose.
SAK4/35	044366	TS35	General purpose.
SAK 6N	019322	TS32	General purpose.
SAK6/35	038056	TS35	General purpose.
SAK10	011002	TS32	General purpose.
SAK10/35	044376	TS35	General purpose.
SAK35N	055062	TS32	General purpose.
SAK35N/35	060826	TS35	General purpose.
SAKG32	017032	TS32	Stud type terminal M6 stud
SAKG32/35	063732	TS35	Stud type terminal M6 stud
DK4	037116	TS35	4-way terminal. May not be used for terminating external cables

Screw and Spring Clamp Terminal Blocks and Fuse Holders

**WAGO**

Terminal Cat No	Rail	Comments
279-101, 279-104	TS35	Non-vital only.
279-102, 279-105	TS32	Non-vital only.
280-101, 280-104	TS35	May not be used to terminated external cables.
280-102, 280-105	TS32	May not be used to terminated external cables.
281-101, 281-104	TS35	General purpose.
281-102, 281-105	TS32	General purpose.
282-101, 282-104	TS35	Stud type terminal M6 stud
282-102, 282-105	TS32	Stud type terminal M6 stud
284-101, 284-104	TS35	General purpose.
284-102, 284-105	TS32	General purpose.
283-101, 283-104	TS32	General purpose.
283-102, 283-105	TS32	General purpose.
280-647, 280-657	TS32	4-way terminal. May not be used to terminated external cable
280-646, 280-656	TS35	4-way terminal. May not be used to terminated external cable
280-641, 280-651	TS35	3-way terminal. May not be used to terminated external cable
280-642, 280-652	TS32	3-way terminal. May not be used to terminated external cable
281-631, 280-651	TS35	3-way terminal block

**PHOENIX**

Terminal Type	Cat No	Rail	Comments
UK2.5	30 01 01 9	TS32/35	May not be used for terminating external cables
K2.5	13 01 07 0	TS32	May not be used for terminating external cables
	13 01 01 2		May not be used for terminating external cables
UK4	30 03 01 7	TS32/35	General purpose.
	13 02 07 9	TS32	General purpose.
K4	13 02 01 1		General purpose
UK10	30 05 01 5	TS32/35	General purpose.
K10	13 03 08 7	TS32	General purpose.
	13 03 01 0		General purpose.
UK16	30 06 01 4	TS32/35	General purpose.
UK16N	30 06 04 3	TS32/35	General purpose.

Screw and Spring Clamp Terminal Blocks and Fuse Holders

Terminal Type	Cat No	Rail	Comments
K16	13 04 07 7	TS32	General purpose.
	13 04 01 9		
UK25	30 07 01 3	TS32/35	General purpose.
K25	13 05 07 6	TS32	General purpose.
	13 05 01 8		General purpose.
UK35	30 08 01 2	TS32/35	General purpose.
K35	13 06 07 5	TS32	General purpose.
	13 06 01 7		General purpose.

**Entrelec**

Terminal Type	Cat No	Rail	Comments
M4/6	115.116.07	TS32/35	General purpose.
M10/10	115.120.17	TS32/35	General purpose.
M35/16	115.124.07	TS32/35	General purpose (Not suitable for lip blade lugs)
M70/22.1	115.216.13	TS32/35	General purpose (Not suitable for lip blade lugs)
			Minimum Conductor 16mm <sup>2</sup> solid, 25mm <sup>2</sup>
M6/8	115.118.11	TS32/35	General purpose
DR4/6N	110.491.17	TS	May not be used for terminating external cables
DR4/6N	120.491.11	TS	May not be used for terminating external cables

## 10.3 Heavy Duty Feed Through

**KLIPPON**

Terminal Type	Cat No	Rail	Comments
SAK70	034082	TS32	Minimum conductor 16mm <sup>2</sup> solid, 25mm <sup>2</sup> stranded
SAKG40	017042	TS32	Stud type terminal 10mm stud
SAKG46	017062	TS32	Stud type terminal 12mm stud

**PHOENIX**

Terminal Type	Cat No	Rail	Comments
UKH95	30 10 01 3	TS32/35	Minimum conductor 25mm <sup>2</sup>
UKH150	30 10 11 0	TS32/35	Minimum conductor 35mm <sup>2</sup>
UKH240	30 10 21 7	TS32/35	Minimum conductor 95mm <sup>2</sup>
UHV25M8/M8	21 30 20 8	TS32/35	Stud type terminal 8mm stud
UHV50M10/M10	21 30 21 1	TS32/35	Stud type terminal 10mm stud



Screw and Spring Clamp Terminal Blocks and Fuse Holders

Terminal Type	Cat No	Rail	Comments
UHV95M12/M12	21 30 22 4	TS32/35	Stud type terminal 12mm stud
UHV150M12/M12	21 30 23 7	TS32/35	Stud type terminal 12mm stud

**ENTRELEC**

Terminal Type	Cat No	Rail	Comments
M35/26.FF	115 140 23	TS32/35	Stud type terminal
M120/35.FF	115 146 15	TS32/35	Stud type terminal
M300/42.FF	115 149 20	TS32/35	Stud type terminal
M35/26EE	115 151 12	TS32/35	Stud type terminal
M150/35EE	115 156 17	TS32/35	Stud type terminal

## 10.4 Test/Disconnect Terminals

**KLIPPON**

Terminal Type	Cat No	Rail	Comments
SAKC10	032402NP	TS32	1 plug bolt
	032412NP		2 plug bolts
SAKT1	043792	TS32	Limited Application. Local Telephone circuits only

## 10.5 Fuse Holders

**KLIPPON**

Terminal Type	Cat No	Rail	Comments
SAKS1	019112	TS32	25mm x 5mm Indicator Fuse – max. 6.3 amps
SAKS1/35	050152	TS35	
SAKS3	021112	TS32	1" x ¼" non indicating fuse – max 13 amps
SAKS3/35	066742	TS35	
SAKS3	024892	TS32	1 ¼ x ¼ fuse – max 10 amps
SAKS3/35	066752	TS35	
SAKS5	035942	TS32	Neozed fuse – 20, 25, 35, 50, 63 amps
SAKS5/35	050212	TS35	

Screw and Spring Clamp Terminal Blocks and Fuse Holders

**WAGO**

Terminal Cat No	Rail	Comments
282 – 126	TS35	25mm x 5mm indicating fuse – 10 amp max.
282 – 127	TS32	
282 – 128	TS35	1 ¼ x ¼ fuse – max 10 amps
282 – 129	TS32	

**ENTRELEC**

Terminal Type	Cat No	Rail	Comments
M10/12.SF1	111 035 05	TS32/35	25mm x 5mm fuse – max. 6.3 amps
M10/13.SF2	119 014 11	TS32/35	1 ¼ x ¼ fuse – max 16 amps
M10/16SF	115 377 24	TS32/35	1 ¼ x ¼ fuse to – max 16 amps
MB25/30SF	116 305 26	TS32/35	Neozed fuse 20, 25, 35, 50, 63 amps

## 10.6 Earthing Terminals

**KLIPPON**

Terminal Type	Cat No	Rail	Comments
EK1	032290	TS32	Single conductor
EK2	032310	TS32	Two conductors
SAKE35	014440	TS32	Single conductor

**WAGO**

Terminal Type	Rail	Comments
282 – 107	TS35	Two conductors – max 7/0.85
282 – 108	TS32	
283 – 107	TS35	Two conductors – max 7/1.7
283 – 108	TS32	

## 10.7 Track Connection Terminals

**BURNDY**

Terminal Type	Rail	Comments
B25M6	N/A	Multistrand Conductor – 6mm connection to rail stud

## 11 Appendix A - Installation Procedures – Cable to Rail Connections

### 11.1 Procedure 1 - Grooved Channel Pin Rail Connections – Galvanised Steel or Stainless Steel Hypalon Cable

Grooved channel pin rail connections shall be used for the connection of **Galvanised Steel or Stainless Steel Hypalon Cables** to rails and shall be installed in accordance with the following procedure:

1. Drill 2x holes in the neutral axis of the rail (centre of the web) using a sharp accurate 7.0mm (9/32") machine twist drill, drill jig and water based coolant/lubricant (if required). Oil shall not be used as part of the drilling process.
2. Drill hole centres shall be within 5mm of the neutral axis of the rail. The leading edge of any drilled hole is not to be within 100mm of the centre line of a weld and at least 50mm from any holes.
3. The holes are to be finished free of sharp edges, burrs, loose scale, shavings and other foreign matter. The entrance and exit holes shall be chamfered to approximately 1mm at an angle of 45 degrees.
4. Bare 80mm in length of the insulation from the end of the galvanised steel or stainless steel Hypalon cable.
5. Insert the flexible steel conductors directly into the hole until the insulation is 10mm from the rail.
6. Insert the grooved channel pin with groove facing downward ensuring that the steel strands of the cable are bunched together and placed in the groove of the channel pin.
7. Hammer the channel pin into the hole as far as possible.

*Note: To prevent rusting of the hole, the fitting shall be installed immediately the hole is drilled.*

### 11.2 Procedure 2 - Stainless Steel Tapered Rail Bolt Connections – Copper Hypalon Cable

Stainless Steel Tapered Bolt Rail Connections shall be used for the connection of **Copper Hypalon Cables** to rails. The rail bolt assembly shall consist of:

- Grade 316 Stainless steel tapered rail bolt x 6mm thread. Refer to figure 1 and figure 2.
- Grade 316 Stainless steel nyloc nut, spring washer and "star" lock washer.
- "Burndy" type B25M6 crimp lug.

The assembly shall be installed in accordance with the following procedure:

- Drill holes in the neutral axis of each rail (centre of the web) using a sharp accurate 7.0mm (9/32") machine twist drill, drill jig and water based coolant/lubricant (if required). Oil shall not be used as part of the drilling process. The drilling of holes in rails should be minimised.
- Drill hole centres shall be within 5mm of the neutral axis of the rail. The leading edge of any drilled hole is not to be within 100mm of the centre line of a weld and at least 50mm from any holes. The drilling of holes in rails should be minimised.

## Appendix A - Installation Procedures – Cable to Rail Connections

- The holes are to be finished free of sharp edges, burrs, loose scale, shavings and other foreign matter. The entrance and exit holes shall be chamfered to approximately 1mm at an angle of 45 degrees.
- Bare 20mm in length of the insulation from the end of the copper Hypalon cable.
- Insert the flexible copper conductors directly into a “Burndy” type B25M6 or equivalent crimp lug and apply 2x indent crimps with the manufacturer’s recommended crimping tool.
- Insert the stainless steel tapered rail bolt into the 7.0mm hole and hammer the rail bolt into the hole as far as possible.
- Apply the stainless steel star washer between the crimp lug and rail surface.
- Attach the lugged copper Hypalon cable to the stainless steel tapered rail bolt and apply the stainless steel spring washer and 6mm stainless steel nyloc nut. All stainless steel threads shall have anti-seize applied prior to fitting the nut to prevent the nut seizing on the thread.
- Tighten the assembly with a suitable tool ensuring that the final connection is tight and secure.

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*Note: Nyloc nuts must not be re-used.*

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Appendix A - Installation Procedures – Cable to Rail Connections

<b>Material</b>	Grade 316 Stainless steel		
<b>Thread Form</b>	Metric Course M6-1.0	<b>Thread Type</b>	Cut thread
<b>D<sup>1</sup></b>	M6-1.0	<b>H</b>	11mm
<b>D<sup>2</sup></b>	7.30mm	<b>A</b>	6mm
<b>D<sup>3</sup></b>	8mm	<b>B</b>	4mm
<b>L</b>	45mm	<b>C</b>	5mm
<b>T</b>	19mm	<b>G</b>	9.5mm
<b>Note</b>	Nuts and washers to suit.		

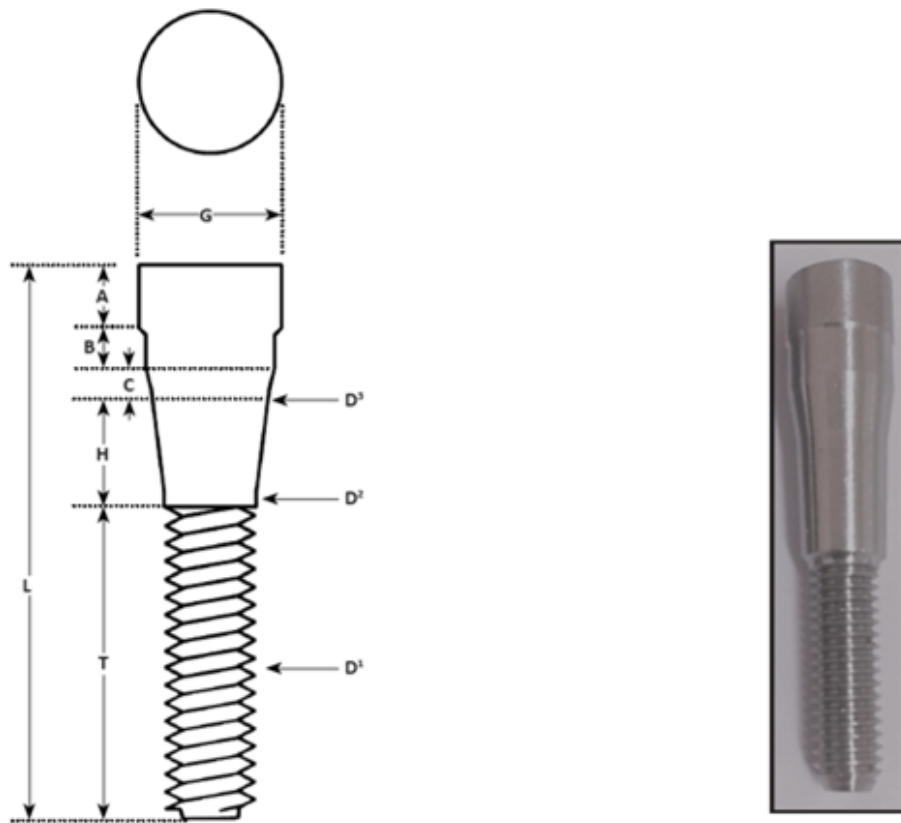


Figure 1 – Round head stainless steel tapered rail bolt

<b>Material</b>	Grade 316 Stainless steel		
<b>Thread Form</b>	Metric Course M6-1.0	<b>Thread Type</b>	Cut thread
<b>D<sup>1</sup></b>	M6-1.0	<b>H</b>	13mm
<b>D<sup>2</sup></b>	7mm	<b>A</b>	12mm
<b>D<sup>3</sup></b>	7.5mm	<b>C</b>	10mm
<b>L</b>	45mm	<b>T</b>	20mm
<b>Note</b>	Nuts and washers to suit.		

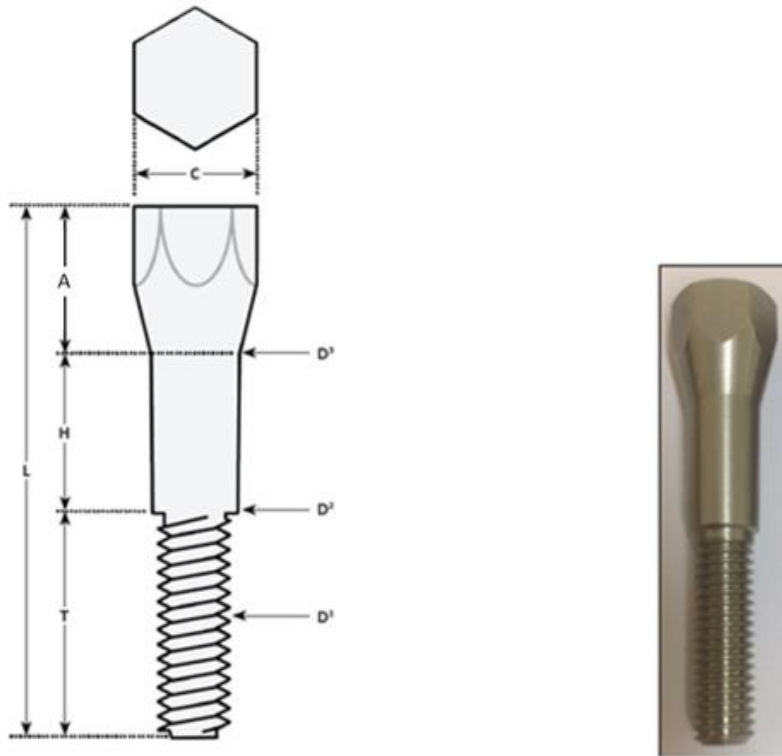


Figure 2 – Hexagonal head stainless steel tapered rail bolt

### 11.3 Procedure 3 – Pin Brazing Connection

Pin brazing connections is an optional method for the connection to rails in accordance with the following procedure:

1. Connect cables to the pin brazing unit. The brazing unit shall have a maximum heating temperature not exceed 650°C.
2. Grind an area for the ground clamp and the brazing area. Use a carbide bur or non-resin stone for a clean surface. Only apply pin brazing to the web at neutral axis.
3. Attach the ground clamp to the rail. Make sure ground clamp is tight and secure close to the bond area.
4. Inspect the pin and copper bond for oxidation, use emery cloth to remove. Check that ring is dry and not broken.



Figure 3 – Brazing pin, copper bond and ring example

5. Load the pin into the brazing gun first, make sure the pin fits snug in the pin holder, then load the ring second.



Figure 4 – brazing gun with pin and ring example

6. Take the bond and hang it from the tip of the pin, this ensures the braze starts at the top of the bond opening allowing the silver to melt down and around the circumference of the opening.
7. Press the pin and bond firmly against the clean rail surface. Pull the trigger to engage the brazing process.
8. Upon pulling the trigger the brazing process starts, the capsule of the pin releases a flux powder to clean the surface, then the silver begins melting. Hold the gun in this position for 2-3 seconds.
9. Hold the gun in position for an addition 3-5 seconds after the brazing process has been completed to allow the bond to fix. The connection must be allowed to cool naturally by air. No forced cooling is permitted.
10. Knock off the pin nipple with a small hammer.
11. Pull on the bond to ensure proper braze.