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Specification

Installation of Equipment Racks and Termination of Cables and Wiring

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Document history

Revision	Effective date	Summary of changes
Version 1.1	30 January 2022	TfNSW template applied.
Version 2.0	30 January 2022	Internal revision only – no change.
Version 3.0	30 January 2022	First full UGLRL release.

Table of contents

1. General

1.1. Scope

This Specification describes the requirement 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 stagework.
- Labelling.

1.2. Referenced Documents

The following documents or publications are referenced within this Specification:

CRN Specifications

CRN SA 001	RIC Grandfather Rights Type Approved Signalling Equipment
CRN SA 002	ARTC Predecessor Rights Type Approved Signalling Equipment
CRN SA 003	CRN Type Approved Signalling Equipment
CRN SC 002	Traction Return, Track Insulation and Bonding
CRN SC 004	Lightning and Surge Protection Requirements
CRN SC 014	Type Approval Requirements for Signalling Systems and Equipment
CRN SC 021	Construction of Cable Route, Associated Civil Works
CRN SE 022	Solderless Terminals and Cable Lugs for Signalling Applications
CRN SE 029	Supply and Installation of Cable Jointing Material for the Jointing and Repair of PVC and Power Cable
CRN SE 033	Solderless Terminals Screw and Spring Clamp Terminal Blocks
CRN SE 035	Cables for Railway Signalling Applications

Australian Standards:

AS 2700	Colour Standards
AS 1394	Round Steel Wire for Ropes
AS 2373.1	Multi-Core Control Cables

Drawings

D08301

E08616

E08179-3

1.3. Definitions

Main Cables

Any cables which are run from a cable termination point in one building or location case, to a cable termination point in another building or location case.

Note:

That joints in cables including those for loading and balancing purposes do not constitute a termination point of the cable for the purposes of defining Main and Local cables.

Local Cables

All other cables.

Internal Cables

Any cables which are wholly contained within a building or location case.

External Cables

Any cables which run outside a building or location case.

Hypalon

Synthetic rubber sheathing material, R-90-BP or equivalent

1.4. Quality

The standard of materials and workmanship shall ensure that the installed equipment, cabling and wiring is fit for purpose, over the lifetime of the asset in its physical and operational environment, in terms of the standards of safety, reliability, durability, maintainability, operability and supportability as set out in this Specification and referenced documents.

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

1.5. 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 in light grey blue (No. B44) to AS2700 using a robust finish which will resist chipping and scratching and will provide corrosion protection to the steelwork for a period of at least 25 years.

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 which 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.

Where steelwork is galvanised or provided with equivalent metallic protection no other surface treatment is necessary except where otherwise required by the Particular Specification.

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.

1.6. Alternative Materials, Products or Processes

Where this Specification proposes a particular material, product or process or range of materials, products or processes, alternatives may be accepted for use where permitted by the Particular Specification, provided that they receive Type Approval and it can be demonstrated that the alternative:

- Is fit for purpose.
- Is better rather than worse in optimally achieving the performance requirements.
- Improves rather than reduces system safety, security and availability.
- Is closer rather than further from best practice.
- Is equally or more suitable in form, fit and function, and equally or more compatible with its interfaces, operating environment and maintenance environment.
- Increases rather than decreases compliance with environmental and occupational health and safety requirements.
- Decreases rather than increases life cycle costs.
- Improves rather than reduces maintainability and supportability.
- Increases rather than decreases adaptability for foreseeable changes.
- Provides a net benefit to CRN.

Acceptance of alternatives shall only entail acceptance of variations to the specification to the extent these are fully explained and explicitly detailed and documented.

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, except where otherwise directed.

The minimum clearance between racks, cubicles, cupboards etc with all equipment mounted shall be:

- 800mm 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)
- 900 mm at the rear of any rack which requires rear access.
- 900mm at the front of any rack.
- 1200mm between racks which require front and rear access.
- 750mm in front of any roll or slide out drawer or tray when extended.

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

2.2. Equipment Racks and Cubicles

2.2.1. Equipment Racks

Except where otherwise specified or approved, the height of equipment racks and cubicles shall not exceed 2 metres.

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 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.

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

3. Termination

3.1. General

Soldering shall not be used as a means of terminating signalling conductors, vital or non-vital.

3.2. Fuse Holders and Terminal Blocks

Fuse holders and terminal blocks used within buildings and location cases shall be in accordance with Specification CRN SE 033 and shall be DIN rail mounted screw clamp type (stud 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.

Type Approved fuse holders and terminal blocks are listed in CRN AS 001, CRN SA 002 and CRN SA 003.

3.3. Plug Connectors

Plug connectors shall comply with Specification CRN SE 006.

Plug connectors, both wire to wire and wire to circuit board edge, shall have gold plated (flashed) 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 150mm 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 16mm.

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 terminals or on other lugs even if they become loose or be bent. Separate lock nuts shall be fitted to stud terminals except where self locking nuts, such as Nyloc nuts, are used.

3.5. Crimp Lugs and Ferrules

Crimp lugs, crimp pins and bootlace ferrules shall comply with Specification CRN SE 022.

Application of lugs, pins and ferrules shall be in accordance with Specification CRN SE 022 using the appropriate approved 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.

3.6. Terminal Blocks

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

Cables and wires to neutral busbars shall be terminated on Type Approved test/disconnect terminal blocks.

Terminal blocks for inter rack wiring etc. shall be Type 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.

3.7. 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.

3.8. 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.

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 and forward to Tester in Charge for safekeeping.
- 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,
- 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 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.

Crimp lugs, crimp pins and bootlace ferrules and their applications are listed in Specification CRN SE 022.

3.9. 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 which may be subject to change of polarity after installation during setting up, such as the track circuit connections to bootleg risers etc.

4. Termination and Wiring of Equipment

4.1. Termination of Signalling Cables in Relay Rooms and 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.

Not 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.

Where cables are manufactured with a copper sheath around the bundle of conductors, these 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 and shall be connected separately to a lightning arrestor using a minimum conductor size of 7/0.85mm yellow/green earth wire.

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 spare conductors shall be terminated in core number sequence.

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, except for the rail end of the steel hypalon cable.

All vital signalling cables shall be to Specifications as applicable in CRN SE 035.

Non-vital signalling cables shall be to Specifications 556B, 765 and 516D (0.9mm diameter conductor).

All cables and wires shall be installed such 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 or, 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.

Connection of cables to the track shall be performed in accordance with the appropriate procedure nominated in Appendix A.

4.2.2. Track Circuits

The track circuit trackside equipment shall be installed on mounting posts in accordance with Specification CRN SC 021.

The cables from the trackside equipment boxes or bootleg risers to rail shall be, as applicable, or equivalent cable for audio frequency track circuits and steel or copper hypalon cables for all other track circuits. The choice of steel or copper hypalon cable will depend on cable lengths and resistance considerations.

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.

Steel and copper hypalon cables shall be laid directly on the ballast and secured to the sleepers with suitable clips at not greater than 600mm intervals. Where the hypalon cables run parallel to each other from trackside equipment boxes or bootleg risers, the cables shall be tied together with non metallic UV stabilised cable ties at not greater than 600mm intervals to form a single unit.

Note:

Hypalon insulated cables shall never be direct buried.

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

- Steel Hypalon:- Connected to rails by means of the stainless steel grooved channel pins installed as detailed in Procedure B Appendix A.

- Copper Hypalon (84 x 0.3mm):- Connected to rails by means of either the stainless steel tapered bolt, nut and washers installed as detailed in Procedure C Appendix A or 6mm welded stud installed as detailed in Procedure D Appendix A.
- Copper Hypalon (37/1.78):- Connected to rails by means of either the stainless steel tapered bolt, nut and washers installed as detailed in Procedure C Appendix A or 12mm welded stud installed as detailed in Procedure D Appendix A or “Y”-link rail head welded connection as described in Appendix B.

4.2.3. Traction Bonding

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

For copper hypalon 608/0.50mm and 962/0.50, bonding cable 37/1.78mm, aluminium hypalon 962/0.50mm and 1524/0.50;

Copper bush and stainless steel tapered bolts installed as detailed in Procedure A, Appendix A or 12mm welded studs as detailed in Procedure D, Appendix A or “Y”-link rail head welded connection as described in Appendix B.

4.2.4. Impedance Bonds

Impedance bonds shall be mounted as described in Specifications CRN SC 021 and CRN SC 015**.**

Bonding cables between adjacent impedance bonds, from impedance bonds to rail and from impedance bonds to negative busbars shall be as indicated on the track bonding plan.

Bonding cables sizes from signalling equipment to impedance bonds shall be as detailed in Specification CRN SC 002.

All side lead cables to any one impedance bond shall be of equal length.

Copper hypalon cables shall be encased in a rigid or semi-rigid non-metallic conduit to within 250 mm of rail or impedance bond, except where the Particular Specification states that this is not required, in which case the bonds shall be laid directly on the ballast. The ends of these conduits shall be sealed with a hard setting sealant.

Aluminium hypalon covered cables shall be laid directly on the ballast as detailed and fixed to sleepers as detailed in sub-clause 4.2.2.

Impedance bonds used for traction tie ins or sectioning hut and substation connections shall not be installed within 50 metres of a audio frequency track circuit tuned loop, except with specific prior approval.

Traction cables shall be fixed to impedance bonds with stainless steel bolts, nuts and washers. Bolt threads shall be treated with anti seize compound before assembly.

4.2.5. Rail Bonds, V&K Crossing Bonds

The bonding cable sizes and types shall be as indicated in Specification CRN SC 002.

Bonding cables shall be fitted with crimped lugs in accordance with the provisions of Section 3 except for steel hypalon cable ends which shall be connected to the rail using the stainless steel grooved channel pin method of connection.

All bonds shall be duplicated except in areas subject to heavy traction currents when additional bonds may be required between adjacent impedance bonds and between impedance bonds and rails, as shown on the track bonding plans.

In general, all rail bonds shall be 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 Specification CRN SC 021.

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

Rail joints in non electrified areas shall be bonded using copper hypalon, steel 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 steel, grooved channel pins installed as detailed in Procedure B Appendix A, tapered bolts as detailed in Procedures A and C or welded studs as detailed in Procedure D Appendix A as applicable to the type of cable.

Rail joints in electrified areas shall be bonded using cables as nominated in Specification CRN SC 002. The connections to the rail shall be made using the copper bushes and stainless steel tapered bolts installed as detailed in Procedure A Appendix A or welded studs installed as detailed in Procedure D Appendix A or “Y”-link rail head welded connection as described in Appendix B.

Where parallel bonding is approved, the bonds on the parallel leg of a points track circuit in an electrified area shall be installed not more than 50 metres apart.

4.2.6. Rail Connection for Spark Gap Arrestor Bond

Spark gap arrestors are provided on some overhead wiring masts (generally at or near stations) and on all steel bridge structures. Connection is made using a PVC sheathed steel bonding cable from the spark gap terminated in a suitable crimp lug and connected to the rail using either the copper bush and stainless steel tapered bolt installed as detailed in Procedure A Appendix A or welded stud installed as detailed in Procedure D Appendix A or “Y”-link rail head welded connection as described in Appendix B.

For single rail track circuits the spark gap arrestors shall be connected to the common (traction) rail.

For double rail track circuits spark gap arrestors shall, in general, be connected to one rail for one half of the track circuit and to the other rail for the remainder of the track circuit.

4.2.7. Connections from Traction Negative Busbars to Rails

For single rail track circuits the bonds from the negative busbar shall be connected directly to the common (traction) rail.

For double rail track circuits, including audio frequency track circuits, the bonds from the negative busbar shall be connected to the rails via the neutral points of paired impedance bonds on each track.

The size and quantity of the bonds shall be as shown in. CRN SC 002.

The bonds shall be fitted with crimp lugs in accordance with the provisions of Section 3 and the rail connections shall be made using either copper bushes and stainless steel tapered bolts installed as detailed in Procedure A Appendix B or welded studs as detailed in Procedure D Appendix A.

4.2.8. Tie-in Bonds Between Tracks

For single rail track circuits the common (traction) rails shall be bonded directly together at the tie-in points.

The size and quantity of bonds shall be as indicated in CRN SC 002.

The bonds shall be fitted with crimp lugs in accordance with the provisions of Clause 4 and the rail connections shall be made using either the copper bushes and stainless steel tapered bolts installed as detailed in Procedure A Appendix A or welded studs as detailed in Procedure D Appendix A or “Y”-link rail head welded connection as described in Appendix B.

4.2.9. Electrolysis Bond Connections

Electrolysis bonds shall be as specified in Specification CRN SE 048.

Electrolysis bond connections shall be by twin copper hypalon (84/0.3mm) cables to each rail connected as detailed in Procedure C Appendix A or 6mm welded stud installed as detailed in Procedure D Appendix A.

Cables shall be to Specification CRN SE 035.

4.2.10. 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 Specification CRN SE 035 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 lampcases, half pilot staff boxes etc) which is mounted on the signal post.

Terminals in both the signal base and signal lampcases, including subsidiary lampcases, shall be numbered in accordance with Specification CRN SE 036.

Multi-core cables to Specification CRN SE 035 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.

4.2.11. Point Machines

Local power and multi-core cables to points machines and associated equipment shall be to Specifications CRN SE 035 and 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 Specification CRN SC 021.

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

Flexible conduits shall be securely fixed to the point 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.

4.2.12. 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 Specification CRN SE 035 and 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 Specification CRN SC 021 for buried cable route.

A multi-core cable with the same conductor size, conductor insulation and sheath as required by Specification CRN SE 035 but without metallic screen or outer sheath, shall be installed between the terminals in the post base and those in the releasing switch.

4.2.13. Guards Indicators

Cables or wiring to guards indicators shall be protected by rigid and/or flexible conduit where the cable is not within the post on which the indicator is mounted. The cable or wire shall be to Specifications CRN SE 035.

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.

4.2.14. Emergency Switch Machine Lock (ESML), Emergency Operation Lock (EOL)

Where ESML's or EOL's are mounted on relay room walls, 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 to Specification CRN SE 035.

5. Wiring of Internal Equipment

5.1. General

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

Protection shall be provided at corners of cable trays, etc. and 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 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 7/0.4mm wire manufactured to the requirements of Specification CRN SE 035.

All internal wiring shall be terminated using crimp pins, bootlace ferrules or crimp lugs, as applicable, in accordance with the provisions of Clause 3.1.2.

5.3. Non-Vital Wiring

Non-vital wiring which is within the same cable tray or trunking as vital wiring shall be either 7/0.4mm wire manufactured to the requirements of Specification CRN SE 035 or multi-pair communications cable of 0.64mm minimum conductor size to Telstra Specifications.

Where single wires are used on non-vital equipment racks, the conductor shall be not less than 0.9mm in diameter.

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 Specification CRN SE 035. The minimum size of conductors shall be 7/0.85mm for DC mains cables and 7/1.70mm for AC mains cables.

6. Temporary Wiring and Stagework

Temporary wiring and stagework wiring shall be terminated using crimp lugs and crimp pins, as applicable, in accordance with the requirements of Clause 4.

Temporary cables and internal wiring shall preferably not be coloured black, and shall not be coloured red, blue or green. Alternatively if black they shall be fitted with a coloured sleeve at each end of the cable or wire for a distance of not less than 150mm.

The conductor cross sectional area in temporary cable shall be at least equivalent to 7/0.5 but the cable used may be to AS2373.1. Internal wiring shall be of at least equivalent conductor size to 7/0.4.

Where the work involves multiple commissionings, 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 stagework or other purposes shall be insulated and secured in a manner to prevent its contact with working circuits.

Limited in line crimp joints may be made in temporary or stagework wiring subject to specific prior approval. In-line crimps shall be covered with heat shrink sleeves extending over the wiring installation.

7. Jointing of Signalling Cables

7.1. General

All signalling and power cables shall be jointed with the materials and in accordance with the procedures in Specification CRN SE 029.

7.2. Inspection

Cable joints of signalling cable shall not be covered or backfilled until the joint has been inspected and approved.

8. Jointing of Communications Cables

8.1. General

This section applies only to copper conductor communications cables which are used in hard wired non-vital signalling applications. It does not apply to communications cables used for voice or data transmission.

8.2. Jointing Requirements

- All joints shall be enclosed in a re-enterable enclosure. Under no circumstances shall non re-enterable techniques be used.
- When jointing communications cables of up to but excluding 50 pairs a Krone PSI Z Type or equivalent joint enclosure shall be used.
- When jointing communications cables of 50 pairs or more a Krone PSI Type 2A or equivalent joint enclosure shall be used.
- 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.
- The protective jelly coating around the pairs of conductors shall, where possible, not be removed when jointing the cable. If small portions have to be removed, the Contractor shall use a soft, dry cloth. No de-greaser or similar substance shall be used.
- 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 'Scotchlocks' 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.
- Before commencing to crimp on each day the jointer 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, designated as defective and returned for repair.

- Under no circumstances shall defective crimping tools 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.
- The resistance per unit length of the connection between conductive screens at joints shall preserve or be less than the resistance per unit length of the respective screen.
- Each completed joint shall be tested and the original certified record shall be submitted to CRN's Representative.
- The Contractor shall ensure that all staff under their control are familiar with Occupational Health and Safety requirements regarding jelly filled 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 stagework paper labels may be used. The format and quality of these temporary labels shall be as approved.

High voltage equipment shall be conspicuously labelled in accordance with the relevant Australian Standards and Occupational Health and Safety 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 such 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 generally be white or yellow 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.

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.
- Busbars shall be clearly labelled (e.g. BX120, NX120, B50, N50, etc.)
- Each wire shall be labelled to identify the circuit which it feeds.
- At interface terminals between main cables and internal wiring, each internal wire shall be labelled to identify the circuit to which it belongs.

9.4. Plug-In Relays - Vital

All relay positions shall be labelled 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 the BR930 series relay coils (R1, R2, R3 and R4) shall be labelled with white beads with black inscriptions.

The labels on wires to all non BR930 series relays shall be white 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 which 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 background or black on a white or silver background.

The ends of all cables and wires to terminations on trackside equipment shall be labelled using appropriate 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.

9.8. Temporary Work and Stagework

All temporary work and stagework 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.

Unless otherwise approved, 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".

Appendix A Installation Procedures - Cable to Rail Connections

A.1. Procedure A

A.1.1 Copper Bush and Tapered Bolt Style Rail Connections

Copper bush style rail connections may be used for the connection of:

- track circuit cables (37/1.78mm),
- impedance bond cables,
- rail joint bonds (electrified areas),
- traction negative busbar cables,
- tie in bond cables,
- to the rails and installed in accordance with Standard Drawing No. D08301 and the following procedure:
    - Drill hole in the centre of the web using a sharp accurate machine twist or “Rotabroach” drill and using a water lubricant. (Oil shall not be used as part of the drilling process). Flat rail drills shall not be used.
    - Insert the copper bush from the outside of the track immediately the hole is drilled.
    - Insert the special three stage tapered punch as shown on Standard Drawing No. E08616 sheet 1 into the copper bush in the direction in which the bush has been inserted and hammer in the first stage of the punch to expand the copper bush into the hole in the rail.
    - Remove the special punch, and hammer the stainless steel tapered bolt into the copper bush in the opposite direction from which the bush was inserted into the rail. (i.e. from the inside of the track).
    - Check that the copper bush has not moved. If it has, remove the stainless steel tapered bolt and repeat the procedure nominated in 3 above using stage 2 of the special punch. The stainless steel tapered bolt shall then be re-inserted as nominated in 4 above.
    - Fit the track connections and nuts as shown on Standard Drawing No. D08301 and treat the bolt thread with anti-seize.
    - Tighten the nut and locknuts on the tapered bolt to 55 ± 5 Nm.

A.1.2 Procedure B

A.1.2.1 Stainless Steel Grooved Channel Pin Rail Connections

Stainless steel grooved channel pin rail connections shall be used only for the connection of steel hypalon or 7/1.4mm un-insulated steel cables to rails and shall be installed in accordance with the following procedure:

- Drill hole in the centre of the web using a sharp accurate 7.1mm (9/32″) machine twist drill and using a water lubricant. (Oil shall not be used as part of the drilling process).
- Bare 80mm in length of the insulation from the end of the steel hypalon cable.
- Insert the flexible steel conductors directly into the hole from the outside of the rail until the insulation (where present) is 10mm from the rail.
- Insert the grooved stainless steel channel pin with groove facing downward from the inside of the rail ensuring that the steel strands of the cable are bunched together and placed in the groove of the channel pin.
- 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.

A.1.3 Procedure C

A.1.3.1 Stainless Steel Tapered Bolt Rail Connections

Copper hypalon cables (84 x 0.3mm) shall be connected to rails using stainless steel tapered bolts, nuts and lock washers installed in accordance with the following procedure:

- Drill hole in the centre of the web using a sharp accurate machine 7/8″ twist drill and using a water lubricant. (Oil shall not be used as part of the drilling process).
- Hammer the tapered stainless steel bolt into the hole as far as possible, from the inside of the rail.
- Fit the track connections as shown on Standard Drawing No. E08179/3.

A.1.4 Procedure D

A.1.4.1 Welded Stud Rail Connections (involving exothermic welding process)

A.1.4.2 Qualified Personnel

The connection of cable to rail using welded stud rail connections shall only be performed by persons who have been trained and accredited in the application of welded stud rail connections by the supplier of the material being used or by a recognised signalling training organisation.

Welded stud rail connections shall be installed in accordance with the following procedure:

A.1.4.3 Safety

- Persons involved in the installation of welded stud rail connections shall wear appropriate protective clothing.
- Equipment designed and constructed for welded stud installation shall be used.
- Ensure the mould and the welding materials are free of moisture and contaminants. Contact of molten weld metal with moisture or contaminants may cause the weld metal to spurt out of the mould.

A.1.4.4 Weld Preparation

Before commencing the weld ensure:

- The mould is not worn or broken. Worn or broken moulds may cause leakage of molten weld metal and result in safety problems and unsatisfactory weld connections.
- The mould fits the weld area and closes correctly.
- The mould is securely attached to the rail using the manufacturer’s recommended rail clamp.
- The mould is clean of slag from previous welds. (Foreign material shall be removed with a short haired brush. Wire brushes or sharp implements shall not be used as these will shorten the life of the mould).
- The mould is not wet or damp. (Wet or damp moulds will result in porous welds). Remove moisture from the mould using a hand operated butane torch or by firing a charge in the mould before making the desired weld.

A.1.4.5 Rail Preparation

- Select the area on the rail for attachment of the stud. Ensure there is a minimum distance of 80mm is between the proposed weld and any other weld. (This will prevent the second bond cable applying pressure to the lug of the first bond at the weld location).
    - Do not attempt to apply stud over raised lettering on the rail web.
- Grind off all mill scale and rust from the rail surface over the required area of the neutral axis of the rail such that the area is bright, clean and dry.
    - Warm the weld area and remove any moisture using a gas torch.
- Ensure the stud is completely clean. Studs shall be stored in a clean container with an airtight lid.

A.1.4.6 Igniters

Use a flint gun to ignite the cartridge. Ensure the flint gun is in good working order and will produce enough spark to ignite the cartridge. Clean fouled up flint guns by soaking gun in household ammonia.

A.1.5 Welding Procedure

- Insert the clean bright stud into the mould making sure there is a minimum of 1mm between the stud and the rail. If this distance cannot be achieved, the mould is uneven or worn and should be replaced.
- Secure the mould to the neutral axis of the rail making sure the mould is firmly against the clean bright web section of the rail.
- Insert the steel disk, dished side up, directly centred over the hole in the bottom of the crucible.
- Pour the correct weld powder cartridge size into the crucible being careful not to disturb the steel disk. The initial powder material will flow out of the container easily. Do not attempt to scrape the material out of the container.
- Tap the bottom of the cartridge to loosen all the starting powder and spread the powder evenly over the top of the weld powder.
- Close the safety lid.
- Check the mould and crucible ensuring the arrangement is secure and safe for ignition. Stand upwind of the arrangement and aim the flint gun to the opening in the safety lid and ignite.
- As soon as the charge ignites, withdraw the flint gun quickly.

- Check that molten metal is not escaping from the mould during the welding process.
- Allow approximately 20-30 seconds for the weld metal to solidify before opening the mould.
- Loosen the mould securing devices and remove the mould pulling directly and squarely from the rail. Remove the sprue and any excess slag from the top of the rail.
- Check that there has been no excess overflow of weld metal which indicates an unsatisfactory porous weld. Check also that the surface of the copper boss around the stud is smooth and clean.
- Where there has been an overflow of weld metal or any other indication of a defective weld, the civil representative is to be informed to permit an assessment to be made on whether the integrity of the rail has been affected.

A.1.6 Fixing Cables to Studs

Always ensure the stud and contact surface is clean before fitting the lug. Fit the cable lugs onto the studs, treat the threads with anti-seize and tighten nuts and locknuts to 50 ± 5 Nm.

Appendix B "Y" Link Rail Head Welded Connection

B.1. General

This method of connection to the rail uses the 'Cadweld' system of welding 70mm″ copper cable to the outside of the head of the rail.

B.1.1 Applicability

This method of connection may be used with the following traction bonding cables:

- 608/0.5 copper
- 962/0.5 copper
- 962/0.5 Aluminium
- 494/0.5 Aluminium

B.1.2 Materials Required

Cable	Cadweld Bond	Crimp Link	Heatshrink Tube	Crimping Device
608/.05 Copper	355mm	CASR 199/120 RSA	40/12 TK-125	HT-130-C-150
962/0.5 Copper	355mm	CASR 199/185 RSA	40/12 TK-125	38-223A1
962/0.5 Aluminium	355mm	BLK 182/199	40/12 TK-125	HT-150/185 A1
494/0.5 Aluminium	355mm (half only)	BLK 97/70 RSA	34/7 TK-100	HT-95/120 A1

B.1.3 Description

For 608/0.5 and 962/0.5 copper and 962/0.5 aluminium cables the connection consists of the 355mm Cadweld bond cut in half with the two ends inserted into the nominated crimp link and crimped to the end of the bonding cable. The nominated heat shrink sleeve is placed over the link and cable (not over the Cadweld bond). The Cadweld bonds are then welded to the rail head using the Cadweld process.

For the 494/0.5 aluminium cable the connection consists of one half of a 355mm Cadweld bond inserted into the nominated crimp link and crimped to the end of the bonding cable. The nominated heat shrink sleeve is placed over the link and cable (not over the Cadweld bond). The Cadweld bond is then welded to the rail head using the Cadweld process.

The procedure for the welding shall be otherwise as per Procedure D of Appendix A