

Category 2 Standard

S2525 Signalling Installation Handbook

(Includes S&CSE-ST0021 A2)

Issue No.: A3

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MAYOR OF LONDON

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1 Purpose

- 1.1 This standard defines the minimum requirements for the installation, testing and commissioning of asset types and equipment associated with LU's legacy signalling system, which comprises two aspect signalling with AC fed track circuits, plus mechanical trainstops and interlocking.
- 1.2 The purpose of this cover document is to enable continuity of signalling documentation, consistency of document numbering and provide traceability through the recorded document history.

2 Scope

- 2.1 The details of legislative requirements, national and international standards, company rules and procedures, equipment, tools and PPE may have changed since the issue of S&CSE ST0021-A2, but the principles of safety, security, training, efficiency and responsibility remain.
- 2.2 This standard is to be superseded by a new Installation Handbook, planned for November 2012.
- 2.3 This document contains S&CSE-ST0021-A2 (dated February 2001) as an Appendix.

3 Requirements

These are detailed in the attached document.

4 Responsibilities

Responsibilities are detailed as necessary in the various topics addressed by C&CSE-ST0021-A2.

5 Supporting information

Written Notice LU-WN-00980, dated 10-03-2011 clarifies requirements for temporary and permanent labelling of wires at installation, and gives details of permanent labels that may be used.

Written Notice LU-WN-01102 dated 24-01-2012 clarifies the requirements regarding the fitting of permanent labels to cable cores prior to terminating the ends in external trackside equipment such as CCTB's/DB's/TDB's/ Kiosks etc.

6 References

Documentary references are detailed in the attached document, but it should be noted that they are subject to update and revision.

6.1 Technical content manager

Paragraph number	Technical content manager
All	The Professional Head of Signalling



6.2 Document history

Issue no	Date	Changes
S&CSE-ST0021-A2	February 2001	Standards categorisation data added. No technical changes. Authorised for use.
S2525 A3	March 2012	As per DRACCT 00609, cover document added to provide traceability and consistency in CMS. No technical changes.



7 Appendix

'Installation Handbook Standards', S&CSE-ST0021 A2, February 2001 (250 pages), plus
Written Notice LU-WN-01102 dated 24-01-2012.



Written Notice	LUL Ref No: LU-WN-01102	
	Suppliers Ref No:	

1.	Written Notice Completed By	
	Technical Content Manager:	J. M. Irwin
	Directorate:	CPD
	Date issued:	24 January 2012
2.	Details of Standard Requiring Clarification	
	Title:	Installation handbook Standards
	Standard No:	SCS-ST0021
	Version:	A2
	Clause:	9.1 and 9.5
3.	Details of Definitive LU Interpretation of Requirements	
	Title:	Labelling during installation
	Written Notice Issued 10 March 2011 (LUL Ref No: LU-WN-00980) clarifies the requirements in clauses 9.1 and 9.5 for labelling during installation. These requirements do apply to fitting permanent labels to cable cores prior to terminating the ends in external trackside equipment such as CCTB's/ DB's / TDB's/ Kiosks etc.	



**LONDON UNDERGROUND LIMITED
SIGNAL & CONTROL SYSTEMS ENGINEERING**

INSTALLATION HANDBOOK STANDARDS

**DOCUMENT NO. S&CSE-ST0021-A2
DATE FEB '01**

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1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

This document sets out the requirements for the installation, testing and commissioning of signalling equipment. All signalling equipment on LUL must be installed, tested and commissioned in such away that it meets the following objectives:-

- a) To provide assurance of safety for customers and staff at all times;
- b) To cause a minimum of disruption to the normal running of the railway;
- c) To verify and record that the immediate design aims of the system have been achieved;
- d) To permit efficient and effective maintenance of the completed system..

(Cat 3)

To ensure that high standards of Safety and Quality are achieved it is important that all staff involved in the installation of equipment be provided with adequate working conditions, documentation, tools, equipment, transport, communications and time. Staff must be fully trained for the job and be given refresher training as appropriate. (Cat 3)

Safety Standards must be followed absolutely. These cover both the requirements of equipment and personnel and are dealt with in section 1.2. (Cat 3)

This document includes installation practices which may be relevant to all types of signalling work, including new construction, modernisation projects and modification of existing installations. However, it assumes current or recent practice and is therefore not exhaustive. For example the installation practices relating to interlocking machines are included but other types of mechanical interlocking are excluded. (Cat 3)

The document sets out minimum requirements that may be adopted, but if a contractor's methods exceed those of this document they may be adopted if approved by the S&CSE. (Cat 3)

This document must be read in conjunction with S & CSE Standards, Systems Specifications, Equipment Specifications, Quality Systems Specifications and Departmental Quality Notices. (Cat 3)

Where drawing numbers are quoted in this Handbook the contractor must ensure that they are using the most recent issue. (Cat 3)

1.2 Safety statement

When carrying out any form of installation work the most important aspect of the work is safety. Due regard shall be given to all aspects of safety, and in particular:-

Occupational Safety The Health and Safety of employees whilst the work is being carried out.

Operational Safety The Safe operation of the Railway during and after the work.

(Cat1) & (Cat 5)

1.2.1 Occupational Safety

To ensure that the work is carried out such that staff will not be endangered, all relevant Rules and legislative requirements must be followed, including:-

Health and Safety at Work etc. Act 1974
The London Underground Railway Rule Book and its Appendices
Safety Reference Manual
Engineering Instructions
Local Safety Procedures
Electricity at Work Regulations 1989
Compressed Air Regulations
Control of Substances Hazardous to Health Regulations 1988
Fire Precautions ACT 1971 - and later Section 12 requirements
Safety Signs Regulations 1980
Noise at Work Act Regulations 1989

(Cat1) & (Cat 5)

Many locations or jobs will require that Personal Protective Equipment (PPE) is worn. It is essential that the correct PPE is worn and that the condition of the PPE is of the standard required to give protection. Prior to using the equipment the user must be trained in its use such that the manufacturers instructions for use are followed at all times. All PPE should be regularly inspected and a record kept. Any PPE that fails an inspection must be discarded. (Cat1) & (Cat 5)

Personal Protective Equipment includes any item of clothing, footwear, gloves, pads, headgear, spectacles/visor, respiratory device, High Visibility vest, ear defenders or other device that provides protection for an individual against injury, industrial disease or disablement that may be incurred as a result of occupational responsibilities. (Cat1) & (Cat 5)

Personal Protective Equipment must comply with the relevant statutory provisions on design and manufacture with respect to safety and health, and all appropriate British Standards. (Cat1) & (Cat 5)

Personal Protective Equipment shall meet the following requirements:

- a) It must be appropriate for the risks involved, without itself leading to any significantly increased risk.
- b) It must correspond to existing conditions at the site of work.
- c) It must take account of ergonomic requirements and the employee's state of health.
- d) It must fit the wearer correctly after any necessary adjustment.

e) Where the presence of more than one risk makes it necessary for an employee to wear simultaneously more than one item of PPE, all items must be compatible and continue to be effective against the risk or risks in question.

f) The conditions of use of PPE, in particular the occasions on which it is to be used, shall be determined on the basis of the seriousness of the risk, the frequency of the exposure to the risk, the characteristic of the work location of each employee and the performance of the PPE, **except where PPE is specified by local regulations and/or the Rule Book (e.g. the wearing of approved high visibility jackets when on the track).**

g) PPE may be issued on a personally allocated basis where frequency of use or considerations of hygiene dictate.

If the circumstances require PPE to be worn by more than one person then, appropriate measures shall be taken to ensure that such use does not create any health or hygiene problem for the different users.

h) There shall be a record kept for the controlling of the issue and use, inspection, maintenance and replacement of all non-disposable items that will comply with any of the statutory provisions. This record should be available for inspection.

i) Staff must be informed of the risks against which the PPE protects them.

j) Staff will be instructed in the need for and use of, cleaning and maintenance of PPE. This instruction will be recorded.

(Cat1) & (Cat 5)

1.2.2 Operational Safety

Where the work is carried out on or near to a commissioned installation it is essential that the following conditions are met:

a) The working of the signalling equipment during traffic hours must remain safe in every respect. (Equipment must be protected whenever there is a risk of tools, debris etc. coming into contact with it. see chapter 4.3)

b) Except where a specific agreement has been reached with the Passenger Services Directorate and published in the Traffic Circular, work must be planned so that the operation of trains is not disrupted in any way.

When these conditions cannot be met then the work shall be carried out during Engineering Hours or a Possession, when there will be no interference with the working of trains. When any such work is carried out which interferes with the operation of signalling there shall be a full test (or in some cases a partial test if authorised by the S&CSE or by the Standards and Safety Engineer) of the installation work and affected equipment prior to the running of trains. (Cat1) & (Cat 5)

1.3 Security

Site security is necessary to prevent the following:-

- a) Unauthorised interference with signalling equipment or secure installations;
- b) To prevent injury to untrained staff;
- c) To prevent loss of equipment and materials.

(Cat 2)

Access to equipment rooms, from the pre-commissioning stage onwards shall be controlled in accordance with S&CSE DQN 001 and S&CSE DQN 023. (Cat 2)

After working at a trackside location it is essential that equipment cases are closed and secured. At surface sites equipment cases must be locked and equipment not in cases secured in its prescribed manner. (Cat 2)

Where work is going to take more than one shift and there is a significant amount of materials and equipment then equipment must be left in a secure place where it will not obstruct any emergency passage or exit from any building. Such material shall not normally be stored within commissioned signal equipment rooms unless special arrangements have been authorised by the Standards and Safety Engineer and agreed by the responsible Line Engineering Manager's representative. Where equipment is temporarily stored at a trackside location it shall be stored such that it is secured, and cannot become foul to gauge. Cabling in track areas should not be installed with excessive slack so that it could become foul to gauge (See section 4.5 of this Handbook, including storage of flammable liquids). Refer to 6000/EI/009 & 046. (Cat 2)

The Control of Keys to Secure Rooms Refer to DQN No. S&CSE-SQ-DQN-009- (Cat 2)

1.4 Working in Equipment and Control Rooms

During Installation work it is essential that the site of work is kept tidy for both safety and efficiency. If the room is a working installation then the work should be carried out in accordance with sections 4,5,6,7 & 13 of this handbook.

The following rules shall apply:

- a) The room must be kept clean and tidy at all times.
- b) Smoking is not permitted as laid down in the Rule Book and general notices.
- c) Food or drink may only be consumed in designated areas.
- d) Only persons engaged in installation, testing or inspection of the work are allowed in the room. (Also maintenance staff in the case of a commissioned room being prepared for modification).
- e) Ladder racking and trunking must not be allowed to accumulate debris. Debris must not be allowed to build up anywhere in the room.

- f) Metallic materials/equipment must not be left at any time in a position such that it can fall onto relay tops or other electrical connections if disturbed (See section 4.3 for the protection of working equipment).
- g) All tools on site must be in good working order and must be made available at any time for inspection by the Supervisor or other authorised persons.
- h) All entrances and exits to the room must be kept clear and Staff made aware of fire evacuation procedures and other local rules and regulations.
- i) All staff shall be made aware as to the location of First Aid Equipment and First Aider.
- j) Where work is liable to damage walls or floors adequate protection should be provided.
- k) Protection must be provided for all working equipment and circuits in the room that may be affected by the work.

(Cat 2)

1.5 Working Environment

Environmental Conditions must be good enough to allow high quality work to be produced

This involves achieving as far as possible:

- a) Adequate lighting.
- b) Easy access to equipment and wiring runs.
- c) General cleanliness and removal of non essential materials and equipment.
- d) Adequate provision of heating, ventilation or cooling fans.
- e) Adequate time to carry out the designated task.

(Cat 2)

1.6 Amendments Procedure

All controlled copies of the Signal Installation Handbook will be subject to a controlled amendment procedure by the S&CSE. Instructions on how to amend the Handbook will be issued with the amendments. (Cat 3)

1.7 Suggestions procedure

To enable errors or omissions to be highlighted an amendment suggestion form is included. Please photocopy the form as required and include any sketches, drawings etc. on further Continuation sheets as required and forward via the issuing authority to the S&CSE.

Signalling Installation Handbook S&CSE ST0021 Amendment Suggestion	
Page	of
To	The Specifications Manager Systems & Control Engineering London Underground Limited, 8th Telstar House, Eastbourne Terrace, London W2 6LW
From:-	
Position:-	
Company:-	
Address:-	
Tel:-	
Your Ref:-	
Date:-	
Chapter:-	
Revision:-	
Page (s) No (s)	
Amendment Suggestion	

Signalling Installation Handbook
S & SCSE ST0021
Amendment Suggestion
Continuation Sheet

Page	of	Your Ref:-
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2.0 TOOLS, TECHNIQUES AND EQUIPMENT

2.1 HAND TOOLS

2.1.1 Tool Selection

Each job will almost always require some form of hand tool to be used. Always use the correct tool for the job and ensure that it is in a serviceable condition. Failure to use the correct tool can lead to equipment damage and injury to the user or other persons. Always ensure that the tool being used has been manufactured to a British Standard or other approved standard, and is in a sound condition. When using tools such as spanners, screw drivers or nut spinners etc. always ensure that the correct size tool is used to avoid both damage to the tool and nut/screw. Never use pliers to tighten nuts and bolts as they are not designed for this purpose. Tools should only be selected by a person who is competent to ensure their correct use. (Cat 2)

Insulated tools for electrical work must be insulated to either of the following standards:-

ESI 26-3 Hand Held Insulated Tools for live working up to 1000 V
CEI IEC 900 Hand Tools for Live working up to 1000 V AC & 1500 V DC
(Cat 2)

These insulated tools must have the integrity of the insulation checked periodically (6 months or less). They must be kept apart from other tools and each other in tool boxes to prevent mechanical damage during transit. Tools that use two layers of different coloured insulation must be tested if the inner insulation shows through to the surface. (Cat 2)

2.1.2 Tool Storage and Carriage

All tools must be stored and carried in accordance with manufacturers instructions. Care must be taken to ensure that blades, spikes and sharp edges are protected with suitable guards. Tools must be stored or carried in such a manner that they do not damage each other. All carrying cases must be of a sturdy construction and must not allow tools to protrude through holes. (Cat 2)

Sharp tools should never be carried in pockets. Unguarded tools must not be carried on public transport. (Cat 2)

Always return tools to the tool kit when not in use. (Cat 2)

2.1.3 Tool Maintenance

Defective tools must not be used. The matter should normally be raised with the supervisor and a replacement/repair sought. Tools should be checked regularly as part of the normal working routine. Cutting edges should be kept sharp, hammer and file handles checked that they are secure and have no splits. Chisels must be checked to ensure they do not have mushroom heads. A light oil on some tools will prevent rusting (see manufacturers instructions for oil type). (Cat 1)

When a tool becomes damaged and a repair can be affected it should only be undertaken by a competent person. (Cat 1)

Insulated tools for electrical work must not be derated if damaged. They must be either repaired by a qualified person and re-certificated or disposed of. (Cat 1)

2.1.4 Protection

Manufacturers safety instructions must be observed to use tools safely and to prolong their life. Never use a tool for a job not intended for its purpose eg never use a chisel as a screw driver or pliers as a spanner. (Cat 1)

The most important rule for all jobs involving striking or struck tools is to wear eye protection. Eye injuries are the most traumatic suffered by users of hand tools. Remember that with some jobs there may be no choice in the matter as the wearing of eye protection is a statutory requirement that must be enforced. (Cat 1)

On certain jobs such as breaking brick, it may also be advisable to wear suitable gloves to protect the hands and lower arms. When carrying out work with tools, the user must ensure he is correctly protected and if unsure the user should seek guidance from their supervisor or manager. (Cat 1)

2.2 POWER TOOLS (Including Battery Driven Tools)

2.2.1 Tool Selection

As for hand tools the selection of the correct power tool for a job is essential to produce a safe and efficient result. All power tools used on LUL should conform to BS 2769. All tools should be inspected before use to ensure the electrical insulation on leads and plugs is not split, or the sheath is exposing the internal wires. If any fault is suspected the tool must be labelled and returned to stores for repair by a competent person. Tools must not be issued or accepted for use unless they have a current Flash Test Certificate. (Cat 2)

When using the tools ensure that the drill/grinding wheel etc is correct for the work being undertaken, for example do not use drills designed for metal to drill masonry. (Cat 2)

2.2.3 Maintenance

All tools must at least annually and whenever repaired be flash tested to test the integrity of the insulation. A record of each test must be kept and action taken in the case of failures. When a tool passes the test it shall be issued with a certificate recording the date of the test. Specialist tools such as Bright Bond should be returned to the manufacturer or approved service engineer for maintenance and testing at least annually. When a tool becomes damaged and a repair can be affected it should only be undertaken by a competent person. (Cat 2)

2.2.4 Protection

When drilling or grinding eye protection must be worn at all times by all persons in the vicinity of the work, not just the person carrying out the work. If it is not possible to protect all persons in the vicinity then protective screens must be provided.

Most modern power tools when operated are reasonably quiet, however in certain circumstances they can become noisy and produce a health hazard. When drilling into concrete in a confined space such as a tunnel or platform invert ear defenders should be worn to protect the ears as the noise levels could be damaging. (Cat 2)

Angle grinder operators must be qualified to the Abrasive Wheels Regulations 1970 (see Health and Safety Executive Guidance Note PM22) before using such equipment. Bench operated power tools must have the correct guard(s) in place during use. (Cat 2)

2.3 CRIMPING

A crimped termination is formed under controlled compression causing equal displacement of metal. All voids, within the area of pressure, are filled forming a cold weld. Crimp terminations shall be used for all stranded conductors. (Cat 3)

Cable with a solid conductor, that is less than, or equivalent to, the pitch of the thread of the stud, to which it is to be electrically connected to, shall use crimped terminations. For the forming of a wire loop is covered in section 2.3.6 of this handbook. (Cat 3)

2.3.1 Tooling

Tools and dies listed in section 2.3.2 below are presently approved and used by London Underground Limited. The notes given on calibration are for guidance only and not exhaustive. The manufacturers handbook shall be consulted for areas omitted from this text. Monitoring of the tools and dies shall be conducted via a Quality Assurance procedure that is acceptable to the Client Engineer. (Cat 3)

In the event that either a procedure does not exist or does not satisfy S&CSE requirements, S&CSE procedure S&CSE DEP 703 PR Control of Inspection, Measuring & Test Equipment shall be adopted. (Cat 3)

2.3.2 Tools, Manufacturers and Uses

a) RTB 510 (Manufacturer CTT)

This tool is predominantly used within London Underground, and when used with a range of interchangeable dies, covers the majority of terminations used. The tool incorporates a ratchet mechanism, which once engaged, will not release until the crimping cycle has been completed.

DIE INSERTION

Prior to the insertion of dies the compression force of the tool shall be checked. A slip gauge (CTT Part No. GNG 10RT) shall be used. The tool shall be closed to the last click before release, and the gauge at this point shall not be able to be removed from the jaws. Any tool failing this inspection operation shall not be used.

Ensure die locator grooves, on underside of dies, and tool jaws are clean prior to the assembly. Die with colour identification shall be assembled to the fixed jaw of the tool. Hand tighten die securing screws and close tool to last click before release. Tighten securing screws fully.

Using the appropriate GO NO-GO gauge for the particular die being used, check for worn dies. Close tool to the last click before release and insert the GO end of the gauge, this shall slide through the dies. The NO-GO gauge may enter partially into the dies but not through. Any dies failing this inspection operation shall not be used.

(Cat 3)

b) RTU-H-150 (Manufacturer CTT)

The RTU-H-150 hand operated ratchet tool is used to form crimps on heavy duty terminations within the range of 10 sq mm to 150 sq mm.

The tool incorporates a double eccentric drive and maintains an even gradual build up of compression.

The crimping cycle is complete when the indicator on the 'T' handle is in line with the indicator on the body of the tool (usually shown by yellow dots). Further activation of the handles will release the pressure from the dies which will begin to open.

The completed termination is removed by backing off the pressure from the dies and releasing the spring catch to hinge back the crimping head.

Sizes up to 50 sq mm need only one crimping operation but 50 sq mm and above require a dual crimp with a spacing of 2 to 3 mm between them See fig 2.5.

DIE INSERTION

Prior to the insertion of dies the compression force of the tool shall be checked. A gauge (CTT Part No. TB-150RT) shall be used. The tool shall be closed until the die faces come in contact with one another and the number of clicks counted from this point to the moment of release (when the two indicators are adjacent to one another). This shall be within the range of 4 to 6 clicks. Any tool failing this inspection operation shall not be used.

Dies are retained within the tool by spring loaded balls within the tool head. These balls, when the dies are inserted, drop into recesses within the dies. Ensure that these balls are free moving prior to the assembly of the dies.

Using the appropriate GO NO-GO gauge for the particular die being used, check for worn dies. Close tool to the last click before release and insert the GO end of the gauge, this shall slide through the dies. The NO-GO gauge may enter partially into the dies but not through. Any dies failing this inspection operation shall not be used.

(Cat 3)

c) BUCHCANAN TOOL (Manufacturer Astro Tools Ltd.)

This tool has a four indentation crimping action and is used for the termination of pins and sockets used within the Harting and Thomas & Betts connectors.

For each size of pin/socket to be terminated a separate gauging pin is required. Refer to Appendix 2.3.A.

Using the thumb wheel, between the handles, adjust the crimping jaws so that the guide pin is a slide fit. Lock adjustment using special 'C' spanner prior to use.

Each different size of pin/socket requires a separate locator, which positions the pin/socket for crimping. See Appendix 2.3.A for locator required for each contact.

(Cat 3)

d) CRIMP TOOL (M22520/1/01) Refer to appropriate Quality Products List for approved sources. (See Appendix 2.3.A)

This tool will eventually become the mainstay tool for pin and sockets for the BICC Vero, Harting, Thomas & Betts and Litton connectors.

The tool shall be gauged using GO NO GO gauge M22520/3-1.

This is done by setting the wire gauge dial to 4. The tool shall be closed and the NO GO end of the gauge offered to the jaws, the gauge shall not enter the jaws.

The correct turret (refer to Appendix 2.3.A) shall be selected for the range of contacts to be terminated and secured in position using screws supplied. Each turret has the contact part number on it.

(Cat 3)

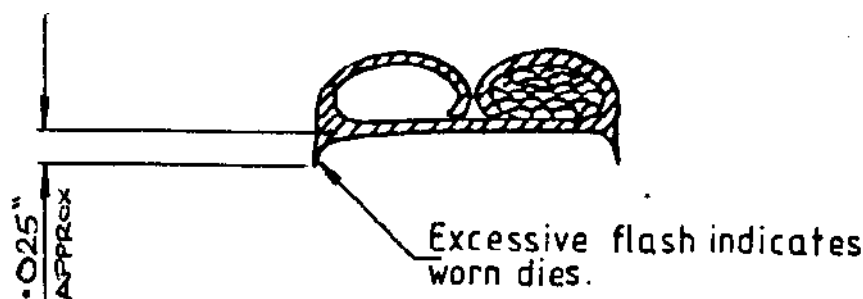


Fig. 2.1 Effect of Worn Dies

(Cat 3)

e) H7-B (Manufacturer Interconnection Products)

This tool is used for the use of butt splice crimps. These crimps SHALL not be used without prior written approval from the Safety Engineer S&CSE. (Cat 3)

This tool is handed, and care must be taken to ensure the crimping operation is being conducted correctly. (Cat 3)

(Cat 3)

f) RS8 & RS10 (Manufacturer Hellermann)

These tools are used in the termination of plug-in style Q relays. (Cat 3)

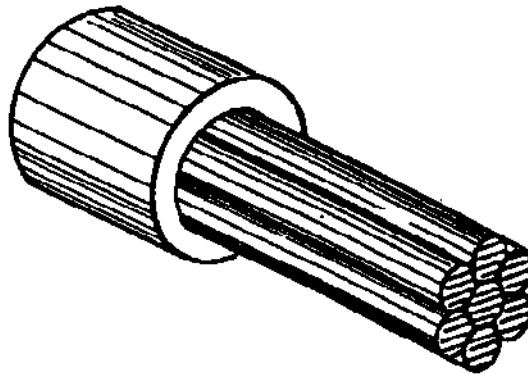
Both the tools and crimps are coloured coded to aid identification. White handled tools, the RS10, are for use with the 1,5 sq mm gold flashed terminations and the blue/red handled tools, the RS8, are for the 1 sq mm silver plated terminations. These tools and crimps are NOT interchangeable. (Cat 3)

Prior to usage of the tool a sample crimp shall be made and inspected for excessive flash on the underside of crimp. Excessive flashing indicates a die wear and shall not be used. See Figure 2. (Cat 3)

2.3.3 Cable Preparation

The strength and integrity of the crimped termination is very much dependant on the preparation of the cable end to be terminated. (Cat 3)

The conductor end when cut shall be left square. See Figure 2.2 (Cat 3)



AFTER INSULATION, STRIPPING, CONDUCTOR STRANDING SHALL BE LEFT UNDAMAGED AND CUT SQUARE. INSULATION SHALL BE UNDAMAGED.

Fig. 2.2 Conductor End After Cutting

(Cat 3)

If wire stops are to be used, to aid stripping length, it is recommended that a piece of spare cable is used to adjust settings of the stripping length prior to commencing work, this setting shall be checked periodically during use. Cable strippers used shall not nick, or cut the conductor stranding and shall leave the insulation clean and square on the conductor. For this task it is recommended that radial cutting blades to Mil 16878 Type E are employed. The stripping tool jaws shall not puncture the cable insulation. Jaw impressions shall be permissible but shall not penetrate the insulation/sheathing. (Cat 3)

2.3.4 Termination Selection

The termination shall be selected from Appendix 2.3.A to suit the cable gauge and stud diameter. Only pre insulated crimps are to be used, with the exception of copper tube crimps (Heavy Duty), 'Q' relay crimps and connector contacts (Litton, Verospeed & Harting). (Cat 2)

Ring tongue and forked terminations have colour coded insulation relating to compatible wire gauges, these are as follows :

Red insulation denotes cable entry size of 0,25 to 1,65 sq mm

Blue insulation denotes cable entry size of 1,04 to 2,65 sq mm

Yellow insulation denotes cable entry size of 2,63 to 6,64 sq mm

(Cat 2)

For bootlace ferrules the insulation colours are as follows :

Red insulation for 1 sq mm cable,

Black insulation for 1,5 sq mm cable and grey insulation for 2,5 sq mm cable.

(Cat 2)

Vibration resistance crimps shall be used for equipment that will be mounted on or adjacent to the track. (Cat 2)

Selection of terminations other than those listed in Appendix 2.3.A shall be referred to the S&CSE Specification Section for approval, prior to them being used on any Signalling installation. (Cat 2)

2.3.5 Making Of The Crimp

a) RING TONGUE AND FORKED TERMINATIONS

Refer to Appendix 2.3.A for tool and die selection.

The termination shall be inserted into the die with the palm facing up and protruding from the right hand side of the die. The insulation on the termination shall be centrally disposed within the die faces.

The only exception to this is the screw in Q relay terminations. For this application specially developed dies for London Underground are used. The crimp in this instance does not protrude from the die and incorporates a stop to position the crimp within the die.

Apply pressure to the tool handle, enough to gently hold the termination in place, too much pressure and the barrel will be deformed and insertion of the conductor will be difficult or even impossible.

Cable is to be inserted into crimping barrel. Ensuring all strands of the conductor are included. The conductor shall protrude 1 mm (0.04") through the barrel. The insulation of the conductor shall not protrude into the barrel but shall enter the insulation support tube of the termination. See Figure 2.3

Close the handles of the tool fully to complete the crimping cycle.

Remove termination from tool and visually inspect for correct operation and professionally made crimp.

(Cat 2)

b) BOOTLACE FERRULES

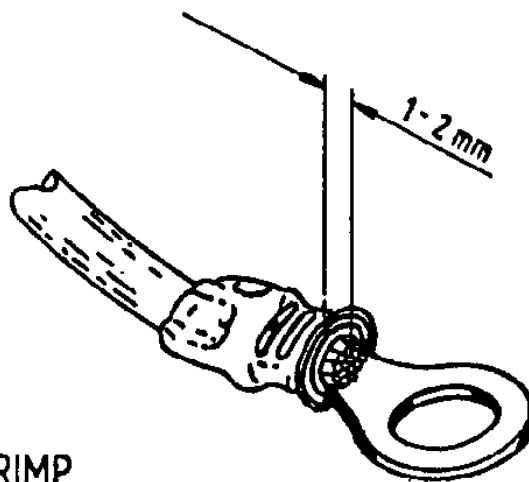
Refer to Appendix 2.3.A for tool and die selection.

Strip insulation from conductor so that when the conductor is inserted into the ferrule the conductor are flush or sub flush with the end of the ferrule. Insulation of the cable shall enter the insulation tube on the ferrule.

Place the ferrule into the correct dies for the ferrule and activate the tool through the full crimping cycle.

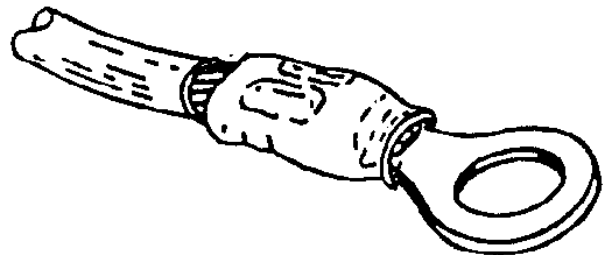
Remove ferrule from the tool and visually inspect for correct operation and professionally made crimp.

(Cat 2)



ACCEPTABLE CRIMP

Cable insulation gripped.
Dies central on termination.
Cable stranding protruding.



FAULTY CRIMP

Cable insulation short.
Dies not central on termination.
Cable stranding not protruding sufficiently enough.

Fig. 2.3 Acceptable and Faulty Crimps

(Cat 2)

c) CONNECTOR TYPE CONTACTS

Refer to Appendix 2.3.A for tool, locator and gauge selection.

Connector pins and sockets have blind crimping barrels. Conductors when inserted, shall be visible through the inspection hole in the crimping barrel. See Figure 2.4. It shall be permissible for the cable insulation to be

1 mm (0.04") Max. from the face of the crimping barrel.

Tooling for connector contacts incorporate locators that position the die jaws in the correct position on the crimping barrel. Ensure the correct locator and tool is used for the pin/socket to be terminated.

Insert conductor into pin/socket and inspect for conductor protrusion through inspection hole. Place pin/socket into tool until the pin/socket bottoms within the locator.

Apply pressure to tool and complete the crimping cycle.

Remove pin/socket from the tool and visually inspect for correct operation and professionally made crimp.

(Cat 2)

d) HEAVY DUTY TERMINALS

Refer to Appendix 2.3.A for tool and die selection.

Heavy duty terminals have inspection holes to facilitate the inspection of full insertion of the conductor into the crimping barrel. Cable insulation shall butt against the crimping barrel.

Tool shall be viewed with the fixed jaw on top.

Termination shall be inserted from the left hand side of the tool until the bell mouthed crimping barrel butts against the die sides.

Non bell mouthed crimping barrels shall be positioned so that the dies crimp on the barrel 1 to 2 mm from the cable entry.

Operate the tool through its complete crimping cycle. Release tool and for cable gauges 50 sq mm and above, reposition termination and repeat the action such that a second crimp is formed 2 to 3 mm from the first.

See Figure 2.5. Release tool and visually inspect the crimps'.

(Cat 2)

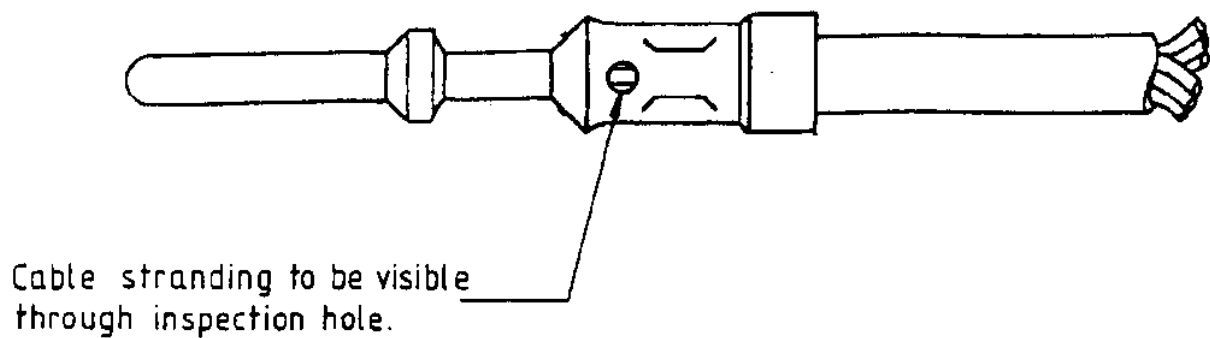


Fig. 2.4 Crimping Connector Pins

(Cat 2)

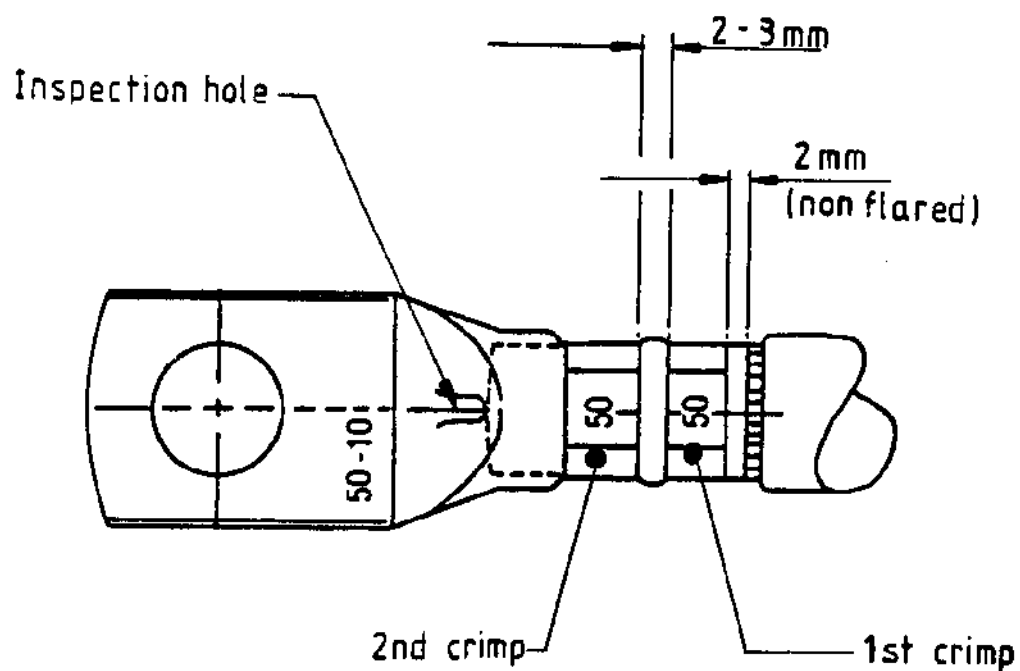


Fig. 2.5 Crimping of Heavy Duty Terminals

(Cat 2)

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e) IN-LINE BUTT CRIMPS

A range of in-line butt crimps have been approved (refer to Appendix 2.3.A) but SHALL NOT be used for general use. Any requirements for the use of such crimps shall require prior approval from the Safety Engineer S&CSE.

The operator shall be made aware that the tool used for this operation is HANDED.

To preform the crimp on the right hand end of the splice. Hold the tool so that the engraved tool number is facing to the right. Position the splice so that the inner facing dies align with the edge of the crimping barrel. Insert cable ensuring the cable stranding is hard against the cable stop and the insulation of the cable is within the insulation sleeve of the splice. Apply pressure to the tool and complete the crimping cycle.

To connect the other end the tool SHALL be reversed and the operation as above repeated. See Figure 2.6.

(Cat 2)

f) PLUG IN 'Q' RELAY TERMINATIONS

The tools and crimps are coloured coded to aid identification. White handled tools, the RS10, are for use with the gold flashed terminations for 1,5 sq mm cable and the blue/red handles are for the 1 sq mm silver plated terminations.

The correct combination of tool and crimp MUST be used.

Strip insulation from cable allowing for conductor stranding, when inserted into crimping barrels, to protrude by 1 to 2 mm.

Ensure ALL strands enter the crimping barrel, slight twisting of the stranding may aid this operation.

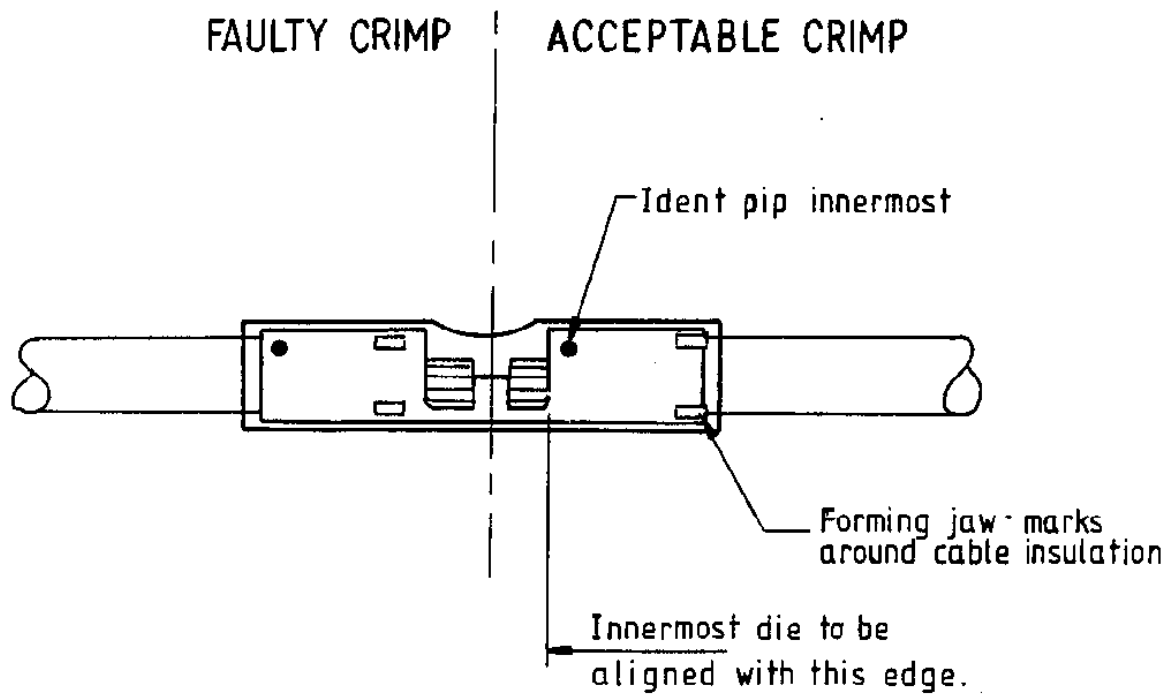
Ensure cable insulation fully enters the insulation support portion of the crimps prior to offering crimp to tool.

Conductor on single connections shall be positioned into the crimping barrel furthestmost from the crimp stop. See Figure 2.7.

Termination to be inserted into the tool until the crimp stop bottoms on the locator. Apply pressure to tool and complete crimping cycle.

Remove crimp from tool and inspect crimp for good formation of crimp and secure insulation grip.

(Cat 2)



Both conductors shown butting up against wire stop. Cable insulation also shown within sleeve of splice.

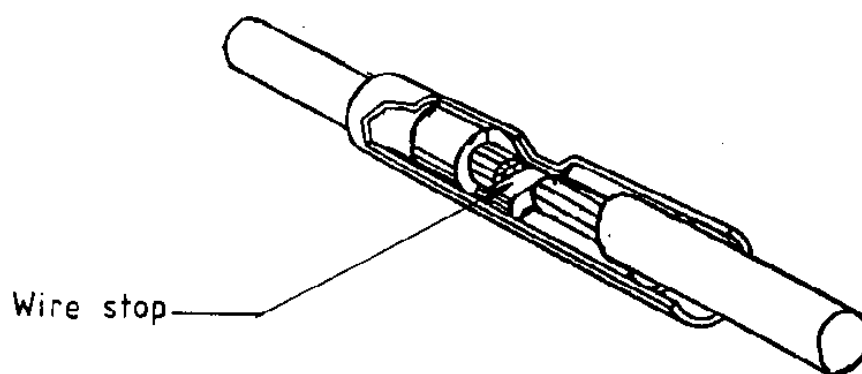
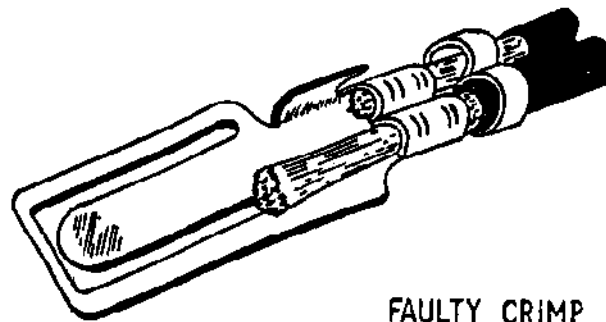


Fig. 2.6 Acceptable and Faulty Crimps

(Cat 2)



FAULTY CRIMP.

Conductor stranding
a. too short
b. too long

Insulation not gripped.

ACCEPTABLE CRIMP.

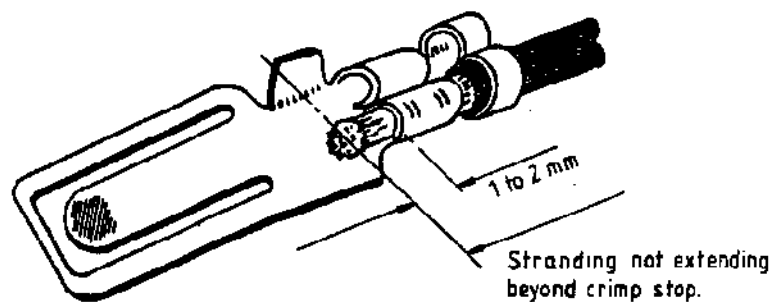


Fig. 2.7 Plug in 'Q' Relay Terminations

(Cat 2)

2.3.6 Forming a Wire Loop

A Multi-strand conductor **MUST** always have a crimped connector fitted. (Cat 3)

A solid strand conductor is normally connected to a pillar terminal by forming a loop of wire. An exception is where the diameter of the conductor is less than the thread pitch of the terminal post. In this case, a crimped connector is used. Without the crimped connector the thin wire might become trapped in the thread groove and be severed as the nut is screwed down. (Cat 3)

WIRE LOOP CONNECTION

- a) It is an advantage if your round-nose pliers are first marked for 0BA and 2BA terminals. Push one of each size of washer tightly onto the nose of the pliers (See figure 2.8). Mark completely around the nose, just on the lower side of each washer. Remove the washers and use the marks to position the wire then forming a loop.
- b) Remove the insulation in accordance with section 2.3.3 of this handbook. The strip needs to be approximately 20 mm for 2BA and 30 mm for 0BA terminals.
- c) Form the neck by bending the wire at right angles, 3 mm from the insulation. (See Figure 2.9).
- d) Hold the wire in the round-nose pliers and form a loop by rotating the pliers (See Figure 2.9).
- e) cut off the surplus wire with side cutters. Re-form the loop if necessary so that there is approximately 1 mm gap.
- f) When complete, check that the loop slides easily onto the terminal.

(Cat 3)

Points to be noted:

The loop must go clockwise around the pillar and must be just large enough to move freely over the terminal (See Figure. 2.10).

Mount the loop between washers.

The insulation must stop short of the washers and the wire must not overlap on to itself.

The loop must be properly formed as shown. The wire must not be just wrapped around the terminal.

(Cat 3)

2BA & 0BA Washers

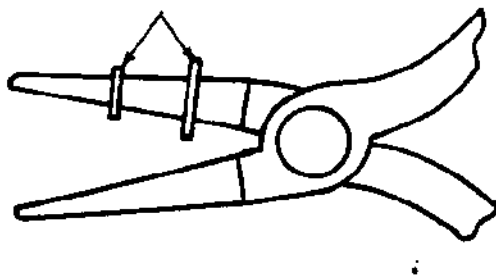
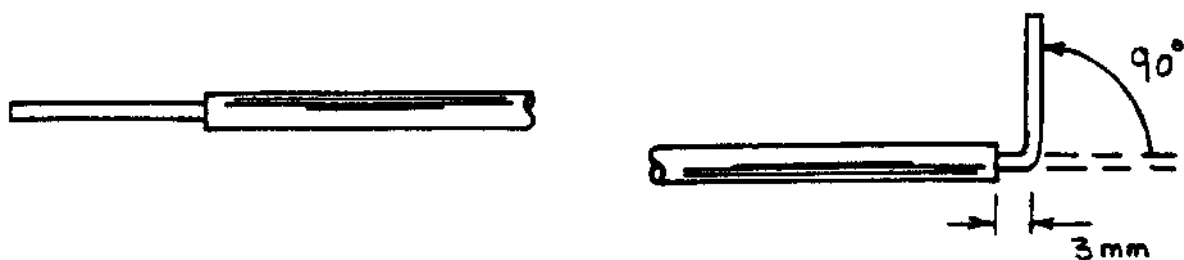


Fig. 2.8 Marking pliers for loop size

(Cat 3)

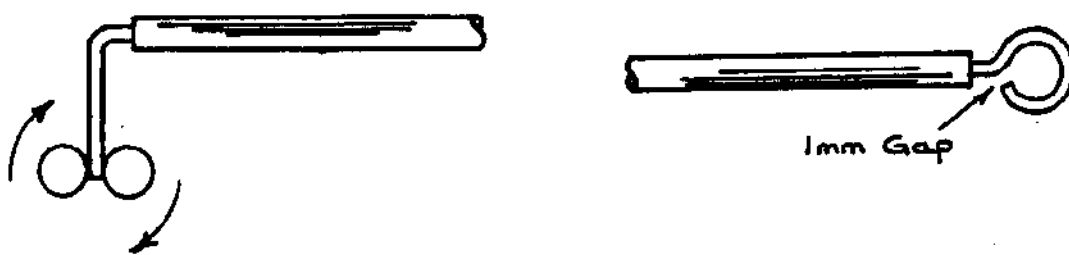
(Cat 3)



a) Strip Wire

b) Bend Wire

Fig 2.9 Forming Loop for Terminal Post



c) Grip conductor

d) Complete Loop at mark on pliers

Fig. 2.9 Forming Loop for a Terminal Post

(Cat 3)

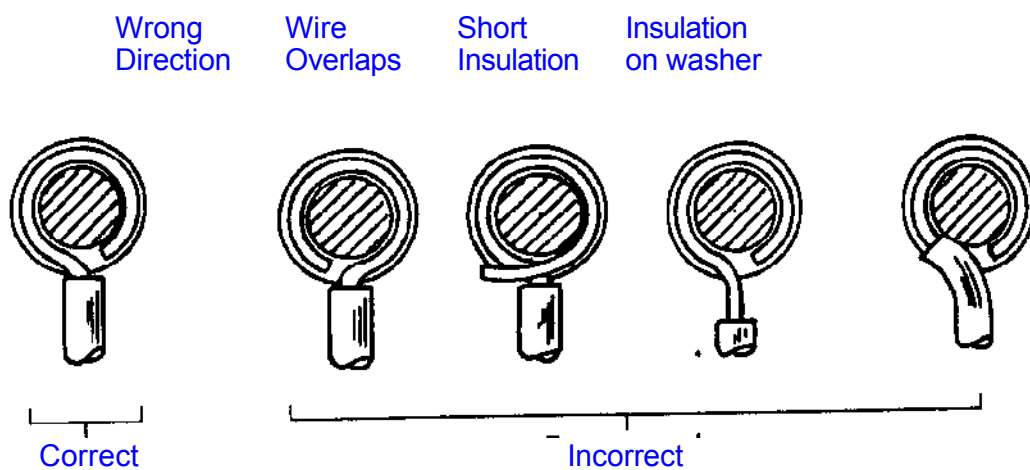


Fig. 2.10 Wire Loop Faults

(Cat 3)

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APPENDIX 2.3.A

(Cat 3)

RING TONGUE AND FORKED TERMINALS

1st Character = Cable Entry Size R = Red (0.25 to 1.65 sq mm), B = Blue (1.04 to 2.63 sq mm), Y = Yellow (2.63 to 6.64 sq mm)
 2nd pair of numbers = Hole Diameter in palm i.e. 53 = 5.3 mm dia
 3rd pair of letters = PR - Preinsulated, UR = Uninsulated
 4th pair of letters = VR - Vibration Resistant (where applicable)
 Insulation material denoted as N - Nylon.

	MANUFACTURER'S PART No	TOOL	DIES	POSITION IN DIES	GO NO-GO (DIE)	GO NO-GO (TOOL)
a)	R37PR-N	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
i)	FN1.25 M3	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
a)	R43PR-N	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
i)	FN1.25 M4	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
a)	R53PR-N	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
i)	FN1.25 M5	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
a)	R53PR-VR-N	RTB 510	PVRD15S-10RT	SINGLE	GPVRD15-10RT	GNG-10RT
a)	B53PR-N	RTB 510	PD2525-10RT	BLUE	GPD5625-10RT	GNG-10RT
i)	FN2 M5	RTB 510	PD2525-10RT	RED	GPD5625-10RT	GNG-10RT
a)	R65PR-N	RTB 510	PD2525-10RT	RED		GNG-10RT
l)	FN1.25 M6	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT
a)	R65PR-VR-N	RTB 510	PVRD15S-10RT	SINGLE	GPVRD5615-10RT	GNG-10RT
a)	R53PFS-N	RTB 510	PD2525-10RT	RED	GPD5615-10RT	GNG-10RT

(Cat 3)

APPENDIX 2.3.A

HEAVY DUTY TERMINATIONS

(Cat 3)

For the termination of cables 4 sq mm and above where a robust termination is preferable.

MANUFACTURER'S PART No	TOOL	DIES	POSITION IN DIES	GO NO-GO (TOOL)
a) HDT 4-*	RTB 510	UHD56-10RT	4	GNG-10RT
* Hole Diameters Available in palm quoted in millimetres : 4, 5 & 6				
a) HDT 6-*	RTB 510	UHD56-10RT	6	GNG-10RT
* Hole Diameters Available in palm quoted in millimetres : 4, 5, 6 & 8				
a) HDT 10-*	RTU-H-10150	RHD120-15RT	10	TB-150RT
* Hole Diameters Available in palm quoted in millimetres : 5, 6, 8, 10, 12 and Blank				
a) HDT 16-*	RTU-H-10150	RHD95-16-150RT	16	TB-150RT
* Hole Diameters Available in palm quoted in millimetres : 5, 6, 8, 10, 12 and Blank				
a) HDT 25-*	RTU-H-10150	RHD70-25-150RT	25	TB-150RT
* Hole Diameters Available in palm quoted in millimetres : 6, 8, 10, 12 and Blank				
a) HDT 35-*	RTU-H-10150	RHD50-35-150RT	35	TB-150RT
* Hole Diameters Available in palm quoted im millimetres : 6, 8, 10, 12 and Blank				
a) HDT 70-*	RTU-H-10150	RHD-25-150RT	70	TB-150RT
* Hole Diameters Available in palm quoted im millimetres : 6, 8, 10, 12, 14, 16 and Blank				
a) HDT 185-*	RTU-10400	HD185-25-400RT	185	TB-400RT
* Hole Diameters Available in palm quoted im millimetres : 10, 12, 14, 16, 20 and Blank				

(Cat 3)

APPENDIX 2.3.A

(Cat 3)

NOTES :

- 1) GO NO GO gauges are not available for the heavy duty dies.
- 2) The Miles Roystone D36 hydraulic crimping tool has been approved for use on all the CTT range of copper tube lugs. The tool is suitable for cable sizes from 4 to 150 sq mm.
- 3) For 'D' sectioned cable to S & CSE SE 881 & 882, Elpress, KRF terminations have been approved. This range of lug deletes the necessity of reforming the conductors to fit the crimping barrel.

(Cat 3)

APPENDIX 2.3.A

(Cat 3)

CONNECTOR CONTACTS.

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	LOCATOR/TURRE T	GO NO-GO
b)	Pin 229 90018J	1 sq mm	AF8 (M22520/1-01)	TH499	M22520/3-1
b)	Socket 229 90019F	17 AWG			
b)	Pin 229 90016D	0.5 sq mm	AF8 (M22520/1-01)	TH499	M22520/3-1
b)	Socket 229 90017A	20 AWG			
c)	Pin 0933 000 6121				
d)	Pin MP 2018	0.5 sq mm	Presently Used Buchanan	Presently Used 0999 000 0007	N/A
c)	Socket 0933 000 6220	20 AWG	Recommended AF8 (M22520/1-01)	Recommended 621332	M22520/3-1
d)	Socket FP2018				
c)	Pin 0933 000 6105				
d)	Pin MP1800	1 sq mm	Presently Used Buchanan	Presently Used 0999 000 0007	N/A

(Cat 3)

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APPENDIX 2.3.A

CONNECTOR CONTACTS. (cont)

(Cat 3)

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	LOCATOR/TURRE T	GO NO-GO
c)	Socket 0933 000 6205	17AWG	Recommended AF8 (M22520/1-01)	Recommended 650003-1	M22520/3-1
d)	Socket FP1800				

NOTES:

AWG (American Wire Gauge) quoted for reference.

QPL 22520 is available through TSL (Technical Standards & Services) Tel No. 0462 453211.

(Cat 3)

APPENDIX 2.3.A

(Cat 3)

CONNECTOR CONTACTS. (Contd.)

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	LOCATOR/TURRET	GO NO-GO
c)	Pin 0933 000 6104				
d)	Pin MP1600	1.5 sq mm	Presently Used Buchanan	Presently Used 0999 000 0008	N/A
c)	Socket 0933 000 6204	15 AWG	Recommended AF8 (M22520/1-01)	Recommended 650003-1	M22520/3-1
d)	Socket FP1600				
c)	Pin 0933 000 6102				
d)	Pin MP1400	2.5 sq mm	Presently Used Buchanan	Presently Used 0999 000 0008	N/A
c)	Socket 0933 000 6202	13 AWG	Recommended AF8 (M22520/1-01)	Recommended 621332	M22520/3-1
d)	Socket FP1400				
c)	Pin 0933 000 6107	4 sq mm	Presently Used Buchanan	Presently Used 0999 000 0006	N/A

(Cat 3)

APPENDIX 2.3.A

CONNECTOR CONTACTS. (Contd.)

(Cat 3)

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	LOCATOR/TURRET	GO NO-GO
c)	Socket 0933 000 6207	11 AWG	Recommended AF8 (M22520/1-01)	Recommended 621332	M22520/3-1
e)	Pin 45453 T12	1 to 1.5 sq mm	AF8 (M22520/1-01)	TH469	M22520/3-1
e)	Socket 45473 T12	16 to 22 AWG			
e)	Pin 45454 T12	2 to 3 sq mm	AF8 (M22520/1-01)	TH469	M22520/3-1
e)	Socket 45474 T12	12 to 14 AWG			

NOTE: AWG (American Wire Gauge) quoted for reference.

(Cat 3)

APPENDIX 2.3.A

(Cat 3)

'Q' RELAYS

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	DIES	GO NO- GO(DIE)	GO NO GO(TOOL)
g)	J4137	1 sq mm	RS8	N/A	N/A	N/A
h)	HC7816	1.5 sq mm	RS10	N/A	N/A	N/A
a)	R53UR-3	1 to 1.5 sq mm	RTB510	UID15-RT3	GUID15-10RT- 3	GNG-10RT

BOOTLACE FERRULES

	MANUFACTURER'S PART No.	TOOL	DIES	POSITION IN DIES	GO NO GO (DIE)	GO NO GO (TOOL)	CABLE SIZE
a)	100-PET-N	RTB 510	PETD256-10RT	1/1.5	NOT AVAILABLE	GNG-10RT	1 sq mm
a)	150-17-PET-N	RTB 510	PETD256-10RT	1/1.5		GNG-10RT	1.5 sq mm
a)	250-17-PET-N	RTB 510	PETD256-10RT	2.5		GNG-10RT	2.5 sq mm

BUTT IN-LINE CRIMPS

This item **shall not** be used without prior written approval from the Safety Engineer S & CSE.

	MANUFACTURER'S PART No.	CABLE SIZE	TOOL	LOCATOR/TURRET	GO NO-GO
f)	B1870 BN	0.3 to 1.65 sq mm	H7-B	N/A	N/A

(Cat 3)

APPENDIX 2.3.A

(Cat 3)

KEY TO CRIMP MANUFACTURERS

- a) Compression Tools and Terminals
- b) Verospeed or ITT Cannon
- c) Harting
- d) Thomas & Betts
- e) Litton or AB Contractors
- f) Interconnections Products Ltd
- g) Westinghouse
- h) Hellermann Deutsch Ltd
- I) Takbro Limited (approval given using RTB510 tooling only)

(Cat 3)

2.4 Soldering

Soldering is a hot working process and gives off fumes. Checks must be made prior to the work commencing to ensure that fire detection systems (if fitted) are isolated for the duration of the work. (Cat 3)

2.4.1 Soldering Iron selection

Soldering Irons shall be selected for each individual application. If insufficient heat is used then the joint will not be made properly and left 'dry'. If too much heat is used then equipment or components may be damaged. The following is a guide as to soldering iron selection.

12 Watt Thermostatically controlled for Printed Circuit Boards.

25 Watt Used for general duties.

100 Watt Used for heavy duty soldering where a large amount of heat is required.

(Cat 3)

2.4.2 Solder and Flux Selection

Solder gauges (diameters) shall be selected with care. Too large a diameter will cause excessive solder to be deposited and too small a diameter insufficient solder preventing good mechanical or electrical joints. (Cat 2)

Solders used should be as follows:-

a) Solder, rosin cored 60/40

Grade KP to BS 219/BS 441 Class 6 Grade 2

b) For solid solder:-

Solder, 60/40 to BS219 Grade KP

c) Common solder diameters available are: 0.7 mm, 1 mm, 1.5 mm, 2 mm & 2.5 mm

(Cat 2)

Non corrosive fluxes shall be used and shall be ordered as follows:

a) Flux, paste to BS 5625 class 6

(Cat 2)

More active fluxes are available but are not considered suitable for a railway environment, unless adequate cleaning processes are available for flux removal. (Cat 2)

(Cat 3)

2.4.3 Making of the Joint

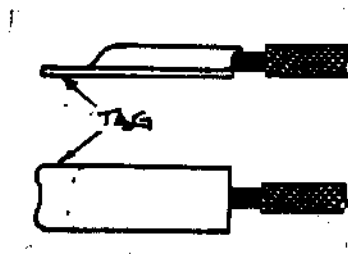
The terminal/lug shall be clean, free from grease and used solder. Flux paste shall be added, if required, sparingly onto the terminal (for the majority of applications rosin cored solder is adequate. The wire shall be stripped, tinned if necessary and then wrapped once around the terminal/lug to provide a secure mechanical joint. Enough wire shall be left available for the solder joint to be remade up to three times (Only if a Design Requirement). A 2 mm gap (or as stated in the design) between the wire insulation and terminal shall be left as to minimise heat damage to the insulation. (Cat 3)

The soldering iron bit shall be held against the terminal/lug and solder offered to the joint 180 degrees from the soldering iron bit. This ensures the whole joint reaches the melting point of the solder, aiding good even flow around the joint.

When the solder is seen to melt and flow evenly about the joint, then the iron shall be removed. The joint shall be bright in appearance and free from excessive solder, spikes and voids. (See figure 2.11)

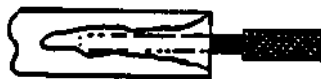
(Cat 3)

Solder smooth,
Even flow,
Bright & Base metals
not visible

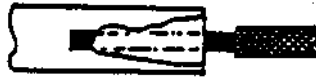


Good

Poor Solder flow
(dirty metals or
insufficient flux)



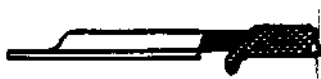
Insufficient Solder



Solder spikes & dry
joint
(Insufficient heat or flux
or moved when
cooling)



Damaged Insulation



Faulty (Reject)

Fig 2.11 Solder Joints

(Cat 3)

2.4.4 Care of Soldering irons

Soldering irons shall be inspected prior to use and if damaged must not used. (Cat 3)

Pitted and corroded soldering iron bits shall be repaired using a fine file to give a flat surface or replaced. Bits shall be tinned then wiped clean to remove excessive solder and contaminants prior to each soldering operation. (Cat 3)

2.5 Meters

2.5.1 Approved Instruments

For reasons of Safety and Quality all electrical measurements performed on LUL fixed or portable equipment/systems must be with instruments and leads approved by LUL and in accordance with the requirements of the Electricity at Works regulations (1989). (Cat 2)

Privately owned or non-approved measuring equipment must not be used in the performance of LUL work. (Cat 2)

Meters will need to conform to IEC 348, IEC 1010-Installation Category 3, or equivalent standard, to be approved. This excludes many older instruments along with many of the modern inexpensive pocket types. Instruments which have old style 4 mm. "banana" sockets are also excluded. Raised insulated screw terminals with 4 mm sockets (like AVO 8) are allowed provided that totally shrouded lead terminations are used. (Cat 2)

Most models in the current ranges of AVO and Fluke are approved, but a list is available from LUL on application. (Cat 2)

This document is concerned exclusively with the acquisition and use of conventional meters with analogue or digital read-outs for the measurement of AC RMS or DC voltage and current. No mention is made of the wide variety of probes and devices used purely for indicating the presence of a voltage by means of LEDS, neons etc. or miniaturised digital displays. (Cat 2)

It should be borne in mind that while such devices are usually high impedance, voltage only, modules and therefore an attractive alternative to meters for some applications, the hazards associated with their use are similar: ie. damage to leads, low resistance faults due to electronic component failures. Personal protection with these devices is more difficult to ensure due to a lack of adequate construction standards and the use of captive leads. (Cat 2)

2.5.2 Voltage Measurements

Measurement of voltages exceeding 50 V AC (120 V DC) must include fused test leads in compliance with HSE Guidance Note GS38. This note was published in 1986 but is now a requirement under the EAW Regs (1989). The leads should meet the requirements of IEC 1010 Part 2 - 3. Both leads must be fused with 500 milliamp HRC fuses. (Cat 2)

Internal meter fuses, irrespective of type and rating, will not provide the overall protection for the user during measurement. (Cat 2)

Special fuses are needed in leads used for work which involves the presence of DC traction voltages at the meter, irrespective of the circumstances. (Cat 2)

These special fuses, which are also suitable for AC voltages up to 1000 V, are currently available only from Le Carbone and are type ref. Ferraz P76465 500MA. (Cat 2)

No other fuse or fuse substitute may be used in the special circumstances above. Lead sets which will accommodate and are supplied with these special fuses are available from AVO Megger International Ltd., type refs. FPK3, FPK5, or FPK6 depending upon the instrument used with them. Probes to IEC 1010 part 2-3 and which can accommodate the special fuse may be available from other manufacturers in the future. (Cat 2)

The lead sets are supplied with insulated probe tips as standard. Clips obtained for use with fused leads conform to IEC 1010 Part 2. (Cat 2)

Though it is possible to obtain leads and fuses designed for lower voltages or applications without traction DC voltage, it is recommended that the fuses/leads required for the worst case duty (special circumstances above) should be used in order to avoid the accidental use of inappropriate items. This is in keeping with one of the underlying philosophies of the Electricity at Work Regulations. (Cat 2)

The above lead sets are suitable for voltage measurements using approved meters on all parts of the:-

- (i) DC traction distribution system up to 900V including substations.
- (ii) AC Signalling and Lighting distribution up to 1000V.

(Cat 2)

Approved multimeters with appropriate fused leads are acceptable for measuring DC voltages associated with traction. However, consideration should be given to the use of dedicated voltmeters ie. single range volts only, (fused lead still required) for Staff/Contractors who frequently need to measure such voltages. Instrument damage due to incorrect range setting is virtually eliminated. See also Section 4 Para 4. (Cat 2)

The general reliability of dedicated instruments tends to be better since they are less complex than multimeters. (Cat 2)

2.5.3 Current Measurements

The use of the fused leads as described in the section above precludes the measurement of current (above 500mA) in the conventional way with any of the approved instruments. (Cat 2)

In cases where there is a need to measure current the options are:-

- a) Use conventional non fused meter leads having isolated the circuit prior to and after measurement. Strict discipline would be required to ensure circuit isolation and to control the location and ownership of leads in order to avoid inappropriate use.
- b) Dedicated clamp type meters or Hall Effect probe attachments for approved voltmeters or multimeters. Problems with accuracy below 1A.

(Cat 2)

2.5.4 Operational

Instruments and leads must be formally inspected, at intervals not exceeding 12 months, for defects which might compromise safety. This applies particularly to breeches of the outer insulation on leads. (Cat 2)

Instruments must also be used only within the unexpired calibration period. (Cat 2)

When meters are removed from circuits in between measurements or at conclusion, both probes/clips must be disconnected in order to avoid possibly dangerous voltages being present on one probe tip or clip. (Cat 2)