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Signalling

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Specification - Solderless Terminals - Cable Lugs for Signalling Applications

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About This Standard

This specification describes the general requirements for cable lugs of compression types, used in wiring signal equipment, to be manufactured and supplied to Australian Rail Track Corporation or contractors to Australian Rail Track Corporation.

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1. Introduction

This specification describes the general requirements for cable lugs of compression types, used in wiring signal equipment, to be manufactured and supplied to Australian Rail Track Corporation or contractors to Australian Rail Track Corporation.

This sets forth the general requirements for the solderless type terminals for wire sizes from 0.5 sqmm to 300 sqmm cross sectional area. These terminatals may serve to connect flexible stranded, or solid conductors of copper, nickel, or other corrosion-resistant materials.

This Specification is applicable to terminal lugs of insulated type, non-insulated type and to boot lace ferrules.

2. Applicable Documents

2.1. Australian Standards

This Specification refers to the following Australian Standards:

AS 1099 2.6-1988	Basic environmental testing procedures for electro-technology-Tests:Fc-vibration (sinusoidal)}
AS 1099.2Ka-1978	Basic environmental testing procedures for electro-technology-Tests-Salt mist)
AS 1125	Conductors in Insulated Electric Cables and Flexible Cords (including Conductors, Insulation and Sheath).
AS 1199-1988	Sampling procedures and tables for inspection by attributes SAA Wiring Rules.
AS 3000 AS 3100	Approval and test specification-general requirements for electrical equipment
AS 3169	Approval and Test Specification - Flat, Quick Connect Terminations.

2.2. International Standards

This Specification refers to the following International Standards:

BS 442	Electrical Terminals - Railway Signalling Apparatus.
BS 4579	Specification for the Performance of Compression Joints in Electric Cable and Wire Connectors.

3. Definitions

For the purpose of this specification, the following definitions shall apply :-

Vital Circuits

Circuits directly involved in ensuring the safety of the signalling system.

Non-Vital Circuits

Circuits involved in the control and indication of the signalling system, but not directly connected with the safety functions.

4. Environmental Conditions

Temperature: -10 C to 85 C, unless otherwise specified

Humidity: Relative Humidity 0 to 95%

Exposure to atmospheric conditions such as; dust, dirt, oil, chemicals, rain, uv radiation, immersion in water, etc., as applicable for lugs used in outdoor applications (on railway tracks).

5. Compliance with Specifications

5.1. General Requirement of AS 3100

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

5.2. Specific Requirements of this Specification

A cable lug shall be deemed to comply with this Specification only if it complies with all the requirements of this Specification and passes the relevant tests specified herein.

6. General Description

Cable Lugs shall be supplied of the 3 essential types such as:

- Non-insulated type including bimetal lugs
- Insulated type
- Bootlace ferrules

Terminal/cable lugs shall be capable of being applied to the conductor with tools recommended by manufacturer, to provide mechanical security and electrical performance, as required. Crimping tool must provide for full crimping cycle before permitting the crimping jaws to return to the original open position.

The current carrying portions of terminals shall be of copper or suitable copper alloy to meet prescribed tests.

Cable lugs used for signalling applications shall be in accordance with signals standard drawings (M08-580/1) to (M08-580/11), attached to this specification in terms of dimensions, material, and specific applications, etc.

Reasonable length of barrel shall be provided on the lug for crimping process. This compression process shall provide satisfactory electrical contacts and tensile strength as specified in Appendix A: Acceptance testing of terminal lugs. The current carrying portions of terminals shall be of Copper or suitable Copper alloy, as specified under technical data and shall comply with prescribed tests as laid down

under test requirements.

All conducting materials shall be coated with tin, nickel, or silver plating or equivalent, to prevent corrosion. Cadmium and zinc shall not be used. Coating shall be of quality and thickness to withstand tests specified in Section 8 (test requirements), without exposing the base metal.

6.1. Non-insulated Cable Lugs

All non-insulated cable lugs shall be in accordance with the technical-general data, and drawings supplied, as specified

6.2. Insulated Cable Lugs

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

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

Insulation shall be of a quality and thickness to withstand prescribed tests and shall remain in the crimped position when exposed to a temperature of 85C.

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

6.3. Bootlace ferrules

Thin sheet Copper sleeve fitted with an insulated cone to assist entry of wire strands, and provide some support to the shaped system. The insulation on the ferrules shall be colour coded to identify the proper cross sectional area of the wire size that it should be used with. The standard colour code adopted by ARTC is as specified under the section "identification and marking".

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

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

7. Technical Data - Terminals

Conductive Material (except Quick Connect Range) :

Copper	99.9% Pure
Tensile Strength	200MPa

Ductile Rating	35%
Final Metal State	Fully Annealed
Oxygen Content	50 p.p.m. max

Conductive Material - Quick Connect Range :

Brass	30% Zinc Copper 70%
Tensile Strength	580MPa
Ductile Rating	6% min.
Final Metal State	Annealed

Electroplating :

Material	Tin
Tin Content	99.9%
Other Metals	Lead & Antimony
Plating Thickness	2.5 Microns

General Electric Properties :

Total Conductivity	99.5% IACS
Total Resistivity	17.38 Micro Ohms / cubic mm

Insulation (for insulated terminals) :

Material	PVC - for all (except Nylon 6 or Nylon 66 - for FIQC)
Breakdown Voltage	3.5 KV (min)
Insulation Resistance	Above 100 Megaohms
Working Voltage	Up to 600 volts AC/DC
Working Temperature:	0 C to 85 C

Torque Recommendations:

For Hardware being Metric 8.8 Tensile Grade

Dia. Thread	Torque
3mm	2 Nm
4mm	3 Nm
5mm	5 Nm
6mm	9 Nm
8mm	22 Nm

10mm	44 Nm
12mm	77 Nm

Nominal "Pull Out" Force

Wire Size	Pull Out Force
0.5 mm ²	8.2 Kg (80N)
0.75mm ²	12.2 Kg (120N)
1.0mm ²	16.3 Kg (160N)
1.5mm ²	20.4 Kg (200N)
2.5mm ²	25.5 Kg (250N)
4.0mm ²	35.7 Kg (350N)
6.0mm ²	51.0 Kg (500N)

8. Test Requirements

Cable lugs shall meet the following requirements when attached to the conductor size for which they are designed and when crimped with the tools recommended by manufacturer:

8.1. General

All tests shall be made at room temperature unless otherwise specified and the test area shall be free from drafts. Cable lugs under overload and temperature tests shall be securely bolted back to back and suspended in free air with a minimum clearance of 450 mm. Insulation supports, where provided, shall be closed on the conductor insulation for all the tests outlined herein after.

8.2. Temperature Rise

Test currents, as specified in Appendix-A shall be conducted through the conductor and attached terminals continuously until the temperature is stabilized. The normal temperature rise shall not exceed 5C above that of the cable to which it is connected. Temperature rise shall be measured at the barrel of each terminal by means of a thermo-couple or other thermo-resistive devices. The temperature of the conductor shall be measured by thermo-couples or other thermo-resistive devices embedded in the conductor strands at a minimum distance of 900mm from the terminals and from the power source.

8.3. Current Overload

Immediately following the temperature rise and with the temperature stabilized at the normal load current specified in Appendix-A, overload tests of 125 percent test current for two hours and 200 percent test current for five minutes shall be applied in this order and temperature rise measurements made at the conclusion of each period. The temperature rise shall not be more than 10C above that of the conductor to which it has been connected.

8.4. Resistance

The resistance of the conductor connection in the terminal/cable lug barrel shall be determined from the voltage drop measured between the intersection of the tongue and barrel of the connector and a point on the conductor 3 mm minimum from end of insulation support. The voltage drop shall not exceed the initial values specified in Appendix A.

8.5. Corrosion

Terminal assemblies as used for resistance test shall be subjected to tests as specified in AS 1099.2Ka-1978 : (Basic environmental testing procedures for electro-technology-Tests-Salt mist)

8.6. Vibration

Tests shall be performed in accordance with AS 1099 2.6-1988 {Test Fc-vibration (sinusoidal) }

8.7. Tensile Strength

The mechanical connection of the conductor and terminal shall not break when subjected to the tensile load specified in Appendix-A. Strain shall be applied at the rate of 12mm per minute.

8.8. Dielectric Strength for Insulated Terminals

The terminal insulation shall be wrapped with a thin, conductive foil firmly pressed into and around the crimped surface of the barrel. The foil may extend back along the conductor insulation but shall be far enough away from the terminal tongue to prevent flashovers. A test voltage of 50 Hz shall be applied between the terminal tongue and the foil and shall be increased from 0 to 1,000 volts rms within 1/2 minute and maintained at that figure for a period of one minute. No breakdown of the insulation shall be evident within that time. Flashovers below the minimum dielectric strength shall be cause for retest but not rejection.

9. Identification and Marking

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

9.1. Colour code & preparation of wire for Pre-Insulated Cable Lugs

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

9.2. Colour code for Bootlace Ferrules

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

10. Information Required

The manufacturer should provide all documentation necessary for identification and selection of proper lugs and ferrules based on the particular requirements, along with the application notes and suggestions, and tooling guide for using different types of lugs and ferrules.

11. Crimping Tools

Standard "Utilux" or equivalent tools shall be used as specified for each cable terminations. The type of crimping tool shall be specified when supplying lugs other than the specified ones, in terms of dimensions, wall thickness, etc.

Crimping tool shall be selected, so that when the cable is terminated with the appropriate die, the jaws of the die will close completely. A Go - Nogo gauge can be used to inspect the completed termination, in certain applications, to assess the result of the crimping.

11.1. Compaction ratio

The nominated cable lug shall have sufficient wall thickness to provide proper compaction, when compression joint is formed. The figure for compaction shall be around 8%.

To calculate the percentage reduction in cross sectional area the following formula shall be used.

$$\% \text{ reduction} = \left(\frac{La + Ca}{La + Ca} - Da \right) \times 100$$

Where, La = area in mm^2 of the annulus of the connector barrel

Ca = area in mm^2 of the conductor

Da = area in mm^2 of the hexagon compression die, when closed

11.2. Crimping Tools for Bootlace ferrules

Crimping tool should possess a constant crimping pressure and ratchet release mechanism and should be able to crimp a range of ferrule sizes in one tool seat, using an automatic cross section detection system. The type of crimping tool shall be nominated.

12. Packaging & Documentation required with/before delivery

The packaging shall be suitably packed to avoid mechanical damage to cable lugs. Unless otherwise specified, the information provided on the package shall be as follows:

- Item Description
- Supplier/manufacturer's Name or identification
- Quantity per package
- The standard of QA system may be specified, if applicable
- The following documentation shall be provided when supplying material to

13. Check-list for inspection for the acceptance of cable lugs

Batch testing shall be performed. testing samples shall be selected in accordance with AS1199-1988

Visual inspection:

Overall finish

Electro-plating on the metal surfaces, insulation, etc, as applicable Physical dimensions:

Whether dimensions of bore hole, palm hole, wall thickness, etc, are within reasonable tolerances.

Physical strength:

Compression jointing with the relevant cable, using the specified tool and die.
Tensile strength of the made-up joint with the wire/cable

Electrical tests:

Resistance across the compression joint

Non-conforming units or the complete supply shall be rejected and returned,

depending on the discretion of the nominated person for quality inspection.

14. Acceptance Testing of terminal lugs

(typical values, unless otherwise specified)

Conductor Size		TEST CURRENT (AMPERES)	Maximum voltage drop(mV) millivolt drop of equivalent length of wire		Tensile load Strength (min) Kg
SQmm	AWG		INITIALLY	AFTER TEST	
0.50	22	9	1	3	6.8
0.75	20	11	1	3	8.6
1.00	18	16	1	3	17.3
1.38					
1.50	16	22	1	3	22.7
2.50	14	32	1	3	31.8
4.00	12	41	1	3	50.0
6.00	10	55	1	3	68.2
10.00	8	73	1	3	102.3
16.00	6	101	1	3	136.4
50.00			1	3	200.94
95.00			1	3	391.3
120.0		1000	1	3	400
185		1000	1	3	400
195		2000	1	3	400
300		2000	1	3	400

Resistance across the compression joint shall be less than 15 micro-Ohms when crimped, in all cases, unless otherwise specified.