NPS/002/009 - Technical Specification for Mechanical Cable Lugs and Connectors

1. Purpose

The purpose of this document is to detail the requirements of Northern Powergrid in relation to mechanical cable lugs and connectors for use on copper or aluminium power cables.

This document supersedes the following documents, all copies of which should be destroyed:

Document Reference	Document Title	Version	Published Date
NPS/002/009	Technical Specification for Mechanical Cable Lugs and Connectors	5.0	June 2024

2. Scope

This document details the technical requirements for a range of mechanical cable lugs and mechanical phase/neutral connectors to cover a wide range of cable combinations of both solid and stranded types which can be found on or introduced to the Northern Powergrid distribution network. Cable lugs are required to connect mains or service cables to various items of plant/switchgear.

2.1. Table of Contents

3. Design Parameters

3.1. Conductor Types

Designed to meet BS EN IEC 61238 -1-1, BS EN IEC 61238 -1-3, Engineering Recommendation C79 & C93, and BS 4579, the connectors and lugs shall be suitable for use on stranded copper, compacted stranded copper, solid aluminium, in both circular and sector-shaped cross section (3-core 120^{o} shape and 4-core 90^{o} shape). The typical sizes of cables are as detailed in Appendix 1.

3.2. Design

The design must be such that the application of the connector/ lug results in rupture of metal oxide from the cable core to provide a true metal to metal contact.

3.3. Stress Relaxation Conductor Types

Connectors and lugs shall be so designed to allow for stress relaxation and differential thermal expansion under electrical loading.

3.4. Electrical Stability of the Interface Connection

Aluminium connectors and lugs for use on copper conductors should be, either tinned to stop electrical interaction, or supplied with brass gauze for insertion between the aluminium connector/lug and the copper conductor to ensure low contact resistance during heat cycling. If other methods are proposed, details of testing and service experience to support the design should be provided.

3.5. Palm of Lug

The size of the palm shall reflect the current carrying capacity of the body of the connector.

3.6. Torque Feature

The design of the connector and lug shall include a toque related feature, which not only ensures that the correct clamping pressure is achieved and maintained but can also be consistently reproduced between each screw in a multi screw connector/lug. The shear-off bolt shall be so designed that the bolts always break at the edge of barrel of the lug/connector.

3.7. Conditions of Storage and Installation

During storage and after installation the lugs and connectors can be expected to be subjected to the full range of climatic conditions found within the UK.

3.8. Stud Size

Stud size in the range of M6 to M16 is utilized on the majority of plant/equipment used within Northern Powergrid.

3.9. Tooling

No specialist tooling shall be required to shear the bolt heads utilised within the lugs and connectors.

3.10. Mechanical Connectors

A range of mechanical connectors is required to terminate cables onto bus-bars ends; the connectors shall be suitable for use on stranded copper, compacted stranded copper, solid aluminium, in both circular and sector-shaped cross section (3-core 120^{o} shape and 4-core 90^{o} shape) in the range 95mm^2 – 300mm^2.

Connection onto the busbar shall be side or rear fixing and to aid the removal/replacement of the connector from the busbar the connectors shall have double headed shear bolts. A disc spring type washer shall be supplied for use with the bus bar connection screw.

3.11. Mechanical Cable Lugs

A Class “A” range of mechanical cable lugs is required to terminate cables as detailed in Appendix 1 to various items of plant and switchgear. A typical range of lugs and palm size is detailed in Appendix 2.

4. References

4.1. External Documentation

Mechanical cable lugs and connectors shall comply with the latest version of relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of tendering, except where varied by this standard.

In this respect the following documents are particularly relevant.

Reference	Title
BS EN IEC 61238 -1-1	Compression and mechanical connectors for power cables. Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (Um = 1,2 kV) tested on non-insulated conductors
BS EN IEC 61238 -1-3	Compression and mechanical connectors for power cables. Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (U_m = 1,2 kV) up to 36 kV (U_m = 42 kV) tested on non-insulated conductors
ER C79	Type Tests for Connectors for Copper and Aluminium Conductors of Insulated Power Cables
ER C93	Type approval tests for mechanical connections to metallic sheaths of cables
BS 4579	Performance of mechanical and compression joints in electric cable and wire connectors

4.2. Internal Documentation

Reference	Title
NPS/002/019	Technical Specification for LV Distribution and Service Cables

4.3. Amendments from Previous Version

Reference	Description
Document Version	Updated from V5.0 to V6.0
3.1 Conductor Types	Added ER C93 & BS 4579
3.11 Cable Lugs	Changed to 3.11 Mechanical Cable Lugs
6. Authority for Issue	Change to Author and Technical Assurance and dates
Appendix 2 - Typical Current Range of Lugs with Palm Size	Add 'and Connectors' to heading. Remove and add items from list and update descriptions.
Appendix 5 – Self Certification Conformance Declaration	Additional alternative type test requirements, ER C79, ER C93 & BS 4579

5. Definitions

Reference	Title
n/a	

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Joe McAndrew	Governance Administrator	11/12/2024

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period:

Standard CDS review of 3 years?	Non-Standard Review Period & Reason	
No	**Period:** 5 Years	**Reason:** Update will be dictated by contract renewal date or any significant changes in the specification or documents referenced.
Should this document be displayed on the Northern Powergrid external website?		Yes

		Date
Paul Hanrahan	Engineer – Asset Management	11/12/2024

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Aaron Chung	Policy and Standards Engineer	11/12/2024
Steven Salkeld	Policy and Standards Engineer	11/12/2024

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	Head of System Engineering	11/12/2024

Appendix 1 – Cable Types

The main types of cable found on the Northern Powergrid distribution system for which cable lugs may be required:

3-Core Waveform Cables with Sectoral Aluminium Cores
95mm^2 - Solid Aluminium Core & Copper Neutral Earth
185mm^2 - Stranded Copper Core or Solid Aluminium Core & Copper Neutral Earth
300mm^2 - Stranded Copper Core or Solid Aluminium Core & Copper Neutral Earth
4-Core Waveform Cables with Sectoral Aluminium & Stranded Copper Cores
95mm^2 - Solid Aluminium Core & Copper Neutral Earth
185mm^2 - Solid Aluminium Core & Copper Neutral Earth
300mm^2 - Solid Aluminium Core & Copper Neutral Earth
185mm^2 – Stranded Copper Core & Copper Neutral Earth (Generally to BS 7870)
300mm^2 – Stranded Copper Core & Copper Neutral Earth (Generally to BS 7870)
Low Voltage Single Core Cable for Substations
480mm^2 - Solid Sectoral (4x120mm^2) Aluminium Single Core
800mm^2 - Armoured Stranded Copper Single Core
Single and Three Phase CNE Service Cables
16mm^2 – Circular Stranded Copper Core & Copper Neutral Earth
25mm^2 – Stranded Copper Core or Solid Aluminium Core & Copper Neutral Earth
35mm^2 – Circular Solid Aluminium Core & Copper Neutral Earth
Single and Three Phase SNE Service Cables
16mm^2 – Circular Stranded Copper Core & Copper Neutral Earth
25mm^2 – Circular Stranded Copper Core or Solid Aluminium Core & Copper Neutral & Earth
35mm^2 - Solid Aluminium Core & Copper Neutral & Earth
Earthing Conductors
6.0mm^2, (7/1.04mm), Green/Yellow PVC Insulated 450/750V
16.0mm^2, (7/1.70mm), Green/Yellow PVC Insulated 450/750V
25mm^2, (7/2.14mm)Green/Yellow PVC insulated 450/750V
35mm^2, (19/1.53mm) Green/Yellow PVC Insulated 450/750V
70mm^2, (7/3.55mm) Green rated voltage 450/750V
120mm^2, (37/2.03mm) Green/Yellow PVC insulated 450/750V

Appendix 2 – Typical Current Range of Lugs with Palm Size and Connectors

Description	Commodity Code
Mechanical lug offset palm with M10 hole suitable for circular shaped 6 - 25mm^2 stranded copper or 16 - 35mm^2 solid aluminium conductors	367446
Mechanical lug offset palm with M10 hole suitable for circular shaped 16 - 50mm^2 stranded copper or 16 - 70mm^2 solid aluminium conductors	350252
Mechanical lug offset palm with M12 hole suitable for circular shaped 16 - 50mm^2 stranded copper or 16 - 70mm^2 solid aluminium conductors	367395
Mechanical lug offset palm with M12 hole suitable for circular shaped 35 - 70mm^2 stranded copper or 35 - 95mm^2 solid aluminium conductors	069427
Mechanical lug offset palm with M16 hole suitable for circular shaped 35 - 70mm^2 stranded copper or 35 - 95mm^2 solid aluminium conductors	069443
Mechanical lug offset palm with M12 hole suitable for circular shaped 35 - 95mm^2 stranded copper or 35 - 120mm^2 solid aluminium conductors	367427
Mechanical lug offset palm with M12 hole suitable for sector shaped 50 - 95mm^2 stranded copper or solid aluminium conductors	069344
Mechanical lug offset palm with M16 hole suitable for sector shaped 50 - 95mm^2 stranded copper or solid aluminium conductors	069351
Mechanical lug offset palm with M12 hole suitable for sector shaped 120 - 185mm^2 stranded copper or solid aluminium conductors	069377
Mechanical lug offset palm with M16 hole suitable for sector shaped 120 - 185mm^2 stranded copper or solid aluminium conductors	069369
Mechanical lug offset palm with M12 hole suitable for sector shaped 240 - 300mm^2 stranded copper or solid aluminium conductors	069401
Mechanical lug offset palm with M16 hole suitable for sector shaped 240 - 300mm^2 stranded copper or solid aluminium conductors	069419
Mechanical lug offset palm with M16 hole suitable for circular shaped 480(4x120) - 600(4x150)mm^2 solid conductor	164785
Mechanical lug offset palm with M20 hole suitable for circular shaped 480(4x120) - 600(4x150)mm^2 solid conductor (suitable for WF cable bunched)	367662
Mechanical lug offset palm with 4xM8 holes suitable for circular shaped 480 - 740mm^2 stranded copper or solid aluminium conductor (incl. double back-to-back cable connections)	367660
Mechanical lug centre palm with 4xM8 holes suitable for circular shaped 480 - 740mm^2 stranded copper or solid aluminium conductor (incl. 185mm2 waveform cable bunched)	367658

Description	Commodity Code
LV Module - Consac Mains Service Joint Aluminium sheath connector for 16 - 35mm^2 neutral/earth conductors.	367408
LV Module - Consac Mains Straight and Branch Joints Aluminium sheath connector for Waveform neutral/earth 25 - 120mm^2 conductors.	168358
Neutral earth connector with fixing bolt suitable for 25 - 120mm^2 stranded conductor (can be used for connecting stranded copper neutral/earth wires to bus bars etc.)	168360
Brass neutral/earth connector for re-servicing modern LV distribution boards suitable for 0 - 125mm^2 stranded conductors	164778
Bus bar cable end connector suitable for 35 - 185mm^2 conductor	367393
Bus bar cable end connector suitable for 185 - 300mm^2 conductor	367394
Washer Transition with M12 hole surface penetrating grease protected	079947
Washer Transition with M16 hole surface penetrating grease protected	079954
3 Phase LV Board Termination kit for 185mm² Waveform – 3 x phase connectors & 1 x neutral/earth connector	086694
Waveform Neutral/Earth Connector – Range 25 – 120mm² stranded conductors	168343
Waveform Neutral/Earth Connector – Range 120 – 240mm² stranded conductors	168413
Mechanical connector for 16 - 35mm² copper neutral/earth conductors of hybrid service cables	169223
Mechanical Splice connectors for connecting 185/300mm² Waveform neutral/earth conductor to 95mm Insulated and Sheathed conductor or 95/120mm ABC	262348

Appendix 3 – Addendum to Supplier Requirements

The supplier shall provide with the tender full technical details of the equipment offered and shall indicate any divergence from these standards or specification.

To enable Northern Powergrid to install the connectors/lugs in accordance with the manufacturer's recommendations the supplier should provide full instructions detailing the manufacturer's recommended method of installation of each product with due consideration, where applicable, to the range of application.

Where the products are considered to be suitable for a range of applications then the full scope of application within the range should be provided by the supplier for each tendered product.

No specialist tooling shall be required for the application of lug/connector.

Appendix 4 – Logistical Requirements

To enable the Company to store the product(s) in accordance with the manufacturer's recommendations the Tenderer should provide details of the recommended storage environment with respect to each tendered product.

Details should be provided where relevant in respect to the minimum and maximum exposure levels, frequency of exposure and duration of exposure of the packaged item with respect to;

- Ambient temperature
- Atmospheric corrosion
- Humidity
- Impact
- Water
- Vibration
- Dust
- Solar radiation

The Tenderer shall ensure that each item is suitably packaged and protected to maintain the product and packaging as "fit for service" prior to installation taking account of the potential for an outdoor storage environment. All packaging shall be sufficiently durable giving regard to the function, reasonable use and contents of the packaging. Where product packages tendered are made up of sub packages all the sub packages shall unless varied by this specification, be supplied securely packaged together. Where items are provided in bagged/boxed form the material from which the bags are manufactured shall be capable of sustaining the package weight and resisting puncture by the materials within. Tenderer shall submit at the time of tendering the details of the proposed packaging (i.e., materials composition and structure) to be used for each product. Where the Tenderer is unable to provide packaging suitable for outdoor storage then this should be stated at the time of tender.

Palletised goods shall be supplied on standard 1200mm x 1000mm pallets.

Clearly legible, easily identifiable, durable and unambiguous labelling shall be applied to each individual and where relevant multiple package of like products. Where products packages tendered are made up of sub packages each sub packages shall be marked. As a minimum requirement the following shall be included;

- Manufacturer's trademark or name
- Supplier's trademark or name
- Description of item
- Date of packaging and/or batch number
- Northern Powergrid product code
- Weight
- Shelf Life

Tenderer shall submit at the time of tendering a sample of the proposed labelling for each product package type.

Appendix 5 - Self Certification Conformance Declaration

Cable Lugs and Connectors for use on aluminium or stranded copper cables shall comply with the latest issues of the relevant international and international standards.

BS EN IEC 61238 -1-1, BS EN IEC 61238 -1-3 and C79 - 1 are intended to amplify and/or clarify the requirements of those Standards.

This check sheet identifies the clauses of the aforementioned standard relevant to cable lugs and connectors for use on the Northern Powergrid distribution network.
The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes.

Conformance declaration codes
N/A = Clause is not applicable/ appropriate to the product
Cs1 = The product conforms fully with the requirements of this clause
Cs2 = The product conforms partially with the requirements of this clause
Cs3 = The product does not conform to the requirements of this clause
Cs4 = The product does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

Instructions for completion
- When Cs1 code is entered the supplier shall provide evidence to confirm conformance.
- When any other code is entered the reason and supporting evidence for non - conformance shall be entered.
- Prefix each remark with the relevant 'BS EN' 'IEC' or 'ENATS' as appropriate.
- Provide technical data sheets and associated drawings for each product.

Manufacturer/Supplier:

Manufacturer/ Supplier Product Reference:

Northern Powergrid Product Reference (Commodity Code):

Details of the Product Type: (e.g., lug/connector type and size) designed to be used with):

Name:

Signature:

Date:

NOTE: One sheet shall be completed for each item or variant submitted.

Mechanical Connectors

BS EN IEC 61238 -1-1 Compression and mechanical connectors for power cables. Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (Um = 1,2 kV) tested on non-insulated conductors. Test methods and requirements				
Clause/Sub-clause	**Requirement**	**Conformance Code**	**Evidence Reference**	**Remarks/Comments**
6	Electrical Tests carried out as per Clause 6			
7	Mechanical Tests carried out as per Clause 7			
BS EN IEC 61238 -1-3 Compression and mechanical connectors for power cables. Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (Um = 1,2 kV) up to 36 kV (Um = 42 kV) tested on non-insulated conductors. Test methods and requirements				
Clause/Sub-clause	**Requirement**	**Conformance Code**	**Evidence Reference**	**Remarks/Comments**
6	Electrical Tests carried out as per Clause 6			
7	Mechanical Tests carried out as per Clause 7			
BS 4579 part 3: Performance of mechanical and compression joints in electric cable and wire connectors - Part 3: Mechanical and compression joints in aluminium conductors				
1 to 12	Full Type Test requirements			
ER C79: Type Tests for Connectors for Copper and Aluminium Conductors of Insulated Power Cables				

5, 6 & 7	Full Type Test requirements			
ER C93: Type approval tests for mechanical connections to metallic sheaths of cables				
6, 7 & 8	Full Type Test requirements			

Mechanical Lugs

BS EN IEC 61238 -1-1 Compression and mechanical connectors for power cables. Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (Um = 1,2 kV) tested on non-insulated conductors. Test methods and requirements				
Clause/Sub-clause	**Requirement**	**Conformance Code**	**Evidence Reference**	**Remarks/Comments**
6	Electrical Tests carried out as per Clause 6			
7	Mechanical Tests carried out as per Clause 7			
BS EN IEC 61238 -1-3 Compression and mechanical connectors for power cables. Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (Um = 1,2 kV) up to 36 kV (Um = 42 kV) tested on non-insulated conductors. Test methods and requirements				
Clause/Sub-clause	**Requirement**	**Conformance Code**	**Evidence Reference**	**Remarks/Comments**
6	Electrical Tests carried out as per Clause 6			
7	Mechanical Tests carried out as per Clause 7			

BS 4579 part 3: Performance of mechanical and compression joints in electric cable and wire connectors - Part 3: Mechanical and compression joints in aluminium conductors				
1 to 12	Full Type Test requirements			
ER C79: Type Tests for Connectors for Copper and Aluminium Conductors of Insulated Power Cables				
5, 6 & 7	Full Type Test requirements			

Appendix 6 - Technical Information Check List

The following information shall be provided by the supplier for review by Northern Powergrid. Additional information shall be provided if requested.

Requirement	Provided (Y/N)
Full product descriptions and part number/reference	
Complete set of drawings for each item	
Type test evidence	
Quality Plan	
Pre-commissioning testing/inspection requirements	
Appendix 5 – completed self-certification conformance declaration	
Packaging/delivery information	
ISO:9001, ISO:14001 and ISO:18001 certificates	