

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 1 | of 40 |

NPS/003/021 – Technical Specification for Continuous Maximum Rated (CMR) Transformers

1. Purpose

This specification details the technical requirements for Continuous Maximum Rated (CMR) transformers for use at 132kV, 66kV or 33kV on the Northern Powergrid distribution networks.

This document supersedes the following document, all copies of which shall be removed from circulation;

| Document Reference | Document Title | Version | Published Date |
|--------------------|---|---------|----------------|
| NPS/003/021 | Technical Specification for Continuous Maximum Rated (CMR) Transformers | 4.0 | July 2019 |

2. Scope

This specification covers 132kV, 66kV and 33kV CMR transformers, associated neutral displacement voltage transformers (NVDT) and tank mounted auxiliary transformers and states the requirement for suppliers to provide periodic inspection and maintenance information for the transformers.

Tenderers should consider and include any project specific requirements as detailed in Appendix 1, Addendum to Supplier Requirements.

The following appendices form part of this technical specification:

- Appendix 1 - Addendum to Supplier Requirements – Technical Schedules
- Appendix 2a - Self certification conformance with ENA TS 35-3
- Appendix 2b - Self certification conformance with Northern Powergrid NPS/003/021
- Appendix 3 - Pre-commission testing, Routine Inspection and Maintenance requirements
- Appendix 4 - Technical Information Check List
- Appendix 5 - Declaration of Places of Manufacture, Test and Inspection
- Appendix 6 - Specification for Transformer Tank-mounted NDVTs
- Appendix 7 - Specification for Transformer Tank-mounted Auxiliary Transformers

This specification does **not** cover Continuous Emergency Rated (CER) transformers.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|---|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 2 | of | 40 |

2.1. Table of Contents

| | |
|--|-----------|
| 1. Purpose | 1 |
| 2. Scope | 1 |
| 2.1. Table of Contents | 2 |
| 3. Technical Requirements | 3 |
| 3.1. Compliance with other Specifications and Standards..... | 3 |
| 3.2. Technical Specification | 3 |
| 3.2.1. Overall Requirements | 3 |
| 3.2.2. Variations to ENA TS 35-3 | 3 |
| 4. References | 11 |
| 4.1. External Documentation | 11 |
| 4.2. Internal Documentation..... | 11 |
| 4.3. Amendments from Previous Version | 11 |
| 5. Definitions | 12 |
| 6. Authority for Issue | 13 |
| 6.1. CDS Assurance..... | 13 |
| 6.2. Author | 13 |
| 6.3. Technical Assurance..... | 13 |
| 6.4. Authorisation | 13 |
| Appendix 1 - Addendum to Supplier Requirements (Project or Site Specific Requirements) | 14 |
| Appendix 2a - Self-Certification Declaration of Conformance with ENA TS 35-3 Issue 2 2014 | 17 |
| Appendix 2b - Clause by Clause Conformance with Northern Powergrid NPS/003/021 | 29 |
| Appendix 3 - Pre-commission Testing, Routine Inspection and Maintenance Requirements | 34 |
| Appendix 4 - Technical Information Check List | 35 |
| Appendix 5 - Declaration of Manufacturers, Places of Manufacture, Test & Inspection | 36 |
| Appendix 6 - Specification for Transformer Tank Mounted NDVTs | 37 |
| A6-5. NDVT Conformance Declaration | 38 |
| Appendix 7 - Specification for Transformer Tank Mounted Auxiliary Transformers | 39 |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|---|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 3 | of | 40 |

3. Technical Requirements

3.1. Compliance with other Specifications and Standards

Technical documents referenced within this specification refer to the latest versions of the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENA TS) current at the time of supply.

3.2. Technical Specification

3.2.1. Overall Requirements

The equipment shall comply fully with the Energy Networks Association Technical Specification ENA TS 35-3: Continuous Maximum Rated (CMR) System Transformers (for use on systems up to 132kV) Issue 2, unless varied by this specification in which case this specification shall take precedence.

The equipment shall also comply fully with the current versions of all other relevant, IEC International Standards, British Standard Specifications or equivalent Euro-Norms, and Energy Networks Association Technical Specifications, except where varied by this standard.

The equipment must comply with, and allow the end user to comply with, all relevant Health & Safety legislation.

Wherever “OF” cooling is referenced; the use of “OD” (directed) cooling is permitted.

Multicore wiring shall meet the requirements of BS 7870-8.1 and ENA TS 09-6.

3.2.2. Variations to ENA TS 35-3

The principles of ENATS 35-3 shall also be applied to CMR transformers with specified power ratings different to those in ENATS 35-3.

Where appropriate, the following variations, additions and clarifications to ENATS 35-3 issue 2 are referenced to the clause numbers in that document:

6.4 Specification of Tapping Range in Enquiry and Order

The tapping range shall be as specified in Appendix 1: Addendum to Supplier Requirements.

6.5 Specification of short-circuit Impedance

Values of maximum and minimum impedance and +/- tolerances shall be as listed in Appendix 1: Addendum to Supplier Requirements.

6.6 Load Loss and Temperature Rise

Northern Powergrid will establish the value of Iron Loss and Copper Loss (£/kW) based on the transformer specification and network attributes at the point of connection. Losses shall be capitalised using the loss capitalisation values in Appendix 1 of this document. A full description of how Northern Powergrid calculates losses for system transformers can be found in IMP/001/103 – Code of Practice for the Methodology of Assessing Losses.

Lifetime Cost =

Purchase price + ((No load loss kW x No load £/kW) + (Load loss kW x Load loss £/kW)).

Note that the Northern Powergrid loss £/kW figures incorporate utilisation factor and time span.

| | | | |
|---|--------------------------------------|---|----------------------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | | Page 4 of 40 |

7.0 Connection and phase displacement symbols for three-phase transformers

The requirement will be specified in Appendix 1 Addendum to Supplier Requirements. The normal vector groups required for use on the Northern Powergrid networks are:

| Voltage (kV) | Yorkshire | Northeast |
|--------------|-------------|----------------|
| 33/11.5 | YNyn0 | YNyn6 or Dyn11 |
| 33/20 | -- | Dyn11 |
| 66/11.5 | YNyn0 | Dyn11/Dyn1* |
| 66/20 | -- | YNyn0 |
| 66/33 | YNyn0 | YNd11/YNd1* |
| 132/11.5 | YNd11/YNd1* | YNd11/YNd1* |
| 132/33 | YNd11/YNd1* | YNd11/YNd1* |
| 132/66 | YNd11/YNd1* | YNyn0 |

*the transformer shall have vector changeover links

8.2 Rating Plates

In addition, the rating plate shall state:

- The ONAN rating at 30°C ambient temperature
- The CMR rating at 30°C ambient temperature
- The nominal tap position
- The tapping range shall be expressed in the format:
 - + / - 10% in 16 steps (+ / - 8 x 1.25%) or
 - + 5.72 / -17.16% in 16 steps (+ 4 x 1.43% / - 12 x 1.43%)

9.3 Liquid preservation system

Where the oil preservation system is a free breathing system the breathing pipe shall be terminated with a 3/4" male BSP thread to allow the use of a cartridge desiccant filter system, such as the Brownell Type W system or equivalent. The pipework shall be arranged to allow these cartridges to be changed easily from ground level. These requirements apply to all oil systems that form part of the transformer installation.

11.1 Tests: General requirements for routine, type and special tests

The mechanical pressure tests shall be completed before any electrical type or routine tests

11.1.1 Tests: General

Table 2 in ENATS refers to the highest voltage for equipment. These values shall be applied to the appropriate voltage of all windings, not just the highest voltage one.

The Rated lightning impulse (LI) for 11.5kV shall be 95kV (peak) and 28kV (rms).

11.1.3 Type tests

For any unit to be connected to the Northern Powergrid distribution network, the full range of type tests shall be performed on the first unit of that type and rating from the given production facility. This requirement may be waived if Northern Powergrid has had sufficient experience of transformers from the production facility and the production facility can supply type test criteria from similar units supplied to other UK Distribution Network Operators or National Grid.

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 5 | of 40 |

Where Appendix 1 does not require the short circuit test to be carried out, the manufacturer shall demonstrate by calculation, or by providing evidence from a unit of the same design, that the transformer can withstand short circuit forces in accordance with IEC 60076-5.

11.13 Temperature rise test

A graph of ONAN rating versus ambient temperature and a graph of CMR rating versus ambient temperature shall be produced for every transformer. Copies of these graphs shall be supplied to Northern Powergrid. The graphs shall be verified against temperature rise test results during type and/or routine testing.

11.14 Determination of sound levels

Sound level measurement shall be carried out under full load conditions. This requirement can only be waived if the condition outlined in IEC 60076-10-1: Clause 9.4 is met and calculations associated with the clause are submitted for approval.

Type test measurements of sound level shall be carried out for ONAN and for CMR ratings. The type test CMR measurement shall be carried out with the cooler bank and ancillary cooling plants running at full capacity i.e. all associated fans and pumps running at full load. The routine ONAN measurement may be carried out without the cooler bank and ancillary cooling plants fitted.

11.15 Frequency Response Analysis (FRA)

FRA shall be carried out on the transformer at the manufacturing facility after all other routine tests and before the transformer is moved or dismantled. FRA shall be repeated again on-site after off-loading and installation/assembly but before on-site commissioning testing. FRA shall be carried out as stated in IEC 60076-18: Clause 4. The test requirements shall be agreed with Northern Powergrid beforehand.

11.18 Site tests

All site tests stated in 11.18 shall be carried out unless otherwise agreed between the manufacturer and Northern Powergrid.

14.2 Cooling medium

Where transformers contain insulating fluid then this fluid shall comply fully with the current Northern Powergrid Technical Specification NPS/003/019: Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear. This requirement also applies to any fluid used for first fill and for flushing of the unit.

Cooler banks shall be transformer tank mounted unless otherwise specified in Appendix 1: Addendum to Supplier Requirements.

15.1 Tanks and covers

The mechanical pressure tests shall be completed before any electrical tests.

15.1.1 Tanks

Working at Height Regulations: The requirements in ENA TS 35-3 shall apply. Details of the provisions incorporated into the design to comply with the Working at Height Regulations must be agreed with Northern Powergrid.

Where work at height is unavoidable and access is to be provided by portable ladder: restraining brackets shall be incorporated into the transformer steelwork to locate and secure the ladder both at the top and at the bottom. Locations are likely to include access to the Buchholz relay, winding temperature indicator thermocouples and connections, and CT terminations.

Ladders used by Northern Powergrid conform to BS 1129 and BS EN131-1 and are manufactured from either wood or glass-fibre. The dimensions of ladders used by Northern Powergrid are listed below;

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|---|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 6 | of | 40 |

| | |
|--|-------------------|
| Rung diameter (mm) | 22 (min) 80 (max) |
| Internal width of section: The minimum distance between stiles is not less than | 235mm. |

Provision shall be made for both fall restraint and fall prevention systems.

Fall restraint: An anchor point shall be provided at the centre of the lid of the transformer to allow secure connection of a fall restraint lanyard.

Fall Prevention: To facilitate safe working on top of the transformer, the transformer design shall incorporate a series of sockets installed a maximum of 2.1m apart to allow the installation of standard 48.3mm diameter scaffolding tubing of composite, aluminium or steel construction (to suit specific site requirements) to form a post and rail safety system. The sockets shall be designed so that water cannot be retained in the socket.

15.2 Surface Finish

The surface finish colour shall be uniform across the transformer and its auxiliaries and shall be medium neutral grey.

15.3 Terminals

Cable terminations shall comply with Northern Powergrid technical specifications:

- NPS/002/015 Technical Specification for 11kV and 20kV Joints and Terminations
- NPS/002/016 Technical Specification for 33kV Joints and Terminations
- NPS/002/017 Technical Specification for 66kV and 132kV Cable Accessories

The impulse level of all cable termination arrangements shall be at least equal to that specified for the transformer.

Where an air cable box or outer cone separable connectors are used, these shall be housed in an earthed metal enclosure that:

- (i) When installed on the transformer provides physical protection, tested to 10 Joules energy impact, in accordance with BS EN 62262, at the most vulnerable points on all exposed faces and on all exposed edges.
- (ii) Provides a minimum IP rating of IP21B in accordance with IEC 60529, with the requirements that:
 - (a) Insulation without metallic screening is to be classed as a hazardous part and 50mm clearance shall be maintained from the end of the IP21B test probe.
 - (b) Exposed primary conductors - clearances, as specified for live metal to earth in 15.3.1 below, shall be maintained from the end of the IP21B test probe.

The IP rating test shall be immediately after the BS EN 62262 IK test is carried out and these two tests shall be done on the same test sample.
- (iii) Is ventilated so that it does not create a micro-climate that is detrimental to the performance of the components contained in the enclosure
- (iv) Provides a feature(s) that allows the escape of any water from inside the enclosure.
- (v) Does not allow water to stand on, or remain in any internal or external features or fastenings of the enclosure
- (vi) Provides gland plates that are split across each row of gland holes to ease cable installation and termination.
- (vii) Provides an insulated arrangement to allow connection between the cable sheaths at the terminations inside the enclosure and external circuits, without electrical contact with the enclosure.

Outer cone cable connectors shall not be stacked more than two per bushing.

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 7 | of 40 |

There shall be the same number of connectors on each bushing unless varied by formal agreement with Northern Powergrid.

Regardless of connection arrangement; a means of disconnecting the cables from the transformer to allow independent testing of cables and/or transformer shall be provided.

If separable connectors are used, then disconnecting links shall be provided in a separate oil filled chamber such that the links can be removed without draining any oil from the main oil system.

Where cable connections are provided, then a suitable supporting bracket equipped with cable cleats assessed against NPS/002/011 Technical Specification for Cable Cleats and Saddles, shall be provided for the type and number of cables specified in Appendix 1: Addendum to Supplier Requirements.

Standard cable sizes are stated in IMP/001/914 Code of Practice for the Economic Development of the 132kV System and IMP/001/913 Code of Practice for the Economic Development of the EHV System.

All AIS bushings shall be fitted with co-ordinating gaps and these shall be set as specified in Table 9 of ENA TS 35-3.

15.3.1 Cable Boxes and Unfilled Cable Enclosures

Where a fully air insulated cable box is supplied, minimum air clearances must comply with the table below:

Fully Air Insulated Cable Box Minimum Clearances

| Voltage (kV) | Live Metal to Earth Flashover distance (mm) | Air end Creepage Distance (mm) | Phase to Phase Clearance (mm) |
|--------------|---|--------------------------------|-------------------------------|
| 12 | 200 | 406 | 250 |
| 24 | 220 | 550 | 250 |
| 36 | 380 | 1116 | 430 |

15.3.4 HV terminals

Where cable connections are required at 33kV and above, then separable plug-in cable terminations shall be provided unless otherwise stated in Appendix 1. Separable plug-in cable terminations shall meet the specification stated in NPS/002/015 – Technical Specification for 11kV and 20kV Cable Joints & Terminations or NPS/002/016 – Technical Specification for 33 kV Cable Joints and Terminations.

15.3.5 HV neutral

When the HV neutral is brought out to facilitate the connection of a neutral displacement voltage transformer (NDVT) to meet the specific requirements stated in Appendix 1 Clause 7.0, the NDVT shall comply with the technical specification in Appendix 7 of this document.

15.3.6 LV terminations

Cable terminations below 33kV shall normally be by means of an air filled cable box unless otherwise stated in Appendix 1.

15.3.7 LV neutral

An accessible isolatable link shall be provided on the neutral point of the LV winding to allow testing.

15.3.8 Earthing/auxiliary transformer

The tank mounted auxiliary transformer shall comply with Appendix 7 of this specification and all relevant parts of IEC 60076 and shall be connected as described in ENA TS 35-3.

A tank-mounted, cable connected auxiliary transformer with bolt on separable connectors will be considered by Northern Powergrid. Any agreed design will need to satisfy Northern Powergrid’s protection policy requirements and accessibility requirements.

15.3.8 Earthing/auxiliary transformer

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 8 | of 40 |

The positive sequence impedance voltage between the higher voltage winding and the lower voltage (auxiliary) winding shall not be more than 3.0% on 200kVA rating.

15.4 On-load tap-changer

Tapchangers shall be equipped with tapchangers designed to perform a minimum of 250,000 operations between maintenance intervals.

The term ‘Raise’ shall mean raise tap number and raise LV volts; The term ‘Lower’ shall mean reduce tap number and reduce LV volts.

15.4.2 On Load Tapchanger: Segregation of compartments

All breather pipework shall comply with the connection requirements of clause 9.3 of this specification.

15.6.2 Cooling plant

Contactors controlling the power supply to the fans and/or pumps, which are operated from the winding temperature indicator panel in the local substation control room, shall be 110V AC. This supply shall be provided from the marshalling kiosk.

If the transformer cooling system does not have an oil pump and there are four or more cooling fans, then in order to maintain the required level of flexibility, half of the cooling fans shall be controlled by what would have been the oil pump control circuit.

An option shall be provided for temperature related variable speed fan motors to avoid any step increases in noise-level.

15.6.3 Gas-and-oil actuated relay

All valves and relay test facilities shall be padlockable using Northern Powergrid standard padlocks.

The oil actuated relay shall also operate in the event of loss of oil from the system.

Relay hydraulic pipework shall be of stainless steel or plastic covered copper construction of diameter 6mm and 10mm for drain and test functions, respectively. It shall have petcock type sampling valves contained within a lockable steel enclosure.

15.6.5 Winding Temperature Indicators (WTI)

Winding temperature indicators shall be provided in both the high voltage and low voltage windings in the case of grid transformers (i.e. transformers with a primary winding voltage of 132kV). A single winding temperature indicator shall be provided in the low voltage winding for primary transformers (i.e. transformers with primary winding voltage of 66kV or 33kV).

A winding temperature sensor shall utilise a platinum resistance thermometer (PT100), located in the top of the transformer and a CT monitoring the winding current. The resistance thermometer should be installed in such a way that the unit can be replaced without significant work.

The resistance thermometer shall be wired in accordance with Northern Powergrid drawing Y030S6701 in the case of transformers with a primary voltage of 132kV, or drawing Y030S2704 for transformers with a primary voltage of 66kV or 33kV.

The output from the resistance thermometer shall be terminated in weatherproof compartment using connectors capable of accepting a screened multi-core cable. Northern Powergrid will supply and install the multicore cable and the winding temperature monitoring relay (Ashridge 852, or equivalent) which will be located in the substation control room.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|---|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 9 | of | 40 |

15.6.6 Current transformers

Transformers with a primary voltage of 132kV shall have winding temperature indicator (WTI) current transformers on both the HV and LV windings. Transformers with a primary voltage of 66kV or 33kV shall have a winding temperature indicator current transformer on the LV winding only.

Winding temperature indicator (WTI) and line drop compensation (LDC) current transformers shall be installed on the L2 winding within the transformer tank and shall be in accordance with Northern Powergrid drawing Y030S6701 in the case of transformers with a primary voltage of 132kV, or drawing Y030S2704 for transformers with a primary voltage of 66kV or 33kV. Current transformers shall be terminated in the transformer control wiring marshalling cubicle.

The table below states the WTI and LDC current transformer ratios applicable to **grid** CMR transformers (i.e. with 132kV primary winding voltage).

| Winding voltage | CMR TX Size (MVA) | 60 | 90 | 120 |
|-----------------|---------------------------------------|--------|---------|---------|
| 33kV | LV Winding Temperature CT Ratio (WTI) | | 1575/1A | 2099/1A |
| | Line Drop Compensation CT Ratio (LDC) | | 1575/1A | 2099/1A |
| 66kV | LV Winding Temperature CT Ratio (WTI) | 525/1A | 787/1A | 1050/1A |
| | Line Drop Compensation CT Ratio (LDC) | 525/1A | 787/1A | 1050/1A |
| 132kV | HV Winding Temperature CT Ratio (WTI) | 328/1A | 492/1A | 656/1A |

Transformer LV WTI & LDC

Burden: 15VA
 Class: 1.0 (Measurement)
 RCTC: 150% transformer rating

3s Rating: As per transformer 3s short circuit rating

Transformer HV WTI

Burden: 5VA
 Class: 1.0 (Measurement)
 RCTC: 150% transformer rating

3s Rating: As per transformer 3s short circuit rating

RCTC = Rated Continuous Thermal Current

The table below states the WTI and LDC current transformer ratios applicable to **primary** CMR transformers (i.e. with 66kV or 33kV primary winding voltage). All CTs shall be Class 1 type.

| | TX Size (MVA) | 10 | 15 | 24 | 30 | 40 | 50 |
|------|---------------------------------|-------|-------|--------|--------|--------|--------|
| 11kV | LV Winding Temperature CT Ratio | 500/1 | 750/1 | 1200/1 | 1500/1 | 2000/1 | 2500/1 |
| | Line Drop Compensation CT Ratio | 500/1 | 750/1 | 1200/1 | 1500/1 | 2000/1 | 2500/1 |
| 20kV | LV Winding Temperature CT Ratio | | | 750/1 | 1000/1 | 1200/1 | |
| | Line Drop Compensation CT Ratio | | | 750/1 | 1000/1 | 1200/1 | |

Where specified in the Addendum to Supplier Requirements, CTs shall be provided for protection schemes. These shall be accommodated within the bushing turret or supported on the cable below the cable box as appropriate. If slip-over CTs are specified, the transformer manufacture will provide a suitable support below the cable box.

Two solid core CTs (15/0.015A and 0.05VA) shall be provided for fan and pump current monitoring. These shall be connected in accordance with Northern Powergrid drawing Y030S6701 in the case of transformers with a primary voltage of 132kV, or drawing Y030S2704 for transformers with a primary voltage of 66kV or 33kV.

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 10 | of 40 |

WTI and LDC CTs installed in the transformer tank require a test loop. Where CTs are mounted in bushing turrets, CT test loops shall be provided in accordance with Figure 2 of ENA TS 35-3.

15.12 Condition monitoring equipment

In addition to the above, all CER Transformers shall be equipped with three pairs of fibre optic temperature sensors; one active sensor and one spare sensor per phase, to insure against failure in service.

Each pair of sensors shall be located at the winding design predicted hotspot in each phase.

Sensors shall be in accordance with BS EN 61757-1, terminated with ST-type optical connectors and suitable for use with a Nortech Sentinel II analyser, or equivalent.

The fibre optic sensor outputs shall be terminated in a tank mounted cabinet that provides sufficient space for a Nortech Sentinel II analyser, or similar, and associated communication and 110V ac cables.

Each fibre optic sensor termination shall be labelled to identify the location of the sensor, including which phase they relate to and whether they are in the HV or LV winding.

The transformer supplier shall provide Northern Powergrid with details, including a drawing, of where the sensors are located within the windings.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 11 | of | 40 |

4. References

The products described within this specification shall comply with all current versions of the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENA TS) current at the time of issue.

4.1. External Documentation

| Reference | Title |
|---------------|---|
| BS 1129 | Specification for portable timber ladders, steps, trestles and lightweight staging |
| BS 2562 | Cable boxes for transformers and reactors |
| BS 7870-8.1 | LV and MV polymeric insulated cables for use by distribution and generation utilities. Specification for multicore and multipair cables for installation above and below ground. Single wire armoured and PVC sheathed multicore cable with copper conductors. Section 8.1 Single wire armoured and PVC sheathed multicore cable with copper conductors |
| BS EN 131-1 | Ladders. Terms, types, functional sizes |
| BS EN 61757-1 | Fibre optic sensors Part 1: Generic specification |
| BS EN 61869-1 | Instrument transformers. General requirements |
| BS EN 61869-2 | Instrument transformers. Additional requirements for current transformers |
| BS EN 61869-3 | Instrument transformers. Additional requirements for inductive voltage transformers |
| BS EN 62262 | Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code) |
| ENA TS 09-6 | Auxiliary multicore and multipair cables |
| ENA TS 35-3 | Continuous Maximum Rated (CMR) system transformers (for use on systems up to and including 132 kV) |
| IEC 60076-1 | Power transformers. General |
| IEC 60076-10 | Power transformers - Part 10-1: Determination of sound levels –Application guide |
| IEC 60076-18 | Power transformers - Part 18: Measurement of frequency response. |
| IEC 60076-3 | Power Transformers - Part 3: Insulation levels , dielectric tests and external clearance in air |
| IEC 60529 | Degree of protection provided by enclosures (IP Code) |
| The Grid Code | The Grid Code (GB) |

4.2. Internal Documentation

| Reference | Title |
|-------------|--|
| IMP/001/103 | Code of Practice for the Methodology of Assessing Losses |
| IMP/001/913 | Code of Practice for the Economic Development of the EHV System |
| IMP/001/914 | Code of Practice for the Economic Development of the 132kV System |
| NPS/002/011 | Technical Specification for Cable Cleats and Saddles |
| NPS/002/015 | Technical Specification for 11kV and 20kV Cable Joints & Terminations |
| NPS/002/016 | Technical Specification for 33kV Cable Joints and Terminations |
| NPS/002/017 | Technical Specification for 66kV and 132kV Cable Accessories |
| NPS/003/019 | Technical Specification for Electrical Insulating Fluids for use in Plant & Switchgear |
| Y030S2704 | Primary TX FDR/TX Transformer control Ashridge 852 Plus-P (panel mounted) HV and LV winding temperature indicators. |
| Y030S6701 | Supply point TX FDR/TX Transformer control Ashridge 852 Plus-P (panel mounted) HV and LV winding temperature indicators. |
| Y213X99312 | Tank and covers general arrangement |

4.3. Amendments from Previous Version

| Reference | Description |
|----------------|---|
| Whole Document | Updated to current CDS Document Template, incl. Information Classification |
| Whole Document | Document reviewed - no update or content change required – Republished as version 3.1 with a new 3 year review period set |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 12 | of | 40 |

5. Definitions

| Term | Definition |
|------|------------|
| None | |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 13 | of | 40 |

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 |
| Liz Beat | Governance Administrator | 24/01/2024 |

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 | |
|--|-------------------------------------|-------------|
| Yes | Period: n/a | Reason: n/a |
| Should this document be displayed on the Northern Powergrid external website? | | Yes |
| | | Date |
| Paul McAdoo | Lead Policy and Standards Engineer | 22/02/2024 |

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 |
| Joe Helm | Lead Policy and Standards Engineer | 13/02/2024 |

6.4. Authorisation

Authorisation is granted for publication of this document.

| | | |
|------------|----------------------------|-------------|
| | | Date |
| Paul Black | Head of System Engineering | 26/02/2024 |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 14 | of | 40 |

Appendix 1 - Addendum to Supplier Requirements (Project or Site Specific Requirements)

Enquiry Ref:

Substation Name:

| ENATS 35-3 Issue 2 (2014) | Description | Requirements |
|------------------------------|---|--------------|
| 5.1 | Rated Power | MVA |
| | <i>Tertiary Rated Power (if applicable)</i> | MVA |
| | No-load Voltage Ratio | kV |
| | <i>Alternative voltage ratio</i> | |
| 5.3 | Generator Transformer Load Rejection | |
| 5.4 | Tapping Range | |
| 6.4 | Short Circuit Impedance % at CMR | |
| 5.6 | Loss Capitalisation Values | |
| | (i) No-load Loss £/kW (ii) Load Loss at 50% CER rating £/kW | |
| 7.0 | Vector group | |
| 7.0 | Vector Links required | |
| | If yes; state alternative vector group required | |
| 9.2 | Neutral conductor and Terminal intended to carry Load | |
| 9.3 | Oil Preservation System | |
| | If free breathing, breather type | |
| 11.1.2.1 | FRA test required at works and on site | |
| 11.1.4 | Short Circuit Test required | |
| | Third Harmonic Test required | |
| 11.13 | Temperature Rise Test required for Overload Condition | |
| 11.14 | Sound power level ONAN | dB(A) |
| | Sound power level CMR | dB(A) |
| 14.6 | Maximum HV System Short Circuit Capacity | |
| | Maximum LV System Short Circuit Capacity | |
| 15.1.5 | Transformer to be suitable for Sound Attenuation Enclosure | |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 15 | of | 40 |

| ENATS 35-3 Issue 2 (2014) | Description | Requirements |
|--------------------------------|--|--------------|
| | Access through Enclosure Roof Permitted | |
| 15.2 | Finish Colour Required | |
| 15.3 | Type of HV Terminations | |
| | Type of LV Terminations | |
| | Type of Tertiary Terminations | |
| | Type of HV Neutral Termination | |
| | Type of LV Neutral Termination | |
| 15.3.1 | Number and Size of Single Core Cables for Terminations | |
| | For HV Terminations | |
| | For LV Terminations | |
| | For Tertiary Terminations | |
| | For HV Neutral Termination | |
| | For LV Neutral Termination | |
| 15.3.2 | Bushing Stem Material | |
| | Co-ordinating Gaps required | |
| | Surge Arresters required | |
| | Brackets for Surge Arresters required | |
| 15.3.8 | Earthing / Auxiliary Transformer Required | |
| | Free Standing or Tank Mounted | |
| | No-Load Voltage Ratio (kV) | |
| | CMR Rating (kVA) | |
| | Zero Sequence Impedance (Ohms/Phase) | |
| | HV Rated Short-Time Neutral Current (A) | |
| | HV Terminations | |
| Vector Group (if not standard) | | |
| | Vector Link Required | |
| | Alternative Vector Group if yes | |
| 15.4.1 | Max / Min Tap Position Indicator required | |
| 15.6.2 | Separate Cooler Bank required | |
| 15.6.5 | Winding Temperature Indicators (WTI) | |
| | WTI on HV winding | |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 16 | of | 40 |

| ENATS 35-3 Issue 2 (2014) | Description | Requirements |
|--------------------------------------|--------------------------------------|---------------------|
| | WTI on LV winding | |
| | Test Loops for CT Required | |
| 15.6.6 | Additional CT accommodation required | |
| | CTs for Voltage Control | |
| | CTs for Protection Schemes | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 17 | of 40 |

Appendix 2a - Self-Certification Declaration of Conformance with ENA TS 35-3 Issue 2 2014

Transformers covered by ENA TS 35-3 shall comply with the latest issues of the relevant International and British Standards. ENA TS 35-3 is intended to amplify and/or clarify the requirements of those Standards.

This check sheet identifies the clauses in ENA TS 35-3 and the clauses of IEC 60076-1.

The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes.

| | |
|--|---|
| <p>Conformance declaration codes N/A = Clause is not applicable or 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 with the requirements of this clause, but the manufacturer proposes to modify and test the product in order to comply.</p> | <p>Instructions for completion</p> <ul style="list-style-type: none"> – When Cs1 code is entered no remark is necessary – When any other code is entered the reason for non-conformance shall be entered – Where options are specified, the remark shall identify the option offered by the manufacturer |
|--|---|

| Clause / Sub-clause | Requirement | Conformance Code IEC 60076-1 | Conformance Code ENA TS 35-3 | Schedule item | Remarks |
|---------------------|-----------------------------|------------------------------|------------------------------|---------------|---------|
| 1 | Scope | | | N/A | |
| 2 | Normative references | | | N/A | |
| 3 | Definitions | | N/A | N/A | |
| 3.1 | General | | N/A | N/A | |
| 3.2 | Terminals and neutral point | | N/A | N/A | |
| 3.3 | Windings | | N/A | N/A | |

| | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|-------------|------------------|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 18 | of | 40 |

| | | | | | |
|------|---|--|-----|-----|--|
| 3.4 | Rating | | N/A | N/A | |
| 3.5 | Tappings | | N/A | N/A | |
| 3.6 | Losses and no-load current | | N/A | N/A | |
| 3.7 | Short-circuit impedance and voltage drop | | N/A | N/A | |
| 3.8 | Temperature rise | | N/A | N/A | |
| 3.9 | Insulation | | N/A | N/A | |
| 3.10 | Connections | | N/A | N/A | |
| 3.11 | Test classification | | N/A | N/A | |
| 3.12 | Meteorological data with respect to cooling | | N/A | N/A | |
| 4 | Service conditions | | N/A | N/A | |
| 4.1 | General | | | N/A | |
| 4.2 | Normal service conditions | | | N/A | |
| 5 | Rating and general requirements | | N/A | N/A | |
| 5.1 | Rating | | | N/A | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 19 | of | 40 |

| | | | | | | |
|-------|---|--|-----|---|-----|--|
| 5.1.1 | General | | | Rated power | MVA | |
| | | | | No-load voltage ratio | kV | |
| 5.1.2 | Preferred values of rated power | | | Graph of ONAN vs. ambient | | |
| | | | | Graph of CMR vs. ambient | | |
| 5.1.3 | Minimum power under alternative cooling modes | | | N/A | | |
| 5.1.4 | Loading beyond rated power | | | N/A | | |
| 5.2 | Cooling mode | | | N/A | | |
| 5.3 | Load rejection on transformers directly connected to generators | | | Is the transformer suitable for generator transformer load rejection? | | |
| 5.4 | Rated voltage and frequency | | N/A | N/A | | |
| 5.4.1 | Rated voltage | | | HV rated voltage | kV | |
| | | | | LV rated Voltage | kV | |
| 5.4.2 | Rated frequency | | | Rated frequency | Hz | |
| 5.4.3 | Operation at higher than rated voltage and/or at other than rated frequency | | | N/A | | |
| 5.5 | Provision for unusual service conditions | | N/A | N/A | | |
| 5.6 | Highest voltage for equipment Um and dielectric test levels | | N/A | N/A | | |
| 5.7 | Additional information required for enquiry | | N/A | N/A | | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 20 | of | 40 |

| | | | | | |
|-------|---|--|-----|---|--|
| 5.7.1 | Transformer classification | | N/A | N/A | |
| 5.7.2 | Winding connection and number of phases | | N/A | N/A | |
| 5.7.3 | Sound level | | N/A | N/A | |
| 5.7.4 | Transport | | N/A | N/A | |
| 5.8 | Components and materials | | N/A | N/A | |
| 6 | Requirements for transformers having a tapped winding | | N/A | N/A | |
| 6.1 | General - Notation of tapping range | | N/A | N/A | |
| 6.2 | Tapping voltage, current, etc. | | N/A | N/A | |
| 6.3 | Tapping power | | | N/A | |
| 6.4 | Specification of tappings | | | Tapping range offered | |
| 6.5 | Specification of short-circuit impedance Short-circuit impedance between HV and Tertiary | | | Graph of impedance vs. tap position Maximum impedance (%) at rating MVA | |
| 6.6 | Load loss and temperature rise | | | Guaranteed load loss kW or Peak Efficiency Index % | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 21 | of 40 |

| | | | | Regulation (EU) No 548/20: Tier 1 compliance? Tier 2 compliance? If not, give reasons | |
|-----|--|--|-----|---|--|
| 7 | Connection and phase displacement symbol | | | Vector group Alternative vector group where links are provided Stabilising winding provided for star-star transformer | |
| 8 | Rating plates | | N/A | N/A | |
| 8.1 | General | | N/A | N/A | |
| 8.2 | Information to be given in all cases | | N/A | N/A | |
| 8.3 | Additional information to be given | | N/A | N/A | |
| 9 | Safety, environmental and other requirements | | N/A | N/A | |
| 9.1 | Safety and environmental requirements | | N/A | N/A | |
| 9.2 | Dimensioning of neutral connection | | | Is neutral connection dimensioned for load current? | |
| 9.3 | Liquid preservation system | | | Description of oil preservation system | |
| 9.4 | d.c. currents in neutral circuits | | | | |

| | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|-------------|------------------|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 22 | of | 40 |

| | | | | | |
|----------|---|--|-----|---|--|
| 9.5 | Centre of gravity marking | | N/A | N/A | |
| 10 | Tolerances | | N/A | N/A | |
| 11 | Tests | | | N/A | |
| 11.1 | General requirements for routine, type and special tests | | | N/A | |
| 11.1.1 | General | | | Lightning impulse voltage (LI) test voltage? | |
| 11.1.2 | Routine tests | | | Guaranteed sound power level at ONAN dB(A) | |
| 11.1.2.1 | Routine tests for all transformers | | | Where are FRA tests to be carried out? | |
| 11.1.2.2 | Additional routine tests for transformers with Um > 72.5 kV | | | N/A | |
| 11.1.3 | Type tests | | | Are type test results from an identical unit available? Guaranteed sound power level at CMR dB(A) Power taken by the fan and liquid pump motors kW No-loss loss and current at | |

| | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|-------------|------------------|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 23 | of | 40 |

| | | | | | |
|--------|--|--|-----|---|--|
| | | | | 90% of rated load kW, A 110% of rated load kW, A | |
| 11.1.4 | Special tests | | | Guaranteed and expected change of impedance after short-circuit test Special tests included in offer | |
| 11.2 | Measurement of winding resistance | | | N/A | |
| 11.3 | Measurement of winding ratio and phase displacement | | | N/A | |
| 11.4 | Measurement of short-circuit impedance and load-loss | | | N/A | |
| 11.5 | Measurement of no-load loss and current | | | Guaranteed no-load loss kW Regulation (EU) No 548/20: Tier 1 compliance? Tier 2 compliance? If not, give reasons | |
| 11.6 | Measurement of zero-phase sequence impedance (ZPSI) | | | Expected ZPSI at 10% FLC Ω/ph Expected ZPSI at FLC Ω/ph | |
| 11.7 | Tests on OLTC | | N/A | N/A | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 24 | of | 40 |

| | | | | | |
|-------|---|-----|-----|---|--|
| 11.8 | Leak testing with pressure for liquid immersed transformers | | | N/A | |
| 11.9 | Vacuum deflection test | | | N/A | |
| 11.10 | Pressure deflection test for liquid immersed power transformers | | N/A | N/A | |
| 11.11 | Vacuum tightness on site for liquid immersed power transformers | | N/A | N/A | |
| 11.12 | Check of core and frame insulation | | N/A | N/A | |
| 11.13 | Temperature rise test | | | Temperature rise test at overload condition (if applicable) | |
| 11.14 | Determination of sound levels | N/A | | Guaranteed sound power level (ONAN) dB(A) Guaranteed sound power level (CMR) dB(A) | |
| 11.15 | Frequency Response Analysis | N/A | | Is frequency response analysis included in offer? | |
| 11.16 | Measurement of the harmonics | N/A | | 3 rd harmonic component % | |
| 11.17 | Insulation resistance measurements | N/A | | N/A | |
| 11.18 | Site tests | N/A | | N/A | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 25 | of | 40 |

| | | | | | |
|--------|-------------------------------------|-----|-----|---|--------|
| 12 | EMC | | N/A | N/A | |
| 13 | High frequency switching transients | | N/A | N/A | |
| 14 | Transformer details | N/A | | N/A | |
| 14.1 | No. of phases and frequency | N/A | | N/A | |
| 14.2 | Cooling medium | N/A | | Cooling medium offered | |
| 14.3 | Cooling | N/A | | Cooling type at CMR | |
| 14.4 | Anti-vibration mountings | N/A | | Percentage isolation value and description of AV mountings | |
| 14.5 | Auxiliary supply voltage | N/A | | Supply voltage for tap-changer and cooler | |
| 14.6 | Duty under fault conditions | N/A | | Short circuit capability demonstrated? (supply details & test certificates) | |
| 15 | Construction details | N/A | | N/A | |
| 15.1 | Tanks and covers | N/A | | N/A | |
| 15.1.1 | Tanks | N/A | | Total oil required (including cooling system) | litres |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 26 | of | 40 |

| | | | | | |
|--------|------------------------------|-----|--|--|--|
| | | | | Filling medium for transport Overall height when arranged for transport on trailer mm Overall weight when arranged for transport on trailer tonnes Total weight as installed in service including cooler plant, all fittings and oil tonnes Type of haulage facilities offered | |
| 15.1.2 | Covers | N/A | | Is offer for bolted or welded cover? | |
| 15.1.3 | Gaskets | N/A | | Description of gasket material and thickness | |
| 15.1.4 | Earthing connections | N/A | | N/A | |
| 15.1.5 | Sound attenuation enclosures | N/A | | Is sound attenuation enclosure offered? | |
| 15.2 | Surface finish | N/A | | Finish colour offered | |
| 15.3 | Terminals | N/A | | Type of terminals offered HV LV Tertiary | |

| | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|-------------|------------------|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 27 | of | 40 |

| | | | | | |
|----------|---|-----|--|---|--|
| | | | | HV neutral LV neutral NVD capacitor taps NVD capacitance | |
| 15.3.1 | Cable boxes and unfilled cable enclosures | N/A | | Are separate disconnecting chambers provided? Position of cable boxes? | |
| 15.3.1.1 | Cable termination chambers | N/A | | N/A | |
| 15.3.2 | Outdoor bushings | N/A | | Stem diameters and lengths Description of surge protection provision | |
| 15.3.3 | Plug-in separable connectors | N/A | | Type of cone offered | |
| 15.3.4 | HV terminals | N/A | | N/A | |
| 15.3.5 | HV neutral terminal | N/A | | Type of terminal offered Accessible isolatable link offered? | |
| 15.3.6 | LV terminations | N/A | | Type of terminal offered Accessible isolatable link offered? | |
| 15.3.7 | LV neutral termination | N/A | | Type of termination offered Cable disconnecting links included? | |
| 15.3.8 | Earthing/auxiliary transformer | N/A | | Earthing/auxiliary | |

| | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|-------------|------------------|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 28 | of | 40 |

| | | | | | |
|--------|---------------------------------|-----|--|---|--|
| | | | | transformer type? Is flange and valve included? Rating HV terminations Other details, if not standard | |
| 15.4 | On-load tap-changer | N/A | | N/A | |
| 15.4.1 | Operating mechanism | N/A | | Description of motor protection Is a max/min tap position indicator included? | |
| 15.4.2 | Segregation of compartments | N/A | | N/A | |
| 15.4.3 | Method of operation | N/A | | N/A | |
| 15.5 | Clearance to exposed conductors | N/A | | N/A | |
| 15.6 | Fittings | N/A | | N/A | |
| 15.6.1 | Conservator | N/A | | Is low oil level alarm included? | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 29 | of 40 |

Appendix 2b - Clause by Clause Conformance with Northern Powergrid NPS/003/021

| ENA TS 35-3 Clause | Requirement | Conformance Code | Schedule item | Remarks |
|--------------------|--|------------------|--|---------|
| N/A | Multicore wiring | | Multicore wiring shall meet the requirements of BS 7870-8.1 and ENA TS 09-6. | |
| 5.4.3 | Operating frequency limits. | | Continuous operation at 47.5Hz and 20 second rating at 47Hz | |
| 6.6 | Load loss and temperature rise | | Loss capitalisation basis as described in IMP/001/103 – Code of Practice for the Methodology of Assessing Losses | |
| 7.0 | Connection and phase displacement symbols | | Vector groups required for use on the Northern Powergrid networks | |
| 8.2 | Rating plates | | Format and content of rating plates | |
| 9.3 | Liquid Preservation System | | Breather pipe thread ¾" BSP | |
| 11.1 | General requirements for routine, type and special tests | | Mechanical tests before electrical tests. | |
| 11.1.1 | General | | The Rated lightning impulse (LI) for 11.5kV shall be 95kV (peak) and 28kV (rms) | |
| 11.3 | Type tests | | Full type tests on first unit of each type from each production facility. | |
| 11.14 | Determination of sound levels | | CER type test with radiators fitted and all cooling on Benchmark ONAN type test without radiators fitted Routine ONAN noise measurement without radiators fitted | |
| 11.15 | Frequency Response Analysis (FRA) | | FRA before leaving the manufacturer's works and repeated at site | |
| 14.2 | Cooling medium | | Cooling medium to NPS/003/019 | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 30 | of | 40 |

| ENA TS 35-3 Clause | Requirement | Conformance Code | Schedule item | Remarks |
|--------------------|----------------------------------|------------------|---|---------|
| 14.2 | Separate cooler bank arrangement | | Cooler banks transformer tank mounted unless otherwise specified | |
| 15.1 | Tanks and covers | | Mechanical tests to precede electrical tests | |
| 15.1.1 | Tanks | | Working at height arrangements; retraining brackets for ladders for short time inspection/work and socket system to allow post and rail fall prevention | |
| 15.2 | Surface finish | | Medium neutral grey | |
| 15.3 | Terminals | | Compliance with Northern Powergrid cable termination specifications | |
| 15.3 | Terminals | | Impulse level of cable termination arrangements at least equal to that specified for transformer | |
| 15.3 | Terminals | | Earthed metal enclosure for outer cone connectors | |
| 15.3 | Terminals | | Cable box tested to 10 Joules energy impact | |
| 15.3 | Terminals | | Cable box min IP rating of IP21B, unscreened insulation to be classed as a hazardous. 300mm clearance maintained from the end of the IP21B test probe | |
| 15.3 | Terminals | | Cable box ventilated and to shed rain water | |
| 15.3 | Terminals | | Split gland plates to ease cable installation and termination | |
| 15.3 | Terminals | | Cable box to allow connection between the cable sheaths at the terminations inside the enclosure and external circuits, without electrical contact with the enclosure | |
| 15.3 | Terminals | | Outer cone cable connectors shall not be stacked more than two per bushing. There | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 31 | of 40 |

| ENA TS 35-3 Clause | Requirement | Conformance Code | Schedule item | Remarks |
|--------------------|--------------------------------|------------------|--|---------|
| | | | shall be the same number of connectors on each bushing. | |
| 15.3 | Terminals | | A means of disconnecting the cables from the transformer to allow independent testing of cables and/or transformer shall be provided | |
| 15.3 | Terminals | | If separable connectors are used, disconnecting links shall be provided in a separate oil filled chamber | |
| 15.3 | Terminals | | Where cable connections are provided then a suitable supporting bracket equipped with NPg approved cable cleats shall be provided | |
| 15.3 | Terminals | | AIS bushings fitted with co-ordinating gaps | |
| 15.3 | HV Terminals | | Provision of cable cleats on supporting bracket | |
| 15.3 | HV Terminals | | Cable disconnecting links where inner cone connectors are used | |
| 15.3.4 | HV Terminals | | Cable connections at 33kV shall have separable plug-in cable terminations unless otherwise stated | |
| 15.3.5 | HV neutral | | Where HV neutral brought out to connect a NDVT, the NDVT shall comply with the technical specification in Appendix 6 | |
| 15.3.6 | LV Terminations | | Cable terminations below 33kV shall be by means of an air filled cable box unless otherwise stated | |
| 15.3.7 | LV neutral | | Accessible isolatable link shall be provided on the neutral point of the LV winding to allow testing | |
| 15.3.8 | Earthing/auxiliary transformer | | Provision of tank mounted auxiliary transformer to comply with Appendix 7 | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 32 | of 40 |

| ENA TS 35-3 Clause | Requirement | Conformance Code | Schedule item | Remarks |
|--------------------|--------------------------------|------------------|--|---------|
| 15.3.8 | Earthing/auxiliary transformer | | Tank mounted, cable connected option for connection of auxiliary transformer subject to protection and accessibility requirements | |
| 15.4 | On-load tap-changer | | Tapchangers equipped with tapchangers designed to perform a minimum of 250,000 operations between each maintenance. | |
| 15.4 | On load tap-changer | | 'Raise' and 'Lower' tap change terminology | |
| 15.6.2 | Cooling plant | | Control supply 110V | |
| 15.6.2 | Cooling plant | | Staged operation of fans where no oil pumps | |
| 15.6.2 | Cooling plant | | Option for variable speed fan motors | |
| 15.6.3 | Gas and oil actuated relay | | Sampling and testing points lockable | |
| 15.6.3 | Gas and oil actuated relay | | Relay operation for loss of oil | |
| 15.6.3 | Gas and oil actuated relay | | Relay hydraulic pipework of stainless steel or plastic covered copper construction of diameter 6mm and 10mm for drain and test functions respectively with petcock type sampling valves with colour-coded fittings | |
| 15.6.5 | Winding Temperature Indicators | | Winding temperature utilised using a platinum resistance thermometer (PT100), and a CT monitoring the LV winding current. | |
| 15.6.5 | Winding Temperature Indicators | | PT100 should be installed in such a way that the unit can be replaced without significant work | |
| 15.6.5 | Winding Temperature Indicators | | Temperature sensor criteria | |
| 15.6.5 | Winding Temperature Indicators | | Wired as per Y030S6701 | |
| 15.1.6.6 | Current Transformers | | WTI and LDC current transformers installed on the L2 winding within the transformer tank connected as shown in drawing Y030S6701 | |

| | | | | | | | | |
|-----------------------------|-----|------------------------|------------------------|---------------|------------------|----|-----------|----|
| Document Reference:- | | NPS/003/021 | Document Type:- | | Code of Practice | | | |
| Version:- | 5.0 | Date of Issue:- | | February 2024 | Page | 33 | of | 40 |

| ENA TS 35-3 Clause | Requirement | Conformance Code | Schedule item | Remarks |
|--------------------|--------------------------------|------------------|--|---------|
| 151.6.6 | Current Transformers | | WTI and LDC current transformer ratios as specified | |
| 151.6.6 | Current Transformers | | CTs for protection schemes In bushing turret or cable box | |
| 151.6.6 | Current Transformers | | Where CTs are mounted in bushing turrets CT test loops shall be provided in accordance with Figure 2 of ENA TS 35-3. | |
| 151.6.6 | Current Transformers | | Two solid core CTs (15/0.015A and 0.05VA) for fan and pump current monitoring wired as per Y030S6701 | |
| 15.12 | Condition monitoring equipment | | Also equipped with three pairs of fibre optic temperature sensors; each pair of sensors shall be located at the winding design predicted hotspot in each phase | |
| 15.12 | Condition monitoring equipment | | Fibre optic temperature sensor criteria as specified | |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 34 | of | 40 |

Appendix 3 - Pre-commission Testing, Routine Inspection and Maintenance Requirements

Suppliers shall provide :

- (a) details of the recommended pre-commission testing and inspection required.
- (b) details of periodic inspection and maintenance requirements to be undertaken during the lifetime of their product.
- (c) Detailed inspection and maintenance instructions, workface documents and associated parts lists for the installation, pre-commission testing and inspection and periodic inspection and maintenance.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 35 | of | 40 |

Appendix 4 - Technical Information Check List

The following information shall be provided by the supplier for technical 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 variant | |
| Appendix 2a - Completed self-certification conformance declaration against ENA TS 35-3 | |
| Appendix 2b- Completed self-certification conformance declaration against NPS/003/021 | |
| Appendix 3 - Pre-commission Testing, Routine Inspection and Maintenance Requirements | |
| Appendix 5 – Declaration of Manufacturers, Places of Manufacture, Test & Inspection | |
| Appendix 6 - Completed self-certification conformance declaration against requirements for transformer tank-mounted NDVT | |
| Appendix 7 - Completed self-certification conformance declaration against requirements for transformer tank-mounted auxiliary transformer | |
| Copies of ISO 9001 certificate of accreditation for main manufacturing facility(s) | |
| Declaration of technical non-conformances against technical specification clauses | |
| Type test evidence (summary list and copies of all type test evidence) | |
| Routine test plan (example) | |
| Details of Insulating fluid type proposed and confirmation of compliance with NPS/003/019 | |
| COSHH sheets | |
| Work at Heights provision – details of system(s) offered | |
| UK DNO references/previous customers that have been supplied with these products | |
| Copy of pricing schedule template populated with product codes/description | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 36 | of 40 |

Appendix 5 - Declaration of Manufacturers, Places of Manufacture, Test & Inspection

| Item | Manufacturer's Drawing Number and/or Type Designation | Manufacturer | Place of Manufacture | Place of Testing & Inspection |
|---|---|--------------|----------------------|-------------------------------|
| Transformers complete On-load tap-change equipment HV Bushings LV Bushings Neutral Bushings Radiators Pipework Expansion Devices Oil valves Oil Pumps Oil Pump Motors Fans Fan Motors Dehydrating Breather Gas and Oil Actuated Relay(s) Outdoor Marshalling/Control Box Temperature Indicating Devices Auxiliary Transformer Material for Anti-Vibration Mounting | | | | |
| Any subsequent deviation from this declaration schedule shall be notified in writing as soon as possible for the Purchaser's approval. | | | | |

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 37 | of | 40 |

Appendix 6 - Specification for Transformer Tank Mounted NDVTs

Specification for Transformer Tank Mounted Neutral Displacement Voltage Transformers (NDVTs)

A6-1 Overview

A6.1.1 ENA TS 35-3 allows for flange mounting of an outdoor voltage transformer for neutral displacement protection. The NDVT primary winding shall be connected between the transformer winding star point and earth.

A6.1.2 The NDVT shall be designed, constructed and tested in accordance with BS EN 61869-3 Instrument transformers - Additional requirements for inductive voltage transformers.

A6-2. Electrical Performance Requirements

| | |
|---|--------------|
| A6.2.1 Highest voltage for equipment (Um) | 36 or 72kV |
| A6.2.2 Secondary winding output voltage | 63.5 V |
| A6.2.3 Minimum rating | 50 VA |
| A6.2.4 Accuracy Class | 6P |
| A6.2.5 Basic Insulation | Oil Immersed |

A6-3. General Construction and Fittings

A6.3.1: The oil in the NDVT shall be separated from the oil in the main transformer by means of an internal barrier that shall be pressure tested in accordance with section 11.8 of ENA TS 35-3, in both directions.

A6.3.2: The NDVT shall incorporate the following features:

- Oil preservation system in accordance with Sub clause 9.3 of section 3.3.2 of NPS/003/021
- Tank and covers in accordance with Sub clause 15.1 of section 3.3.2 of NPS/003/021 and within the constraints Northern Powergrid drawing number Y213X99312.
- Oil level indicator
- Rating and diagram plate
- Terminal box with removable, padlockable cover. This terminal box shall contain links as required to comply with the winding arrangements specified in section A6-4 below. These links shall be clearly identified.
- A cable gland for a 2 core multicore cable

A6-4. Winding Arrangements

A6.4.1: The earthing of the primary winding shall be independent of, and segregated from, the earthing of the secondary winding.

A6.4.2: Primary winding terminal "N": The primary winding neutral point shall be provided with an accessible isolatable link to allow testing. The primary winding neutral link shall be enclosed in a lidded, dry metal box. A drawing of the proposed arrangement shall be provided for approval.

A6.4.3: The primary winding terminal "A" shall be connected to a HV bushing by a flexible lead. This bushing shall connect the NDVT to the main transformer HV neutral and shall be within the main transformer oil system.

It shall be possible to easily disconnect this flexible lead to the bushing for the purpose of testing the main transformer.

A6.4.4: The secondary winding terminals "a" and "n" shall be connected to links (typically GEC RS20 type) or equivalent in the terminal box. The "n" terminal winding neutral point shall be provided with an accessible isolatable link to allow testing. The secondary winding neutral link shall be enclosed in a lidded, dry metal box. A drawing of the proposed arrangement shall be provided for approval.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 38 | of | 40 |

A6-5. NDVT Conformance Declaration

The conformance declaration table below shall be completed for each unit.

| Clause | Description | Confirmation/Comment/Description |
|--------|--|----------------------------------|
| A6.1.1 | NDVT primary winding | |
| A6.1.2 | Compliance with BS EN 61869-3 Instrument transformers - Additional requirements for inductive voltage transformers. | |
| A6.2.1 | Highest voltage for equipment (Um) | |
| A6.2.2 | Secondary winding output voltage | |
| A6.2.3 | Burden rating | |
| A6.2.4 | Accuracy class | |
| A6.2.5 | Basic insulation type | |
| A6.3.1 | Barrier pressure test | |
| A6.3.2 | Oil preservation system in accordance with section 9.3 of NPS/003/021 | |
| | Tank and covers in accordance with section 15.1 of NPS/003/021 and within the constraints of drawing number Y213X99312 | |
| | Oil level indicator | |
| | Rating and diagram plate | |
| | Terminal box with removable, padlockable cover. | |
| | This terminal box links. | |
| | Cable gland for a 2 core multicore cable | |
| A6.4.1 | Independent, segregated primary and secondary earthing | |
| A6.4.2 | Primary winding terminal "N" | |
| A6.4.3 | Primary winding terminal "A" | |
| A6.4.4 | Secondary winding terminals "a" and "n" | |

| | | | |
|---|--------------------------------------|---|--------------|
| Document Reference:- NPS/003/021 | | Document Type:- Code of Practice | |
| Version:- 5.0 | Date of Issue:- February 2024 | Page 39 | of 40 |

Appendix 7 - Specification for Transformer Tank Mounted Auxiliary Transformers

A7.1 Overview

ENA TS 35-3 allows for flange mounting of an outdoor auxiliary transformer. The auxiliary transformer shall be designed, constructed and tested in accordance with ENA TS 35-1 Distribution transformers, except where varied by this specification.

A7.2. Electrical Performance Requirements

| | |
|--|--|
| A7.2.1: Input voltage for equipment (Um) | to match the main transformer secondary voltage. |
| A7.2.2: Output voltage | 433V at no load. |
| A7.2.3: Vector Group | Dyn11 |
| A7.2.4: Rating | 50kVA |
| A7.2.5: Tappings | Not required |
| A7.2.6: Impedance Voltage (at 75°C) | 4.5% of rated power |

A7.3. Mounting Arrangements

A7.3.1: The flange facing and mounting arrangement need not comply with the flange facings specified in ENA TS 35-3, or in ENA TS 35-1, but shall optimise the interface between the main unit and the auxiliary transformer.

If the flange arrangement is NOT in accordance with ENA TS 35-3, or in ENA TS 35-1 then the manufacturer/supplier shall provide full details of the flange to Northern Powergrid.

A7.3.2: Mounting Arrangements: The auxiliary transformer shall be rigidly supported by the flange mounting arrangement. Additional bracings shall be provided between the auxiliary and main transformer if necessary to ensure adequate and rigid support.

A7.4. LV Terminal Arrangements

A7.4.1: An LV fuseboard shall be mounted on the auxiliary transformer and the LV terminals of the auxiliary transformer shall be connected to this LV fuseboard. The means of connection shall minimise any risk from failure of this connection(s).

A7.4.2: The LV fuseboard shall conform fully to Form 4 Type 2 requirements of BS EN 60439-1, Low-voltage switchgear and controlgear assemblies – Type-tested and partially type-tested assemblies. All terminals and exposed live metalwork shall be shrouded.

A7.4.3: The LV fuseboard shall be designed and constructed to be suitable for outdoor use. The fuseboard, its components (excluding insulating parts) and its mountings shall not require maintenance for a period of at least 30 years in a polluted / coastal environment according to EN ISO 12944-2 Category C4.

A7.4.4: The fuseboard housing shall have a padlockable access door/non-bolted cover; suitable for use with a padlock hasp of 3-6mm diameter.

A7.4.5: The auxiliary transformer LV phase connections shall be terminated in the LV fuseboard, onto three 100A fuse units that shall be in accordance with Type 3 of BS 7657 (1993); each of which shall be fused with a 60A fuse that shall be in accordance with Type II b of BS1361 (1971).

A7.4.7: The auxiliary transformer LV fuses shall be ergonomically accessible from ground level and be mounted not less than 900mm and not more than 1600mm above ground level.

| | | | | | | | |
|-----------------------------|-------------|------------------------|------------------|-------------|----|-----------|----|
| Document Reference:- | NPS/003/021 | Document Type:- | Code of Practice | | | | |
| Version:- | 5.0 | Date of Issue:- | February 2024 | Page | 40 | of | 40 |

A7.4.8: The auxiliary transformer LV neutral connections shall be terminated onto an arrangement with two independently removable, bolted links inside the LV fuseboard:

(a) the outgoing side of one link shall be connected to a designated earth connection point on the auxiliary transformer

(b) the outgoing side of one link shall be connected to the outgoing LV cable

A7.4.9: The underside of the LV fuseboard housing shall have a suitably positioned 20mm diameter cable access hole, equipped with a compression gland for a 4-core armoured 25mm² cable that will be used to connect to the outgoing sides of the LV fuses.

A7.4.10: The LV fuseboard shall be equipped with all necessary connections/lugs to allow termination of a 4-core armoured 25mm² cable used to connect to the outgoing sides of the LV fuses

As an alternative to the LV fuseboard; an arrangement incorporating an LV fuse switch will be considered, provided that all the above specified performance and operational requirements are met.

A7.5. Earthing Terminal Arrangement

A7.5.1: An earthing connection shall be provided on the exterior of the auxiliary transformer. This connection shall be designed to accept neutral/earth connection(s) from the bolted link in the LV fuseboard described above.

A7-6. Auxiliary Transformer Conformance Declaration

The conformance declaration table below shall be completed for each unit.

| Clause | Description | Confirmation/Comment/Description |
|--------|--|----------------------------------|
| A7.1.1 | Conformance with ENA TS 35-1 | |
| A7.2.1 | Input voltage | |
| A7.2.2 | Output voltage | |
| A7.2.3 | Vector group | |
| A7.2.4 | Rating | |
| A7.2.5 | Tappings | |
| A7.2.6 | Impedance voltage (at 75°C) | |
| A7.3.1 | Flange facing | |
| A7.3.2 | Mounting arrangements | |
| A7.4.1 | LV terminals & connection | |
| A7.4.2 | Form 4 Type 2 requirements of BS EN 60439-1 | |
| A7.4.3 | Withstand 30 years in EN ISO 12944-2 Category C4 | |
| A7.4.4 | Padlockable door/cover | |
| A7.4.5 | LV fuse & link arrangements | |
| A7.4.6 | Neutral connection | |
| A7.4.7 | Cable hole & gland | |
| A7.5.1 | Earth terminal arrangement | |