NPS/003/020 – Technical Specification for 11kV and 20kV Voltage Regulators

1. Purpose

This document provides the technical specification for voltage regulators for use on Northern Powergrid (the Company) distribution networks.

This document supersedes the following documents, all copies of which shall be destroyed.

Reference	Date	Version	Title
NPS/003/020	Dec 2017	V3.0	Technical Specification for 11kV and 20kV Voltage Regulators

2. Scope

This technical specification covers single and three phase voltage regulators for use in outdoor ground mounted/elevated structure substations or pole mounted locations on the Company's 11kV and 20kV distribution networks.

The units described in this specification are intended to be utilised on the Northern Powergrid distribution system in accordance with the Northern Powergrid Application Guide IMP/001/915/001 "***An Application guide for modelling and selecting HV Voltage regulators***"

The regulators shall be fluid-immersed, step-type voltage regulators. The voltage regulator must be completely self-contained and provide a minimum of ±10% regulation in thirty-two (32) steps of approximately 0.625% each.

The equipment shall fully conform to this specification and all national and international standards referenced.

2.1. Table of Contents

3. Technical Requirements

3.1. Technical Specification

Both Pole Mounted and Ground Mounted equipment shall be designed to fully comply with ANSI Std IEEE C57.15-2009 or its direct IEC Equivalent of IEC 60076-21, unless varied by this specification.

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

3.2. Variances and Clarifications to ANSI Standard IEEE C57.15-2009/IEC 60076-21

Where appropriate, the following variations, additions and clarifications to ANSI Standard IEEE C57.15-2009/IEC 60076-21 are referenced to the clause numbers in that document:

4.1 Service conditions

The Voltage regulators shall be capable of operation within the following service conditions:

a) Ambient temperature range of -25°C to +40°C where the average value of the ambient air temperature, measured over a period of 24h, does not exceed 30°C.

b) Maximum installation altitude not exceeding 1000m.

Account shall be taken of any detrimental effects resulting from condensation and/or precipitation.

4.4 Frequency

The rated frequency shall be 50Hz.

5.1 Cooling classes of regulators

The cooling class of regulators to this specification shall class ONAN be as specified in IEC 60076-21, clause 5.1.1

5.2 Ratings

Ratings for step-voltage regulators are continuous and based on not exceeding the “winding temperature rise by resistance limit” of 65°C and the ”hottest spot winding temperature rise” limit of 80°C in accordance with IEC 60076-21, clause 5.2 table 2 . (This design is based on an average ambient temperature of 30°C).

All regulators shall be identified with the 65 °C winding temperature rise limit on the units rating plate.

5.2.2 Preferred Ratings

The standard range of preferred ratings for liquid-immersed 50Hz step voltage regulators (single phase) shall be as detailed in IEC 60076-21, clause 5.2.2 Table 4. To provide a standardised range and to incorporate the need for regulators to satisfy the minimum short circuit ratings, Table 1 has been prepared.

Note

To avoid confusion when specifying regulators they shall be specified by using the Nominal System Voltage and Continuous Rated Current of the regulators instead of the regulated KVA or the System KVA.

The Regulator rated KVA is defined by:-

(Regulated KVA) = Regulating Range x Nominal Nameplate Voltage x Continuous Rated Current @ 65°C)

(Where the regulating range is normally 10% on single phase units).

Example 22kV x 200A x 10% = 440KVA

The selection of the required rated load current may be determined by the need for a regulator to withstand a stated minimum short circuit requirement as detailed in IEC 60076-21, clause 5.9.1.

- By default regulators are provided with a maximum short circuit value of 25 times the base rms symmetrical rated load current.
- Where the default value does not achieve the expected short circuit value for the point on the system that it is being installed, then the user may specify a larger short circuit withstand of 40 times the base rated load current.
- If this is still insufficient then the user will be required to specify a larger rated load current to achieve the required value or locate the regulator at a location more remote from the supply source. Further details can be seen in table 1 below

Table 1 Principle Parameters – Multiple Single Phase Pole Mounted Regulators or Three Phase Ground Mounted

Nom System Voltage (kV)	Apparent Rated Power (MVA)	Cont. Rated Load Currents (standard sizes) (A)	Regulated KVA	(1)Rating Multiplier x Full load current	Resultant Short Circuit Withstand (kA)	Voltage Ratio Req (kV)	Tapping Range (%)	Lightning Impulse Withstand (kV)
11	3.8	200	220	25	8kA	11.5/11.5	+/- 10% Or +/- 15%	95
	7.6	400	440	40	12kA			
20	6.9	200	440	40	8kA	20/20		150
	10.4	300	660	40	12kA			

Note

1. Max Tap Step (%) 0.625
2. Tapping Range. In case of closed delta arrangements, the tapping range can be as much as +/- 15% by using three single phase regulator units connected in closed delta.
3. Pole mounted regulators can be connected in open or closed delta configurations.
4. Open Delta arrangements - consist of 2 single phase regulators
5. Closed Delta arrangements – consist of 3 single phase regulators

5.4 Taps

The regulator shall be designed to provide approximately ±10% automatic adjustment of the unregulated supply on the source side of the voltage regulator. This shall be done in approximately 0.625% steps, with sixteen steps above and below the rated voltage.

5.7 Insulation Levels

The required BIL levels for regulators designed in accordance with this specification shall be as detailed in table 1

5.8 Losses

Capitalisation costs shall be calculated using the values provided by the Company at the time of calculation.

Loss Capitalisation Calculation:

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

Note that the Company's loss £/kW figures incorporate utilisation factor and time span.

5.9.1 Short Circuit requirements

These requirements will be specified at the time of ordering and will be maximum prospective fault level at the proposed installation site.

All regulator units shall be provided with a K value of 2.55 (50Hz value) as identified in clause 5.9.1, Table 13 of ANSI Standard IEEE C57.15-2009/IEC 60076-21.

5.10 Testing

The full range of type tests required by IEC 60076-21, clause 5.10 shall be performed on, at least, the first unit of a given type and rating from a production facility unless type tests for similar designs have been provided to confirm short circuit, temperature and dielectric performance.

5.10.1 Routine Tests

Routine tests shall be made on all voltage regulators as detailed in IEC 60076-21, clause 5.10.1

5.10.2 Type Tests

Unless existing test evidence is available and is formally accepted by Northern Powergrid, the full range of type tests required by IEC 60076-21, clause 5.10.2 shall be performed on, at least, the first unit of a given type and rating from a production facility.

6.0 Construction

6.1 Bushings

6.1.1 Pole Mounted Voltage regulators (inc. height and weight limitations)

Shall be equipped with UV stable bushings in accordance with IEC 60076-21, clause 6.1 and in addition all bushings 15 kV and above shall have a minimum creep distance of 500mm.

All pole mounted regulators shall be provided with externally mounted metal oxide bypass arresters designed generally in accordance with NPS/001/008 and connected across the series winding.

11kV units shall be provided with 3kV series arrestors and 20kV units shall be provided with 6kV series arrestors.

Stainless steel mounting bosses shall be provided for the addition of lightning arresters adjacent to the source (S), load (L), and source-load (SL) bushings. The bosses shall be fully welded around their circumference. Spot welding is not acceptable.

To allow pole mounted voltage regulators to satisfy existing NPg standard arrangement drawings, then the offered units shall satisfy the following weight and height dimensional limitations;

200A units will have weights of less than 1300kgs per single phase unit

200A units will have overall unit heights of less than 2200mm

300A units will have weights of less than 1800kgs per single phase unit

200A units will have overall unit heights of less than 2400mm

400A units will have weights of less than 2100kgs per single phase unit

400A units will have overall unit heights of less than 2700mm

6.1.2 Ground Mounted Three Phase regulators

All Ground mounted three phase regulators shall be equipped with HV cable boxes that comply with ENA TS 12-11. The cable box shall be supplied equipped with a split gland plate and three CE6 glands (or equivalent) suitable for use with single core cables, each of which shall enter the cable box vertically below its termination bushing. The cable box shall also be supplied equipped with a suitably rated insulated bushing that is designed to allow the three HV cable earth screens to be connected to it inside the cable box and a connection from the substation earth to be connected to it outside the cable box.

HV cable connections shall be made utilising screened separable connectors, which shall be outside cone type (non-load-break) in accordance with BSEN 50180 -1.

For HV cable connections rated up to and including 20kV, the Interface shall be 630A Type C1.

HV cable connections that do not incorporate a fully rated metallic earth screen shall be enclosed by an earth-bonded metal cover that:

a) When installed on the switchgear provides physical protection, tested to 5J impact at the most vulnerable point on all exposed sides and at the vulnerable point on each exposed edge.

b) Provides a minimum IP rating of IP21B in accordance with IEC 60529. For the purposes of this test the separable connector is to be classed as a hazardous part that requires 20mm clearance from the end of the IP21B test probe

6.2 Terminal Markings

Voltage Regulator terminals shall be marked as detailed in IEC 60076-21, clause 6.2.1 where the terminal connected to the load shall be designated by an L, and those that are connected to the source shall be designated by an S. The bushing designations (S, L, and SL) shall be permanently marked on the regulator cover adjacent to the bushings.

6.4 Nameplates

Two durable laser-etched metal nameplates shall be furnished with each voltage regulator and shall be affixed to the regulator main tank and on the front of the control cabinet. The name plates shall as a minimum provide the detail stated in IEC 60076-21, clause 6.4.

6.5 Tank Construction

Voltage regulators shall have a sealed-tank fluid preservation system as detailed in IEC 60076-21, clause 6.5 complete with a pressure relief valve.

The external parts of the tank and control enclosure shall not require maintenance for a period of at least 30 years in a polluted / coastal environment according to ISO 12944-2 Category 4. The colour of the final coat of paint on all exterior surfaces shall preferably be dark grey. The inside of the tank and bottom of the cover shall also be primed and painted.

Voltage regulators shall be provided with a fluid sight gauge that indicates fluid colour and critical level at -20°C

Two diagonally opposite earthing tags or bonding positions shall be located on the tank and one on the control enclosure, the tags shall incorporate an M18 or M22mm hole to allow the tank to be bonded to the pole earthing system.

Voltage regulators rated 668A or below shall include features that will permit additional current-carrying capabilities at reduced regulation, as shown in IEC 60076-21, clause 7.1, Table 16, but not to exceed 668A. The additional current carrying adjustment shall be located inside the position-indicator faceplate to prevent inadvertent adjustment. In addition, a software control feature shall be available which allows for adjustment through the control keypad.

An external, corrosion-resistant position indicator shall indicate the tap-changer position. The position indicator shall be polymer constructed, mounted above the oil level, and slanted downward at a 45-degree angle for ease of reading when the regulator is mounted above ground level.

6.5.2 Lifting Lugs

All regulators shall be provided with two lifting lugs, painted yellow and located to ensure a balanced lift in a vertical direction for the completely assembled voltage regulator and shall be designed to provide a safety factor of 5.

Manual Handling

The regulator design for three phase ground mounted units shall take into account, and allow for, methods of manual handling including, but not limited to, the use of a pinch bar and 50-75mm diameter rollers.

The regulator shall return to the upright position when tilted 20° from the vertical.

6.6 Components and accessories

6.6.1 Components for full automatic control and operation

Voltage regulators shall be provided with a series of components and accessories to facilitate full automatic control and operation as detailed in IEC 60076-21, clause 6.6.1 together with the following additional requirements

A multi-conductor neoprene 600 V, –50 ºC to 105 ºC cable with disconnect plugs at each end shall provide the connection between the internal circuitry of the voltage regulator and the control.

An electronic device shall be provided to protect the internal CT from high voltages due to the control cable being disconnected or cut while the voltage regulator is energized.

6.6.2 Accessories for single-phase pole mounted voltage regulators

Bushing terminal connections

The pole mounted voltage regulators shall be provided with mechanical parallel groove type connectors or double holed lugs to allow the connection of insulated jumpers onto the HV terminals. The current rating of these connectors shall be matched to the rating of the voltage regulator. The clamps shall be designed to allow the connection of flexible copper insulated jumpers of minimum cross section 70mm2 or 120 mm2 dependent upon the rating of the voltage regulator. All connections shall be provided with shrouds to protect against interference from birds or small animals.

7.2 Other components and accessories

- 2 x 9.1m an 1 x 35m long armoured and fully shielded control cables to allow the 3rd regulator unit to be positioned on a single pole located behind the main 'H' pole containing the other two regulators
- Conductor clamp bushing terminals, 3 per regulator unit
- Bushing and series arrester bird guards
- Earth Connector(s) on tank
- Earth Connector on control box
- A source-side internal differential potential transformer (IDPT) to provide control accuracy of ±1% (ANSI® Class 1) under reverse power flow conditions. (Control allows for reverse power without this, with control accuracy of ±1.5%)
- All external hardware shall be stainless steel

9.0 Control Systems

9.1 General

The control system of the voltage regulator shall be composed of sensing apparatus to provide signals proportionate to the system voltage and load current, and a control device that interprets the output of the sensing apparatus, relates this input to conditions set by the operator and automatically commands the voltage regulator to function to hold the requested output.

9.2 Control device construction

The regulator control device shall be mounted in a stainless steel weather-resistant enclosure which is capable of being padlocked and provides the following minimum degrees of protection:-

- The Protection against Access and Ingress of Moisture shall be IP34D in accordance with (IEC 60529)
- The regulator control device enclosure shall have an external stainless steel welded earthing tag incorporating an M18 or M22mm hole to allow the enclosure to be bonded to the pole earthing system.
- The control cabinet shall allow external communications aerials to be terminated into the base of the cabinet. To achieve this requirement the control cabinet shall be supplied with a bulkhead type TNC-TNC antenna fitting (installed in a M16 hole) with female sockets on each side.
- The control panel shall be hinge-mounted and designed for easy replacement. The control panel shall be constructed to provide direct interchangeability without removal of the control enclosure.
- The control device shall incorporate a double pole isolator in the LV power supply circuit to de-energize and isolate the control panel and associated circuitry in the back of the enclosure, and to short the voltage regulator's internal current transformer prior to testing or removal of the control cabinet.
- All leads in the control device shall be colour coded and connections labelled for easy identification.
- The terminal strips of the control back panel shall consist of dead front clamp-style quick connectors for ease of access and protection of operator. All terminals and wiring should be accessible without the removal of fixed plates.
- A ratio-correction transformer for each internal voltage supply shall be provided inside the control enclosure for easy access and fine voltage adjustment. Ratio-correction taps and the corresponding system voltage shall be clearly identified on unit nameplates.
- The control device shall be supplied complete with thermostatically controlled heaters designed to maintain the cabinet at 20°C
- The equipment shall be tested to provide a physical protection IK rating of 5J at the most vulnerable point on all exposed sides and at the vulnerable point on each exposed edge.

9.2.2 Components and accessories

As a minimum the control device shall be provided with following list of features:-

a) A single control device shall be provided that is capable of operating either two or three regulator units to provide multiphase operation incorporating a front panel for each phase.

b) 'Auto'/'Manual' changeover switch with the ability to accept a padlock.

c) Raise and Lower buttons for use in 'Manual' mode. These shall not be operative when 'Auto' mode is selected and these shall be padlockable. Alternatively, pad lockable control boxes and password protected functions on the voltage regulating controller can also be accepted.

In the case of 1ph regulators connected for 3ph regulation, each 1ph unit shall have the ability to display:-

a) A six digit operations counter, which records every tap change.

b) Tap position indicator

c) Indication of input voltage.

d) Indication of output voltage.

e) Indication of output currents.

f) Indication of status and voltage control operation; examples include: 'Tap Change in Operation', 'Supply Healthy' and 'Null Position'.

g) All indications available locally shall be capable of being monitored via SCADA

h) Internal-Off-External power switch – A three-position voltage source switch, labelled INTERNAL-OFF-EXTERNAL, which allows the control to be energized from the regulator's internal voltage supply or from an external source. Inadvertent energization of the internal supply is to be prevented while applying external source to control. The OFF position is provided to de-energize the control

i) A momentary three-position RAISE-OFF-LOWER control switch, which shall be active only when the adjacent control switch is in the MANUAL position. The switch must be hardwired and capable of operating the tap-changer even when the control CPU is not functional.

j) A supervisory switch shall inhibit tap-changer motor control and parameter changing via digital SCADA, but will allow for monitoring of the control database via SCADA.

k) A position-indicator drag-hand reset switch.

l) A USB port to be used for a temporary direct communications connection to a personal computer. The port must be capable of uploading and downloading data without the need for special cables or connectors.

m) A USB drive port for control programming and data retrieval capabilities using a USB drive mass storage device.

n) The motor shall be protected by a standard replaceable BS type fuse. The fuse size shall be clearly marked near the fuse holder and shall include for a spare fuse located within the control enclosure.

o) The equipment (including control and communication systems) shall comply with EMC Directive 89/336/EEC and BS EN 62271-1.

p) A backlit LCD display, 4 lines by 20 characters each, for displaying relevant information. The display shall have an adjustment for contrast.

q) Where appropriate; further specification details for the voltage regulator controller, protection and associated components will be supplied by the Company's Technical Services.

3.3. Insulation Fluid

Insulating fluid contained in the regulators shall comply fully with the current version of Northern Powergrid Specification NPS/003/019 – Specification for Electrical Insulating Fluids for use in Plant & Equipment.

3.4. Standard Control Device Features

Tap Position Indication: A tap position indication capability, which tracks the operation of the tap-changer, shall provide the present tap position and the highest and lowest positions since last reset. The highest and lowest values shall be date and time tagged. Tap position indication feature shall use the Neutral and extreme positions, 16 raise and 16 lower, to check the accuracy of its tracking. Tap position shall correct itself in those positions if an error is found. Tap Position Tracking feature shall maintain a counter to record all self-corrections performed at Neutral and the extreme positions, 16 raise and 16 lower.

Voltage Limiting: A voltage-limiting capability that prevents the regulator from making additional tap changes once the regulator output voltage meets a programmed upper- or lower-limit setting. If the source voltage should change, causing the regulator output voltage to exceed either limit, the control, after an initial fixed short time delay, dependent on the voltage swing outside the voltage limit, shall have the tap-changer step the voltage to within the voltage-limiter setting.

Voltage Reduction: A configurable 2 stage voltage reduction capability which shall be capable of being able to be set locally at the control or remotely via a digital SCADA/communications system.

Reverse Power Flow: A Reverse Power Flow Detector that automatically senses a power reversal and provides local and remote indication that a power reversal is taking place.

The regulator control shall incorporate separate forward and reverse control settings for voltage level, bandwidth, time delay, and line-drop compensation R and X.

At a minimum, the following modes of reverse power operation shall be provided:

- Locked forward mode
- Locked reverse mode
- Reverse idle mode
- Bidirectional mode
- Neutral idle mode
- Generation mode
- Reactive bidirectional mode

Source Voltage Calculation: A configuration point which, when turned on, will calculate the source voltage, based on tap position, regulator type, and internal impedance. The regulator types are either Type A or Type B per IEEE Std C57.15™ standard. The calculated source voltage will enable reverse power flow operation without the use of a source-side supply from an additional internal potential transformer or utility winding.

3.5. Additional Control Panel Required Features:

3.5.1. Small Wiring and Terminal Blocks

All small wiring shall comply with Clause 5.4.4.5.1 of IEC 62271-1 and ENA TS 50-18 issue 5, clause 5.1

Small wiring cable shall be single core multi-stranded, copper conductor, PVC insulated and compliant with BS 6231. In the interest of mechanical strength, the nominal minimum conductor size shall be 1.5mm² for applications e.g. SCADA, where smaller sizes are appropriate, their use shall be the subject to agreement with the Northern Powergrid project engineer.

Current transformer secondary connections shall have a minimum conductor cross sectional area of 2.5mm²

Terminal blocks and terminations shall comply with the relevant provisions detailed in IEC 62271-1 clause 5.4.4.5.2, BSEN 60947-7-1 and ENA TS 50-18 issue 3 clause 6.2.1 and 6.2.2. They shall generally be either screw or stud type for use with an approved ring type crimped termination or spring loaded insertion type incorporating an approved hook type crimped connector.

Telecontrol / SCADA Terminal Blocks	1.5mm SAKR or equivalent
AC/DC Terminal Blocks	2.5mm RSF3 or equivalent
CT/VT Terminal Blocks	6.0mm RSF1 or equivalent
Buswiring and Supply Terminal Blocks (J1/J2)	6.0mm RSF1 or equivalent

All terminal blocks shall be grouped on the terminal rails in the above order from the top of the rail to the bottom. Bus wiring terminal blocks shall be located at the top of the panel and labelled accordingly.

3.5.2. Marking and Labelling

The Control device enclosures shall be marked in accordance with clause 5.10 of IEC 62771-1

All equipment and apparatus shall be labelled in accordance with clause 5.4.4.4 of IEC 62271-1 and the following:

Labels shall be provided where instruction, explanations or warnings are appropriate to the operation or maintenance of the equipment.

Circuit identification labels, secured with screw fixings, shall be provided on the front and at the back where rear access is provided. Where identification labels are fixed to doors an identical label shall be provided internally on the fixed portion, at a point that is clearly visible.

Safety warning labels shall comply with BS 5499

All labels shall be suitably rated for the environment conditions and last the lifetime of the equipment to which they apply.

The function and rating of fuses and MCB's shall be marked adjacent to the device.

All identification markings shall be unambiguously associated with the relevant equipment and shall be clearly visible from normal viewing angles of the equipment.

Equipment wire end terminations shall be identified using permanent Alpha-Numeric local end marking.

3.5.3. Indications

The following Indication features shall be provided by the control device, where this is provided through the use of LED's they must be of the high-intensity type and easily readable in direct sunlight :-

- Dual neutral position LEDs that are actuated via the tap-changer to provide neutral position indication.
- LED indicators to indicate whether the voltage is inside or outside of the set voltage band, and whether the voltage is high or low.
- LED indicators for Alarms, configurable via the interface software provided by the manufacturer.
- LED indicators for Warnings, configurable via the interface software provided by the manufacturer.
- LED indicator for a diagnostics test failure.
- Transmit and Receive LEDs for all communication ports located on the front panel of the control for user visibility.
- LED indicators to indicate whether the voltage is inside or outside the voltage limiter settings, when active, and whether the voltage is high or low.
- LED indicator to indicate activation of a Tap-Changer-Auto-Blocked condition.
- LED indicator to indicate activation of a reverse power flow mode in the Reverse direction.
- LED indicator to indicate activation of the voltage reduction feature.

3.5.4. Front-Panel Programming

The control device shall be microprocessor-based, shall be accessible from the keypad via a combination structure using function codes and a scrollable nested menu, and shall have provisions for programming of the following parameters:

- Set voltage settings adjustable from 80.0 to 135.0 V in increments of 0.1 V both for forward and reverse power flow.
- Bandwidth settings shall be adjustable via a % step in line with the regulator tap set in increments of 0.67%, both for forward and reverse power flow.
- Time delay settings adjustable from 5 seconds to 180 seconds in 1-second increments both for forward and reverse power flow.
- Line Drop Compensation settings, resistance and reactance, adjustable from -96.0 to +96.0 V in increments of 0.1 V both for forward and reverse power flow. A means shall be provided to set the polarity.
- System configuration, Wye (Star), Delta Lead and Delta Lag settings for ease of programming. Separate setting of phase angle for Delta connections is not acceptable.
- Three control operating modes: Sequential, Voltage Averaging and Time Integrating.

3.5.5. Control Device Communications Systems

The voltage regulator control device shall include the following communications features:

- A front-panel data port for a temporary direct communication connection for uploading or downloading data without the need for special cables or connectors.
- Two permanent communications ports for use with communication accessories.
- Protocol DNP 3 (Serial and Ethernet) and IEC 60870-5-(101) (104) resident and the options of DATA 2179, MODBUS, IEC 61850 in the control and user-configurable for all communication ports. The control device shall be DNP 3 protocol certified level 2 compliant and be supplied with a software programming tool.
- The following communication card options shall be available: RS-232, Serial Fibre ST, RS-485, Ethernet Fibre ST, Ethernet Single-Mode LC, Ethernet Multi-Mode MTRJ, Ethernet ST, Ethernet SC, and Ethernet RJ-45.
- The control cabinets shall be supplied with a (2 wire) 12V power lead suitable for supplying power to the radio. The length of this wire shall be sufficient in length to reach the rear of the radio units and be fitted with a 10A in line fuse. The free end of the power lead shall be terminated into a connector block. To satisfy the worst case radio power requirements for a 25Watt RF output during the transmit phase the specified maximum load current for the radios is 7Amp @ 13.8Volts.
- To support communications to the RTU / SCADA interface, the control cabinet shall be supplied with a battery charger and rechargeable 12V batteries that have a minimum operational lifetime of 10 years.
- The control cabinet shall be designed to accommodate a typical radio size of 12approx.. 200 x 120 x 50mm, where the radio shall be capable of being mounted on a shelf or secured to a flat surface.

3.5.6. Alarms

The control shall allow for user-configurable Status (binary) and Data (analogue) alarms. Alarms shall be able to turn on an LED viewed on the front panel, generate time-tagged events which can be sent via the SCADA interface, profile snapshots, and be used as a programmable I/O input.

3.5.7. Digital Metering

Digital Metering Package: Shall be Class 1 accuracy in accordance with BS EN 61869-2 and shall provide the following information:

Instantaneous values of load voltage, compensated voltage, current, power factor, kVA load, kW load, kVar load, voltage harmonics, and current harmonics. Voltage and current harmonics shall include, at a minimum, total harmonic distortion.

Demand values of load voltage, compensated voltage, current, kVA load, kW load, and kVar load. For each of these values, the present value, highest value since last reset, and lowest value since last reset shall be provided. Highest and lowest values shall be time and date tagged. Power factor at maximum and minimum kVA load shall be provided. Metering values must be available for both forward and reverse power flow conditions and be designed to be available via SCADA

3.5.8. Data Acquisition

Profiler: The control device shall have a profiler with user-selectable metering values and configurable sample time intervals. It shall be capable of storing at least 1000 data items.

Event Recorder: The control device shall allow for date and time-tagged recording of user-definable Events with the last 50 Events viewable through the LCD display.

3.5.9. Electromagnetic Compatibility

Communications GPRS Electromagnetic Compatibility Tests for communication equipment

All equipment shall be compatible with the following EMC standards:

BS EN 61000-6-3: 2007 – Generic Emissions standard

BS EN 61000-6-2: 2005 – Generic Immunity standard

BS EN 61000-4-2: 1995 – Electrostatic discharge immunity Test ((Requirement Air 8kV, Contact 4kV)

BS EN 61000-4-3: 2006 Radiated radio Frequency, Electromagnetic Field Immunity. (Requirement

80MHz – 1GHz @ 10V/m)

BS EN 61000-4-6: 2007 Immunity to conducted disturbances induced by radio frequency fields

(Requirement 150kHz – 80MHz @ 10V/m)

BS EN 61000-4-4: 2004 Electrical Fast Transient/Bursts Immunity (Requirements +/- 1kV).

3.6. Advanced Control Device Features

Software: A single software program must be available that is capable of fully configuring the control and downloading all metering, voltage regulator operation and maintenance data. The required use of multiple software programs to fully interface with the control is not acceptable.

Logical I/O Programming n: The control device shall have programmable I/O capabilities, which will allow the user to write logical equations to perform user-defined control and communication operations. These logical equations shall have the ability to relate control status, conditions, I/Os and metering points. Based on the results of these logical equations, definitive control action can be taken.

The control device shall have the option of three discrete 120 Vac inputs for discrete I/O interfacing. The user shall add an accessory option to add multiple I/Os.

Auto Restore Local: Control device shall have the ability when communications to a SCADA host is lost to restore specific configuration settings. These settings shall be specified by the user when the function is enabled on the control device. At a minimum, the following settings should be restored when communications is lost: Forward and reverse settings for set voltage, bandwidth, time delay, and line-drop compensation; Auto-Block feature state; Reverse Power mode; Voltage Reduction; Tap-to-Neutral, and software additional current feature.

Alternate Configuration: Control device shall have the ability to utilize an additional set of configuration settings. These settings shall be selected by the user, or can be incorporated into the logical I/O programming scheme to allow the control to automatically select a specific group of settings based on control status, conditions, or metering points.

Leader/Follower Scheme: Control device scheme designed to keep two or three voltage regulators on the same mechanical tap position. When utilized with single phase controls, the scheme will use a fibre optic intelligence loop between the phases to provide the communications necessary to initialize a tap change and provide positive feedback in maintaining equal tap positions. When utilized in a multi-phase control, no fibre optic loop or communications cards shall be necessary.

Max Deviation Scheme: Control scheme designed to keep two or three regulators in a predetermined moving tap position window. This feature will limit the maximum number of tap positions the regulators can differ. When active, this mode constrains the regulator tap positions to a user defined maximum deviation. When utilized with single phase controls, the scheme will use a fibre optic intelligence loop between the phases to provide the communications necessary. When utilized in a multi-phase control, no fibre optic loop or communications cards shall be necessary.

4. References

4.1. External Documentation

The products described within this specification shall comply with 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.

Reference	Title
IEC C57.15-2009 / IEC 60076-21	Power Transformers – Part 21: Standard requirements, terminology, and test code for step-voltage regulators
ENA TS 12-11	Indoor and Outdoor cable Boxes for switchgear for service at voltages of 6.6, 11 and 33kV
ENA TS 50-18 :2023	Application of Ancillary Electrical Equipment
BSEN 50180-1:2015	Bushings above 1kV up to 52kV and from 250A to 315kA for liquid filled transformers
IEC 60529:1992 +A2:2013	Degrees of protection provided by enclosures (IP code).
BS EN 62271-1 :2008+A1:2011	High-voltage switchgear and controlgear – Part 1 : common specifications
ISO 12944-2	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments
IEC 60870-5 (104)	Telecontrol equipment and systems. Transmission protocols
IEC 61850	Communication networks and systems for power utility automation.
IEC 61000-4-30	Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power Quality measurement methods
BS EN 61000-6-2 :2005	Generic standards – Immunity standards for industrial environments
BS EN 61000-4-3 :2006 +A2:2010	Testing and measurement techniques. Radiated, radio-frequency, electromagnetic field immunity test
BS EN 61000-4-4:2004-07	Testing and measurement techniques – Electrical fast transient/burst immunity test
BS EN 61000	Electromagnetic compatibility
BS EN 60076-1	Power transformers. General

4.2. Internal Documentation

Reference	Title
IMP/001/103	Code of Practice for the Assessment of Asset-Specific Losses
IMP/001/915/001	An Application guide for modelling and selecting HV Voltage regulators
NPS/001/008	Technical specification for surge diverters
NPS/003/019	Technical Specification for Electrical Insulating Fluids for use in Plant and Switchgear.

4.3. Amendments from Previous Version

Reference	Subject	Amendments
4.1	External Documents	References updated

5. Definitions

Term	Definition
SCADA	Supervisory control and data acquisition
The Company	Northern Powergrid

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	22/01/2024

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	
No	Period: 5 Years	Reason: Update will be dictated by contact 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
Steven Salkeld	Policy and Standards Engineer	23/01/2024

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
Ged Hammel	Senior Policy and Standards Engineer	23/01/2024

6.4. Authorisation

Authorisation is granted for publication of this document

		Date
Paul Black	Head of System Engineering	22/02/2024

Appendix 1 – Schedule of requirements for standard units

Item	Voltage	Cont. Rated Load	Short Circuit Withstand (kA)	Regulated KVA	Description	Quantity	Price
1	11kV	200 A	8kA	220 kVA	3 x 1PH Pole Mounted Regulators with CL7 multi-phase control panels		
2		400 A	12kA	440 kVA			
4	20kV	200 A	8kA	440 kVA			
5		300 A	12kA	660 kVA			

Appendix 2 – Summary of Principle Characteristics (to be completed by the supplier for each variant offered).

Characteristic	Value/Description
Regulator Manufacturer	
Regulator Model/Type Reference	
Predominant Standard (ENATS/BS/IEC/ANSI, etc.) (Where units are tested to ANSI Standard the supplier shall produce evidence that all tests meet the requirement of the ENATS or IEC)	
Nominal System Voltage (kV)	
Rated Power (MVA)	
Nominal Voltage Ratio (kV/kV)	
Short Circuit Withstand (kA)	
Voltage Impedance (%)	
Tapping Range (+/-%)	
Tapping Step (%)	
Lightning Impulse Withstand (kV)	
Surge Arrestors / Manufacturer/Reference	
Weight (kg) State separate units & total where appropriate	
Dimensions (mm) Height Width Length State separate units & total where appropriate	
Regulator Fixing Type – Hang on pole / Support Platform / Ground Mount	
Losses (kW) Load No Load	
Guaranteed Maximum Noise Level (dBA)	
Summary Of Control Arrangement Inc Principles Of Operation & Make(s)/Model(s)	
Control Cabinet Description and Mounting Arrangement	

Maintenance Requirements chronological lifetime	
Ingress protection Voltage regulator Control device	
Control device Communications protocol capability	

Appendix 3 – Declaration of Compliance with IEC 60076-21

SELF-CERTIFICATION CONFORMANCE DECLARATION

CLAUSE BY CLAUSE CONFORMANCE WITH IEC 60076-21

Voltage Regulators covered by IEC 60076-21 shall comply with the latest issues of the relevant International and British Standards. This specification is intended to amplify and/or clarify the requirements of those standards.

This check sheet identifies the clauses in IEC 60076-21 or alternative clauses in specific to this document. (the alternative clauses specific to this document are shown in brackets. 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 (Voltage, Type and Size)

Name:

Signature:

Date:

NOTE: One sheet shall be completed for each type of regulator offered.

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
1.1 (2.0)	Scope				
2.0	Normative references		N/A		
3.0	Definitions		N/A		
4.1 & (3.2 / 4.1)	Service conditions				
4.4 & (3.2 / 4.4)	Frequency				
5.1 & (3.2 / 5.1)	Cooling Classes of voltage Regulators				
5.2 & (3.2 / 5.2)	Ratings				
(3.2 / 5.2.2)	Preferred Rating	N/A			
5.3	Supplementary continuous ratings		N/A		
5.4 & (3.2 / 5.4)	Taps				
5.5	Operating Voltage Limits				
5.6	Voltage Supply Ratios		N/A		
5.7 & (3.2 / 5.7)	Insulation levels		N/A		

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
5.8 & (3.2 / 5.8)	Losses		N/A		
5.9 & (3.2 / 5.9)	Short Circuit Requirements		N/A		
5.9.3	Thermal capability of voltage regulators for short circuit conditions		N/A		
5.10	Tests		N/A		

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
5.10.1	Routine Tests a) Resistance Measurements all windings b) Ratio test on all tap connections c) Polarity Test d) Operational test of all devices e) Leak test f) No Load – loss at rated voltage g) Excitation current h) Impedance and load loss i) Lightning Impulse test j) Applied Voltage test k) Induced voltage test l) Insulation power factor test m) Insulation resistance test		N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A		
5.10.2	Design tests		N/A		
5.10.2.1	Thermal Test		N/A		

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
5.10.2.2	Lightning Impulse Test		N/A		
5.10.2.3	Short Circuit Test		N/A		
6.0	Construction		N/A		
6.1 & (3.2 / 6.1) (3.2 / 6.1.2)	Bushings – Overhead Ground Mounted	N/A			
6.2 & (3.2 / 6.2	Terminal markings				
6.2.1	Terminal markings – Single phase Terminal markings – Three Phase				
6.3	Diagram of connections		N/A		
6.4 & (3.2 / 6.4)	Nameplates				
6.5 & (3.2 / 6.5)	Tank Construction				
6.5.1	Pressure Relief Valve		N/A		
6.5.2 & (3.2/6.5.2	Lifting Lugs & Manual Handling	N/A			

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
6.5.3	Support Lugs				
6.5.4	Moving facilities				
6.5.5	Tank Grounding facilities				
6.6	Components and accessories				
6.6.1	Components for full automatic control and operation				
6.6.2	Accessories for single phase voltage regulators				
7.0	Other requirements				
7.1	Other supplementary continuous –current ratings		N/A		
7.2	Other components and accessories				
8.0	Test Code				
8.1	Resistance Measurements				
8.2	Polarity Test				
8.3	Ratio Tests				
8.4	No-Load losses and excitation current				

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
8.5	Load losses and impedance Voltage				
8.6	Dielectric Tests				
8.7	Temperature Rise Tests				
8.8	Short Circuit Tests				
8.9	Calculated Data				
9.0	Control Systems				
9.1	General				
9.2 & (3.2 / 9.2)	Control Device Construction				
9.2.2 & (3.2/9.2.2)	Components and Accessories				
9.3 & (3.2/9.3)	Control System Requirements				
3.3	Insulation fluid	N/A			

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
3.4	Standard Control Device Features	N/A			
3.5	Additional Control panel Required features	N/A			
3.5.1	Small Wiring and terminal blocks	N/A			
3.5.2	Marking and labelling	N/A			
3.5.3	Indications	N/A			
3.5.4	Front Panel Programming	N/A			
3.5.5	Control Device Communication Systems	N/A			
3.5.5.1	Radio Systems	N/A			
3.5.5.2	Message Length	N/A			

Clause / Sub-clause	Requirement	Conformance Code BS EN 60076-1	Conformance Code NPS/003/020	Evidence Reference	Remarks / Comments
3.5.5.3	Other Communication Routes	N/A			
3.5.6	Alarms	N/A			
3.5.7	Digital Metering	N/A			
3.5.8	Data Acquisition	N/A			
3.6	Advanced Control Device Features	N/A			

Appendix 4 – Addendum to Suppliers Requirements

Losses

Lifetime costs shall be calculated, for every design variant, using the formula below and the latest Northern Powergrid capitalisation figures, which will be provided at the tender stage.
The £/kW loss figures* incorporate utilisation factor and time span.
* Sourced from Northern Powergrid document IMP/001/103 Section 3.3.4.

Lifetime Cost = Purchase price + (No load loss kW x No load £/kW) + (Load loss kW x Load loss £/kW)

The tenderer shall supply details of each element of this calculation, in addition to the answer.
The tenderer shall also declare the maximum guaranteed loss figures for each design variant.

Appendix 5 - Pre-commission testing, Routine Inspection and Maintenance requirements

Tenderers shall provide details of the recommended pre-commission testing and inspection required.
Details of the Test Voltage Levels, duration, pass/fail criteria, etc. shall be provided.
Tenderers shall state any maximum voltage that may be applied or any other limitations that may apply.

Tenderers shall provide information regarding detailed and periodic inspection and maintenance requirements to be undertaken during the lifetime of their product.

Appendix 6 – 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.

Provided Y/N	Requirement
	Full product descriptions and part number/reference
	Complete set of drawings for each variant
	Appendix 1– Completed schedule of requirements
	Appendix 2 – Summary of Principle Characteristics
	Appendix 3 – Declaration of Compliance
	Appendix 4 – Addendum to Suppliers requirements
	Appendix 5 – Pre-commission testing, routine inspection and maintenance requirements
	Appendix 6 – Technical Information Check List
	Type test & special test listing and/or evidence
	Routine test/quality plan (example)
	Packaging/transport/delivery/handling/storage information