NPS/003/003 – Technical Specification for Arc Suppression Coils

1. Purpose

This specification details the technical requirements for Arc Suppression Coils (ASCs) for use on the Northern Powergrid (NPg) distribution networks.

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

Reference	Version	Date	Title
NPS/003/003	4.0	Nov 2021	Technical Specification for Arc Suppression Coils

2. Scope

The Arc Suppression Coils specified in this document are suitable for connection to the neutral of 11 kV or 20 kV secondary windings of primary transformers on the Northern Powergrid distribution network.

2.1. Table of Contents

3. Technical Requirements

3.1. Overview

An Arc Suppression Coil (ASC) shall be applied in conjunction with a bypass circuit breaker and a neutral earthing resistor, to the secondary neutral of a transformer to form a system that will suppress fault current resulting from transient earth faults on the secondary system.

The ASC consists of a variable reactor and its associated controller. The controller tunes the variable reactor to the phase-to-earth capacitance of the 11 kV or 20 kV network to which it is connected such that during a single phase to earth fault, the current flowing through the transformer neutral is anti-phase and equal to the phase-to-earth capacitance current of the system. The earth fault current at the point of the fault is the sum of these two components and is therefore zero. In practice, the coil is generally adjusted slightly out of resonance to prevent resonance from causing over voltages in case of phase unbalance.

This severe constriction of the fault current reduces the temperature of the arc to such an extent that it extinguishes itself, thereby minimising customer interruptions.

It is undesirable to maintain an un-cleared earth fault on the system for an extended period of time. To prevent this, the bypass circuit breaker is timed to close after a delay of a few seconds (typically 3 seconds), diverting fault current to flow through the neutral earthing resistor and whereupon the earth fault protection will operate.

3.2. General

Arc Suppression Coils covered by this code of practice shall comply with BS EN 60076 *Power Transformers Part 6: Reactors*, and the clauses of ENA Technical Specification 35-1 *Distribution Transformers (from 16 kVA to 2000 kVA) (ENA TS 35-1)*, unless otherwise specified in this document.

The equipment shall also conform 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 all relevant UK health and safety legislation.

- Appendix 1 lists user requirements required by this Specification.
- Appendix 2 is a Declaration of Technical Performance to be completed by the supplier.
- Appendix 3 is a Manufacturers and Places of Manufacture, Testing and Inspection Schedule.
- Appendix 4 details any additional supplier requirements.
- Appendix 5 details any pre-commissioning testing, routine inspection or maintenance requirements recommended by the supplier.
- Appendix 6 is a Technical Information Check List that must be completed by the supplier.

3.3. Amendments or Variations to Standards

The following are variations, additions or clarifications to relevant standards. The original standard clause numbers are stated in brackets.

3.3.1. BS EN 60076: Power Transformers. Part 6: (Reactors)

Clause 6 and all parts of Clause 11 in BS EN 60076-6 are applicable, with the following clarifications.

3.3.1.1. Rated Voltage (11.4.1)

The rated voltage between the neutral and earth terminals of the main winding shall be 6,350 V or 11,547 V as specified in Appendix 1.

3.3.1.2. Maximum Continuous Voltage (11.4.2)

The maximum continuous voltage shall be the same as the rated voltage.

3.3.1.3. Rated Current (11.4.3)

This will be determined by the maximum rated power specified in 3.4.7 and will be specified by Northern Powergrid in Appendix 1.

3.3.1.4. Rated Current Duration (11.4.4)

The ASC shall be capable of carrying the rated current continuously.

3.3.1.5. Adjustment Range (11.4.5)

The adjustment range shall be 10 % - 100 %, and alternative adjustment ranges shall be offered where specified in the project detail e.g. 20-100%.

3.3.1.6. Auxiliary (Measuring) Winding (11.4.6)

An auxiliary winding shall be provided for measurement and control purposes, rated at 110V, 50 VA.

3.3.1.7. Secondary (Power) Winding (11.4.7)

A secondary winding shall be supplied to allow the connection of a damping resistor, to aid tuning on unbalanced networks, rated at 5% of the main winding. A matching damping resistor shall be fitted where specified in the project detail.

3.3.1.8. Insulation Level (11.6)

The insulation level of the neutral side of the ASC shall be 95 kV (peak) and 38 kV (r.m.s) for units connected to the 11 kV network, or 125 kV (peak) and 50 kV (r.m.s) for units connected to the 20 kV network. The insulation level of the earth side of the ASC shall be a minimum of 1 kV.

3.3.1.9. Testing (11.8)

There are no special tests required in addition to the routine and type tests stipulated in Clause 11.8 of BS EN 60076-6 which are mandatory.

3.3.2. ENA Technical Specific 35-1: Distribution Transformers (from 16 kVA to 2000 kVA)

Only those requirements specified below from ENA TS 35-1 shall be applied as amended/clarified in this document.

3.3.2.1. Service Conditions (Part1, 4.1)

Life expectancy shall be as specified in ENA TS 35-1, Part 1 Clause 4.1.

3.3.2.2. Cooling Mode (Part 1, 5.2)

Where the ASC contains insulating liquid, this liquid shall comply fully with the current version of NPg specification NPS/003/019 - Technical Specification for Electrical Insulating Fluids for use in Plant and Switchgear. Facilities for liquid filling and sampling shall be provided.

3.3.2.3. Liquid Preservation System (Part 1, 9.3)

Where a liquid preservation system is used it shall be a free breathing system and the breathing pipe shall be terminated with a 1” (one inch) BSP thread to allow the use of a cartridge system of desiccant filters, 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.

3.3.2.4. Centre of Gravity (Part 1, 9.5)

The ASC centre of gravity shall conform to the requirements stated in ENA TS 35-1, Part 1 Clause 9.5.

3.3.2.5. Surface Finish (Part 1, 14.2)

The surface finish colour shall be a neutral medium grey. The corrosion protection system shall conform to the requirements of ENA TS 98-1 *Surface Preparation and Coating Systems for New Plant and Equipment*.

3.3.2.6. Earthing Terminals (Part 1, 14.5.3)

All earthing terminals shall comply with ENA TS 35-1, Part 1 Clause 14.5.3.

3.3.2.7. Assembly, Operation and Maintenance Instructions (Part 1, 15.2)

An electronic copy of the assembly, operation and maintenance instructions shall comply with Part 1, 15.2 and shall be supplied in a format stipulated in the Schedule Requirements (pdf/word/other) by the manufacturer.

3.3.2.8. Combined Drain and Sampling Valve (Part 2, 4.7.2)

On units that are not hermetically sealed, a combined drain and sampling valve shall be fitted.

3.3.2.9. Liquid Level Indication (Part 2, 4.7.4)

Any liquid level indication shall comply with ENA TS 35-1, Part 2 Clause 4.7.4.

3.3.2.10. Jacking Lugs (Part 2, 4.7.5)

Jacking lugs shall comply with ENA TS 35-1, Part 2 Clause 4.7.5.

3.3.2.11. Manual Handling (Part 2, 4.7.6)

The ASC design shall take into account and allow for methods of manual handling including, but not limited to, the use of a pinch bar and 50-75 mm diameter rollers. ASCs shall be designed and constructed to allow the fitting of axles and wheels and the subsequent removal of the wheels once the transformer is in position.

3.3.2.12. Lifting and Mechanical Properties (Part 3, 4.2)

The ASC shall remain stable when tilted from the upright position up to a maximum of 20° from the vertical, either backwards or forwards.

Lifting fittings shall be provided, to suit slings or shackles, of adequate design to facilitate lifting in a reasonably upright position with or without cable boxes fitted. Lifting fittings provided shall comply with ENA TS 35-1 Part 1 Clause 14.5.4.

3.3.2.13. HV Terminations (Part 2, 4.3)

Coils shall be provided with:

a) For the connection towards the power transformer neutral, either cable or busbar connection, as specified in each order;

b) For the earth connection, a cable connection

The cable terminations shall be as specified in Appendix 1: Schedule of Requirements. Where cable connections are required, separable plug-in cable terminations are preferred. Terminations shall comply with the Northern Powergrid specification NPS/002/015 - Technical Specification for 11 kV and 20 kV Cable Joints and Terminations.

Where open terminal bushings are required, these shall be in accordance with IEC 60137 *Insulated Bushings for Alternating Voltages above 1000 V.*

3.4. Northern Powergrid Requirements

In addition to the requirements of Sections 3.2 and 3.3 the following provisions, which are specific to Northern Powergrid, shall be adhered to.

3.4.1. Operating Mechanism

Indication of the position of the regulating mechanism shall be provided and shall be clearly visible from the operating position.

The local control of the ASC shall be provided in a lockable cabinet mounted on or adjacent to the ASC.

A padlockable local/remote control selector switch shall be provided in the local control cabinet. This selector switch shall disable the local raise and lower controls when remote is selected, and shall disable the remote raise and lower controls when local is selected.

The ASC motor supply shall be rated for a supply voltage of 400/230 V, 50 Hz.

Anti-condensation heaters shall have a rated supply voltage of 230 V AC.

3.4.2. Arc Suppression Coil Controller

The ASC controller shall be suitable for mounting in a 19" rack in a suitable cabinet in the substation control/relay room.

The ASC (earth fault compensation) controller shall provide:

i. Manual adjustment of ASC with push buttons on the controller

ii. Automatic tuning of ASC within selectable boundaries to:

   a. the maximum value of the neutral to ground voltage,

   b. a pre-set degree of over or under compensation.

iii. A system analysis mode providing:

   a. Graphical monitoring of the neutral to ground voltage versus ASC setting.

   b. Graphical monitoring of the neutral to ground voltage versus time on a variable scale (from 30 mins to 4 days)

   c. damping, de-tuning & asymmetry of the system to ground versus time on a variable scale (from 30 mins to 4 days)

Event recording facilities shall be available.

The controller shall be self-monitoring and shall provide an appropriate local and remote alarm facility.

The controller shall monitor the ASC operating mechanism and provide an appropriate local and remote alarm facility.

The controller shall be rated for use with supply voltages of 110 V AC or 110VDC as specified in Appendix 1.

3.4.3. ASC Interface Towards Controller

Raise/lower controls: 110VDC or 30VDC contactors, to be specified when ordering

Raise/lower normally-open output contacts to confirm operation

High/low limit normally-open output contacts

Two MCB aux contacts:

- Open when the MCB is open, to break the supply to controller raise/lower contactors
- Closed when the MCB is open, as an alarm

Watch-dog (e.g. OTI) normally-open output contacts

1kΩ potentiometer for position indication

All indications 110VAC/DC nominal rating

6350/110 or 11550/110 VT, rated 50VA, 1% accuracy

3.4.3.1. ASC Controller Interfaces

110VAC nominal VT input from ASC

Connection to 1kΩ potentiometer on the ASC for position indication

Digital input to disable automatic tuning

Output relays 110VDC nominal rating

- To drive ASC raise/lower contactors (two outputs)
- Automatic mode on and off (two outputs)
- Earth fault detected (normally-open)
- Controller internal watchdog (normally-closed)

0-10 mA current loop outputs for

- Coil position
- Coil voltage

3.4.4. Auxiliary Supplies, Small Wiring and Ancillary Equipment (substation applications)

The design and application of electrical ancillary equipment shall be in accordance with ENA TS 50-18: *Application of Ancillary Electrical Equipment.*

All fuses and links shall be Red Spot (or equivalent) in accordance with ENA TS 50-18 having labels mounted adjacent to the relevant fuse or link. The label inscription shall include the fuse current rating.

In any control panel or connection chamber; terminals that cannot be isolated electrically shall be fitted with shrouds to prevent the possibility of electric shock by accidental contact.

3.4.5. Oil Temperature Indication (OTI)

A single stage oil temperature alarm gauge will be fitted. Two alarm changeover type contacts from the device will be required.

3.4.6. Maximum Rated Power

This will be determined by the phase to earth capacitance of the network on which the arc suppression coil is to be installed and will be specified by Northern Powergrid in Appendix 1. Arc Suppression Coils with maximum rated powers up to 500A (3200 kVAr) at 11kV nominal system voltage and 650A (7500kVAr) at 20kV are required.

4. References

4.1. External Documentation

Reference	Title
BS EN 60076-6	Power Transformers: Reactors
ENA TS 35-1 Part 1	Distribution Transformers Part 1 Common clauses
ENA TS 35-1 Part 2	Distribution Transformers Part 2 Ground mounted transformers – not close coupled
ENA TS 35-1 Part 3	Distribution Transformers Part 3 Ground mounted transformers – close coupled
ENA TS 50-18	Application of Ancillary Electrical Equipment
ENA TS 98-1	Environmental classification and corrosion protection of structures, plant and equipment
IEC 60137	Insulated Bushings for Alternating Voltages above 1000 V

4.2. Internal Documentation

Reference	Title
NPS/002/015	Technical Specification for 11 kV and 20 kV Cable Joints & Terminations
NPS/003/019	Technical Specification for Electrical Insulating Fluids for use in Plant and Switchgear

4.3. Amendments from Previous Version

Reference	Amendments
3.3.1.7 and Appendix 1	Updated the requirement of Secondary (Power) Winding
3.4.1, 3.4.2 and 3.4.3	Aligned the power supply voltage and control voltage
Appendix 1	Requirements updated
Whole document	Wording, reference document and associated clauses number updated

5. Definitions

Reference	Title
ASC	Arc Suppression Coil
HV	High Voltage – in excess of 1,000V and less than 22,000V
LV	Low Voltage – up to 1,000VVoltages ≥ 1000 V
r.m.s	Root Mean Squared

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	07/08/2023

6.2. Author

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

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

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

		Date
Aaron Chung	Policy & Standards Engineer	30/08/2023

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
Alan MacDonald	Policy & Standards Engineer	09/08/2023
David Miller	Protection Engineer	07/08/2023
Ged Hammel	Senior Policy & Standards Engineer	08/08/2023

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	Head of System Engineering	28/09/2023

Appendix 1 – Schedule of Requirements

Item	Clause	Description	User Requirements
1		Nominal system voltage (11 kV or 20 kV)	kV
2	3.3.1.1	Rated voltage (6350 V or 11547 V)	V
3		Rated frequency	50 Hz
4	3.3.1.2	Maximum continuous voltage	Same as Item 2
5	3.3.1.3	Rated current	A
6	3.3.1.4	Rated current duration	Continuous
7	3.3.1.5	Adjustment range	10% - 100% (see note 1)
8	3.3.1.6	Auxiliary (measuring) winding voltage[1]	110 V AC
9	3.3.1.6	Auxiliary (measuring) winding rating	50 VA
10	3.3.1.7	Secondary (Power) Winding	[5% of main winding]
11	3.3.1.7	Damping Resistor	kW
12	3.3.1.8	Insulation Level [BIL] (11 kV system – 95 kV) or (20 kV system – 125 kV)	kV
13	3.3.1.8	Insulation Level [RMS] (11 kV system – 38 kV) or (20 kV system – 50 kV)	kV
14	3.3.2.13	Termination type (a) Open terminal bushing (b) Cable connection (c) Cable Size for the cable termination	
15	3.4.2 & 3.4.3	Controller Voltage	110 / 230 V AC/DC
16	3.3.2.11	Assembly, Operation and Maintenance Instruction format.	

Note 1 - alternative adjustment ranges may be offered where specified in the project detail e.g. 20-100%

[1] this is a measuring winding for instrumentation and control, not the power auxiliary winding required for a de-tuning resistor

Appendix 2 – Self-Certification Conformance Declaration

Arc Suppression Coils are required to be supplied against this specification and shall comply with the latest issues of ENA TS 35-1 and BS EN 60076:6 along with relevant International and British Standards.

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 is entered, no remark is necessary.
- When any other code is entered, the reason for non-conformance shall be entered.
- Prefix each remark with the relevant 'BS EN', 'Northern Powergrid' or 'TS 35-1' as appropriate
- Additional sheets may be referred to if more detail is required

Manufacturer:

Product Reference:

Name:

Signature:

Date:

Arc Suppression Coil Specification						
Item No	**Description**	**Clause / Requirements**	**Conformance Code**	**Schedule item**	**Evidence Reference**	**Remarks / Comments**
1	Design, testing, tolerances and application	BS EN 60076-6 – 6				
2	General Requirements	BS EN 60076-6 – 11.1				
3	Design	BS EN 60076-6 – 11.2				
4	Nominal System Voltage					
5	Rated Voltage	NPS/003/003 – 3.3.1.1.		6,350 V or 11,547 V		
6	Maximum Continuous Voltage	NPS/003/003 – 3.3.1.2		6,350 V or 11,547 V		
7	System Frequency			50 Hz		
8	Rated Current	NPS/003/003 – 3.3.1.3				
9	Rated Current Duration	NPS/003/003 – 3.3.1.4		Continuous		
10	Adjustment Range	NPS/003/003 – 3.3.1.5				
11	Auxiliary (Measuring) Winding	NPS/003/003 – 3.3.1.6		110 V AC		
12	Secondary (Power) Winding	NPS/003/003 – 3.3.1.7				
13	Linearity	BS EN 60076-6 – 11.4.8				
14	Temperature Rise	BS EN 60076-6 – 11.5		Temperature rise values (K)		

Arc Suppression Coil Specification						
Item No	**Description**	**Clause / Requirements**	**Conformance Code**	**Schedule item**	**Evidence Reference**	**Remarks / Comments**
15	Insulation Level	NPS/003/003 – 3.3.1.8		95 kV (Peak), 38 kV (RMS) @ 11 kV or 125 kV (Peak), 50 kV (RMS) @ 20 kV		
16	Rating Plates	BS EN 60076-6 – 11.7				
17	Testing	BS EN 60076-6 – 11.8 and NPS/003/003 – 3.3.1.9		List any Special tests offered as per Clause 11.8.4 in BS EN 60076:6		
18	Tolerances	BS EN 60076-6 – 11.9				
19	Service Conditions	NPS/003/003 – 3.3.2.1				
20	Cooling Mode	NPS/003/003 – 3.3.2.2 and NPS/003/019				
21	Liquid Preservation System	NPS/003/003 – 3.3.2.3				
22	Centre of Gravity	ENA TS 35-1, Part 1 Clause 9.5				
23	Surface Finish	NPS/003/003 – 3.3.2.5				
24	Earthing Terminals	ENA TS 35-1, Part 1 Clause 14.5.3				

Arc Suppression Coil Specification						
Item No	**Description**	**Clause / Requirements**	**Conformance Code**	**Schedule item**	**Evidence Reference**	**Remarks / Comments**
25	Assembly, Operation and Maintenance Instructions	NPS/003/003 – 3.3.2.7				
26	Combined Drain and Sampling Valve	NPS/003/003 – 3.3.2.8				
27	Liquid Level Indication	ENA TS 35-1, Part 2 Clause 4.7.4				
28	Jacking Lugs	ENA TS 35-1, Part 2 Clause 4.7.5				
29	Manual Handling	NPS/003/003 – 3.3.2.11				
30	Lifting and mechanical properties	NPS/003/003 – 3.3.2.12				
31	HV Terminations	NPS/003/003 – 3.3.2.13 and NPS/002/015		Details of terminations fitted	.	
32	Operating Mechanism	NPS/003/003 – 3.4.1		Specify component details where applicable		
33	ASC Controller	NPS/003/003 – 3.4.2		Specify component details where applicable		
34	ASC Interfaces	NPS/003/003 – 3.4.3		Specify component details where applicable		

Arc Suppression Coil Specification						
Item No	**Description**	**Clause / Requirements**	**Conformance Code**	**Schedule item**	**Evidence Reference**	**Remarks / Comments**
35	Auxiliary Supplies, Small Wiring & Ancillary Equipment	NPS/003/003 – 3.4.4		Specify component details where applicable		
36	Current Transformer	NPS/003/003 – 3.4.5		Specify component details where applicable		
37	Oil Temperature Indication	NPS/003/003 – 3.4.6		Specify component details where applicable		
38	Maximum Rated Power	NPS/003/003 – 3.4.7				

Appendix 3 – Manufacturers and Places of Manufacture, Testing and Inspection Schedule

Item	Manufacturer	Manufacturer's Drawing Number and / or Type Designation	Place of Manufacture	Place of Testing and Inspection
Arc Suppression Coil Complete				
Radiators				
Pipework Expansion Devices				
Oil Valves				
Breather				
Gas and Oil Actuated Relay(s)				
Control Cubicle				
Temperature Indicating Device(s)				
Anti-Vibration Mounting				
Controller				
Any deviation from this Schedule shall be notified in writing as soon as possible for the Purchaser's approval.				

Appendix 4 – Addendum to Supplier Requirements

Packaging/delivery information
Details of how this product will be packaged and delivered shall be provided.

Project specific requirements
Any project specific requirements will be provided by Northern Powergrid for inclusion in this appendix.

Appendix 5 – Pre-commissioning testing, Routine Inspection and Maintenance requirements

Suppliers shall provide details of the recommended pre-commission testing and inspection required. They shall also provide information regarding periodic inspection and maintenance requirements to be undertaken during the lifetime of their product.

Detailed inspection and maintenance instructions shall also be provided.

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

Requirement	Provided (Y/N)
Full product descriptions and part number/reference	
Appendix 2 – Completed self-certification conformance declaration	
Appendix 3 – Completed technical schedules	
Appendix 5 – Inspection and testing recommendations	
Complete set of drawings and data sheets for each variant	
Type test evidence	
Routine test plan (example)	
Packaging/delivery information	