1. SCOPE

This document details PowerSystems requirements for 132 kV, 275 kV and 400 kV single core cables. Additional requirements for different types of cable and associated equipment, apparatus and services are given in other PowerSystems specifications detailed within this document.

2. ISSUE RECORD

This is a controlled maintained document.

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3. ISSUE AUTHORITY

Author	Owner	Issue Authority
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4. REVIEW

This document will be subject to review as and when required.

5. CONTENTS

6. INTRODUCTION

This document is a second level specification in a three-tier structure, dealing with the protection requirements of the Company 33,132,275 and 400kV network. Each successive level in the structure provides greater detail in a specific discipline and, collectively, these documents define the Company technical requirements for plant, equipment and apparatus for use on, and for direct connection to, its electricity transmission/distribution system.

These documents translate the actual operating characteristics of the Company electricity transmission system into standardised values that assure safe & reliable operation. As far as possible, ratings and requirements are selected from values given in the appropriate IEC standards. Deviations from these standards relate to particular requirements of company network configurations or operational & safety procedures.

In order to facilitate the three-tier structure outlined above whilst at the same time utilising existing documents, the relevant Company documents are listed below alongside their NGTS equivalents. Where appropriate, any relevant ENA document is also listed. Where no Company document yet exists, reference is made to the appropriate NGTS.

6. REFERENCES

This specification makes reference to and should be read in conjunction with the latest edition of the following documents:

6.1 International Standards

IEC 60050 International Electrotechnical Vocabulary

IEC 60060 High Voltage Test Techniques

IEC 60099-4 Metal-Oxide Surge Arrestors Without Gaps for A.C. Systems

IEC 60287 Calculations of the Continuous Current Rating of Cables

IEC 60815 Guide for the Selection of Insulators in respect of Polluted Conditions

ENA-ER-C55/4 Insulated Sheath Power Cable Systems

6.2 PowerSystems Specifications

CAB-15-003 Handling and Installation of cables up to and including 33kV

CAB-03-020 Technical specification for Power Cables up to and including 33kv and associated Auxiliary cables

SPTS 1 Ratings and General Requirements for Plant, Equipment, Apparatus and Services for The ScottishPower System and Direct Connections to It

6.3 NGT Specifications

NGTS 3.2.12 Substation Earthing

NGTS 3.5.1 132 kV, 275 kV and 400 kV Oil-Filled Cable

NGTS 3.5.2 132 kV, 275 kV and 400 kV XLPECable

NGTS 3.5.3 Sheath Voltage Limiters for Insulated Sheath Cable Systems

NGTS 3.5.4 Sheath Bonding and Earthing for Insulated Sheath Cable Systems

NGTS 3.5.5 Cable Temperature Monitoring

NGTS 3.5.6 Cable Sealing End Insulators

NGTS 3.5.7 Installation Requirements for Power and Auxiliary Cables

NGTS 3.5.8 Cable Cooling Systems

7. DEFINITIONS

The terms used in this set of documents are defined in IEC 60050 or as listed below.

Approved Profile
An insulator profile is the design of insulator outer surface which has satisfied the pollution Type Tests detailed in this specification with a creepage distance equal to or less than that specified in IEC 60815 for the pollution severity defined as heavy.

Attenuation
Attenuation is a measure of the loss in optical power in a fibre (dB).

Backfill
The material used immediately around the cable(s).

Barrier Equipment
Barrier equipment includes any equipment such as relays or transformers which protects station wiring from the effects of induced voltages in the pilot circuits.

Cable Accessories
Cable terminations which provide connections to other items of transmission plant or joints which connect lengths of cable.

Cable Ancillaries
Equipment, other than cables and accessories, used to complete a cable system including that which is used to provide monitoring and maintenance facilities.

Cable Basement
An enclosure within a substation in which power cables, cable accessories and ancillary equipment are housed and in which personnel may be required to work for construction, routine inspection and maintenance purposes. Cable basements are usually below substation buildings.

NB: Passages carrying cables between substation buildings are sometimes known as *cableways and they should generally be dealt with in the same manner* as *cable basements.*

Cable Bridge
An enclosure above ground level in which power cables, cable accessories and ancillary equipment are housed and in which personnel may be required to work for construction, routine inspection and maintenance purposes. Cable bridges may be on Scottish Power

property or utilise structures to which other utilities and/or members of the public may have access. They may be used to facilitate the passage of power cables over roads, railways or rivers.

Cable Tunnel
An enclosure which is significantly below local ground level in which power cables, cable accessories and ancillary equipment are housed and in which personnel may be required to work for construction, routine inspection and maintenance purposes.

N.B: The boundary between a *cable tunnel and* a *cable basement or cable way should be clear from the context and Scottish Power should be consulted if there is any uncertainty.*

Company
Refers to SP Transmission Ltd, SP Distribution Ltd, and SP Manweb plc including all associated design and planning practices.

Condition Monitoring Alarms
Condition monitoring alarms are those used by Scottish Power to help in the process of care and maintenance of transmission assets.

Control Room
The room from which the access to and egress from a tunnel is controlled. The room shall contain the appropriate control and communication facilities for the tunnel. The equipment necessary to allow safe access to and egress from the tunnel may be kept in the Control Room or elsewhere as appropriate.

Cooling Pipes
Cooling pipes are used to carry a cooling fluid along a cable route.

Cooling Station
The term cooling station refers collectively to the heat exchangers, water pumps and control equipment associated with a cooling section. A building may house more than one cooling station.

Corrosion Interaction
The corrosion of plant caused by the current flow in the soil from a cathodic protection system installed to protect another structure.

Current Impulse Front Time
The Current Impulse Front Time is associated with the part of the impulse which occurs prior to the peak. The Front Time duration is defined in Clause 24.3 of IEC 60060-1.

Current Impulse Time to Half-Value
The Current Impulse Time to Half Value is associated with the part of the impulse that occurs after the peak value. The Time to Half Value is defined in Clause 24.5 of IEC 60060-1.

Design Engineering Solution (DES)
The chosen method for complying with all of Scottish Powers requirements for a safe and reliable cable system and infrastructure.

Directly Buried Cables
Cables buried in the ground with a depth of cover greater than 0.7 m. Installation requirements and details of the backfill materials surrounding the cables are specified in CAB–15-003 (for cables up to 33kV) and NGTS 3.5.7 (132kV and above).

Earth Continuity Conductor
An earth continuity conductor (ECC) is a conductor which joins two separate points on a cable sheath so as to reduce the fault path impedance between them.

Earthed Working
The method of working where all exposed conductive materials in the work area are effectively bonded together and earthed at the point of work.

Earthing System Potentials (Classification)
When earth fault current passes through an earth electrode, equipment connected to it will experience a potential rise with respect to earth and potential gradients will develop in the surrounding ground. Under these circumstances the following potentials may be created:

Fire Safety Engineering Solution (FSES)
The product of a methodology for assessing the risk of fire and dangers to personnel and for devising the means to minimise such risk. It would be normal practice for an FSES to be discussed with the local Fire Authorities before it was implemented.
NB: The need for a fire safety engineering solution applies generally when cables pass through tunnels, bridges, basements or other cable ways where a risk of fire poses potential dangers to personnel.

Fusion Splicing
In fusion splicing the fibres are joined together using melting by an electric arc. This technique can compensate for a certain amount of core misalignment, as the surface tension at the melting ends tends to result in self-alignment of the fibres. This enables extremely Iow loss splices to be achieved.

Front Time
The front time, T_1 is 1.25xT where T is the time taken for an impulse voltage to rise from 10% to 90% of its peak voltage.

Good Agricultural land
All arable and pastureland that is not agreed to be permanent pasture land.

Go Pipes
The go pipes carry the cooling fluid from the cooling station.

High Current Impulse (Sheath Voltage Limiter)
The high current impulse is used to represent the effect induced by a direct lightning strike. The waveform is as defined in Clause 2.31 of IEC 60099-4. Note that this impulse has a front time duration of 4!0.5 ③s and a time to half value of 10 !1.0③s.

Induced Voltages
Induced voltages are the voltages which can be induced in power cables and associated auxiliary cables, even when isolated from the system, due to their proximity to cables, overhead lines or to natural phenomena.

Induced Voltage Working
Induced voltage working is the method of working which employs the procedures set down in the Scottish Power Power Systems Safety Instruction (PSSI) 5 to protect persons against dangerous induced voltages or differences in earth potential.

Insulated Working
The method of working where the person is insulated from contact with objects at differing potentials.

Lightning Current Impulse (Sheath Voltage Limiter)
As defined in Clause 2.17 of IEC 60099-4.

Line Isolation Units
A line isolation unit is any equipment which protects oil kiosk wiring from the effects of induced voltages in the pilot circuits.

Link Person
The person responsible for keeping a record of all personnel entering and leaving a tunnel and their location within that tunnel.

Major Section
A major section comprises three adjacent minor sections. At the two joint positions connecting the three minor sections, the sheath is sectionalised and cross connected with a phase transposition to create three continuous sheath runs, electrically insulated from each other and each containing approximately equal lengths for all three power cable sheaths.

Maximum Range of Adjustment
The Maximum Range of Adjustment for oil pressure gauges is the maximum scale value, for pressure switches it is the manufacturer's declared actual range of adjustment.

Maximum Working Pressure
The maximum working pressure is the maximum pressure to which a device can be

continuously subjected without its accuracy changing beyond the specified limits of error. For pressure gauges this corresponds to the maximum scale reading.

Mechanical Splicing
This technique employs a mechanical connector to position the ends of the fibres.

Minor Section
A minor section comprises the run of three single core power cables between adjacent sheath sectionalising positions.

Nominal Discharge Current
As defined in Clause 2.3 of IEC 60099-4.

Nominal Residual Voltage (Sheath Voltage Limiter)
The nominal residual voltage is the peak value of voltage which appears across the device when it is conducting the SVLs normal discharge current rating.

Operational Alarms
Operational alarms are those alarms used by Scottish Power for the management of power flows on the transmission system.

Pilot Circuits
Pilot circuits are auxiliary multicore or multipair cables that are used for protection and control purposes, and are subject to induced voltages.

PowerSystems
SP PowerSystems Ltd, operator of network on behalf of the company.

Prequalification Test
A long-term accelerated ageing test for cable systems, which is performed as the final stage of the manufacturer's development process.

Protective Voltage Level (Sheath Voltage Limiter)
The protective voltage level is the higher of the following:

(i) The maximum Residual Voltage measured during the Steep Current Impulse Type Test.

(ii) The maximum Residual Voltage measured during the High Current Impulse Type Test.

Rated Voltage (Sheath Voltage Limiter)
The rated voltage is the maximum design rms value of power frequency voltage which can be applied between the terminals of a SVL (its phase terminals and star point terminal for a three-phase SVL) for a period not less than one second, without causing damage.

Reference Voltage (Sheath Voltage Limiter)

The reference voltage is the mean voltage measured between the terminals when the SVL conducts +10 mA and -10 mA D.C. at ambient temperature of 20°C!10°C.

Residual Gas Pressure
The residual gas pressure (RGP) of a liquid is the pressure at which gas dissolved in the liquid will just start to come out of solution.

Residual Voltage (Sheath Voltage Limiter)
The residual voltage is the peak voltage that appears between the terminals of an SVL when the device is in the conducting mode.

Return Pipes
The return pipes carry the cooling fluid to the cooling station.

Selected Sand Backfill
A backfill which has a dried out thermal resistivity not greater than 2.7 KmW^{-1}

Sheath Voltage Limiter
A sheath voltage limiter (SVL) is the common name which is used to describe a metal oxide surge arrestor which is used to protect any part of the sheath insulation from transient over voltages.

Splice
A splice is the joint between two optical fibres. There are two basic splicing techniques, Mechanical and Fusion.

SP Transmission
The distribution Licence Holder for the Transmission service area formally known as ScottishPower.

SPTS
Scottish Power Technical Specification.

Stabilised Backfill
A backfill with a stabilised composite material which has a dried out thermal resistivity not greater than 1.2 KmW^{-1}.

Station Wiring
Station wiring includes substation protection, alarm and auxiliary wiring.

Steep Current Impulse (Sheath Voltage Limiter)
As defined in Clause 2.16 of IEC 60099-4.

Step Potential
The Step Potential is the potential difference between two points on the ground level one metre apart.

Surface Trough
A concrete trough for carrying cables whose covers are flush with the ground surface. The trough can be filled with backfill or can be unfilled. The depth to the top of the cables is usually about 0.25 m.

NB: This is a special case of the IEC 60287 definition of buried troughs, which encompasses both troughs flush with the ground surface and those having a depth of cover over the top of the trough.

Switching Differential (In relation to alarm and trip contacts for two stage pressurised cable systems)
The switching differential is the difference in pressure between the true switch operating pressure on making of contacts on falling pressure and the breaking of contacts at rising pressure.

Switching Error (In relation to alarm and trip contacts for two stage pressurised cable systems)
The switching error is the difference between the switch pressure setting and the true switch operating pressure.

Temporary Over Voltage
A Temporary Over Voltage is a power frequency sheath voltage caused by a system fault. The duration of the Temporary Over Voltage is a function of the system fault clearance time which, for each system operating voltage, is defined in SPTS 1.

Time to Half-Value, T_2
The time to half-value, T_2, of an impulse is the time interval between the virtual origin and the instant when the voltage has decreased to half the peak value.

Time to Peak, T_p
The time to peak, T p, is the time interval between the actual origin and the instant when the voltage has reached its peak voltage.

Touch Potential
The Touch Potential is the potential difference between a metallic earthed conductor, and the ground one metre away.

Transfer Potential
Where a metallic conductor extends from one earth system into another it will be able to transfer the potentials between the two systems. The transfer potential is the potential

difference that a person will experience by hand to hand contact between the two earthing systems via the conductor.

Type Registration

The process defined in SPTS 1 Section 9, whereby Scottish Power uses information from connectors, including Self Certification Statements for specific products complying with specific SPTSs, and its own audit processes to judge which products can be Type Registered for subsequent use on the Scottish Power transmission and distribution system.

Water Vapour Transmission Rate

The steady water vapour flow in unit time through a unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface.

8. GENERAL REQUIREMENTS

Connectors shall be responsible for ensuring the satisfactory performance of all aspects of the cable system design which shall meet the requirements in each appropriate Level 3 Specification.

8.1 Cable and Cable Accessories

Requirements for 132 kV, 275 kV and 400 kV XLPE insulated cables are specified in NGTS 3.5.1

Requirements for submarine cable for A.C. system voltages up to 150 kV are specified in NGTS 3.5.11

For land cables with system voltages below 132 kV the requirements of the Electricity Association Type Approval shall apply, along with those set out in CAB-03-020

8.2 Cable System

8.2.1 Sheath Losses

To reduce sheath losses special bonding arrangements may be adopted. The requirements for insulated sheath cable systems are specified in ENA-ER-C55/4

Sheath Voltage Limiters (SVLs) may be used. Requirements for SVLs are specified in NGTS 3.5.3

8.2.2 Fibre-Optic Temperature Sensors

All 275 kV and 400 kV cables shall be constructed or installed with optical fibres for use as part of a distributed cable temperature and rating monitoring system. The requirements for cable temperature monitoring are specified in NGTS 3.5.5

8.2.3 Cable Outdoor Termination Insulators

Requirements for cable outdoor termination insulators are specified in NGTS 3.5.6

8.2.4 Installation

Installation requirements for power and auxiliary cables are specified in NGTS 3.5.7

The thermal resistivity and method of preparation of any backfills used shall be disclosed.

8.2.5 Cable Cooling Systems

Requirements for cable cooling systems are specified in NGTS 3.5.8

8.2.6 Cable Tunnels and Cable Bridges

Requirements for cable tunnels and cable bridges are specified in NGTS 3.5.12

8.2.7 Transient Sheath Voltages

To reduce the Rise of Earth Potential (ROEP) on cable systems the cable sheath system and any additional earth continuity conductor shall be connected to earth via suitable low impedance connections at joint bays and terminations except where this is not practicable. The earth connections are specified in NGTS 3.5.4 and NGTS 3.5.7 for cables and in NGTS 3.2.12 for adjacent substation and overhead line earth systems with the intention of ensuring that an adequate continuous metallic earth conductor is provided for the Company network. The transient sheath voltages arise from lightning and switching impulses and additionally from any faults producing 50 Hz short-circuit currents.

8.2.8 Steady State Sheath Voltages

Where metalwork may be subject to a standing voltage in excess of 10V A.C precautions shall be taken to prevent accidental contact.

9. PERFORMANCE REQUIREMENTS

9.1 Operation

The system conditions under which the cable system shall be capable of operating are specified in SPTS 1.

9.2 Cable System Life

Cable systems shall be designed for an operating life of 40 years.

9.3 Transient Sheath Voltages

Special bonding arrangements will normally require the sue of sheath sectionalising insulation. Where it is necessary to control transient voltages across the sectionalising insulation sheath voltage limiters (SVLs) may be used.

9.4 Steady State Sheath Voltages

Where SVLs are fitted the sheath voltage shall not exceed their maximum A.C. continuous voltage rating under both normal loading, emergency loading and the external single-phase-to-earth short-circuit conditions defined in SPTS 1.

9.5 Short Circuit Rating

The cable system design shall ensure that the full declared three-phase and single-phase short-circuit currents can be carried for the durations in Table 1 without the cable system sustaining any permanent damage. The short-circuit capability shall be calculated for operation at the maximum conductor temperature.

Table 1: Maximum Short-Circuit Durations

System Voltage (kV)	Duration of Short-Circuit (s)
132	3
275	1
400	1

NB: Commonly specified short-circuit rating requirements may be found in SPTS 1 *and Scottish Power will provide these requirements in the Enquiry Document.*

10. TYPE TEST REQUIREMENTS

The following requirements are in addition to the type tests detailed in the Level 3 Specifications.

10.1 General

Type tests shall be carried out to ensure that cable system equipment comply with this specification.

The PowerSystems Approvals engineer shall be given the opportunity to witness any type tests of equipment covered by this specification and will require 28 days notice to make the necessary arrangements.

Wherever possible a qualified independent body shall witness the type tests.

The connector shall submit a copy of the type test report to the PowerSystems Approvals engineer to demonstrate compliance with the type test requirements.

PowerSystems shall be notified of all design modifications of Type Registered products. Where a modification may, in PowerSystems opinion have an effect on the test performance, it shall be necessary for the connector to demonstrate that the new performance characteristics comply with this specification.

NB: Design modification includes changes to the composition or processing of material used in the cable or accessories.

No equipment to be tested shall be subject to any form of conditioning which might modify its electrical or mechanical performance.

All measuring equipment shall comply with IEC 60060-2 or be approved by PowerSystems.

10.2 Test Report

A test report shall be produced detailing the type tests carried out on the equipment.

NB: Submitted test reports may be stored electronically by PowerSystems.

Where measurements are made during the type tests the values shall be included in the report.

NB: The recording of a *measurement in the test report is of benefit to both PowerSystems and the connector in that it provides more information than* a *simple "Passed" statement.*

10.3 Type Tests

Further type test requirements are specified in the Level 3 Specifications.

11. ROUTINE TEST REQUIREMENTS

Routine test requirements are specified in the Level 3 Specifications.

12. SAMPLE TEST REQUIREMENTS

Sample test requirements are specified in the Level 3 Specifications.

13. SITE TEST AND INSPECTION REQUIREMENTS

Site test and inspection requirements are specified in SCT 36.