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132 KV, 275 KV AND 400 KV OIL-FILLED CABLE

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PURPOSE AND SCOPE

This specification forms part of a suite of documents that define National Grid requirements for new plant. The Level 2 Specifications for cable, TS 2.5, covers major requirements and there is a series of Level 3 Specifications covering various specific requirements.

This document is a Level 3 Specification giving the requirements for 132 kV, 275 kV and 400 kV oil-filled single core cable.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 Cable

1.1.1 Conductor

The maximum D.C. resistance for conductors with cross-sectional areas up to 2500 mm² shall be as specified in IEC 60228 and for conductors with cross-sectional areas in excess of 2500 mm² shall be determined from the D.C. resistivity of copper or aluminium at 20°C.

The cable conductor shall be designed to minimise any particle contamination of the cable oil. Milliken-type conductor segments shall be wrapped to restrict particle movement.

1.1.2 Insulation

The amount of water-soluble impurities present in the insulating paper before impregnation shall be determined as described in Appendix A.

Cable oil shall comply with IEC 60867. In addition the cable oil shall comply with the oil characteristic requirements given in Table 1 (including non-corrosive sulphur content and particle count) and the residual gas pressure (RGP) given in Table 2.

Oil Characteristic	Requirement
Maximum particle count (2-5 µm range)	50,000 per 100 ml
Maximum dielectric loss angle	100×10^{-4}
Minimum dielectric strength	10 kV·mm ⁻¹
Minimum volume resistivity	$10 \times 10^{10} \Omega\text{m}$
Maximum moisture content	20 ppm
Maximum sulphur content	50 ppm

Table 1 – Oil Characteristic Requirements

System Voltage (kV)	Maximum RGP (kPa)
132	1.3
275	0.7
400	0.7

Table 2 – RGP Acceptance Levels for New Cable Systems

Cable oil shall be readily biodegradable as defined in OECD 301D.

1.1.3 Sheath

Note: Metallic sheaths provide mechanical strength, current carrying capability, an electrical earth surface and a corrosion-resistant water barrier for the main insulation. Mechanical strength is required to reduce the effect of changes in external environmental conditions, including accidental third-party damage, and to retain the oil in self-contained pressurised cable systems.

Metallic sheaths are required to act as a pressure containment system and shall be seamless corrugated aluminium.

Note: Other sheath materials may be considered where the supplier can show their suitability.

1.1.4 Oversheath

Note: The oversheath provides electrical and mechanical protection for the sheath.

The protective oversheath shall be seamless and shall be sealed to the metallic sheath to prevent the passage of moisture along the interface between the two components.

To reduce the penetration of moisture through the oversheath it shall comply with the requirements of the Vapour Transmission Test specified in the Type Test Requirements below.

Note: The rate of corrosion of sheath materials is highly dependent on the chemical behaviour of all components. Research suggests that oversheath materials with high vapour transmission capability provide poorer protection against corrosion than those with low vapour transmission capability.

The oversheath shall not be constructed of materials which may cause unnecessary hazards in the event of fire.

Note: These requirements will exclude the use of currently available polyvinyl chloride (PVC) materials.

Except for installations where fire risk is considered a hazard, the oversheath shall be covered with a conducting layer of graphite, or other conductive material, with good adhesion properties. The conductive layer shall be such that it shall be visually apparent in daylight when the layer is removed if required during jointing or the supplier shall use a method of work such that it is demonstrated that the layer has been removed.

The oversheath shall be indelibly marked with a legend in accordance with Table 3. The legend shall run along the cable in two or more lines, equally spaced around the circumference of the cable, and the distance between the end of one legend and the start of the next legend shall not be greater than 150 mm. The characters shall be at least 10 mm in height. Any additional information marked on the sheath, such as the manufacturer's name shall not affect the spacing between repetitions of the legend.

System Voltage (kV)	Legend
132	Electric Cable 132 000 V
275	Electric Cable 275 000 V
400	Electric Cable 400 000 V

Table 3 – Cable Oversheath Legends

Note: Oversheaths may be constructed of multiple layers provided the above requirements are met.

1.2 Drumming

Each drum shall bear a distinguishing number, securely marked on the outside of the flange. Particulars of the cable, including voltage, cable type, length, conductor size, number of cores, finish, length number, gross and net weight shall be clearly shown on one flange of the drum. The direction for rolling shall be indicated by an arrow.

Immediately after the tests at the manufacturer's works are completed, both ends of every length of cable shall be sealed and pressure gauges fitted to provide visual indication of the cable oil pressure. While the cable is on the drum a positive pressure shall be maintained at all times. Any cable ends left projecting shall be protected against damage.

The cable oil pressure measured at the factory shall be recorded on the drum together with the temperature at which this measurement was made.

1.3 Cable Connections to Metal-clad Equipment

Connections to gas-insulated metal-enclosed switchgear shall comply with IEC 62271-209.

The termination assembly shall incorporate sheath sectionalising insulation. The termination shall be suitable for the fixing of short circuit straps as defined TS 3.5.4.

1.4 Cable Hydraulic Systems

The installation shall consist of one or more hermetically sealed closed hydraulic sections in each of which pressure shall be separately maintained within specified limits by means of a pressure tank or tanks suitably spaced along the route. The standard pressure ranges for the feed tanks are set out in Appendix B.

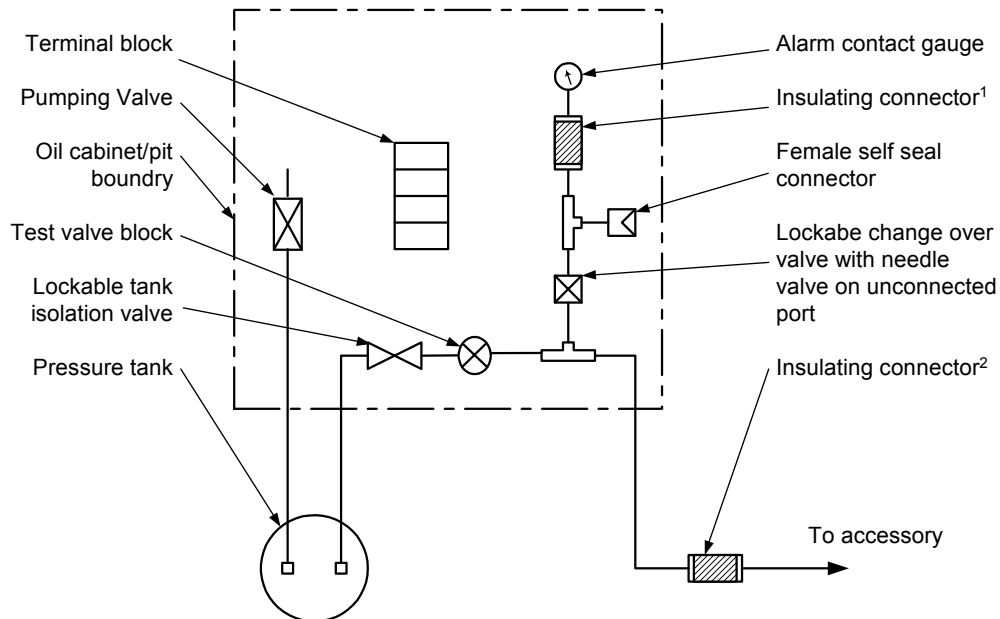
An independent hydraulic system shall be provided for each single-core cable.

1.4.1 Pressure Monitoring

Each closed hydraulic section shall be instrumented to provide local indication of oil pressure and two individual user-adjustable pressure activated alarms. It may be necessary to provide additional indication and alarm facilities where there is:

- a) More than one oil feed position.
- b) A section of cable in air.
- c) A leak location requirement.

The general pipework and instrumentation layout shall be as indicated in Figure 1. A tee-point and self-seal coupling shall be supplied to enable future provision of a transducer.



- ¹⁾ The insulating connector may alternatively be placed below the female self seal connector tee-point but in this case the assembly above the connector must be insulated to withstand the 15kV duty
- ²⁾ The insulating connector may be brought into the oil cabinet or pit but in such cases any metal pipe work liable to induced voltages must be suitably insulated

Figure 1: Arrangement of Oil Feeding Equipment

Note: The requirements for the cable oil pressure gauges and switches are defined in TS 3.5.9

All gauges, transducers and any other equipment that may need to be exposed to the environment or below ground, shall be watertight and capable of withstanding without leakage immersion in water to a depth not less than 1 m at the highest point or external pressure of 100 mbar for 1 h.

The connections and any valves, gauges or transducers shall be easily accessible.

1.5 Equipment Housing

1.5.1 Oil Monitoring Position

Equipment located at sites remote from the substation shall be, where practicable, housed above ground level in a weatherproof kiosk. The kiosk shall be provided with sufficient security to prevent unauthorised access and should, where possible, be compatible with the local environment.

Metal work used for the equipment housing shall be galvanised and protected with a paint finish.

The oil pressure monitoring equipment for each circuit shall be housed in separate kiosks. The earthing requirements for oil monitoring kiosks are specified in TS 3.5.7.

Where the pilot cable enters the kiosk, facilities shall be provided to enable periodic D.C. testing between the armouring and the conducting coating of the oversheath.

1.5.2 Substation

Equipment located at a substation shall be housed in lockable indoor wall-mounted cabinets fitted with either easily removable hinged doors or detachable covers. Where lift-off doors are provided the top hinge pin will be designed to engage before the lower to ease door replacement.

An earthing terminal shall be provided at the lower right hand side and clear of any obstructions.

An earthing bar of not less than 40 mm² copper equivalent shall be fitted in all cabinets. The earthing bar shall be provided with a separate terminal for each earth connection. Terminals of the pinch screw type are not acceptable.

A link shall be provided to isolate the pilot cable sheath/armouring from earth. The links open contacts shall be rated to withstand 15 kV A.C.

Where cable glands are used an earth tag shall be provided.

1.5.3 Labelling

All labels shall be red lettering on a white background.

Equipment housed in a substation wall-mounted cabinet shall have the following wording in a height not less than 20 mm and fitted in a prominent position on the front of the enclosure.

CABLE PRESSURE MONITORING EQUIPMENT

DANGER - INDUCED VOLTAGES

A schematic diagram shall be fitted on the rear of the hinged doors/detachable cover to clearly identify all components and connections.

The shrouding over the pilot circuit termination block shall be provided with the following legend.

DANGER - INDUCED VOLTAGES

EARTH ALL EXPOSED CONNECTIONS AFTER REMOVING THIS COVER

The lettering shall be clearly legible at a distance of 1 m.

1.6 Alarm and Indication Requirements

Alarms shall be displayed within 1 s following the development of an alarm condition.

Alarms shall be displayed locally at the oil monitoring position, and remotely at a substation and/or Grid Control Centre.

Where alarms are grouped the re-setting of the alarm shall not prevent new alarms being displayed.

1.6.1 Local

A label shall be clearly displayed inside the oil kiosk detailing the oil pressure falling and oil pressure low pressure alarm settings as defined by the cable supplier.

1.6.2 Remote

Alarms shall be displayed on an annunciator or monitor. Where a monitor is used the alarm display shall contain:

DATE	TIME	CIRCUIT	OIL SECTION	ALARM TEXT
------	------	---------	-------------	------------

Unaccepted alarms shall be highlighted by a flashing display, which on acceptance will revert to a continuous display.

The alarm display shall only clear once the alarm condition is removed.

Where a group alarm is accepted the alarm display shall re-flash for each new alarm condition within the group.

Alarm information is transmitted between the substation and Grid Control Centre via National Grid's Substation Control System and alarm inputs to this system shall be provided via clean volt-free contacts rated at 0.2 A and 48 V D.C.

1.7 Oil Pressure Tanks

The outer casing of oil pressure tanks shall be made of corrosion resistant material or where this is not practicable shall be galvanised or otherwise protected from corrosion.

1.8 Position of Oil Pressure Tanks

The preferred positions for the oil pressure tanks are as follows:

- a) At terminations - above ground, mounted on a concrete plinth or on a platform erected on an overhead line terminal tower.
- b) At intermediate points - above ground, mounted on a concrete plinth - where local conditions permit. Where this is not possible burial in a concrete tube or brick pit is acceptable.

Pressure tanks shall be banded, where practicable, to minimise the risk of contamination of the surrounding area.

1.9 Oil Feed Pipework

All pipe work laid in the ground shall have a seamless anti-corrosion covering which shall carry the legend ELECTRIC CABLE OIL FEED. The lettering shall be at least 10 mm in height.

When used, lead pipework shall be provided with protection against mechanical damage and aluminium pipework shall be corrugated.

In the case of insulated sheath systems, oil feed pipes connected to the bases of sealing ends or to joints shall be provided with a connector to isolate electrically the cable sheath from the oil feed pipe work. The connector shall be rated to withstand the 15 kV A.C.

Note: Examples of satisfactory feed pipe construction are given in Table 4.

Pipe Material	Details of Pipe		Details of Protective Covering
	Bore Diameter (mm)	Wall Thickness (mm)	
Corrugated Aluminium	20	1.0	2.5 mm wall extruded polyvinyl chloride (PVC)
Lead	13	3.2	2.0 mm wall extruded PVC 1.6 mm diameter G.S. wires 2.3 mm wall extruded PVC
Lead	20	3.2	2.0 mm wall extruded PVC 2.0 mm diameter G.S. wires 2.3 mm wall extruded PVC
Copper	13	1.2	Nil
Copper	20	1.6	Nil

Table 4 – Examples of Satisfactory Feed Pipe Construction

1.10 Oil Pipework Insulating Link

An insulating connector shall be provided in the oil pipework to electrically isolate the kiosk metal work from the incoming oil feed pipework. The connector shall be rated to withstand 15 kV A.C.

1.11 Isolation Valves

Oil control valves shall be provided to isolate the:

- The tank(s) from the cable.
- The tank(s) from the pumping point.

1.12 Test Valves

Test valves shall be installed to facilitate testing of the gauges and transducers.

The test valve shall:

- Disconnect the gauge/transducers from the cable hydraulic circuit.
- Enable the gauge/transducer hydraulic pressure to be released in a controlled manner to initiate the different alarm settings in turn.

It shall only be possible to retain the test valve in the test position by the continual application of pressure or by the use of an approved locking arrangement.