



هيئة تنظيم الكهرباء - عمان
AUTHORITY FOR ELECTRICITY REGULATION, OMAN

AUTHORITY FOR ELECTRICITY REGULATION, OMAN
STANDARD : OES 2 – CABLES & ACCESSORIES

OES 2 – STANDARD CABLES AND ACCESSORIES 3RD EDITION – REV. 0 (2010)

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GENERAL REQUIREMENTS

STANDARD – CABLES

STANDARD – CABLE ACCESSORIES



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OES 2 - CABLES AND ACCESSORIES 3RD EDITION – REV. 0 (2010)

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**GENERAL REQUIREMENTS
(APPLICABLE TECHNICAL STANDARDS, TESTS, ETC.)**

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هيئة تنظيم الكهرباء - عمان
AUTHORITY FOR ELECTRICITY REGULATION, OMAN

AUTHORITY FOR ELECTRICITY REGULATION - OMAN

OES 2 - MV, LV & CONTROL CABLES AND ACCESSORIES
3RD EDITION – REVISION 0 (2010)

GENERAL REQUIREMENTS
(Applicable Technical Standards, Tests, etc.)

OES2: S-CAB-GEN (REV.0-2010)



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GENERAL REQUIREMENTS (APPLICABLE TECHNICAL STANDARDS, TESTS, ETC.)

1 CABLES AND ACCESSORIES

General

This part of the Standard shall cover:

- Factory Testing
- Site Testing and Commissioning

of cables and their accessories specified in the following Specifications:

2 APPLICABLE CODES & STANDARDS

The cables provided under this Standard shall be manufactured under quality assurance system conforming to latest ISO issues or Equivalent National Standard.

The latest Revision or Edition of the following Standards shall be applicable:

Common Standards for Underground and Submarine Cables

IEC	60028	International standard of resistance for copper
IEC	60038	Standard Voltages
IEC	60060	High voltage test techniques
IEC	60068	Environmental Testing
IEC	60071	Insulation co-ordination
IEC	60183	Guide to the selection of high-voltage cables
IEC	60228	Conductors of insulated cables
IEC	60229	Tests on cable over-sheaths, which have a special protective function and are applied by extrusion
IEC	60287	Calculation of the continuous current rating of cables (100 % load factor)
IEC	60330	Methods of test for PVC insulation and sheath of electric cables



IEC	60331	Tests for electric cables under fire conditions
IEC	60332	Tests on electric and optical fibre cables under fire conditions
IEC	60529	Classification of degrees of protection provided by enclosures
IEC	60754	Halogen content test
IEC	60811	Common test methods for insulating and sheathing materials of electric and optical cables
IEC	60885	Electrical test methods for electric cables
IEC	61000	Electromagnetic Compatibility (EMC)
IEC	61034	Measurement of smoke density of cables burning under defined conditions
IEC	62095	Electric Cables – Calculation of current rating – Cable current rating calculations using the finite element method
VDE	0207	Insulating and sheathing compounds for cables and flexible cords
VDE	0209	Specification for insulating coverings and sheaths of thermo-plastic material for insulated cables and flexible cords
VDE	0472	Testing of insulated cables, wires and flexible cords
ASTM	B-49	Copper Rod Material

Cable Type Oriented Standards

2.1.1 11 kV and 33 kV XLPE-Insulated Underground Cables

IEC	60093	Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials
IEC	60121	Recommendation for commercial annealed aluminium electrical conductor wire
IEC	60230	Impulse tests on cables and their accessories
IEC	60270	Partial discharge measurements
IEC	60330	Methods of test for PVC insulation and sheath of electric cables
IEC	60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV - 30 kV
IEC	60853	Calculation of the cyclic and emergency current ratings of cables



IEC	60949	Calculation of thermally permissible short circuit currents, taking into account non-adiabatic heating effects
IEC	60986	Guide to the short circuit temperature limits of electric cables with a rated voltage from 1.8/3(3.6) kV to 18/30(36) kV
VDE	0271	PVC-insulated cables with nominal voltages up to and including 6/10 kV
EHD	620	European Harmonisation Document for Long Term Water Ageing Test

2.1.2 11 kV and 33 kV XLPE-Insulated Cable Accessories

IEC	60230	Impulse Tests on Cable and Their Accessories
IEC	60793	Generic specification and measuring methods
IEC	61238	Compression and mechanical connector for power cables with copper and aluminium conductor
IEC	61442	Test methods for accessories for power cables with rated voltages from 6kV ($U_m=7.2kV$) up to 30kV ($U_m=36kV$)
ESI	09-13	Performance specification for high-voltage heat-shrinkable components for high-voltage solid type cables up to and including 33 kV
BS	7888	LV and MV accessories for power cables with rated voltage from 0.6/1 kV ($U_m=1.2kV$) up to and including 20.8/36kV ($U_m=42kV$)
DIN EN	50180	Plug-in termination
HD	629.1-S1	Test requirements on accessories for use on power cables of rated voltage from 3.6/6(7.2)kV up to 20.8/36(42)kV Part 1: Cables with extruded insulation
HD	628-S1	Test methods for accessories for power cables with rated voltage from 3.6/6kV ($U_m=7.2kV$) up to and including 20.8/36 ($U_m=42kV$)
VDE	0278	Power cable accessories with nominal voltages U up to 30 kV (U_m up to 36 kV); Requirements and test methods



2.1.3 LV XLPE-Insulated Underground Cables

IEC	60093	Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials
IEC	60121	Recommendation for commercial annealed aluminium electrical conductor wire
IEC	60227	PVC insulated cables of rated voltages less than or equal to 450/750 V
IEC	60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV - 30 kV
IEC	60949	Calculation of thermally permissible short circuit currents, taking into account non-adiabatic heating effects
BS	5467	600/1000 V and 1900/3300 V armoured electrical cables having thermosetting insulation
BS	7665	Insulating and sheathing materials for cables
BS EN	10257-1	Zinc or zinc alloy coated normally steel wire for armouring either power cables or telecommunication cables. Land cables.

2.1.4 LV XLPE-Insulated Underground Cables Accessories

IEC	61238	Compression and mechanical connector for power cables with copper and aluminium conductor
IEC	60230	Impulse Tests on Cable and Their Accessories
IEC	60793	Generic specification and measuring methods
IEC	61238	Compression and mechanical connector for power cables with copper and aluminium conductor
ESI	09-13	Performance specification for high-voltage heat-shrinkable components for high-voltage solid type cables up to and including 33 kV
BS	7888	LV and MV accessories for power cables with rated voltage from 0.6/1 kV ($U_m=1.2kV$) up to and including 20.8/36kV ($U_m=42kV$)
VDE	0278	Power cable accessories with nominal voltages U up to 30 kV (U_m up to 36 kV); Requirements and test methods

2.1.5 17 Pair Protection/Telephone/Control/Signal Cables

IEC	60189	Low frequency cables and wires with PVC insulation and PVC sheath
ASTM-D	4566	Standard test methods for electrical performance properties of insulations and jackets for telecommunications wire and cable
VDE	0816	External cables for telecommunication systems
VDE	0845	VDE Specification for protection of telecommunication installations from overvoltages
BS EN	10257-1	Zinc or zinc alloy coated normally steel wire for armouring either power cables or telecommunication cables. Land cables.
ANSI/ESI-A	359	Colour Coding

2.1.6 17 Pair Protection/Telephone/Control/Signal Cable Accessories

ESI	09-13	Performance specification for high-voltage heat-shrinkable components for high-voltage solid type cables up to and including 33 kV
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2.1.7 Coaxial Cables

IEC	60078	Characteristic impedances and dimensions of radio frequency coaxial cables
IEC	60096	Radio frequency cables
IEC	61196-1	Coaxial communication cables

2.1.8 Fibre Optic Cables and Submarine Fibre Optic Cables

Common:

IEC	60793	Optical Fibres
IEC	61300	Fibre Optic Interconnection Devices & Passive component- Basic Test and Measurement Procedures
IEC	61315	Calibration of fibre optic power meters
ITU-T,G	650	Definition and test methods for the relevant parameters of single-mode fibres
ITU-T,G	652	Characteristics of a single-mode optical fibre cable



ICEA	S-66-524	Minimum Weights of Zinc Coating (galvanised steel wire armour)
ANSI/EIA-A	359	Color Coding

Outdoor Fibre Optic Cables:

IEC	60794-3	Optical Fibre Cables – Outdoor optical fibre cables
IEC	60794-1-2	Basic Optical Cable Test Procedures
BS EN	10257-1	Zinc or zinc alloy coated normally steel wire for armouring either power cables or telecommunication cables.

Indoor Fibre Optic Cables:

IEC	60794-2	Optical Fibre Cables – Indoor optical fibre cables
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Alternative Codes and Standards

The MANUFACTURER/SUPPLIER may propose alternative Codes and Standards provided it is proven that it gives an equivalent degree of quality as the referenced Codes and Standards. Acceptability of any alternative Codes or Standard is at the discretion of the PURCHASER.

Precedence of Codes and Standards

In case of discrepancy between this Oman Electrical Standard and any of the applicable Codes and Standards, the following order of precedence shall apply:

- i) Technical Requirements of this Oman Electrical Standard
- ii) Applicable Codes and Standards *
- iii) Acceptable Alternative Codes and Standards *

**) The Oman Grid Code and the Oman Distribution Code must not be infringed by the application of any code or standard!*

The MANUFACTURER/SUPPLIER shall note that compliance of the manufacturer with these specifications does not relieve him from his responsibility to supply the cables and their accessories of proper design, electrically and mechanically in order to meet the guaranteed operation at the specified service conditions.

3 FACTORY & SITE TESTS

General

Defects discovered during the type tests shall result in rejection of the Cable type or its relevant Accessories by the PURCHASER.

Any major defects discovered during the routine test of the successfully type tested cable shall lead to rejection of the Cable drum by the PURCHASER.

The MANUFACTURER/SUPPLIER shall fabricate the cable lengths and accessories necessary for the tests, over and above those within the Scope of Supply, and shall furnish them for the tests free of charge.

Prior to energizing a cable circuit, including all accessories, tests shall be performed on the complete installation.

When a new cable circuit (section) is joined with an existing cable circuit (section), the combined (new & old) cable(s) shall be tested by applying **Rated Voltage for 24 hours**. The test(s) shall be deemed passed when no break down has been registered.

Definition

For the definitions of the Type Tests; Sample Tests, Routine Tests and Tests after installation, reference shall generally be made to the relevant IEC Standards.

3.1.1 Type Tests

Evidence shall be given that the proposed Underground Cables to be supplied have been subject to all the type tests at an internationally recognised testing station, or in the MANUFACTURER/SUPPLIER own laboratories, witnessed and certified by an internationally recognised and the PURCHASER accepted certification body or laboratory. If considered necessary by the PURCHASER, the PURCHASER will decide whether additional tests are necessary from the MANUFACTURER/SUPPLIER.

Type tests shall be executed in accordance with latest IEC Standards as a minimum requirement.

The MANUFACTURER/SUPPLIER shall submit certified copies of type test certificates covering the proposed Cables.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted on an identical (each component) cable at an internationally recognised laboratory acceptable to the PURCHASER.



2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the PURCHASER.

The following additional type tests shall be carried by the Bidder/Supplier at their own cost prior to the first shipment of all offered cable:

Fire Resistant (where applicable) according to IEC 60331, BS 6387

Flame Retardant (where applicable) according to IEC 60332

Low Smoke Test (where applicable) according to IEC 61034

Halogen Content Test (where applicable) according IEC 60754

Water Tree Test of XLPE Insulation (accelerated) [for MV Cables only]

- Test voltage = 3 x U_o
- Test frequency = 500 Hz
- Core environment = 40⁰C water
- Duration of test = 4 month
- Test after 4 months: Dielectric stress withstand >14kV/mm

If the presented type test reports are not in accordance with the above requirements, the PURCHASER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the PURCHASER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

Applicable Material Characterization Test Methods and Definitions:

Note to FT-IR and Thermal Analysis:

All insulating and semi-conducting XLPE material used in the manufacture of all cable and/or accessories to be supplied and installed for any contract within the Sultanate of Oman shall be identical to those used to manufacture the Type Test Cable(s) and/or Accessories. In order to demonstrate compliance, Manufacturer/Supplier/Contractor shall fingerprint samples from the Type Test Cable(s) and/or Accessories manufactured under the relevant contract concerned.

Cables

FT – IR	=	Fourier Transform - Infrared Spectroscopy
Thermal Analysis	=	Differential Scanning Calorimeter (DSC) Melting Point, Oxygen Induction Time of Polymers Thermo Gravimetric Analysis (TGA) Content of by-products: Carbon black in polymers, Water, Cumylic alcohol, Acetophenon, Methyl-styrene, Weight loss of polymer components



Gas Chromatography Analysis

Content of by-product: Methan (most dangerous by-product of polymer components)

Joints

FT – IR	=	Fourier Transform - Infrared Spectroscopy
Thermal Analysis	=	Thermo Gravimetric Analysis (TGA) Content of by-products: Carbon black in polymers, Water, Cumylic alcohol, Acetophenon, Methyl-styrene, Weight loss of polymer components
		Gas Chromatography Analysis Content of by-product: Methan (most dangerous by-product of polymer components)
Dielectric Loss Angle	=	DLA

Lead Alloy for Cable Sheaths

Composition (BS9308, BS EN 12548)	=	Optical Emission Spectrometer (OptES) Measuring of the optical spectrum, measuring the light emitted by the metal sample and at various wave lengths
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3.1.2 Sample Tests

In order to verify that the finished cable meets the design specification sample tests shall be applied on:

- Min. 10% of total number of drums of the contract.

One sample shall be taken for batches between 4 km and 20 km ordered core length. Two samples shall be taken for batches of more than 20 km ordered core length.

Sample tests shall be executed in accordance with latest IEC 62067 recommendations as a minimum requirement and shall include additional:

- a) Measurement of protrusion at XLPE insulation and semi-conducting screen shall be performed for two samples per every extrusion run (the contact surface between the screen and the insulation shall be cylindrical, smooth and free from protrusions and irregularities which extend more than 0.03mm into the insulation)
- b) Measurement of cable layers thickness (see IEC 60502-2, for example table no. 6 for insulation)
- c) Water pressure test to prove longitudinally water tightness of the cable (according to IEC, no water shall emerge from the unpressurised end of the test piece)
- d) Lead alloy composition and behaviour (in accordance with BS 3908, BS EN 12548).

3.1.3 Routine Tests

Routine tests shall be executed in accordance with latest IEC Standards as a minimum requirement.

The MANUFACTURER/SUPPLIER is required to carry out routine tests on each finished cable drum lengths to demonstrate the integrity of the XLPE-Insulated Single-Core Underground Cables.

Failure of any routine test leads into rejection of the particular cable length.

Routine test certificates shall be submitted for the PURCHASER's review and approval before shipment of the cable.

Applicable Tests

3.1.4 33 kV XLPE-Insulated Underground Cables and their Accessories

3.1.4.1 Type Tests for Cable PEST₇ outer covering:

- Construction and dimensions (IEC 60811)
- Mechanical properties (IEC 60811)
- Pressure test at high temperature (IEC 60811)
- Carbon black content
- Water absorption test (IEC 60811)
- Shrinkage test (IEC 60811)

3.1.4.2 Type test for Cables and their Accessories:

Generally, the standards of IEC 60502, VDE 0278 and IEEE 48 shall be applied.

3.1.4.3 Sample Cable Tests according to:

- VDE 0263, IEC 60502 and IEC 60811.

The following tests shall be carried by the MANUFACTURER/SUPPLIER at their own cost prior to shipment of the underground cable:

- a) Measurement of size of protrusion at insulation and semi-conducting screens shall be performed for two samples per 10 km of cable
- b) Measurement of thickness of insulation and sheath layers
- c) The flame retardant characteristics of the cable (where applicable) shall be tested according to IEC 60332, Part 1
- d) HV_{dc} test on outer sheath insulation (shall withstand without breakdown)



e) Water pressure test to prove longitudinally water tightness of the cable conductor.

In addition, the following shall be performed:

- Dielectric test $4 \times U_0$ for 4 hours
- Measurement of weights of metallic components per meter for adjustment of metal prices for final Contract Price

3.1.4.4 Routine Cable Tests according to IEC 60502

In addition, the following shall be performed:

- Capacitance test (the capacitance shall not exceed the nominal value declared by the manufacturer for a certain % (as per IEC 62067 for example it is 8%))
- Insulation resistance test (Insulation resistance test shall be carried out as per the approved method in order to ensure soundness of the cable insulation prior to and after performing the high voltage tests on the cable. The insulation resistance will vary and will be affected by the ambient temperature, ambient humidity and lengths of the HV test leads)

3.1.4.5 Routine Tests on 33 kV XLPE-Insulated Underground Cables Accessories

- Insulation Resistance Not less than $1000 \text{ M}\Omega$ (using a Megaohmmeter applying 5 kV DC for 1 minute)
- Impact (Joints for armoured cables only) As per BS 7888
- A.C. Voltage Withstand $2.5 \times U_0$
- Impulse Voltage Withstand $194 \text{ kV}_{\text{peak}}$ (HD 629.1-S1)
- Partial Discharge less than 3 pC at $1.73U_0$ (HD 629.1-S1)
- Load Cycling without sheath damage As per BS 7888 with 1 m head of water.
- Load Cycling after sheath damage As per BS 7888 with 1 m head of water with damaged sheath.



3.1.5 11 kV XLPE-Insulated Underground Cables and their accessories

3.1.5.1 Type tests

Cable PVC outer covering:

- Construction and dimensions (IEC 60811)
- Mechanical properties (IEC 60811)
- Loss of mass test (IEC 60811)
- Pressure test at high temperature (IEC 60811)
- Test at low temperature (IEC 60811)
- Heat shock test (IEC60811)
- The flame retardant characteristics of the cable (where applicable) shall be tested according to IEC 60332, Part 1
- Water absorption test (IEC 60811)
- Sodium or potassium sulphide solution test for 4 hrs at ambient temperature

Cables and their accessories:

Generally, the standards of IEC 60502, IEC 60332, VDE 0278 and IEEE 48 shall be applied.

3.1.5.2 Sample Cable Tests according to:

- VDE 0263, IEC 60502, IEC 60332 and IEC 60811

The following sample tests shall be carried by the MANUFACTURER/SUPPLIER at their own cost prior to shipment of the underground cable:

- a) Measurement of size of protrusion at insulation and semi-conducting screens shall be performed for two samples per 10 km of cable
- b) Measurement of thickness of insulation and sheath layers
- c) The flame retardant characteristics of the cable (where applicable) shall be tested according to IEC 60332, Part 1
- d) Outer sheath colour test (dipping of outer sheath samples in a sodium or potassium sulphide solution) for a period of 4 hrs at ambient temperature. The sample shall not show any sign of discoloration after the test.

In addition, the following shall be performed:

- Dielectric test $4 \times U_0$ for 4 hours



- Cable Sheath Colour Test (dipping of cable sheath insulation samples in a sodium or potassium sulphide solution) for a period of 4 hrs at ambient temperature. The sample shall not show any sign of discoloration after the test
- Measurement of weights of metallic components per meter for adjustment of metal prices for final Contract Price

3.1.5.3 Routine Cable Tests according to IEC 60502

In addition, the following shall be performed:

- Capacitance measurement (the capacitance shall not exceed the nominal value declared by the manufacturer for certain % (as per IEC 62067 for example it is 8%))
- Insulation resistance test (Insulation resistance test shall be carried out as per the approved method in order to ensure soundness of the cable insulation prior to and after performing the high voltage tests on the cable. The insulation resistance will vary and will be affected by the ambient temperature, ambient humidity and lengths of the HV test leads)

3.1.5.4 Routine Tests on 11 kV XLPE-Insulated Underground Cable Accessories

- | | |
|--|--|
| ➤ Insulation Resistance | Not less than 1000 MΩ (using a Megaohmmeter applying 5 kV DC for 1 minute) |
| ➤ Impact (Joints for armoured cables only) | As per BS 7888 |
| ➤ A.C. Voltage Withstand | 2.5 x U ₀ |
| ➤ Impulse Voltage Withstand | 95 kV _{peak} (HD 629.1-S1) |
| ➤ Partial Discharge | less than 3 pC at 1.5 U ₀ (HD 629.1-S1) |
| ➤ Load Cycling without sheath damage | As per BS 7888 with 1 m head of water. |
| ➤ Load Cycling after sheath damage | As per BS 7888 with 1 m head of water with damaged sheath. |



3.1.6 LV XLPE-Insulated Cables

3.1.6.1 Type Test for Cables and their Accessories:

- According to BS 5467
- Conductor Insulation Colour Test (dipping of conductor insulation samples in a sodium or potassium sulphide solution) for a period of 4 hrs at ambient temperature. The sample shall not show any sign of discoloration after the test.

3.1.6.2 Sample Cable Tests According to:

- According to IEC 60502 and IEC 60332

The following sample tests shall be performed in accordance with IEC 60332 –1 and BS 5467 or equivalent:

- 1) Spark test on cores and over sheaths
- 2) Voltage test on completed cable
- 3) Conductor resistance test
- 4) Conductor insulation colour test (dipping of conductor insulation samples in a sodium or potassium sulphide solution) for a period of 4 hrs at ambient temperature. The sample shall not show any sign of discoloration after the test
- 5) Armour resistance test
- 6) The flame retardant characteristics of the cable (where applicable) shall be tested according to IEC 60332
- 7) Measurement of thickness and weights: One metre length cable shall be cut from every 20 drums of finished cable, selected at random by the PURCHASER representative and samples thus obtained examined in detail and the following measurements and weight taken:
 - 8) Thickness of insulation
 - 9) Thickness of PVC inner sheath
 - 10) Number and diameter of the armour steel wires
 - 11) Thickness of PVC outer sheath
 - 12) Weight of copper conductor in kg/m
 - 13) Weight of armour steel wires in kg/m
 - 14) Weight of zinc coating of armour steel wires in mg/m²
 - 15) Sodium or potassium sulphide solution test (see above)

3.1.6.3 Routine Cable Tests according to:

- According to BS 5467



3.1.7 17 Pair Protection/Telephone/Control/Signal Cables and Accessories

3.1.7.1 General

Tests for the Protection/Telephone Cables shall be performed according to IEC 60229, 60330, 60332, VDE 0472, 0816 and 0845.

3.1.7.2 Type Tests

Type Tests shall be performed comprising as a minimum the following tests:

a) Mechanical/Material Characteristics:

- Elongation of the conductor at break
- The tensile strength of the conductor
- The tensile strength and elongation of the conductor insulation
- Elongation after aging 100 ± 2 °C/240 h (conductor insulation)
- Shrinkage of conductor insulation after 100 ± 2 °C/1 h
- Weight increase in conductor insulation
- Tensile strength and elongation of inner sheath
- Elongation after aging 100 ± 2 °C/240 h (inner sheath)
- Tensile strength and elongation of outer sheath
- Elongation after aging 100 ± 2 °C/336 h (outer sheath)
- Carbon black content for inner and outer sheaths
- The flame retardant characteristics of the cable shall be tested according to IEC 60332, Part 1
- Environmental stress cracking
- Zinc weight of the armoring
- Dipping test of armoring.

b) Electrical Characteristics:

- Near and far end cross talk at 500 kHz for protection/telephone pairs
- Characteristic impedance, attenuation and phase constant for telephone pairs and protection pairs at + 20 °C, at frequencies as per Technical Data Sheets
- Screening factor at 50 Hz, 1.0 Ohm/km earth resistance and at voltages as per Technical Data Sheets.



- Voltage test on outer sheath (including joint) as follows:
 - 10 kV AC for 1 min. between armoring and conductive coating for the outer sheath of both the cable and joint, after the sample had been already immersed in water at + 75 °C for 5 hours, followed by natural cooling. This procedure shall be carried out seven times (one per day)
 - High voltage test (15 kV AC / 1 min) on the cable cores during each of the above mentioned seven cycles, including joints, between any core and ground while all screens/armour and remaining cores are grounded.
 - High voltage test on the marshaling cabinets with connected protection/telephone cable of approx. 5 m length (15 kV AC for 1 min. between adjacent terminal connections for protection and telephone cores, with all remaining terminals and the cable screens and armoring earthed).

3.1.7.3 Sample Tests

Sample Tests shall be performed, comprising as a minimum the following tests:

- High voltage test (15 kV AC / 1 min between any core and ground while all screens/armour and remaining cores are grounded).
- The flame retardant characteristics of the cable shall be tested according to IEC 60332, Part 1
- Cable construction and measurements of dimensions
- Sheath marking as per Technical Data Sheets.

3.1.7.4 Routine Tests

Routine Tests shall be performed, comprising as a minimum the following tests:

- Conductor resistance measurement
- Capacitance measurement at 800 Hz
- Insulation resistance measurement
- High Voltage test (8 kV AC / 1 min. between any core and ground while all screens/armour and remaining cores are grounded).
- Voltage tests on outer sheath (10 kV AC / 1 min. between armoring and conductive coating).



3.1.8 Coaxial Cables

3.1.8.1 Type Tests

Type tests shall be performed comprising, as a minimum, the following tests:

- Dimensions
- Resistance of inner and outer conductors
- Dielectric strength
- Insulation resistance
- Spark test
- Characteristic impedance
- Attenuation
- Labelling
- The flame retardant characteristics of the cable shall be tested according to IEC 60332, Part 1

3.1.8.2 Sample Tests

Sample tests on the coaxial cables shall be performed, comprising, as a minimum, the following tests:

- Cable construction and measurements of dimensions
- Sheath marking as per Technical Data Sheets
- The flame retardant characteristics of the cable shall be tested according to IEC 60332, Part 1

3.1.8.3 Routine Tests

Routine tests shall be performed comprising, as a minimum, the following tests:

- Resistivity of inner conductor
- Dielectric strength of core
- Insulation resistance
- Characteristic impedance
- Attenuation constant

OES 2 - 3rd EDITION, DRAWINGS - Rev.0-2010

01_general

Drawing No.		Rev.	Title
Former DWG No.	New 3rd EDITION DWG No.		new

There are no drawings available under this Section 01_general !



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**33 KV & PILOT, 11 KV & L.T. UNDERGROUND CABLES
INSTALLATION & SPECIFICATIONS
3RD EDITION : REV. 0 - 2010**

TYPICAL DRAWINGS – INSTALLATION & CABLES

SULTANATE OF OMAN



هيئة تنظيم الكهرباء - عمان
AUTHORITY FOR ELECTRICITY REGULATION, OMAN

AUTHORITY FOR ELECTRICITY REGULATION - OMAN

STANDARD – OES 2

**33 kV & PILOT, 11 kV & L.T.
UNDERGROUND CABLE
INSTALLATIONS & SPECIFICATIONS**

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1 CABLES

33kV, 11kV and L.T. cables shall be cross-linked polyethylene insulated PE sheathed, galvanised steel wire or galvanised steel tape armoured and PE served overall. The cables shall comply with the attached specifications UG1, UG 2 and UG3.

The rated cable sheath design fault levels and clearing times shall be considered as follows:

Nominal Voltage (kV)	Clearing Time (sec.)	Current (kA)
33	0.5	31.5 *
11	0.5	25
0.4	1	46

* screen and armour connected!

Pilot Cable for use in association with 33kV cable circuits (where applicable) shall be XLPE insulated with copper tape screen, PE sheathed, galvanised steel wire, or galvanised steel tape, armoured and PE served overall.

2 JOINTS AND TERMINATIONS

Joints and terminations for the cables (33kV, 11kV and L.T.) shall be of an approved cold shrink, hot shrink or hybrid type.

3 INSTALLATION

3.1 General

For underground cable installations, local skilled and unskilled labourers shall only be employed for excavation, cable bedding, cable laying, backfilling and for civil works.

For cable joints and terminations, only qualified cable fitters shall be employed.

3.2 Excavation of cable trenches and joint pits

Prior to the commencement of work based on route design drawings approved by the EMPLOYER, final route approval clearance for the execution of the work shall be obtained from the Ministry of Housing, Supreme Department for Town Planning, Municipality, Ministry of Communications, Public Authority for Electricity & Water, Omantel (and/or other licensees for this service) and, where applicable, from Royal Oman Police, the Ministry of Defence, Ministry of Commerce and Industry, Petroleum Development of Oman (PDO), etc.

During trench excavation, safety rules (according to an approved HSE plan) shall be strictly followed.

New cable routes installed shall, as minimum, maintain a vertical and horizontal clearance of 500 mm to existing facilities and underground services. Trench alignments shall be as straight as possible and shall be excavated to approved formations and dimensions. Trenches shall have vertical sides and shall be close timbered and strutted where necessary to prevent subsidence.

Where sub soil water is encountered, at the specified depth for trenching and/or joint pits, the work site shall be dewatered to maintain the trenches dry during cable laying and/or jointing operations.

During trench excavation and cable laying, the safety of the public is of paramount importance. Hence picket fences and warning ropes along the routes of open trenches, as well as danger notices, barriers and yellow warning lights during the hours of darkness shall be provided. HSE rules shall be strictly followed. A watchman shall be provided for every span of open trench.

Throughout the process of trench excavation, the excavated material must be placed at only one side of the trench. The other side of the trench must be kept free and clean for the purpose of cable laying.

The depth of excavated trenches with reference to the general ground level at the sites (and their width at the specified bottom) shall be as follows:-

	DEPTH	WIDTH
a) 33kV cables together with pilot cable (3C-circuit or each SC cable)	100 cm	50 cm
b) 11kV cables together with pilot cable (3C-circuit or each SC cable)	100 cm	40(50) cm
b) L.V. for each single cable circuit or each SC cable	75 cm	30 cm

Further reference is made to drawings of typical cable trench sections:

- DWG/OES2/UG/0101 A – typical LV cable trench sections,
- DWG/OES2/UG/0102 A – typical 11 kV cable trench sections,
- DWG/OES2/UG/0103 A – typical 33 kV cable trench sections,

Drawings for the typical cable trench sections show the lay of the cables, layers of filling material, position of cable cover tiles, warning tapes, etc.

Where trench/joint pit excavations involve the removal of pavement slabs, interlock tiles, etc., the permission for taking them out shall be obtained from the relevant Competent Authorities. All care and attention shall be exercised in their removal and later reinstatement to the entire satisfaction of the relevant Competent Authorities concerned.

3.3 Road Crossing Ducts

3.3.1 Motorways, Highways, Major Roads

No motorway, highway, or other major asphalted road shall be opened for the purpose of installing ducts for the crossing of underground cables and/or associated control cables.

Instead, horizontal boring/drilling shall be deployed to install road crossing ducts made of a material suitable for the process as well as for the protection and routing of the cables. For each road crossing, two spare ducts shall be provided

3.3.2 Normal Roads, Unpaved Roads, Graded Road and Bridges

For all other cases permitting the opening of roads, unpaved roads and graded tracks, for the installation of underground ducts, heavy duty PVC or spun concrete pipes may be utilised encased in concrete grade C 40 providing at least 15 cm cover to the ground and 10 cm between the pipes.



All necessary diversions and warning signs and/or alternative diversion routes shall be provided in case of existing roads or graded tracks are temporarily blocked for execution of the route.

In case of bridge crossings, the ducts may be in the form of galvanised steel pipes incorporated into the bridge design/structure. Alternatively, ducts may be attached to bridge structures at a later date, subject to a review of the load bearing capacity of the bridge(s) to be undertaken by the successful bidder.

3.3.3 Applicable to all Road Crossings

Ducts, wherever deployed, shall have a minimum internal diameter of 200 mm for 33kV cables and 150 mm for 11 kV and LV cables. In case of ducts made of PVC material, a minimum thickness of 5 mm shall be provided.

After the installation and successful testing of the cables, ducts containing cables shall be completely filled/closed with Bentonite to ascertain the unhindered heat dissipation from the cable to the soil surrounding the duct(s).

Unused ducts shall be sealed at each end with teak wood plugs and bitumen to avoid the ingress of water and vermin.

Two spare ducts shall be foreseen for every road crossing.

Typical road crossing sections are provided by drawing nos.: DWG/OES/UG/0106, 0107 and 0108.

3.4 Cables Crossing or Laid in Parallel to Installations Underground

3.4.1 Spacing of Cables when laid parallel to other Cables or Installations

3.4.1.1 Spacing between Cables

Cables of different voltages laid parallel shall generally be spaced as shown below and in Drawing No.: DWG/OES/UG/0112 :

	<u>L.V.</u>	<u>11kV</u>	<u>33kV</u>
L.V.	300mm	400	500
11kV	400mm	500	500
33kV	500mm	500	500



Where space restriction is encountered, the following minimum space shall be maintained:

	<u>L.V.</u>	<u>11kV</u>	<u>33kV</u>
L.V.	200mm	250	300
11kV	250mm	300	300
33kV	300mm	300	300

3.4.1.2 Between Telecommunication Cables and Power Cables

Power cables shall not be laid in the same trench as Omantel cables [or the ones of other communication licensees] without written permission from Omantel [or other licensees].

When power cables are laid in trenches parallel to communication cable trenches, a minimum distance between trenches shall be as follows:

L.V.	300mm
11kV	450mm
33kV	500mm

3.4.1.3 Sewage Pipes and Water Pipes

To allow for safe excavation and to permit maintenance work to be executed, the following minimum clearance shall be maintained for power cables up to 33kV.

See Drawing No.: DWG/OES/UG/113.

House connections	< 50mm	Ø Pipe	500mm
	< 100 mm	Ø Pipe	1000mm
	100 – 300mm	Ø Pipe	1500mm
	300 – 600mm	Ø Pipe	2000mm
	above 600mm	Ø Pipe	3000mm

For 132kV and above, minimum clearance of 2 meters up to 600mm Ø Pipe and 3 meters for pipes above 600mm Ø.

3.4.2 Crossing - Power Cables

Generally, power cables crossing other installations shall be avoided. If unavoidable, the following clearances shall be maintained:



3.4.2.1 Crossing of Water Pipes/Sewage Pipes

Drawing No.: DWG/OES/UG/0114

Whenever cables are crossing a water/-sewage pipe line, minimum clearance of 500mm below the power cable shall be maintained and cable shall be protected by heavy duty PVC or spun concrete pipe duct 200/150mm \varnothing encased in concrete to length of 2 meters on both sides of crossing for pipes up to 600mm \varnothing and 3 meters for pipes above 600mm \varnothing and covered with cable tiles, warning tapes and cable markers shall be fixed both of the cable duct. Hand excavation will be done at point of crossing.

3.4.2.2 Crossing of Power Cables

Drawing No.: DWG/OES/UG/0112

Whenever cables are crossing each other, the top cable is to be protected by heavy duty PVC or spun concrete pipe duct 200/150mm \varnothing encased in concrete to a length of 2 meters, over the crossing and cable markers shall be fixed at both ends of the cable duct. Hand excavation will be done at point of crossing.

The clearance between cables of different voltage levels at crossings shall be as per depth of laying stipulated in the standard.

In the case of cables of the same voltage level, the clearance at crossings shall be equal to the larger diameter of the cables.

3.4.2.3 Crossing of Telecommunication / Omantel [or other licensees for this service] Cable by Power Cable

See Drawing No.: DWG/OES/UG/0113.

Minimum clearances shall be as follows:

L.V.	300mm
11kV	450mm
33kV	500mm

Also telephone cables shall be protected by split PVC duct over the crossing to a length of 1 meter.



Special cable marker shall be fixed at the crossing point of the cables with identification showing the upper and lower cables, as follows: -

Omantel [or other Licensee] or **[Disco's name]**
[Disco's name] **Omantel [or other Licensee]**

3.5 Cable Laying

The design of the cable routes as well as the actual cable installation shall consider the minimum permissible bending radius of the cable(s) as per the advice of the cable manufacturer.

Before the cable is laid down into the trench, it shall be stretched from the drum and laid along the free and clean side of the open trench. The bottom of the trench must be sufficiently levelled and properly cleaned. Then, the cable is laid in the trench and covered with an amount of sifted soil or approved soft sweet sand that will provide the 100mm bed for the cable. Finally, the cable is to be raised up along its length allowing the filling material to form the bed.

After the cables are laid, the cover of backfill shall consist of sifted soil or approved soft sweet sand and tamped down to depth as shown on Drawing No.: DWG/OES2/UG3/0101, DWG/OES2/UG2/0102 and DWG/OES2/UG1/0103. Some water may be applied for the compaction of the soil.

Cables shall be laid direct from drums.

Rollers, spaced not more than 2 meters apart, shall be provided to avoid abrasion to the cable serving as well as twisting of cable on its longitudinal axis during pulling operation.

If power driven cable pulling is employed, it shall be by bond pulling method using steel carrier wire.

Cable laying operation shall be carried out with all care and attention, to ensure that no damage to the sheath, armour, or its serving is caused during the process.

The ends of cross-linked polyethylene cables shall be capped to prevent ingress of moisture into the filler or other hygroscopic elements of cable. The caps shall remain intact during transport and laying operations.

3.6 Backfilling and Reinstatement

After the cables have been laid, the trenches shall be backfilled in 15mm thick layers of natural and properly riddled soil, each layer being well compacted, watered if necessary, and consolidated around and over the cables. Mechanical punners must not be used for this work.

Unsuitable excavated material shall be removed from site and selected soil supplied and used for backfilling.

After backfilling to depth as shown in Drawing Nos. DWG/OES/UG-0101, 0102 and 0103, either interlocked polyethylene cover tiles or concrete cable cover tiles shall be placed in continuous length. After backfilling to further depth as shown in the drawings, caution tape 150 mm wide in (yellow) colour printed with black letters in indelible material shall be placed in continuous length.

The design of the interlocked polyethylene tiles and the concrete cable cover tiles shall follow drawings:

- a. DWG/OES2/UG/0109 A (Polyethylene Cable Cover Tiles),
- b. DWG/OES2/UG/0116 A (Concrete Cable Cover Tiles).

3.7 Jointing and Termination

Cable sealing and joining shall be carried strictly in accordance with manufacturer's instructions and shall be of the best workmanship. Sealing ends and cable joints shall be either of the cold shrink, hot shrink or hybrid type.

Cable sheath and armour used as earth continuity conductors shall be properly bonded to glands and bonding clamps to provide a low resistance path under fault conditions. XLPE insulated termination cores shall be protected from UV radiation by approved means.

All termination boxes shall have an enclosure rating of IP 68 for direct buried and IP 55 for indoor installation. Nameplates of all boxes/panels shall be mounted by using of stainless steel type bolts and nuts without affecting the IP rating.

Cable joints and termination works at the 33kV, 11 kV and LT voltage levels, shall be executed by a certified Cable Joiner. For the cable jointing and termination works, the cable jointers shall always use proper tools for cable supporting, cutting, removal of insulation or semiconducting material, cleaning etc. Cable jointers with tools not satisfying the minimum recommendations of the cable manufacturer shall be suspended from the work and disqualified.

Jointing and Termination Procedures

The Contractor shall submit drawings of the layout and construction of joint bays which shall be designed where required with concrete rafts and formed so as to enable jointers to carry out work efficiently and expeditiously. The joint bay enclosure will be double skinned for additional security against weather borne contamination.

The entrance to the joint bay will be preceded by an antechamber to permit personnel entering the joint bay to change into clean overalls and shoe covers and thus minimize the possibility of outside contamination being carried into the joint bay. The concrete floor of the joint bay will be sealed with a suitable, durable sealant to contain any dust that should otherwise rise from the floor.

For termination:

Cables shall be terminated under controlled environmental conditions preventing ingress of moisture and dust. The point of termination shall be covered with a waterproof and dust proof cover with a slanting roof mounted on a fixed frame to give adequate working space both above and below sealing end base plate. Adequate floor space shall be provided at more than one level to enable the cable to be clamped and plumbed if applicable below the sealing end base plate. Complete preparation of cleaning, plumbing of metallic sheaths and earth bonding may be cleared out before termination work commences. The humidity of atmosphere shall be kept below the acceptable value stated in approved installation procedure. The Contractor shall ensure that only one team of jointers is assigned to one three phase termination until it is completed to ensure that the termination is continuous without changing personnel. Terminations shall be carried out in situ and in no case shall be completed at ground level and lifted in a suitable position under the cable terminations. Each end of a cable run shall be provided with labels for identification. The labels shall be fitted in a suitable position under the cable termination.

3.8 Cable and Installation Records (As-Built Documents)

Detailed records of cables shall be carefully taken on site during the execution of the works. The records shall show the routes, the exact location of each cable, or cable circuit, the position of joints and terminations, the date of jointing, prevailing weather conditions, the name of the jointer, the lengths between joints, the serial number of the cable drum, the direction of lay from A to Z ends, the date of testing. In addition to the above where more than one cable is laid, sectional insert of the cable trench. Any other underground services that cross the cable route or are running in close vicinity parallel to it shall be recorded.

The position readings of the cable routes, cable joints and joint pits, points of change of direction, road crossings, etc., shall be obtained by GPS/GSNN (Global Positioning System / Global Satellite Navigation Network). Depth of cables, joints, etc. with reference to road levels and/or general level at site, shall be obtained by Theodolite.



All position recordings, as-built route drawings, details of technical information, cable specifications, test certificates, etc. shall be incorporated in electronic files and data bases compatible with Geo-graphical Information Systems maintained by the EMPLOYER. Hardcopies as well as Softcopies, electronic files and databases shall be handed over to the EMPLOYER at the conclusion of an underground cable installation project.

3.9 Earthing

All cable or armour to have links to earth to enable testing of the sheath. Earthing resistance obtained by measurement shall not be greater than 10 ohms.

Where cables are connected as link between overhead line structures, armour not being bonded to a substation earthing system at the substation end, the armour of such cable shall be bonded to the structural steel earths at both ends.

3.10 Cable Identification

3.10.1 Cable Route and Joint Markers

Cable route and joint markers shall be manufactured using reinforced concrete 1:2:4 as shown in Drawing Nos. DWG/OES/UG/0104 and 0105. Route markers shall be placed at intervals of not more than 30 meters and at points of route alignment changes.

3.10.2 Cable Markers

All power and pilot cables shall be provided with identification markers at intervals of not more than 25 meters along the route and at their terminations. Markers shall be made of a permanent material of an approved type. The identification nomenclature to be applied must be obtained from the EMPLOYER.

3.10.3 Core Markers

Cores of solid dielectric and plastic insulated low voltage multicore pilot/control cables shall be identified with lettered and numbered marking ferrules which shall be made of permanent material and shall be of an approved type.



3.11 Cable Protection

Protection from the Sun

Where cable and/or their terminations are installed and exposed to direct solar radiation, sunshields of approved material and design shall be provided.

3.12 Bonding

a) Pilot Cables

The armour of pilot cables with extruded outer sheaths shall be bonded together and connected to earth at all terminating and jointing accessories. Solid bonding connections shall also be made between adjacent multicore cables at terminations and joints.

b) Power Cables

All schemes employing cables having an extruded outer covering shall be installed as an insulated system.

Cable screens shall be solidly bonded to earth at each end of the route.

c) Copper Earthing Connections

Bonding leads shall be of sufficient cross-sectional area to carry the maximum short circuit current.

3.13 Site Tests

3.13.1 General

Cables shall be tested as indicated below after installation, but before they are placed in normal service. The purpose of these tests is to verify the integrity of the cable and to detect major insulation damage that may have occurred during shipping, storage and installation.

3.13.1.1 Physical Site Inspection of all Cable Types

1. Checking of proper layout of power, control and instrumentation cables



2. Checking of the cable attachments to trays, trenches and manholes, if according to instructions and this specification and whether appropriate number and quality of cable ties / attachments have been applied.
3. Checking of the cable termination whether properly terminated and properly marked for easy identification.
4. Checking of the proper connection of the power cable screens/shields and control cable screens to the earthing network.
5. Checking of the cable entrances to equipment, terminal box, glands and floor openings whether appropriate sealing have been provided.
6. Checking of cleanliness of cables, cable trays, trenches, hand holes and manholes.

3.13.2 MV - XLPE Cables

3.13.2.1 Minimum tests after installation including all accessories:

- According to IEC 60502

In addition, the following shall be performed:

1. Phase identification check
2. DC conductor resistance test (IEC 60228)
3. Insulation resistance measurement before and after HV test
4. AC high voltage withstand test (phase to phase voltage)
5. Visual and function test of earthing system
6. Outer sheath DC voltage withstand test (10 kV/1 minute) between metallic sheath/ screen/armouring including cross bonding system, etc. and ground (33kV cables, only)
7. Capacitance test (the measured value of capacitance shall not exceed the nominal value declared by the manufacturer by certain % (as per IEC 62067 for example it is 8%))
8. Primary connection check
9. Cable supporting check
10. Cable fixing check

Note: Partial discharge test is basically necessary after installation, however, it is usually undertaken for cable systems of 132 kV and higher voltage levels only.



3.13.3 LV - XLPE Cables

3.13.3.1 Minimum tests after installation including all accessories shall be performed, comprising as a minimum the following tests:

1. Phase identification check
2. Insulation resistance measurement before and after HV test
3. Visual and function test of earthing system
4. Primary connection check
5. Cable supporting check
6. Cable fixing check

3.13.4 Control Cables

3.13.4.1 Minimum tests after installation including all accessories shall be performed, comprising as a minimum the following tests:

1. Cores identification
2. Conductor resistance measurement
3. Insulation resistance measurement
4. Capacitance measurement
5. High voltage test (15 kV DC / 1 min between any core and the ground while all screen/armour and remaining cores are grounded, when terminated inside the termination cubicle)
6. Cable supporting and fixing check
7. Continuity fixing test
8. Attenuation over the frequency range after terminating all cable cores as specified in the Technical Data Sheets



3.13.5 Coaxial Cables

3.13.5.1 Minimum tests after installation including all accessories shall be performed, comprising as a minimum the following tests:

1. Conductor resistance measurement
2. Insulation resistance measurement
3. Capacitance measurement
4. High Voltage test (2 kV AC / 1 min.) between the core and the ground while the outer conductor any screens/armour are grounded
5. Voltage test on outer sheath (10 kV DC / 1 min between armouring and ground)
6. Attenuation over the frequency range as stated in the technical data sheets
7. Continuity check
8. Cable termination check
9. Cable supporting and fixing check

3.13.6 Optical Fibre Cables

3.13.6.1 Pre-installation tests

Attenuation tests shall be carried out on FOC drums prior to installation to ensure healthiness of cable before laying into trenches.

3.13.6.2 Minimum tests after installation including all accessories shall be performed, comprising as a minimum the following tests:

1. attenuation versus wave length at wavelengths of 1310 and 1550 nm.
2. HV test for outer sheath (10 kV / 1 min between steel tape and ground)
3. back scatter measurement
4. integrity test



3.14 Inspection

Inspection by the EMPLOYER and/or appropriate authority shall be carried out at the following stages of the work:

- a) Cable trench before laying of cables,
- b) Cables laid in trench before backfilling,
- c) After protection tiles have been laid,
- d) After warning tape has been placed.

Further work at each stage shall proceed only after inspection and approval.



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33kV & PILOT, 11 kV & L.T. UNDERGROUND CABLE INSTALLATIONS

4 SPECIFICATIONS



4.1 SPECIFICATION : UG1 - 33kV CABLES

1. GENERAL

Reference is made to typical cable cross sections as follows:

- DWG/OES2/UG1-SC, single core XLPE cable with aluminium wire armour,
- DWG/OES2/UG1-3C-1 A, 3 core XLPE cable with steel tape armour.

The 33000 volts cable is for operation on Oman Licensees 33 kV systems and shall be designed in accordance with and conform to relevant IEC specifications.

Highest System Voltage	36 kV
Rated Service Voltage (U_o/U)	19 / 33 kV
No of phases	3
Design fault level	31.5 kA, 0.5 seconds
Neutral	Earthed through 12.5 ohms resistor
Impulse withstand voltage (+90°C)	170 kV _{peak}
Power frequency withstand test voltage (4 x U_o)	76 kV/4hrs
Maximum partial discharge at 1.73 U_o	
Routine Test	3 pC
Type Test	3 pC
Maximum metallic screen short-circuit (0.5 sec)	
Temperature	200 °C

Cables to be procured must have passed a type test not more than 3 years ago.

2. CONDUCTOR

Cable conductors shall be compacted circular comprising stranded bare clean smoothed annealed copper wires in accordance with IEC 60228 class 2 free from burrs and surface imperfections likely to damage the conductor screen or cause uneven electrical stress distribution.

The conductor shall be longitudinally water tight and shall meet requirement of water penetration test of Clause 19.22 of IEC 60502. Water swelling tapes shall be applied around each layer of the conductor wires.

Note:

Aluminium conductors shall be deployed in exceptional cases only and requiring the specific approval of the Distribution and Supply Licensee holder in who's License area the cables are to be utilised. Furthermore, cables with aluminium conductors must fulfil all other cable characteristics as specified within these OES2 document(s).

3. CONDUCTOR SREEN (SHIELD)

The conductor screen with a minimum thickness of 0.8 mm shall be of an extruded layer of black, semi-conducting compound over which the insulation is applied.

The contact surface between conductor screen and insulation shall be smooth and free from protrusion. The protrusions at the surface between the conductor screen and insulation shall be limited to 0.075 mm into the insulation and 0.175 mm into the conductor screen. The screen material shall adhere to the conductor surface but not penetrate into the conductor.

The conductor screen (non-strippable) shall be firmly bonded to the insulation and the bonding shall not be affected due to the effects of bending, load cycling and short circuit.

The volume resistivity of the screen material shall not exceed 1000 Ωm at 90°C.

4. INSULATION

The insulation raw material shall be extra clean class with an extremely low level of contamination.

The insulation shall be an extruded homogeneous layer of tree-retardant cross-linked polyethylene complying with IEC 60502 meeting the following requirements:

Normal operating temperature	:	90 °C
Permitted overload conductor temperature	:	107 °C
Short circuit temperature of conductor *	:	250 °C
Chemical resistance **	:	high
Moisture resistance **	:	high
Thermal resistivity **	:	low
Fire resistance **	:	good
Minimum insulation thickness	:	8.0 mm
Maximum insulation thickness	:	8.7 mm

The maximum deviation of the insulation thickness shall not be more than 4 % of the average thickness of six measurements at any point.

* *provided conductors at joints are welded or connected by hydraulically pressed sleeve*

** *The cable manufacturer shall provide the required quality characteristics of the insulation raw material by means of valid certificates of analysis.*

5. INSULATION SCREEN (non-metallic)

The insulation screen with a minimum thickness of 0.8 mm shall be an extruded layer of black, semi-conducting compound and continuously covering the whole surface of the insulation.



The contact surface between insulation and insulation screen shall be smooth and free from protrusion. The protrusions at the surface between the insulation and insulation screen shall be limited to 0.125 mm into the insulation and 0.125 mm into the insulation screen.

The inner surface of the insulation screen shall adhere continuously to the outer surface of the insulation and shall have no tendency to separate from the insulation due to the effect of bending during installation, load cycling and short circuit under service conditions.

This insulation screen shall be a cold strippable layer and capable of being removed by hand without any special tool or applying heat, without impairing the performance of insulation and leaving no semi-conductive material which cannot be removed easily. When tested, the stripping force shall be not less than 4 N and not more than 45 N according to IEC 60502-2 (Clause 19.21.2).

The volume resistivity of the insulating screen material shall not exceed 500 Ω m at 90°C.

Phase identification shall be provided, by means of thin coloured tape Red, Yellow and Blue and placed between the non-metallic insulation screen and the metallic core tape. The phase identification tape shall be heat resistant, suitable for continuous operation at 90°C and the colour shall not fade when exposed to heat or organic chemicals.

6. Manufacturing Process of Conductor Screen, Insulation and Insulation Screen

The conductor shall be covered with three layers (screen, insulation, screen) the insulation being of tree-retardant MV insulation compound, extruded under high pressure and heat treatment.

The conductor screen, the insulation and the insulation screen shall be mutually compatible and shall, in the same manufacturing process, be continuously extruded and completely dry cured by a common head (simultaneously).

For insulation raw material handling, DIRECT FEED SYSTEM and for cooling, after vulcanization, dry cooling are the preferred methods.

7. Insulation Screen (metallic)

In case a metallic insulation screen is required, it shall be of plain annealed copper tape with a nominal thickness of 0.075 mm wrapped with a 50% overlay.

7.1 Interstitial Copper Conductor

Three (3) numbers of annealed bare copper wire conductors, each having a minimum cross-section of 50 mm², shall be placed in the interstices in contact with the copper tapes during the three core assembly.

7.2 Short-circuit

A calculation by the manufacturer shall prove that the interstitial copper conductors together with the insulation metallic screens are adequate to meet the specified short-circuit current. The calculation results shall be supported by actual executed Short-Circuit test results.

When carrying the short time current as specified, the integrity and performance of any part of the cable shall not deteriorate due to the rise of the surrounding temperature. The sheath temperature under specified short circuit conditions shall not exceed the allowable temperature rise of the insulation or the allowable short circuit temperature of the sheath protection covering whichever is lower.

8. Laying Up

The three cores and the interstitial copper conductors shall be laid up together with polypropylene yarn filler or equivalent to form a compact circular cable and wrapped with polyester binder tapes. The materials used shall be suitable for the operating temperature of the cable and compatible with the insulating materials.

9. Inner Sheath

The extruded inner sheath shall meet IEC 60502-2. The material shall be PE-ST₇ with a nominal thickness of 2.3mm. The inner sheath shall not be susceptible to cracking during the life of the cable.

10. Armour

The preferred type of armour for 3-core cables shall consist of two layers of galvanised steel tapes, each with a nominal thickness of 0.8 mm. The tape armour shall be applied helically in two layers around the bedded cables so that the outer tape is approximately central over the gap of the inner tape. The gap between adjacent turns of each tape shall not exceed 50% of the width tape. The galvanising of the steel tapes shall be of a smooth finish. The zinc coating shall be applied on both sides as well as on the edges, either by the hot dip or the electro galvanising process.

The armour of single core cables shall consist of round aluminium wires, each wire having a nominal diameter of 2.5 mm.

11. Outer Sheath

The outer covering shall meet IEC 60502-2 and be of PE-ST₇ with a minimum density of 0.94 g/cm³ and minimum thickness of 4.2 mm. It shall be suitably prepared against cracking and



decomposition under the prevailing service conditions at site. The entire outer sheath shall be covered with a black semi-conductive layer.

On the outer sheath the following shall be embossed at one meter intervals starting from “000” against each drum length:

- Voltage designation
- Cable size
- Number of cores
- Manufacturers name
- Year of manufacturing
- EMPLOYER’s name as ‘PROPERTY OF [DISCO’s name as appropriate *]’
- Sequential length marking at every meter intervals starting from “000”.

* MEDC or MAZOOON or MAJAN or any other name of a licensee as to be specified!

12. DRUM LENGTH

Only steel drums shall be deployed for the transport of the cables.

Nominal drum length shall be as follows:

3 core 300 mm ²	:	250 meters
3 core 50 mm ²	:	500 meters
1 core 500 mm ²	:	500 meters
1 core 630 mm ²	:	500 meters

SPECIFICATION : UG2 - 11kV CABLES

1. GENERAL

Reference is made to typical cable cross sections as follows:

- DWG/OES2/UG2-SC, single core XLPE cable with aluminium wire armour,
- DWG/OES2/UG2-3C-1 A, 3 core XLPE cable with steel tape armour,
- DWG/OES2/UG2-3C-2 A, 3 core XLPE cable with steel wire armour.

The 11000 volts cable is for operation on Oman Licensees 33 kV systems and shall be designed in accordance with and conform to relevant IEC specifications including 60502-2, 60332-2, 60228.

Highest System Voltage	12.5 kV
Rated Service Voltage (U_o/U)	6.35 / 11 kV
No of phases	3
Design fault level	25 kA, 0.5 seconds
Neutral	Solidly Earthed
Impulse withstand voltage (+90°C)	75 kV _{peak}
Power frequency withstand test voltage (4 x U_o)	25 kV/4hrs
Maximum partial discharge at 1.73 U_o	
Routine Test	3 pC
Type Test	3 pC
Maximum metallic screen short-circuit (0.5 sec)	
Temperature	200 °C

Cables to be procured must have passed a type test not more than 3 years ago.

2. CONDUCTOR

Cable conductors shall be compacted circular comprising stranded bare clean smoothed annealed copper wires in accordance with IEC 60228 class 2 free from burrs and surface imperfections likely to damage the conductor screen or cause uneven electrical stress distribution.

The conductor shall be longitudinally water tight and shall meet requirement of water penetration test of Clause 19.22 of IEC 60502. Water swelling tapes shall be applied around each layer of the conductor wires.

Note:

Aluminium conductors shall be deployed in exceptional cases only and requiring the specific approval of the Distribution and Supply Licensee holder in who's License area the cables are to be utilised. Furthermore, cables with aluminium conductors must fulfil all other cable characteristics as specified within these OES2 document(s).

3. CONDUCTOR SHIELD

The conductor screen with a minimum thickness of 0.7 mm shall be of an extruded layer of black, semi-conducting compound over which the insulation is applied.

The contact surface between conductor screen and insulation shall be smooth and free from protrusion. The protrusions at the surface between the conductor screen and insulation shall be limited to 0.075 mm into the insulation and 0.175 mm into the conductor screen. The screen material shall adhere to the conductor surface but not penetrate into the conductor.

The conductor screen (non-strippable) shall be firmly bonded to the insulation and the bonding shall not be affected due to the effects of bending, load cycling and short circuit.

The volume resistivity of the screen material shall not exceed 1000 Ωm at 90°C.

4. INSULATION

The insulation raw material shall be extra clean class with an extremely low level of contamination.

The insulation shall be an extruded homogeneous layer of tree-retardant cross-linked polyethylene complying with IEC 60502 meeting the following requirements:

Normal operating temperature	:	90 °C
Permitted overload temperature	:	107 °C
Short circuit temperature*	:	250 °C
Chemical resistance**	:	high
Moisture resistance**	:	high
Thermal resistivity**	:	low
Fire resistance**	:	good
Minimum insulation thickness	:	3.4 mm
Maximum insulation thickness	:	3.7 mm

The maximum deviation of the insulation thickness shall not be more than 4 % of the average thickness of six measurements at any point.

* *provided conductors at joints are welded or connected by hydraulically pressed sleeve*

** *The cable manufacturer shall provide the required quality characteristics of the insulation raw material by means of valid certificates of analysis.*

5. INSULATION SCREEN (non-metallic)

The insulation screen with a minimum thickness of 0.7 mm shall be an extruded layer of black, semi-conducting compound and continuously covering the whole surface of the insulation.



The contact surface between insulation and insulation screen shall be smooth and free from protrusion. The protrusions at the surface between the insulation and insulation screen shall be limited to 0.125 mm into the insulation and 0.125 mm into the insulation screen.

The inner surface of the insulation screen shall adhere continuously to the outer surface of the insulation and shall have no tendency to separate from the insulation due to the effect of bending during installation, load cycling and short circuit under service conditions.

This insulation screen shall be a cold strippable layer and capable of being removed by hand without any special tool or applying heat, without impairing the performance of insulation and leaving no semi-conductive material which cannot be removed easily. When tested, the stripping force shall be not less than 4 N and not more than 45 N according to IEC 60502-2 (Clause 19.21.2).

The volume resistivity of the insulating screen material shall not exceed 500 Ω m at 90°C.

Phase identification shall be provided, by means of thin coloured tape Red, Yellow and Blue and placed between the non-metallic insulation screen and the metallic core tape. The phase identification tape shall be heat resistant, suitable for continuous operation at 90°C and the colour shall not fade when exposed to heat or organic chemicals.

6. Manufacturing Process of Conductor Screen, Insulation and Insulation Screen

The conductor shall be covered with three layers (screen, insulation, screen) the insulation being of tree-retardant MV insulation compound, extruded under high pressure and heat treatment.

The conductor screen, the insulation and the insulation screen shall be mutually compatible and shall, in the same manufacturing process, be continuously extruded and completely dry cured by a common head (simultaneously).

For insulation raw material handling, DIRECT FEED SYSTEM, and for cooling, after vulcanization, dry cooling are the preferred methods.

7. Insulation Screen (metallic)

In case a metallic insulation screen is specified, a metallic screen of plain annealed copper tape having a nominal thickness of 0.075 mm shall be wrapped around each conductor with a 50% overlay.

7.1 Interstitial Copper Conductor

Three (3) numbers of annealed bare copper wire conductors, each having a minimum cross-section of 40 mm², shall be placed in the interstices in contact with the copper tapes, during the three core assembly.



7.2 Short-circuit

A calculation by the manufacturer shall prove that the interstitial copper conductors together with the insulation metallic screens are adequate to meet the specified short-circuit current. The calculation results shall be supported by actual executed Short-Circuit test results.

When carrying the short time current as specified, the integrity and performance of any part of the cable shall not deteriorate due to the rise of the surrounding temperature. The sheath temperature under specified short circuit conditions shall not exceed the allowable temperature rise of the insulation or the allowable short circuit temperature of the sheath protection covering whichever is lower.

8. Laying Up

The three cores and the interstitial copper conductors shall be laid up together with polypropylene yarn filler or equivalent to form a compact circular cable and wrapped with polyester binder tapes. The materials used shall be suitable for the operating temperature of the cable and compatible with the insulating materials.

9. Inner Sheath

The extruded inner sheath shall meet IEC 60502-2. The material shall be PVC-ST2 with a nominal thickness of 1.9 mm. The inner sheath shall not be susceptible to cracking during the life of the cable.

10. Armour

The preferred type of armouring for 3-core cables shall consist of two layers of galvanised steel tapes, each having a nominal thickness of 0.5 mm. The tape armour shall be applied helically in two layers around the bedded cables so that the outer tape is approximately central over the gap of the inner tape. The gap between adjacent turns of each tape shall not exceed 50% of the width tape. The galvanising of the steel tapes shall be smooth finish. The zinc coating shall be applied on both sides as well as over the edges, either by the hot dip or the electro galvanising process.

Alternatively, the armour for 3 core cables shall be made up of round galvanised steel wires in accordance with BS.

The armour of single core cables shall consist of round aluminium wires, each wire having a nominal diameter of 2.5 mm.



11. Outer Sheath

The outer covering shall meet IEC 60502-2 and be of PVC-ST2 with a nominal thickness of 4.2 mm. It shall be suitably prepared against cracking and decomposition under the prevailing service conditions at site. The colour shall be red.

On the outer sheath the following shall be embossed at one meter intervals starting from “000” against each drum length:

- Voltage designation
- Cable size
- Number of cores
- Manufacturers name
- Year of manufacturing
- EMPLOYER’s name as ‘PROPERTY OF [DISCO’s name as appropriate *]’
- Sequential length marking at every meter intervals starting from “000”.

* MEDC or MAZOOON or MAJAN or any other name of a licensee as to be specified!

12. DRUM LENGTH

Nominal drum length shall be as follows:

3 core 185 and 240 mm ²	:	250 meters
3 core 50, 70, 120 mm ²	:	500 meters
1 core 500 mm ²	:	500 meters
1 core 630 mm ²	:	500 meters



SPECIFICATION : UG3 - 600/1000 VOLTS CABLES

1. GENERAL

Reference is made to typical cable cross sections as follows:

- DWG/OES2/UG3-SC, single core XLPE cable with aluminium wire armour,
- DWG/OES2/UG3-4C-1 A, 4 core (4x16mm²) XLPE cable with steel wire armour,
- DWG/OES2/UG3-4C-2 A, 4 core (4x4, 4x10 & 4x25mm²) XLPE cable with steel wire armour,
- DWG/OES2/UG3-4C-3 A, 4 core (4x25, 4x35, 4x50, 4x70, 4x95,4x120, 4x185 & 4x240mm²) XLPE cable with steel wire armour,
- DWG/OES2/UG3-2C-1 A, 2 core (2x50 & 2x120mm²) XLPE cable with steel wire armour,
- DWG/OES2/UG3-2C-2 A, 2 core (2x6 & 2x10mm²) XLPE cable with steel wire armour.

The 600/1000 volts cables are for operation on Oman Licensees 415/240 volt system, the characteristics of which are given below and shall be constructed in accordance with and conform to relevant IEC specifications.

Highest System Voltage (U_{max})	1.2 kV
Rated Service Voltage (U_o/U)	0.6 / 1 kV
No of phases	3
Design fault level	40 kA, 0.5 seconds
Neutral	Solidly Earthed
Power frequency withstand test voltage (4 x U_o)	2.4 kV/4hrs
Maximum metallic screen short-circuit (0.5 sec)	
Temperature	200 °C

Cables to be procured must have passed a type test not more than 3 years ago.

2. CONDUCTOR

The conductors, three phases and full size one neutral, shall consist of stranded plain annealed copper wires of 99.99% purity and not less than 100% conductivity according to the International Annealed Copper Standard

The conductors shall comply with requirements of IEC 60228 and BS 6360.

Note:

Aluminium conductors shall be deployed in exceptional cases only and requiring the specific approval of the Distribution and Supply Licensee holder in who's License area the cables are to be utilised. Furthermore, cables with aluminium conductors must fulfil all other cable characteristics as specified within these OES2 document(s).



3. SHAPE of CORES

Cores shall be compacted and 90° shaped for all 4-core cables (except for 16 mm² conductors, where the shape shall be circular), in accordance with BS 6360 and IEC 60228.

Four core cables with cross sections of 4x4, 4x10 and 4x25mm² shall have assembled circular cores in accordance with BS 6360 and IEC 60228.

Two core cables with cross sections of 2x50 and 2x120mm² shall have compacted and semi-circle shaped cores.

Two core cables with cross sections of 2x6 and 2x10mm² shall have assembled circular shaped cores.

4. DRESSING

The conductors shall be rendered clean, smooth and free from foreign particles and defects likely to penetrate the insulation.

5. INSULATION

The conductor insulation shall be an extruded homogeneous layer of cross-linked polyethylene (XLPE) complying with grade GP8 of BS 5467.

The insulation thickness shall be in accordance with BS 5467.

The phase identification shall be according to BS/IEC recommendations.

To avoid any fading of the colours during the life span of the cable, the conductor insulation material shall be UV resistant and shall comprise of anti-ageing and anti-sulfuration components.

The insulation shall suit the following requirements:

Normal operating temperature	:	90 °C
Permitted overload temperature	:	107 °C
Short circuit temperature	:	250 °C
Short circuit temperature*	:	250 °C
Chemical resistance**	:	high
Moisture resistance**	:	high
Thermal resistivity**	:	low
Fire resistance**	:	good

* provided conductors at joints are welded or connected by hydraulically pressed sleeve

** The cable manufacturer shall provide the required quality characteristics of the insulation raw material by means of valid certificates of analysis.



The minimum average insulation thickness shall be as follows:

	2/4 Core												Single Core		
Size [mm ²]	4	6	10	16	25	35	50	70	95	120	185	240	:	500	630
Thickness[mm]	0.7	0.7	0.7	0.7	0.9	0.9	1.0	1.1	1.1	1.2	1.6	1.7	:	2.4	2.4

6. LAYING UP / ASSEMBLY

The four conductors shall be laid up, where required with non-hydroscopic fillers to form a compact and circular cable.

7. BINDER

The material for the binder shall be polypropylene.

8. INNER SHEATH (BEDDING)

The bedding layer shall consist of an extruded layer of PVC-ST2/LSZH. The Bedding Material shall not be susceptible to cracking during the service life of the cable. The Bedding Material shall fully comply with BS 7655/IEC and the thickness as per BS 5467/IEC recommendations.

The nominal thickness shall be as follows:

	2/4 Core												Single Core		
Size [mm ²]	4	6	10	16	25	35	50	70	95	120	185	240	:	500	630
Thickness[mm]	0.8	0.7	0.8	0.8	1.0	1.0	1.0	1.2	1.2	1.4	1.4	1.6	:	1.2	1.2

9. STEEL WIRE ARMOUR

The cable armouring for 4-core cables shall consist of a single layer of round galvanised steel wires applied helically around the bedded cable to cover the entire periphery. The zinc content in the steel armour, the diameter and the electrical resistance shall be according to BS 5467 as well as BS EN 10257-1. For single core cable, the armour shall consist of aluminium strips. The size of the armour shall be as follows:

	2/4 Core												Single Core		
Size [mm ²]	4	6	10	16	25	35	50	70	95	120	185	240	:	500	630
Thickness[mm]	0.9	0.7	1.25	1.25	1.6	1.6	1.6	2.0	2.0	2.5	2.5	2.5	:	2.0	2.0



Short-Circuit

The Manufacturer shall prove by calculation that the steel wire armouring is adequate to meet the specified short-circuit current. The calculation results shall be supported by actual executed Short-Circuit Test results.

When carrying the short time current as specified, the integrity and performance of any part of the cable shall not deteriorate due to the rise of the surrounding temperature. The sheath temperature under specified short circuit conditions shall not exceed the allowable temperature rise of the insulation or the allowable short circuit temperature of the sheath protection covering whichever is lower.

10. OUTER SHEATH

The outer covering shall be of PVC-ST2/LSZH and meet BS 7655. It shall be suitably prepared against cracking and decomposition under the prevailing service conditions at site.

The outer covering shall be free from chlorinated paraffin and termite resistant as well as resistant to sulphides found in the ground.

The thickness of the outer sheath shall be as specified in BS 5467.

The colour of the outer sheath shall be black.

On the outer sheath the following shall be embossed at one meter intervals starting from “000” against each drum length:

- ELECTRIC CABLE 600/1000V
- Cable size
- Number of cores
- Manufacturer’s name
- Year of manufacturing
- EMPLOYER’s name as ‘PROPERTY OF [DISCO’s name as appropriate *]’
- Sequential length marking at every meter intervals starting from “000”.

* MEDC or MAZOON or MAJAN or any other name of a licensee as to be specified!



11. DRUM LENGTH

The cables shall be transported deploying steel drums.

Nominal drum length shall be as follows:

4 core	16, 25 and 35 sq.mm	:	1000 meters
4 core	50, 70, 95 and 120 sq.mm	:	500 meters
4 core	185 and 240 sq.mm	:	250 meters
1 core	500 sq.mm	:	500 meters
1 core	630 sq.mm	:	500 meters



SPECIFICATION : UG4 -

**17 PAIR PROTECTION/TELEPHONE PILOT
CABLE**

1. GENERAL

Reference is made to typical cable cross sections as follows:

- DWG/OES2/UG4-1 A, cross section of Protection/Telephone underground cable with steel wire armour,
- DWG/OES2/UG4-2 A, cross section of Protection/Telephone underground cable with steel tape armour.

The pilot cable shall comply with IEC 60811. The protection/telephone pilot cable shall have 5 pairs for protection and 12 pairs for telephone usage, i.e. the type of the cable shall therefore inherently be:

$$\underline{5 \times 2 \times 1.4 + 12 \times 2 \times 1.0}$$

ELECTRICAL DATA

Voltage withstand (core/screens) 1 min.

- | | |
|----------------|----------|
| - Type test | 15 kV AC |
| - Routine test | 12 kV AC |

Voltage withstand of outer sheath

between Armour and conductive coating 10 kV AC

Minimum insulation resistance per km
of completed cable at 20°C

- | | |
|----------------------------|----------|
| - between protection cores | 10 GΩ.km |
| - between telephone cores | 10 GΩ.km |

2. CONDUCTORS

The conductors shall comprise clean, smooth, soft annealed, electrolytic copper wires with standardized conductivity. They shall be stranded for the protection and solid for the telephone cores.

The core diameter shall be 1.4 mm for the protection pairs and 1.0 mm for the telephone pairs.

3. INSULATION

The conductor insulation shall be extruded PE with a minimum thickness of 1 mm.



The cores shall be twisted in Pairs and each wrapped with swell-able plastic tape followed by wrapping with two layers of cooper tape (thickness 0.05 mm) screen with a wrapping gap of 50%.

The cable cores shall be colour coded in accordance with specified standards.

4. FILLERS

The material of fillers between screened pairs shall be PE and all pairs shall be wrapped with plastic tape before the application of the sheath.

5. WATER BLOCKAGE

The method of water blockage in the longitudinal direction shall be by using jelly compound in the interstices between pairs and inside each pair. However, using of swelling tapes inside the pair may also be considered if jelly compound can not be deployed. The applicable standard is EN 18700-605B.

6. INNER SHEATH / COMMON SCREEN / BEDDING

The inner sheath shall consist of an extruded layer of black PE with a nominal thickness of 2 mm over which the common screen is wrapped.

The common screen shall consist of two layers of copper tape with an individual minimum thickness of 0.15 mm and a lapping gap of 50% each layer, the second one covering the butt space of the first layer.

The plastic bedding consists of 2 layers of PE tape layer of plastic tape with a nominal thickness of 2.0 mm.

7. ARMOURING

The armouring shall preferably consist of two layers of galvanised steel tapes, each tape having a minimum thickness of 0.5 mm, lapped with a short lay, the second one covering the butt space of the first layer.

An armouring of steel wires may also be considered, in which case the cable armouring shall consist of a single layer of round galvanised steel wires applied over the sheath. The galvanised steel wires shall comply with BS EN 10257 as a minimum.



8. OUTER SHEATH

The outer covering shall be of PE-ST7 or LSZH, termite resistant, vermin proof, fire retardant and suitable for the prevailing service conditions at site.

The outer covering shall be black and have a semi-conductive coating.

A distinctive marking, including the following details, shall be embossed every one meter continually along the outer covering:

- Manufacturer's name and/or trade mark
- Year of manufacture
- 19 PAIR PROTECTION/TELEPHONE
- Marks one meter apart showing the cable length
- PROPERTY OF '[DISCO's name as appropriate *]'

* MEDC or MAZOON or MAJAN or any other name as to be specified

9. MAKE UP OF PILOT CABLES

- | | | | |
|----|---------------------|---|---|
| a) | 5 pairs (10 Cores) | : | Each core being a stranded copper conductor of 1.4 mm dia. and 5 times two cores twisted together, each pair screened with 2 layers of cooper tape – pairs for use with pilot wire protection system. |
| b) | 12 pairs (24 Cores) | : | Each core being a solid cooper telephone conductor of 1 mm dia. and 14 times two cores twisted together, each pair screened with 2 layers of cooper tape – pairs for telephone usage. |
| c) | Voltage Grade | : | The telephone pairs shall be 500 V D.C. volt grade and the rest of the cores shall be A.C. 600 volt grade. |
| d) | Identification | : | Cores shall be numbered in accordance with BSS 6346. |

10. DRUM LENGTH

Only steel drums shall be deployed for transporting the cables.

The nominal drum length shall be 500 meters.

SPECIFICATION : UG5 - FIBRE OPTIC CABLE (FOC)

1. GENERAL

Reference is made to typical cable cross sections as follows:

- DWG/OES2/UG5 - A, Cross-section of underground Fibre Optic Cable.

All cables shall be designed in accordance with the latest issues of IEC, EN & ITU-T G652 Publications and other standards as may be approved by the EMPLOYER at the time before procurement.

The cables shall be suitable for outdoor as well as indoor use, either directly buried in the ground or laid in ducts/cable trays.

The cables may be exposed to direct UV rays of the sun at the termination gantries, etc. The cable outer sheath shall be capable of withstanding such exposure continuously without any detrimental effect.

The Fibre optic cable shall have optical Fibres of the single-mode type. The Fibre cores shall be laid loose in buffer tubes. Water blocking compound shall be provided inside the buffer tubes as well as in the interstices between these buffer tubes. The construction of the cable shall be such as not to allow water/moisture penetration in either longitudinally or axially direction.

The Fibre cores shall be made of ultra pure fused silica glass suitable for operation at 1310 and 1550 nm wave lengths. The design shall be generally as per the latest versions of recommendations and specifications made by International Committees/Organizations such as ITU-T and IEC, and others which might be referred to, if required, for the conventional single mode Fibre optic cable. It shall provide low dispersion values over the entire possible wavelength range above the cut-off wavelength of the cabled Fibre, which should not be more than 1270 nm.

The Fibre Optic Cable shall generally be laid in 4" PVC ducts or PE-HD piping (DN90-SDR=17.6), either separately or in the same trench, parallel to power cables or water pipes and shall be terminated in suitable enclosures.

2. CABLE CONSTRUCTION

2.1 Central Strength Member

In the centre of the Fibre Optic Cable, a rod, preferably made of Glass Reinforced Plastic (GRP), shall be placed, around which the buffer tubes, housing the Fibres, are to be stranded.

2.2 Buffer Tube

The Fibre Optic Cable shall have loose buffer tubes to accommodate the Fibre cores which shall be distributed among these tubes equally. The buffer tubes must hold their shape, be tough, not susceptible to ageing and be very flexible, so that the cable can be handled without noticeable stressing the optical Fibres.

The buffer tube shall be composed of an inner layer with a very low friction coefficient and an outer layer to shield the Fibre against mechanical influences. The design of the loose buffer shall be in such a way that the elongation of the cable under normal operating conditions does not result in increase in the attenuation beyond the limits specified by the above mentioned standards.

For the technical requirements of loose buffer tubes reference shall be made to DIN VDE 0888 in connection with dimensions, colour codes and temperature range.

2.3 Buffer Tube Filling Compound

The buffer tubes and the interstices among them shall be filled with a slightly thyratropic and chemically neutral compound. This is to prevent water from entering the buffer and running through it which may affect the Fibre and result in attenuation increases. This compound shall not corrode the Fibre or cause it to swell. It also shall not drip out at the temperature range of: 0°C to + 60°C and shall be easy to wipe and wash off without leaving residue that would make it difficult to connect the Fibres.

The compound shall not contain highly inflammable materials and shall have relatively low thermal coefficient.

2.4 The Cable Core

The buffer tubes with the fillers, stranded around a GRP (glass reinforced plastic) central member shall form the core of the Fibre Optical Cable. The GRP member shall serve both, as a support (buckling protection against kink) and as a strain relief member.

The stranding shall be in such a way, that the bending radius will be as low as possible and the optical Fibres having a well defined free space within which strain, buckling, pressure and bending stresses will have no influence on the transmission characteristics.

The stranded buffer tubes/fillers around the GRP member with the moisture resistant compound in the empty interstices among them are wrapped by the core covering which consists of at least one layer of non-hygroscopic tape, applied helically or longitudinally with an overlap.



2.5 The inner sheath

A PE sheath layer shall be extruded above the core covering with a thickness of not less than 1.5 mm.

2.6 Aramide Layer

A layer of aramide yarns shall be laid over the inner PE sheath layer to serve mainly as a strength member.

2.7 Intermediate Sheath

The intermediate sheath shall consist of black PE-ST₅ with a thickness of not less than 1.0 mm.

2.8 Armouring

The armouring shall consist of a corrugated steel tape applied longitudinally with an overlap. The tape thickness shall not be less than 0.2 mm.

2.9 Outer Sheath

The applicable standard is IEC 60502. The outer sheath layer of PE-ST₇ with a density of 0.94g/cm³ shall have a thickness of not less than 1.5 mm and be covered by a semi-conductive coating.

The outer sheath shall be UV resistant.

2.10 Colour Coding of the Fibre/Buffer Tube

The colour coding shall be generally in compliance with Standard EIA-A-359. However, the final colour coding may be subject to a mutual agreement at the time of procurement.

2.11 Marking

The outer sheath of the Fibre Optic Cable shall have the following marking embossed into the PE sheath, repeated at 1 meter intervals:

- **Fibre Optical Cable** (Fibre Optic Cable)
- Manufacturer's Name



- Year of manufacturing
- length of cable (running meter)
- PROPERTY OF '[DISCO's name as appropriate *]'

* MEDC or MAZOOON or MAJAN or any other name as to be specified

3. INSTALLATION

Fibre Optic Cables shall either be laid:

- Separately,
- Parallel with pipe lines keeping a distance of at least 500 mm or
- along power cable routes at the same depth of the power cables and adjacent to them.

Fibre Optical Cables shall be laid in separate PVC conduits within urban boundaries, at the same depth as the power cables or adjacent to pipe lines.

In rural districts including desert environment, FO Cables shall be directly buried underground preferably following OHTLs or pipe line routes, as the case may be.

The FOC shall be tested prior to and immediately after installation.

3.1 Splicing/Non-Permanent Joints/Straight Joints

Splicing of the optical fibre cable, either along the route or at the terminals, shall be carried out in such a way as to minimise losses (maximum average loss of any individual splice is ≤ 0.05 dB).

Non-permanent connectors are to be located at the ends of routes only. These connectors shall have a minimum attenuation (losses of connector and bulkhead together with the pigtail splice loss) of not more than 0.3 dB and shall comply with the latest technology at the time of procurement.

3.2 Fibre Optic Cable Splicing and Termination (Substation/Pumping Station End)

The optical fibre cables shall be terminated at easily accessible terminal blocks inside distribution/termination boxes. The fibres shall be terminated in low loss, screw-on type of connectors suitable for withstanding high voltage hazards.

The connectors shall be fixed inside the termination box on connector holders, which shall allow easy access to each of the connectors. The length of Patch cord cables shall be 10m and are to be provided with suitable male connector of the screw-on type. The loss of connector bulkhead and pig tail splice shall not be more than 0.3 dB.



4. TESTING and INSPECTION

After installation of the cables have been completed, electrical and function tests shall be carried out in accordance with the latest edition of ITU-T & IEC recommendations or as otherwise specified.

5. DRUM LENGTH

The nominal drum length shall be up to 4000 meters depending on design and site requirements.

SPECIFICATION : UG6 - COAXIAL CABLE FOR CCTV

1. GENERAL

The Coaxial Cables shall be designed such as to have a service life of not less than 20 years in the working condition and installation environment prevailing in the SULTANATE OF OMAN. It shall also fully satisfy the safety, health and environmental requirements enforced by the laws established in the SULTANATE OF OMAN.

The Coaxial Cables shall be suitable for in-door and outdoor installations, either directly buried in the ground or laid in ducts/cable trays. Water stopping in the longitudinal axis of the cable shall be provided.

All cables shall be designed in accordance with the latest issues of IEC Publications and other standards as may be approved by the EMPLOYER.

The cables may be exposed to the direct solar radiation of the sun at the termination gantries, etc. The cable outer sheath shall be capable of withstanding such exposure continuously without any detrimental effect.

The operating frequency range shall be 50 – 500 kHz when deployed for Power Line Carrier systems and with low attenuation for operation between 0.5 – 30 MHz when deployed for CCTV systems.

The characteristic impedance of the required Coaxial cables shall be 75 Ohm. The cable shall be suitable for operating voltages up to 300 volts.

2. DESIGN

2.1 Inner conductor

The inner conductor shall be solid made of clean, smooth, soft annealed, electrolytic copper wire with standardized conductivity.

2.2 Insulation

The insulation between the inner conductor and outer conductor shall be solid PE having water tightness characteristics. A plastic or cotton separation tape shall be provided over the outer insulation onto which the braided outer conductor is applied.

2.3 Outer conductor

The outer conductors shall be made of braided copper wires and the surface of the individual wires shall be smooth and clean before the insulation is applied.



2.4 Sleeve – Outer Conductor

The outer conductor shall be sleeved with PVC having a minimum thickness of 1 mm.

2.5 Armour

The Coaxial cable shall be armoured to provide adequate mechanical protection. Two layers of galvanised steel tape, each having a minimum thickness of 0.3 mm, shall be over-lapped, the second one should cover the butt space of the first layer.

A tape bedding of plastic material shall be wrapped over the armour before the outer sheath is applied.

2.6 Outer Sheath

The outer covering shall be of high-density polyethylene (HDPE) with a minimum thickness of 2 mm, termite resistant, vermin proof, and suitable for the prevailing service conditions at site.

3. MARKING

A distinctive marking, including the following details, shall be embossed continually along the entire outer covering in 1 meter intervals:

- Manufacturer's name and/or trade mark
- Year of manufacture
- Coaxial cable 75 Ohm
- Marks one meter apart showing the cable length
- PROPERTY OF '[DISCO's name as appropriate *]'

* MEDC or MAZOOON or MAJAN or any other name as to be specified!

4. DRUM LENGTH

The standard delivery cable length shall be 1000 meters.



5. COAXIAL CABLE TERMINATIONS

The Coaxial Cable shall be terminated directly into the respective equipment through a suitable connector. The appropriate plug-in matching connector with low loss shall be used with the corresponding type of cable.

All cable glands required for the termination shall be supplied and installed.



SPECIFICATION : UG7 - CONTROL / SIGNAL CABLE

1. GENERAL

The Control/Signal Cables generally shall be installed within substation premises.

2. TECHNICAL DESCRIPTION

2.1 Design

2.1.1 General

The Control/Signal Cables to be offered shall be designed such as to have a service life of not less than 30 years in the working condition and installation environment prevailing in the Sultanate of Oman.

All cables shall be designed in accordance with the latest issues of IEC Publications and other standards as may be approved by the EMPLOYER.

The cables may be exposed to the direct rays of the sun at the termination cubicles, etc. The cable outer sheath shall be capable of withstanding such exposure continuously without any detrimental effect.

2.1.2 Cable Construction

For further details on the cable construction, reference shall be made to the following drawings of this specification:

- DWG/OES2/UG-CC (Type 1) A, typical cross section of Control Cable (Type 1),
- DWG/OES2/UG-CC (Type 2) A, typical cross section of Control Cable (Type 2),
- DWG/OES2/UG-CC (Type 3) A, typical cross section of Control Cable (Type 3),

2.1.2.1 Conductor

The conductors shall be stranded cooper wires in accordance with BS 6380 and IEC 60228 having a cross section of 2.5mm².

2.1.2.2 Insulation

The insulation material shall be cross linked polyethylene (XLPE) with a minimum thickness of 0.7mm. The applicable standard is BS 7655.



2.1.2.3 Binder / Screen

The assembled cores shall be wrapped with layers of polyester tape over which cooper tapes are wrapped to form a screen with a cross-section of 2.5mm^2 . a thickness to a nominal thickness of 1mm of bedding.

2.1.2.4 Bedding / Armour

The bedding over the screen shall be of Low Smoke Zero Halogen Compound with a nominal thickness of 1mm.

Control Cable Type 1 – No armour.

Control Cable Type 2 - The armouring shall consist of galvanised steel wire with dia. of 1.25 or 1.0mm.

Control Cable Type 3 - The armouring shall consist of galvanised steel tape .

2.1.2.5 Outer Sheath

The outer sheath shall consist of **Low Smoke Zero Halogen Compound** – LSZH – having a nominal thickness of 1.8mm. The applicable standards are IEC 60332-1 and BS 7655.

A distinctive marking, including the following details, shall be embossed continually along with the whole outer covering:

- Manufacturer's name and/or trade mark
- Year of manufacture
- Control cable
- Number/size of cores
- Marks one meter apart showing the cable length
- PROPERTY OF (*) – Oman.

The control cable construction details and the outer covering shall meet requirements as specified and shall be suitably prepared against cracking and decomposition under the prevailing service conditions at site.

The outer covering shall be free from chlorinated paraffins and resistant to sulfides found in the ground.



2.2 Cable Installation

Control cables directly buried underground shall be armoured, either by means of galvanised steel wires or galvanised steel tape.

For installations shall be installed All appropriate cable racks, pipes, supporting structures, cable terminals, ferrules, and auxiliary equipment as necessary for proper installation, connection and operation shall be suitably and sufficiently provided such as not to affect the control cable capability.

Control/Signal Cables shall be copper screened/shielded to protect internal conductors of the control cable against interference, which can be coupled capacitively and inductively or galvanically. The copper screen/shield must be earthed on both sides. The connection between the sub-system to be connected with the screened/shielded cable shall have a lower resistance than the screen/shield circuit to prevent interference from bonding currents on the screen/shield.

Copper tape screened/shielded and galvanised steel wire armoured Control/Signal Cables shall be used for directly buried applications or for installations in trenches between substation buildings where control cables are installed by pulling machines.

Inside substation buildings copper tape screened/shielded control/signal cables without armouring might be applied.

The cables shall be jointed by Heat Shrink, Cold Shrink or Hybrid joints.

3. TESTING AND INSPECTION

3.1 General

The Control/Signal Cables shall be tested in the Manufacturer's work place as well as at site upon completion of installation.

The required tests (type, sample & routine) are to be carried out as stated in this Specification under the witness of the EMPLOYER and/or its representatives.

The test of Control/Signal Cables shall include the factory and site test.

3.2 Factory Tests

3.2.1 Type Tests

Evidence shall be given to prove that the proposed Control/Signal Cables under this specification, has been subjected to all the type tests at an internationally recognised testing station. The EMPLOYER will decide whether additional tests are necessary to be performed by the manufacturer if deemed necessary.

An internationally recognised laboratory shall certify the type test reports.



The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed Control/Signal Cables.

Type test certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to the EMPLOYER.
2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the EMPLOYER.
3. If the presented type test reports are not in accordance with the above requirements, the EMPLOYER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the EMPLOYER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

Type Tests shall be performed comprising as a minimum the following tests:

- a) Fire Resistant according to IEC 60331, BS 6387
- b) Flame Retardant according to IEC 60332-3 Cat C
- c) Low Smoke Test according to IEC 61034
- d) Halogen Content Test according IEC 60754
- e) Mechanical/Material Characteristics:
 - Elongation of the conductor at break
 - The tensile strength of the conductor
 - The tensile strength and elongation of the conductor insulation
 - Elongation after ageing 100 ± 2 °C/240 h (conductor insulation)
 - Shrinkage of conductor insulation after 100 ± 2 °C/1 h
 - Weight increase in conductor insulation
 - Tensile strength and elongation of inner sheath
 - Elongation after ageing 100 ± 2 °C/240 h (inner sheath)
 - Tensile strength and elongation of outer sheath
 - Elongation after ageing 100 ± 2 °C/336 h (outer sheath)
 - Carbon black content for inner and outer sheaths
 - Environmental stress cracking



- Zinc weight of the armouring
- Dipping test of armouring.

Type tests may be waived if satisfactory type test certificates are submitted before signing a procurement contract.

f) Electrical Characteristics

- High-Voltage test between any conductor and all remaining cores and screen/armour connected to ground
- High-Voltage test on outer sheath.

3.2.2 Sample Tests

Sample Tests shall be performed, comprising as a minimum the following tests:

- Cable construction and measurements of dimensions
- Sheath marking as per this specification.

3.2.3 Routine Tests

The routine tests shall be carried out in the factory for each type of Control Cable.

The Bidder/Contractor is required to carry out routine tests on all finished cable drum lengths to demonstrate the integrity of the Control/Signal Cables.

Routine Tests shall comprise as a minimum the following tests:

- Conductor resistance measurement
- Insulation resistance measurement
- High Voltage test (2 kV AC / 1 min. between any control conductor and conductors and screens/armour connected to ground).

3.3 Site Tests

Site Tests shall be performed, comprising as a minimum the following tests:

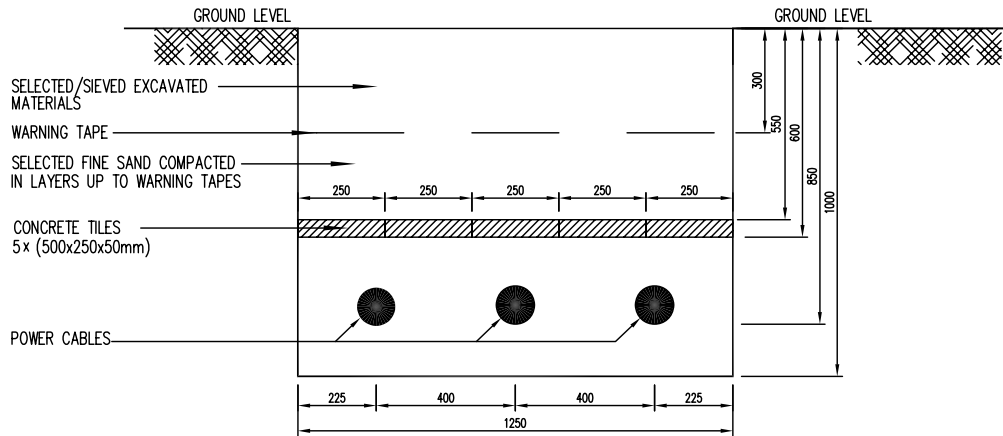
- Cores identification,
- Conductor resistance measurement,
- Insulation resistance measurement,
- High voltage test (2 kV AC / 1 min between conductors and all remaining conductors and screens/armour connected to ground),

and loop tests when installation of the cables has been completed.

OES 2 - 3rd EDITION, DRAWINGS - Rev.0-2010

02_cables

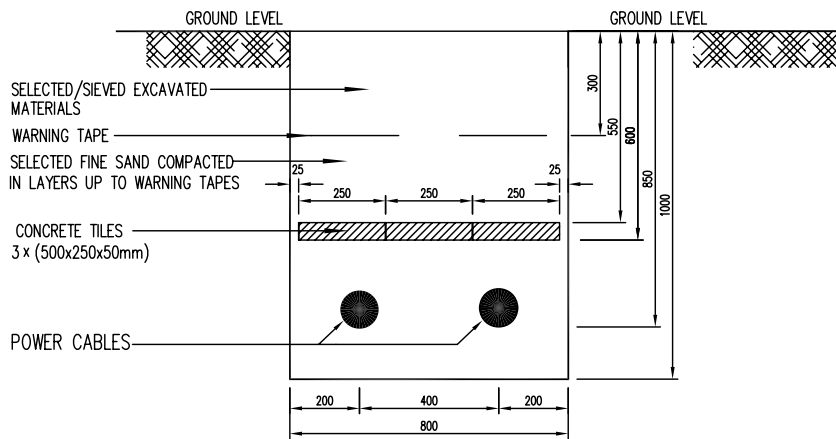
Drawing No.		Title
Former DWG No.	New 3rd EDITION DWG No. Rev.	
MEW/E/U.G./0101	DWG/OES2/UG3/0101	B Typical Sections of LV Cable Trenches
MEW/E/U.G./0102	DWG/OES2/UG2/0102	B Typical 11 kV Cable Trench Sections
MEW/E/U.G./0103	DWG/OES2/UG1/0103	C Typical Sections of 33kV Cable Trench
MEW/E/U.G./0104	DWG/OES2/UG/0104	- Details of Joint/Route Markers for Power Cables
MEW/E/U.G./0105	DWG/OES2/UG/0105	- Details of Cable Markers for Side Walks
MEW/E/U.G./0106	DWG/OES2/UG/0106	- Detail of Road Crossing Ducts for 33kV Cable & Pilot Cable
MEW/E/U.G./0107	DWG/OES2/UG/0107	- Detail of Road Crossing Duct for 11kV Cable
MEW/E/U.G./0108	DWG/OES2/UG/0108	- Detail of Road Crossing Duct for L.V. Cable
MEW/E/U.G./0109	DWG/OES2/UG/0109	- Details of Cable Covering Tiles
MEW/E/U.G./0110	DWG/OES2/UG/0110	- Format for Under Ground Power Cable Record
MEW/E/U.G./0111	DWG/OES2/UG/0111	-
MEW/E/U.G./0112	DWG/OES2/UG/0112	- Cable Trench Details for Different Voltage Cables Laid Parallel
MEW/E/U.G./0113	DWG/OES2/UG/0113	- Details of Power Cables Laid Parallel to Water Pipe Line
MEW/E/U.G./0114	DWG/OES2/UG/0114	- Details of Cable Crossing by Water Pipe Line
MEW/E/U.G./0115	DWG/OES2/UG/0115	- Details of Cable Crossing by Telephone Cables
-	DWG/OES2/UG/0116	- Concrete Cable Cover Tiles
-	DWG/OES2/UG1-3C	A Typical Cross Section of 33kV XLPE 3-Core Underground Cable
-	DWG/OES2/UG1-SC	A Typical Cross Section of 33kV XLPE Single-Core Underground Cable
-	DWG/OES2/UG2-3C	A Typical Cross Section of 11kV XLPE 3-core Underground Cable
-	DWG/OES2/UG2-SC	A Typical Cross Section of 11kV XLPE Single-Core Underground Cable
-	DWG/OES2/UG3-SC	A Typical Cross Section of LV XLPE Single-Core Underground Cable
-	DWG/OES2/UG3-4C/1	A Typical Cross Section of LV XLPE Four Core Underground Cable
-	DWG/OES2/UG3-4C/2	A Typical Cross Section of LV XLPE Four Core Underground Cable - 4x4, 4x10, 4x25mm ²
-	DWG/OES2/UG3-4C/3	A Typical Cross Section of LV XLPE Four Core Underground Cable - 4x25, 4x35, 4x50, 4x70, 4x95, 4x120, 4x185, 4x240mm ²
-	DWG/OES2/UG3-2C/1	A Typical Cross Section of LV XLPE Two Core Underground Cable - 2x50, 2x120mm ²
-	DWG/OES2/UG3-2C/2	A Typical Cross Section of LV XLPE Two Core Underground Cable - 2x6, 2x10, 2x16mm ²
-	DWG/OES2/UG4-1	A Typical Cross Section of Protection/Telephone (PILOT) Underground Cable, Tape Armour
-	DWG/OES2/UG4-2	A Typical Cross Section of Protection/Telephone (PILOT) Underground Cable, Wire Armour
-	DWG/OES2/UG5	A Typical Cross Section of Fiber Optical Cable - Underground
-	DWG/OES2/UG7-1	A Typical Cross Section of Control (Type 2), 19x2.5, 27x2.5mm ² - Wire Armour
-	DWG/OES2/UG7-2	A Typical Cross Section of Control (Type 1), 7x2.5, 12x2.5, 19x2.5, 27x2.5mm ² - No Armour
-	DWG/OES2/UG7-3	A Typical Cross Section of Control (Type 3), 7x2.5, 12x2.5, 19x2.5, 27x2.5mm ² - Tape Armour



TYPICAL SECTION OF TRENCH

(FOR THREE CABLES)

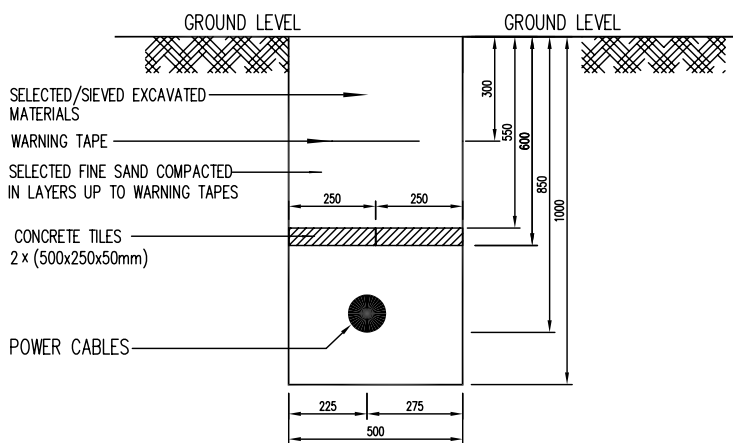
(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)



TYPICAL SECTION OF TRENCH

(FOR TWO CABLE)

(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)



TYPICAL SECTION OF TRENCH

(FOR ONE CABLE)

(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)

NOTES :
1.0 ALL DIMENSIONS IN mm

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	

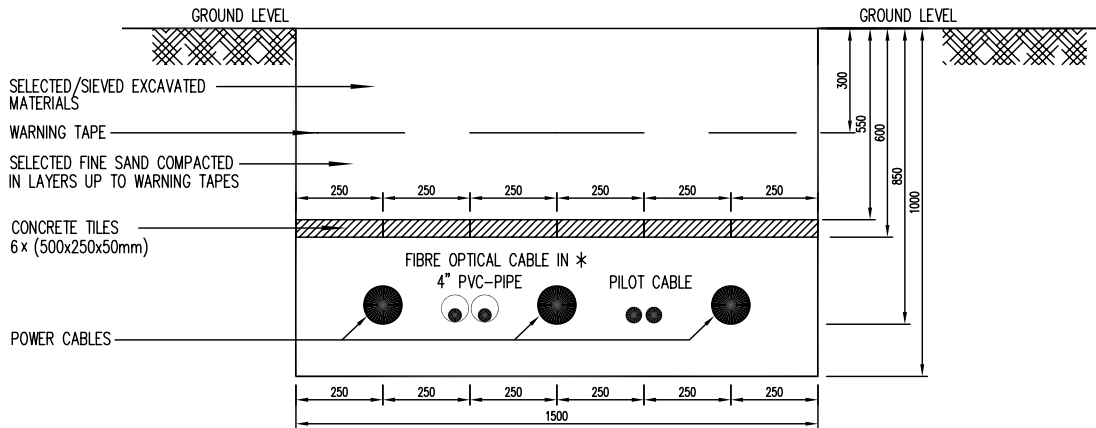
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE
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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG NO:		

**TYPICAL 11KV CABLE
TRENCH SECTIONS**

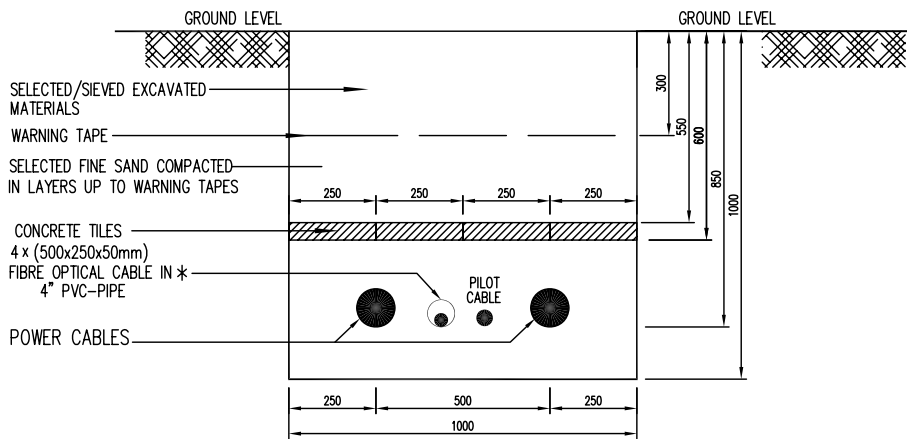
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TYPICAL SECTION OF TRENCH

(FOR THREE CABLES)

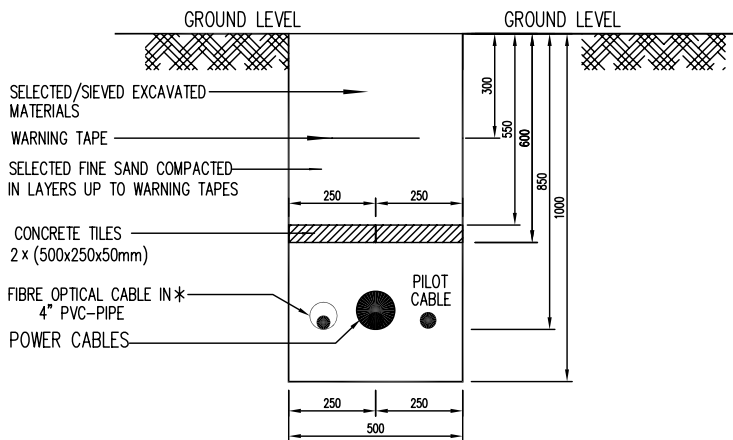
(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)



TYPICAL SECTION OF TRENCH

(FOR TWO CABLE)

(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)



TYPICAL SECTION OF TRENCH

(FOR ONE CABLE)

(SLOPE OF TRENCH SIDES WILL DEPEND ON GROUND / SOIL CONDITIONS)

* ALTERNATIVELY PE-HD PIPING DN90-SDR=17.6

NOTES :
1.0 ALL DIMENSIONS IN mm

REVISIONS	NAME	DATE	NOTE
B	GEWHS	03.2009	PE-HD PIPING ADDED
A	Buckow	03.2009	ORIGINAL ISSUE



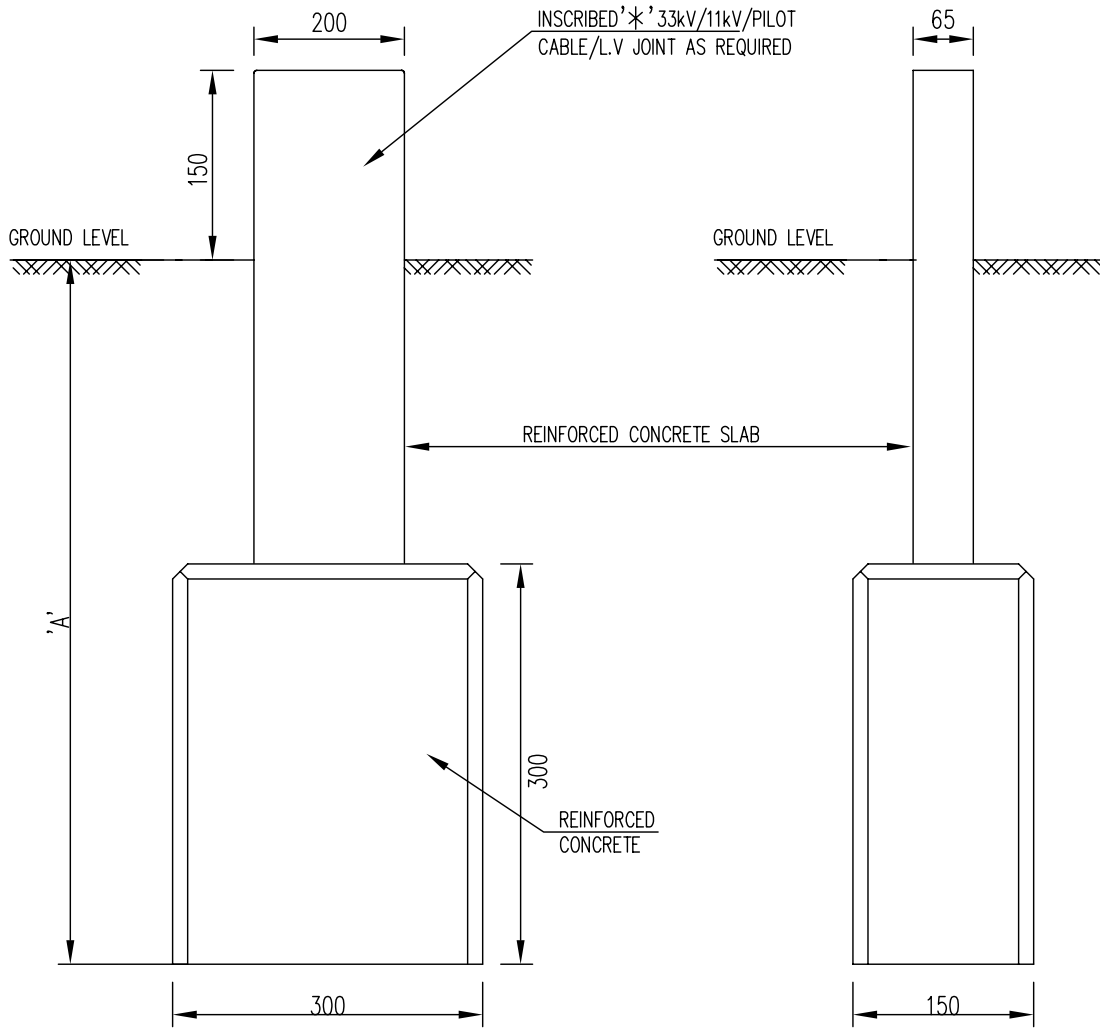
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OMAN ELECTRICAL STANDARDS

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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG NO:		

TYPICAL SECTIONS OF 33kV CABLE TRENCH

CAD-FILE	SCALE N.T.S	DRWG NO: DWG OES2/UG1/0103 C
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ALL DIMENSIONS IN MM

'A' 33kV 600

'A' 11kV 400

'A' LV 300

'*' NAME OF LICENSEE

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



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OMAN ELECTRICAL STANDARDS

	NAME	DATE
PREPARED	Buckow	03.2009
DRAWN	Saji	03.2009
CHECKED	GE'WHS	03.2009
APPROVED	AER-TD	03.2009

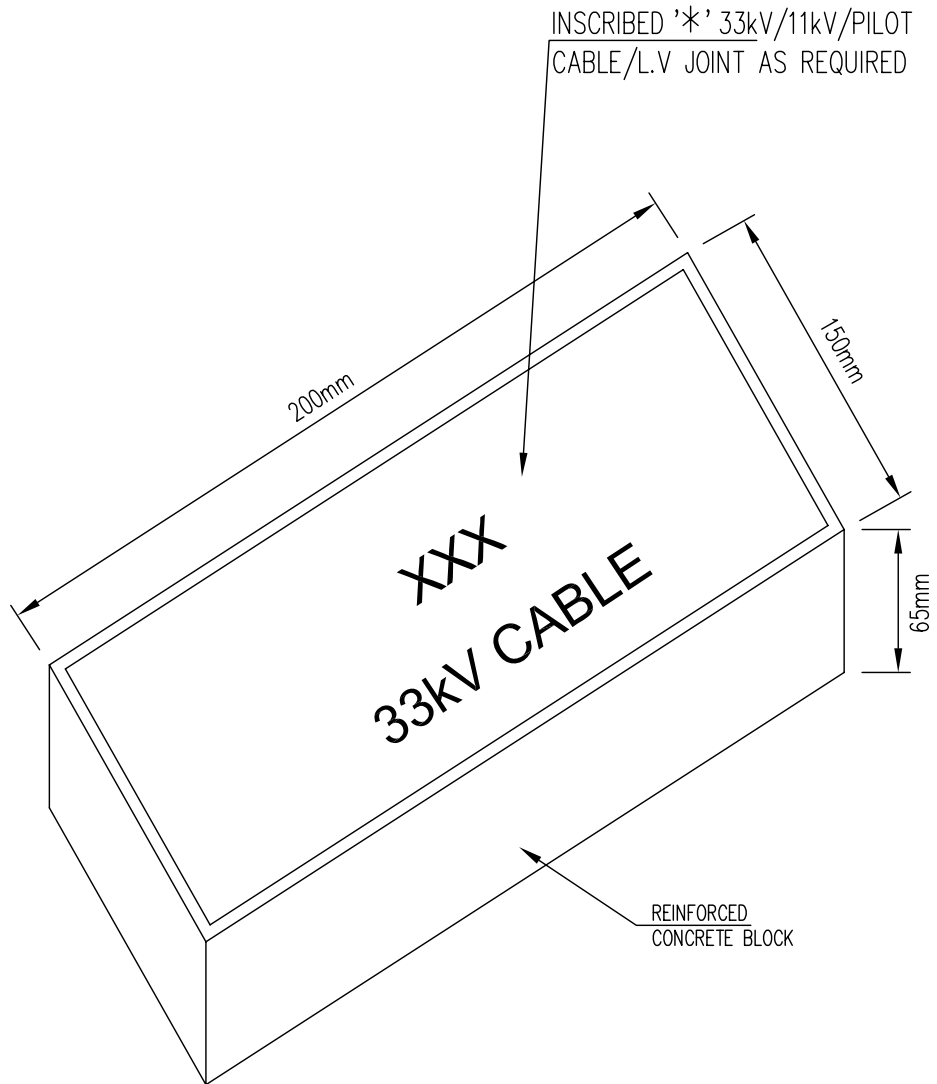
DETAILS OF JOINT/ROUTE
MARKERS FOR POWER CABLES

SUPERSEDED BY DRWG. NO.:

CAD-FILE

SCALE
N.T.S

DRWG. NO.
DWG/OES2/UG/0104



ALL DIMENSIONS IN MM

'*' = NAME OF LICENSEE

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



SULTANATE OF OMAN

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	NAME	DATE
PREPARED	Buckow	03.2009
DRAWN	Saji	03.2009
CHECKED	GE'WHS	03.2009
APPROVED	AER-TD	03.2009

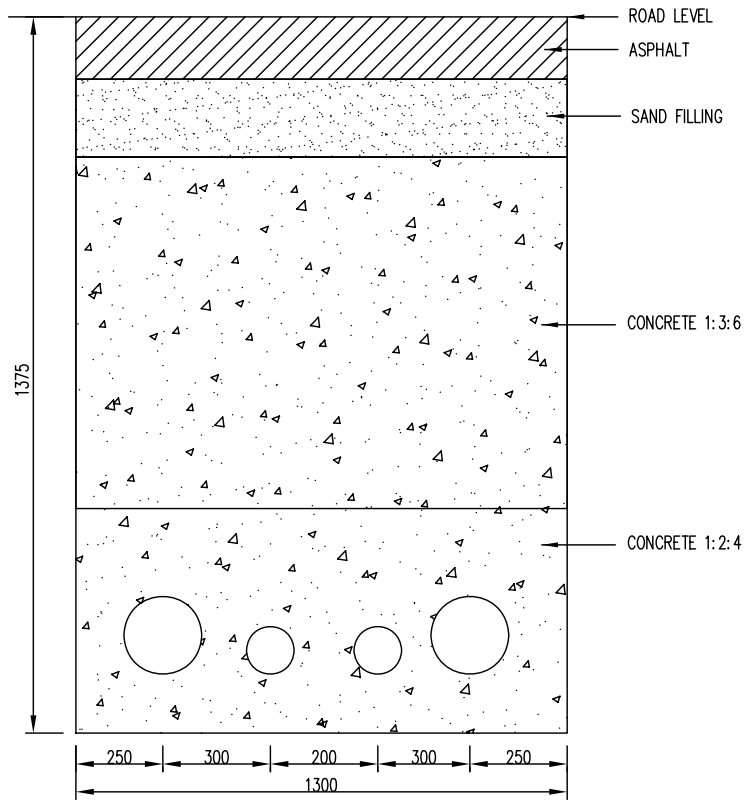
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SUPERSEDED BY DRWG. NO.:

**DETAILS OF CABLE MARKERS
FOR SIDE WALKS**

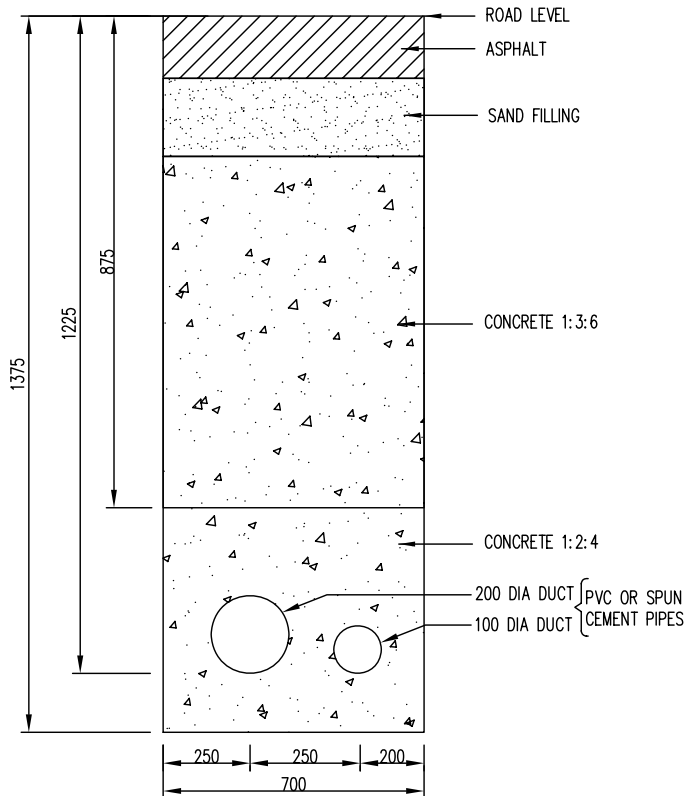
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SCALE
N.T.S

DRWG. NO:
DWG/OES2/UG/0105



DETAILS FOR TWO CABLES



NOTES:

1. ALL DIMENSIONS IN MM
2. A MINIMUM OF ONE SET OF SPARE DUCTS SHALL BE PROVIDED

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



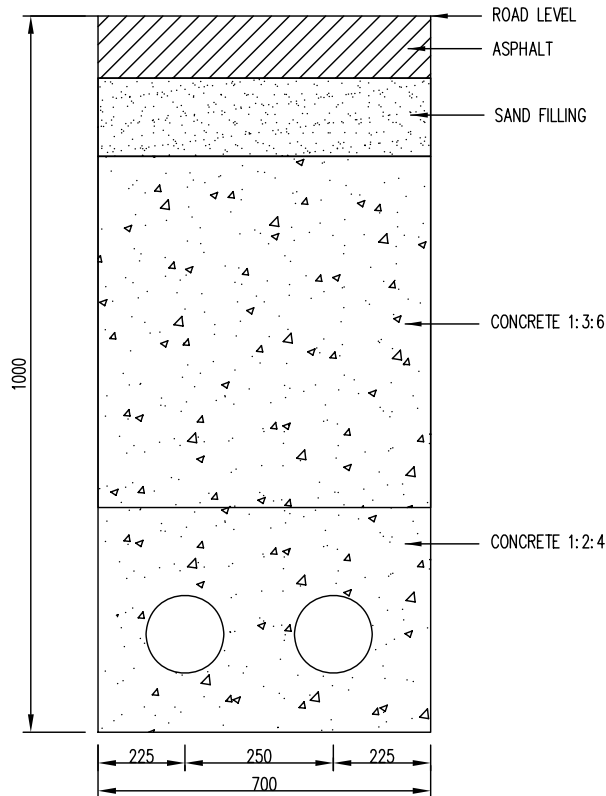
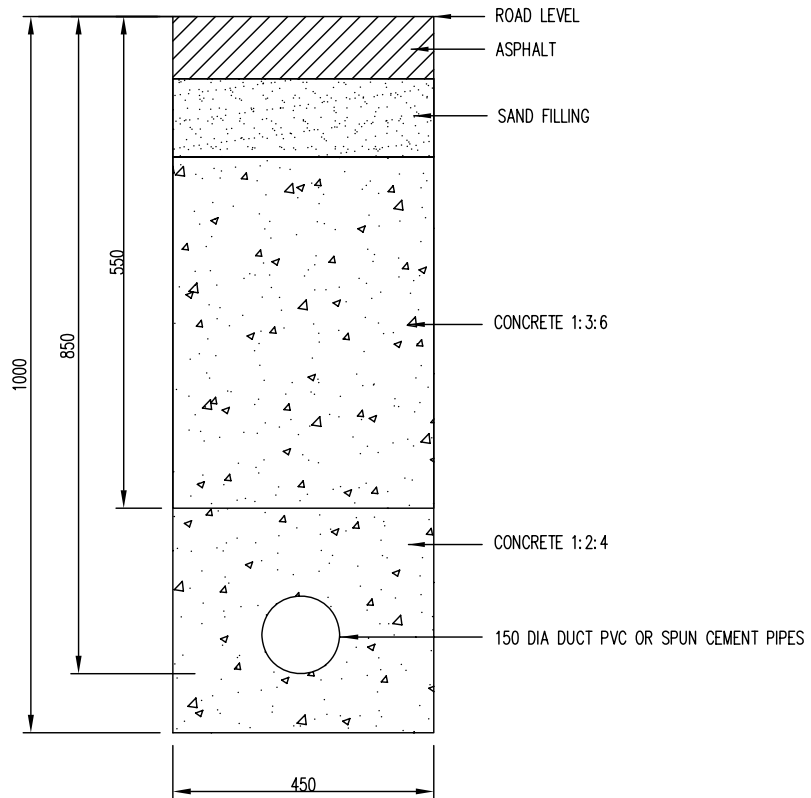
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

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PREPARED	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DN A4	

DETAIL OF ROAD CROSSING
DUCTS FOR 33kV CABLE &
PILOT CABLE

SUPERSEDED BY DRWG. NO:	SCALE N.T.S	DRWG. NO: DWG/OES2/UG/0106
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DETAILS FOR TWO CABLES

NOTES:

1. ALL DIMENSIONS IN MM
2. A MINIMUM OF TWO SPARE DUCTS SHALL BE PROVIDED

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



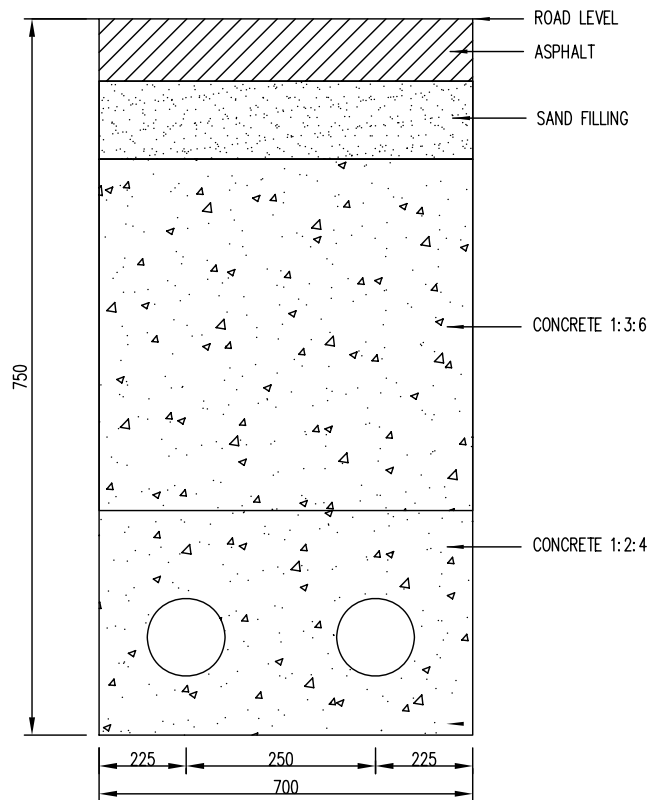
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

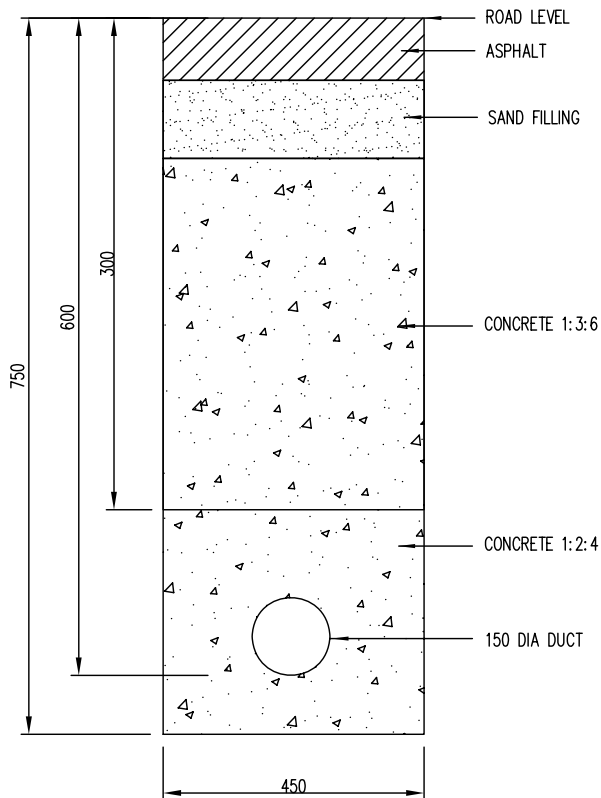
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PREPARED	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DIN A4	

DETAIL OF ROAD CROSSING DUCT FOR 11KV CABLE

SUPERSEDED BY DRWG. NO:	SCALE N.T.S	DRWG. NO: DWG/OES2/UG/0107
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DETAILS FOR TWO CABLES



NOTES:

1. ALL DIMENSIONS IN MM
2. A MINIMUM OF TWO SPARE DUCTS SHALL BE PROVIDED

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



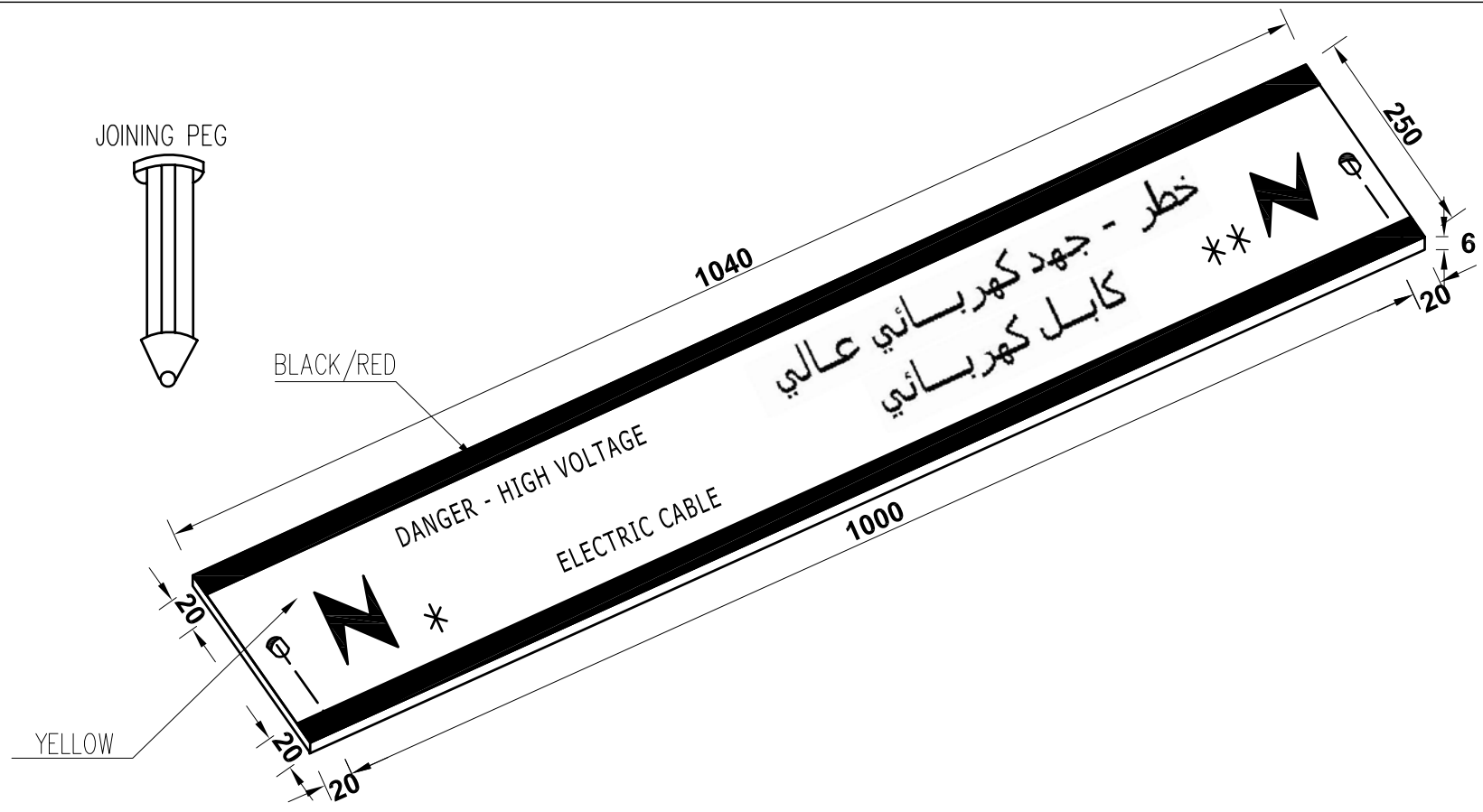
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OMAN ELECTRICAL STANDARDS

NAME	DATE
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DRAWN: Sajj	03.2009
CHECKED: GEWHS	03.2009
APPROVED: AER-TD	03.2009
SHEET SIZE: DIN A4	
SUPERSEDED BY DRWG. NO.:	

DETAIL OF ROAD CROSSING DUCT FOR L.V. CABLE

CAD-FILE	SCALE: N.T.S	DRWG. NO.: DWG/OES2/UG/0108
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* NAME OF LICENSEE * اسم المرخص له *

NOTES:

1. ALL DIMENSIONS IN MM
2. MATERIAL POLYETHYLENE OR RECYCLED POLYETHYLENE
3. ONE JOINING PEG PER TILE WILL BE FITTED ON ONE SIDE

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



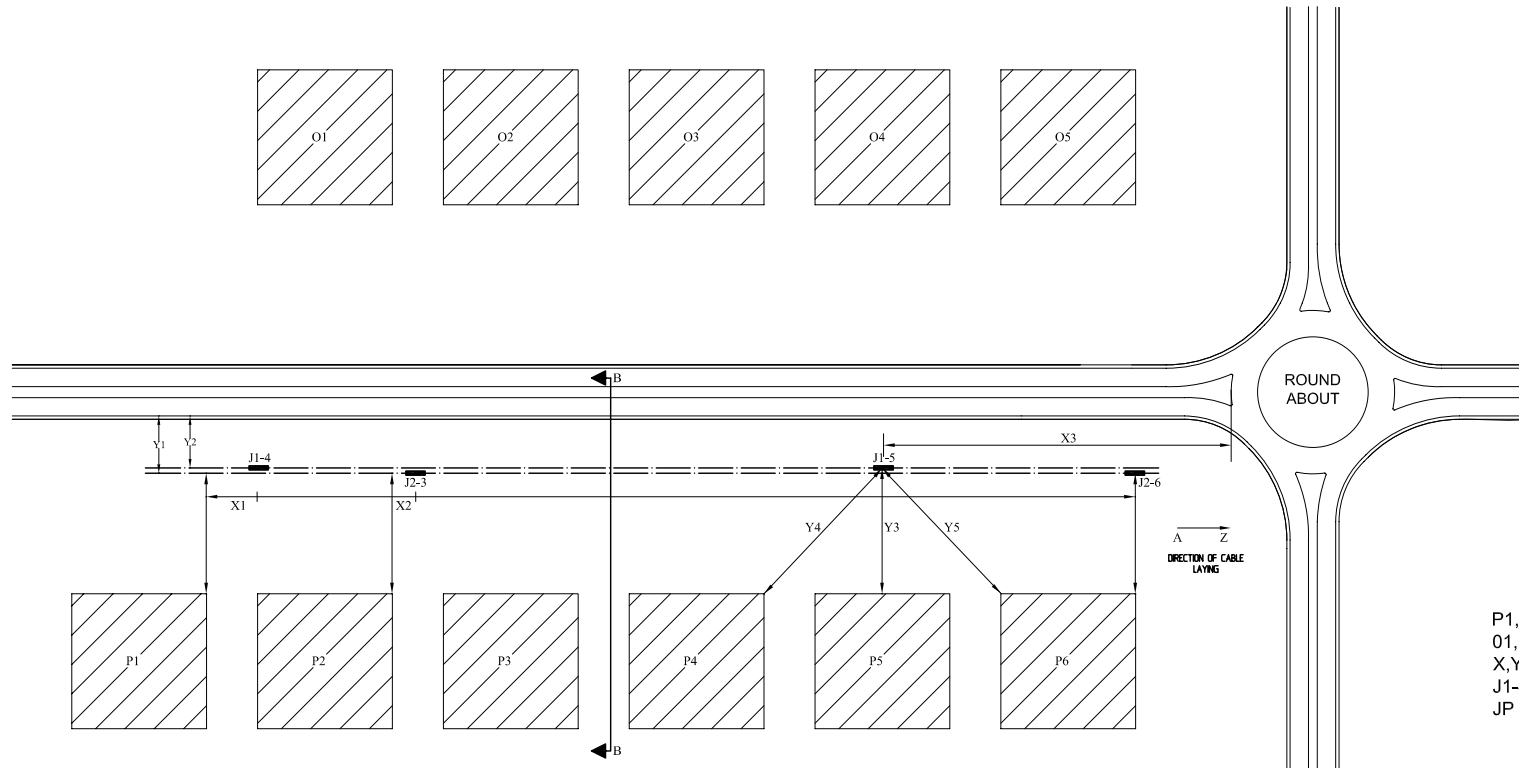
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE
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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
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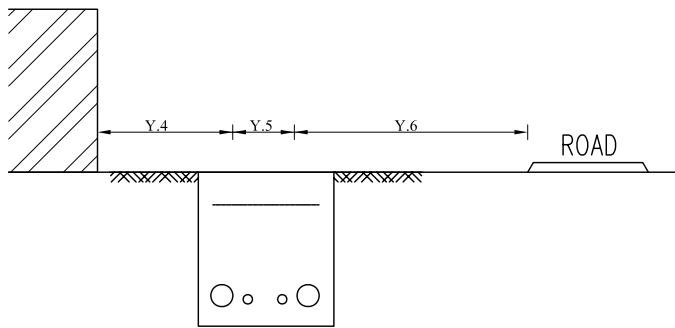
DETAILS OF CABLE COVERING TILES

CAD-FILE	SCALE N.T.S	DRWG. NO. DWG/OES2/UG/0109
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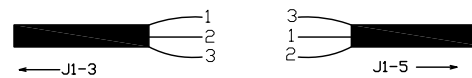
KEY TO DRAWING

- P1,P2 PERMANENT STRUCTURE
- O1,O2 PERMANENT STRUCTURE
- X,Y OFFSETS/DISTANCES IN METERS
- J1-4,J2-3 POWER CABLE JOINTS
- JP PILOT CABLE JOINTS



SECTION B-B

DETAILS OF J1-4



MAKE:
 JOINTER :
 DATE :
 WEATHER :
 SIMILAR DETAILS FOR J1-5 J2-3 ETC

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE
PREPARED	Buckow	03.2009
DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.:		

**FORMAT FOR UNDER GROUND
POWER CABLE RECORD**

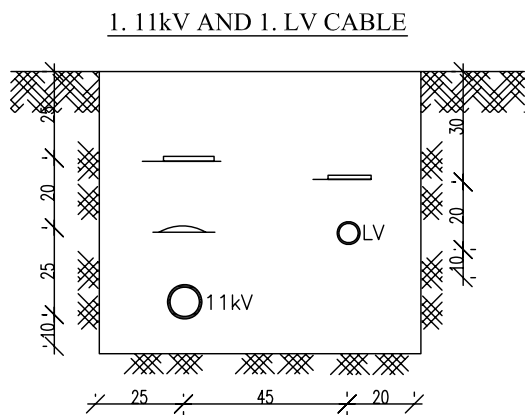
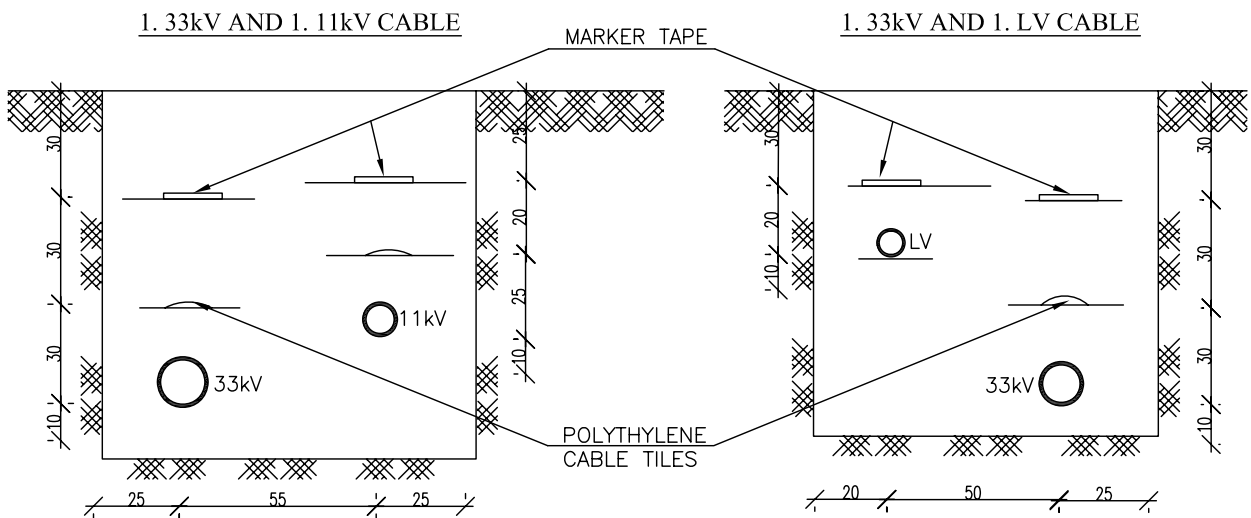
CAD-FILE

SCALE

N.T.S

DRWG. NO.:

DWG/OES2/UG/0110



DEFFERENT VOLTAGE
CABLE SPACING CHART

	LV	11kV	33kV
LV	40cm	45cm	50cm
11kV	45cm	50cm	55cm
33kV	50cm	55cm	60cm

NOTES :
1.0 ALL DIMENSIONS IN mm

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



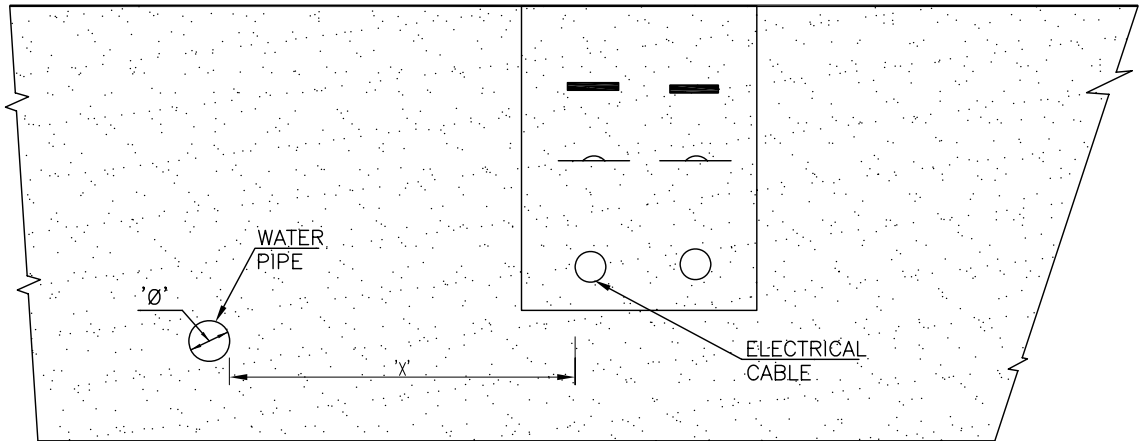
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE
PREPARED	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO:		


CABLE TRENCH DETAILS FOR
DIFFERENT VOLTAGE CABLES
LAID PARALLEL

CAD-FILE	SCALE N.T.S	DRWG. NO: DWG/OES2/UG/0112
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'Ø' DIA OF WATER PIPE	DISTANCE 'X' IN M.M	
	UPTO 33kV	132kV
in mm	in mm	in mm
LESS THAN 100	1000	2000
100 TO 300	1500	2000
300 TO 600	2000	3000
ABOVE 600	3000	3000

REVISIONS	NAME	DATE	NOTE
		Buckow	03.2009



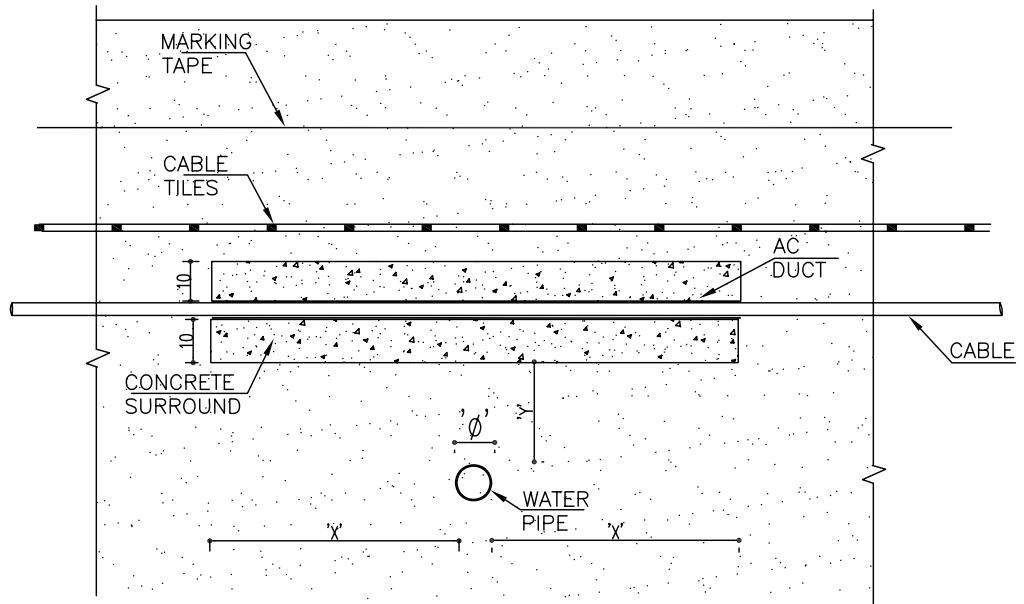
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

NAME	DATE
PREPARED: Buckow	03.2009
DRAWN: Sajj	03.2009
CHECKED: GEWHS	03.2009
APPROVED: AER-TD	03.2009
SHEET SIZE: DIN A4	
SUPERSEDED BY DRWG. NO:	

**DETAILS OF CABLES LAID
PARALLEL TO WATER PIPE LINE**

CAD-FILE	SCALE: N.T.S	DRWG. NO: DWG/OES2/UG/0113
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SL No	'Ø' OF WATER PIPE	'Y' IN MM	'X' IN MM
1	UPTO 600mm	500	2000
2	ABOVE 600mm		3000

NOTES :
1.0 ALL DIMENSIONS IN mm

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



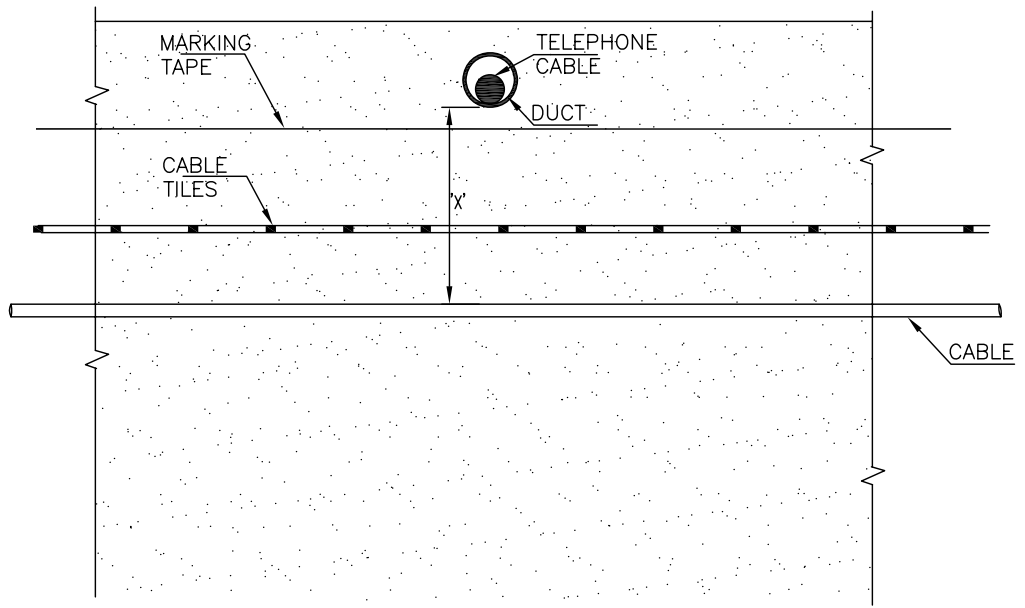
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE
PREPARED	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DN A4	

DETAILS OF CABLE CROSSING
BY WATER PIPE LINE

SUPERSEDED BY DRWG NO:	SCALE N.T.S	DRWG. NO: DWG/OES2/UG/0114
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SL No	SIZE OF CABLE	'X' IN MM	DUCT BOTH SIDES IN MM
1	L.T.	300	1000
2	11kV	400	1000
3	33kV	500	1000

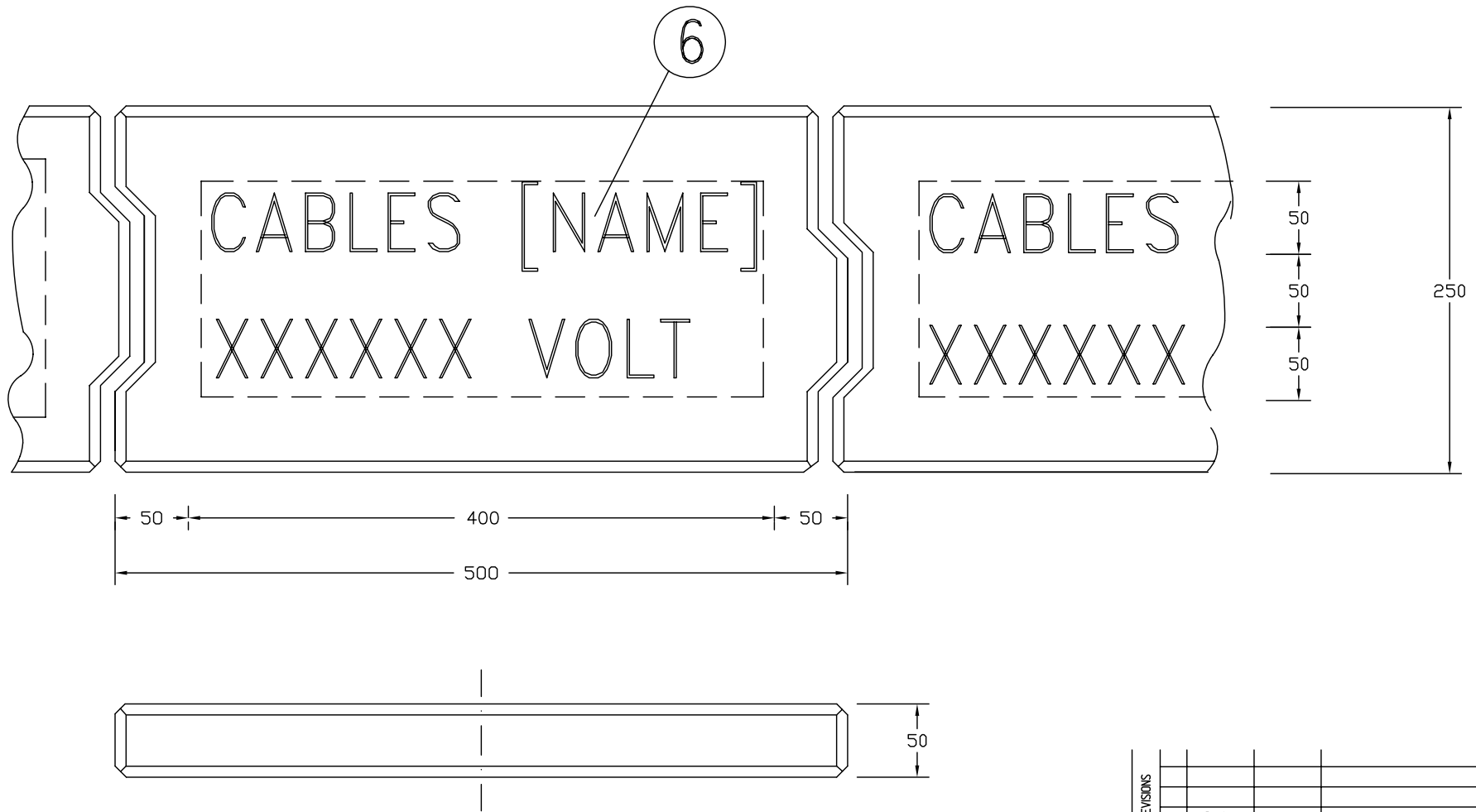
NOTES :
1.0 ALL DIMENSIONS IN mm

REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



OMAN ELECTRICAL STANDARDS


PREPARED	Buckow	03.2009	DETAILS OF CABLE CROSSING BY TELEPHONE CABLES
DRAWN	Sajj	03.2009	
CHECKED	GEWHS	03.2009	
APPROVED	AER-TD	03.2009	
SHEET SIZE	DN A4		
SUPERSEDED BY DRWG NO:			
CAD-FILE	SCALE	N.T.S	DRWG. NO: DWG/OES2/UG/0115



NOTES :

1. ALL DIMENSIONS IN MM
2. CONCRETE GRADE C35
3. CEMENT TYPE V (SRC); MIN. 370 kg³/m
4. HYDRULICALLY PRESSED
5. ALL EDGES TO BE CHAMFERED
6. APPLICABLE NAME OF LICENSEE

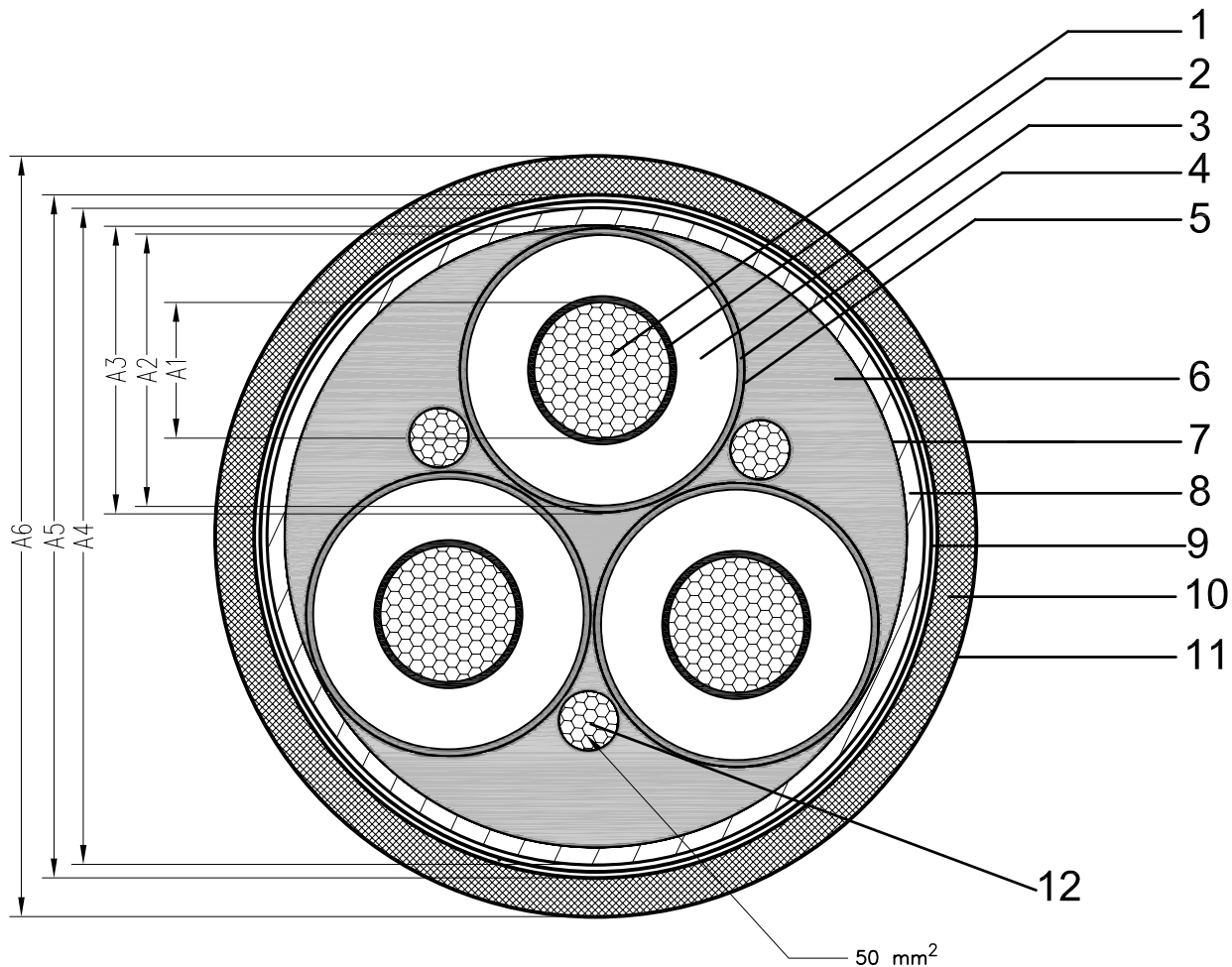
REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

	NAME	DATE	CONCRETE CABLE COVER TILES
PREPARED	Buckow	03.2009	
DRAWN	Saji	03.2009	
CHECKED	GEWHS	03.2009	
APPROVED	AER-TD		
SHEET SIZE			DIN A4
SUPERSEDED BY DRWG. NO.:			
CAD-FILE		SCALE	DRWG. NO.:
		N.T.S	DWG OES2/UG/0116-A



CONSTRUCTION DATA

No.	Description	Material	Standard
1	Conductor	Copper, water tight **	IEC 60228
2	Conductor screen	Semi conducting	
3	Insulation	XLPE, Tree-retardant	IEC 60502
4	Insulation screen	Semi conducting	
5	Metallic layer	Copper tape *2	
6	Fillers	Polypropylene yarn	
7	Binder tape	Polyester	
8	Inner sheath	PE-ST7, black	IEC 60502-2
9	Armour	Galvanized steel tape	
10	Outer sheath	PE-ST7, black	IEC 60502-2
11	Conductive layer	Semi conducting	
12	Interstitial Conductor	Copper *1	IEC 60228

Tests: IEC 60502

S.E.:

GIS – Plug-in

Outd. – Heat Shrink
Cold Shrink

Joint: Heat Shrink
Cold Shrink
Hybrid

DIMENSIONS


No.	Details		
	Conductor cross section, mm ²	3x240	3x300
	Interstitial cross section, mm ²	50	50
A1	Approximate diameter of conductor, mm		
A2	Approximate diameter over core insulation, mm		
A3	Approximate diameter over core metallic layer, mm		
A4	Approximate diameter over inner sheath, mm		
A5	Approximate diameter over armour, mm		
A6	Approximate overall diameter, mm		
t1	Minimum thickness of conductor screen, mm	0.8	0.8
t2	Min./Max. thickness of core insulation, mm	8.0/8.7	8.0/8.7
t3	Minimum thickness of core insulation screen, mm	0.8	0.8
t4	Nominal thickness of core metallic layer, mm	0.075	0.075
t5	Nominal thickness of inner sheath, mm	2.3	2.3
t6	Nominal thickness of armour tapes, mm	2x0.8	2x0.8
t7	Nominal thickness of outer sheath, mm	4.2	4.2

Cable Drum Length, m	xxxxx
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(*1 + *2)x3 = 31.5kA , 0.5 Sec. (150 mm²)

** Water swelling tape around each layer of conductor wires

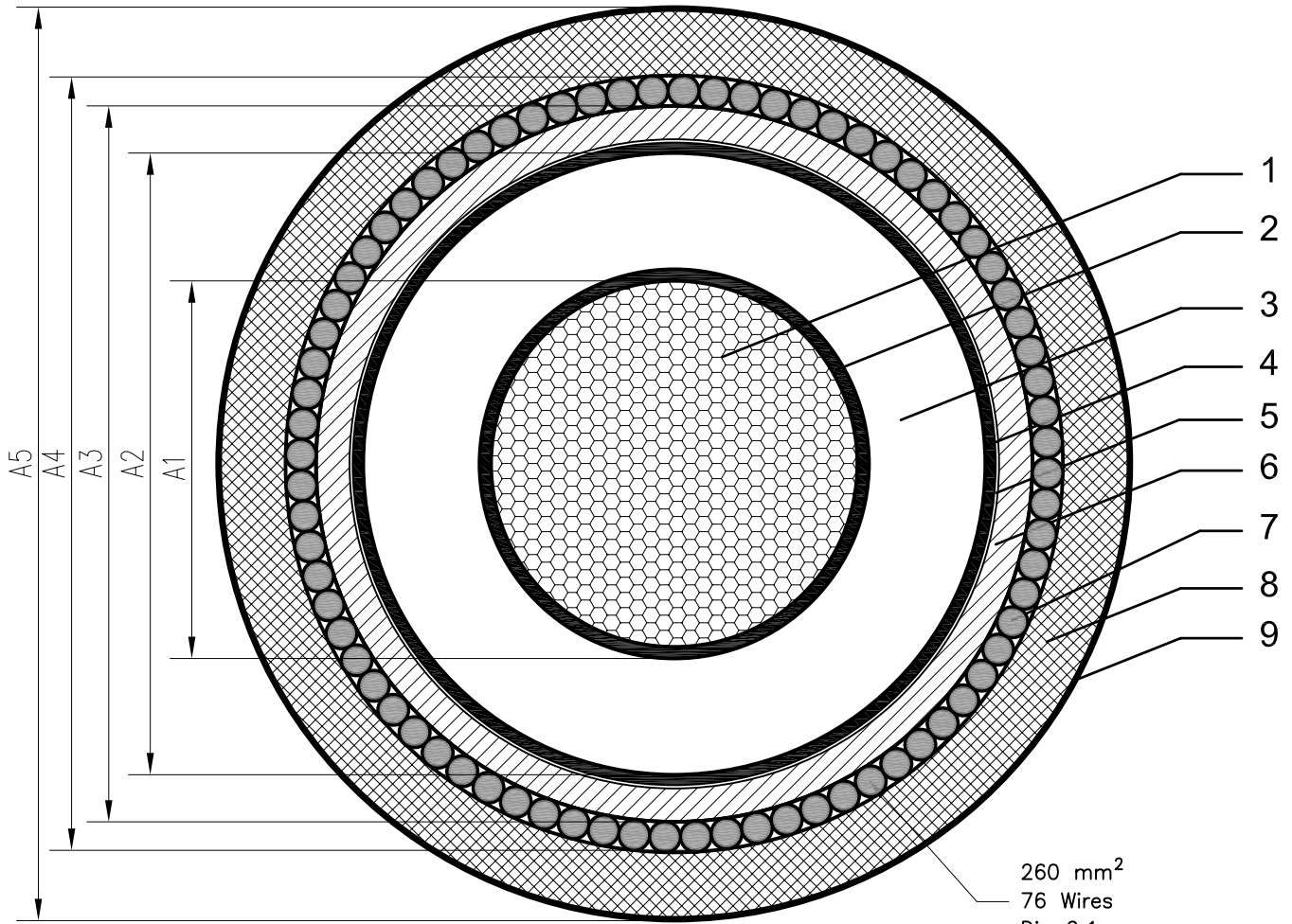
REVISIONS			NAME	DATE	NOTE
	Buckow	03.2009			ORIGINAL ISSUE



SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009	Typical Cross Section of 33kV XLPE 3-Core Underground Cable
DRAWN	Saji	03.2009	
CHECKED	GEWHS	03.2009	
APPROVED	AER-TD	03.2009	
SHEET SIZE	DIN A4		
SUPERSEDED BY DRWG NO.:			
CAD-FILE		SCALE	DRWG NO.:
		N.T.S	DWG OES2/UG1-3C-A



260 mm²
76 Wires
Dia 2.1 mm

CONSTRUCTION DATA

No.	Description	Material	Standard
1	Conductor	Copper, water tight **	IEC 60228
2	Conductor screen	Semi conducting	
3	Insulation	XLPE, Tree-retardant	IEC 60502
4	Insulation screen	Semi conducting	
5	Metallic layer	Copper tape	
6	Inner sheath	PE-ST7, black	IEC 60502-2
7	Armour	Aluminum wire *	
8	Outer sheath	PE-ST7, black	IEC 60502-2, 60332-1
9	Conductive layer	Semi conducting	

Tests: IEC 60502
IEC 60332-1

S.E.:

GIS - Plug-in

Outd. - Heat Shrink
Cold Shrink

Joint: Heat Shrink
Cold Shrink
Hybrid

DIMENSIONS

No.	Details	*	
	Conductor Cross Section, mm ²	500	630
A1	Approximate diameter of conductor, mm		
A2	Approximate diameter over core insulation, mm		
A3	Approximate diameter over inner sheath, mm		
A4	Approximate diameter over armour, mm		
A5	Approximate overall diameter, mm		
t1	Minimum thickness of conductor screen, mm	0.8	0.8
t2	Min./Max. thickness of core insulation, mm	8.0/8.7	8.0/8.7
t3	Minimum thickness of core insulation screen, mm	0.8	0.8
t4	Nominal thickness of metallic layer, mm	0.075	0.075
t5	Nominal thickness of inner sheath, mm	2.3	2.3
t7	Nominal diameter of armour wire, mm	2.5	2.5
t7	Nominal thickness of outer sheath, mm	4.2	4.6


Cable Drum Length, m	xxxxx
----------------------	-------

* 31.5 kA , 0.5 Sec.(260mm²)

** Water swelling tape around each layer of conductor wires

REVISIONS			
NO.	DESCRIPTION	DATE	BY

Buckow	03.2009	ORIGINAL ISSUE	NOTE
NAME	DATE		



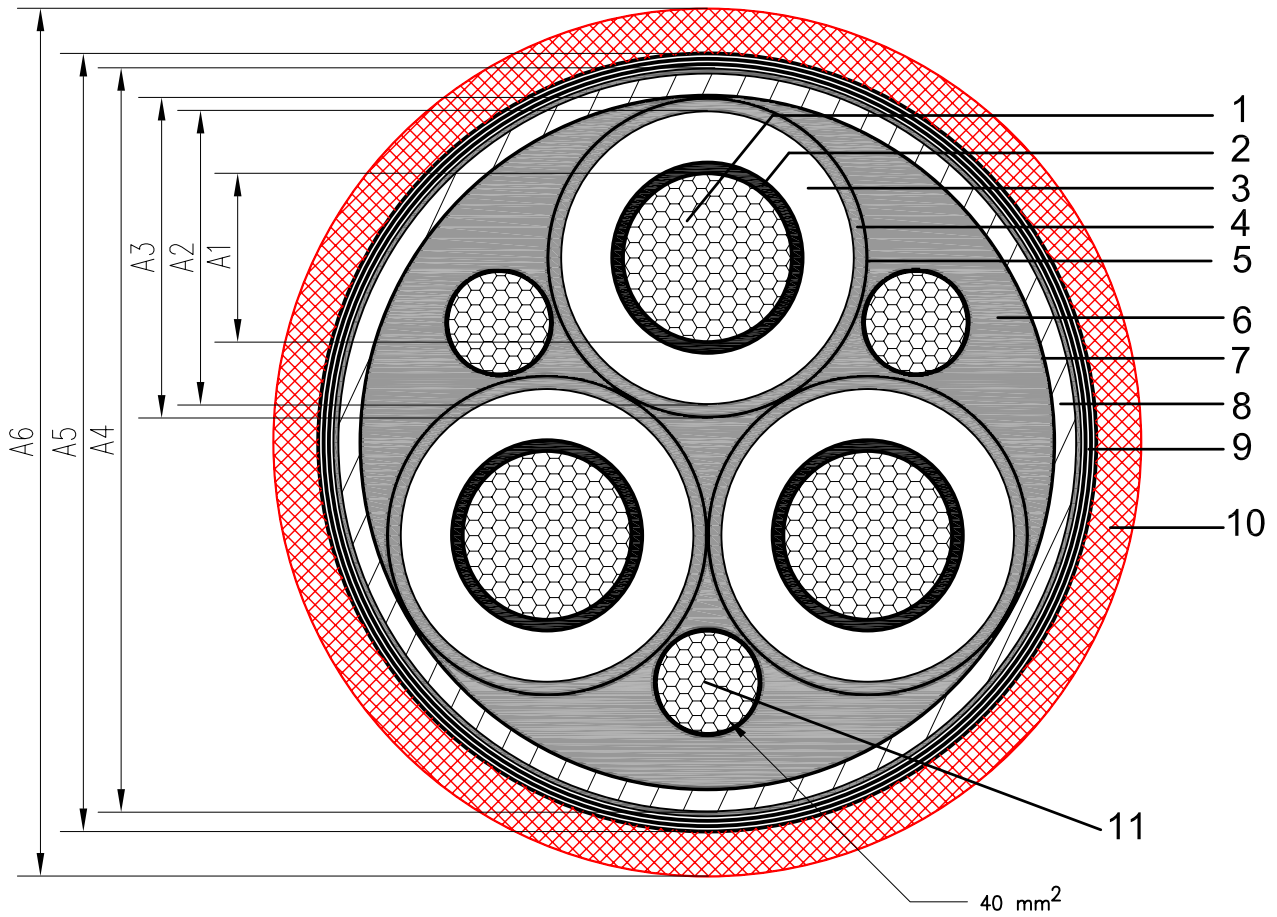
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DN A4	
SUPERSEDED BY DRWG NO.		

Typical Cross Section of 33kV
XLPE Single-Core
Underground Cable

CAD-FILE	SCALE	DRWG NO.
	N.T.S	DWG OES2/UG1-SC-A



DIMENSIONS

No.	Details	scct. conductor, 0.5 Sec.	19	25	>25	>25	>25
	Conductor ** Cross Section, mm ²		*				
	Interstitial Conductor Cross Section, mm ²		40.0	40.0	40.0	40.0	40.0
A1	Approximate diameter of conductor, mm						
A2	Approximate diameter over core insulation, mm						
A3	Approximate diameter over core metallic layer, mm						
A4	Approximate diameter over inner sheath, mm						
A5	Approximate diameter over armour, mm						
A6	Approximate overall diameter, mm						
t1	Minimum thickness of conductor screen, mm		0.7	0.7	0.7	0.7	0.7
t2	Min./Max. thickness of core insulation, mm		3.4/3.7	3.4/3.7	3.4/3.7	3.4/3.7	3.4/3.7
t3	Minimum thickness of core insulation screen, mm		0.7	0.7	0.7	0.7	0.7
t4	Nominal thickness of core metallic layer, mm		0.075	0.075	0.075	0.075	0.075
t5	Nominal thickness of inner sheath, mm		1.5	1.6	1.7	1.8	1.9
t6	Nominal thickness of armour tapes, mm		2x0.5	2x0.5	2x0.5	2x0.5	2x0.5
t7	Nominal thickness of outer sheath, mm		2.9	3.0	3.25	3.4	3.5

Tests: IEC 60332-1
IEC 60502

S.E.:

GIS – Plug-in

Outd. – Heat Shrink
Cold Shrink

Joint: Heat Shrink
Cold Shrink
Hybrid

CONSTRUCTION DATA


No.	Description	Material	Standard
1	Conductor	Copper	IEC 60228
2	Conductor screen	Semi conductive compound	
3	Insulation	XLPE, Tree-retardant	IEC 60502
4	Insulation screen	Semi conductive compound	
5	Metallic layer	Copper tape *2	
6	Fillers	Polypropylene yarn	
7	Binder tape	Polyester	
8	Inner sheath	PVC-ST2, black	IEC 60502-2
9	Armour	Galvanized steel tape	
10	Outer sheath	PVC-ST2, red	IEC 60502 IEC 60332
11	Interstitial Conductor	Copper *1	IEC 60228

Cable Drum Length, m	XXXXX
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(*1 + *2)x3 = 25kA , 0.5 Sec. (120mm²)

** Water swelling tape around each layer of conductor wires

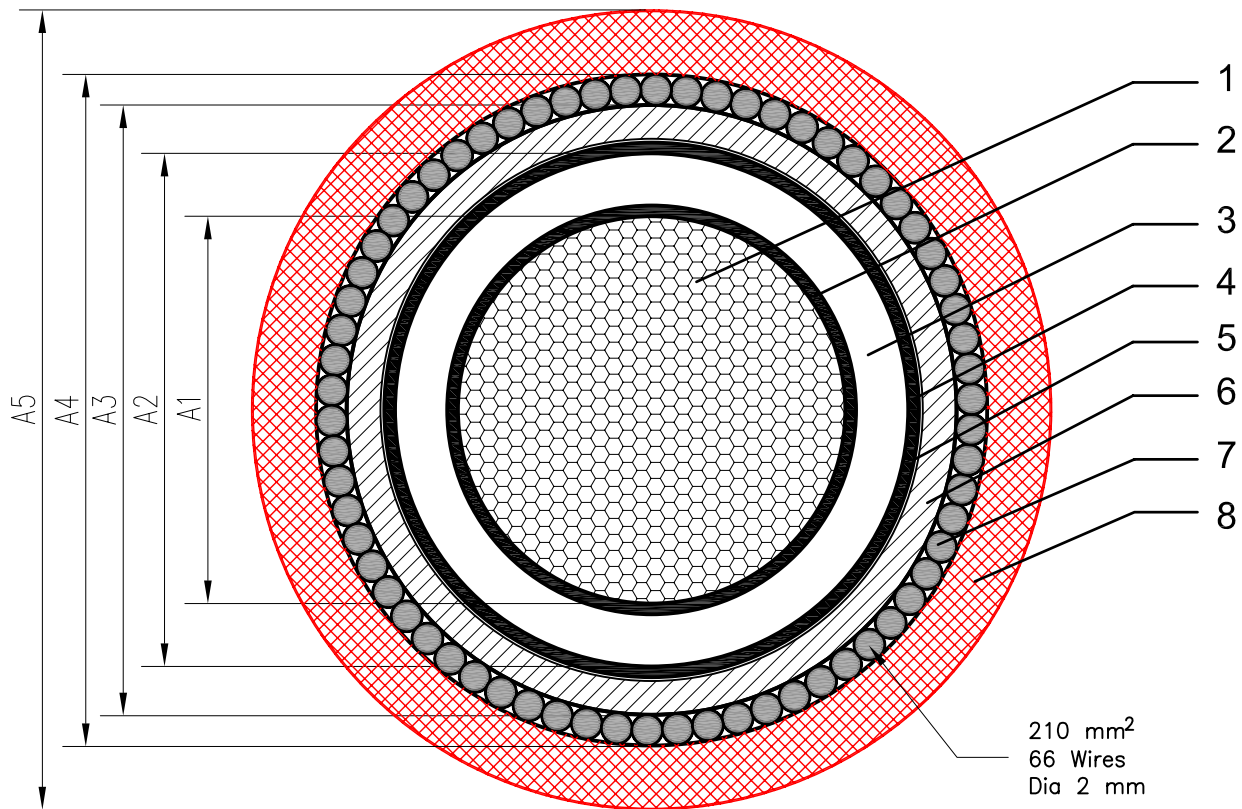
REVISIONS		NAME	DATE	NOTE
		Buckow	03.2009	ORIGINAL ISSUE


SULTANATE OF OMAN
OMAN ELECTRICAL STANDARDS

NAME	DATE
PREPARED: Buckow	03.2009
DRAWN: Saj	03.2009
CHECKED: GEWHS	03.2009
APPROVED: AER-TD	03.2009

Typical Cross Section of 11kV
XLPE 3-Core
Underground Cable

CAD-FILE	SCALE: NTS	DRWG. NO.: DWG OES2/UG2-3C-A
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CONSTRUCTION DATA

No.	Description	Material	Standard
1	Conductor	Copper, water tight **	IEC 60228
2	Conductor screen	Semi conducting	
3	Insulation	XLPE, Tree-retardant	IEC 60502
4	Insulation screen	Semi conducting	
5	Metallic layer	Copper tape	
6	Inner sheath	PVC-ST2, black	IEC 60502-2
7	Armour	Aluminum wire *	
8	Outer sheath	PVC-ST2, red	IEC 60502-2, IEC 60332

Tests: IEC 60332-1
IEC 60502

S.E.:

GIS – Plug-in

Outd. – Heat Shrink
Cold Shrink

Joint: Heat Shrink
Cold Shrink
Hybrid

DIMENSIONS

No.	Details	*	
	Conductor Cross Section, mm ²	500	630
A1	Approximate diameter of conductor, mm		
A2	Approximate diameter over core insulation, mm		
A3	Approximate diameter over inner sheath, mm		
A4	Approximate diameter over armour, mm		
A5	Approximate overall diameter, mm		
t1	Minimum thickness of conductor screen, mm	0.7	0.7
t2	Min./Max. thickness of insulation, mm	3.4/3.7	3.4/3.7
t3	Minimum thickness of insulation screen, mm	0.7	0.7
t4	Nominal thickness of metallic layer, mm	0.075	0.075
t5	Nominal thickness of inner sheath, mm	2.2	2.2
t6	Nominal diameter of armour wire, mm	2.5	2.5
t7	Nominal thickness of outer sheath, mm	4.2	4.6


Cable Drum Length, m	XXXXX
----------------------	-------

* 25kA , 0.5 Sec. (210 mm²)

** Water swelling tape around each layer of conductor wires

REVISIONS			
NO.	DESCRIPTION	DATE	BY

Buckow	03.2009	ORIGINAL ISSUE	NOTE
NAME	DATE		

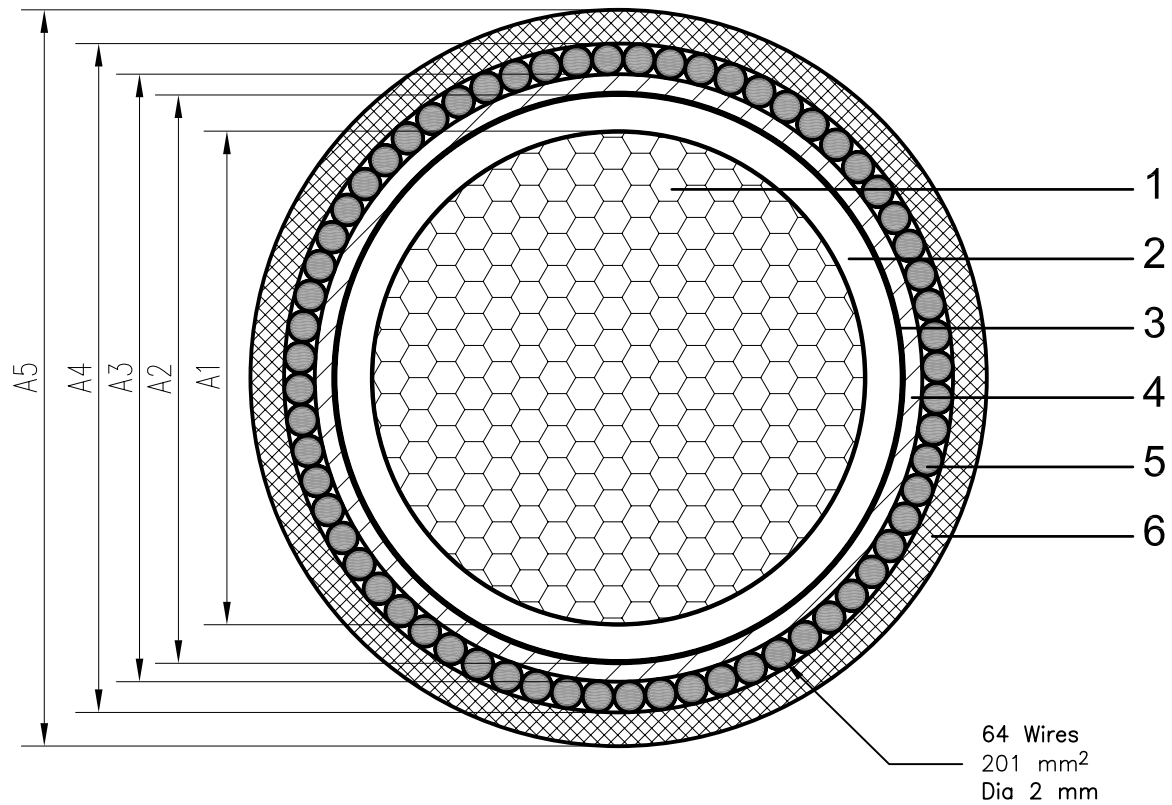


SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009	Typical Cross Section of 11kV XLPE Single-Core Underground Cable
DRAWN	Sajj	03.2009	
CHECKED	GEWHS	03.2009	
APPROVED	AER-TD	03.2009	
SHEET SIZE	DN A4		

CAD-FILE	SCALE	DRWG. NO.
	N.T.S	DWG OES2/UG2-SC-A




CONSTRUCTION DATA

No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467
3	Separation Tape	Polypropylene	
4	Inner sheath (Bedding)	PVC or LSZH, extruded	BS 7655, BS 5467
5	Armour	Aluminium wire	BS 5467
6	Outer sheath	PVC or LSZH compound	

DIMENSIONS

No.	Details		
	Conductor cross section, mm ²	630	500
A1	Approximate diameter of conductor, mm		
A2	Approximate diameter over insulation, mm		
A3	Approximate diameter over inner sheath, mm		
A4	Approximate diameter over armour, mm		
A5	Approximate overall diameter, mm		
t1	Nominal thickness of insulation, mm	2.4	2.4
t2	Nominal thickness of inner sheath (Bedding), mm	1.2	1.2
t3	Nominal diameter of armour wire, mm	2.0	2.0
t4	Nominal thickness of outer sheath, mm	2.2	2.2

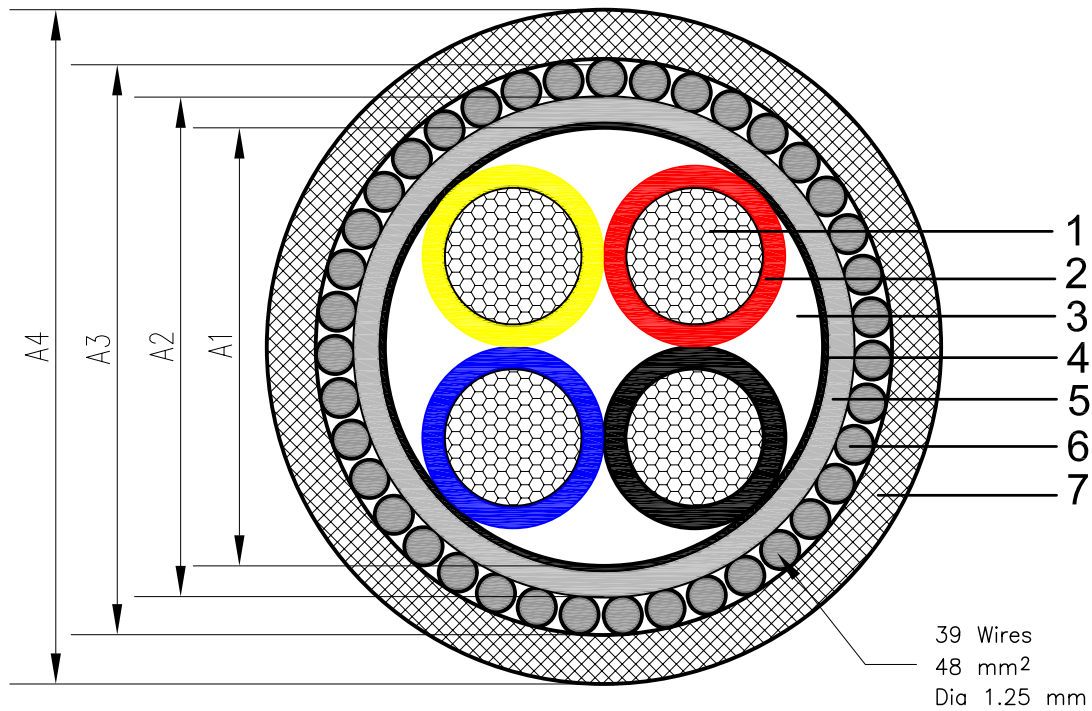
REVISED	NAME	DATE	ORIGINAL ISSUE	NOTE
	Buckow	03.2009		


SULTANATE OF OMAN
OMAN ELECTRICAL STANDARDS

PREPARED	NAME	DATE
	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.:		

Typical Cross Section of LV
XLPE Single-Core
Underground Cable

CAD-FILE	SCALE	DRWG. NO.
	N.T.S	DWG OES2/UG3-SC-A




SCHEDULE OF DIMENSIONS

No.	Details	sct. steel 1 Sec.	2.2
		sct. conductor 1 Sec.	2.2
	Conductor cross section, mm ²		4x16
A1	Approximate diameter over assembled cores, mm		
A2	Approximate diameter over inner sheath, mm		
A3	Approximate diameter over armour, mm		
A4	Approximate overall diameter, mm		
t1	Nominal thickness of insulation, mm		0.70
t2	Nominal thickness of inner sheath (Bedding), mm		0.80
d3	Nominal diameter of armour wire, mm		1.25
t4	Nominal thickness of outer sheath, mm		1.60

LEGEND

No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467
3	Fillers	Non hydroscopic	
4	Binder/Separation tape	Polypropylene	
5	Inner sheath (Bedding)	PVC or LSZH, extruded	BS 7655, BS 5467
6	Armour	Galvanised steel wire	BS 5467, BS EN 10257-1
7	Outer sheath	PVC or LSZH compd.	

REVISIONS			
NO.	DESCRIPTION	DATE	BY
1	Buckow	03.2009	ORIGINAL ISSUE
NAME	DATE	NOTE	

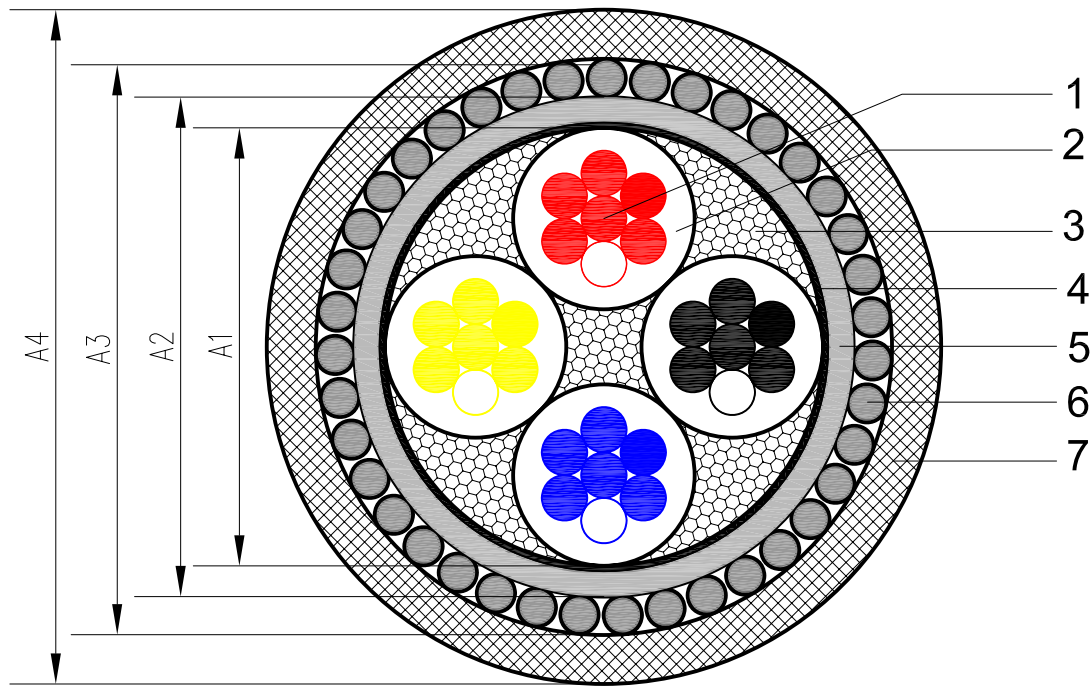


SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

NAME	DATE
PREPARED: Buckow	03.2009
DRAWN: Sajj	03.2009
CHECKED: GEWHS	03.2009
APPROVED: AER-TD	
SHEET SIZE: DIN A4	
SUPERSEDED BY DRWG. NO.:	
CAD-FILE	SCALE: N.T.S.
DRWG. NO.:	DWG OES2/UG3-4C/1-A

Typical Cross Section of LV
XLPE Four Core
Underground Cable




SCHEDULE OF DIMENSIONS

No.	Details	sct. steel 1 Sec.		
		1.0	1.9	3.2
		sct. conductor 1 Sec.		
		0.572	1.43	3.6
	Conductor cross section, mm ²	4x4	4x10	4x25
A1	Approximate diameter over assembled cores, mm	9.7	13.2	19.6
A2	Approximate diameter over inner sheath, mm	11.8	15.3	21.6
A3	Approximate diameter over armour, mm	13.5	17.7	24.8
A4	Approximate overall diameter, mm	15.70	20.0	27.5
t1	Minimum average thickness of insulation, mm	0.70	0.70	0.9
t2	Nominal thickness of inner sheath (Bedding), mm	0.80	0.80	1.0
d3	Nominal diameter of armour wire, mm	0.90	1.25	1.6
t4	Nominal thickness of outer sheath, mm	1.40	1.50	1.7

LEGEND

No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467, BS 7655
3	Fillers	Non hydroscopic	
4	Binder/Separation tape	Polypropylene	
5	Inner sheath (Bedding)	PVC or LSZH, extruded	BS 5467
6	Armour	Galvanised steel wire	BS 5467, BS EN 10257-1
7	Outer sheath	PVC or LSZH compd.	

REVISIONS		NAME	DATE	NOTE
		Buckow	03.2009	ORIGINAL ISSUE



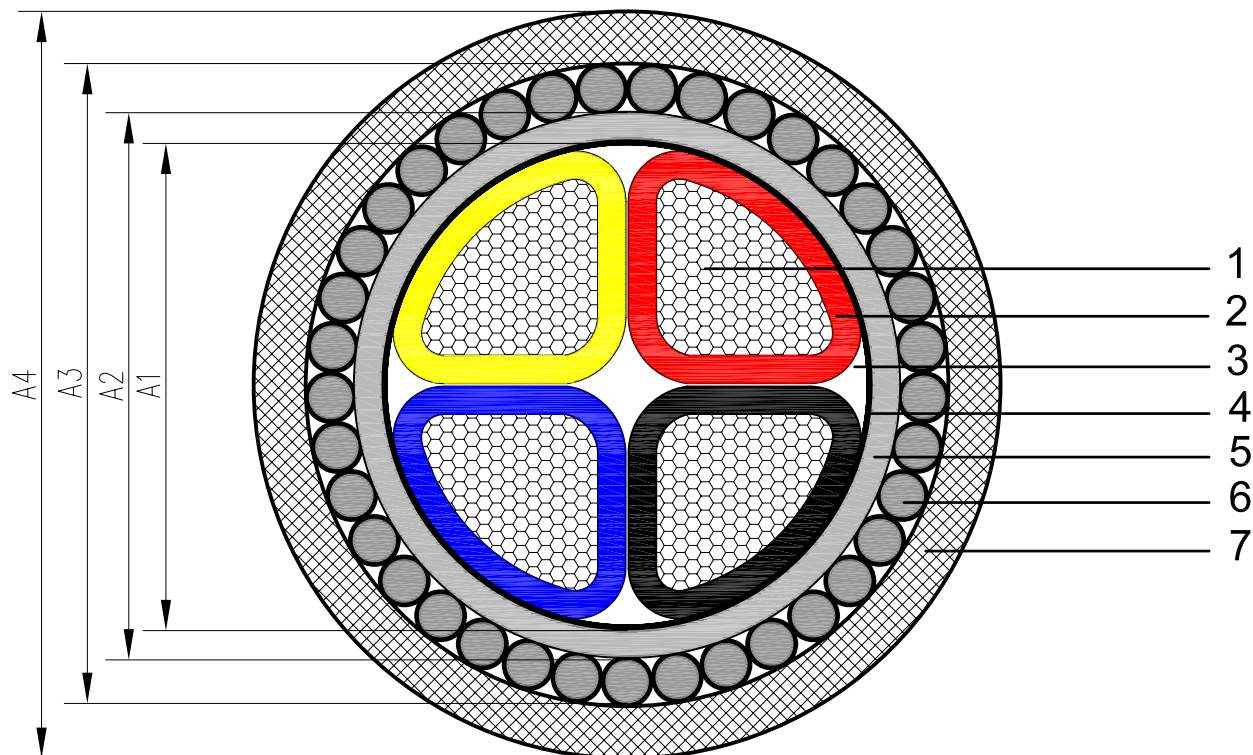
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	NAME	DATE
	Buckow	03.2009
DRAWN	NAME	DATE
	Saj	03.2009
CHECKED	NAME	DATE
	GEWHS	03.2009
APPROVED	NAME	DATE
	AER-TO	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.		

Typical Cross Section of LV
XLPE Four Core
Underground Cable
4x4, 4x10, 4x25mm²

CAD-FILE	SCALE	DRWG. NO.
	N.T.S	DWG OES2/UG3-4C/2-A



SCHEDULE OF DIMENSIONS

No.	Details	scct. steel 1 Sec.	3.2	3.6	4.1	6	6.7	9.4	11.7	13.2
		scct. conductor 1 Sec.	3.6	5.0	7.2	10	13.6	17.2	26.5	34.3
	Conductor cross section, mm ²		4x25	4x35	4x50	4x70	4x95	4x120	4x185	4x240
A1	Approximate diameter over assembled cores, mm		18.1	20.6	23.3	27.0	31.0	34.3	43.4	48.4
A2	Approximate diameter over inner sheath, mm		20	22.7	25.4	29.1	33.1	36.5	45.6	51.0
A3	Approximate diameter over armour, mm		23.2	25.9	28.6	33.1	37.1	41.5	50.6	56.0
A4	Approximate overall diameter, mm		26.1	28.6	31.5	36.4	40.6	45.2	54.8	60.3
t1	Minimum average thickness of insulation, mm ⁺		0.9	0.9	1.0	1.1	1.1	1.2	1.6	1.7
t2	Nominal thickness of inner sheath (Bedding), mm ⁺		1.0	1.0	1.0	1.2	1.2	1.4	1.4	1.6
d3	Nominal diameter of armour wire, mm ⁺		1.6	1.6	1.6	2.0	2.0	2.5	2.5	2.5
t4	Nominal thickness of outer sheath, mm ⁺		1.8	1.8	1.9	2.1	2.2	2.3	2.6	2.7


+BS 5467 Tests: IEC 60332-1
BS 5467

S.E : Lugs
Joints : Heat Shrink
Cold Shrink
Hybrid

LEGEND

No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467, BS 7655
3	Fillers	Non hydroscopic	
4	Binder/Separation tape	Polypropylene	
5	Inner sheath (Bedding)	PVC, extruded	BS 5467
6	Armour	Galvanised steel wire	BS 5467, BS EN 10257
7	Outer sheath	PVC or LSZH compd.	

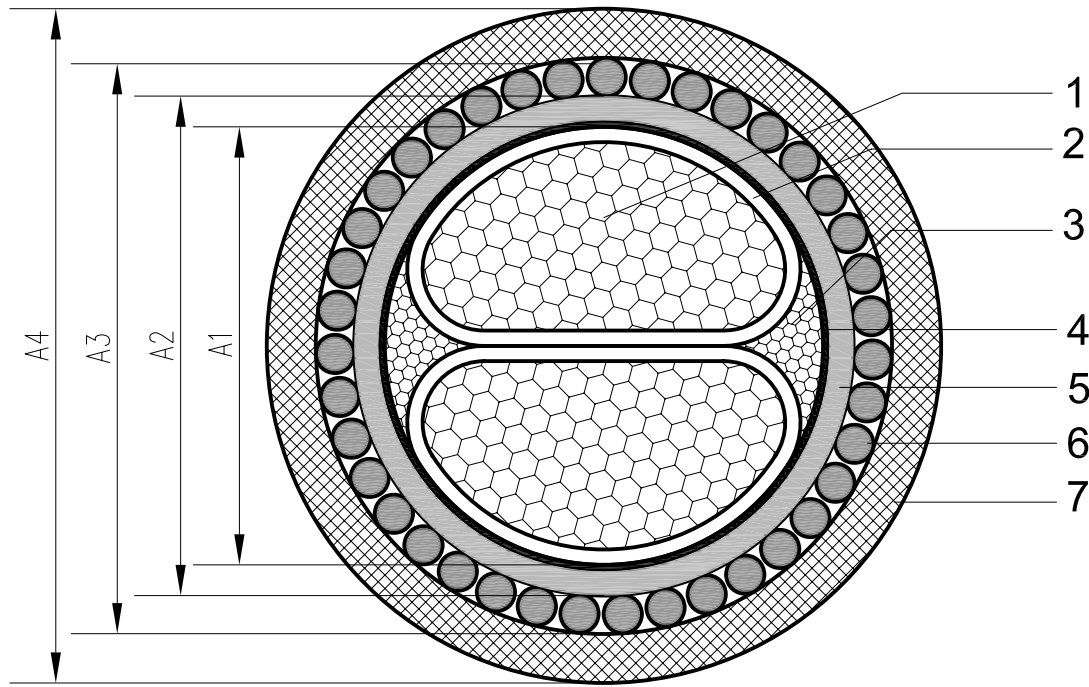
REVISIONS		
NO.	DESCRIPTION	DATE
1	Buckow	03/2009
ORIGINAL ISSUE		
NAME	DATE	NOTE


SULTANATE OF OMAN
 OMAN ELECTRICAL STANDARDS

PREPARED	NAME	DATE
Buckow		03/2009
DRAWN	Sajj	03/2009
CHECKED	GEWHS	03/2009
APPROVED	AER-TD	03/2009
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.		

Typical Cross Section of LV
 XLPE Four Core
 Underground Cable
 4x25, 4x35, 4x50, 4x70, 4x85, 4x95, 4x120, 4x185, 4x240mm²

CAD-FILE	SCALE	DRWG. NO.
	N.T.S	DWG OES2/UG3-4C/3-A




SCHEDULE OF DIMENSIONS

No.	Details	scct. steel 1 Sec.	3.1	5.8
		scct. conductor 1 Sec.	7.15	17.2
	Conductor cross section, mm ²		2x50	2x120
A1	Approximate diameter over assembled cores, mm		16.0	25.6
A2	Approximate diameter over inner sheath, mm		18.1	27.7
A3	Approximate diameter over armour, mm		21.3	31.7
A4	Approximate overall diameter, mm		24.3	35.1
t1	Minimum average thickness of insulation, mm		1.0	1.2
t2	Nominal thickness of inner sheath (Bedding), mm		1.0	1.2
d3	Nominal diameter of armour wire, mm		1.6	2.0
t4	Nominal thickness of outer sheath, mm		1.8	2.1

LEGEND

No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467, BS 7655
3	Fillers	Non hydroscopic	
4	Binder/Separation tape	Polypropylene	
5	Inner sheath (Bedding)	PVC or LSZH, extruded	BS 5467
6	Armour	Galvanised steel wire	BS 5467, BS EN 10257-1
7	Outer sheath	PVC or LSZH compd.	

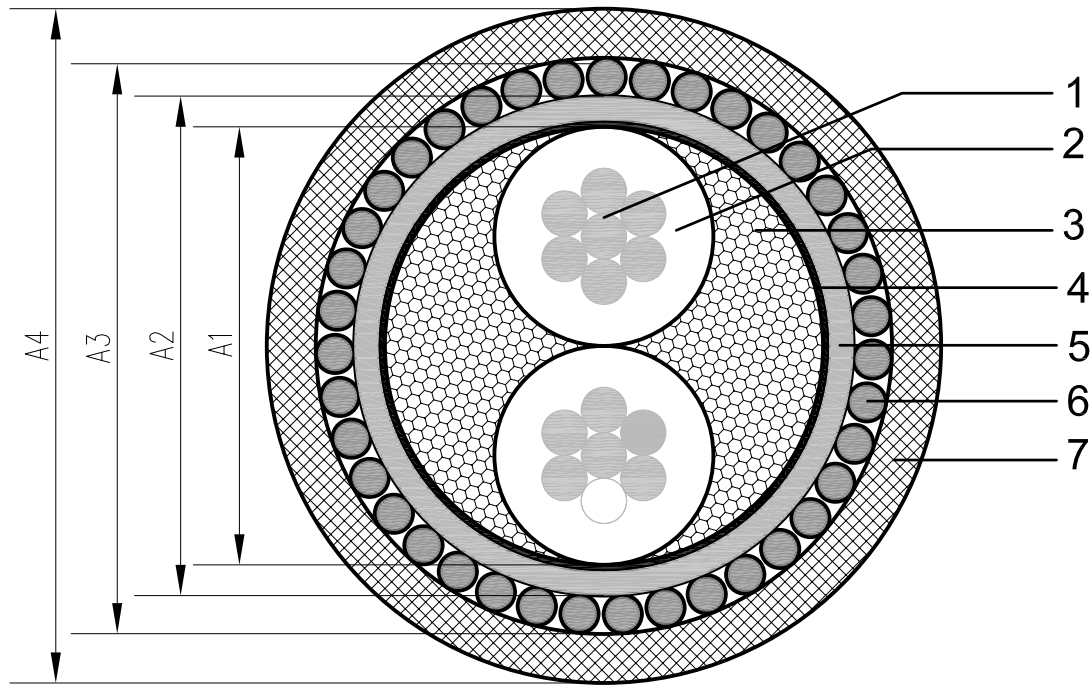
REVISIONS			
NO.	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	NAME	DATE	Typical Cross Section of LV XLPE Two Core Underground Cable 2x50, 2x120mm ²
Buckow		03.2009	
DRAWN	Sajj	03.2009	
CHECKED	GEVHS	03.2009	
APPROVED	AER-TD		
SHEET SIZE: DIN A4			
SUPERSEDED BY DRWG NO.:			
CAD-FILE		SCALE	DRWG. NO.
		N.T.S	DWG OES2/UG3-2C/1-A




SCHEDULE OF DIMENSIONS

No.	Details	scct. steel 1 Sec.	1.01	1.2	1.8
		scct. conductor 1 Sec.	0.858	1.43	2.29
	Conductor cross section, mm ²		2x6	2x10	2x16
A1	Approximate diameter over assembled cores, mm		9.1	10.9	13.1
A2	Approximate diameter over inner sheath, mm		11.2	13.0	15.2
A3	Approximate diameter over armour, mm		12.9	14.7	17.7
A4	Approximate overall diameter, mm		15.1	17.0	20.4
t1	Minimum average thickness of insulation, mm		0.7	0.7	0.7
t2	Nominal thickness of inner sheath (Bedding), mm		0.8	0.8	0.8
d3	Nominal diameter of armour wire, mm		0.9	0.9	1.25
t4	Nominal thickness of outer sheath, mm		1.4	1.5	1.5

LEGEND

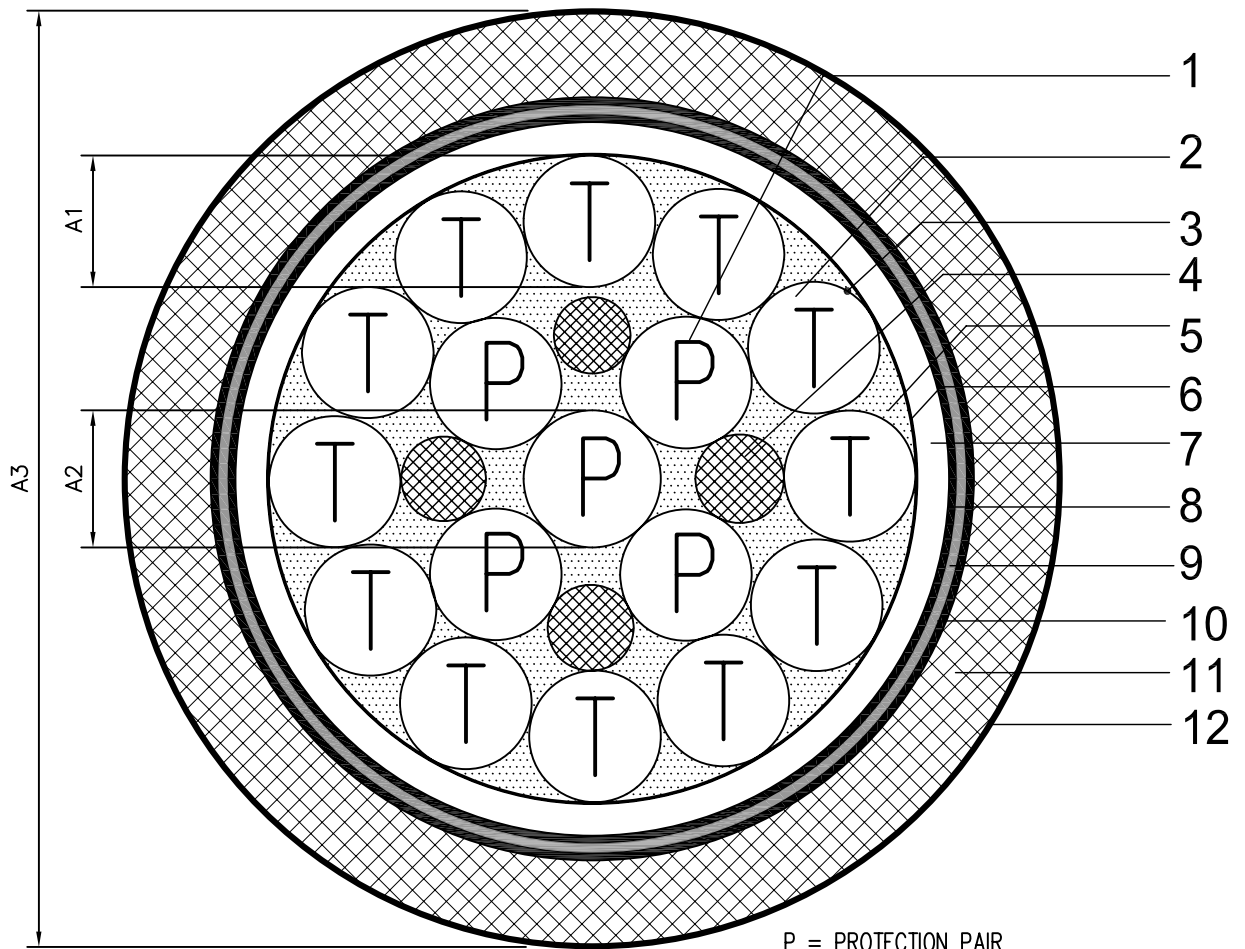
No.	Description	Material	Standard
1	Conductor	Copper	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467, BS 7655
3	Fillers	Non hydroscopic	
4	Binder/Separation tape	Polypropylene	
5	Inner sheath (Bedding)	PVC or LSZH, extruded	BS 5467
6	Armour	Galvanised steel wire	BS 5467, BS EN 10257-1
7	Outer sheath	PVC or LSZH compd.	

REVISIONS		NAME	DATE	NOTE
		Buckow	03.2009	ORIGINAL ISSUE

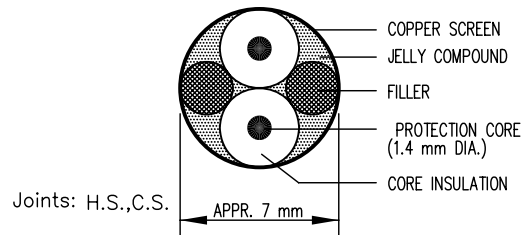


SULTANATE OF OMAN
OMAN ELECTRICAL STANDARDS

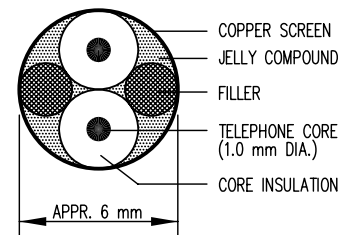
PREPARED	Buckow	03.2009	Typical Cross Section of LV XLPE Two Core Underground Cable 2x6, 2x10mm ²
DRAWN	Saj	03.2009	
CHECKED	GEVHS	03.2009	
APPROVED	AER-TD		
SHEET SIZE	DIN A4		
SUPERSEDED BY DRWG. NO.:			
CAD-FILE		SCALE	DRWG. NO.:
		N.T.S	DWG OES2/UG3-2C/2-A



P = PROTECTION PAIR



T = TELEPHONE PAIR



CONSTRUCTION DATA

No.	Description	Material
1	Protection Pair	Core: Annealed Copper(Stranded)
		Insulation: PE
2	Telephone Pair	Core: Annealed Copper(Solid)
		Insulation: PE
3	Pair screening	Copper tapes (2 layers)
4	Filler	PE
5	Water stopper	Jelly component
6	Wrapping	Plastic tape
7	Inner sheath	PE
8	Common screen	Copper tape
9	Bedding	Plastic tape
10	Armouring	Galvanized steel tape
11	Outer sheath	LSZH compound
12	Conductive layer	Semi conductive


DIMENSIONS

No.	Details	
A1	Approximate diameter of telephone pair, mm	6
A2	Approximate diameter of protection pair, mm	7
A3	Approximate overall diameter, mm	
t1	Minimum diameter of telephone core insulation, mm	1.0
t2	Minimum diameter of protection core insulation, mm	1.0
t3	Minimum thickness of common screen, mm	
t4	Nominal thickness of inner sheath, mm	2
t5	Minimum thickness of outer sheath, mm	3.0

Tests:

Standards	IEC & ESI
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REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE

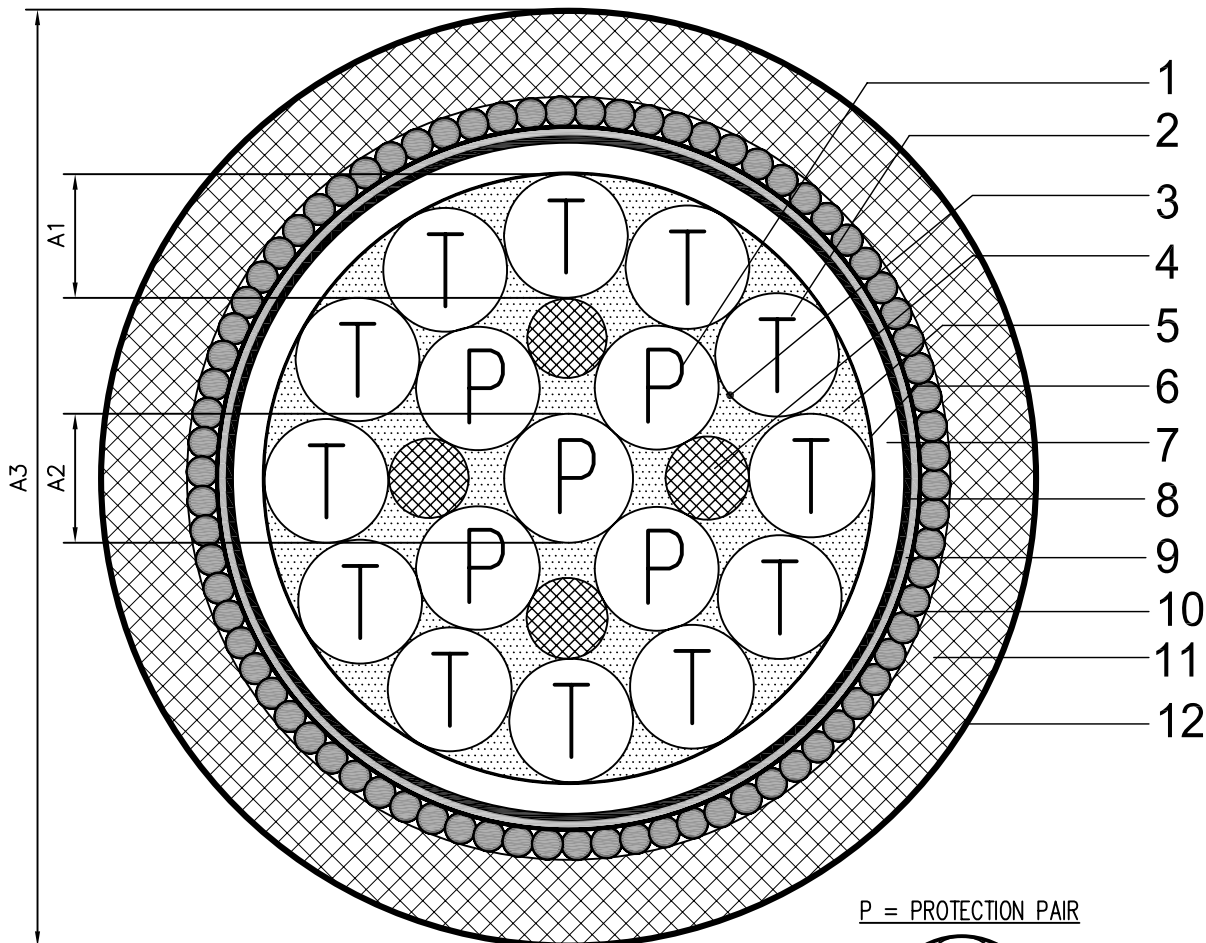


SULTANATE OF OMAN

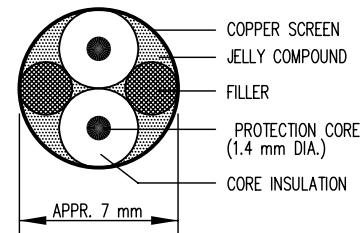
OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009
DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE: DIN A4		
SUPERSEDED BY DRWG. NO.:		
CAD-FILE	SCALE: N.T.S	DRWG. NO.: DWG OES2/UG4-1-A

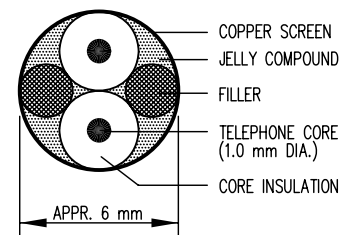
Typical Cross Section of
Protection /Telephone (PILOT)
Underground Cable,
Tape Armour



P = PROTECTION PAIR



T = TELEPHONE PAIR



Joints: H.S., C.S.

CONSTRUCTION DATA

No.	Description	Material
1	Protection Pair	Core
		Insulation
2	Telephone Pair	Core
		Insulation
3	Pair screening	Copper tapes (2 layers)
4	Filler	PE
5	Water stopper	Jelly compound
6	Wrapping	Plastic tape
7	Inner sheath	PE
8	Common screen	Copper tape
9	Bedding	Plastic tape
10	Armouring	Galvanized steel wires
11	Outer sheath	PEST7 or LSZH compd.
12	Conductive layer	Semi conductive

BS-EN 10257-1


DIMENSIONS

No.	Details	
A1	Approximate diameter of telephone pair, mm	6
A2	Approximate diameter of protection pair, mm	7
A3	Approximate overall diameter, mm	
t1	Minimum diameter of telephone core insulation, mm	1.0
t2	Minimum diameter of protection core insulation, mm	1.0
t3	Minimum thickness of common screen, mm	
t4	Nominal thickness of inner sheath, mm	2
t5	Nominal diameter of steel armour wires, mm	2
t6	Minimum thickness of outer sheath, mm	3

Tests:

Standards	IEC & ESI
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REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE



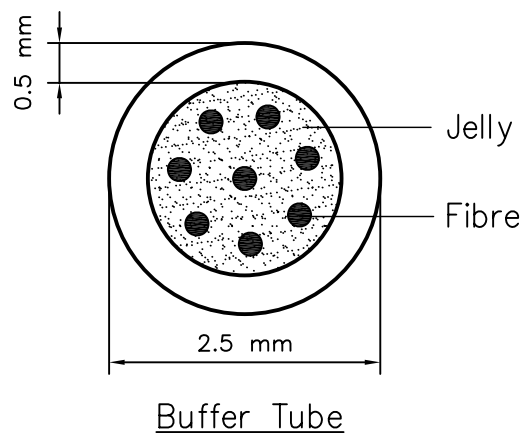
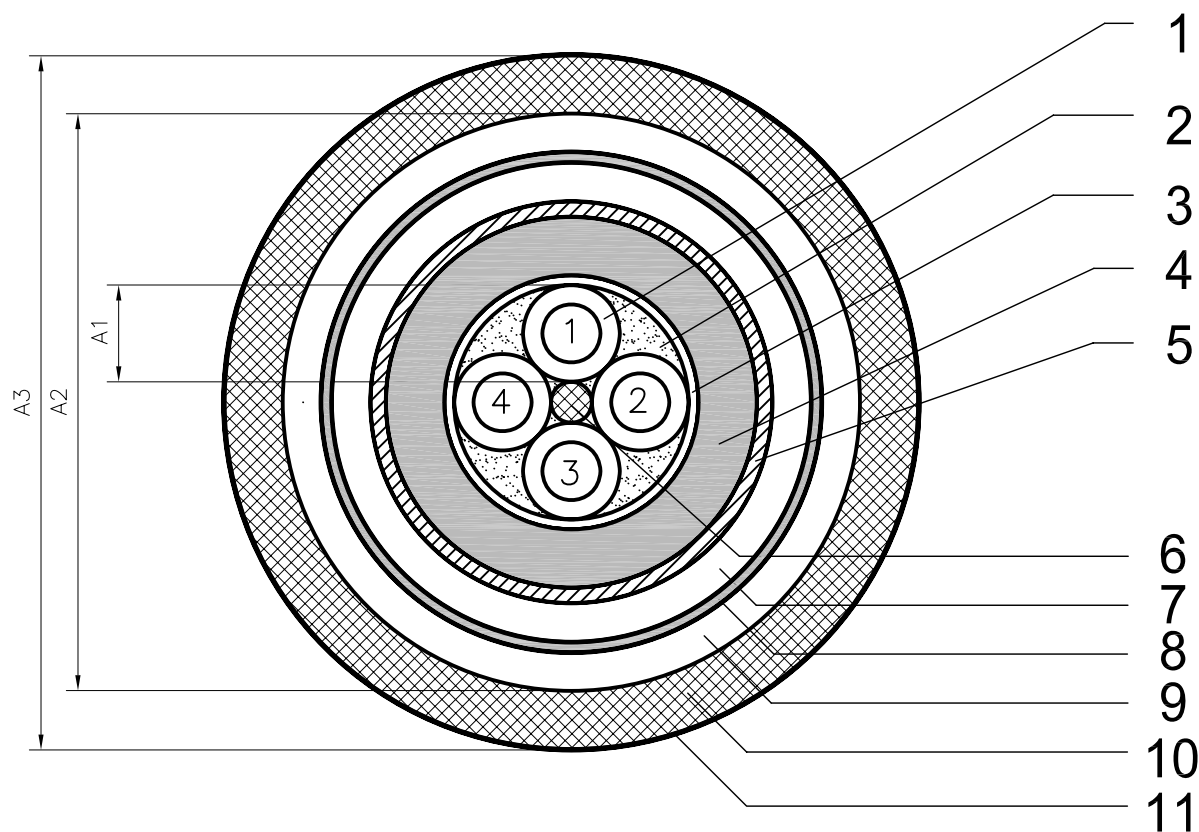
SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009
DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.:		

Typical Cross Section of
Protection /Telephone (PILOT)
Underground Cable
Wire Armour

CAD-FILE	SCALE	DRWG. NO.:
	N.T.S	DWG OES2/UG4-2-A



CONSTRUCTION DATA

No.	Description	Material
1	Loose Buffer Tube	Thermo plastic polyester
2	Filling Compound	Jelly
3	Wrapping-1	Plastic tape
4	Inner Sheath	PE
5	Peripheral Strength Member	Aramide yarns
6	Strength Member	GRP
7	Intermediate Sheath	PE ST5
8	Wrapping-2	Plastic tape
9	Armouring	Galvanized corrugated steel tape
10	Outer sheath	LSZH compound
11	Conductive layer	Semi conductive


DIMENSIONS

No.	Details	
A1	Approximate diameter(outer)of loose buffer tube, mm	2.5
A2	Approximate diameter of armour, mm	17
A3	Approximate overall diameter, mm	20
t1	Nominal thickness of inner sheath, mm	1.5
t2	Nominal thickness of intermediate sheath, mm	1.0
t3	Minimum thickness of outer sheath, mm	1.5

Tests:

Standards	ITU-T, IEC
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REVISIONS	NAME	DATE	NOTE
	Buckow	03.2009	ORIGINAL ISSUE

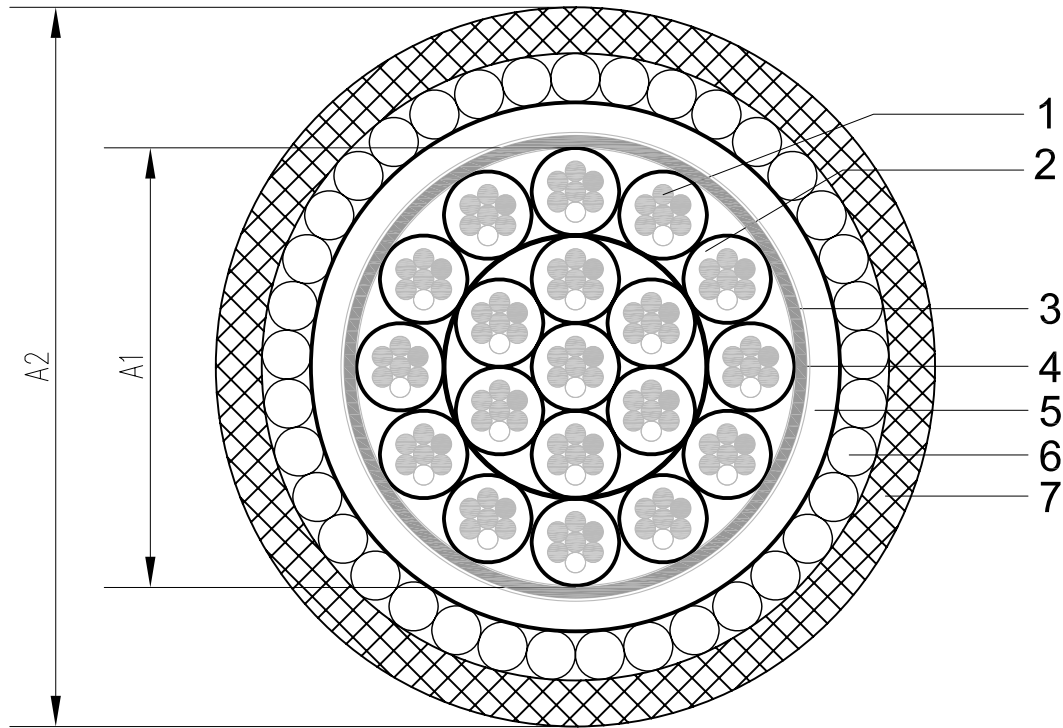


SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009
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CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO:		
CAD-FILE	SCALE	DRWG. NO:
	N.T.S	DWG OES2/UG5-A

Typical Cross Section of
Fiber Optic Cable - Underground



SCHEDULE OF DIMENSIONS

No.	Details	scct. Copper Tape Screen 1 Sec.	0.21	0.29	0.36	0.44
	Conductor cross section, mm ²		7x2.5	12x2.5	19x2.5	27x2.5
A1	Approximate diameter over assembled cores, mm		10.4	14.5	17.4	21.5
A2	Approximate overall diameter, mm		18.0	22.0	25.7	29.9
t1	Minimum average thickness of insulation, mm		0.70	0.70	0.70	0.70
t2	Nominal thickness of inner sheath (Bedding), mm		1.0	1.0	1.0	1.0
	Cross-Section of copper screen, mm		2.5	2.5	2.5	2.5
d1	Nominal diameter of armour wire, mm ²		1.25	1.25	1.6	1.6
t4	Nominal thickness of damping layer, mm		-	-	-	-
t5	Nominal thickness of outer sheath, mm		1.80	1.80	1.80	1.8

TEST IEC 60502-1
IEC 60332-1


S.E : Lugs
Joints : Heat Shrink
Cold Shrink
Hybrid

LEGEND

No.	Description	Material	Standard
1	Conductor	Stranded Copper Wires	IEC 60228
2	Insulation	XLPE	BS 7655
3	Electrom. Shield	Copper Tapes	
4	Binder	Polyester Tapes	
5	Bedding	Low Smoke Zero Halogen Compound	
6	Armour	Galvanised Steel Wires	
7	Outer Sheath	Low Smoke Zero Halogen Compound	IEC 60332-1, BS 6724

REVISIONS			
NO.	DESCRIPTION	DATE	BY

Buckow	03.2009	ORIGINAL ISSUE	NOTE
NAME	DATE		

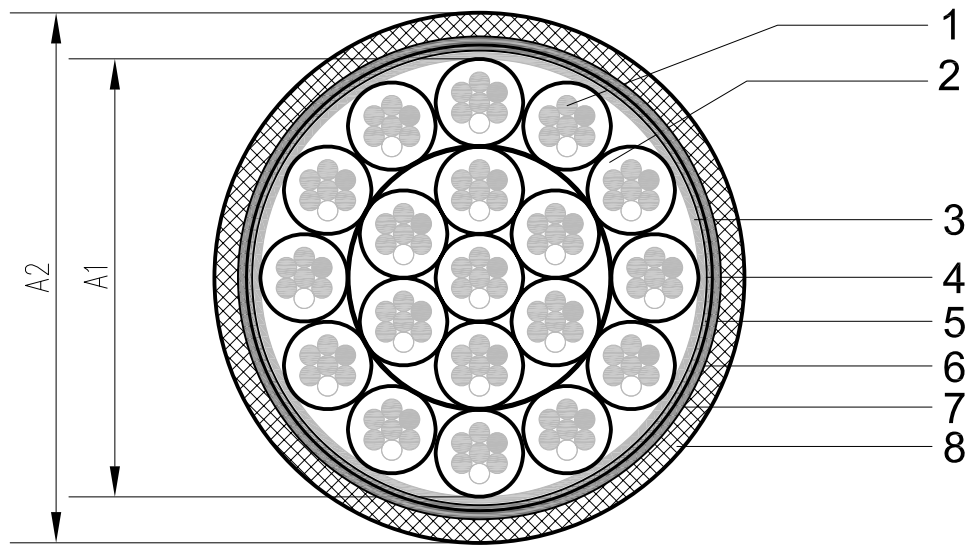


SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	NAME	DATE
Buckow	Buckow	03.2009
DRAWN	Sajj	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE: DIN A4		
SUPERSEDED BY DRWG NO:		
CAD-FILE	SCALE	DRWG NO:
	N.T.S	DWG OES2/UG7-1-A

Typical Cross Section of Control Cable (Type 2), 19x2.5,27x2.5mm² -Wire Armour




SCHEDULE OF DIMENSIONS

No.	Details	sctt. Copper Tape Screen 1 Sec.			
		0.21	0.29	0.36	0.44
	sctt. Conductor 1 Sec.	0.358	0.358	0.358	0.358
	Conductor cross section, mm ²	7x2.5	12x2.5	19x2.5	27x2.5
A1	Approximate diameter over assembled cores, mm				
A2	Approximate overall diameter, mm	–	–	–	–
t1	Minimum average thickness of insulation, mm ⁺	0.70	0.70	0.70	0.70
t2	Nominal thickness of inner sheath (Bedding), mm ⁺	–	–	–	–
	Cross section of copper screen, mm ²	2.5	4.0	6.0	10.0
d1	Nominal thickness of steel tape, mm				
t4	Nominal thickness of damping layer, mm				
t5	Nominal thickness of outer sheath, mm	1.80	1.80	1.80	1.80

+BS 5467 Tests: IEC 60502-2 S.E : Lugs
 IEC 60332-1 Joints : Heat Shrink
 BS 5467 Cold Shrink
 Hybrid

LEGEND

No.	Description	Material	Standard
1	Conductor	Stranded Copper Wires	BS 6360, IEC 60228
2	Insulation	XLPE	BS 5467
3	Binder	Polyester Tapes	
4	Bedding	Low Smoke Zero Halogen Compound	
5	Electrom. Shield	Copper Tapes	
6	Bedding	Low Smoke Zero Halogen Compound	
7	Armour	Galvanised Steel Tapes	
8	Outer Sheath	Low Smoke Zero Halogen Compound	BS 5467, IEC 60332-1 BS 7655

REVISIONS			NAME	DATE	NOTE
	Buckow	03/2009			ORIGINAL ISSUE
 SULTANATE OF OMAN OMAN ELECTRICAL STANDARDS					
PREPARED	Buckow	03/2009	Typical Cross Section of Control Cable (Type 3), 7x2.5, 12x2.5, 19x2.5, 27x2.5mm ² - Tape Armour		
DRAWN	Saji	03/2009			
CHECKED	GEWHS	03/2009			
APPROVED	AER-TD				
SHEET SIZE	EIN A4				
SUPERSEDED BY DRWG NO:			SCALE	DRWG NO:	
CAD-FILE			N.T.S	DWG OES2/UG7-3-A	



OES 2 - CABLES AND ACCESSORIES 3RD EDITION – REV. 0 (2010)

CONTENTS

OES2: S-CAB-ACC-MV-S&I (REV.0-2010)

OES2: S-CAB-ACC-LV-S&I (REV.0-2010)

OES2: S-CAB-ACC-PROT-TEL (REV.0-2010)

OES2: S-CAB-ACC-FOC-I (REV.0-2010)

DRAWINGS – TYPICAL ACCESSORIES

SULTANATE OF OMAN



هيئة تنظيم الكهرباء - عمان
AUTHORITY FOR ELECTRICITY REGULATION, OMAN

AUTHORITY FOR ELECTRICITY REGULATION - OMAN

OES 2 - CABLES AND ACCESSORIES
3RD EDITION – REV. 0 (2010)

11 kV AND 33 kV XLPE-INSULATED UNDERGROUND CABLE ACCESSORIES
(SUPPLY & INSTALLATION)

OES2: S-CAB-ACC-MV-S&I (REV.0-2010)

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11 kV AND 33 kV XLPE-INSULATED UNDERGROUND CABLE ACCESSORIES (SUPPLY & INSTALLATION)

1 GENERAL

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to the site, installation, site testing and commissioning of 11 kV or 33 kV XLPE-Insulated Cable Accessories (Sealing Ends and Joints) including hydraulic compression tool kits.

Further detailed and specific data are contained in the drawings, data sheets and other documents that form part of these Bid Documents.

For applicable technical standards, tests and general requirements reference shall be made to:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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2 TECHNICAL DESCRIPTION

2.1 General

This section specifies technical requirements for cable accessories for connecting 11 kV or 33 kV Underground Cables. The cable accessories comprise but are not limited to termination, straight joint for connecting 11 kV or 33 kV cables forming an 11 kV or 33 kV XLPE cable circuit.

The cable accessories offered must have been in commercial operation satisfactorily for at least 5 years continually in the similar installation environments as the Sultanate of Oman.

The designed service life of all cable accessories must be at least the same as the power cable with a service life expectancy of not less than 30 years, or even better than it. Preference will be given to longer designed service life and warranty service life proposed by the Manufacturer than the minimum requirement in per the Bid invitation document, if any. In addition, preference will be given to those accessories requiring no maintenance throughout their operation.

The straight through joints and cable sealing ends shall be suitable for cables specified in OES 2 Standard(s).

11 kV or 33 kV XLPE-Insulated Underground Cable Accessories (Supply & Installation)

The straight through joints and cable sealing ends shall be used for XLPE – insulated 11 kV or 33 kV cables with the following conductor cross-sections and outer sheath diameter:

Conductor Size (mm ²)	Diameter over Outer Sheath, mm
3 x 95	58 – 60
3 x 120	61 – 63
3 x 185	69 – 71
3 x 240	74 – 76
3 x 300	79 – 81
1 x 500	48 – 51
1 x 630	52 – 54

The cable core insulation diameter of the XLPE-insulated 11 kV or 33 kV cables with the following cross-sections are as follows:

Conductor Size (mm ²)	Diameter over non-metallic Insulation Screen, mm
3 x 95	18.4 – 19
3 x 120	19.8 – 20.4
3 x 185	22.9 – 23.5
3 x 240	25.2 – 25.8
3 x 300	27.4 – 28
1 x 500	33.4 – 34
1 x 630	36.6 – 37.2

The external heat/cold shrink hose/tube of joints and terminations shall overlap (after shrinking) the outer cable sheaths a specified in the Technical Data Sheets.

2.2 Sealing Ends

2.2.1 General

The termination shall be made of hydrophobic, non-flammable, fungus resistant silicon rubber. The creepage distance shall not be less than 42 mm/kV based on highest system voltage (line-to-line). The terminations shall be supplied complete with fixing brackets, etc.

The cable terminations shall be suitable for outdoor or indoor termination of 11 kV or 33 kV XLPE-insulated cables.

The termination kit shall include splicing instructions and all necessary materials such as consumable material and other components to complete the termination work.

Suitable finishes with high resistance to atmospheric conditions shall be provided for metals liable to corrosion or rusting, including metal coating, plastic coating, painting and inorganic treatment or a suitable combination of these.

Corrosion at the junction of two different metals under conditions of high humidity shall be prevented by effective means such as by the insertion of a bi-metallic plate at the junction.

The cable lug shall be fully covered with insulating material and shall be supplied as part of termination kit.

All material of cable terminations and its associated consumable equipment shall be environmental friendly and do not cause any hazard to the personnel who are carrying out the termination work.

The insulation and screening components shall withstand the operation temperature of the conductor of 90°C and shall not be affected by the temperature variation resulting from cyclic loading of the cable or from short-circuit currents.

The Bidder/Supplier shall submit the raw material and material safety data sheets of 11 kV 33 kV XLPE Underground Cable Accessories, which are used for the termination work for approval.

A complete and detailed list of tools and equipment required for the terminations shall be submitted with the Bid.

2.2.2 Termination Lugs

Dimensions of the termination lugs shall be according to tables as provided in the Drawings Section:

<u>Drawing No.</u>	<u>Title</u>
DWG/OES2/UG1-AUX-CL-A	33 kV Cable Lug Dimensions
DWG/OES2/UG2-AUX-CL-A	11 kV Cable Lug Dimensions

The lugs shall be suitable for 11 kV or 33 kV applications and shall be tinned high conductive copper, circular compressed type complying with latest IEC recommendations. Each lug should also be suitable embossed with die reference and it should be water blocked.

2.2.3 Plug-In Type Cable Termination for GIS (Gas Insulated Switchgear)

Plug-In Type Cable Termination Sets for GIS consist of two components, a plug connection fitted to the cable end and a receptacle permanently attached to the equipment.

The connection of the conductors shall be made by plugging the two components together. The Plug connection part shall be suitable for bushings made of epoxy resin installed in the GIS.

The electrical field within the whole connecting system shall be controlled by a stress control element. The realization of the contact and dielectric sealing components shall provide a cable termination free of partial discharge on all kind of environments.

The connector (Termination) shall provide absolute protection against humidity and dust by means of having a heat shrinkable tube on the bell flange and sealing gasket between the two parts of the termination (connector – bell flange – bushing).

The connector shall be absolutely touch proof, by means of having a grounded metal housing (bell flange), which shall consists of integrated plastic pressure sleeve and compression spring to provide an exit for the cable screen without touching metal housing of the termination. The compression sleeve (bell flange) shall have a housing for the voltage tap to provide voltage monitoring and cable testing without unplugging of the connector (Termination).

2.2.4 Screened Elbow and T-Connectors Slip-on type for 11 kV RMU Cable Termination

The following features shall be applicable:

- Made of high stretchable, non flammable pre-moulded silicone rubber including all required stress control elements
- The cable lug area inside the connector shall be fully covered with the integrated stress control tube, i.e. to build a Faraday cage.
- Free partial discharge due to outer screened and earthed surface of connectors. Moisture in high humidity areas and dust covering of the connectors shall not lead to partial discharge due to the earthed outer surface.
- 100% staff safety due to the earthed touch-proof outer screened surface.
- Cable testing shall be possible without dismantling of the cable connector from the bushing.
- Covering cross-sections 25mm^2 up to 300mm^2 with only two stress cone sizes.
- Allow connection of surge arresters and/or double cable connection (installation depth of combined versions shall be less than 300mm).
- Integrated capacitive measuring point in the insulated plug.

2.2.5 Cold Shrink Sealing End Type

Cold shrink components offered shall be made of silicon composite based rubber and shall comply with appropriate international standards. The applied tubes and moulds shall shrink to a predetermined size.

Cold shrink type terminations shall be applied in a single operation, i.e. all stress control mastics, stress control tubes and ferrule seals shall be applied in a single stage. Moulded rain sheds shall be incorporated for outdoor type sealing ends. The termination kits shall be supplied complete with tinned copper lugs (water blocked) as specified above, sealing sleeves, insulation tubes, cable breakouts, and earthing kits.

2.2.6 Heat Shrink Sealing End Type

Heat shrink components offered shall comply with appropriate international standards. The applied tubes and moulds shall shrink to a predetermined size.

Heat shrink type terminations shall be applied in stages, i.e. all stress control mastics, stress control tubes and lug seals shall be applied in stages as to splicing instructions. Moulded rain sheds shall be incorporated for outdoor type sealing ends. The termination kits shall be supplied complete with tinned copper lugs (water blocked) as specified above, sealing sleeves, insulation tubes, cable breakouts, and earthing kits, right angle boots or straight angle (indoor terminations).

2.3 Straight Through Joints

2.3.1 General

The straight through joints shall be made of silicon/composite based rubber.

The straight through joints shall be suitable for 11 kV or 33 kV XLPE-insulated cables.

The jointing kit shall include splicing instructions and all necessary materials such as consumable material and other components to complete the jointing work.

All materials of cable joints and its associated consumable equipment shall be environmental friendly and do not cause any hazard to the personnel who are carrying out the termination work.

The Bidder/Supplier shall submit the raw material and material safety data sheets of 11 kV 33 kV XLPE Underground Cable Accessories, which are used for the jointing work for approval.

The insulation and screening components shall withstand the operation temperature of the conductor of 90°C and shall not be affected by the temperature variation resulting from cyclic loading of the cable or from short-circuit currents.

All specified types of joints shall be designed to withstand 1m water pressure. The water temperature shall be not less than 65°C.

A complete and detailed list of tools and equipment required for the cable joints shall be submitted with the Bid.

2.3.2 Jointing Ferrules

Dimensions of the jointing ferrules shall be according to tables as provided in the Drawings Section:

<u>Drawing No.</u>	<u>Title</u>
DWG/OES2/UG-AUX-CJF-A	MV Cable Joint Ferrule Dimensions

The ferrules shall be suitable for 11 kV or 33 kV applications and shall be tinned high conductive copper, circular compressed type complying with latest IEC recommendations. Each ferrule should also be suitable embossed with die reference and it should be water blocked.

2.3.3 Heat Shrink Type

Heat shrink components offered shall comply with appropriate international standards. The applied tubes and moulds shall shrink to a predetermined size.

Insulation material shall consist of prefabricated or heat shrinkable components e.g. prefabricated stress cones, tubes etc. to facilitate the splice-making and also to cut short the time.

The metallic screens shall be connected by means of tinned copper shielding braid or equivalent.

Compression type tinned copper jointing ferrules shall be provided for the jointing of the conductors. The ferrules shall be mechanically strong with adequate contact and cross-sectional area for efficient and reliable service. Alternatively the conductors may be spliced by means of welding or equivalent (e.g. cadweld process).

Heat shrink type joints shall be applied in a single operation, i.e. all stress control mastics and stress control tubes shall be applied in a single stage. The jointing kits shall be supplied complete with tinned copper ferrules as specified above and insulation tubes.

2.3.4 Cold Shrink Type

Cold shrink components offered shall comply with appropriate international standards. The applied tubes and mouldings shall shrink to a predetermined size.

Insulation material shall consist of prefabricated or cold shrinkable components e.g. prefabricated stress cones, tubes etc. to facilitate the splice-making and also to cut short the time.

The metallic screens shall be connected by means of tinned copper-braided tape or equivalent.

Compression type tinned copper jointing ferrules shall be provided for the jointing of the conductors. The ferrules shall be mechanically strong with adequate contact and cross-sectional area for efficient and reliable service. Alternatively the conductors may be spliced by means of welding or equivalent (e.g. cadweld process).

Cold shrink type joints shall be applied in a single operation, i.e. all stress control mastics and stress control tubes shall be applied in a single stage. The jointing kits shall be supplied complete with tinned copper ferrules as specified above and insulation tubes.

2.3.5 Hybrid Type (Cold and Heat-Shrink Combination)

The XLPE insulated cable straight through joints shall be of outer heat shrink tube encapsulated type, using cold applied insulation and stress control components for the re-insulation of the connector and stress control of the semi-conducting screen removal position of XLPE insulated cables.

The joints shall be designed to withstand 1m water pressure. The temperature of the water can reach 65°C.

Cold shrink components offered shall be made of silicon based rubber and shall comply with appropriate international standards. The applied tubes and moulds shall shrink to a predetermined size.

The cold applied tubes shall shrink to a pre-determined size. Upon recovery joint bodies shall seal the electrical connection against moisture without any additional coatings or sealant, the term coating or sealant excludes any lubricant used to facilitate the application of the joint body.

Cold shrink type joints shall be applied in a single operation, i.e. all stress control mastics, stress control tubes and sleeve seals shall be applied in a single stage. The joint kits shall be supplied complete with armour bonds, connection ferrules, cold shrinkable insulation/screening/stress control components, earth screen/continuity and outer protection heat shrink wrap/tube. The kit for each type of joints shall include information about length of tube, thickness before and after recovery, shrink ratio for outer protection tube only.

The cable armour continuity shall be provided by means of a galvanized steel case with contact to be achieved by the use of worm drive clips (two numbers), and suitable ferrules to connect the copper interstitial conductors.

The outer protection of the joints shall be two heat-shrink tubes.

2.4 Bonding & Earthing

Earthing and Bonding systems shall meet Electra (128) CIGRE study committee 21, Work Group 7 (guide to the protection of specially bonded cable systems against over voltage) recommendations

3 TESTING AND INSPECTION

3.1 General

All 11 kV or 33 kV XLPE-insulated cable accessories shall be tested in the manufacturers factory. The Bidder/Supplier may be required to carry out any one or all of the tests stated in this Specification to be witnessed by the OWNER or his representatives.

The approval of the OWNER or the passing of any such inspection or test will not however, prejudice the right of the purchaser to reject the cable if it does not comply with the Specification when supplied, or if it does not give complete satisfaction in service.

3.2 Factory Tests

3.2.1 Type Tests

Evidence shall be given that the proposed cable and accessories to be supplied under this Contract has been subject to all the type tests of service frequency, impulse, insulation level and electrical and mechanical. Performance shall be as appropriate and as specified in IEC 60502, BS 7888-4.1, HD 629.-S1, HD 628-S1 and VDE 0278. If considered necessary by the OWNER, additional tests might be required from the Bidder/Supplier.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Supplier shall submit certified copies of type test certificates covering the proposed 11 kV or 33 kV Cable Accessories.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to the OWNER.
2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the OWNER.

If the presented type test reports are not in accordance with the above requirements, the OWNER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the OWNER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

3.2.2 Sample Tests

In order to verify that the cable accessories meet the design specifications, a sample from each type of the accessories shall be subjected to mechanical and electrical tests in accordance with

IEC 60502, BS 7888-4.1, HD 629.-S1, HD 628-S1, VDE 0278 and as per instructions by the OWNER.

3.2.3 Routine Tests

Routine tests shall be in accordance with IEC 60502, BS 7888-4.1, HD 629.-S1, HD 628-S1 and VDE 0278 or an approved equivalent international recognised standard. The routine tests are to be carried out in the factory for each type of equipment.

3.3 Site Tests

3.3.1 Pre-commissioning Test

The following test, but not limited to it, shall be carried out prior to commissioning:

High Voltage d.c. test on the main cable insulation including accessories according to IEC 60502. The scope of the installation test should be finalised and submitted to the OWNER for approval prior to implementation.

The scope of the pre-commissioning test should be finalised and submitted to the OWNER for approval prior to implementation.

The Bidder/Contractor shall carry out and supply the test equipment for the above tests. The Bidder/Contractor shall ensure that their equipment is suitable for these tests and advise whether any further site test is considered necessary prior to commissioning. The test reports under the scope of the above tests shall be submitted to the OWNER within one week after the completion of the tests.

3.3.2 Commissioning Test

The Bidder/Contractor shall carry out electrical tests when installation of the cable and accessories has been completed. Such tests shall be in accordance with the latest edition of IEC 60502 and as specified in Technical Specification, Part:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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Accessories supplied/installed shall be suitable for the specified functions illustrated in this specification and to the satisfaction of the OWNER.

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OES 2 - CABLES AND ACCESSORIES
3RD EDITION – REV. 0 (2010)

LV XLPE-INSULATED UNDERGROUND CABLE ACCESSORIES
(SUPPLY AND INSTALLATION)

OES2: S-CAB-ACC-LV-S&I (REV.0-2010)



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LV XLPE-INSULATED UNDERGROUND CABLE ACCESSORIES (SUPPLY AND INSTALLATION)

1 GENERAL

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to the site, installation, site testing and commissioning of LV XLPE-Insulated Cable Accessories (Joints, etc.) including hydraulic compression tool kits.

Further detailed and specific data are contained in the drawings, data sheets and other documents that form part of any Bid Documents.

For applicable technical standards, tests and general requirements reference shall be made to:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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2 TECHNICAL DESCRIPTION

2.1 General

This section specifies technical requirements for cable accessories for connecting LV Underground Cables. The cable accessories comprise but are not limited to termination, straight joint for connecting LV cables forming a LV XLPE cable circuit.

The cables and joints supplied under this Bid should be made by the same cable manufacturer. Preference and priority will be given to the Bidder/Contractor if all the cables, joints, are made by the same cable manufacturer to ensure compatibility, reliability and responsibility.

The cable system used must have been in commercial operation satisfactorily for at least 5 years continually in the similar installation environments as the Sultanate of Oman.

The designed service life of all cable accessories must be at least the same as the power cable with a service life expectancy of not less than 30 years, or even better than it. Preference will be given to longer designed service life and Warranty service life proposed by the Bidder/Contractor longer than the minimum requirement in the Bid document. In addition, preference will be given to those accessories requiring no maintenance throughout their operation.

The straight through joints and cable sealing ends shall be suitable for cables specified in the following technical standard specifications:

Underground Cables and Accessories, Parts:

- LV XLPE-Insulated, Four-Core Underground Cables (S-CAB-LV-4C-I)

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- LV XLPE-Insulated, Single-Core Underground Cables (S-CAB-LV-SC-I).

The straight through joints and cable sealing ends shall be used for XLPE – insulated LV cables with the following conductor cross-sections and outer sheath diameter:

Conductor Size (mm ²)	Diameter over Outer Sheath, mm
4 x 16	22 – 25
4 x 25	25 – 27
4 x 50	31 – 33
4 x 70	36 – 39
4 x 120	46 – 49
4 x 185	55 – 58
4 x 240	62 – 64
1 x 630	48 – 50

The external heat/cold shrink hose/tube of joints and terminations shall overlap (after shrinking) the outer cable sheaths a specified in the Technical Data Sheets.

2.2 Sealing Ends

2.2.1 Termination Lugs

Dimensions of the termination lugs shall be according to tables as provided in the Drawings Section:

<u>Drawing No.</u>	<u>Title</u>
DWG OES2/UG3-AUX-CL-A	LV Cable Lug Dimensions

The lugs shall be suitable for LV application and shall be tinned high conductive copper, circular compressed type complying with latest IEC recommendations. Each lug should also be suitable embossed with die reference and it should be water blocked.

2.3 Straight Through Joints

2.3.1 General

The straight through joints shall be made of silicon rubber.

The straight through joints shall be suitable for LV XLPE-insulated cables.

The jointing kit shall include splicing instructions and all necessary materials such as consumable material and other components to complete the jointing work.

All materials of cable joints and its associated consumable equipment shall be environmental friendly and do not cause any hazard to the personnel who are carrying out the termination work.

The Bidder/Contractor shall submit the raw material and material safety data sheets of LV XLPE Underground Cable Accessories, which are used for the jointing work for approval.

The insulation and screening components shall withstand the operation temperature of the conductor of 90°C and shall not be affected by the temperature variation resulting from cyclic loading of the cable or from short-circuit currents.

All specified types of joints shall be designed to withstand 1m water pressure.

2.3.2 Jointing Ferrules

Dimensions of the jointing ferrules shall be according to tables as provided in the Drawings Section:

<u>Drawing No.</u>	<u>Title</u>
DWG OES2/UG3-AUX-CJF-A	LV Cable Joint Ferrule Dimensions

The ferrules shall be suitable for LV application and shall be tinned high conductive copper, circular compressed type complying with latest IEC recommendations. Each ferrule should also be suitable embossed with die reference and it should be water blocked.

2.3.3 Heat Shrink Type

Heat shrink components offered shall comply with appropriate international standards. The applied tubes and mouldings shall shrink to a predetermined size.

Insulation material shall consist of prefabricated or heat shrinkable components e.g. prefabricated stress cones, tubes etc. to facilitate the splice-making and also to cut short the time.

The metallic sheath shall be connected by means of tinned copper-braided tape or equivalent.

Compression type tinned copper jointing ferrules shall be provided for the jointing of the conductors. The ferrules shall be mechanically strong with adequate contact and cross-sectional area for efficient and reliable service. Alternatively the conductors may be spliced by means of welding or equivalent (e.g. cadweld process).

Heat shrink type joints shall be applied in a single operation, i.e. all stress control mastics a stress control tubes shall be applied in a single stage. The jointing kits shall be supplied complete with tinned copper ferrules as specified above and insulation tubes.

2.3.4 Cold Shrink Type

Cold shrink components offered shall comply with appropriate international standards. The applied tubes and mouldings shall shrink to a predetermined size.

Insulation material shall consist of prefabricated or cold shrinkable components e.g. prefabricated stress cones, tubes etc. to facilitate the splice-making and also to cut short the time.

The metallic sheath shall be connected by means of tinned copper shielding braid or equivalent.

Compression type tinned copper jointing ferrules shall be provided for the jointing of the conductors. The ferrules shall be mechanically strong with adequate contact and cross-sectional area for efficient and reliable service. Alternatively the conductors may be spliced by means of welding or equivalent (e.g. cadweld process).

Cold shrink type joints shall be applied in a single operation, i.e. all stress control mastics a stress control tubes shall be applied in a single stage. The jointing kits shall be supplied complete with tinned copper ferrules as specified above and insulation tubes.

2.3.5 Hybrid Type (Cold and Heat-Shrink Combination)

The XLPE insulated cable straight through joints shall be of outer heat shrink tube encapsulated type, using cold applied insulation and stress control components for the re-insulation of the connector and stress control of the semi-conducting screen removal position of XLPE insulated cables.

Cold shrink components offered shall be made of silicon based rubber and shall comply with appropriate international standards. The applied tubes and moulds shall shrink to a predetermined size.

The cold applied tubes shall shrink to a pre-determined size. Upon recovery joint bodies shall seal the electrical connection against moisture without any additional coatings or sealant, the term coating or sealant excludes any lubricant used to facilitate the application of the joint body.

Cold shrink type joints shall be applied in a single operation, i.e. all stress control mastics, stress control tubes and sleeve seals shall be applied in a single stage. The joint kits shall be supplied complete with armour bonds, connection ferrules, cold shrinkable insulation/screening/stress control components, earth screen/continuity and outer protection heat shrink wrap/tube. The kit for each type of joints shall include information about length of tube, thickness before and after recovery, shrink ratio for outer protection tube only.

The cable armour continuity shall be provided by means of a galvanized steel case with contact to be achieved by the use of worm drive clips (two numbers), and suitable ferrules to connect the copper interstitial conductors.

The outer protection of the joints shall be two heat-shrink tubes.

3 TESTING AND INSPECTION

3.1 General

All LV XLPE-insulated cable accessories shall be tested in the manufacturer's factory. The Bidder/Contractor may be required to carry out any one or all of the tests stated in this Specification to be witnessed by the OWNER or his representatives.

To prevent additional ageing of the cable insulation during high-voltage after installation of the cable circuits including accessories, the Bidder/Contractor shall propose Low-Frequency High-Voltage Test procedures for approval.

The approval of the OWNER or the passing of any such inspection or test will not however, prejudice the right of the Purchaser to reject the cable if it does not comply with the Specification when supplied, or if it does not give complete satisfaction in service.

3.2 Factory Tests

3.2.1 Type Tests

Evidence shall be given that the proposed cable and accessories to be supplied under this Contract has been subject to all the type tests of service frequency, impulse, insulation level and electrical and mechanical. Performance shall be as appropriate and as specified in IEC 60502, BS 7888 and VDE 0278. If considered necessary by the OWNER, the OWNER will decide whether additional tests are necessary from the Bidder/Contractor.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed LV Cable Accessories.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to the OWNER.
2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the OWNER.

If the presented type test reports are not in accordance with the above requirements, the OWNER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the OWNER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

3.2.2 Sample Tests

In order to verify that the cable accessories meet the design specifications, a sample from each type of the accessories shall be subjected to mechanical and electrical tests in accordance with IEC 60502, BS 7888, VDE 0278 and as per the OWNER instructions.

3.2.3 Routine Tests

Routine tests shall be in accordance with IEC 60502, BS 7888 and VDE 0278 or an approved equivalent international recognised standard. The routine tests are to be carried out in the factory for each type of equipment.

3.3 Site Tests

3.3.1 Pre-commissioning Test

The following test, but not limited to it, shall be carried out prior to commissioning:

High Voltage d.c. test on the main cable insulation according to IEC 60502. The scope of the installation test should be finalised and submitted to the OWNER for approval prior to implementation.

The scope of the pre-commissioning test should be finalised and submitted to the OWNER for approval prior to implementation.

The Bidder/Contractor shall carry out and supply the test equipment for the above tests. The Bidder/Contractor shall ensure that their equipment is suitable for these tests and advise whether any further site test is considered necessary prior to commissioning. The test reports under the scope of the above tests shall be submitted to the OWNER within one week after the completion of the tests.

3.3.2 Commissioning Test

The Bidder/Contractor shall carry out electrical tests after installation of the cables and accessories have been completed. Such tests shall be in accordance with the latest edition of IEC 60502.

Accessories supplied/installed shall be suitable for the specified functions illustrated in this specification and to the satisfaction of the OWNER.

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17 PAIRS PROTECTION/TELEPHONE UNDERGROUND
CABLE ACCESSORIES

OES2: S-CAB-ACC-PROT-TEL (REV.0-2010)

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1 GENERAL

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to site, installation, site testing and commissioning of 17 Pairs Protection/Telephone Underground Cable Accessories. Further detailed and specific data are contained in the Technical Data Sheets and other documents that form part of these Tender Documents.

The accessories for the protection/telephone cable shall generally be installed either in the control building or along the power cables circuits of the 33,132, 220 & 400 kV cables.

For applicable technical standards, tests and general requirements, reference shall be made to:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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2 TECHNICAL SPECIFICATION

2.1 Marshalling Cubicle for the 17 Pair Protection/Telephone Underground Cable

2.1.1 General

The Protection/Telephone Underground Cables shall be terminated in suitable, easily accessible terminal blocks inside marshaling cubicles at all locations either in the switchgear rooms or along the cable routes.

The marshalling cabinet shall consist of outer casing, terminal blocks, cable gland, isolating links, insulated gland plate and any other fittings necessary, for terminating 17 pair protection/telephone cable. Spare terminal to cater for additional 20% of each type of terminals shall also be considered.

The marshalling cabinets shall be designed to have a minimum service life of not less than 30 years.

The marshalling cabinets shall be industrially produced and a standard product of a reputable manufacturer, internationally approved by independent test bodies.

The marshalling cabinet shall be made of high-grade stainless steel sheet with a wall thickness of not be less than 1.5 mm, however the door sheet thickness shall be at least 2 mm.

The marshalling cabinets shall be suitable for wall mounting or for erection on galvanized steel structures.

The doors shall be of hinged construction, with not less than 130° opening angle, and shall be with self-locking arrangement.

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The required marshalling cabinet size shall not be smaller than:

$$WxDxH = 600x250x800\text{mm.}$$

However, if larger cubicle size is deemed required, the same shall be supplied without extra cost.

The marshalling cubicle shall be complete with suitable two entries for termination of two main Protection/Telephone Underground Cables and a gland plate for various facilities cables.

The terminal blocks shall have terminals with an insulated bridging plug, so as to allow a circuit to be isolated. The terminal blocks shall be labeled and numbered according to the appropriate cable cores i.e. (either protection or telephone cores) connected therewith. The proper and adequate earthing points/cables of the cubicle shall be provided.

The Bidder/Contractor shall fit numbered ferrules of an approved type at all terminals. The ferrules shall be of insulating material, which shall be white and shall have a glossy finish. The ferrules shall be resistive against oil or dampness. Characters shall be suitably marked in black.

Only approved compression lugs or washers shall be used at the terminals.

Cable glands required for the terminals shall be supplied and installed. A gland plate of an adequate size to allow glanding of incoming cables from various facilities such as protection, communication (telephone, alarms and data, etc) shall be provided in the bottom of the marshalling cubicle.

The Protection/Telephone Underground Cables entering the marshaling cabinet shall be sealed by compression-type armor gripping mechanical glands. These glands shall be provided with an earth tag and PVC shroud.

The marshaling cabinets shall be equipped with by:

- A marshaling rack with surge arresters for the telephone cores
- A rack with 15 kV AC insulated terminations for the protection cores
- A rack with 15 kV AC insulated terminations for the telephone cores.

Two types of Marshalling Cubicles shall be considered:

- Indoor Marshalling Cubicle
- Outdoor Marshalling Cubicle.

2.1.1.1 Indoor Marshalling Cubicle

The indoor marshalling cubicle shall be insect proof with a protection degree of IP52, made of stainless steel which shall be treated and painted by using an approved type of paint similar to that used for the substation cubicles.

It shall be installed inside the Grid-Stations, Substations or Power Stations.

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It shall possible to be installed in the switchgear rooms on suitable galvanized steel structure or as wall mounted.

The final locations for installation of the marshaling cubicles inside the substations shall be agreed upon by THE OWNER.

The marshaling cubicle shall have a fluorescent lamp for lighting, which shall be controlled by door switch. The lamp shall switch on when the door is open and shall go off upon closing the door.

A 230 V, AC BS socket of not less than 10 A rating, shall be provided in the cabinet for the maintenance purposes.

2.1.1.2 Outdoor Marshalling Cubicle

The outdoor marshaling cubicle shall be insect-proof and water-tight with protection degree of IP55W (weather proof)/NEMA 12, made of stainless steel of a quality corresponding to 1.4301 (V2A) and suitably painted steel and shall be designed such as to form an extremely rigid structure.

The outdoor marshalling cubicles shall be generally installed along the power cable routes at locations that supports the specified voltage withstand of the various cores and correspondingly the respective marshalling cubicle terminals and in the same time to avoid having excess number of straight joints. Therefore it is the responsibility of the Bidder/Contractor to study and propose the laying profile that can achieve this goal successfully which shall be based on calculation taking into consideration the maximum short circuit current as specified for the respective power circuit and the cable laying arrangement/route length.

The outdoor marshalling cubicle shall have rain roof, to enable get rid of any water residue.

The final locations for installation of the marshaling cabinets along the cable route shall be agreed upon by the OWNER.

2.2 Joint for the 17 - pair Protection/Telephone Underground Cable

2.2.1 General

Generally, it is recommended to avoid installing excess number of straight joints for the protection/telephone underground cables by inserting the outdoor termination cubicles. However, inserting straight joints of cable upon failures during service life becomes inevitable.

It is preferable to have the straight joint from the same manufacturer of the respective Protection/Telephone cable manufacturer.

Heat shrink components to be offered shall comply with latest international.

Cold jointing is also considered and therefore all required accessories for the same shall be included in the straight joint to be offered.

2.2.2 Heat Shrink or Cold Shrink Type

The joint for the 17 pair protection/telephone cable shall be embedded in reinforced casing and shall be complete with cable clamps, inner sleeve, protecting sheet, adapter core, outer sleeve, auxiliary heat shrinkable sleeve (if heat shrinkable jointing is performed), self-bonding tape, water blockage compounds, etc.

3 TESTING AND INSPECTION

3.1 General

In connection with the performance of tests general reference is made to the Standard Technical Specification, Part:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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All tests shall be performed in line with these Standards.

The Bidder/Contractor may be required to carry out any one or all of the tests stated in this Specification under the witness of the OWNER or their representatives.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed 17 pair Protection/Telephone Underground Cable Accessories.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to the OWNER.
2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the OWNER.

If the presented type test reports are not in accordance with the above requirements, the OWNER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the OWNER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

The tests shall comprise but not limited to the following:

3.2 Factory Tests

3.2.1 Type Tests

Type Tests shall be performed comprising as a minimum the following tests:

a) Mechanical/Material Characteristics:

- Impact test on joint
- Water tightness for joint.

b) Electrical Characteristics:

- Voltage test on cable outer sheath (including joint) as follows:
 - 10 kV AC for 1 min. between armouring and conductive coating for the outer sheath of both the cable and joint, after the sample had been already immersed in water at + 75 °C for 5 hours, followed by natural cooling. This procedure shall be carried out seven times (one per day)
 - High voltage test (15 kV AC / 1 min) on the cable cores during each of the above mentioned seven cycles, including joints, between any core and ground while all screens/armour and remaining cores are grounded.
 - High voltage test on the marshaling cabinets with connected protection/telephone cable of approx. 5 m length (15 kV AC for 1 min. between adjacent terminal connections for protection and telephone cores, with all remaining terminals and the cable screens and armorings earthed).

3.2.2 Sample Tests

Sample Tests shall be performed, comprising as a minimum the following tests:

- High voltage test (15 kV AC / 1 min between any core and ground while all screens/armour and remaining cores are grounded).
- Cable construction and measurements of dimensions
- Sheath marking as per Technical Data Sheets.

3.2.3 Routine Tests

Routine Tests shall be performed, comprising as a minimum the following tests:

- Conductor resistance measurement

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- Capacitance measurement at 800 Hz
- Insulation resistance measurement
- High Voltage test (8 kV AC / 1 min. between any core and ground while all screens/armour and remaining cores are grounded).
- Voltage tests on outer sheath (10 kV AC / 1 min. between armoring and conductive coating).

3.3 Site Tests

Site Tests on the installed protection/telephone cable shall be performed, comprising as a minimum the following tests:

- Cores identification
- Conductor resistance measurement (loop test)
- Insulation resistance measurement
- Capacitance measurement

Attenuation over the frequency range after terminating all cable cores as given in the

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FIBRE OPTIC CABLE ACCESSORIES

OES2: S-CAB-ACC-FOC-I (REV.0-2010)



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FIBRE OPTIC CABLE ACCESSORIES

1 GENERAL

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to site, installation, site testing and commissioning of Fibre Optic Cable Accessories. Further detailed and specific data are contained in the drawings, Technical Data Sheets and other documents that form part of these Tender Documents.

The required Fibre Optic Cable Accessories shall be complete in all respects necessary for their effective and trouble free operation when connected to the system.

For applicable technical standards, tests and general requirements reference shall be made to:

➤ OES2: S-CAB-GEN	-	General Requirements (Applicable Technical Standards, Tests, etc.)
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2 TECHNICAL DESCRIPTION

2.1 General

This specification covers the technical requirements for the accessories of the Fibre Optic Underground Cable. The cable accessories comprise but not limited to the indoor and outdoor termination/splice cubicle as well as the straight joints.

A suitable jointing technology shall be applied to minimise the equipment and components necessary for jointing, maintenance and repairing. The joints shall consist of common components (fibre splicing, etc.), end components (clamping material of the armour wires, etc.) and protection components (outer casings, etc.).

To reinstate the physical properties of the cable after jointing, the requirements shall be followed:

- Fibre package restrain to allow free movement of the fibres
- Management of the fibres to prevent bending beyond the permissible radius
- Fibre splicing with specified attenuation limits

The Fibre Optic Underground Cable, its termination cubicles and joints to be offered under this specifications shall preferably be made by the same cable manufacturer in order to ensure the compatibility, reliability and responsibility. The cable accessories must be type tested to the internationally recognised standards such as IEC & other relevant international Standards, in respect of mechanical, environmental and optical performance prior to shipment to site.

The design service life of the required cable accessories must be at least the same as that for fibre optic cable. Preference will be given to longer design service life and warranty, if proposed by

the Bidder/Contractor. In addition, preference will be given to those accessories, which are maintenance free during their operation life.

2.2 Indoor Termination/Splice Cubicles

The Fibre Optic Underground Cables shall be terminated at easily accessible terminal blocks inside termination/splice cubicles. The fibres shall be terminated in low loss, screw-on type of connectors suitable for withstanding high voltage hazards.

The indoor Termination Cubicles shall be insect-proof and with protection degree of at least IP 52 made of suitably painted Stainless Steel and shall be designed such as to form an extremely rigid structure. The doors shall be of hinged construction with self-locking arrangement. The termination boxes shall be suitable for wall mounting or for erection on steel structures. They shall be installed inside the control building.

The design of the termination cubicle shall consider in general two Fibre Optic Underground Cable entries and sufficient number of outlets for patch cords (not less than the number of fibres) with the required cable gland(s). The same number of pigtails shall be supplied and spliced to the main Fibre Optic Cable or to the approach cable (reaching from the Gantry) and terminated by a female low loss connector.

The connectors shall be fixed inside the termination cubicle on connector holder, which shall allow easy access to each of the connectors. The Patch cord cable's length shall be 10m and shall be provided with suitable male connector in order to form screw-on type. The loss of connector bulkhead and pigtail splice shall not be more than 0.3 dB.

While executing the termination works, the cable sheath and any armouring shall be stripped off and then affixed to the termination/splice cubicle. Finally, the buffer fibres are affixed in special fibre splice trays (metal) and stripped with sufficient extra length.

The fibres are stored on these trays and spliced to the departing fibres or to the pigtails. The pigtails then shall be terminated by the female connectors.

The number of connectors shall be equal to the number of fibres plus 20%.

The number of splice slots shall be equal to the number of fibres plus 20%.

2.3 Outdoor Splice Cubicles

Along the cable route Fibres shall be spliced inside a transit Splice cubicle with all splices racked on splice holders. The splice loss shall not be more than 0.05 dB.

The outdoor splice cubicle shall be insect-proof and water-tight with protection degree of IP55W (weather proof), made of suitably painted Stainless Steel and shall be designed such as to form an extremely rigid structure. The doors shall be of hinged construction with self-locking arrangement. The splice cubicle shall be suitable for mounting on steel structures. They shall be installed along the cable route at distances approximately equal to the cable length on the drum.

The design of the splice cubicle shall consider at least two Fibre Optic Underground Cable entries. The cubicle shall cater for a number of splice slots for the specified number of fibres plus 20%.

The sheath and any armouring shall be stripped and then affixed to the splice cubicle. Finally, the buffer fibres are affixed in special fibre splice trays (metal) and stripped with sufficient extra length.

The fibres are stored on these trays and spliced to the departing cable fibres.

2.4 Straight Joint

Generally, it is not recommended to have excess number of Fibre Optic Underground Cable joints along the cable route and instead termination cubicles to be used. However, in the case of cable damage during the service life, the straight joint becomes inevitable.

It is preferable to have the straight joint from the same manufacturer of the respective Fibre Optic Underground Cable.

The Fibre Optic Underground Cable joints shall be embedded in reinforced nylon/glass fibre sleeves. The joints shall be complete with cable clamps, inner split sleeve, protecting sheet, fibre guide, adapter core, outer sleeve, auxiliary heat shrinkable sleeve, self-bonding tape, etc.

Heat shrink components to be offered shall comply with latest international.

Cold jointing is also considered and therefore all required accessories for the same shall be included in the straight joint to be offered.

2.4.1 Heat Shrink or Cold Shrink Type

The joint for the Fibre Optic Underground Cable shall be embedded in reinforced casing and shall be complete with cable clamps, inner sleeve, protecting sheet, adapter core, outer sleeve, auxiliary heat shrinkable sleeve (if heat shrinkable jointing is performed), self-bonding tape, water blockage compounds, etc.

3 TESTING AND INSPECTION

3.1 General

In connection with the performance of tests general reference is made to the Special Conditions of Contract. All tests shall be performed in line with these Conditions.

The Bidder/Contractor may be required to carry out any one or all of the tests stated in this Specification to be witnessed by the OWNER or its representatives.

Tests of the Accessories of Fibre Optic Underground Cables shall be performed according to the relevant latest issues of ITU-T and IEC recommendations valid at time of awarding the Contract. If any single test to be referred to other recommendation, the same shall clearly be stated and the deviation from the ITU-T & IEC must be stated, upon which decision can be made by the OWNER.

The tests range shall comprise but not limited to the following:

3.2 Factory Tests

3.2.1 Type Tests

Evidence shall be given that the proposed Fibre Optic Underground Cable Accessories to be supplied under this specifications has passed successfully all the type tests in respect of the optical, electrical, environmental and mechanical performance. The OWNER may decide to require additional tests, without extra cost, if deemed necessary.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed Fibre Optic Underground Cable Accessories.

Type tests certificates/reports shall be considered acceptable if they are in compliance with the relevant Standards and the following:

1. Type Tests conducted at an internationally recognised laboratory acceptable to the OWNER.
2. Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to the OWNER.

If the presented type test reports are not in accordance with the above requirements, the OWNER may decide to ask for the type tests to be carried out in the manufacturer premises or other places subject to the approval of the OWNER at no additional cost, and in the presence of an internationally recognised laboratory who should issue the relevant type test certificates upon successful test.

The type tests on the Accessories of Fibre Optic Underground Cable shall comprise but not be limited to:

- 1) Visual checking (termination cubicle and straight joint)
- 2) Vibration test (termination cubicle)
- 3) Water tightness for outdoor items (termination cubicle and straight joint)
- 4) Insertion loss (termination cubicle and straight joint)
- 5) Temperature performance (termination cubicle and straight joint).

3.2.2 Sample Tests

Sample tests on the Accessories of Fibre Optic Underground Cable shall comprise but not limited to:

- 1) Visual checking
- 2) Dimensions
- 3) Insertion loss.

3.2.3 Routine Tests

- 1) Visual checking
- 2) Dimensions.

3.3 Site Tests

3.3.1 Pre-Commissioning Test

Upon installation of the Accessories for the Fibre Optic Underground Cable, the following tests, but not limited to, shall be carried out:

- 1) Visual and cable termination checks
- 2) Earthing
- 3) Splice and connector loss
- 4) Labelling.

3.3.2 Commissioning Tests

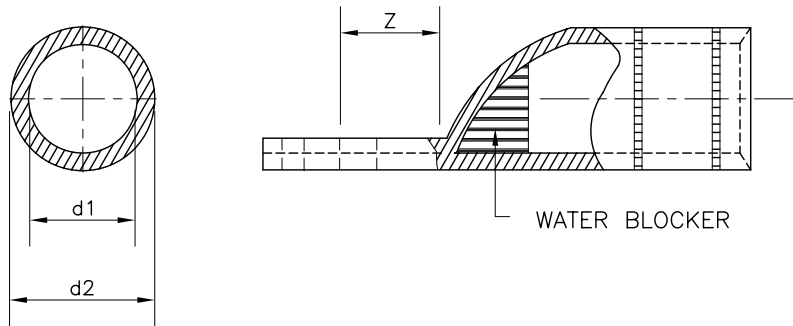
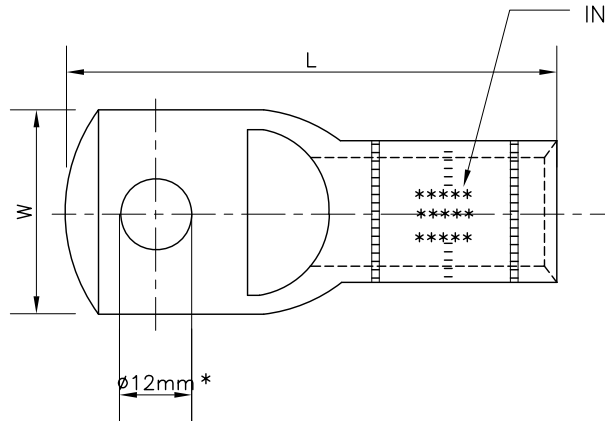
The Bidder/Contractor shall carry out all optical and electrical tests on the accessories after installation of the fibre optic cables and accessories have been completed, according to latest IEC recommendations.

OES 2 - 3rd EDITION, DRAWINGS - Rev.0-2010

03_accessories

Drawing No.		Title
Former DWG No.	New 3rd EDITION DWG No.	Rev.
-	DWG/OES2/UG1-AUX-SC	A Typical Cross Section of 33, 132kV XLPE Coaxial Bonding Cable
-	DWG/OES2/UG1-AUX-CL	A 33 kV Cable Lug Dimensions
-	DWG/OES2/UG1-AUX-CJF	A 33 kV Cable Joint Ferrule Dimensions
-	DWG/OES2/UG2-AUX-CL	A 11 kV Cable Lug Dimensions
-	DWG/OES2/UG-AUX-CJF	A MV Cable Joint Ferrule Dimensions
-	DWG/OES2/UG3-AUX-CL	A LV Cable Lug Dimensions
-	DWG/OES2/UG3-AUX-CJF	A LV Cable Joint Ferrule Dimensions
-	DWG/OES2/UG-AUX-WC	A Sample of Wooden Cleat
-	DWG/OES2/UG-AUX-TFC	A Sample of Trefoil Cleat
-	DWG/OES2/UG-AUX-MC	A Sample of Multicleat

MANUFACTURES NAME AND SIZE
IN mm² TO BE EMBOSSED ON LUG




Conductor Size mm ²	L mm	W mm	Z mm	d1 mm	d2 mm
240	107.2	41.5	14.4	20.3	29.7
300	107.2	45.0	14.4	23.0	29.7
500	136.8	55.4	17.4	29.8	38.1
630*	173.0	62.7	28.0	34.3	44.1

Remarks:

*630 mm² Lug hole =16 mm

REVISIONS		
NO.	DESCRIPTION	DATE

Buckow	03.2009	ORIGINAL ISSUE
NAME	DATE	NOTE



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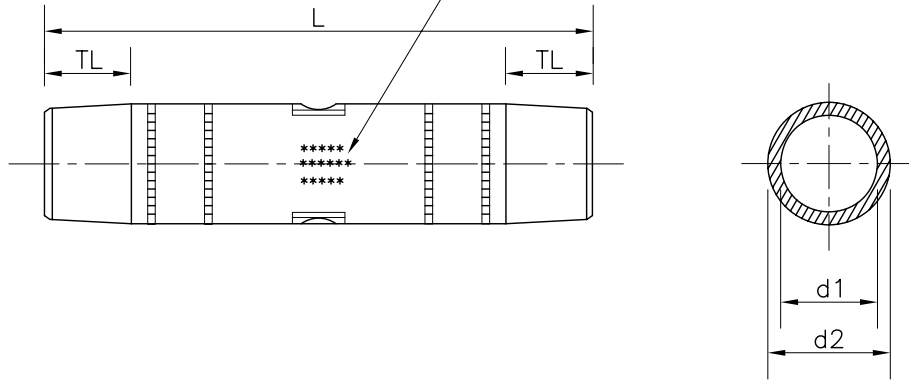
OMAN ELECTRICAL STANDARDS

	NAME	DATE
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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	03.2009
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.:		


**33 kV Cable Lug
Dimensions**

CAD-FILE	SCALE N.T.S	DRWG. NO. DWG OES2/UG1-AUX-CL-A
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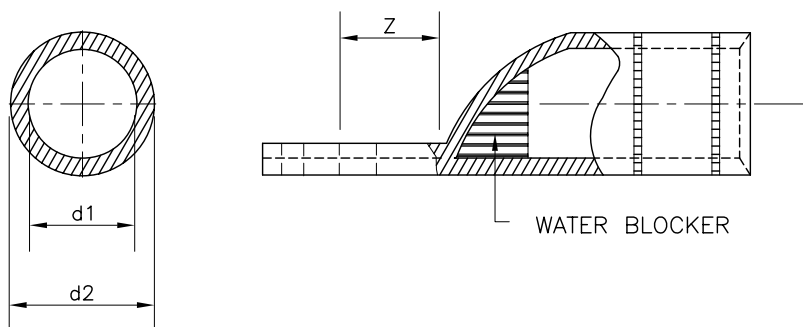
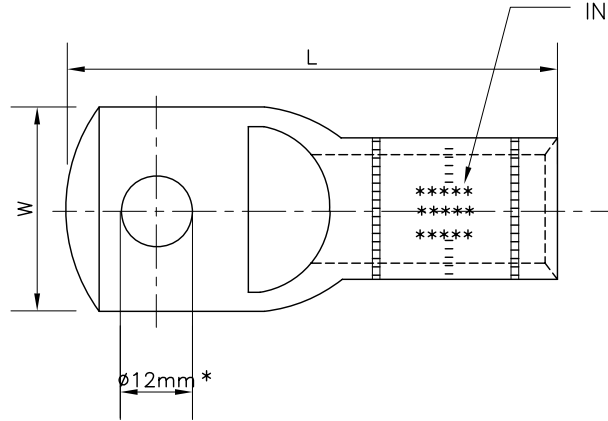
MANUFACTURES NAME AND SIZE
IN mm² TO BE EMBOSSED ON
CONNECTOR



Conductor Size mm ²	L mm	d1 mm	d2 mm	TL mm
240	120	20.3	29.7	19.8
300	120	23.0	29.7	19.8
500	120	29.8	38.1	13.0
630	159	34.3	44.1	5.0

REVISIONS		
	Buckow	03.2009
	NAME	DATE
		ORIGINAL ISSUE
		NOTE
 SULTANATE OF OMAN OMAN ELECTRICAL STANDARDS		
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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
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SUPERSEDED BY DRWG. NO.:		
CAD-FILE	SCALE	DRWG. NO.:
	N.T.S	DWG OES2/UG1-AUX-CJF-A
33 kV Cable Joint Ferrule Dimensions		

MANUFACTURES NAME AND SIZE
IN mm² TO BE EMBOSSED ON LUG




Conductor Size mm ²	L mm	W mm	Z mm	d1 mm	d2 mm
95	78.0	27.2	12.4	12.8	20.0
120	90.6	32.0	14.4	14.3	22.5
185	95.6	32.0	14.4	17.8	22.5
240	107.2	41.5	14.4	20.3	29.7
300	107.2	45.0	14.4	23.0	29.7
500	136.8	55.4	17.4	29.8	38.1
630*	173.0	62.7	28.0	34.3	44.1

Remarks:

* 630 mm² Lug hole = 16 mm

REVISIONS		
NO.	DESCRIPTION	DATE

Buckow	03.2009	ORIGINAL ISSUE
NAME	DATE	NOTE



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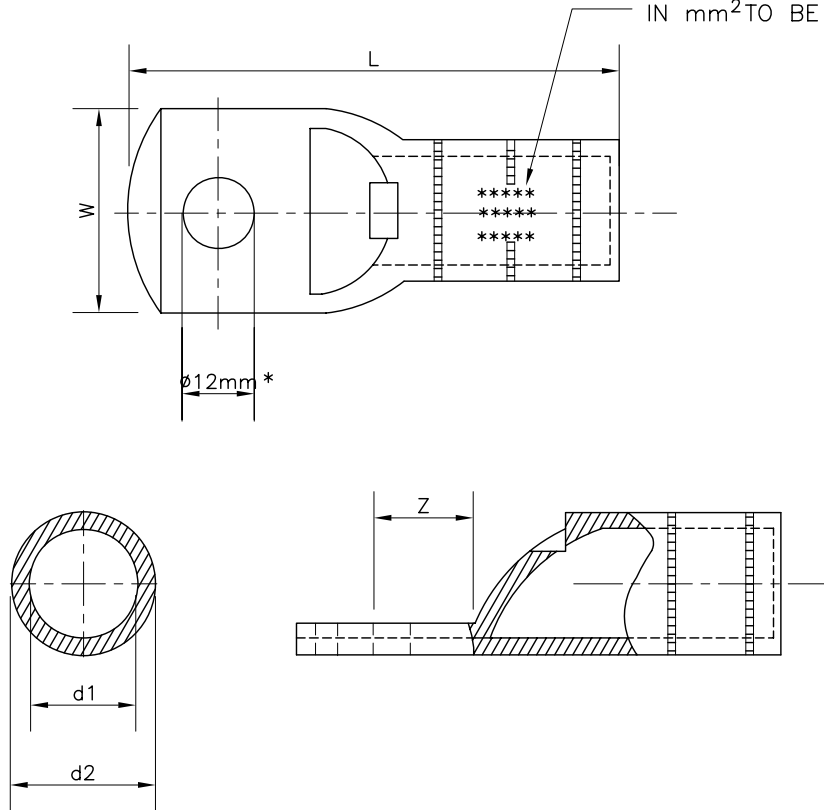
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DRAWN	Saji	03.2009
CHECKED	GEWHS	03.2009
APPROVED	AER-TD	
SHEET SIZE	DIN A4	
SUPERSEDED BY DRWG. NO.:		

**11 kV Cable Lug
Dimensions**

CAD-FILE	SCALE N.T.S	DRWG. NO. DWG OES2/UG2-AUX-CL-A
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MANUFACTURES NAME AND SIZE
IN mm² TO BE EMBOSSED ON LUG




Conductor Size mm ²	L mm	W mm	Z mm	d1 mm	d2 mm
16	43.4	20.8	11.9	5.7	7.9
25	44.1	20.6	13.4	7.2	9.5
50	47.3	21.8	14.3	9.3	13.0
70	58.7	23.9	14.3	12.8	16.1
120	59.5	29.0	14.3	15.9	19.6
185	88.5	35.6	14.3	19.4	24.2
240	90.3	41.1	14.3	22.2	28.6
630*	119.8	62.7	20.6	34.3	44.1

Remarks:

* 630 mm² Lug hole = 16 mm

REVISIONS		NAME	DATE	NOTE
		Buckow	03.2009	ORIGINAL ISSUE



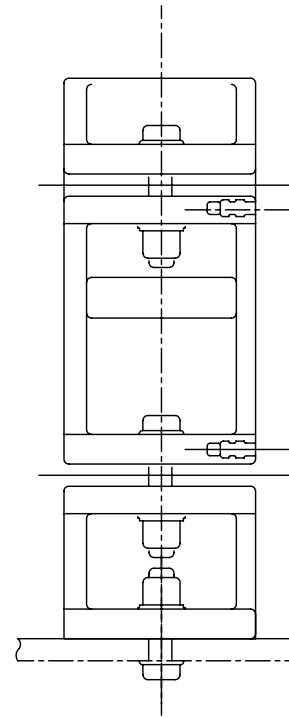
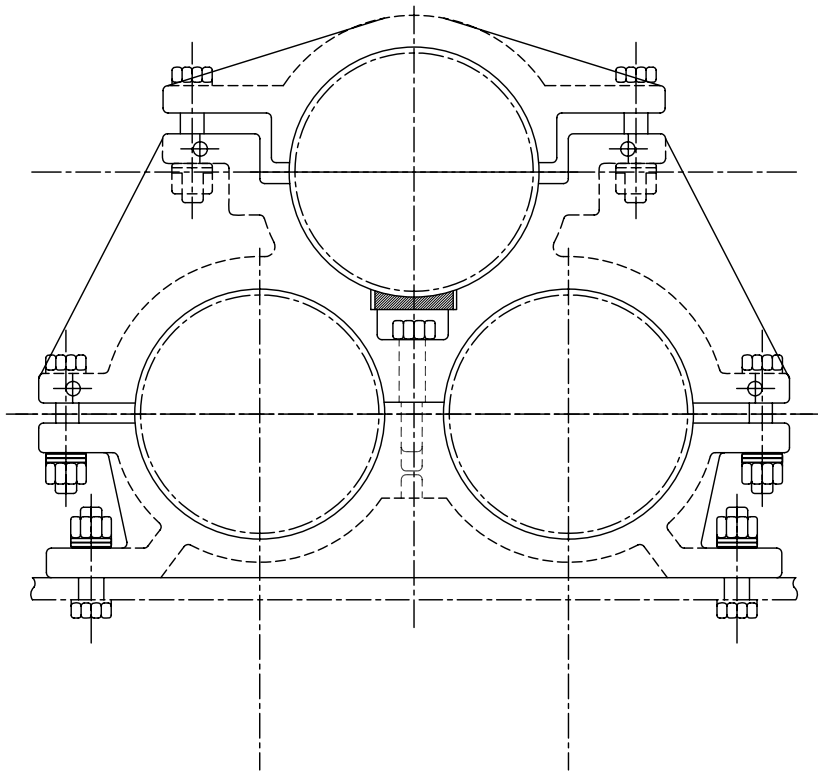
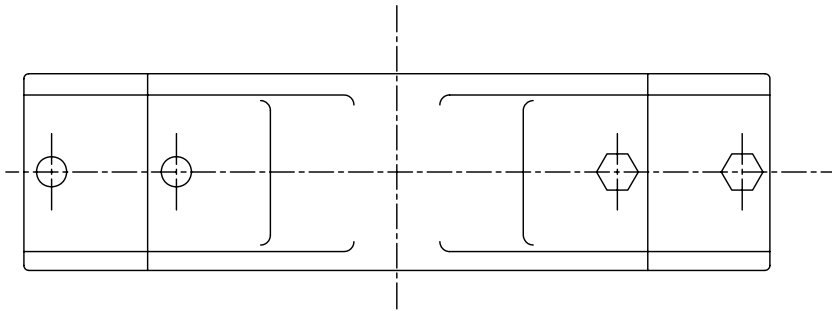
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APPROVED	AER-TD	03.2009
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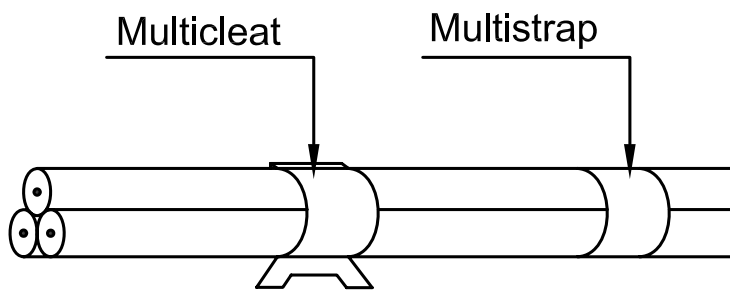
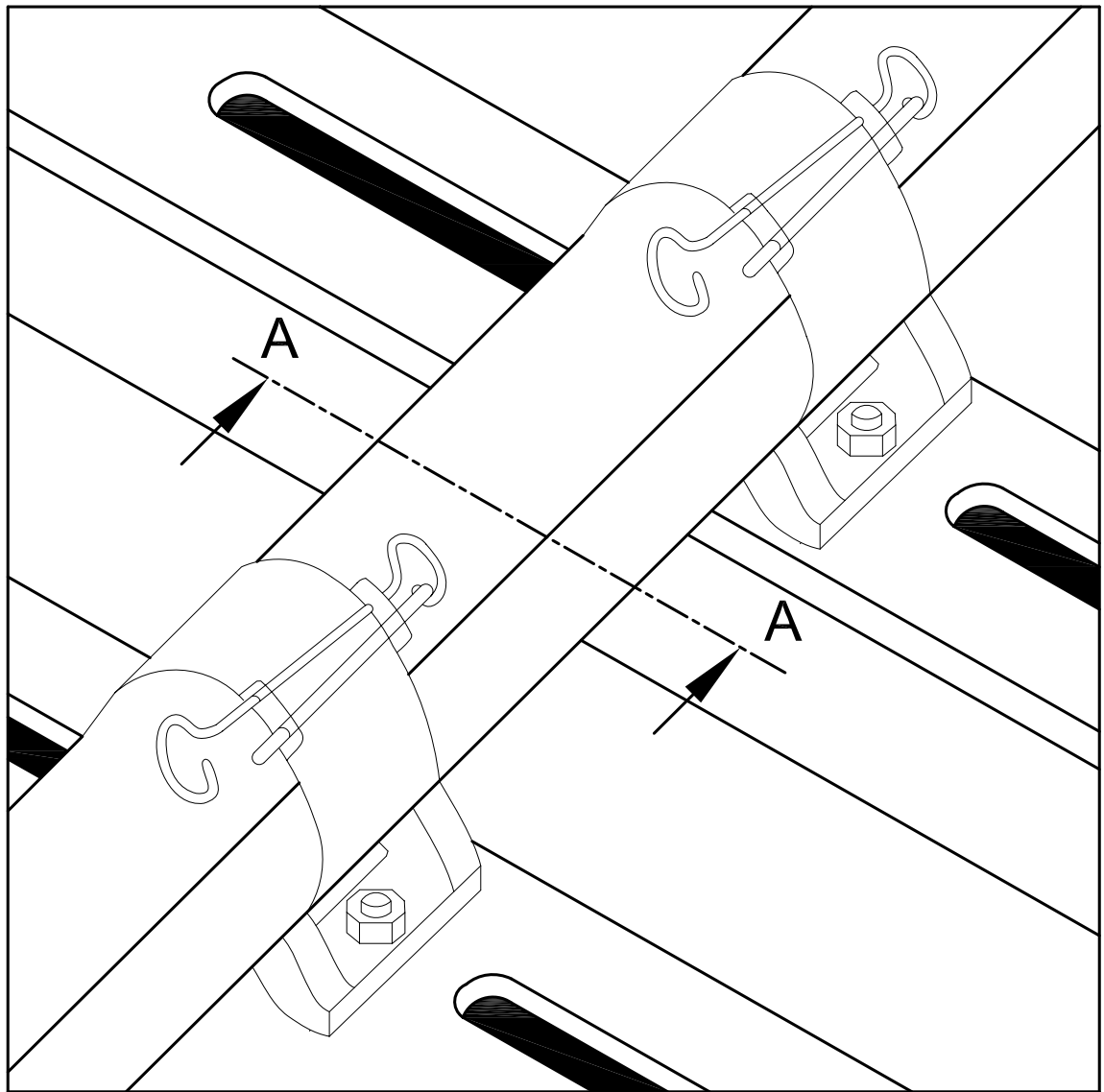
**LV Cable Lug
Dimensions**

CAD-FILE	SCALE N.T.S	DRWG NO: DWG OES2/UG3-AUX-CL-A
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REV	NAME	DATE	NOTE
01	Buckow	03.2009	ORIGINAL ISSUE

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APPROVED	AER-TD	03.2009																						
SHEET SIZE	DIN A4																							
SUPERSEDED BY DRWG NO:																								
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	N.T.S	DWG OES2/UG-AUX-TFC-A																						



Section A-A

REVISIONS	NAME	DATE	ORIGINAL ISSUE	NOTE
	Buckow	03.2009		



SULTANATE OF OMAN

OMAN ELECTRICAL STANDARDS

PREPARED	Buckow	03.2009	Sample of Multicleat
DRAWN	Saji	03.2009	
CHECKED	GEWHS	03.2009	
APPROVED	AER-TD	03.2009	
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SUPERSEDED BY DRWG NO:			
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