

**OMAN WASTEWATER
SERVICES COMPANY S.A.O.C**



**الشركة العمانية
لخدمات الصرف الصحي ش.م.ع.م**

OMAN WASTEWATER SERVICE COMPANY

ELECTRICAL STANDARD SPECIFICATION

SECTION 09

POWER CABLES

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TABLE OF CONTENTS

Item	Description	Page
01	Scope	1/17
02	Codes And Standard	1/17
03	Service Construction	2/17
04	Cable Glands	16/17
05	Inspection And Testing	17/17
06	Deviations	17/17

1-0 SCOPE

This specification covers the design, manufacture and testing of power and control cable to be installed to be installed within Oman Wastewater Services Company projects.

2-0 CODES AND STANDARDS

All power and control cable shall be manufactured and tested (except where otherwise specified) with the latest versions of the following codes and standards:

2-1 British Standards

2-2 IEC Standards:

§ IEC 228 Conductors of insulated cables,

§ IEC 332 Tests on electric cables under fire conditions,

§ IEC 382 Extruded solid dielectric insulated power cables for rated voltages from 1kV to 30 kV,

§ IEC 541 Test methods for insulation and sheaths of electric cables and cords.

2-3 National Fire Protection Association (NFPA)

2-4 Omani Electrical Standards.

3-0 CABLE CONSTRUCTION

3-1 General

Cable construction shall be in accordance with the following:

- 3-1.1 The cable sheath shall be marked with the information required by the relevant BS or BS EN.
- 3-1.2 Cables shall be delivered within 12 months of manufacture and shall be delivered to site on cable drums or coiled with protective wrappings.
- 3-1.3 Cables shall be new and drummed in maximum continuous lengths.
- 3-1.4 Cables shall be delivered, stored and handled in accordance with the cable manufacturer's instructions. If the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at either end.
- 3-1.5 Cables shall be of the voltage grade, conductor size, and type appropriate to the application and be in accordance with the type specification.
- 3-1.6 The outer sheath of all cables shall be coloured black, with the exception of protective conductors, where the sheath shall be coloured green/yellow.
- 3-1.7 Oversheaths shall be embossed at no greater than 1m intervals with the following: Manufacturer name, voltage grade, number of cores, size of conductors and year of manufacture.
- 3-1.8 Cables shall have copper conductors complying with BS EN 13602. Cores of cross sectional area greater than 1.5 mm² shall be stranded or flexible.
- 3-1.9 If neutral conductors are provided, they shall be of the same cross sectional area as the associated phase conductor.
- 3-1.10 Any damage to any of the cables, or the outer sheaths, during installation shall not be accepted.

3-2 Cable Applications:

3-2.1 Power Cables:

They are defined as low voltage cables between power transformers, low voltage switchgear and controlgear assemblies and motors etc. and used for the distribution and utilisation of power.

The minimum cross sectional area of cable conductors shall be 2.5 mm².

3-2.2 Control Cables:

They are defined as low voltage and extra low voltage cables between low voltage switchgear and controlgear assemblies and control switches, pushbuttons and indicating lamps and used for the control of power.

The minimum cross sectional area of cable conductors shall be 0.75 mm².

3-2.3 Small Power and Lighting Cables:

They are defined as low voltage cables between low voltage switchgear and socket outlets, heating, ventilation and lighting systems and used for the distribution and utilisation of ancillary/domestic power.

The minimum cross sectional area of cable conductors shall be 1.5 mm².

3-2.4 Signal/Instrument Cables:

They are defined as extra low voltage and discrete or analogue signaling (up to 24 V, 0-20 V, and 4-20 mA) cables between common control and instrumentation systems used for control and monitoring of the process.

The minimum cross sectional area of cable conductors shall be 0.75 mm² (24/0.2 mm).

As recommended by the equipment manufacturer, individual screens shall be used for connections to signalling and instrumentation equipment including, but not limited to, measuring transmitters, analogue controllers (4-20 mA dc), data loggers, telemetry systems, microprocessors, computers, strain gauges, transducers etc.

3-2.5 Data Transmission Cables:

They are defined as extra low voltage, digital signalling cables between computers, programmable logic controllers (PLCs) and remote telemetry units (RTUs) and other data transmission equipment.

The minimum cross sectional area of cable conductors shall be 0.5 mm².

Individual and collective screens shall be used for data transmission cables.

3-2.6 Telecommunication Cables:

They are defined as extra low voltage, voice and low frequency digital signaling cables and forming part of a telephone network.

3-3 Types of Cable Permitted:

3-3.1 Power and Control Cables (Including Small Power and Lighting Cables)

The following types of cable are permitted:

Type of Cable	Relevant Standard	Rating (V)
1. XLPE/PVC (single core)	BS 7889	600/1000
2. (XLPE/AWA/PVC and XLPE/SWA/PVC)1	BS 5467	600/1000
3. PVC/PVC	BS 6346	600/1000
4. (PVC/AWA/PVC and PVC/SWA/PVC)1	BS 6346	600/1000
5. (Single core PVC)2, 3	BS 6004 (Table 1)	450/750
6. (Flat twin and earth PVC)	BS 6004 (Table 5)	300/500
7. (Flexible PVC/PVC)4	BS 6500 (Table 26 or 28)	300/500
8. (Flexible PVC/PVC)5	BS 7919	300/500
9. (Armoured, heat and oil resisting and flame retardant (formally designated HOFRR))1, 6	BS 6883	600/1000

10. Flexible, heat and oil resisting and flame retardant (formally designated HOFR)	BS 7919	450/750
11. (XLPE/LSF)7	BS 7211	450/750
12. (XLPE/AWA/LSF and XLPE/SWA/LSF)1, 7	BS 6724	450/750
13. (XLPE/LSF)7, 8, 9	BS 7629	300/500
14. (XLPE/AWA/LSF and XLPE/SWA/LSF)1, 7, 8, 9	BS 7846	600/1000
15. (MI/PVC10 and MI/LSF)7, 8, 9	BS EN 60702-1	750

Notes:

1. Single core, armoured cables shall have aluminum wire armour.
2. The insulation shall be phase coloured and, if used in single-phase systems, line cables shall be red and neutral cables black.
3. This type of cable shall only be used within conduit or trunking.
4. This type of cable shall only be used in offices and similar environments.
5. This type of cable shall be used in industrial and similar environments.
6. This type of cable shall comply with BS 6883, Section 3 (insulation type GP4 (BS 7655-1, Section 1.2); sheathing type A/RS3 (BS 7655-2, Section 2.3)).
7. LSF cables shall only be used in public areas and in areas where there is a significant risk of harm to persons or equipment in the event of a fire involving cabling.
8. These types of cable shall be used if there is a specific requirement to maintain circuit integrity under fire conditions in accordance with BS 6387 (e.g. gas detection systems, fire detection/alarm/fighting systems, protected lighting circuits, emergency lighting systems).
9. This type of cable shall not be buried directly in the ground or in the fabric of the building.
10. The PVC sheath shall be coloured as follows:
 - a) Gas detection systems Black;
 - b) Fire detection/alarm/fighting systems Red;
 - c) Emergency lighting Orange; and
 - d) Security systems Grey.

3-3.2 Signal/Instrument Cables

The following types of cable are permitted:

Type of Cable	Relevant Standard	Rating (V)
1. (PE/IS/PVC and PE/CS/PVC)1	BS 5308-1 (Type 1)	300/500
2. (PE/IS/SWA/PVC and PE/CS/SWA/PVC)1	BS 5308-1 (Type 2)	300/500

3. (PVC/IS/PVC and PVC/CS/PVC)1	BS 5308-2 (Type 1)	300/500
4. (PE/IS/SWA/PVC and PE/CS/SWA/PVC)1	BS 5308-2 (Type 2)	300/500

Notes:

Cables shall have stranded, copper conductors.

3-3.3 Data Transmission Cables:

The following types of cable are permitted:

- a) Those complying with BS 5308: Parts 1 and 2;
- b) Belden or equivalent;
- c) Category 5; and
- d) Those specified by the equipment manufacturer.

3-3.4 Telephone:

For external or exposed applications, cables shall comply with Oman and British Telecom specifications CW 1128 and CW 1198.

For internal applications, cables shall comply with British Telecom specification CW 1308.

Cables shall have the required number of 1.0 or 0.5 mm diameter copper conductors (minimum of 3 pairs).

3-3.5 Special:

The particular specification shall detail cable specifications for other specialized applications including the following:

- a) Steel tape armoured PVC flexible, SY Control flexible
- b) High energy circuits or low level signal circuits
- c) Co-axial cables for ultra-sonic transducer connections
- d) Compensating cables for thermocouple connections
- e) Ethernet, FDDI (fibre optic Ethernet), field bus, optical fibre
- f) Manufacturers specials (e.g. flow meters)


Special cables shall be installed strictly in accordance with the cable manufacturer's recommendations.

Where a non-rigid power cabling installation is necessary, the cabling shall have multi-stranded copper conductors and be selected from the following: -

- a) Un-armoured cable to be used for final connections to low power equipment operating at 230v and below and for flex outlet wiring accessories.
- b) Braided armour cable to be used for final power connections to moving plant, where total flexibility and significant abrasion resistance are required e.g. submersible pumps. Core insulation shall be EPR, with braided or pliable wire armour and a CSP outer sheath.

3-4 Installation of Cables:

- 3-4.1 Cable installation shall comply with the requirements of BS 7671 and the recommendations of IEE Guidance Note No. 1: Selection and Erection (latest Edition) with particular reference to Appendix I.
- 3-4.2 Cables shall be installed strictly in accordance with the cable routes drawing.
- 3-4.3 Cables installed in groups shall run in straight lines and not cross over each other.
- 3-4.4 Cables installed above ground shall, as far as practicable, run parallel with the lines of building construction.
- 3-4.5 Cables buried below ground shall, as far as practicable, follow the features of the site such as roadways and building lines.
- 3-4.6 Cables and their support systems shall not be fixed to protective barriers, guards or directly to guard-rails.
- 3-4.7 Cables shall be installed strictly in accordance with the cable manufacturer's instructions with respect to:
 - a) Minimum bending radii
 - b) Temperature of installation

	STANDARD SPECIFICATION		Page 8 of 17
	Doc. Number	Date of issue	Rev
	PRJ – SS- 04-09	04/06/2008	01

c) Operating environment

3-4.8 Unless agreed otherwise with the Engineer, joints shall not be permitted in individual power and control cables. This does not preclude the use of marshalling boxes for control circuits or local junction boxes for motor control cables.

3-4.9 Cables that may be subject to accidental mechanical damage shall be suitably protected by cable guards.

3-4.10 Proprietary cable support systems shall be used.

3-5 Segregation/Separation

Cables shall be classified as follows:

- a) Band 1 (refer to BS 7671) - extra low voltage cables (signal /instrument, data transmission and telecommunication)
- b) Band 2 (refer to BS 7671) - low voltage cables (power, control, small power and lighting)
- c) Intrinsically safe
- d) HV

Unless otherwise specified by the cable manufacturer or for reasons of EMC or safety, the minimum segregation between cables of different classifications and other non-electrical services, shall comply with the following table:

Segregation (mm)	Band 1	Band 2	IS	HV	Other Services (Above Ground)	Other Services (Below Ground)
Band 1	-	300	50	500	150	500
Band 2	300	-	300	300	150	500
IS	50	300	-	500	150	500
HV	500	300	500	-	300	500
Other Services (Above Ground)	150	150	150	300	-	-
Other Services (Below Ground)	500	500	500	500	-	-

Notes:

The above figures need not apply to short lengths of cables local to the equipment to which they are connected.

Cables of different classifications shall not be installed in the same duct.

3-6 Sealing of Cable Routes

The open ends of all cable ducts (included unused ducts) and openings in building structures specifically provided for the passage of cables (including unused openings) shall be sealed after cable installation to prevent the ingress of harmful or flammable gases, liquid, smoke, fire and vermin.

The type of sealing systems used shall be agreed with the Engineer and shall be selected and installed with due regard to environmental and hazardous area requirements. They shall form one of the following:

- Approved water, gas and fire sealing transit units with fillers and insert blocks fitted to suit all cables and conduits
- Approved oil based, non-setting, reusable sealing compound inserted into the duct or

- opening around all cables and conduits
- Approved fire retardant, caulking compound or fibre blocks supplied in two halves and
- Shaped to accommodate all cables and conduits

If 'long-haul' telemetry cables between sites enter and leave a duct in a draw pit, the entries and exits shall be left unsealed, if agreed with the Engineer.

3-7 Cable Installation - Inside Buildings

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

Cables are to be adequately supported as to prevent sagging.

Fixing of cables direct to structures via cable cleats shall be prohibited on cable routes containing more than two cables.

No direct fixing shall be made onto any pipe, vessel or equipment.

3-8 Cable Installation - Outside Buildings and Below Ground

Any damage to the cable, or the outer sheath, during installation shall not be accepted.

Cables of rated voltage above 1000 V up to and including 11 kV shall be buried at a depth of 800mm to the cable centre.

All cables shall be installed in continuous lengths without through joints or tees. Joints shall be installed where approved by the Engineer and then joints shall be to BS6910 and recorded on the drawings. Joints shall not be permitted under roads or other inaccessible areas.

3-9 Trenches, Ducts and Draw pits

3-9.1 Trenches:

- a) The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.

- b) Machine digging shall not be permitted within 1 m of suspected cable positions.
- c) Lines of trenches shall be kept as straight as possible.
- d) Trenches shall have vertical sides, supported to avoid subsidence. If a change in ground level is necessary, the bottom of the trench shall rise or fall gradually.
- e) To ensure that trench bottoms are firm, smooth and free of loose stones and debris, they shall be lined with approximately 75 mm of sand or other approved material.
- f) The trench backfill shall be compacted in layers of a maximum thickness of 150 mm and the surface reinstated to a condition not inferior to that of the surrounding ground.
- g) 150 mm wide, yellow, PVC marker tape, marked 'DANGER ELECTRIC CABLE' shall be laid over the centre of each 300 mm width of the trench, 150 mm below ground level.
- h) Proprietary concrete cable markers shall be placed at a minimum of 50 m intervals, changes in trench direction and at road crossings.

3-10 Installation of Direct Buried Cables

3-10.1 Cables shall be installed in ducts if trenches pass under roads, footpaths and foundations.

3-10.2 In soft ground, cables shall have a minimum of 500 mm of cover.

3-10.3 Cables shall be laid on a bed of 150mm of sand and covered by a further 150mm of sand (after tamping). Selected backfill shall be used above the sand bed and surround. The first 250 mm of reinstatement above the sand layer shall be free of stones and sharp objects. Cable identification tape to be laid on top of the final sand cover before backfill.

3-10.4 Cables shall not be pulled tight before back-filling to allow for the effects of ground movement/subsidence.

3-10.5 All cables shall be of armoured construction.

3-10.6 Where HV cables are laid direct in trenches, it is essential that spoil can not fall onto the cables.

3-11 Installation of Cables in Concrete Troughs

3-11.1 All trough covers shall be lifted before starting work and replaced on completion of the work.

3-11.2 The open trough shall be left in a safe condition at all times and no work shall be carried out in a trough while its covers are in place.

3-11.3 Cables shall not be installed in concrete troughs with pipes conveying flammable gases and liquids, corrosive materials or sewage sludge.

3-11.4 Cables shall be supported on hangers, trays etc. and shall be securely cleated. Cables shall not be laid on the floor of the trough, unless agreed otherwise with the Engineer.

3-11.5 Cable hangers, trays etc. shall be fixed to the trough walls so that cables can be readily removed and properly replaced at a later date. If the cable trough carries mixed services, cables shall be installed to avoid damage from these services.

3-12 Installation of Ducts in Trenches

3-12.1 Types of Ducts

Rigid ducting shall consist of:

- Unplastiscised PVC pipework, complying with BS 4660
- Vitrified fireclay pipework
- Corrugated plastic ducting.

Rigid ducting shall have proprietary, self-aligning, water tight joints and a smooth internal bore.

3-12.2 Installation

- Sufficient ducts shall be installed to provide a spare capacity of 20 %.
- Under roadways carrying vehicular traffic, sufficient ducts shall be installed to provide a spare capacity of 50 %, subject to a minimum of 2 ducts.
- All joints in the duct system shall be achieved by the use of proprietary accessories made of the same material as the duct. All changes in direction in the duct system shall be achieved by the use of drawpits.
- The maximum length of a straight duct run (between drawpits) shall be 100 m.
- Ducts shall be installed at 90° to roadways carrying vehicular traffic and shall be haunched in concrete to prevent damage. There shall be a minimum of 750 mm of cover above the crown of the duct and the duct shall be extended beyond kerbs by a minimum of 750 mm.
- Ducts shall be laid on and surrounded by a backfill material that will not cause damage to the duct.
- Depth of cover in soft ground shall be a minimum of 500 mm above the crown of the duct.
- All duct trenches shall be back-filled immediately after duct laying.
- Ducts passing through floors shall terminate approximately 75 mm proud of the surface of the floor.
- On completion, all duct runs shall have a swab drawn through to clear them of obstructions.
- Ducts shall be left with an excess 1 m length of 8 mm diameter nylon drawcord in place, anchored at each end.
- Draw pit access cover seals shall be renewed as necessary if rendered ineffective following removal.

- Only armoured cables shall be installed within underground cable ducts in order to minimise damage from rodents.

3-13 Marking of Underground Cables

The location of all underground cables shall be identified by marker plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall.

3-13.1 Drawpits

In addition to the guidance provided by CESWI 6th Edition, the following shall apply:

- The minimum size of Drawpits shall be 750 mm square
- If drawpit covers cannot be removed safely by one person, mechanical lifting equipment shall be provided
- If possible, Drawpits shall be provided with suitable drainage
- The sizing of Drawpits shall facilitate cable installation and maintain the required cable
- segregations without contravening the minimum bending radii of the cable
- Drawpits installed under roadways carrying vehicular traffic shall be fit for purpose

3-14 Installation of Cables into Ducts

- If draw cords are used to pull cables through ducts, a replacement draw cord shall be drawn through with the cables.
- Proprietary pulling socks shall be used to attach a draw line to larger cables and care shall be taken to ensure that cable tensions are maintained below cable manufacturer's specifications.
- If practicable, cables shall be pulled directly off the drum into the duct system. They shall not contain twists or kinks resulting from manual handling.


- Where any cable exits a duct, it shall be supported between the duct exit and the start of the fixed wiring support system or entry into another duct.

3-15 Cable And Wiring Support Systems (Ladder, Tray, Trunking And Conduit)

3-15.1 Selection

- Support systems shall be suitable for their intended operating loads and environment.
- Approved material and coating/finish options are given below, together with information relating to the relevant standards:

Material	Coating	Ladder	Tray	Trunking	Conduit	Flexible Conduit 1
Mild steel	Pre galvanised (BS EN10142)	ü	ü	ü (BS 4678-1, BS EN 50085-1)	ü (BS 4568-1, BS EN 50086-1, BS EN 50086-2-1)	ü (BS 731)2
Mild Steel	Post galvanised	ü	ü			
Mild Steel	Epoxy powder/stove enamel			ü (BS 4678-1 BS EN 50085-1)		
St. Steel		ü	ü			
GRP		ü	ü			
Plastic (General)				ü (BS 4678-4, BS EN 50085-1)	ü (BS 4607-1, BS EN 50086-1, BS EN 50086-2-2)	ü (BS 4607-3, BS EN 50086-1, BS EN 50086-2-3)
Plastic (PVC)		ü			ü (BS 4607-2, BS EN	

	STANDARD SPECIFICATION		Page 16 of 17
	Doc. Number	Date of issue	Rev
	PRJ – SS- 04-09	04/06/2008	01

					50086-1, BS EN 50086-2- 1)	
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Notes:

1. Flexible conduit shall be sheathed.

2. This type of flexible conduit shall not be used in wet/damp environments or where spraying/hosing down could be used as part of a process, due to the risk of water ingress.

Cabling and wiring support systems shall be of proprietary manufacture from a single source and shall incorporate manufacturer's accessories (bends, tees, fixtures, fixings, clamps, supports etc).

Cabling and wiring support systems shall be installed strictly in accordance with the support system manufacturer's instructions.

Cabling and wiring support systems shall not be cut or drilled unless approved by the Engineer.

4-0 CABLE GLANDS

- 4-1 Cable glands shall be selected in accordance with the type of bedding, armour and oversheath on individual cables and form a weatherproof seal.
- 4-2 For all cable types other than those with aluminum wire armour the glands shall be constructed from cadmium plated brass. Aluminum wire armoured cables are to be provided with aluminum glands.
- 4-3 All glands should be provided with earth tags of matching metal and have an elastomeric shroud overall.

5-0 INSPECTION AND TESTING

5-1 Tests shall be carried out according to the relevant BS and IEC standards.

5-2 A sample length of each size and type of cable should be test fitted with an appropriate cable gland to prove correct fitting.

6-0 DEVIATIONS

Deviations from this specification must be stated in writing at the quotation stage. In the absence of such statement, it will be assumed that the requirements of the specification are met without exception.

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