

SECTION 16120

WIRES AND CABLES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The work to be performed includes, but is not necessarily limited to, all work involved with the supply and installation of wires and cables and the associated connectors and terminal boards used in electrical power distribution systems.
- B. The types of wires and cables required for the project include the following:
 - 1. Low Voltage Cables (600/1000 V & 450/750 V).
 - a. Single Core PVC insulated cables 450/750V.
 - b. Multicore XLPE/PVC 600/1000V cables.
 - 1. 400 V, outgoing circuit cables shall be 4-core, XLPE 600/1000 volt grade.
 - c. Multicore PVC/PVC 600/1000 V cables.
 - d. Control cables shall be XLPE/SWA/PVC. The number and cross section of cores is to be chosen to suit circuit conditions, but the minimum size shall be 2.5 mm square.
 - e. Cables supplying 3-phase A.C. motors shall be 4-core XLPE. The fourth core shall be used as the earth conductor, i.e., the black coloured conductor. Green/yellow sleeving should be fitted on this fourth conductor at each end so as to identify it as an earth conductor cable.
 - f. Fire resistant cable for fire alarm system.
 - g. Multimode fiber optic cable, 24 strands to allow connection with the local network of the fire alarm system, the BMS, the access control and the data.

1.02 QUALITY ASSURANCE

- A. The Contractor is responsible for the quality of all purchased items and as such must develop and submit a supplier Quality Inspection Plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out same.

- B. Manufacturer: Cables and wires shall be the products of a manufacturer regularly engaged in manufacture of cables and wires of types and sizes required and complying with the requirements of the listed standards and whose products have been in satisfactory use in similar service for not less than 5 years.
- C. Codes and Standards: Comply with requirements of the latest edition of the following codes and standards except as herein specified:
1. BSI - British Standard Institution:

BS 5467	Specification for cables with thermo-setting insulation for electricity supply for rated voltages of up to and including 600/1000V and up to and including 1700/3300V.
BS 6004	Specification for PVC insulated cables (non-armoured) for electric power and lighting.
BS 6007	Specification for rubber-insulated cables for electric power and lighting.
BS 6121	Mechanical cable glands
BS 6231	Specification for PVC insulated cables for switchgear and control gear wiring.
BS 6234	Specification for polyethylene insulation and sheath of electric cables.
BS 6346	Specification for PVC Insulated Cables for Electricity Supply.
BS 6360	Specification for conductors in insulated cables and cords.
BS 6469	Methods of Test for Insulation and Sheaths of Electric Cables.
BS 6746	Specification for PVC insulation and sheath of electric cables.
BS 7655	Elastomeric sheathing compound.
 2. IEC - International Electrotechnical Commission

IEC 60227	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V.
IEC 60228	Conductors of insulated cables.
IEC 60230	Impulse tests on cables and their accessories.

IEC 60245	Rubber insulated cables of rated voltages up to and including 450/750V.
IEC 60287	Calculation of continuous current rating of cables.
IEC 60364	Electrical installation of buildings.
IEC 60724	Guide to the short circuit temperature limits of electric cables with a rated voltage not exceeding 0.6/1.0 KV.
IEC 60811	Common test methods for insulating and sheathing materials of electric cables.
IEC 60853	Calculation of the cyclic and emergency current rating of cables.
IEC 60885	Electrical test methods for electric cables.

1.03 TESTS AND ACCEPTANCE CRITERIA

- A. Testing: Prior to energization, cables and wires shall be checked for the following:
 - 1. Continuity of circuitry.
 - 2. Short circuits.
 - 3. Insulation resistance test, including procedure, equipment required (such as 500V megger) and acceptable values for resistance in accordance with recognized standards.
- B. Malfunctions shall be corrected when detected.
- C. Subsequent to wire and cable hook-ups circuitry shall be energized and circuits tested for performance in accordance with all requirements.
- D. Optical fibre cable shall comply with the following:
 - 1. Certificates of compliance with EIA/TIA specifications, and manufacturer's test certificates attached to the reels/drums,
 - 2. White light tests shall be performed to confirm end to end connectivity on delivery to site, after installation and prior to field termination,
 - 3. After field termination point to point connectivity shall be tested on each cable by a hand held optical time domain reflectometer, (OTDR), or optical power light meter, and

4. Light source, capable of reading and measuring signal loss by generating wave lengths of 950 mm and 1300 mm. This shall check the field termination loss and that no damage has occurred from macro/micro bending.

1.04 SUBMITTALS

- A. Manufacturer's Data: Submit manufacturer's data including specifications, installation instructions, dimensions and general recommendations for each type of cable.
- B. Shop Drawings: Submit dimensioned drawings of cables routing showing accurately layouts of cables installation and their spatial relationship to associated equipment and details of installation.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Wires: All wires used in the lighting and small power installation shall be as indicated on the schedule of points. The minimum size shall be 2.5 mm⁵ except low voltage switching control wires. The identification of final sub-circuit conductors shall be by colour coding. The phases, neutral and earth conductors shall have the following colour coding:

R Phase	:	RED
Y Phase	:	YELLOW
B Phase	:	BLUE
Neutral	:	BLACK
Earth	:	GREEN OR GREEN/YELLOW

- B. Cables: Cables installed in this project shall comply fully with the requirements of this specification.
 1. Size of Cables: The cables are sized for the prevailing climatic conditions.
 2. Cables Routes: The Contractor shall prepare drawings to scale showing the cable routes, type of fixing, placing of brackets. He shall draw up diagrams indicating sizes and types. These drawings shall be submitted to the Engineer.
 3. The Contractor shall demonstrate that the proposed cable insulation will not deteriorate in the high ambient temperature in the vicinity of the equipment for which the Contractor shall be deemed to have knowledge.

4. The standard finish shall consist of an extruded black PVC oversheath conforming to B.S. 6346 and 6746. The external surface shall be embossed with the voltage grade designation. Any deviation from the standard black colour of the PVC oversheath, must first be approved by the Engineer.

2.02 MATERIALS

A. Single Core Cables:

1. Single core cable shall be with copper conductors, and PVC insulation 450/750 volt grade, to BS 6004. Cables having insulation of butyl rubber (to BS 6007), silicon rubber (to BS 6007) or other heat resistant cables to the appropriate BS shall be used in the positions and areas as indicated.
2. The core shall be stranded for 4 mm² and above.
3. The cable shall be coloured throughout the whole length in accordance with the specification and the BS standard.
4. The cable shall be delivered to site with each coil having its seal intact and bearing the name of the manufacturer, classification, size, description of cable, length and grade.

- B. PVC/SWA/PVC: This type of cable shall be 600/ 1000V grade, complying with BS 6346 and shall have stranded conductors of plain annealed copper wires of high conductivity. The conductor shall be PVC insulated and the core insulation shall be coloured for identification. The bedding shall consist of an extruded layer of PVC for which a single layer of galvanized steel wires shall be provided as armouring. The cable shall have a final serving over the armour consisting of a black extruded PVC sheath.

- C. XLPE/SWA/PVC: Each cable shall comprise stranded conductors of plain annealed copper wires having high conductivity. The conductor shall be XLPE insulated and the core insulation shall be coloured for identification. The bedding shall consist of an extruded layer of PVC over which a single layer of galvanized steel wires shall be provided as armour. The cable shall have a final serving over the armour comprising of a black extruded PVC sheath.

The cable shall be 600/1000V grade and shall comply to BS 5467 in every respect.

- D. **Fire Resistant Cables:** The cable shall be to BS 6387 category CWZ. The conductor shall be annealed copper complying with BS 6360. The insulation shall be extruded silicon rubber. The 2, 3, and 4 core cables shall have a full size tinned annealed copper uninsulated circuit protective conductor. The cable shall have an electrostatic screening provided by a laminated aluminum tape applied in contact with the circuit protective conductor. The sheath shall consist of aluminum / hard grade low smoke zero halogen material. Cable shall be rated 300 / 500 V capable of accepting voltage surge up to 5KV, to operate continuously at 150°C and for short duration at 200°C. It is to be certified to have passed IEC 60331 and IEC 60332 flame resistant and fire redundant tests. Cable is to be Pirelli Type FP 200 or other equal and approved.
- E. **Optical Fiber Cables:**
1. Optical fibers, cables shall be multi-mode, graded index optical fibers with nominal 62.5/125 μm core/cladding diameter.
 2. Outdoor optical fibers shall be steel jacketed, jelly filled, rodent proof specifically made for outdoor applications, with 24 strands.
 3. Optical fibers shall meet the graded-index multi-mode performance specified in Table 14.1.

Table 14.1
Graded-Index 62.5/125 μm Multi-mode Cable Characteristics

	850 nm	1300 nm
Attenuation – dB/km	3.75	1.5
Bandwidth – MHz. km	160	500

PART 3 - EXECUTION

3.01 INSPECTION

- A. Contractor shall examine substrates and conditions under which work will be installed and correct any unsatisfactory conditions. Do not proceed with work until all unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 INSTALLATION

A. General:

1. All wiring shall be installed in accordance with the applicable provisions of EDD/R-1 Regulations and as indicated on the Drawings. Detailed wiring diagrams including designations, tagging marks, labelling etc., shall be submitted for approval before implementation.
2. The number and sizes of wires and conduits indicated on the drawings are for guidance only. It is the Contractor's responsibility to supply and install the exact number and sizes of wires required by the equipment to be installed and to provide the right size conduits for this number of wires. The Contractor shall install as many wires and conduits as required and necessary for a complete electrical system and shall provide adequately for the equipment actually to be installed at no extra cost.
3. All conductors to be contained within a single conduit shall be drawn in at the same time. An approved lubricant may be used in drawing conductors through conduits.
4. A reasonable amount of slack shall be left in each conductor at distribution boards, outlet boxes and other devices to facilitate the making of joints and connections to fixtures and equipment.
5. Branch circuits shall be properly balanced on the buses of distribution boards.
6. All cable joints and terminations shall be complete with the correct specified materials, tapes, insulating compounds, glands and bonding materials.
7. General wiring cables are intended for general lighting and small power services.
8. Single core cables shall be drawn into conduit or trunking with multicore cables laid on trays or run on surfaces to which they are affixed as a continuous length between points of termination. Joints in cables shall not be used and the use of junction boxes will only be permitted with the written approval of the Engineer.

9. Cables run on the surface shall be properly supported and clipped at intervals throughout the run in accordance with the requirements of EDD/R-1.
10. Single core cables run in conduit or trunking shall be limited in the number contained in each conduit or trunking in accordance with the grouping allowed in calculating their current rating and the maximum containment in accordance with EDD/R-1.
11. Cables run on the surface shall be rated in accordance with their most onerous ambient surroundings.
12. Circuit Protective Conductors shall be provided for all circuits except where mineral insulated cables are used, when the cable sheath may be used for this purpose.
13. All joints whether terminations to or multicore cable through joints shall be carried out strictly in accordance with the cable manufacturers recommendations.
14. No through joints shall be allowed in LV cables where adequate manufacturer's lengths are available.
15. No cable bend shall have a bending radius of less than eight times its diameter and as recommended by the manufacturer.
16. The use of conduit fittings shall be kept to a minimum and where these are absolutely necessary, they shall be circular boxes with screwed entries of certified flame proof or standard pattern, as appropriate galvanized type for exterior use. (Also to be weatherproofed to BS 4568 Class 4 in relevant location). The use of elbows, tees and adaptable boxes will be permitted only at the discretion of the Engineer.
17. All cable terminations shall conform to standard colour coding.
18. Where cable terminates at motors or other equipment that vibrates, a suitable anti-vibration coil shall be provided adjacent to the termination.
19. Where single core cables are used, the induced circulating currents shall be minimized by keeping the sheathed loop circuit electrically open at one end of the cable (i.e. the equipment entry plate at the outer end shall be brass to avoid eddy currents).
20. The radius of bends shall not be less than six times the diameter of the cable employed except with the written approval of the Engineer.

- B. Core Identification: The color identification for multicore P.V.C. cables shall be as follows:

<u>Type of Cable</u>	<u>Colour Identification</u>
Two Core	RED & BLACK
Three Core	a) RED, YELLOW, BLUE; or b) RED, BLACK (Neutral), GREEN/ YELLOW (Earth).
Four Core	RED, YELLOW, BLUE & BLACK or RED, YELLOW, BLUE & GREEN/ YELLOW

The color identification for single core cables shall be as follows:

Phase Conductor RED, YELLOW, BLUE

Neutral Conductor BLACK

Earth Conductor GREEN or GREEN/YELLOW

- C. PVC Insulated Cables for Lighting and Power Installation:

1. No conductors small than 2.5 sq.mm shall be used other than for panel control wiring.
2. Flexible cables for heaters shall be of special heat resisting cable (e.g. Butyl rubber) of appropriate cross sectional area.
3. Where cables are installed in a heated ceiling, boiler house or other situation with a high ambient temperature, these shall be of Butyl rubber.
4. Where flexible cables are run in flexible conduits or other forms of mechanical protection a separate earth wire shall be installed to ensure that adequate earth continuity is maintained.
5. In all cases the cable installation shall be to the satisfaction of the Engineer.
6. Where cables are installed in conduits or trunking then the cables shall not be drawn in until the section is complete and building is finished. Conduits shall not be dismantled for cabling.

D. Cable Installation:

1. Below the armour clamp of all cable joints a cable identification label shall be fitted giving details of type and size of cable in 5 mm stamp letters and figures. The label is to be of non-corrosive materials.
2. Where cables rise from floor level they shall be protected with a length of steel pipe which shall be sealed with a cold plastic compound.
3. Beyond the consumer's earth point and unless otherwise specified, armouring may be used as earth continuity conductors and, at each termination, the cable sheath and armour and joint box shall be effectively bonded to the associated equipment so that the continuity path resistance is in no place greater than a corresponding length of earth conductor, i.e., sheath or armour. All joints shall be made using the corresponding cable manufacturer's materials unless otherwise specified and to the cable manufacturer's recommendations.
4. In all instances where cables enter building or ducts, they shall be installed into not less than 100 mm diameter duct pipes. The ends of the pipes shall be sealed with cold plastic compound. Where cable enter below floor level the pipes will terminate in a floor recess which shall be filled with sand, and covered with a thin layer of concrete, after cabling.
5. Where cables are run within ducts, or along the surface of walls, they shall be supported by approved heavy gauge galvanized cable tray or ladder.
6. In positions where cables rise vertically, in ducts or on the face of walls etc., they are to be fixed by means of approved cleats and spaced as recommended by the cable manufacturer.
7. All cables shall be adequately supported and run clear of heating pipe.
8. The wiring shall generally be carried out on the loop-in system at accessory points only. The use of junction boxes will not be permitted.
9. Generally all cables shall be concealed above suspended ceiling and it is intended that these shall be installed before any ceiling board is erected or plastering carried out.
10. Cables run in floor voids and roof space, where run parallel with the joists, shall be fixed to the joint side and where run at right-angles shall be supported by cable trays. Care shall be taken to prevent the cables being subjected to pressure or mechanical strain at bends and changes in direction. Easy bends and rounded supports shall be employed at all such positions. The inside radius of any bend is not to be less than 8 times the overall diameter of the cable.

11. All cables shall be prevented by spacing, insulation, or other means from coming into contact with water pipes, telephones and bell installed.
12. Cables run in roof space shall be laid on cable trays or ladders.
13. The cables shall be run and terminated otherwise as specified and as unobstrusive, neat and symmetrical as possible.

E. Fire Resistant (FR) Copper Cable Installation:

1. Where Fire Resistant cables are run on the surface, they shall be fixed by single or multi-way heavy gauge copper saddles at 1 meter intervals and in damp or dusty situations shall be spaced from the surface by means of spacebar saddles. The saddles, of an approved type, shall be affixed by means of brass screws and fixings, and shall be PVC sheathed.
2. Where possible all Fire Resistant cables shall be concealed by making use of floor or ceiling spaces or by burying them in the plaster of the walls and ceilings. All runs must be vertical in walls. Where FR cables are recessed in plaster walls or concrete or similar then these are to be PVC sheathed. No type of FR installation shall be permitted in floor screeds or cast insitu concrete.
3. Under no circumstances will FR cables be run inside metal conduits.
4. Under no circumstances will through joints be allowed in underground FR cables and joints will only be permitted in the FR cables installed in buildings on instruction from the Engineer.

F. Underground cables:

1. Underground armoured cables to be laid in trenches shall be installed as follows except when mentioned otherwise in the electrical drawings:
 - a. 150 mm thick of fine sand bed to be maintained below and above the cables.
 - b. In all cases approved type of concrete cable tiles to be laid above the armoured cables.
 - c. Trench to be backfilled approximately 500 mm.
 - d. Warning tape to be positioned prior to final backfilling.

2. Underground cables crossing main roads shall be drawn through PVC ducts of appropriate sizes with concrete envelope. Empty underground ducts for future use shall be provided with draw ropes and properly plugged at both ends. Mandrill of diameter slightly less than the pipe, or duct shall be drawn through.

G. Terminations:

1. Power and control cables shall be terminated to the equipment by using brass glands compression type complete with PVC shrouds and brass earth rings.
2. All the cable gland accessories, reducers, adopters, locknuts etc., shall be of brass only.
3. Terminations of motor leads and main power connections shall be of the compression type. Where this is not possible claw type washers shall be used.
4. Tools for making off the compression joints shall be those recommended by the manufacturer and shall be of the correct size for the lugs and ferrules.
5. Termination of cables to control panels, junction boxes and enclosures shall in all cases terminate in a minimum size terminal block using termination pins with plastic identification markers.
6. At each end of a cable run markers shall be installed for cable identification and should be placed on the inside of the glanding plate, in an easily reached position.
7. Single core cables are to be identified by coloured tape over the cable above the gland.
8. Screened cables shall be so terminated that additional insulating sleeves are fitted over the screen to prevent the possibility of contact with the main conductor.
9. At all termination points the insulation shall be bared so that no exceeding conductor is exposed outside the termination or that bared conductor is not damaged during the stripping operation.

H. Tagging:

1. Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit shall be tagged as a guide in making connection.

2. Conductors for which outer jacket is not color-coded shall either have an engraved identification mark or shall be tagged.
3. Tags shall identify wire or cable number, conductor size and piece of equipment served in accordance with the schedules as shown on the drawings.
4. Main and feeder cables shall be tagged in all pull boxes, wireway and wiring gutters of panels and at their terminals.
5. All control cables and power cables shall be provided with Critcheely type cable markers attached to the outer sheath of the cables for ease of identification, and every cable shall be labelled with the number it is allocated on the relevant cable schedule.

All control cables shall be suffixed with “C” e.g., C 56.

All power cables shall be suffixed with “P” e.g., P 32.

The cable markers shall be fitted to cables in an accessible position that is clearly readable i.e.,

- a. Inside a control cubicle within 100 mm of the gland position on the cable serving.
 - b. At motors, junction boxes and remote enclosures, as near as possible to the gland position.
6. Additional markers labels shall be fitted where cables enter and leave cable tray, ducts pipes or change direction during a run.

I. Labelling:

1. All controls, push-buttons, switches etc., likely to be operated by personnel in the course of their normal duties shall be permanently labelled. Inscriptions shall be in English/Arabic as per Engineer's request.
2. All cabinets and boxes shall bear clear external marking of their function and the areas covered.
3. All barrier strip outlets and inputs from main equipment shall be labelled as above by means of solidly mounted engraved plastic strips held in by means of non-corroding flush head screws.
4. All labels shall be of two or three layer “traffolyte” or “Gravoply” material or similar, and shall be fixed by means of screws.
5. General information labels must have block characters on a white background with characters not less than 6 mm high.

6. Warning labels must have black characters on a yellow background with characters not less than 8 mm high and not more than 25 mm.
7. Mandatory labels must have white characters on a blue background with characters not less than 8 mm high and not more than 25 mm.
8. A main function label shall be fitted centrally on each junction box and motor stating the device number and labelled under the heading it appears on the electrical schematic/wiring diagram.
9. All control devices such as hydraulic and pneumatic valves, pressure switches and limit switches shall be fitted with labels located adjacent to the unit detailing the device or switch number as it appears on the schematic/wiring diagram.
10. All fuseboards, distribution boards switchboards and motor control centers shall be fully labelled, a main label shall be fixed to the front of the board detailing the heading or name it appears on the schematic/wiring diagram and the source of the cable feeding the distribution board.
11. All sub-circuits in distribution boards and fuse boards shall be correctly and clearly labelled in ink or type setting.

The sub-circuit label diagram attached to the inside of the distribution board cover shall also be marked up to indicate the electrical drawing number of the system being fed from the distribution board.

**** END OF SECTION ****