SECTION 2. 6

LV POWER AND CONTROL CABLES

2.6.1 PREAMBLE

A. This section of specification defines the technical requirements for LT POWER & CONTROL CABLES, as specified in accordance with the requirements of the Contract Documents and codes.

B. Scope of work: Design, Manufacture, Inspection, Testing at Manufacturer's Works, Delivery to Site, Installation and Commissioning LT POWER & CONTROL CABLES, complete as specified in the schedule of requirement meeting the intents of the Tender. This specification shall be used in conjunction with all drawings, Schedule of requirement and BOQ attached.

1. The cables shall comply as specified in technical specification.
2. The finished installation shall ensure that the cabling installation will be sized to ensure the Voltage Drop within the development shall be:
   a. A maximum of 5.8% for landlord common areas,
   b. A maximum of 0.2% to the apartment end circuit/point.

C. In line with the requirements of the Mumbai Fire Brigade (No FB/HR/City/155, date 04/07/2010) the following items shall incorporated into the electrical design. The Contractor shall make full allowance for these requirements in his overall electrical tender return:

1. Electrical cables feeding to Emergency(all life safety equipment) circuits shall be low smoke fire resistance, non flammable, and non toxic type, PH120 in electrical shafts (i.e FRLS/PH120) and for Cables feeding to Normal circuits shall be only Fire Resistant(FR). PVC cables shall have an additional sheathing sprayed on after installation where the cables shall allow for a suitable de rating factor to achieve the required current carrying capacity.
2. Cable conductor for all cables up to and including 16mm2 shall be copper and above 16mm2 shall be aluminium.
3. Fire survival wires having heat barrier over conductor and provided with zero halogen sheathing.
4. The electrical distribution cables/wires will be laid in a separate duct. The duct will be sealed at every alternative floor with non-combustible materials having the same fire resistance as that of the floor. Medium and Low voltage wiring running in shafts and within false ceilings will be run in metal conduits

D. Ensure all equipment and systems are to provide electromagnetic compatibility within the systems and with any other systems installed in the same location.

E. The Contractor shall install systems strictly in line with manufacturers recommendations and shall ensure all works are in line with recommended EMC mitigation measures in IEC 61000-5 (Installation and mitigation guidelines).

2.6.2 SUMMARY

A. General: This section of specification defines the technical requirements for LT & CONTROL CABLES, as specified in accordance with the requirements of the Contract Documents and codes.

B. Scope of work: Design, Manufacture, Inspection, Testing at Manufacturer's Works, Delivery to Site, Installation and Commissioning LT & CONTROL CABLES, complete as specified in the schedule of requirement meeting the intents of the Tender. This specification shall be used in conjunction with all drawings, Schedule of requirement and BOQ attached.

C. Codes & Standards: All cables shall be designed, manufactured and tested in accordance with the latest applicable sections of the IEC/BS/IS codes. Since IS Standards are originated from IEC & BS standards, technical requirements listed in the latest BS & IEC standards supersedes IS standards requirements which do not cover them. All testing for fire survival cables shall be done at ASTA/KEMA KEUR/BASEC/BRE.

D. Equipment meeting the requirements of IEC/ANSI or any other internationally recognised standard which ensure a quality equal to or better than as per the standards indicated below shall also be acceptable. When the equipment conforms to any other standards, salient points of difference between the standards adopted and those prescribed in this specification shall be clearly brought out in the tender and a copy of the applicable standards(s) in English language shall also be enclosed by the supplier with the tender.

IEC 60228	Conductors of insulated cables. Guide to the dimensional limits of circular conductors.
IEC 60331 Parts11 & 21	Fire resisting characteristics of electric cables.
IEC 60332 Part 4-10	Tests on electric cables under fire conditions. Part 4: Tests on bunched wires or cables.
IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1kV to 40 kV.
IEC 60754 Part 1	Test on gases evolved during combustion of materials from cables. Part 1: Determination of the amount of halogen acid gas evolved during combustion of polymeric material taken from cables.
IEC 60811 Parts 1 & 2	Common test methods for insulating and sheathing materials of electric cables.
IEC 60885 Parts 1, 2 & 4	Electric test methods for electric cables.
IEC 60304	Standard colours for insulation for low frequency cables and wires.
IEC 60227 01 Parts 1 to 6	PVC insulated cables of rated voltages up to and including 450/750 V.
IEC 61034 Parts 1 & 2	Measurement of smoke density of electric cables burning under defined conditions.
IEC 60028	International Standard of Resistance for Copper
BS 8519:2008	Selection & installation of fire-resistant power and control cable system for life safety and fire fighting application –Code of practice.
BS 8434-2	Methods of test for assessment of the fire integrity of electric cables. Test for unprotected small cables for use in emergency circuits - BS EN 50200 with a 930℃ flame and with water spray (+A2:2009)
BS 8491:2008	Method for assessment of fire integrity of large diameter power cables for use as components for smoke and heat control systems and certain other active fire safety systems
Trade Association Standards	
EEMUA 133	Underground armoured cable protected against solvent penetration and corrosive attack.
Indian Standards	
IS- 1554	PVC insulated (heavy duty) electric cables.
IS- 694	PVC insulated cables for working voltages up to and including 1100V.
IS- 7098	Cross linked polyethylene insulated PVC sheathed cables.
IS- 5831	PVC insulation & sheath of electric cables.
IS- 10810	Methods of test for cables.
IS- 8130	Conductors for insulated electric cables and flexible cords.
IS- 3975	Mild steel wires, formed wires and tapes for armouring of cables.
IS-12943	Brass Glands for PVC Cables.

2.6.3 SUBMITTALS

A. Technical Data: Submit data for approval including, but not limited to, the following:

1. Constructional details, standards to which cables comply, current-carrying capacities,
2. De-rating factors for grouping and temperature
3. Manufacturer's catalog cuts

4. Dimensional and all electrical characteristics
5. Point-wise compliance statement to the specifications duly signed and certified by the manufacturer /manufacturer's authorized representative and the contractor.

B. Samples of each cable, wire and other accessories.

C. Shop and Construction Drawings: Submit Drawings for approval including, but not limited to, the following:
1. Exact routing layouts, sections and profiles of trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades.
2. Details of supports and fixings for buses, trays and cables.
3. Details of connections to transformers, switchboards, panel boards etc.
4. Details of terminations, splices and tapings where permitted, glands and bushings at enclosures.
5. Number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.
6. Cable sizing calculations.
7. Cable schedule.
8. Cable termination schedule.

D. Certificate of Origin: For each lot of cable supplied, provide a certificate of origin issued by the manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates. All test certificates are to be numbered and comply with the test requirements of the relevant standard to which the cable is manufactured (i.e. type).

E. As-Built (Record) Drawings: Near Project Substantial Completion, submit, certified by Consultant, Record Drawings of installed electrical systems, indicating all existing services and those installed, in accordance with requirements of the Specification.

F. Routine tests at factory. The test certificates shall be numbered.

G. Field Test Reports: Field tests to be as approved by the Engineer. Indicate acceptable values per the regulation and interpret test results for compliance with performance requirements. All field test reports shall be provided with distinctive number.

2.6.4 QUALITY ASSURANCE

A. Standards: Wires and cables are to comply with above mentioned code or other equally approved standards and are to bear the mark of identification of the Standards to which they are manufactured, cable size, voltage grade, minimum drum length, and minimum cable size. Wires and cables not having this identification will be rejected.

B. Current carrying capacities of conductors have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by the Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to the Engineer.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing to ASTA/KEMA/BASEC/BRE with compliance to local authorities.

D. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as per NEC 2011 and IS 732 1989 (reaffirmed 2005), by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

2.6.5 SERVICE CONDITIONS

A. The cables shall in all respects be suitable for operation under an ambient temperature of 45ºC. The Contractor shall verify the cable selection for the temperature rating and grouping factors validating the cable selection. The cable selection shall consider the combination of cable grouping and the temperature derating factors. The cables shall have a design life of at least twenty years.

B. All armoured cables shall be suitable for operation when installed:
1. Direct buried in the ground (including waterlogged ground).
2. In underground ducts.

3. Above ground, fastened to cable ladder rack or tray in the open air exposed to direct sunlight.
4. Below ground in enclosed, air filled trenches, fastened to cable ladder rack or tray.

2.6.6 INSPECTION & TESTING AT MANUFACTURER PREMISES

i. All tests shall be carried out in accordance with relevant Standards, codes of practice and Electricity Rules. The Contractor shall provide necessary instruments, equipment and labour for conducting the above tests and shall bear all expenses in connection with such tests. All tests shall be carried out in the presence of the Employer's representative on Site, results will be noted and signed by all present and record be maintained.

ii. Following Routine Tests shall be witnessed by the Employer's representative at the manufacturer's shop:
   - Survival testing against Fire as per applicable codes and testing procedure
   - Fire Resistance Test.
   - Insulation Resistance Test.
   - Continuity resistance test.
   - Earth test.(in armoured cables)

iii. All the expenses towards the Inspection or witnessing the testing of cables by the Lodha Representative will be in the Contractors scope **excluding boarding and lodging of Lodha Representative.**

iv. The contractor together with the cable manufacturer shall submit detailed Quality Assurance Plan (QAP), Inspection Test Plan (ITP) & test procedures for review/approval of Lodha.

v. The Lodha Representative has the right to have the tests carried out at his own cost by an independent agency whenever there is dispute regarding the quality of supply.

vi. The results of all tests carried out shall be tabulated and signed jointly by manufacture and Lodha Representative. In case the test results are not satisfactory and in accordance of contract specification and there are defects in the materials the same shall be attended and notified to Lodha Representative. The equipment shall be dispatched to site of work only after receipt of acceptance of materials and clearance from Lodha Representative.

vii. Test shall also be conducted at site for insulation between phases and between phase and earth for each length of cable, before and after jointing.

viii. On completion of cable laying work, the following tests shall be conducted in the presence of the Employer representative.
   - Insulation Resistance Test(Sectional and overall)
   - Continuity resistance test.
   - Earth test.
   - Visual inspection throughout the length.

2.6.7 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to those listed in Section G.

2.6.8 CABLE CONSTRUCTION

A. Cable cross sectional area, conductor material, number of cores, rated voltage and type shall be as stated in the contract documents.

B. The cable shall be multi-core and outer sheath should have high resistance to flame propagation.

C. Cable fillers shall be solid, non-hygroscopic and fill the cable cross section to form a compact and reasonably circular cable. Any one of the two types of inner sheath materials, ST1 or ST2 compound shall be used in multi core power cables. Filler materials used to fill up the interstices space between the power cable cores, under the inner sheath shall be PVC or Polypropylene fillers, such that the transmission of gas and hydrocarbons along the length of the cable, under normal pressure is not possible and shall prevent /reduce the water propagation through the cable. The properties of the Filler material shall be same as that of the inner sheath ST1 or ST2.

D. The outer sheath of cables shall be embossed or engraved with
   i. Its BIS Certification Marking
   ii. The voltage designation
   iii. Manufacturers identification
   iv. Number of Cores and nominal cross sectional area of conductors
   v. The drum progressive length of cable at every meter. (The starting point being the cable end at its inner coil on the cable drum)

E. Cable shall have uniformity in insulation and outer sheath colour. The XLPE insulation and insulation screen shall be extruded in one operation by triple extrusion process.

F. The insulation of the cable shall be designed and manufactured for the specified system voltage. Under normal conditions, the FR insulated cables shall have operating temperature upto 70 deg. Celsius & 90 deg. Celsius for XLPE insulated cables. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions. The extrusion method should give very smooth interface between the insulation sheaths. The insulation of the cables shall be of high standard quality. The thickness of the insulation shall not be less than that specified in the relevant standards.

G. Sheath: Inner Sheath: In case of cables consisting of two or more cores inner sheath suitable to withstand the site conditions and the desired temperature shall be provided on the individual core and then surrounded by common covering applied either by extrusion or wrapping of a filling material containing thermoplastic material. It shall be of adequate thickness and applied by continuous process to produce a sheath of consistent quality free from all defects. The use of FR cabling is noted on relevant SLDs and Contract documents.

H. Outer Sheath: This is extruded over the armour for armoured cables and covers the inner sheath for unarmoured cables. For Emergency Feeders cables this shall be specially formulated heat resistant black FR compound conforming to the requirement of type ST2, extruded to form the outer sheath. The cable should also offer a specially formulated Flame Retardant compound (FR) for outer sheath. Suitable additives are added to prevent attack by rodents and termites. All cabling must be given anti-termite treatment. The thickness of the sheaths shall be as per relevant standards. Normal Feeder Cables Sheath shall be Fire Retardant (FR).

I. Equivalent Armour size. Contractor shall refer to SLDs, where armour has been selected as the cabling Circuit Protective Conductor (CPC) the armour shall conform to the following minimum standards:
   - The minimum acceptable technical characteristics for the SWA on cabling shall confirm to the table H2 and N2 on the following page. The Contractor shall be obliged to provide original manufacturer data sheets confirm this criteria is met in all cases. In the absence of original manufacturer data sheets the contractor, at his expense, shall be obliged to submit each SWA cable for laboratory testing to demonstrate.

J. The cables shall in all respects be suitable for operation under an ambient temperature of 40ºC. The Contractor shall verify the cable selection for the temperature rating and grouping factors validating the cable selection. The cable selection shall consider the combination of cable grouping and the temperature derating factors. The cables shall have a design life of at least twenty years.

K. All armoured cables shall be suitable for operation when installed:
   - Direct buried in the ground (including waterlogged ground).
   - In underground ducts.
   - Above ground, fastened to cable ladder rack or tray in the open air exposed to direct sunlight.
   - Below ground in enclosed, air filled trenches, fastened to cable ladder rack or tray.

L. Cables ≤ 16 Sq.mm shall be copper conductor and ≥ 25 Sq.mm shall be Aluminium conductor. For Life safety load FS PH120 type cables shall be used.

M. FIRE SURVIVAL/PH120 CABLES
   1. The test shall be witness by Lodha Associates and design engineers.
   2. All the cables manufactured for Lodha project shall be tested for the compliance by the TUV or equivalent (subject to the approval of Lodha Associate) before the dispatch.
   3. The overlapping of the mica tape shall not be less than 30%
   4. The Thickness as per the manufacturer however shall not be less than 0.125 mm in any case.

5. The number of Tapes shall be as per the manufacturer; however shall not be less than 2 in any case.
6. The point to be noted here is that the sample for the testing send to ERDA shall not be from the end of the cable drum.
7. The cables shall meet the test requirements against standard defined in technical specification, e.g. BS 6387 CWZ.

N. FLEXIBLE / CONTROL CABLES

1. All flexible cables used for pendant lighting fittings or for final connections to fixed or portable equipment shall be of 300/500 volts grade.
2. Flexible cables shall be of annealed copper conductor insulated with heat resisting FR and of circular construction.
3. Flexible cables shall comply with relevant standards and codes of practice mentioned in the specification.

O. HOUSE WIRING POINTS IN CONDUIT AND TRUNKING

1. House wire should be class-2 stranded.
2. Flexible cable for final connection to light fixture /equipment can be used as class-5 stranded.
3. PVC insulated, high conductivity multi stranded copper conductor FR wire shall be used.
4. The cable shall be of 600/1000 volts grade.
5. Single core cables shall not be used for MV (250V to 650V) distribution cabling.
6. The cables shall comply with all relevant regulations and codes of practice as mentioned elsewhere in this specification.
7. The cables shall have colour as per National Electrical Code (NEC).

P. Table for armoured selection:- i.TABLE-H2

i.

Table H.2 — Maximum resistance of conductor and armour for two-, three-, four- and five-core cables having steel wire armour

Nominal cross-sectional area of conductor	Maximum resistance per km of cable at 20 °C											
	Copper[a] conductor	Aluminium conductor	Steel wire armour									
			Cables with stranded copper conductors						Cables with solid aluminium conductors			
			Two-core	Three-core		Four-core	Five-core	Two-core	Three-core		Four-core	
			600/1 000 V	600/1 000 V	1 900/3 300 V	600/1 000 V	600/1 000 V	600/1 000 V	600/1 000 V	1 900/3 300 V	600/1 000 V	
mm²	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	
1.5	12.1	—	10.2	9.5	—	8.8	8.2	—	—	—	—	
2.5	7.41	—	8.8	8.2	—	7.7	6.8	—	—	—	—	
4	4.61	—	7.9	7.5	—	6.8	6.2	—	—	—	—	
6	3.08	—	7.0	6.7	—	4.3	3.9	—	—	—	—	
10	1.83	—	6.0	4.0	—	3.7	3.4	—	—	—	—	
16	1.15	1.91	3.7	3.5	1.9	3.1	2.2	4.0	3.8	2.0	3.4	
25	0.727	1.20	3.7	2.5	1.7	2.3	1.8	4.1	2.7	1.9	2.4	
35	0.524	0.868	2.6	2.3	1.8	2.0	1.6	2.9	2.5	1.9	2.2	
50	0.387	0.641	2.3	2.0	1.3	1.8	1.1	2.6	2.2	1.4	1.9	
70	0.268	0.443	2.0	1.8	1.2	1.2	0.94	2.3	1.9	1.3	1.3	
95	0.193	0.320	1.4	1.3	1.1	1.1	—	1.6	1.4	1.2	1.2	
120	0.153	0.253	1.3	1.2	0.76	0.76	—	—	1.2	0.82	0.82	
150	0.124	0.206	1.2	0.78	0.71	0.68	—	—	0.86	0.76	0.74	
185	0.099 1	0.164	0.82	0.71	0.65	0.61	—	—	0.76	0.71	0.67	
240	0.075 4	0.125	0.73	0.63	0.59	0.54	—	—	0.68	0.64	0.59	
300	0.060 1	0.100	0.67	0.58	0.55	0.49	—	—	0.63	0.59	0.54	
400	0.047 0	—	0.59	0.52	0.50	0.35	—	—	—	—	—	

[a] The values given are for plain annealed copper conductors. For tinned conductors reference should be made to A3 BS EN 60228 A3.

ii. TABLE N2

Table N.2 — Gross cross-sectional area of armour wires for two-, three-, four- and five-core 600/1 000 V cables having steel wire armour

Nominal cross-sectional area of conductor	Gross cross-sectional area of armour wires						
	Cables with stranded copper conductors				Cables with solid aluminium conductors		
	Two-core	Three- core	Four-core	Five-core	Two-core	Three- core	Four-core
mm²	mm²	mm²	mm²	mm²	mm²	mm²	mm²
1.5	15	16	17	19	—	—	—
2.5	17	19	20	22	—	—	—
4	19	20	22	25	—	—	—
6	22	23	36	40	—	—	—
10	26	39	42	46	—	—	—
16	42	45	50	72	39	41	46
25	42	62	70	88	38	58	66
35	60	68	78	100	54	64	72
50	68	78	90	144	60	72	82
70	80	90	131	166	70	84	122
95	113	128	147	—	100	119	135
120	125	141	206	—	—	131	191
150	138	201	230	—	—	181	211
185	191	220	255	—	—	206	235
240	215	250	289	—	—	230	265
300	235	269	319	—	—	250	289
400	265	304	452	—	—	—	—

Q. Until unless specified in BOQ, single line diagram (SLD) all the cables shall follow as below:
Aluminum and copper conductors shall have a 70/90ºC operating temperature for the cable as listed on the drawings/SLD and BOQ's. If not mentioned XLPE should be considered. Constructions detailed as below.

1. For Non Emergency Load cable to be FR.
2. For Emergency Load Cable to be of FS PH120.

Abbreviations:

PVC	Polyvinyl-chloride	
XLPE	Cross linked polyethylene	
SWA	Single Wire Armoured	– (Galvanised steel flat or round wire armour for multicore cables.)
		– (Aluminium wire armour for single core cables.)
PE	Polyethylene	
FR	Fire Retardant	
FS	Fire Survival	
PH120	2 hours fire resistant	

C 1.1 Cable Type: PVC SWA FR 1100V grade (IS 1554 part 1)

Rated Voltage: 650/1100V (IS 1554 part 1)

System Voltage: Up to 1000 V, 3 phase, 3 or 4 wire AC.
Up to 250 V DC.

Service: General purpose power distribution and control.

Construction:

Conductors
Conductors of Cables Up to and including 16mm2 shall be of stranded copper conductor and above (including) 25mm2 shall be Aluminium

Conductor shall be of electrolytic Aluminium/Copper conforming to IS : 8130 and are compact circular or compact shaped.

Insulation
PVC FR

Core Identification
Up to four cores - colours
1 core - black
2 core - red, black
2 core + earth - red, black, green/yellow
3 core - red, yellow, blue
4 core - red, yellow, blue, black.
5 or more cores - numbered
(Black numbers printed on grey coloured insulation)

Laying Up
Cores to be laid up together with non-hygroscopic fillers

Bedding
FR

Armouring
Multi core cables - single layer of galvanised steel wires (round or flat).
Single core cables - single layer of aluminium wires

Over sheath
FR Type ST-1 of IS: 5831-1984 (Reaffirmed 2001) for maximum conductor temperature 70ºC, colour black

Fire Performance
IEC 60331 Fire Resistance Test
IEC 60332 Flame Retardant test
IEC 61034 Smoke Emission Test
IEC 60754 Halogen Content Test
ASTM D 2863 Oxygen Index Test

C 1.2 Cable Type: XLPE SWA FR 1100V grade (IS 7098 part 1)

Rated Voltage: 650/1100V (IS 7098 part 1)

System Voltage: Up to 1000 V, 3 phase, 3 or 4 wire AC.
Up to 250 V DC

Service: General purpose power distribution.

Construction:

Conductors
Conductors of Cables Up to and including 16mm2 Shall be of Stranded Copper Conductor and Above (including) 25mm2 shall be Aluminium Conductor shall be of electrolytic Aluminium/Copper conforming to IS : 8130 and are compact circular or compact shaped.

Insulation
XLPE (Cross linked polyethylene) compound of IS-7098-1988 for Maximum conductor Temperature 90ºC).

Core Identification
Up to four cores - colours
1 core - black
2 core - red, black
2 core + earth - red, black, green/yellow
3 core - red, yellow, blue
4 core - red, yellow, blue, black.
5 or more cores – numbered.

Laying Up
Cores to be laid up together with non hygroscopic fillers

Bedding
FR Type ST-2 of IS: 5831-1984 (Reaffirmed 2001) for maximum conductor temperature 85ºC

Armouring
Multi core cables - single layer of galvanised steel wires (round or flat).
Single core cables - single layer of aluminium wires

Over sheath
FR Type ST-2 of IS: 5831-1984 (Reaffirmed 2001) for maximum conductor temperature 85ºC.

Fire Performance
IEC 60331 Fire Resistance Test
IEC 60332 Flame Retardant test
IEC 61034 Smoke Emission Test
IEC 60754 Halogen Content Test
ASTM D 2863 Oxygen Index Test

C 1.3 **Cable Type:** SWA, **Fire Survival PH 120 cables,** 1.1 kV grade (IEC 60502-1)

Rated Voltage: 600/1000 V (IEC 60502-1)

System Voltage: Up to 1000 V, 3 phase, 3 or 4 wire AC.
Up to 250 V DC

Manufacturing Codes: BS7836, IEC 60502-1, BS 8519

Service: Power distribution to Emergency/Fire Load.

Construction:

Conductors
Conductors of Cables Up to 300mm2 Shall be of Stranded Copper Conductor/ Aluminium Conductor shall be of electrolytic Aluminium/Copper conforming to IS : 8130 and are compact circular or compact shaped as stated on SLD/BOQ.

Insulation
Double layer of Glass mica fire barrier tape covered by an extruded layer of cross linkable halogen free Ethylene Propylene Rubber (EPR) insulation and LSZH inner & outer sheath as per BS7846, IEC60520-1, BS 8519 latest edition.

Core Identification
Up to four cores - colours
1 core - black
2 core - red, black
2 core + earth - red, black, green/yellow
4 core - red, yellow, blue
4 core - red, yellow, blue, black.

Laying Up
Cores to be laid up together with glass mica fillers

Bedding
Cross linkable halogen free Ethylene Propylene Rubber (EPR) insulation and LSZH inner & outer sheath as per BS7846, IEC60520-1,BS 8519 (latest edition) suitable for maximum conductor temperature 850ºC.

Armouring
Multi core cables - single layer of galvanised steel wires (round or flat).
Single core cables - single layer of aluminium wires

Over sheath
Cross linkable halogen free Ethylene Propylene Rubber (EPR) insulation and LSZH inner & outer sheath as per BS7846, IEC60520-1, BS 8519 (latest edition) suitable for maximum conductor temperature 850ºC

Fire Performance
Fire Survival FS, PH120 (Defined as a category 3 cable under BS 8519/ CWZ under BS 6387)
Fire Testing Code Compliance
Fire performance tests as per BS 8491:2008 (120 mins) for cables having overall dia of 20mm and above. Cables with overall dia below 20 mm should meet fire performance test as per BS 8434-2:2009 to provide for PH120 certification. Cables shall have IEC/BRE /BASEC /KEMA/ASTA /ERDA approval.

2.6.9 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions. Splicing and terminations shall be by an experienced person and duly approved by the Lodha Representative.

2.6.10 CABLE TERMINATIONS

A. Multi-conductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 488. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations, allow also for glanding and bimetallic termination lugs.

C. Cable terminating facilities and terminals shall be suitable for the specified cable type and conductor size. Consideration and provision shall be taken by the CONTRACTOR on the equipment design for the use of cables with aluminium / copper conductors as mentioned on One Line Diagram / Switchgear schedule.

D. Terminal blocks shall be arranged and positioned to afford ready access for carrying out external cable termination, testing, inspection and maintenance. There shall be ample clear space allowed between the terminals and the gland-plate for the spreading and termination of external conductors.

E. Terminal blocks shall be mounted in a single deck arrangement. Terminal blocks for the connection of external control wiring shall be of the clamp type with a facility to connect two wires on each side of the terminal. A minimum of 20% spare terminals shall be provided.

F. All external wiring shall be on one side of the terminal block only.

G. All terminal blocks shall be shrouded or provided with transparent covers. Pinch screw type terminals are not acceptable.

H. Terminals for different voltages shall be separated by partitions.

I. Terminal boxes (where specified) shall be suitable for dry type terminations unless otherwise specified.

J. A terminal box or chamber with undrilled gland plate or entry panel of sufficient dimensions to terminate the specified cables shall be provided. Direction of cable entry shall be as stated on the one-line diagram(s).

K. Positioning of cable terminations shall avoid obstruction of other cable terminations, removable covers, etc. and provide for easy access for terminating cables.

L. There shall be sufficient clear space allowed between the terminal block and the cable entry for the spreading and termination of external conductors. Should this not be possible using the standard design in relation to specified cable size then the Contractor shall incorporate an extended cable glanding box within its design to suit site condition for bending of core and facilitate termination.

M. Termination of single core cables shall be through a non-magnetic gland plate and provision made for bonding and earthing any armour and/or concentric ground conductors.

N. Adequate support arrangement shall be provided for each cable to avoid undue strain on the cable terminations.

O. Wherever required extra supports, it shall be provided by subcontractor to reduce the extra weight/ stress on the gland plate.

P. Double compression gland to be used unless otherwise mentioned. FS cables shall have LSF shroud on the cable gland to be protect fire entering the panel.

Q. Bimetallic lugs to be used in case of dissimilar metal usage to avoid corrosion in metals.

R. All cables armour to be connected with earth bar of the panel with flexible earthing cable terminated on panel with lug and on cable armour through jubilee clamp with lug.

2.6.11 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

2.6.12 SHIPPING, HANDLING & STORAGE

A. Cables shall be drummed in maximum continuous lengths on:

1. Returnable steel drums for all LT Power & Control Cables of large cross sectional areas or long drum lengths.
2. Non-returnable wooden drums where the manufacturer can guarantee that such drums are of sufficient strength to protect cable during shipping, handling and outdoor storage for three year period.

B. Cable ends shall be sealed and fixed to the drum so that both ends are accessible. To protect the cable during shipment battens shall be fitted around the entire periphery of the drum. Drums shall be suitable for long-term outdoor storage at site. Each cable run shall be manufactured in one length where no through joints shall be allowed. Phase identification of cable conductors at the termination at each end of the feeder shall be provided by markers on the respective switchboard terminals. If through joints are to proposed then approval shall be obtained from the Lodha Representative.

C. All cable drums shall have the Purchase Order Number, Purchase Order Item Number, Drum Number and Stock Code Number clearly stencilled on the outside of both flanges.

D. Drum identification labels shall be of non-corrosive, non-hygroscopic material and attached to the outside and inside of the drum flanges. Labels shall be protected by transparent plastic envelopes and give the following information:

1. Drum identification number and its direction of rotation for cable removal.
2. Cable voltage grade
3. Cable construction (e.g. FR SWA FR or AYFY)
4. Number of cores and cross sectional area
5. Cable quantity (Metres)
6. Purchase order number and item number
7. Total weight of cable and drum (kg)
8. Manufacturer's name
9. Year of manufacture
10. Stock code number

E. The Contractor shall provide the following data with his quotation:

1. Standard and maximum drum lengths for all the types of cable offered and his proposed drum lengths for all items.
2. Inspection test plan.
3. Cable dimensions (together with tolerances) as follows:
    1. Diameter of (individual in case of multi stranded) conductor wire
    2. Percentage of compaction as per data sheet.
    3. Diameter under conductor screen (where applicable)
    4. Diameter over conductor screen (where applicable)
    5. Diameter over individual core insulators

6. Lay of cable in case of multi-core cable
7. Diameter over inner sheath (mm)
8. Diameter over centre sheath (mm)
9. Diameter over lead sheath (mm) where applicable
10. Diameter under armour (mm)
11. Diameter over armour (mm)
12. Diameter of armour wires (mm)
13. Overall diameter (mm)

4. Cable Physical Properties
    1. The filler materials to be used.
    2. Cable weight in kg/km
    3. Minimum bending radius (x OD)
    4. Maximum conductor continuous operating temperature
    5. FR/FS cabling certification
    6. Suitability of outer sheath to resist attack from chemicals.
5. Cable electrical data as follows:
    1. Conductor dc resistance per km at ambient temperature 40℃
    2. Conductor ac resistance per km at operating temperature and system frequency
    3. Conductor inductive reactance per km at system frequency
    4. Conductor impedance per km at operating temperature and system frequency
    5. Conductor capacitance per km
    6. Cable armour resistance per km

F. The current carrying capacity of single and multi-core cables when installed in defined conditions in air, in ducts and direct buried in the soil, together with rating factors for varying ambient temperatures, grouping and installation conditions and methods.

G. Cable short circuit withstand capacity to include derating factors for temperature, grouping and burying in the ground as per manufacturer recommendation shall be presented in graphical form or by formulae approved by the Lodha Representative.

H. Descriptive literature (catalogues etc.).

I. Cross sectional view of the physical make up of each cable.

J. Recommended temperatures below which installation of cable should not be carried out.

K. Minimum ambient temperature at which cables can be used.

L. Maximum pulling force for each cable and any special pulling instructions.

M. Maximum unsupported run of cable both horizontally and vertically.

2.6.13 COORDINATION

A. Coordinate layout and installation of cable and other service with other installations.

B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by the Engineer.

C. Ensure that cable twists, and crossings are avoided and sufficient bending radius is maintained as per regulations.

D. Contractor to provide a comprehensive Method Statement detailing Site Acceptance Test Procedures. The test should be accounted for insulation test, functional test, continuity test, sectional injection test, relay test, visual inspection, functional testing, torque testing.

2.6.14 EXECUTION

2.6.14.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

2.6.14.2 INSTALLATION

A. ERECTION OF CABLES

1. Notwithstanding the cable routes indicated on the Drawings the Contractor shall be entirely responsible for the supply of correct lengths of the cables to be installed and for all allowances for connecting and terminating the cables to the switchgears and transformers respectively
2. The Electrical Contractor to confirm all sub main and fire circuit cable lengths prior to ordering the cables for installation as this will affect the protective device disconnection time and the cable size. This will give time to verify the cable size prior to purchase preventing an embarrassing situation of pulling additional cables to address volt drop, earth loop impedance or changing the MCCB or MCB prior to practical completion.
3. The Contractor shall submit proposed cable routes including details of supports for the cables for approval before installation. The cable shall not be run in places other than corridor, passageway, electrical riser or other designated areas subject to the Lodha Representative approval. The cost of all cable containment supports shall be included by the Contractor. The Contractor shall allow minimum clearance distance between all other MEP services such as water and gas lines in accordance with local code and the MEP service design criteria.

B. CABLE PULLING

1. Winching of cables through ducts / pipes shall only be carried out with the approval of the Lodha Representative in which event a pulley eye shall be attached to the conductors. Cable shall be run in neat and orderly manner to allow space for future cabling and maintenance. Under any circumstances the cable shall not run diagonally across a room, cable basement, corridor, etc.
2. A cable sheath stocking may be employed or cables where no undue stress in the sheath is likely to occur.
3. Care shall be taken to ensure that the draw strain is applied to the armouring and protected during drawing against damage. All cable pulling shall be carried out using self anchoring cable rollers/ sleeves to prevent damage to the over sheath. Any damaged cable shall be replaced by the Contractor with new cable with no extra cost or time variation to the works.
4. Cable roller shall be placed at every 1.5 meters & guide roller shall be placed at all the diversion change in direction.

C. CABLE LAYING

1. The cable drum shall be placed on jacks before unwinding the cable. Great care shall be exercised in laying cables to avoid forming links. At all changes in directions in horizontal & vertical places, the cable shall be bent with a radius of bend shall be as per manufacturers recommendation. Multiple banking of cables shall not be permitted and the Contractor shall verify the cable tray spatial allowance permits this and any discrepancies shall be highlighted within the bid process.
2. The cable of 1.1KV grade shall be laid not less than 750mm below ground level in a trench (throughout). Where more than one cable is to be laid in the same trench, the width of the trench shall be increased such that the inter axial spacing between the cables except where otherwise specified is at least 150mm minimum or as per site requirements or as approved by the Engineer-in-charge. Where single core cables are used in multiphase systems, the cables shall be installed in trefoil. The cables shall be tied together using low smoke and fume fire resistant cable ties of a steel or plastic construction.

3. In case the cables are laid in vertical formation due to unavoidable circumstance the depth per tier shall be increased by 200 mm (minimum). Cable shall be laid in reasonably straight line, where a change in direction takes place a suitable curvature shall be i.e. either 20 times the dia meter of the cable or the radius of the bend shall not be less than twice the diameter of the cable drum or whichever less is.
4. Greater care shall be exercised in handling the cable in order to avoid forming 'Kinks'. The cable drum shall in-verbally convey on wheels and the cable unrolled in right direction as indicated on the drum by the manufacturer. The cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains.
5. Cables laid in trenches in single tier formation, 10 cms all-around sand cushioning is provided below and above the cable before a protective cover is laid. For every additional vertical tier. The 40 cm of sand cushion is provided over the initial tier. The cable shall be protected by 2nd class brick of size not less than 240 x 115 x 75mm, stone tiles / RCC curved channel be placed on top of the sand breadth wise for the full length of the cable and where more than one cable is to be laid in the same trench the brick shall cover all cables and project at least 8 cms over the outer sides of the end cables.
6. Filling of trenches shall be done after sand cushioning and tiles or bricks lying and inspection is carried out by the Lodha Representative (Refer drawing). Back fill for trenches shall be filled in layer not exceeding 150 mm. Each layer shall be properly rammed & consolidated before laying the next layer.
7. RCC Hume pipes complying to IS standard shall be provided on all road crossing. The size of the pipe shall be above the size of the cable. Sizes of pipes as indicated in the layout are to be provided. The pipe shall be laid in ground with special arrangement and shall be cement jointed and concreting of 1:5:10 shall be provided as per relevant IS with latest amendment. Nothing extra shall be paid on this account. Cable route markers at interval of 40 meters and at the point of direction change shall be provided to indicate cable path. Aluminium strip cable tag of 20mm wide with engraved tag no. shall be provided at both ends of cable.
8. Where the cables are laid in ducts (trenches) inside the building, they will be laid on cable ladder / cable trays cantilever supported on trenches walls. Cables passing through floors shall be protected from mechanical damage by steel channel to a height of one meter above the floor. Metal sleeves shall be provided in the wall for crossing of cables.
9. Where the cables are laid in open (in building) along walls, ceiling or above false-ceiling, cable rack (ladder type) or cable tray shall be provided. The size of the cable tray or rack shall depend on the number of cables to pass over that rack. Cable tray/rack shall be properly supported through wall/ceiling according to the site conditions. Cable laid on tray & riser shall be neatly dressed & clamped at an interval of 1000 mm & 750mm for horizontal & vertical cable run respectively either side at each bend of cable. All power cables shall be clamped individually & control cables shall be clamped in groups of three or four cables. Clamps for multi core cables shall be fabricated of 25x4 GI flats and shall be fastened at both ends to suit the profile of the cables. All power cables above in vertical shaft shall be secured with hot dipped GI clamp. Single core power cable shall be laid in trefoil formation & clamped with trefoil clamps made of PVC/fiber glass.
10. Cable openings in wall/floor shall be sealed by the contractor suitably by Hessian tape & fire stop compound or by any other proven material to prevent the ingress of water and shall be suitably fire stopped.
11. After the cables are laid, shall be tested as per IS and the results submitted to the Employer's Representative and in case the results found unsatisfactory, all the repairing/ replacing of cables will be done by the contractor free of charge.

D. FIRE SEAL FOR CUTOUT & OPENING

1. All the floor/wall openings provided for cable crossing shall be sealed by fire seal system. Sealing shall be both around containment and within containment.
2. The fire proof sealing system shall fully comply with the requirements of relevant IS/ ISO. The fire proof seal system shall comply to the fire rating of the area as per the fire compartmentation plan drawings/architectural intent layouts.
3. The fire proof seal system shall be physically, chemically, thermally stable and shall be mechanically secured to the masonry concrete members. The system shall be completely gas and smoke tight, ant rodent and anti-termite.

4. The material used in fire proof seal system shall be non-toxic and harmless to the working personnel.
5. Type of fire proof seal system shall be mortar type or flame mastic type compound or approved equivalent. All fire stopped openings shall be checked and certified by fire stop material vendor for the integrity of the fire stop. Where cables pass through non fire rated floors or non fire rated walls they shall be protected by a short length of heavy gauge pipe bushed with lead or hard wood at each end. When rising through a floor the protecting barrel shall project to a height of approximately 1200mm.
6. After laying and jointing work is completed, high voltage test should be applied to all cables to ensure that they have not been damaged during or after the laying operation and that there is not fault in the jointing.

2.6.14.3 FIELD QUALITY CONTROL

A. Cable tests are to be carried out in accordance with the requirements of the Regulations and Standards, witness and certified by manufacturer/authorized representative. Cable test certification shall clearly state the acceptable values as per the regulation and in case this is not clearly available, the manufacturer's recommended values.

B. Site tests on LV cables to be carried out and the cables energized within 24 hours of the tests. Program of works to be designed to suit accordingly.

C. Test Equipment: Provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500 V megger on installations with nominal voltage up to 500 V, and 1000 V megger on installations with nominal voltage over 500 V up to 1000 V. All test equipment shall have calibration certificate not older then 6 months on date of test.

D. Insulation resistance for LV power and lighting installations is to be carried out.

E. Insulation resistance for control and signal cables is to be minimum 10000 Meg ohm-km for PE insulated cables and 100 Meg ohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.

F. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.

G. Prior to energization, test wires and cables for electrical continuity and for short-circuits.

H. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

I. Acceptance tests during inspection by the Engineer in the works of manufacturer shall comprise all the routine tests specified for the items under inspection on samples which will be selected by the Engineer. In addition, any of the specified type tests may be required to be carried out in his presence, if satisfactory evidence of carrying out such tests is not available.

J. However, these tests need not be repeated if the manufacturer submits satisfactory tests reports, certificate, acceptable to the Engineer, on tests conducted previously on identical cables.

2.6.15 DATA SHEET FOR LV CABLES

A. (To be filled by Contractors / Bidders)

Sr. No.	Description	Multi Core Cable	Single Core Cable
1	Rated voltage of Cable		
2	Conductor normal operating temperature		
3	Conductor maximum short circuit temperature		
4	No. of Cores		
5	Armored or non-armored		
6	Laying Conditions		
7	Laying depth in ground		
8	Country of manufacture		

B. CONSTRUCTION (To be filled by Contractors / Bidders)

Sr. No.	Clause Ref.	TYPE OF CABLE	SINGLE CORE CABLES	MULTI CORE CABLES	
		Feature	Individual Core	Individual Core	4/2 Core assembly
1		Conductor			
2		Insulation			
3		Armor bedding (Inner Covering)			
4		Laying up			
5		Armour			
6		Over sheath			
7		Core identification			
8		Embossing			
9		Work Tests			
10		Inspection			

2.6.16 SITE ACCEPTANCE TEST FOR LV CABLES

Insulation and High Voltage Test Report for LV cables

1. **Cable Details**
   Cable Route : From To

   Cable Type : Size:

   Approx. Cable Length :

2. **Visual Inspection data**

a. Cable data as per drawing …….

b. No Physical damage …….

c. Shield grounding, cable support and termination ……

d. Cable bends as per manufacturer's recommendation ……

e. Insulation condition ……..

f. Verify colour coding as per specification ……

g. Verify cable identification as per drawing

A. No.	Description	Phase & loop checking of cables				
		R	Y	B	N	E

3. Insulation resistance test

S. No.	Description	Insulation resistance test									
		R-Y	Y-B	B-R	R-N	Y-N	B-N	R-E	Y-E	B-E	N-E

END OF SECTION- B 2.6