MATERIAL AND EQUIPMENT STANDARD

FOR

MEDIUM AND HIGH VOLTAGE

POWER CABLES

SECOND EDITION

AUGUST 2014

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran.

Postal Code- 1585886851

Tel: 021-88810459-60 & 021-66153055

Fax: 021-88810462

Email: Standards@nioc.ir

GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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1. SCOPE

1.1 This Standard specification covers the minimum requirements for the materials, manufacture, inspection and testing of medium voltage and high voltage power cables from 6 kV up to 30 kV to be used in oil, gas and petrochemical industries under the service conditions stated herein. For applications more than 30 kV refer to IEC 60840 and IEC 62067.

1.2 This standard shall also be referred for 3 kV cables in existing plants.

1.3 The general requirements of cables are given in this specification. The specific requirements of individual cases will be given in request for quotation and / or purchase order.

1.4 Cables for special installation and service conditions are not included, for example cables for the mining industry, nuclear power plants (in and around the containment area), submarine use or shipboard application.

Note 1:

The standard specification for cables and wires IPS-M-EL-270(0) is withdrawn, and replaced by the following three standard specifications.

- **IPS-M-EL-271: Low voltage cables and wires**
- **IPS-M-EL-272: Medium and high voltage power cables**
- **IPS-M-EL-273: Submarine power cables with inherent optical fibers**

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2014. Revision (1)-2003 of the said standard specification is withdrawn.

2. REFERENCES

2.1 Cables shall be designed, manufactured, inspected and tested in accordance with applicable sections of the latest edition of international electrotechnical commission “IEC” standards, including the following:

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

IEC 60038	“IEC Standard Voltages”
IEC 60183	“Guide to the Selection of High Voltage Cables”
IEC 60228	“Conductors of Insulated Cables”
IEC 60287	“Electric Cables-Calculation of Current Rating”
IEC 60332	“Tests on Electric and Optical Fibre Cables under Fire Conditions”
IEC 60502-2	“Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV (Um= 1.2 kV) up to 30 kV (Um= 36 kV) - Part 2: Cables for Rated Voltages from 6 kV (Um= 7.2 kV) up to 30 kV (Um= 36 kV)”
IEC 60502-4	“Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV (Um= 1,2 kV) up to 30 kV (Um= 36 kV) - Part 4: Test Requirements on Accessories for Cables with Rated Voltages from 6 kV (Um=7.2 kV) up to 30 kV (Um= 36 kV)”
IEC 60811	“Electric and Optical Fibre Cables-Test Methods for Non-Metallic Materials”

2.2 Where standards other than IEC are specified, it is understood that the equivalent IEC standard is acceptable.

2.3 Any deviation from this specification and the above mentioned references shall be clearly mentioned in the vendor's proposal.

3. SERVICE CONDITIONS

3.1 The cable under this specification will be either buried directly in sand filled underground trenches or will be installed on trays.

3.2 The method of installation and the environmental conditions will be indicated in data sheet appendix A.

4. VOLTAGE DESIGNATIONS

4.1 The voltage levels adopted in the oil, gas and petrochemical industries are based on the IEC recommendation No. 60038.

4.2 The rated voltages $U_0/U(U_m)$ of the cables considered in this standard are as follows:

$U_0/U(U_m)$ = 1.8/3(3.6) – 3.6/6 (7.2) – 6/10 (12) – 8.7/15 (17.5) – 12/20 (24) – 18/30 (36) kV.

In the voltage designation of cables $U_0/U(U_m)$:

U_0 is the rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed;

U is the rated power frequency voltage between conductors for which the cable is designed;

U_m is the maximum value of the "highest system voltage" for which the equipment may be used (see IEC 60038).

4.3 The cables designated 0.6/1 kV rms are called low voltage (LV) cables, the cables designated 3.6/6 kV rms are called medium voltage (MV) cables, and the cables designated 6/10 kV, 12/20 kV and 18/30 kV and higher voltages are called high voltage (HV) cables.

4.4 The available medium voltage power in the Iranian Petroleum industry is 3.6/6 kV.

4.5 The available high voltage power in the Iranian petroleum industry is 6/10 kV and 12/20 kV. For special cases upon the approval of company representative 18/30 kV could be adopted.

4.6 Unless otherwise indicated in data sheet Appendix A, the neutral point of medium voltage and high voltage systems are earthed through current limiting resistors.

5. CABLES CROSS SECTION

5.1 The conductors cross section of cables will be determined according to relevant IPS publication and will be indicated in data sheet Appendix A.

5.2 Unless otherwise approved by the company representative, the maximum conductor cross section of the medium voltage and high voltage power cables shall be limited to 240 mm^2 for three core cables and 400 mm^2 for single core cables.

5.3 Designer shall calculate the cross section of the conductors, taking into account the guidelines outlined in IPS-E-EL-100 including the following factors.

- Ambient temperature
- Method of installation

- Thermal resistivity of the soil for buried cables
- Maximum sunlight temperature for cables in trays
- Grouping factor
- Allowable voltage drop
- System short circuit current
- Current carrying capacity of cables according to manufacturer recommendation and IEC 60287

6. CORE IDENTIFICATION AND CABLE MARKING

6.1 For three core cable each core shall be identified with tapes of appropriate indelible color (red, yellow, blue) or by numbers and letters (L1, L2, L3) based on manufacturer standard.

6.2 The color of the outer sheath of all medium voltage and high voltage power cables shall be red. At least the following information shall be printed on the outer sheath of the cables, at reasonable intervals according to manufacturer standard.

- Manufacturer's name
- Year of manufacture
- Type of insulation
- Rated voltage
- Number of cores
- Size of conductors
- Length indication
- Other information requested in purchase order.

7. CABLE ACCESSORIES

7.1 Where indicated in data sheet, cable accessories such as cable glands, termination kits, straight joints, branch joints, stop-ends, insulating tapes, sealing compounds etc. together with any special tools or testing equipment shall be provided by the cable supplier. Such items shall be quoted separately. The accessories for MV and HV cables shall fulfill the test requirements of IEC 60502-4.

For specification of cable accessories refer to IPS-M-EL-161.

8. MEDIUM AND HIGH VOLTAGE CABLES CONSTRUCTION

8.1 Medium and high voltage cables shall be copper conductor with Cross Linked Polyethylene (XLPE) insulation, lead sheathed, single wire armoured and PVC overall jacket. Lead sheath shall be used for chemical attack cases. Lead sheath may be eliminated with company representative's approval. The cross section of conductors will be indicated in data sheet.

8.2 Conductors

Conductors shall be circular plain annealed stranded copper conforming to class 2 of IEC 60228.

8.3 Conductor Screen

The conductor screen shall be non-metallic and shall consist of extruded semi-conducting compound, which may be applied on top of a semi-conducting tape. The extruded semi-conducting compound shall be firmly bonded to the insulation.

8.4 Insulation

The insulation of medium voltage and high voltage cables shall be extruded Cross Linked Polyethylene (XLPE). The minimum thickness of the insulation shall be according to table 6 of IEC 60502-2.

8.5 Insulation Screen

The insulation screen shall consist of a non-metallic semi-conducting layer in combination with a metallic layer.

The non-metallic layer shall be extruded directly upon the insulation of each core and shall consist of either a bonded or strippable semi-conducting compound.

The metallic layer shall consist of a tape, or a braid, or a concentric layer of wires, conforming to the recommendations of IEC 60502-2.

The metallic layer shall be copper or other non magnetic metal of manufacturer standard, with a thickness of not less than 75 µm and shall be applied with 15% overlap over the non-metallic layer.

8.6 Inner Coverings and Fillers

8.6.1 Construction

The inner coverings may be extruded or lapped.

For cables with circular cores, a lapped inner covering shall be permitted only if the interstices between the cores are substantially filled.

A suitable binder is permitted before application of an extruded inner covering.

8.6.2 Material

The materials used for inner coverings and fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material.

8.6.3 Thickness of extruded inner covering

The approximate thickness of extruded inner coverings shall be derived from Table 8 of IEC 60502-2.

8.6.4 Thickness of lapped inner covering

The approximate thickness of lapped inner coverings shall be 0.4 mm for fictitious diameters over laid-up cores up to and including 40 mm and 0.6 mm for larger diameters.

8.7 Bedding

The bedding under the armour shall be extruded or lapped layer/s of PVC or synthetic tape/s of manufacturer standard. The thickness of the bedding shall be according to the recommendations of IEC 60502-2 and shall not be less than 1.5 mm.

8.8 Metallic sheath

The metallic sheath shall consist of lead or lead alloy and shall be applied as a reasonably tight-fitting seamless tube. The nominal thickness of the lead sheath shall be calculated by the formulas recommended in IEC 60502-2 and shall in no case be less than 1.2 mm. If approved by company representative, for cables which will be installed on trays or will be buried in places where the presence of hydrocarbon is not foreseen lead sheath may be replaced by other metallic sheath/s. In such cases the metallic sheath/s may consist of one or two layer/s of bronze tape/s or equivalent metallic tape/s of manufacturer standard. The total thickness of such metallic sheath shall not be less than the calculated thickness for lead sheath according to the recommended formulas of IEC 60502-2.

8.9 Armour

The armour shall be closed galvanized round steel wire i.e. with a minimum gap between adjacent wires. It may be supplemented by a helix of galvanized steel tape to keep the armour wires tight if necessary. Flat wire armour is not desirable, however it could be considered upon the approval of company representative and consequently the flat armour shall be supplemented by a helix of galvanized steel tape to keep the armour wires tight. The minimum dimensions of the armour wires shall be in accordance with the requirements of IEC 60502-2. The thickness of the galvanized steel tape shall be at least 0.3 mm. For single core cables the armour shall be made of non-magnetic materials.

Round wire armour type shall be used for lead sheathed cable and Flat wire armour type is not accepted.

8.10 Over Sheath

The outer sheath over the armour shall be extruded red PVC complying with the requirements of IEC 60502-2. To protect the non-armour cables against rodent and termite attack, suitable and environmentally friendly substance shall be added to PVC over sheath.

For cables to be installed on trays, as indicated in data sheet, the over sheath shall be made of flame retardant PVC or an elastomeric compound which satisfies the requirements of IEC 60332-1.

9. CABLE TESTS AND INSPECTION

9.1 Routine tests, sample tests and type tests shall be carried out at manufacturer work according to the recommendations of IEC 60502-2, and the relevant publications referred to therein.

9.2 Type tests, electrical and non-electrical, shall be performed on samples from each type of cables.

Type tests are of such a nature that, after they have been made, they need not be repeated, unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

9.3 Test certificates shall be submitted to purchaser in three copies.

9.4 The purchaser may appoint representative/s or third party to witness the factory tests on cables. The supplier shall inform the date of performing such tests, at least four weeks in advance.

9.5 The purchaser's inspectors shall be granted the right for inspection at any stage of manufacture, testing and preparation for shipment.

10. PACKING FOR SHIPMENT

10.1 The cables shall be supplied on non returnable drums with steel reinforced hub plates, the inner end of cables shall be brought out through the side of the drum/s.

10.2 Each drum shall be durably marked on the outside of the flange, with particulars of the cable i.e. voltage, length, conductor size, and cable type. The gross mass shall be shown and the direction of rolling shall be indicated by arrow.

10.3 Cable drums shall be provided with a permanently attached readily visible identification tags. Identification tags should remain intact from the time of initial dispatch at work to the final destination.

10.4 Before dispatch the manufacturer shall seal and cap both ends of cables so that to prevent the ingress of water during transportation and storage, projecting end of cables shall be protected from mechanical damage.

10.5 The cable/s manufacturer shall be the sole responsible for adequacy of preparation for shipment of cables.

10.6 Shipping documents with exact description for custom release shall be included.

11. GUARANTEE

11.1 All cables shall be guaranteed against defective material, poor design and workmanship.

11.2 The vendor shall guarantee the cables performance under specified conditions.

11.3 If any defect is discovered during the d.c. voltage test performed after the cable installation, the vendor shall be responsible for replacement of the cable free of charge.

Unless otherwise agreed between the cable vendor and the purchaser, the d.c. test voltage shall be equal to $4U_0$ and shall be applied for fifteen minutes according to the recommendations of IEC 60502-2.

APPENDIX A

MEDIUM AND HIGH VOLTAGE CABLE DATA SHEET

The vender shall complete and submit this data sheet with his proposal.

1.	Name of project or plant	*
2.	Cable identification number	*
3.	Operating voltage phase to phase (kV)	*
4.	Cable insulation voltage $U_0/U(U_m)$ = 1.8/3(3.6) – 3.6/6 (7.2) – 6/10 (12) – 8.7/15 (17.5) – 12/20 (24) – 18/30 (36) kV	*
5.	System frequency	*
6.	System grounding	*
7.	Method of installation (buried or on trays)	*
8.	Maximum ambient temperature	*
9.	Maximum sunlight temperature	*
10.	Thermal resistivity of soil	*
11.	Numbers of cores (separate list can be attached)	*
12.	Size of conductors (mm^2) (separate list can be attached)	*
13.	Lengths(m) (separate list can be attached)	*
14.	Type of copper conductors; round stranded	
15.	Conductor screen	
16.	Insulation	
17.	Insulation screen, non metallic layer	
18.	Insulation screen, metallic layer	
19.	Type of filler	
20.	Material of binder	
21.	Material and thickness of metallic sheath	
22.	Bedding	
23.	Type of armour, flat or round wire armour	
24.	Wire armour diameter (mm)	
25.	Thickness of the galvanized steel tape (mm)	
26.	Type and thickness of over sheath	
27.	Cores identification (color or letter and number)	
28.	Color of over sheath (red)	
29.	Length indication interval on over sheath	
30.	Current rating in air at ISO condition	
31.	Current rating in ground	
32.	DC resistance at 20°C ohm/km	
33.	AC resistance at 20°C ohm/km	
34.	Inductance milli H/km	
35.	Capacitance core to core micro F/km	
36.	Capacitance core to earth micro F/km	
37.	Voltage drop per ampere per km	
38.	Fault current capacity for one second and 0.5 second	
39.	Diameter under armour (mm)	
40.	Over all diameter (mm)	
41.	Minimum recommended bending radius of the cable (m)	
42.	Maximum tensile strength of the cable	
43.	Weight (kg/m) or kg per 100 meter	
44.	Maximum cable length on each cable drum	
45.	Cable accessories	See Attached list

*** by purchaser**