MATERIAL AND EQUIPMENT STANDARD

FOR

LOW VOLTAGE

CABLES AND WIRES

SECOND EDITION

JUNE 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.

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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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APPENDICES:

1. SCOPE

1.1 This Standard specification covers the minimum requirements for the materials, manufacture, inspection and testing of low voltage electrical cables and wires to be used in oil, gas and petrochemical industries under the service conditions stated herein.

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

1.3 Cables for special installation and service conditions are not included, for example cables for overhead networks, 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 60227	"PVC Insulated Cables of Rated Voltage up to and including 450/750 V"
IEC 60228	"Conductors of Insulated Cables"
IEC 60245	"Rubber Insulated Cables -Rated Voltage up to and including 450/750 V""
IEC 60287	"Electric Cables-Calculation of Current Rating"
IEC 60331-11	"Tests for Electric Cables under fire Conditions - Circuit Integrity – Part 11: Apparatus - Fire alone at a Flame Temperature of at least 750 °C"
IEC 60331-21	" Tests for Electric Cables under Fire Conditions - Circuit integrity – Part 21: Procedure and Requirements-Cables of rated Voltage up to and including 0.6/1.0 kV"
IEC 60332	"Tests on Electric and Optical Fibre Cables under Fire Conditions"

IEC 60502-1 "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 1: Cables for Rated Voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV) "

IEC 60702 "Mineral Insulated Cables and their Terminations with a Rated Voltage not Exceeding 750 V"

IEC 60754-1 "Test on Gases Evolved during Combustion of Material from Cables-Part 1: Determination of the Halogen Acid Gas content"

IEC 60754-2 "Test on Gases Evolved during Combustion of Material from Cables-Part 2: Determination of Acidity (by pH Measurement) and Conductivity"

IEC 60811 "Electric and Optical Fibre Cables-Test Methods for Non-Metallic Materials"

IEC 61034-1 "Measurement of Smoke Density of Cables Burring under Defined Conditions-Part1: Test Apparatus CONSOLIDATED EDITION"

IEC 61034-2 " Measurement of Smoke Density of Cables Burring under Defined Conditions-Part2: Test Procedure and Requirements CONSOLIDATED EDITION"

BSI (BRITISH STANDARD INSTITUTION)

BS 6346 "Electric cables-PVC insulated, Armoured Cables for Voltages of 600/1000V and 1900/3300V"

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 cables 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 0.6/1 (1.2) kV. These cables are called low voltage (LV) cables, and will be used in services with voltages below 1000V.

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

$\boldsymbol{U_0}$ is the rated power frequency voltage between conductor and earth or metallic screen for which the cable is designed;

$\boldsymbol{U}$ is the rated power frequency voltage between conductors for which the cable is designed;

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

4.3 The available low voltage power in the Iranian Petroleum industry is 400 volt three phase and 230 volt single phase with solidly earthed neutral, and also 110 volt single phase, which can be used for instrumentation and control.

4.4 The low voltage cables and wires includes single core power cables, three core and four core power cables, multicore control cables, mineral insulated cables, fire resistant cables, flexible cables, earthing cables and low voltage wires.

4.5 Unless otherwise indicated in data sheet appendix A, the neutral point of low voltage systems is solidly earthed.

5. CABLES CROSS SECTION

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

5.2 In 4 core cables, reduced cross section for neutral conductors is acceptable. Neutral conductor shall be sized according to BS 6346 or equivalent IEC standard.

5.3 Unless otherwise approved by the company representative, the maximum conductor cross section of the low voltage power cables shall be limited to 240 mm^2 for 3 and 4 core cables and 400 mm^2 for single core cables.

5.4 The minimum conductor cross section for control cables shall be 2.5 mm^2.

5.5 The minimum conductor cross section for lighting and power cables or wires shall be 2.5 mm^2.

5.6 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. INSULATION COLOR AND CABLE MARKING

6.1 The conductors insulation color of 3 and 4 core low voltage power cables shall be red-yellow-blue for phase conductors and black for neutral conductor. In special cases, other colors can be specified by the company representative, which will be indicated in data sheet, appendix A.

6.2 Unless otherwise specified in datasheet, the conductor insulation color of control cables shall be black with white identification numbers.

6.3 The insulation color of earthing cables shall be green/yellow.

6.4 The insulation color of low voltage wires can be red, yellow, blue and black. Red, yellow and blue shall be used as phase wires and black shall be used as neutral wire.

6.5 In DC power systems red shall be used as positive conductor and black shall be used as negative conductor.

6.6 The color of the outer sheath of all low voltage power and control cables shall be black. At least the following information shall be printed on the outer sheath of low voltage power and control 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
- Metric 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, 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. For specification of cable accessories refer to IPS-M-EL-161.

8. LOW VOLTAGE POWER CABLES CONSTRUCTION

8.1 The low voltage cables shall be copper conductor with PVC or XLPE insulation 600/1000 V grade, lead sheathed, single wire armoured, with PVC overall jacket. The numbers of cores and cross section of conductors will be indicated in data sheet. Lead sheath may be eliminated for some applications which shall be approved by company representative.

8.2 Conductors

Conductors shall be plain annealed stranded copper in accordance with IEC 60228. Conductor sizes up to and including 10 mm^2 can be solid copper. Type of conductor stranding shall be stated in data sheet.

8.3 Insulation

Insulation of low voltage cables shall generally be PVC. Cross Linked Polyethylene (XLPE) insulation may be quoted as an alternative proposal. The insulation thickness shall be according to IEC 60502-1.

8.4 Inner Coverings and Fillers

8.4.1 Construction

The inner coverings may be extruded or lapped. For cables with circular cores, except cables with more than five 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.

8.4.2 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. For halogen free cables, the inner covering and fillers shall meet the requirements given in Table 23 of IEC 60502-1.

8.4.3 Thickness of extruded inner covering

The approximate thickness of extruded inner coverings shall be derived from Table 8 of IEC 60502-1.

8.4.4 Thickness of lapped inner coverings

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.

8.5 Bedding

The bedding shall be extruded or lapped layer/s of PVC or synthetic tape/s of manufacturer standard, with the approximate thickness as specified in IEC 60502-1.

8.6 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 lead sheath shall be calculated by the formulas recommended in IEC 60502-1 and shall in no case be less than 1.2 mm. If approved by company representative, lead sheath may be eliminated for cables which will be installed on trays or will be buried in places where the presence of hydrocarbon is not foreseen.

8.7 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 60502-1. 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.

8.8 Over Sheath

The outer sheath over the armour shall be extruded black PVC complying with the requirements of IEC 60502-1. 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. CONTROL CABLES CONSTRUCTION

9.1 Control cables are used for the purpose of control, indication and protection of electrical equipment in particular, electric motors. Control cables shall be multicore. The numbers of cores required, will be indicted in data sheet.

9.2 Conductors

Conductors for control cables shall be plain annealed solid or stranded copper. Conductor sizes shall be 2.5 mm^2 as minimum. Conductors shall be in compliance with class 2 of IEC 60228. Conductors in the same cable shall be all of the same size.

9.3 Insulation

Insulation shall consist of an extruded layer of PVC with rated voltage of not less than 600 volt.

9.4 Inner Coverings and Fillers

9.4.1 Construction

The inner coverings may be extruded or lapped. For cables with circular cores, except cables with more than five 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.

9.4.2 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. For halogen free cables, the inner covering and fillers shall meet the requirements given in Table 23 of IEC 60502-1.

9.4.3 Thickness of extruded inner covering

The approximate thickness of extruded inner coverings shall be derived from Table 8 of IEC 60502-1.

9.4.4 Thickness of lapped inner coverings

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.

9.5 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 lead sheath shall be calculated by the formulas recommended in IEC 60502-1 and shall in no case be less than 1.2 mm. If approved by company representative, lead sheath may be eliminated for cables which will be installed on trays or will be buried in places where the presence of hydrocarbon is not foreseen.

9.6 Bedding

The bedding or inner covering shall be extruded layer of PVC or synthetic tape/s of manufacturer standard, with the approximate thickness as specified in IEC 60502-1.

9.7 Armour

The armour shall be galvanized round steel wire supplemented by a helix of galvanized steel tape to keep the armour wires tight. At the discretion of the company representative, such galvanized

steel tape may be eliminated. Flat wire armour is not desirable, however, it could be considered upon the approval of company representative. The minimum dimensions of the armour wires shall be in accordance with the requirements of IEC 60502-1. The thickness of the galvanized steel tape shall be at least 0.3 mm. For cables to be installed on trays, as indicated in data sheet, galvanized steel wire braid armour is acceptable.

9.8 Over sheath

The outer sheath over the armour shall be extruded black PVC complying with the requirements of IEC 60502-1. To protect the cables against rodent and termite attack, suitable chemicals 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.

9.9 Core Identification

The control cable cores identification shall be achieved by numbering the cores. The numbering of the cores shall start from No. one for the wire in center.

The insulation of the cores shall be of the same color and numbered sequentially. There shall be a clear contrast between color of cores and color of numbers. Unless otherwise specified in datasheet, color of cores shall be black and color of numbers shall be white.

The height of individual numbers shall not be less than 1.5 mm, and the interval between adjacent numbers shall not be more than 55 mm.

10. SPECIAL CABLES

In areas where high temperature is expected or for safety purposes (such as F&G system), mineral insulated copper-clad cables (MICC) or fire resistant cables with company's representative approval shall be used.

10.1 Mineral Insulated Cables

10.1.1 Mineral insulated copper-clad cables (MICC) may be used for small power and control purposes.

10.1.2 Where mineral insulated cables are specified, the cables shall be copper conductor, copper sheathed with PVC outer covering. The mineral insulated cables shall be manufactured according to IEC 60702-1.

10.1.3 The terminations of mineral insulated cables shall be in compliance with the requirements of IEC 60702-2.

10.2 Fire Resistant Cables

For test of fire resistant cables IEC 60331-11,21, IEC 60332-1,2,3 (3-10, 3-21~25), IEC 61034-1,2 and IEC 60754-1,2 shall be followed.

11. FLEXIBLE CABLES AND WIRES

11.1 For applications where the equipment connected to the power or control cable is subject to vibration, flexible cables or wires shall be used. Flexible cables and wires shall be capable of with standing bending and other mechanical stresses occurring in normal use and shall comply with the requirements of IEC 60227-2.

11. 2 Conductors

The conductors for flexible cables or wires shall be plain annealed stranded copper. The conductors shall be in compliance with minimum class 5 of IEC 60228.

11.3 Insulation

The insulation shall consist of an extruded layer of PVC or EPR. The PVC for this purpose shall be type PVC/D as defined in IEC 60227-3 and 4. The insulation thickness shall be according to the recommendations of IEC 60502-1.

11.4 Binder Tape

Flexible cable cores shall be lapped with suitable binder tape/s as per manufacturer's standard.

11.5 Bedding and Armour

The armour for flexible cables, where indicated in data sheet shall be galvanized steel wire braid.

The diameter of wires in wire braiding shall be in accordance with relevant IEC recommendation/s and not less than the following:

Diameter under the armour	Wire diameter
Less than 10 mm	0.2 mm
10 to 30 mm	0.3 mm
30 to 70 mm	0.4 mm
Above 70 mm	0.5 mm

The armouring of single core flexible cables shall be made of non magnetic material.

The bedding for wire braiding shall be in accordance with manufacturer's standard.

11.6 Over Sheath

The over sheath of flexible cables and wires shall be PVC compound of the type PVC/ST5 as specified In IEC 60227-4.

12. LOW VOLTAGE WIRES

12.1 Low voltage wires shall be stranded or solid copper conductor, PVC insulated, rated voltage 450/750 volt according to IEC 60227.

12.2 Wires shall be suitable for installation in rigid steel galvanized conduits or truncking.

12.3 The insulation color of low voltage wires shall be according to paragraph 6.4 and 6.5 of this specification.

13. EARTHING CABLES AND WIRES

13.1 Earthing cables and wires shall be single core with plain stranded or solid copper conductor.

13.2 Insulation shall be PVC with rated voltage of 600 volt. No armour is required.

13.3 The color of insulation for earthing cables and wires shall be green/yellow.

14. CABLE TESTS AND INSPECTION

14.1 Routine tests, sample tests and type tests shall be carried out at manufacturer work according to the recommendations of IEC 60502-1 and the relevant IEC publications referred to therein.

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

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.

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

14.4 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.

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

15. PACKING FOR SHIPMENT

15.1 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.

15.2 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.

15.3 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.

15.4 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.

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

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

16. GUARANTEE

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

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

16.3 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 4Uo and shall be applied for fifteen minutes according to the recommendations of IEC 60502-1.

APPENDICES

APPENDIX A

LOW 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 (volt)	*
4.	Cable insulation voltage (U_0/U)	*
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.	Type of cable (power, control, MICC, flexible, earthing etc.)	*
12.	Numbers of cores (separate list can be attached)	*
13.	Size of conductors (mm^2) (separate list can be attached)	*
14.	Lengths(m) (separate list can be attached)	*
15.	Type of copper conductors; stranded/solid, round/shaped	
16.	Insulation	
17.	Type of filler	
18.	Material of binder	
19.	Lead sheath required or not	*
20.	Thickness of lead sheath	
21.	Bedding	
22.	Type of armour, flat or round wire armour or braided	
23.	Wire armour diameter (mm)	
24.	Thickness of the galvanized steel tape (mm)	
25.	Type and thickness of over sheath	
26.	Color of cores	
27.	Color of over sheath	
28.	Length indication interval on over sheath	
29.	Current rating in air at ISO condition	
30.	Current rating in ground	
31.	DC resistance at 20°C ohm/km	
32.	AC resistance at 20°C ohm/km	
33.	Inductance mH/km	
34.	Capacitance core to core micro F/km	
35.	Capacitance core to earth micro F/km	
36.	Voltage drop per ampere per km	
37.	Fault current capacity for 1 second and 0.5 second	
38.	Diameter under armour (mm)	
39.	Overall diameter (mm)	
40.	Minimum recommended bending radius of the cable (m)	
41.	Maximum tensile strength of the cable	
42.	Weight (kg/m or kg per 100 meter)	
43.	Maximum cable length on each cable drum	
44.	Cable accessories	See Attached list

*** by purchaser**