MATERIAL AND EQUIPMENT STANDARD

FOR

DRY TYPE POWER TRANSFORMERS

SECOND EDITION

OCTOBER 2013

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.

CONTENTS: PAGE No.

1. SCOPE

1.1 This standard specification covers the minimum requirements for design, manufacture, and quality control of dry type power transformers.

1.2 Dry type power transformers will be installed in oil, gas and petrochemical industries in Iran under the environmental and service conditions specified herein.

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

Note 1:

The standard specification for power transformers IPS-M-EL-150(0) is withdrawn, and replaced by the following two standard specifications which are issued as revision(1).

- IPS-M-EL-151 "Dry Type Power Transformers"
- IPS-M-EL-152 "Oil Immersed Power Transformers"

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2013. Revision (1)-2005 of the said standard specification is withdrawn.

2. REFERENCES

2.1 Dry type power transformers shall be designed, manufactured, inspected and tested in accordance with the applicable sections of the latest edition of the following International Electrotechnical Commission "IEC" standards. This standard specification is primarily based on IEC 60076-11.

IEC-60038	"IEC Standard Voltages"
IEC 60076-1	"Power Transformers-General"
IEC 60076-2	"Power Transformers - Part 2: Temperature Rise for Liquid-Immersed Transformers"
IEC 60076-3	"Power Transformers - Part 3: Insulation Levels, Dielectric Tests and External Clearances in Air"
IEC 60076-4	"Power Transformers - Part 4: Guide to the Lightning Impulse and Switching Impulse Testing - Power Transformers and Reactors"
IEC 60076-5	"Power Transformers - Part 5: Ability to Withstand Short Circuit"
IEC 60076-8	"Power Transformers-Application Guide"
IEC 60076-10	"Power Transformers - Part 10: Determination of Sound Levels"
IEC 60076-11	"Power Transformers - Part 11: Dry-Type Transformers"
IEC 60085	"Electrical Insulation - Thermal Evaluation and Designation"
IEC 60099-1	"Surge Arresters - part 1: Non-Linear Resistor Type Gapped Surge Arresters for A.C. Systems"
IEC 60137	Insulated Bushings for Alternating Voltages above 1000 v
IEC 60214-1	"Tap-Changers - Part 1: Performance Requirements and Test Methods"
IEC 60214-2	"Tap-Changers –Part 2: Application Guide"

IEC 60529	"Degrees of Protection Provided by Enclosures (IP Code)"
IEC 60616	Terminal and Tapping Markings for Power Transformers
IEC-60076-12	"Power Transformers - Part 12: Loading Guide for Dry-Type Power Transformers"

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

3. SERVICE CONDITION

3.1 The transformer specified herein shall be installed indoor. Dry type transformer can also be installed outdoor in non-industrial areas if approved by company engineering, as indicated in data sheet. (Refer to IPS-E-EL-100(1) for industrial and non-industrial applications)

3.2 The maximum ambient air temperature, relative humidity and the elevation of the location in which the transformer will be installed shall be indicated in data sheet. The maximum ambient air temperature shall in no case be assumed less than 40^{o}C. The lower limit of the ambient air temperature for indoor and outdoor will also be indicated in data sheet.

3.3 The atmosphere is saliferrous, dusty and corrosive as commonly encountered in oil, gas and petrochemical installations.

3.4 The voltage levels adopted in the oil, gas and petrochemical industries of Iran are based on the IEC recommendation No. 60038. The primary and secondary voltages of the transformer will be indicated in data sheet.

3.5 The supply voltage will be three phase symmetrical and the variation will be ±10% of the rated voltage.

3.6 The nominal rated frequency is 50Hz. The system frequency variation will be ±5% of rated frequency. The frequency drop of 5% will only occur at nominal voltage or lower.

3.7 Electromagnetic Compatibility (EMC)

Transformers shall be considered as passive elements in respect to emission and immunity to electromagnetic disturbances.

4. DESIGN CONSIDERATIONS

4.1 Application

4.1.1 Dry type power transformers can be used to feed load capacities up to and including 1250 kVA with secondary voltage of 400/230 volt. Capacities higher than 1250 kVA and/or secondary voltages other than 400/230 volt can be adopted upon the request of purchaser or company representative. The load on dry type transformer will be groups of motors together with lighting and general power supplies.

4.1.2 Dry type transformers are generally used to feed electrical loads in non-process areas. The use of dry type transformers to feed process plants shall be approved by company representative (process plant means an industrial unit where hydrocarbon or other volatile substances are processed).

4.1.3 Dry type transformers shall be with cast resin encapsulated/impregnated windings. The high voltage winding shall be resin encapsulated and the low voltage winding shall be resin impregnated.

4.1.4 Unless otherwise indicated in data sheet, the neutral point of secondary windings of dry type transformers will be solidly earthed.

4.1.5 The rated power of transformer is the apparent power input to the transformer as defined in IEC 60076-1. The rated power values shall be selected from the series of preferred numbers as indicated in IEC 60076-1.

4.1.6 The rated power of transformer indicated in data sheet is the rating at the specified ambient condition and includes 20% excess capacity to be used for feeding future loads. The rated power shall be estimated based on maximum simultaneous load multiplied by 1.2. The maximum simultaneous load shall be calculated by adding the running loads plus 25-75% (according to the project type and designer) of intermittent loads plus the biggest standby load or 10% of all the standby loads, which ever is higher.

4.1.7 When indicated in data sheet, the transformer will operate in parallel with existing transformer/s. In such case the particulars of the existing transformer/s will be given in request for quotation (as per IEC 60076-11).

4.2 Cooling

4.2.1 Unless otherwise specified in data sheet, dry type power transformers with or without protective enclosure shall be natural air cooled AN type as described in IEC 60076-11.

4.3 Noise Limits

4.3.1 The noise limits measured at a distance of 0.3m or 1m according to the recommendation of IEC 60076-10 shall be stated in data sheet by the manufacturer, at quotation stage.

4.3.2 Noise measurement of dry type transformers shall be carried out without enclosure.

4.4 Losses and Efficiency

4.4.1 At principal tap position the no load loss at rated voltage and also the I^2R loss and stray loss at rated current shall be determined and shall be indicated in data sheet.

4.4.2 The manufacturer shall also indicate in data sheet the efficiency of the transformer in percentage, at principal tap and at 100%, 75% and 50% output load.

4.4.3 The measurement of losses shall be performed according to IEC 60076-1.

5. CONSTRUCTION REQUIREMENTS

5.1 General

5.1.1 Dry type power transformer shall be suitable for continuous operation at full load on any tap setting without excessive temperature rise at the ambient conditions indicated in data sheet.

5.1.2 The transformer shall be designed to cause minimum environmental contamination with very low flammability risk.

5.1.3 The transformer shall satisfy the requirements for the climatic classification of C2, environmental classification of E2 and fire classification of F1 as defined in IEC 60076-11.

5.1.4 The transformer shall fulfill at any tap position the requirements of IEC 60076-5 concerning the ability to withstand short circuits for the period of time specified by IEC.

5.1.5 In case the transformer will be installed within a system which requires higher impedance for reducing the short circuit power on the secondary of the transformer, the required short circuit impedance will be specified in data sheet.

5.1.6 Dry type transformer shall be capable of being overloaded according to the guidelines given in IEC 60076-12.

5.1.7 The transformer shall be provided with rollers to enable the movement of transformer in longitudinal and transversal directions. It shall be possible to remove the rollers and fix the transformer to the foundation.

5.1.8 Necessary means shall be provided for lifting the transformer by chain or cable.

5.2 Transformer Core

5.2.1 Transformer core shall consist of individually insulated high permeability silicon steel laminations. The laminations shall be treated to avoid the ingress of moisture.

5.2.2 To protect the core against corrosion, the core shall be given a protective epoxy resin finish.

5.2.3 The core shall be rigidly clamped and the windings shall be firmly braced to the core to ensure adequate mechanical strength and to reduce vibration under operating conditions.

5.3 Winding and Insulation

5.3.1 Transformer shall have separated high and low voltage windings.

5.3.2 Windings shall be made of copper or Aluminum with uniform insulation. Winding material shall be indicated in data sheet at quotation stage.

5.3.3 The windings insulation shall be class F with average winding temperature rise of $100^{o}C$ at rated current and at ambient conditions defined in IEC 60076-11. The average temperature rise shall be reduced according to the instructions of IEC 60076-11 with respect to high cooling air temperature and high altitude as indicated in data sheet.

5.3.4 The insulation level for rated Short Duration Power Frequency Withstand Voltage (rms value) and rated Lightning Impulse Withstand Voltage (peak value) shall not be less than the values of List 1 of table 3 of IEC 60076-11. In case the transformer is to be connected to overhead transmission lines which are not equipped with surge arrestors or when isolated neutral system is to be adopted, the values of List 2 of table 3 is required.

Note: The rated Lightning Impulse Withstand Voltage corresponds to Basic Lightning Impulse Insulation Levels (BIL's) defined in North American practice. The insulation level based on North American Practice is acceptable provided that it is not less than the values recommended in IEC 60076-11.

5.4 Transformer Connection and Phase Displacement Symbol

5.4.1 Unless otherwise indicated in data sheet, transformers shall be connected delta primary and wye secondary.

5.4.2 The angular displacement between high voltage and low voltage shall be Dyn5 according to IEC 60076-1.

5.4.3 Transformers with Dyn11 winding arrangement are acceptable subject to purchaser's approval.

5.4.4 Neutral terminal shall be furnished for wye connected windings and shall be accessible for connection to a four wire system, and/or to ground. The neutral connection shall be capable of carrying full phase rated current.

5.5 Transformer Enclosure

5.5.1 Dry type power transformer for outdoor use shall be provided with dedicated enclosure.

5.5.2 The requirement of enclosure for indoor transformer shall be decided by company representative and shall be indicated in data sheet.

5.5.3 The transformer enclosure shall be made of galvanized sheet steel with 2 mm minimum thickness, and shall be painted according to manufacturer standard. The color and the painting specification of the enclosure shall be indicated in data sheet, by the transformer supplier.

5.5.4 Transformer enclosure shall be adequately ventilated either by natural air flow or by fan/s. When ventilation fan/s is to be supplied, they shall be 230 volt single phase and shall be equipped with suitable protective fuse/s and isolator/s.

5.5.5 The enclosure degree of protection for indoor transformer shall be at least IP 31 as per IEC 60529.

5.5.6 For outdoor application, the enclosure degree of protection shall be at least IP 33 as per IEC 60529.

5.5.7 Rain cover shall be provided for outdoor units in order to avoid the entry of rain water into the enclosure.

5.5.8 Enclosure shall have safety interlocked doors and removable front panel to allow rolling out of the transformer. Suitable eye bolts shall be provided for lifting the enclosure.

5.5.9 Enclosure shall have grounding bolts at least at two points, to be connected to grounding conductors.

5.5.10 The enclosure shall be fixed to the transformer frame. The transformer assembly shall be mounted on a base frame. When required in the project particular specifications/data sheets, shock absorber/anti vibration pads shall be provided.

5.6 Tap Changing

5.6.1 Unless otherwise indicated in data sheet, two off-circuit tapping ranges of 2.5% and 5% below and also 2.5% and 5% above nominal voltage, shall be provided on the high voltage windings.

5.6.2 Off- circuit tap changing shall be performed by the use of suitable bolted links. Clearly marked tags shall be provided to indicate the position of links for each tapping. The position of links shall be observable from outside the transformer enclosure through a removable cover.

5.6.3 Tappings shall be rated for the full rating of the transformer.

5.7 Temperature Indicator

5.7.1 Winding temperature indicator/s with maximum temperature pointer shall be provided for dry type transformers of 250 kVA and above. The sensors for such temperature indicator/s shall be located close to low voltage windings in locations to indicate the hot spot temperature of the windings.

5.7.2 The temperature indicator/s shall be installed in locations that will not maloperate due to vibration under service condition.

5.7.3 Winding temperature indicator/s shall be equipped with two numbers of electrically independent changeover contacts for alarm and trip purposes. The leads of such contacts shall be wired to a terminal box located inside the transformer enclosure, or attached to the transformer frame.

5.8 Current Transformer

5.8.1 If specified in data sheet, current transformer/s for protection purposes (e.g. restricted earth fault) shall be fitted. The location of current transformer/s will be shown on drawings or will be decided by the Company representative.

5.8.2 The purchaser will provide all necessary details of the current transformer/s to be supplied by the transformer manufacturer or will make such current transformers available for the manufacturer to fit on the transformer. The supplier of the current transformers will be indicated in data sheet.

5.8.3 The secondary terminals of current transformer/s shall be wired to a terminal box. The terminals shall be provided with short circuiting links. Means shall be provided to perform primary injection testing of current transformer/s.

5.9 Additional Equipment

5.9.1 When indicated in data sheet additional equipment shall be supplied with the transformer.

5.9.2 The required additional equipment such as earthing switch, neutral earthing resistor, load break switch, low voltage distribution panel, lightning arrestors, etc. will be specified by the purchaser and will be shown on drawings.

5.9.3 Additional equipment shall be installed inside the transformer enclosure with proper partitions.

5.10 External Terminations

5.10.1 Incoming supply to the high voltage side of the transformer will be via underground cable/s. The cable/s will enter the transformer enclosure or transformer room from underground cable trenches. In cases where the transformer will be connected to overhead lines, it will be indicated in data sheet.

5.10.2 The low voltage side of the transformer will be connected to outgoing cable/s or bus duct. The choice between cable/s or bus duct will be indicated in data sheet.

5.10.3 In case bus ducts are specified for connection to the low voltage side of the transformer, the supplier shall provide flanged entry with insulated copper bus bars extending to the flange point on the enclosure. The size of copper bars shall be agreed by the purchaser or company representative.

5.10.4 The numbers and sizes of incoming and outgoing cables or overhead lines will be indicated in data sheet.

5.10.5 On the high voltage side, bolted disconnecting links shall be provided. The links are to be removed for the purpose of testing the high voltage cable/s.

5.10.6 On the low voltage side when more than one conductor are to be connected, sufficient copper bars shall be provided to be connected to the low voltage cables indicated in data sheet. It shall be possible to test the low voltage cables without damaging the cables or the termination points of the transformer.

5.10.7 The termination points of the transformer shall be made of copper or shall be copper coated to be compatible with copper conductors of the cables or bus bars.

5.10.8 Bushings shall comply with the requirements of IEC 60137. Where exposed bushings are fitted to be connected to overhead lines, surge arresters approved by the purchaser or company representative shall be provided. Surge arresters shall comply with the requirements of IEC 60099-1.

5.10.9 For terminal and tapping markings refer to IEC 60616.

5.11 Name Plate

5.11.1 Each transformer shall be provided with a name plate securely fixed in a visible position. The transformer enclosure shall also be provided with a similar name plate.

5.11.2 The name plate/s shall be made of stainless steel.

5.11.3 Name (Rating) plate/s shall be durably and indelibly marked with the items specified in IEC 60076-11 as far as they apply.

5.11.4 In addition to the name plate/s a separate identification plate engraved with the transformer identification number given on data sheet shall be attached to the transformer and to the enclosure. It shall be possible to replace such plate/s by similar plate/s.

5.11.5 When special features are included, a plate showing appropriate instructions shall be fixed to the transformer and the enclosure.

5.11.6 A warning label marked with the voltage and a danger sign shall be attached to the terminals of the transformer.

6. TEST AND INSPECTION

6.1 The equipment under this specification shall be factory tested. Certified copies of test reports and/or certificates shall be submitted to the purchaser. The numbers of certified copies required will be specified by the purchaser in the purchase order.

6.2 Routine tests shall be performed on all completed transformers as detailed in IEC 60076-11 and the relevant IEC publications referred to therein.

6.3 Type tests and special tests, as per IEC 60076-11 shall be performed on selected transformers. The results of such tests on identical transformers are acceptable.

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

6.5 Purchaser will require the presence of his nominated representative to witness the final inspection and tests. The supplier shall inform the date of such tests at least four weeks in advance.

7. SPARE PARTS

7.1 Together with the supply of transformer under this specification, a complete set of spare parts for commissioning and special tools, if required, shall be supplied for each transformer. The supplied spare parts shall comply with the same specifications as the original parts and shall be fully interchangeable with the original parts without any modification. Spare parts shall be preserved to prevent deterioration during transport and storage in a humid tropical atmosphere.

7.2 The vendor shall also supply a list of recommended spare parts for two years of operation.

8. DOCUMENTATION

8.1 The vendor shall supply the necessary information with the quotation to enable evaluation of the submitted proposal. General documents/drawings are not acceptable unless they are revised to show the equipment proposed.

The documents to be supplied with the quotation shall at least include the following:

a) Completed enquiry data sheet.

b) Summary of exceptions/deviations to this standard specification.

c) Brochures and catalogues containing description of typical transformers.

d) Preliminary drawings showing main dimensions, arrangement of components and termination methods.

e) Type of packaging and approximate shipping weight/s.

8.2 The documents which shall be supplied at ordering stage shall at least include the following:

a) Updated and completed enquiry data sheet/s.

b) Drawings showing main dimensions, arrangement of components and termination methods.

c) Wiring diagrams of all accessories, or devices.

d) List of components or accessories, showing complete reordering information for replaceable parts.

e) Installation, commissioning and maintenance instruction/s.

f) Recommended spare parts list for two years of operation.

g) Test reports and/or certificates for routine tests, type tests and special tests.

9. SHIPMENT

9.1 The supplier of the equipment under this specification is the sole responsible for packaging and preparation for shipment.

9.2 The packaging and preparation for shipment shall be adequate to avoid mechanical damage during transport and handling.

9.3 The supplier shall indicate at quotation stage whether the transformer and the enclosure will be shipped separately or they will be shipped as an assembled unit.

9.4 Each shipping package shall be provided with permanently attached identification tag containing necessary information together with the transformer identification number indicated in data sheet Appendix A.

9.5 Shipping documents with exact description of equipment for custom release shall be supplied, with the equipment.

10. GUARANTEE

10.1 The supplier of the equipment under this specification shall guarantee the equipment and shall replace any damaged equipment/parts resulting from poor workmanship and/or faulty design.

10.2 The supplier shall replace any equipment/part failed under the following condition:

- Failure under startup and commissioning tests performed according to IEC recommendations.
- Failure under normal usage for a period of 12 months, not exceeding 18 months from the date of dispatch from the manufacturers works.

APPENDIX A

DRY TYPE POWER TRANSFORMER TYPICAL DATA SHEET

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

Items marked with asterisk will be specified by purchaser.

1.	Name of project or plant	*
2.	Transformer identification No	*
3.	Site elevation above sea level (m)	*
4.	Maximum room temperature, indoor	*
5.	Minimum room temperature, indoor	*
6.	Maximum ambient temperature, outdoor	*
7.	Minimum ambient temperature, outdoor	*
8.	Maximum relative humidity	*
9.	Installation method indoor/outdoor	*
10.	Transformer operation mode (single or in parallel)	*
11.	Nominal primary voltage, phase to phase and voltage variation	*
12.	Nominal secondary voltage, phase to phase and phase to neutral	*
13.	Nominal frequency and frequency variation	*
14.	Total harmonic distortion (THD)	*
15.	Neutral earthing system (solidly earthed/ resistance earthed)	*
16.	Primary side short circuit power	*
17.	Required short circuit impedance (U_k)	*
18.	Winding connection symbol	*
19.	Rated power AN (kVA)	*
20.	Anticipated unbalance loading in percent of rated power	*
21.	Enclosure required or not	*
22.	Additional equipment (required or not)	*
23.	CT to be supplied by (transformer manufacturer/purchaser)	*
24.	CT type and ratio (and numbers required)	*
25.	CT burden and class	*
26.	Type and size of cables or overhead lines (primary side)	*
27.	Secondary side connections (via cable/s or duct)	*
28.	Type and size of cables (secondary side)	*
29.	Tap changing range (±5% in 2.5% steps, off circuit)	
30.	Insulation class (F)	
31.	Winding conductor material (Copper/Aluminum)	
32.	Maximum temperature rise at site condition	
33.	Enclosure degree of protection	

34.	Enclosure sheet steel thickness	
35.	Enclosure painting specification	
36.	Enclosure color	
37.	Enclosure ventilation (natural or by fan/s)	
38.	Enclosure shipment (separate/assembled)	
39.	Short circuit impedance in percent	
40.	Zero sequence impedance in percent	
41.	X/R ratio at principal tap	
42.	No load losses at rated voltage and principal tap	
43.	I^2R loss at rated current and principal tap	
44.	Stray load loss at rated current and principal tap	
45.	Rated short time current and duration	
46.	Efficiency at 100%, 75% and 50% rated power and 0.8 power factor	
47.	Power frequency withstand voltage (kV rms) primary/secondary	
48.	Lightning impulse withstand voltage (kV peak) primary	
49.	Climatic class (C2)	
50.	Environmental class (E2)	
51.	Fire behavior class (F1)	
52.	Noise limit (dB)	
53.	Numbers of winding temperature indicator/s	
54.	Weight of transformer	
55.	Transformer dimensions length, width, height	
56.	Enclosure dimensions length, width, height	
57.	Type tests and special tests certificates	To be attached
58.	Special tools if any	
59.	Deviation from this specification if any	Attach list