IEC 60076-22-3

Edition 1.0 2019-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Power transformers –
Part 22-3: Power transformer and reactor fittings – Insulating liquid to air heat exchangers

Transformateurs de puissance –
Partie 22-3: Accessoires pour transformateurs de puissance et bobines d'inductance – Aéroréfrigérants

IEC 60076-22-3:2019-03(en-fr)

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POWER TRANSFORMERS –

Part 22-3: Power transformer and reactor fittings – Insulating liquid to air heat exchangers

FOREWORD

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International Standard IEC 60076-22-3 has been prepared by IEC technical committee 14: Power transformers.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
14/995/FDIS	14/1003/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60076 series, published under the general title *Power transformers*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Under the part title “Power transformer and reactor fittings”, this part of IEC 60076-22 covers the insulating liquid to air heat exchangers in the cooling circuits of power transformers and reactors.

POWER TRANSFORMERS –

Part 22-3: Power transformer and reactor fittings – Insulating liquid to air heat exchangers

1 Scope

This part of IEC 60076 applies to liquid to air heat exchangers, using forced air and forced liquid circuits, used on liquid immersed power transformers according to IEC 60076-1 and reactors according to IEC 60076-6 with and without conservator for indoor or outdoor installation. It outlines the service conditions and the mechanical and electrical requirements that are common to this equipment.

It also outlines the operation requirements specific to this equipment as well as the preferred dimensions relevant for interchangeability and the type and routine tests to be performed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60076-7, *Power transformers – Part 7: Loading guide for mineral oil-immersed power transformers*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 4406, *Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles*

ISO 7005 (all parts), *Pipe flanges*

ISO 9614-2, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning*

ISO 12944 (all parts), *Paints and varnishes – Corrosion protection of steel structures by protective paint systems*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
insulating liquid to air heat exchanger
component for the cooling of the insulating liquid of the transformer, using forced circulation of the insulating liquid and a forced air flow

4 General requirements

4.1 Service conditions

The normal service conditions set out in IEC 60076-1 represent the normal scope of operation of the device and equipment specified in this document.

Device and equipment specification for operation under unusual service conditions as per IEC 60076-1 shall be subject to agreement between the purchaser and supplier, as they require special consideration in the design of the device and equipment.

In addition to the unusual service conditions of IEC 60076-1, any unusual condition, which can influence the correct functioning of the cooler, shall be mentioned, such as heavy snow, permanent wind, pollen, sealing dust.

4.2 Degree of protection of electrical components (IP)

The degree of protection of the connecting box or terminal box for an outdoor installation shall be at least IP 54 according to IEC 60529, unless otherwise specified by the purchaser.

4.3 Corrosion protection

4.3.1 External (atmosphere)

The materials used for the construction of the equipment or the surface treatment shall be resistant to accidental contact with the insulating liquid and suitable to withstand the environmental conditions given in 4.1. The corrosion protection shall be agreed between purchaser and manufacturer according to ISO 12944 (all parts). The responsibility to specify the correct level of corrosion protection lies with the purchaser and is dependent on the environment where the transformer will be located and on the durability required. Unless otherwise specified, the minimum withstand level shall be C4 medium durability according to ISO 12944-6.

4.3.2 Insulating liquid side

In consideration of the storage conditions and expected time between shipment and commissioning, the corrosion protection on the insulating liquid side of the cooling system shall be agreed between purchaser and manufacturer. As a minimum requirement, precautions shall be taken to prevent the ingress of moisture and the development of internal corrosion. The internal flushing with insulation liquid fully miscible and compatible with the liquid to be used in service conditions and the use of blanking plates with gaskets are considered as a minimum. Internal painting, nitrogen filling, dehydrating material, etc., can be used as other or additional solutions.

4.4 Insulating liquid characteristics

If not otherwise specified, the insulating liquid is mineral oil according to IEC 60296 and the operating temperature shall be in accordance with IEC 60076-7.

When the insulating liquid is not mineral oil then the purchaser shall indicate the viscosity variation, the operating temperature and all the other operating characteristics.

5 Design and characteristics

5.1 Main components and characteristics

5.1.1 Headers

Liquid collecting and guiding compartment with flanged connections to the circuit of the transformer.

5.1.2 Tube sheets

Flat plates at both ends of the cooler where the cooling tubes are connected.

5.1.3 Tube bundle

Consisting of a bundle of single tubes and fins connected to both tube sheets. Tubes might have different shapes and can be made of different materials.

5.1.4 Turbulators

Inserts inside the tubes aimed at enhancing the cooling efficiency.

5.1.5 Passes

Number of times the insulating liquid flows through the exchanger. For instance, the number of passes “1” means that the liquid is flowing one way from one header to the other (liquid inlet and outlet in the opposite headers).

5.1.6 Standard design and cooling arrangement

The liquid to air heat exchanger arrangement can be with:

- vertical cooling pipes and horizontal air direction;
- horizontal cooling pipes and horizontal air direction;
- horizontal cooling pipes and vertical air direction;
- forced-draught type or induced draught type fan arrangement can be used.

5.2 General characteristics

5.2.1 Rating plate information

The rating plate shall be corrosion resistant and acid proof. It shall be visible when the heat exchanger is assembled to the transformer and carry following data:

- logo or name of manufacturer;
- country and manufacturing location;
- number of this document;
- manufacturer identification;
- manufacturer serial number;
- year of manufacturing;
- maximum oil pressure in service [kPa];
- maximum oil temperature [°C];

- minimum ambient temperature [°C].

Rating data:

– rated cooling capacity [kW];
– rated air flow/liquid flow quantity [m^3/h];
– temperature of air and oil at inlet and outlet [°C];
– pressure drop of oil and air [kPa/Pa];
– mass of heat exchanger without oil [kg];
– oil volume [dm^3].

5.2.2 Rated cooling capacity

The rated cooling capacity of the heat exchanger is the minimum capacity which the manufacturer has to guarantee when the cooler is new and in free field conditions.

An additional cooling capacity can be agreed between purchaser and manufacturer to take into consideration the fouling that can occur in service.

The point of operation on the fan characteristic curve for nominal air duty shall be at least 15 % below the area of instability.

Air pollution, piping conditions, wind direction and fan rotation direction not conforming to design can affect the efficiency and the life expectancy of the cooler and the fans.

Unless otherwise agreed between purchaser and manufacturer, the calculation of rated cooling capacity shall consider dry ambient air at a pressure of p_{abs} = 101,3 kPa and the selected cooling liquid.

Conversion of rated cooling capacity into other operating conditions can be calculated according to Annex B. Changes of flow quantities should generally be co-ordinated with the manufacturer.

5.2.3 Information to be provided with enquiry and order

The purchaser shall supply to the manufacturer the following information with the enquiry:

- insulation liquid characteristics;
- design arrangement conforming with 5.1.6;
- required cooling capacity Q_r kW;
- maximum ambient temperature (inlet air temperature) t_1' °C;
- maximum allowed liquid temperature t_2' °C;
- liquid temperature difference (min. value/max. value) Δt_2 K;
- maximum sound power measurement according to ISO 9614-2 or sound pressure measurement according to ISO 3746 L_w dB(A);
- minimum ambient temperature °C;
- altitude above sea level h m.

In case of order, the manufacturer should fix the following rated values:

- insulation liquid characteristics;
- design arrangement conforming with 5.1.6;
- rated cooling capacity Q_r kW;

- rated air flow quantity V_1 m^3/s;
- rated liquid flow quantity V_2 m^3/h;
- air temperature at inlet t_1' °C;
- air temperature at outlet t_1'' °C;
- liquid temperature at cooler inlet t_2' °C;
- liquid temperature at cooler outlet t_2'' °C;
- air side pressure drop Δp_1 Pa;
- liquid side pressure drop Δp_2 kPa;
- maximum sound power level (including any tolerance) L_w dB(A);
- minimum ambient temperature °C;
- altitude A m.

5.2.4 Mechanical design

5.2.4.1 General

The mechanical design is based on the environmental conditions described in 4.1. The maximum liquid temperature shall be 100 °C. Other environmental conditions, temperatures as well as other cooling liquids shall be agreed between manufacturer and purchaser.

Connection between cooling pipes and tube sheets shall be oil tight. Excessive thermal expansion shall be avoided by appropriate design features.

The heat exchanger shall be designed for outside mounting without further protection and without any place to accumulate rain or condense water.

For transformers with a frequency of 50 Hz, significant resonance frequency (mass participation > 20 %) of the operable heat exchanger should not be in the range of (80 to 320) Hz, and for transformers with a frequency of 16 2/3 Hz it should not be in the range of (25 to 180) Hz.

It is the responsibility of the transformer or cooling circuit designer to design the pipework and the dampers to prevent the transfer of vibration from the transformer to the cooling equipment.

Appropriate reinforcements shall be used to prevent vibration of the tube bundle.

Types of flanges and fixing shall be agreed between purchaser and manufacturer. Possible flange arrangements are shown in Figure A.2.

It shall be possible to clean the heat exchanger on the air side by means of water under high pressure.

The mechanical design of the heat exchanger shall withstand a vacuum of 2,5 kPa absolute pressure.

The maximum permissible oil pressure in service for the heat exchanger is limited to 330 kPa.

Annex A provides informative dimensions and design parameters which have to be determined.