An Overview of IEC 60076-10 – Determination Of Sound Levels Of Power Transformers

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An Overview of IEC 60076-10 - Determination Of Sound Levels Of Power Transformers (Photo by besttrafo.com.tr)

Sources of sound

The audible sound radiated by transformers is generated by a combination of magnetostrictive deformation of the core and electromagnetic forces in the windings, tank walls and magnetic shields.

Historically, the sound generated by the magnetic field inducing longitudinal vibrations in the core laminations has been dominant.

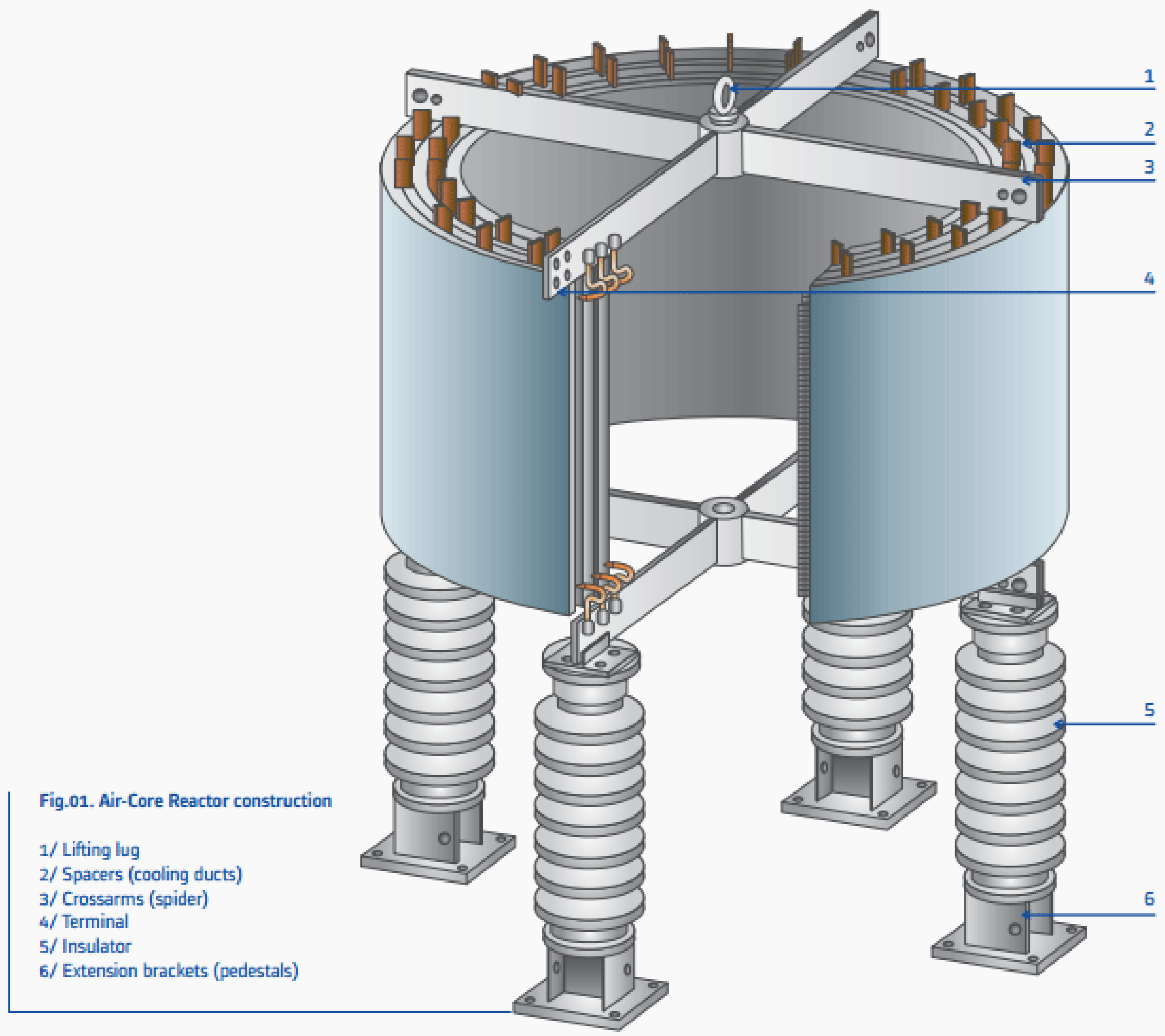
The amplitude of these vibrations depends on the ***flux density in the laminations*** and the magnetic properties o the core steel, and is therefore independent of the load current. Recent advances in ***core design***, combined with the use of low induction levels, have reduced the amount of sound generated in the core such that the sound caused by the electromagnetic forces may become significant.

Current flowing in the winding conductors produces electromagnetic forces in the windings.

In addition, stray magnetic fields may induce ***vibrations in structural components***. The force (*and therefore the amplitude of the vibrations*) is proportional to the square of the current, and the radiated sound power is proportional to the square of the vibrational amplitude. Consequently, the radiated sound power is strongly dependent on the load current.

Vibrations in core and winding assemblies can then induce sympathetic vibrations in tank walls, magnetic shields and air ducts (if present).

In the case of ***dry-type, air-cored shunt or series reactors***, sound is generated by electromagnetic forces acting on the windings in a similar manner to that described above.



Air-core reactor construction

These oscillatory forces cause the reactor to vibrate both axially and radially, and the axial and radial supports and manufacturing tolerances may result in the excitation of modes in addition to those of rotational symmetry. In the case of iron-cored reactors, further vibrations are induced by forces acting in the magnetic circuit.

For all electrical plants, the consequence of the presence of higher harmonics on the power supply should be understood. Normally, vibrations occur at even harmonics of the power frequency, with the first harmonic being dominant. If other frequencies are present in the power supply, other forces may be induced.

For certain applications, this may be significant, particularly because the human ear is more sensitive to these higher frequencies. Any associated cooling equipment will also generate noise when operating. ***Fans and pumps both tend to generate broad-band noise due to the forced flow of air or oil.***

Measurement of sound

Sound level measurements have been developed to quantify pressure variations in air that a human ear can detect. The smallest pressure variation that a healthy human ear can detect is ***20 µPa***. This is the ***reference level (0 dB)*** to which all the other levels are compared.

The perceived loudness of a signal is dependent upon the sensitivity of the human ear to its frequency spectrum. Modern measuring instruments process sound signals through electronic networks, the sensitivity of which varies with frequency in a manner similar to the human ear. This has resulted in a number of internationally standardized weightings of which the ***Aweighting network*** is the most common.

Sound intensity is defined as the ***rate of energy flow per unit area*** and is measured in ***watts per square metre***. It is a vector quantity whereas, sound pressure is a scalar quantity and is defined only by its magnitude.

Sound power is the parameter which is used for rating and comparing sound sources. It is a basic descriptor of a sourceís acoustic output, and therefore an absolute physical property of the source alone which is independent of any external factors such as environment and distance to the receiver.

Sound power can be calculated from sound pressure or sound intensity determinations.

Sound intensity measurements have the following advantages over sound pressure measurements:

1. An intensity meter responds only to the propagating part of a sound field and ignores any non-propagating part, for example, standing waves and reflections;
2. The intensity method reduces the influence of external sound sources, as long as their sound level is approximately constant.

The sound pressure method takes the above factors into account by correcting for background noise and reflections.

This part of IEC 60076 defines sound pressure and sound intensity measurement methods by which sound power levels of transformers, reactors and their associated cooling auxiliaries may be determined.

NOTE For the purpose of this standard, the term “transformer” means “transformer or reactor”.

The methods are applicable to transformers and reactors covered by the IEC 60076 series, IEC 60289, IEC 60726 and the IEC 61378 series, without limitation as regards size or voltage and when fitted with their normal cooling auxiliaries.

This standard is primarily intended to apply to measurements made at the factory. Conditions on-site may be very different because of the proximity of objects, including other transformers. Nevertheless, the same general rules as are given in this standard may be followed when on-site measurements are made.

Reference: *INTERNATIONAL STANDARD IEC 60076-10 (Purchase here)*

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