

Transformer Noise



Engineering

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ABSTRACT

Transformer is the main equipment in the Transmission and Distribution system. It produces humming noise during its normal operation. The noise produced by transformers and the complaints arising there from have become a major problem as a result of the trend toward locating power substations in or near residential areas. Core, winding and cooling equipments are the major sources of transformer noise. Magnetostriction in transformer core gives the major significant effect in noise generation. Generated noise is transferred to tank and radiates in the atmosphere. Standards IEEE, IES & NEMA TR-1 for noise measurement procedure, it depends on the distance between the measuring surface and noise radiating surface by using of noise level meter.

INTRODUCTION

Transformer is the most vital equipment in a power transmission and distribution system. It produces characteristic hum, the magnitude of which increases with increase in transformer capacity. Electricity demand is going to be increase day by day. To meet that increasing public demand, more and larger power transformers must be installed near to the rural, urban and sub-urban areas. The noise of energized power transformers, which may be heard outside of the station, is "noise" and must not exceed beyond the prescribed limit by Indian Government.

The sources of transformer noise are the magnetostriction in core vibration, winding vibration, tank walls and cooling equipments. Magnetostriction gives the major contribution in transformer noise, which is change of dimension, due to magnetization, of a magnetic material in a magnetic field. Their frequency is twice that of the power supply system and their magnitude increase with increasing the value of magnetic flux density.

Reducing the noise level of the power transformers by change in design parameter, use of cold rolled grain-oriented silicon steel material with low magnetostriction, generating a canceling anti-noise signal, use of enclosures, use of stiffeners, use step-lap core joints.

Different scale like A, B, and C weighted are used for noise level measurement. International standards IEC 60076-10 and IEEE standard C57.12.90-1993 lay down the standard procedure for noise level measurements on transformers.

TRANSFORMER NOISE

• Generation of Transformer Noise

There are three major sources of noise generation in power transformers: (1) Core vibration (2) winding vibrations (3) Cooling equipments.

Core vibration is the main factor in the no-load noise level. Flux density, core material, core geometry and waveform of the excitation voltage are the factors that influence the magnitude and frequency components of the transformer core noise levels. Noise level also depends on magnetic property of transformer core material. Factors such as sheet thickness, stress, coatings, induction level and frequency of magnetization affect the magnetic properties of the core material. Magnetostriction was found to play the major part in noise production and it depends on flux density. Magnetostriction is a term used for the small mechanical deformations of core laminations in response to the application of a magnetic field. The frequency of transformer noise is double of the supply power frequency. Variation of 10 percentage in the flux density relative to the rated value produces on an average a difference of about 3 dB(A).

Transformer winding vibrates due to the radial and axial electromagnetic forces, which are produced by the current flowing in the winding conductors. Generally axial vibration of windings contributes to noise but if winding diameter exceeds 6 m, then radial vibration of winding also generates significant noise.

Cooling equipments will also generate noise due to the operation of fans and pumps to the forced flow of air and oil.

• Transmission of Transformer Noise

The transmission of noise energy from the magnetic circuit to the tank takes place in three ways: (1) Air-borne: through the windings, the insulating materials and the oil; (2) Structure-borne: by direct mechanical contact through supports at the bottom of the tank, lateral bracing and top connections; (3) Ground-borne.

During operation of a transformer, the vibrations from its core and windings get transmitted to the transformer tank surface through air-borne transmission. Also, the vibrations can reach the tank by structure-borne transmission at points where the mounting of the core structure is attached to the tank. The vibrating tank surface and ground radiates noise into the exterior air.

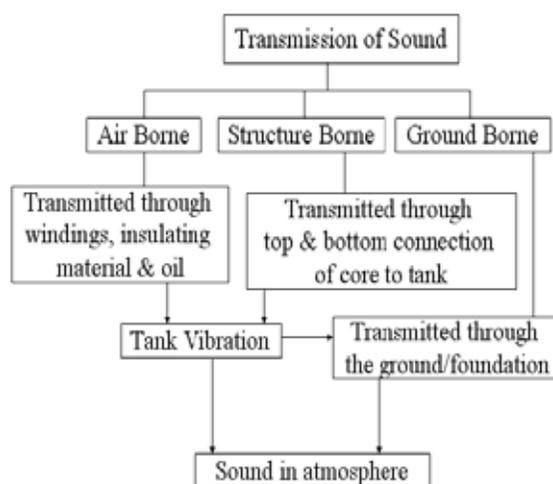


Figure 1: Noise transmission in Transformers

SCALES FOR MEASUREMENT OF NOISE

Basically, there are three types of scales for noise measurement: (1) A-weighted scale (2) B-weighted scale (3) C-weighted scale.

A-weighted scale: Follows the frequency sensitivity of the hu-

man ear at low levels. This is the most commonly used weighting scale, as it also predicts quite well the damage risk of the ear. Noise level meters set to the A-weighting scale will filter out much of the low frequency noise they measure, similar to the response of the human ear. Noise measurements made with the A-weighting scale are designated dB (A).

B-weighted scale: Follows the frequency sensitivity of the human ear at moderate levels, used in the past for predicting performance of loudspeakers and stereos, but not industrial noise.

C-weighted scale: Follows the frequency sensitivity of the human ear at very high noise levels. The C-weighting scale is quite flat, and therefore includes much more of the low frequency range of noises than the A and B scales.

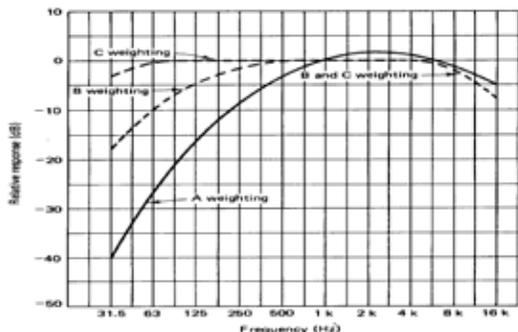


Figure 2: Frequency response for A, B & C weighting networks

Source: www.engineeringtoolbox.com

MEASUREMENT PROCEDURE OF TRANSFORMER NOISE

International standards IEC 60076-10 and IEEE standard C57.12.90-1993 lay down the standard procedure for noise level measurements on transformers. Some of the salient points are extracted from the standards and presented here to introduce the subject.

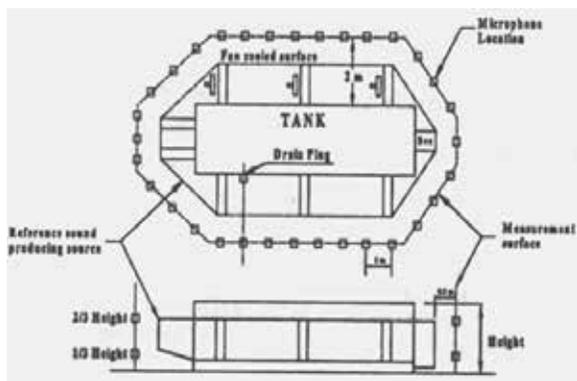


Figure 3: Microphone location for measuring audible noise from transformers

Source: IEEE and IEC Indian standards

Ambient Noise Pressure Level: The ambient noise pressure levels are measured immediately preceding and immediately following the noise measurements with the transformer energized. The ambient noise shall be measured at minimum four locations. Additional measurement may be made if the ambient measurements vary by more than 3 dB around the transformer. At least one of the locations for measuring ambient noise pressure levels shall be on the center of each face of the measurement surface.

Reference Noise-Producing Surface: The reference noise-producing surface of a transformer is a vertical surface that follows the contour of a string stretched around the periphery of the transformer or integral enclosure. The contour shall include radiators, coolers and tubes, switch components, and terminal chambers, but exclude bushings and minor extensions. Such as valves, oil gauges, thermometers, terminal boxes, and projections at or above cover height.

First Measurement Position: The first microphone locations shall coincide with the main drain valve. Additional microphone locations shall be at 1 m intervals in a horizontal direction, proceeding clockwise as viewed from above along the measurement surface defined in this clause.

Locations of Microphone from Noise –Producing Surface: The microphone shall be located on the measurement surface. As per IEEE Standard-1993 and IEC 60076-10:2005, the microphone shall be spaced 1 m from the reference noise-producing surface. When fans are in operation, the microphone shall be located 2 m from any portion of the radiator, coolers, or cooling tubes cooled by forced air.

Generally, noise level is measured from noise-producing surface, apart at 1 m. Because where a doubling of the distance -d- will cause a 6 dB drop in the Noise Pressure Level. For that verification, one formulae is there, which is given below.

$$Lp(d) = LP(1) - (20 \cdot \log(d)) \quad (1)$$

Example: Measuring noise level is 62 dB at 1 m distance. Now from the above equation, we can obtained the noise level at 2 m, 3 m, and 4m, which values are 54 dB, 50.5 dB and 48 dB respectively.

Height of Microphone Locations: AS per IEEE Standard-1993, IEC-60076-10, and NEMA TR-1, for transformers having an overall tank or enclosure height of less than 2.4 m measurement shall be made at half height. For transformers having an overall tank or enclosure height of 2.4 m or more, measurements shall be made at one-third and at two-thirds height.

Correction Factors for Noise Level

Correction factors for noise level are given in Table I, as per IEEE standard, IEC 551, CBIP manual. As per IEEE standard, for combined noise less than 5 dB, correction 1.6 may be used.

TABLE – 1
CORRECTION FACTORS

IEEE		IEC 551		CBIP	
Difference between combined & Background Noise (dB)	Correction to be Subtracted (dB)	Difference between combined & Background Noise (dB)	Correction to be Subtracted (dB)	Difference between combined & Background Noise (dB)	Correction to be Subtracted (dB)
5	1.6	3	3	3	3
6	1.3	4-5	2	4-5	2
7	1.0	6-8	1	6-8	1
8	0.8	9-10	0.5	-	-
9	0.6	-	-	-	-
10	0.4	-	-	-	-
Above 10	0.0	-	-	-	-

Source: IEEE & IEC551 standard, CBIP Manual

CONCLUSIONS

The main factors, for the transformer noise generation, are magnetostriction, tank vibration, cooling fan, oil pumps etc. Proper distance between the noise radiating surface and measuring surface is also important factor for the noise measurement. Noise level is always higher in the site testing of transformer than industry testing of transformer. dB(A) scale is used for transformer noise level.

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