Dry-Type Power Transformers: Understanding Transformer Isolation and Noise

One of the more overlooked aspects of dry-type transformer installations is the removal of shipping bolts and/or shipping blocking material attached to the unit. Questions such as: Should you remove them or leave them connected? What is their purpose? Why does a transformer hum? (Assuming it doesn’t know the words.) We’ll look at these questions and other topics surrounding the dry-type transformers and the noise they make...

The Shipping Bolts and Blocking

Transformer core and coil assemblies are typically very heavy and require supplemental supports prior to shipment so that the unit does not get damaged while being transported from the manufacturer to the job site. It is very important to remove any temporary shipping bolts or blocking materials prior to energization.

Also, it is important to loosen or remove any bolts that are connected to resilient* mounts located on the unit. These resilient mounts are intended to transfer vibration from the core to the frame, and quite often are simply a rubber pad between the core frame and the bottom of the unit. See detail of vibration isolators in Figure 1 and the photograph detail in Figure 2.

*Resilient is defined by Merriam-Webster as capable of withstanding shock without permanent deformation or rupture.

What’s That Buzzing Sound?

In IEEE C57.94, Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers, they tell us that the audible sound produced by transformers is due to energizing of the core by the alternating voltage applied to the windings. This creates vibrations whose fundamental frequency is twice the frequency of the applied voltage. The vibrations producing audible sound can occur in the core, coil, mounting, and housing. The transmission of sound from the transformer can be by various media such as air, metal, concrete, wood, or any combination. Amplification of audible sound can occur in a given area due to the presence of reflecting surfaces.
Reading further in C57.94, to control audible sound sources the core and coil mounting bolts should be adjusted to the manufacturer’s recommendation. Other bolts, fasteners, and devices should be examined for possible audible sound sources.

To control the transmission of audible sound, flexible connections (Figure 3) should be used on all incoming and outgoing cables or bus to reduce vibration transmission. Acoustical absorbing material should be mounted on reflecting surfaces to reduce sound transmission and possible amplification, and transformers should be mounted on a firm support having as great a mass as possible. Vibration pads or properly designed springs will reduce transmittal of sound considerably.

A careful study of the location of vaults within buildings can go far toward not only reducing sound but also reducing complaints. If practicable, vaults should not abut sleeping areas, study areas, or other frequently occupied areas where the ambient sound level is low. Interrupting the sound transmission medium can also be considered during initial vault or pad construction. This could include installing sound absorbing foam, etc., in ceilings and walls or separating the transformer pad from foundation construction.

And finally, in C57.94 it says in 5.1.2.2 that after the transformer is placed in permanent position, shipping braces should be removed, and shipping bolts, if present, should be loosened or removed per manufacturer’s recommendations.

Vibration isolators installed between the transformer and its mount (Figure 2) will reduce case vibration and compensate for slight unevenness of the mount. They should be sized for the appropriate loading at the fundamental frequency.

The transformer housing must be securely fastened to the mount to eliminate possible sound generation.

Fans used for ventilation should be studied carefully for their contribution to the general audible sound level.
Where Does the Sound Come From?

Noise is caused by magnetostriction (changes in shape) of the core laminations while the transformer is energized. Transformers emit a low-frequency, tonal noise that people living in their vicinity experience as an irritating “hum” and can hear even against a noisy background. The electrical power industry produces a range of solutions to abate humming, which originates in the transformer’s core and, when it is loaded, in the coil windings. Core noise is generated by the magnetostriction of the core’s laminations when a magnetic field passes through them. It is also known as “no-load noise,” as it is independent of the load passing through the transformer. As the phenomenon occurs it causes air columns to be formed in the spaces between the transformer core and the low-voltage windings of the core and other adjacent parts of the transformer, and these air columns cause audible noise as it moves between the various parts of the transformer. Magnetostriction takes place at twice the frequency of the supply load: for a 60 Hz supply frequency, a lamination vibrates at 120 cycles per second, and the higher the density of the magnetic flux, the higher the frequency of the even number harmonics.

Also, the audible sound produced by fan-assist cooled (FAC) transformers is partially due to the energizing of the core by the alternating voltage applied to the windings and also by the fans forcing air through the coils. The noise generated by the core, and whose fundamental frequency is twice the frequency of the applied voltage, will create audible sound that will be present even under no load conditions. The vibrations producing audible sound can occur in the core, coil, mounting, housing, and in the conduit. The transmission of sound from the transformer can be by various media such as air, metal, concrete, wood or any combination. Amplification of audible sound can occur in a given area due to the presence of reflecting surfaces.

Transformer hum also arises through the vibration caused when the load current passes through the windings, interacting with the leakage flux it generates. This “load noise” level is determined by the size of the load current.

Control of Transformer Sound Transmission

Acoustical-absorbing material should be mounted on reflecting surfaces to reduce sound reflection and possible amplification. Transformers should be mounted on a firm support having as great a mass as possible. Vibration pads or properly designed isolation mounts under the transformer will reduce transmittal of sound. The neoprene rubber isolation pads (Figure 2) provided with the unit should be installed between the transformer and its mounting surface. This will reduce case vibration and compensate for slight unevenness of the mount. Care must be taken to ensure proper and tight installation of conduit. Flexible conduit is recommended.

A normal conversation is typically 60-70 dB. OSHA has an actionable level to sound exposure at 85 decibels whenever noise levels equal or exceed an eight-hour time-weighted average sound of 85 decibels, or a dose of fifty percent (29 CFR 1910.95(c)(1).

Per General Electric Installation Guide No. 475A667AAP008, dry type transformers are designed and manufactured to comply with NEMA and ANSI standards. The decibel values referenced below (Figure 6) represent average values obtained in a sound laboratory per industry standard test procedures.

<table>
<thead>
<tr>
<th>Size (kVA) at 150° C Rise</th>
<th>Average Sound Level in Decibels (ANSI C89.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>40</td>
</tr>
<tr>
<td>10-50</td>
<td>45</td>
</tr>
<tr>
<td>51-150</td>
<td>50</td>
</tr>
<tr>
<td>151-300</td>
<td>55</td>
</tr>
<tr>
<td>301-500</td>
<td>60</td>
</tr>
<tr>
<td>501-700</td>
<td>62</td>
</tr>
<tr>
<td>701-1000</td>
<td>64</td>
</tr>
<tr>
<td>All with FAC</td>
<td>67</td>
</tr>
</tbody>
</table>

Noise is defined by Merriam-Webster as “any sound that is undesired or interferes with one’s hearing of something.”

So who is to say what sound is undesired or interferes with something? What may be a calming sound of transformer (humming to some), may be a nuisance to others.
Just as rock concerts may be annoying to some, and the loud music and rhythm may be stimulating and desirable to others.

And since different people have different opinions as to what is acceptable and what is not, and how annoying a transformer has become is different in different situations, the best tactic is to try and mitigate the problem on the front end through proper placement and design, and when initially tested and commissioned make sure you carefully inspect the shipping bolts, packing materials, and resilient mounts so sound is kept at a minimum.

Removal or loosening of the shipping bolts will allow for a smooth transfer of vibration and should reduce the overall noise generated by the unit.

Sshhhh! I need to listen to the hum, it’s just getting to the good part…

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