Transformer noise is a *hum* characterized by spectral spikes at harmonics of the fundamental frequency which is twice the line supply of the electrical frequency (50Hz/60Hz). Transformer’s **low frequency tonal** noise components are the major source of annoyance. Other sources of noise, such as the **cooling fans** and the pumps, are considered to be negligible contributors to the far-field noise.

**TRANSFORMER NOISE**

**Sources of Sound**

Core vibration caused by **Magnetostriction of core material**
- 120, 240 and 360 Hz with some 480 Hz for 60 Hz operation
- 100, 200, 300 and 400 Hz for 50 Hz operation

Cooling Equipment Noise – caused by **Fans and Pumps**
- Fan blade or Motor noise: low –frequency components < 100 Hz

An unexpected high level of a frequency component would indicate core / tank resonance.
Transformer Noise Abatement Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double-walled tanks with sound panels</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Core and/or tank resonance</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>High permeability grain-oriented core steel</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Reduced induction</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Resilient absorbers</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: IEEE Std C57.136-2000
VIBRATION PADS – DESIGN GUIDLINES

VIBRATION ISOLATION

NOISE REDUCTION

Center of Gravity

Medium

Temperature

Weight, Dimensions, and Constraints

Frequency

Amorim T&D solutions for Transmission and Distribution applications
OUR SOLUTION – Use our PLUG & PLAY Calculation Tool

*Amorim T&D* solutions for Transmission and Distribution applications
VIBRATION PADS – TRANSMISSIBILITY CURVE

Transmissibility, TR, provides a common measure of Vibration Control performance, and can be expressed in linear units or logarithmically, for example, in decibels (dB).

Briefly, transmissibility is a measure of the vibration response of a system divided by the magnitude of the vibration input to the system.

- Lower transmissibility implies greater isolation.
- Increasing the pad thickness (maintaining the geometry) decreases the natural frequency, and hence increasing the isolation region.
VIBRATION PADS – TRANSMISSIBILITY

Isolation vs. Dampening

Amorim Vibration Control Materials exhibit high material loss factors resulting in low amplification at resonance, giving them operational effectiveness over a broad range of frequencies.

The amount of damping in the isolation system will determine the magnitude of peak transmissibility (Fn) for the system. As damping increases, this peak value will decrease.

A vibration isolator lowers the natural frequency of a system to below the excitation (or disturbing) frequency, keeping these two frequencies greatly apart reduces or isolates vibration.

Note: Properly designed metal springs and rubber mounts can be good isolators but have almost no damping capability.

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VIBRATION PADS – TRANSMISSIBILITY

Material Loss Factor

The loss factor of a material represents the ratio of energy it dissipates to the amount it stores, temporarily for each cycle of vibration. Energy dissipation is achieved through the conversion into heat.

Our specific polymer formulations and the inclusion of CORK, due to it’s unique compressibility and recovery characteristics, absorb energy, yielding high material loss factors.

Cork cells are minute, irregular pentagonal or hexagonal prisms. The cell height rarely exceeds 50 micrometers. Fifty per cent of cork is an air-like gas enclosed in the cork cells. Suberin makes the cork cell membrane impermeable and the cell airtight.
# Transformer Vibration Control Materials

<table>
<thead>
<tr>
<th>VC 2100</th>
<th>VC1001</th>
<th>VC5200</th>
<th>VC 6400</th>
<th>VC 7000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Load</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0 MPa</td>
<td>0.25 MPa</td>
<td>0.6 MPa</td>
<td>2.0 MPa</td>
<td>10.0 MPa</td>
</tr>
<tr>
<td>(290 psi)</td>
<td>(36 psi)</td>
<td>(87 psi)</td>
<td>(290 psi)</td>
<td>(1450 psi)</td>
</tr>
<tr>
<td><strong>Work Load Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 - 1.5 MPa</td>
<td>0.05 - 0.2 MPa</td>
<td>0.2 - 0.5 MPa</td>
<td>0.5 - 1.5 MPa</td>
<td>1.0 - 6.0 MPa</td>
</tr>
<tr>
<td>(72 - 217 psi)</td>
<td>(7 - 29 psi)</td>
<td>(29 - 72 psi)</td>
<td>(72 - 217 psi)</td>
<td>(145 - 870 psi)</td>
</tr>
<tr>
<td><strong>Temperature Range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40°C to 125 °C</td>
<td>-40°C to 90 °C</td>
<td>-40°C to 110 °C</td>
<td>-30°C to 110 °C</td>
<td>-60°C to 175 °C</td>
</tr>
<tr>
<td>(-40°F to 257°F)</td>
<td>(-40°F to 194°F)</td>
<td>(-40°F to 230°F)</td>
<td>(-22°F to 230°F)</td>
<td>(-76°F to 347°F)</td>
</tr>
<tr>
<td><strong>Density (kg/m³)</strong></td>
<td>850</td>
<td>500</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Hardness (Shore A)</strong></td>
<td>65</td>
<td>25</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td><strong>Tensile Strength (MPa)</strong></td>
<td>2.0</td>
<td>0.3</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Creep Rate (%)</strong></td>
<td>2.0</td>
<td>3.0</td>
<td>2.5</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Loss Factor</strong></td>
<td>0.19</td>
<td>0.21</td>
<td>0.21</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Internal Vibration Control (Oil Contact)</td>
<td>External Vibration Control</td>
<td>External Vibration Control</td>
<td>External Vibration Control</td>
</tr>
</tbody>
</table>

(1) ASTM D297
(2) ASTM D412, Die C
(3) ASTM D2240
(4) ISO 8013

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**Amorim T&D** solutions for Transmission and Distribution applications
VIBRATION PADS – DESIGN FOR LIFE

CREEP or DRIFT

Creep is a Log decrement phenomenon, this means that the amount of deflection varies linearly with the Log of time. The amount of deflection in 1 day is the same as that in 10 days, is the same as that in 100 days, etc. This deflection has to be accounted for in the design process.

Amorim Vibration Control materials have been tested according to ISO8013 above their load working conditions, and even so show an excellent retention in height.
On Site Validations & Trouble Shooting

Portable sound instrument system:

• Sound level measurements in the field.
• Sound Intensity measurements in the field
• Reverberation measurements in the field
• Diagnostic tests to indicate weak links in the acoustic system.
VC2100 is used as an internal mat (or pad) replacing Pressboard

- Higher damping $\Rightarrow$ lower amplification at resonance
- Higher isolation level starts to isolate well below pressboard (60/100 Hz versus 210 / 270 Hz)
CASE II – Exterior Control – VC6400 @ 40mm

VC6400 in Power Transformer (40MVA) External Pads

- **Current Noise Level** - 62dBA
- **Target Noise Reduction** - 3dBA
- Pad Dimensions: 900 mm x 200 mm x 40mm
- Weight: 32 tons
- Fluid: mineral oil
- Number of pads: 3

- Material = VC6400 (within load range)
- Transmissibility at 100 Hz (at 40mm) = -28dB
- Isolation = 96%

VC6400 grade has been specifically formulated to perform in longevity in the application environment when subject to the application conditions, such as the presence of Ozone/UV (1).

(1) Ozone gas is produced during electric discharge by sparking or corona discharge (or static electricity build up) for example. Ozone is also produced by the action of sunlight on volatile organic liquids (VOL’s).

Noise measurements performed resulted in a decrease of -5 dBA in the result of using VC6400 Vibration Control Material.
CASE III – Exterior Control – VC6400 @ 40mm

Power Transformer 20ton (8/10MVA) with anchor bolts

- Pad Dimensions: 890 mm x 300 mm x 40mm
- Weight: 20 tons + 4xM20 Anchor bolts (25% - 75% yield torque)
- Number of pads: 2

- Stress= 0,66 – 1,25MPa
- Transmissibility at 100 Hz (at 40mm) = -28,4dB - 29,6dB
- Isolation = 96% - 97%
- Shape Factor = 2,8
CASE IV – Exterior Control – VC5200 @ 30mm

Power Transformer 6,3ton (200kVA) with C-Profile foundation fixing

- Pad Dimensions:
  1. 2 pads 1784 x 50 x 30mm. Each pad is a butt glued through two pieces 892 x 50 x 30mm
  2. 2 pads 356 x 50 x 30mm.

- Weight: 6.25ton
- Number of pads: 4

- Stress = 0.29MPa
- Transmissibility at 100 Hz (at 30mm) = -26.4dB
- Isolation = 95%
- Shape Factor = 0.73 – 0.81
CASE V – Exterior Control – VC5200 @ 12,5mm

Wind Power Transformer 2,8ton (1000kVA) with U-Profile and anti vibration vibration collar

- Pad Dimensions: 480mm x 180mm x 12,5mm
- Weight: 2,8ton + 8xM16 bolts @ 30N.m torque
- Number of pads: 2
- Number of collars: 8

- Stress = 0,16 – 0,4MPa
- Material = Pad - VC5200; Collars – VC6400
- Transmissibility at 100 Hz (at 12,5mm) = -22dB
- Isolation = 94%
CASE VI – Exterior Control – VC6400 @ 40mm

Power Transformer 32ton (10MVA) – Substitute profiled rubber pads

- Pad Dimensions: 230mm x 230mm x 40mm
- Weight: 32ton
- Number of pads: 10

- Stress= 0.6MPa
- Transmissibility at 100 Hz (at 40mm) = -30dB
- Isolation = 98%
- Shape Factor= 1.44
EXTERNAL PADS APPLICATIONS – Flexible Construction and Assembly

122ton Transformer wheel pads
Vibration attenuation: -32dB

Shunt Reactor
34ton, 30MVA

Transformer
51ton, 25MVA

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EXTERNAL PADS APPLICATIONS – Flexible Construction and Assembly

Vibration attenuation on busbar supports for transformer cabling

On Site Substation Concrete Foundation for Transformers with Rotary Mass Motor

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