



**Second South East European
Regional CIGRE Conference SEERC**

Kyiv, Ukraine, 12-13 June 2018

3-104

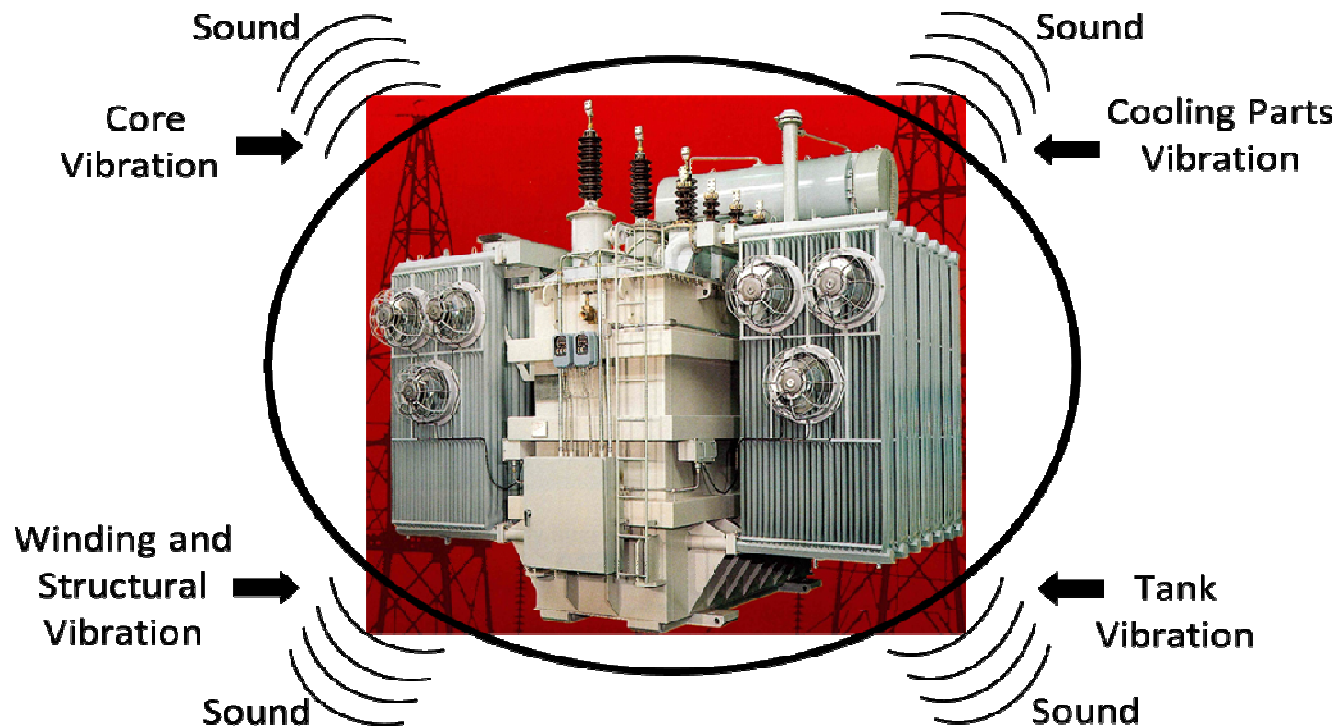
**Sound Levels of Power Transformers
and Reactors in the UHV Substations**

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Enpay Transformer Components

Turkey

The Sound (noise) is Occured by Vibrations in Transformer



Transformer sound becomes disturbing when sound level is 3-6 dB above the ambient sound level

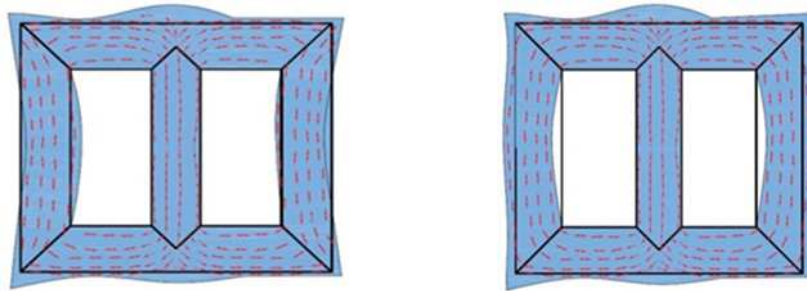
The Sources of Audible Sounds

- The sources of audible sounds in Transformers and reactors:
- Core sound (no load sound), **highest volume**
- Load sound in windings and structural parts
- Sound of auxiliary equipment (cooling fans and pumps)

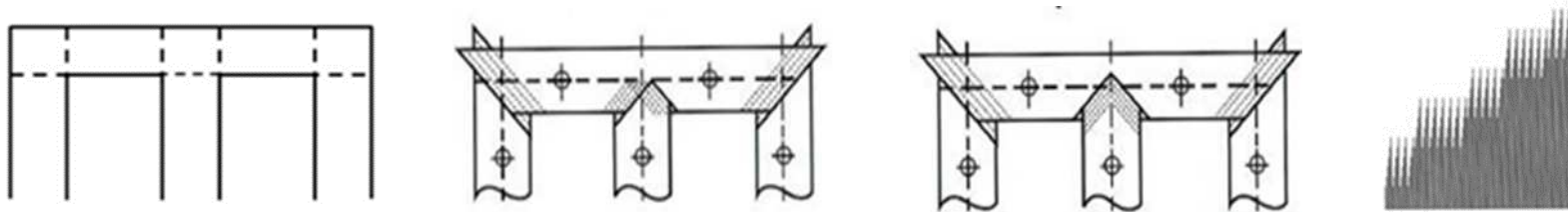
Core Sound (No Load Sound)

- The basic sources of core sound
- Magnetostrictive forces (Maxwell forces)
- Magnetomotive (magnetic) forces (Lorentz forces)
- Mechanical forces on the core (clampings of structures)

Core Sound (No Load Sound)



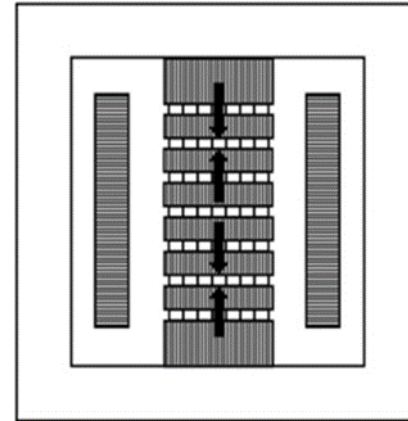
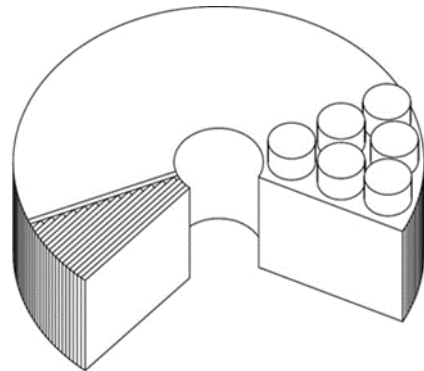
Stacking practice of the core sheets play an important role. Stap-lap stacking reduce sound level compare with conventional lap joints. In joint places the gaps affect significant sound.



Sound level is proportional to designed values, which including magnetic flux density and core volume. Non linear loads cause harmonics, resulting an increase core sound level

For minimizing core Sound it has to use FEM 2-D and 3-D magnetic field modeling

Core Sound (No Load Sound) in Gapped-core Reactors



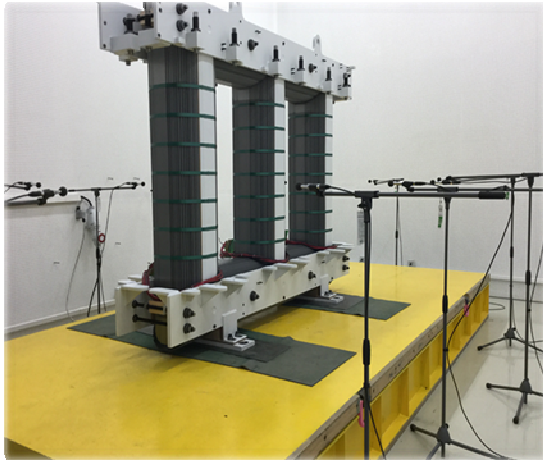
Vibration of air-core type reactors occurs mainly due to magnetic attraction force between winding and yokes located top and bottom of the winding.

Vibration of gapped-core reactors is quite high as compared to transformers.

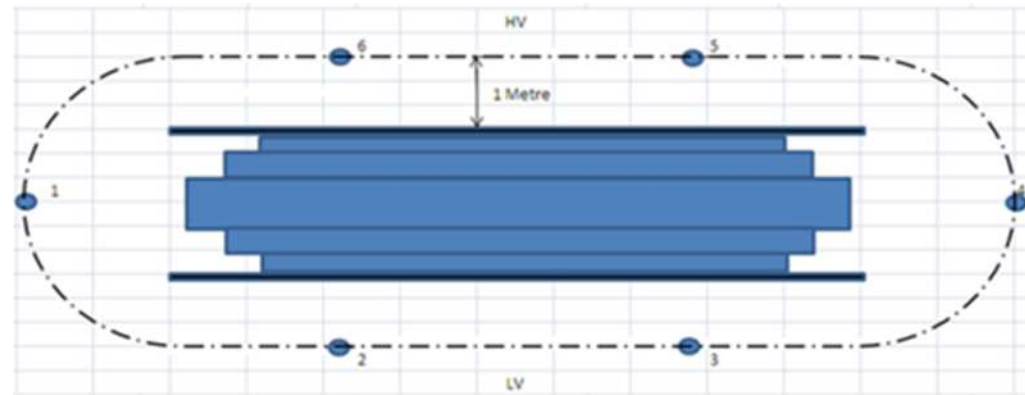
Magnetic field and fringing flux creates pulsating forces across air gaps, which in turn creates vibration. So the spacers in air gaps should be of very stiff material like ceramic discs.

The yoke clamping structural parts also create vibration- sound.

Core Sound Measurement in the Lab



Position of the microphones

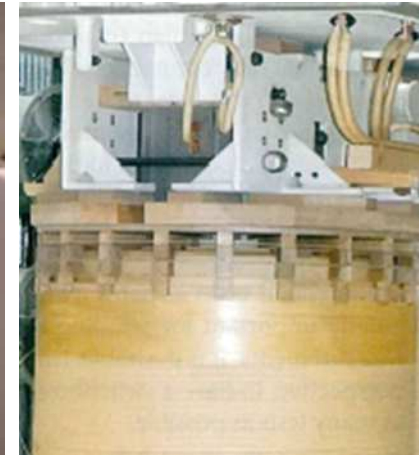
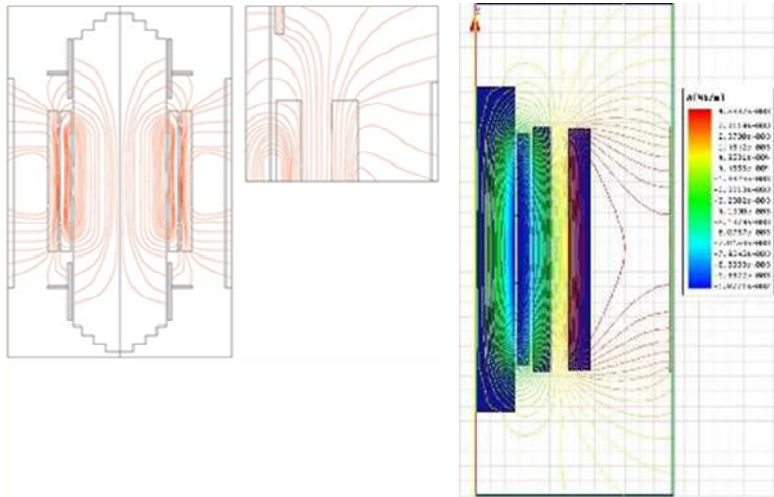


Measurement made according to IEC 60076-10 , Method sound pressure level (dBA) due to requirement

Measuring devices : Sound level meter, acoustic analyzer, measuring microphones, calibrator devices

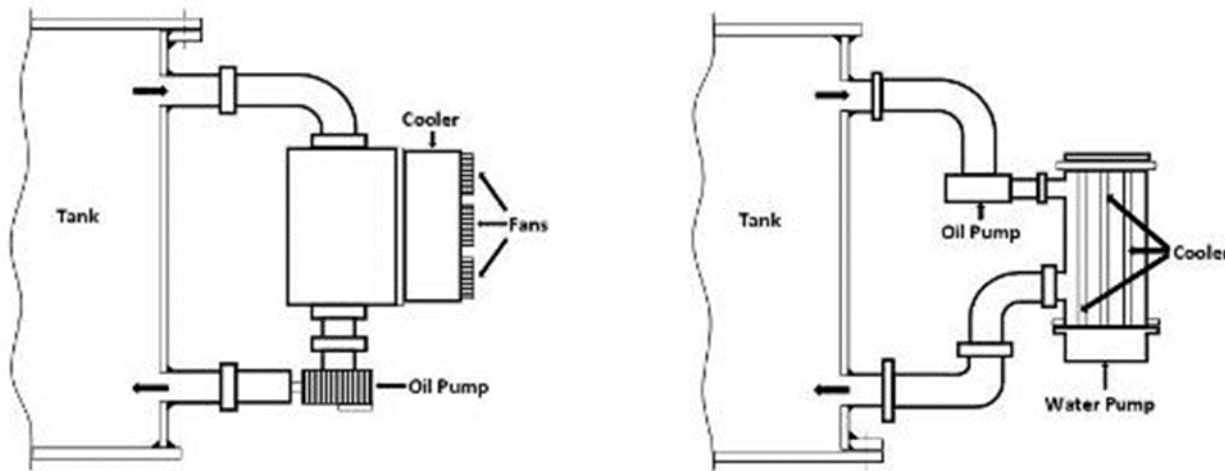
The lab design and structure must be realized according IEC standards+

The Load sound in the Windings



Load sound in windings , due to axial and radial vibration of windings. Load current generate by stray field of winding which has **Lorentz Forces**. Leakage flux creates stray losses (additional eddy losses in the structural parts and within windings)

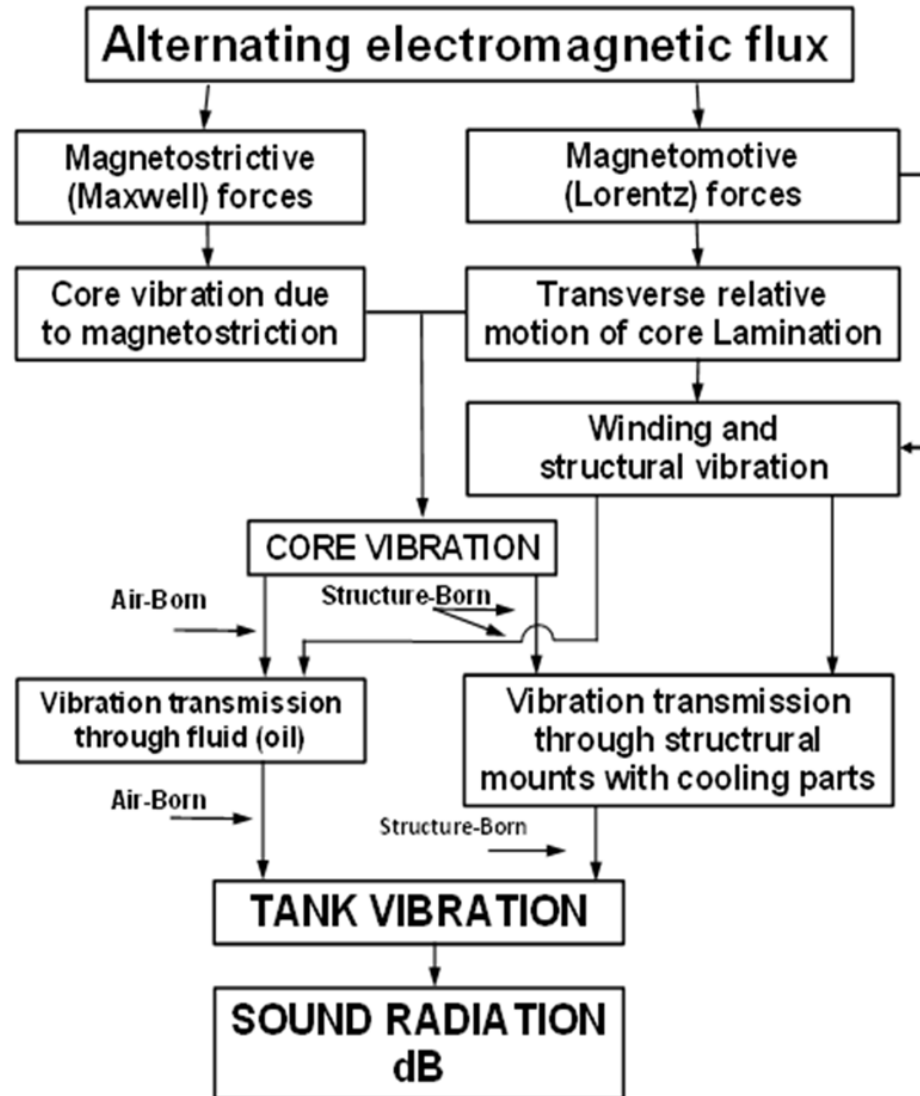
The sound of the auxiliary equipment (fans and pumps)



The major factor for generation of transformer heat is copper loss I^2R , and other losses in core and metallic structural components. The heat is often removed by cooling fans. The coolant of transformer is air, mineral or different type of oils, water and gas. Cooling fans and pumps create mostly broadband sounds coming from forced flow of air or oil.

Nowadays cooling systems are controlled in an improved way by continuously variable speed-controlled fans, to optimize noise and losses. Sound of auxiliary equipment in transformers and oil-immersed type reactors has not any difference.

SUMMARY



The sound level of transformer substations



Main audible sound of substations comes from transformer and reactor in operation. The sound mainly depends on factors such as voltage level, sound source distribution, building arrangement, and the level can be 50- 80 dBA. We can say : in industrial zone <75 dB, in commercial zone <65 dB, in residential zone <55 dB. The values are measured on A-weighted scale which closely follows sensitivity of the human ear.

Due to expansion of urban area it is a need for more power links. So new transformer substations need to be increasingly compact, reliable, safe and intelligent.

Large shunt reactors can have a sound level 70-80 dB.

The sound problems of HVDC and UHVDC converter stations are more severe than of HVAC and UHVAC.

CIGRE WG A2.54- Power Transformer Audible Sound

Requirements

is working since longer than 2 years.

The brochure of the study will be finishing in
approx.

2 years.

Thank you