ASHRAE 2020
Virtual Conference

Magnetic Bearing Centrifugal Chillers: Sound and Vibration Aspects

Seminar 31
When is "Quiet", Quiet Enough? Understanding Sound Generation in Magnetic Bearing Machines

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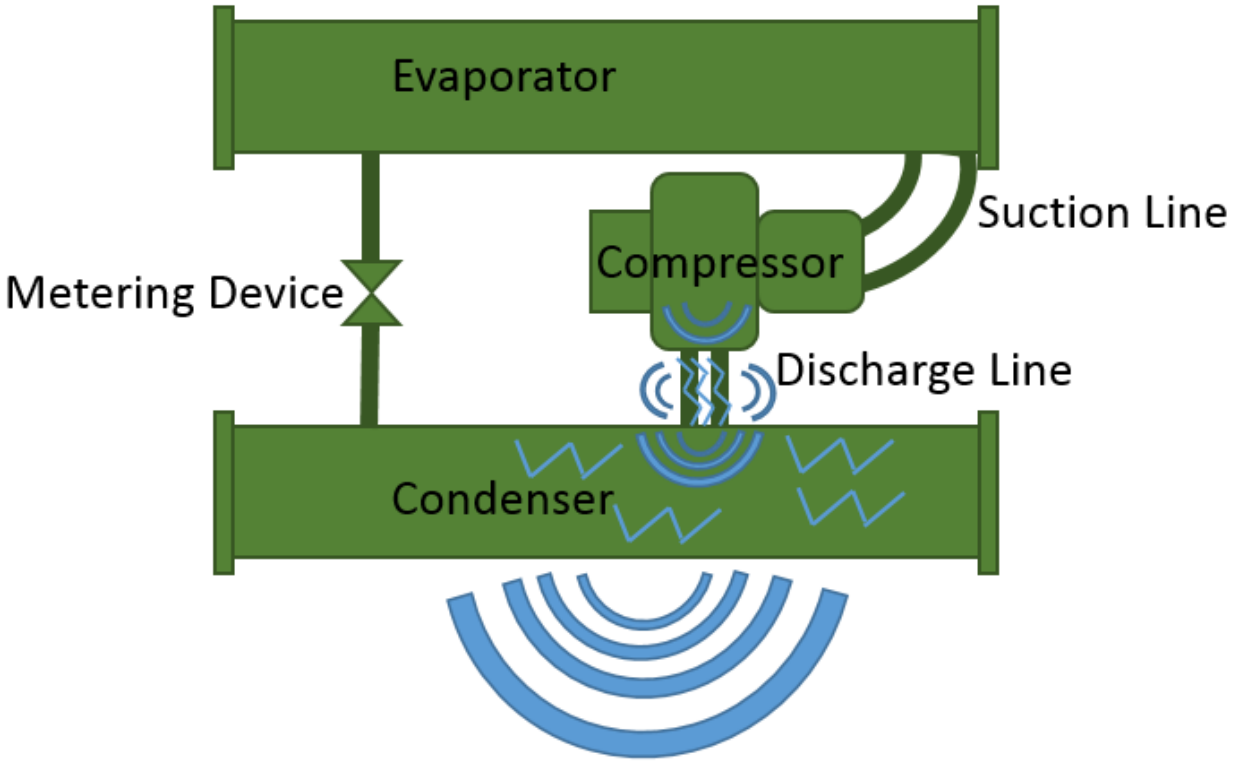
Learning Objectives

- **Learning Objectives:**
- Understand the basics of acoustic testing and sound level ratings.
- Understand the challenge of testing and reporting sound data for magnetic bearing centrifugal compressors.
- Explain the challenge of isolating the impact of refrigeration system components and unit configuration from compressor generated sound.
- Learn how to plan around various acoustic levels and about additional steps that can be taken in the field to mitigate unwanted sound.

Outline/Agenda

- Sources of centrifugal chiller noise and vibration
- Why Magnetic Bearings, what differences do they make?
- How do we measure centrifugal chiller sound?

Sources of Centrifugal Chiller Noise



Compressor the “Heart of The System”

Motor/Gear Box

- **Pumps Refrigerant around the system.**
- **With the pumping comes pulsations:**
  - Not a continuous process.
  - Slug of gas produced each time the blade passes the cut-off.
  - Just like a centrifugal fan but much faster.
  - Blade tone frequency: RPM*# of Blades/60 (in Hz).
  - “Broadband” Flow noise.
  - Pulsation amplitudes are a function of head, flow and speed.
  - Flow control devices can also affect pulsations.

Compressor the “Heart of The System”

Motor/Gear Box

- **Pumps Refrigerant around the system.**
- **What happens if there is an issue?**
  - Surge
    - Complete flow reversal – sounds like a giant vacuum cleaner or worse.
  - Stall
    - Detached flow – low frequency rumble
- **Transient events**

Compressor the “Heart of The System”

Motor/Gear Box

- **Other Compressor Noise Sources**
- **Oil pumps**
  - Typically geared pumps for oil return.
  - Potential motor and bearing noise sources**.**
- **Motors/Gear Box Noise**
  - Cooling fans
  - Rotor bar
  - Bearing noise

Compressor the “Heart of The System”

- **Other Compress ces**

Motor/Gear Box

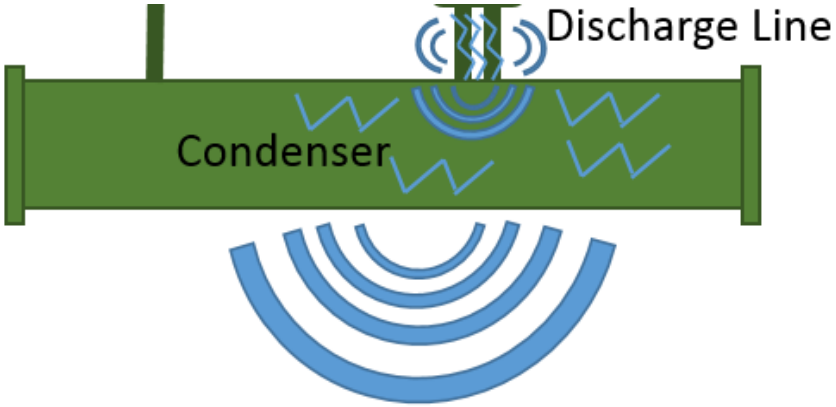
or oil return.

bearing noise sources.

Rotor

- Bearing no

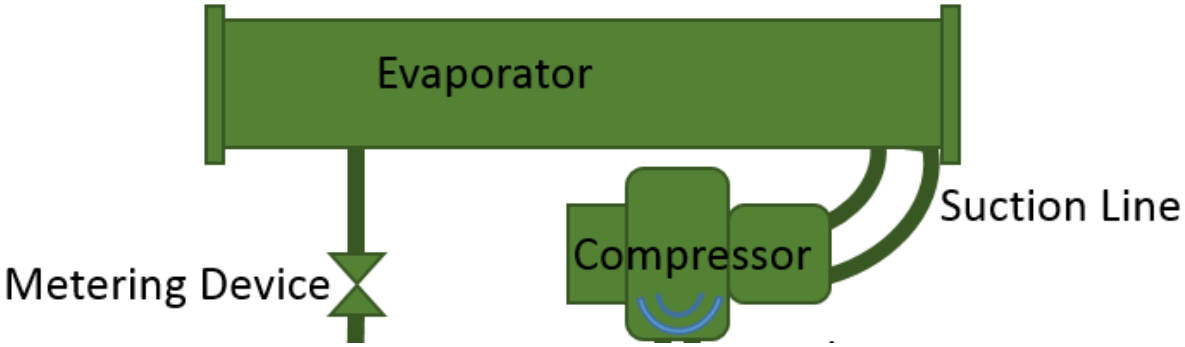
So where do all those pulsations go?



- **Compressor Radiated Noise**
- **Discharge Piping!!!**
  - Typically right after the compressor.
  - Thinner walls than the compressor.
- **Condenser**
  - Large radiating surface for sound.

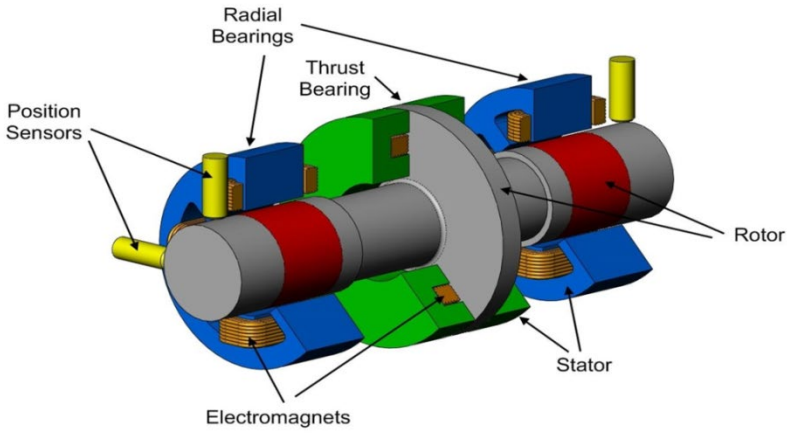
What about the rest of the system?

- **Metering/Expansion device is typically not a noise source.**
- **Suction Line and Evaporators can be driven at high flow/high mach conditions at blade tone similar to condensers, but this is uncommon.**
- **Electrical noise can occur at high loads and with incoming power issues.**

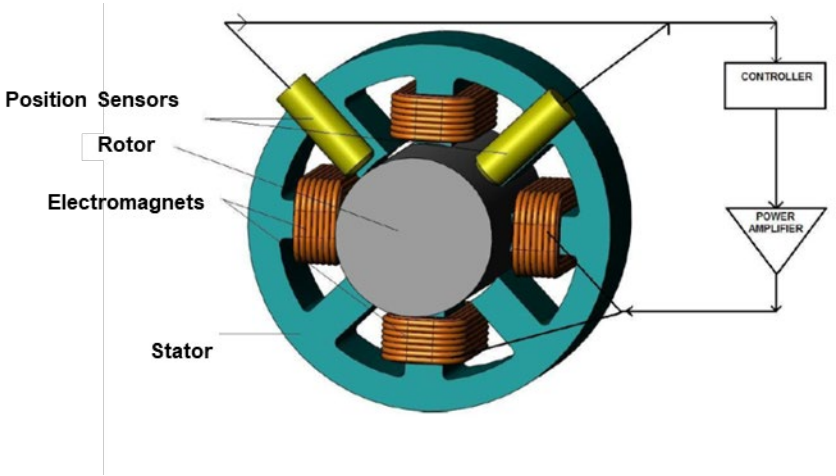


Why Mag Bearings and How do They Work?

- **Typical magnetic bearing system provides 5-axis of control**
  - 2 radial bearings (X1, Y1 and X2, Y2)
  - 1 thrust bearing (Z)
- **Both radial and thrust bearings are non-contact bearings**

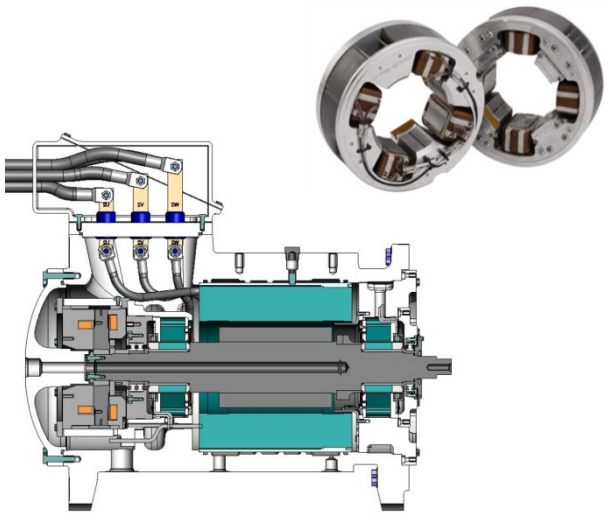


- **Key system components**
  - Position sensors
  - Bearing Controller
  - Power Amplifiers
  - Electromagnets
- **Precise rotor position is maintained by sensors measuring rotor position and regulating electromagnetic force applied to rotating element**



Why Mag Bearings and How do They Work?

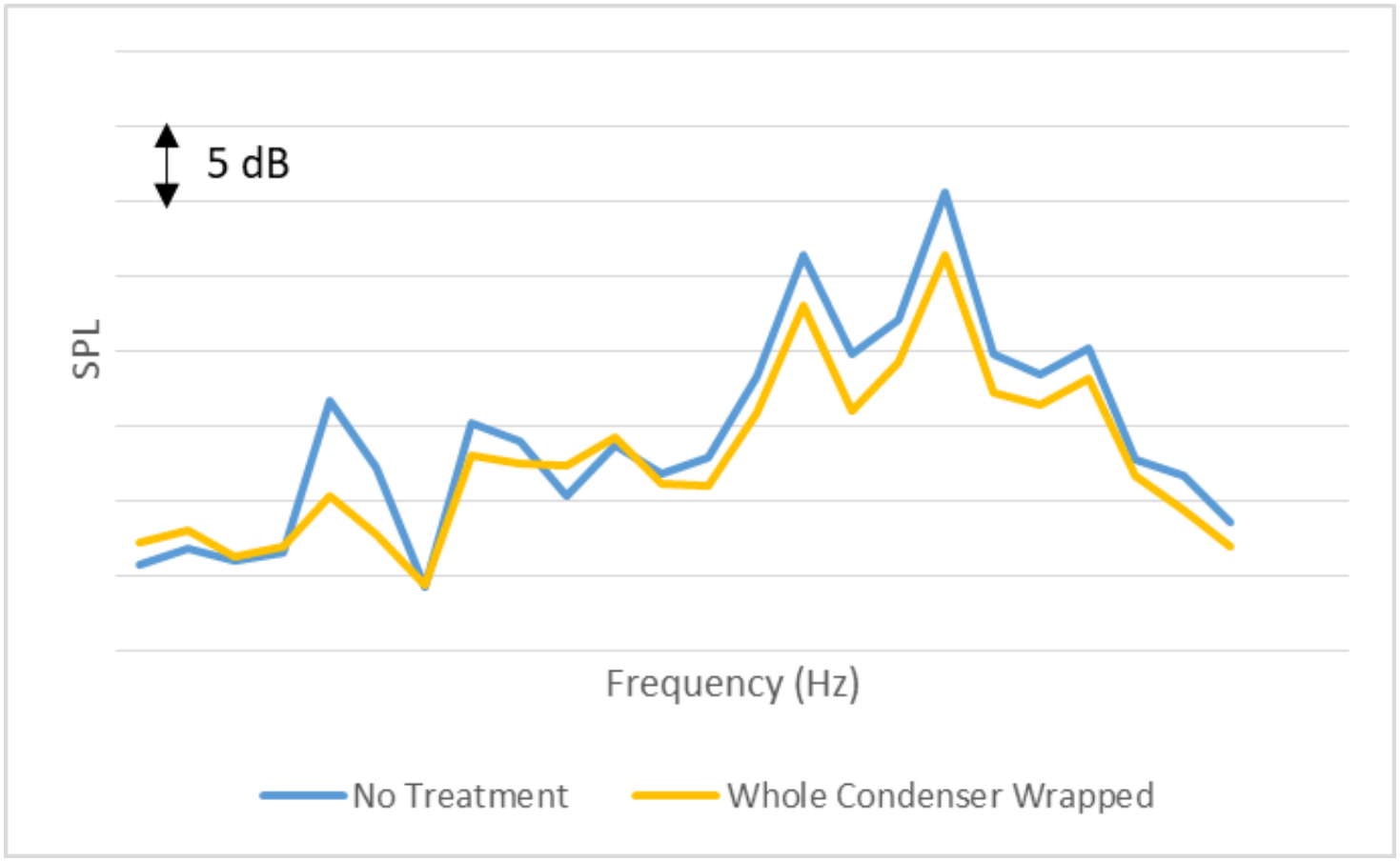
- **Benefits of magnetic bearings**
  - Reduced maintenance
  - Increased efficiency
  - No lubrication system
  - Expanded application range in speed and temperature
  - Rotordynamic benefits in vibration attenuation and noise suppression
  - Provides system performance data (orbit position and force) that can be used for machine health monitoring



ACOUSTICAL Effects of Magnetic Bearings

- **Removes oil system – no pumps.**
- **Increases heat exchanger efficiency (Smaller radiating area).**
- **Eliminates some additional noise sources – motors, bearings.**
- **Allows the compressor to operate at a different duty point. (Potentially lower pulsation levels)**

Typical effect of acoustic treatment



How do we measure sound from chillers?

AHRI 370 – Air Cooled Chillers (Sound Power)

- Free-field over a reflecting plane.
- Reverberation Room
- Sound Intensity

AHRI 575 – Water Cooled Chillers (Sound Pressure)

- In-situ sound pressure.

AHRI 1280 – Water Cooled Chillers (Sound Power)

- Free-field over a reflecting plane.
- Reverberation Room
- Sound Intensity

Conclusions

- Sound Levels from Magnetic Bearing Centrifugal Chillers are governed by the same fundamental physics as other centrifugal chillers.
- Magnetic Bearings help to eliminate or reduce several sources of noise on the chiller.
- For Chiller Noise Measurement and Rating:
  - AHRI 370 (Air Cooled Sound Power)
  - AHRI 575 (Water Cooled Sound Pressure)
  - AHRI 1280 (Water Cooled Sound Power)

Questions?

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