High Tech Chiller for High Tech Facility
Magnetic Bearing Chillers Cooling Office Building

Christine Detz
Agenda

• Case study
  • Facility insight
  • Installed equipment
  • Outcome

• History and future of magnetic bearing chillers
  • Timeline of magnetic bearing
  • Magnetic bearing centrifugal chillers for the future
High Tech – Sustainable Facility

- 385,000 square foot facility
- Used by 1,500 professionals
- Office and laboratory environments
- **LEED® platinum certification** - highest such recognition possible

- Geothermal heat pumps, photovoltaic energy, under-floor heating and cooling, parking structure with plug-ins for hybrids, etc.
Installed Equipment

- Installed August 2017
- Over 7,000 run hours
- Water-cooled centrifugal chiller
- 350 tons
- Variable Speed Drive
- Magnetic Bearing
- Quick Start Feature
- Using R-1233zd (GWP of 1)

“We installed in August, our peak cooling season, and the chiller picked up the pace flawlessly“  - Facility Manager
Existing Refrigerant Bans
• **R-123** - no longer sold in new chillers - Per Montreal Protocol 1/1/20
• **HFC refrigerant** - there is no global ban on HFC refrigerants

Kigali Amendment
• Kigali Amendment to the Montreal Protocol is a **global regulation**
• Ramps down demand for HFCs on a timeline for transition over several decades
• The United States has not ratified the Kigali Amendment

US EPA SNAP Ruling
• SNAP Rule limiting the sale of 134a & 410A chillers in 2024 was vacated
• Some states have joined the US Climate Alliance, aiming to reduce GHG emissions by 2025
• No current legislation impacts the sale, use or servicing of HFC chillers
## QUICK REVIEW - Refrigerant Landscape Today

### Conventional Refrigerants

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Safety</th>
<th>Products</th>
<th>Pressure</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-134a</td>
<td>A1</td>
<td>Centrifugal and Screw</td>
<td>Medium</td>
<td>1300</td>
</tr>
<tr>
<td>R-410A</td>
<td>A1</td>
<td>Scroll</td>
<td>High</td>
<td>1924</td>
</tr>
</tbody>
</table>

### Next Generation Low-GWP Refrigerants

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Safety</th>
<th>Products</th>
<th>Pressure</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-513A</td>
<td>A1</td>
<td>Centrifugal and Screw</td>
<td>Medium</td>
<td>573</td>
</tr>
<tr>
<td>R-1233zd</td>
<td>A1</td>
<td>Centrifugal</td>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>R-514A</td>
<td>B1</td>
<td>Centrifugal</td>
<td>Low</td>
<td>2</td>
</tr>
</tbody>
</table>

*Other low-GWP refrigerants are flammable, requiring revisions to building codes, safety standards, service and transportation practices*
Outcomes To Date

• **Reduced Emissions**
  - Reduced total emissions from efficient chiller and low GWP refrigerant

• **Increased Uptime**
  - Cloud-based analytics to drive increased uptime

• **Reduced Maintenance**
  - Magnetic Bearings means less maintenance
TEWI: Total Equivalent Warming Impact

TEWI = the measurement of a chiller’s **direct + indirect** emissions

- **Indirect Emissions** - Amount of energy used by the chiller (based on energy source mix of power generation used to operate the chiller)

- **Direct Emissions** – determined by impact of possible leak from chiller & GWP of the refrigerant in the chiller (R-1233zd GWP = 1)

Improved efficiency + low GWP refrigerant = **Lower Environmental Impact**
- Direct emissions are reduced by 100%
- Indirect emissions are reduced by 22%
- Total TEWI reduction: 25%

**CO₂ savings equivalent to burning almost 1 million pounds** of coal
Connecting to the cloud in HVAC

Cloud-based Service Platform for Chillers

- Critical alarms sent directly to your local service provider
- Chiller operating data is sent for storage and analysis
- Analytics used to produce Chiller Health Reports, provided every visit
- Operating & trend data accessible anywhere, anytime by our local, regional and global experts

- Constant monitoring of chiller and performance
- Regular reporting
- Preventative maintenance alerts – before failure
Broader algorithms can be applied in multi-chiller plant scenarios to identify which chillers require the most attention.
Regular checks can alert to:

- Need for chiller tube cleaning
- Cooling tower problems
- Refrigerant leaks

*Monitoring and Reporting capabilities to proactively look for potential issues*
• Possible causes and impacts are identified
• Time chart shows when the issue is occurring to help diagnose potential issues
## Rated Performance Comparison

<table>
<thead>
<tr>
<th></th>
<th>VSD Centrifugal Chiller Previously Installed</th>
<th>VSD Magnetic Bearing Centrifugal Chillers Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>300 Tons</td>
<td>300 Tons</td>
</tr>
<tr>
<td><strong>Input Power</strong></td>
<td>170.9 kW</td>
<td>163.9 kW</td>
</tr>
<tr>
<td><strong>Full Load Efficiency</strong></td>
<td>0.5697 kW/Ton</td>
<td>0.5463 kW/Ton</td>
</tr>
<tr>
<td><strong>Part Load Efficiency</strong></td>
<td>0.3935 kW/Ton</td>
<td>0.3216 kW/Ton</td>
</tr>
</tbody>
</table>

- **Full Load:** + 4.1%
- **Part Load:** + 18.3%
Magnetic Driveline Benefits

• Single moving assembly suspended in a magnetic field with no lubrication system
  • 80% fewer moving parts
  • Non-contact design

• Magnetic bearings deliver
  • Extraordinary efficiency & wide operating map
  • Superior durability
  • Simplified maintenance

Enhanced longevity & reduced maintenance!
Bearing Options for Centrifugal Chillers

**OIL-LUBRICATED BEARINGS**

- Filter
- Compressor/Motor
- Pump
- Condenser
- Evaporator

- Primary Refrigerant Circuit
- Bearing Lubrication Oil Circuit (Connection locations may vary)

**REFRIGERANT-LUBRICATED BALL BEARINGS**

- Filter
- Compressor/Motor
- Pump
- Condenser
- Evaporator

- Primary Refrigerant Circuit
- Bearing Lubrication Refrigerant Circuit (Connection locations may vary)

**MAGNETIC BEARINGS**

- Compressor/Motor
- Condenser
- Evaporator

- Refrigerant Circuit
## Lower Driveline Maintenance

<table>
<thead>
<tr>
<th>Driveline Maintenance Tasks</th>
<th>Oil-lubricated Bearings</th>
<th>Refrigerant-lubricated Bearings</th>
<th>Magnetic Bearings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check lubricant sump &amp; temperature control operation</td>
<td>Monthly</td>
<td>Monthly</td>
<td>–</td>
</tr>
<tr>
<td>Check lubrication eductors</td>
<td>Monthly</td>
<td>Monthly</td>
<td>–</td>
</tr>
<tr>
<td>Lubricant analysis</td>
<td>Annually</td>
<td>Annually</td>
<td>–</td>
</tr>
<tr>
<td>Replace lubricant filter(s)</td>
<td>Annually</td>
<td>Annually</td>
<td>–</td>
</tr>
<tr>
<td>Vibration analysis</td>
<td>–</td>
<td>Quarterly</td>
<td>–</td>
</tr>
<tr>
<td>Clean refrigerant pump strainer</td>
<td>–</td>
<td>Monthly</td>
<td>–</td>
</tr>
<tr>
<td>Battery health test</td>
<td>–</td>
<td>Periodically</td>
<td>Periodically</td>
</tr>
</tbody>
</table>
Other Magnetic Bearing Benefits: Lower Driveline Maintenance

Cumulative Driveline Maintenance Cost

Years of Ownership

- Initial Chiller Cost
- Magnetic Bearing Chiller
- Oil-lubricated Bearing Chiller
- Refrigerant-lubricated Bearing Chiller

- 125-150% of initial chiller cost
- 110-120% of initial chiller cost
- <10% of initial chiller cost
History of Magnetic Bearing Technology

- First patents came during WWII
- Magnetic bearing technology introduced in 1998 on critical naval applications
- Introduced in commercial HVAC in 2002
- Bearings support load using magnetic levitation
Advanced Aerodynamic System

- 2 single-stage compressors
- Paired in Series Counterflow arrangement
  - Reduces lift on each compressor
  - Improves overall full load and part load performance
- Capability to run 1 compressor at a time
  - Redundancy in case of a shutdown or failure
  - Low load situations
- Increases turndown capability
Series Counterflow Benefit

- Split shell design – 1 shell, 2 circuits
  - Patented technology
  - Only feasible with low pressure refrigerant
- High efficiency in a compact package
- Inherent 2 pass design

10% lift reduction increases efficiency by more than 5%

85°F → 94.3°F
Condenser

44°F → 49°F
Evaporator

54°F → 89.5°F
## Series Counterflow Example

<table>
<thead>
<tr>
<th></th>
<th>2000 Ton Chiller at AHRI Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parallel Configuration</td>
</tr>
<tr>
<td>Input Power</td>
<td>1010.6 kW</td>
</tr>
<tr>
<td>Full Load Efficiency</td>
<td>0.5053</td>
</tr>
<tr>
<td>IPLV</td>
<td>0.3071</td>
</tr>
</tbody>
</table>

**Benefit**

- Full Load: + 6.4%
- Part Load: + 9.2%
Summary

• Magnetic Bearing innovative technology works well for high tech – high demanding buildings
  • Improved energy efficiency
  • Reduced maintenance

• Now dual compressor design offers series counterflow benefit
QUESTIONS?