

Energy Efficiency - Innovation, Technology & Experience Workshop

Oil-Free Magnetic Bearing Compressors for Air-Conditioning Plants

19 November 2008



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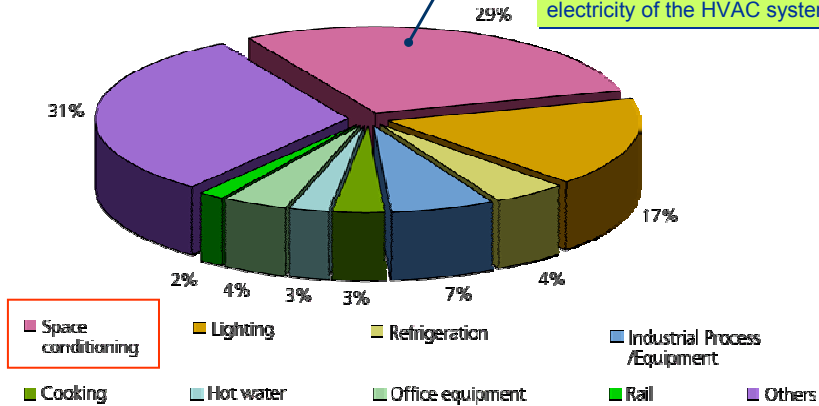
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Electricity Consumption of Chiller Equipment

● Electricity End-uses of 2006

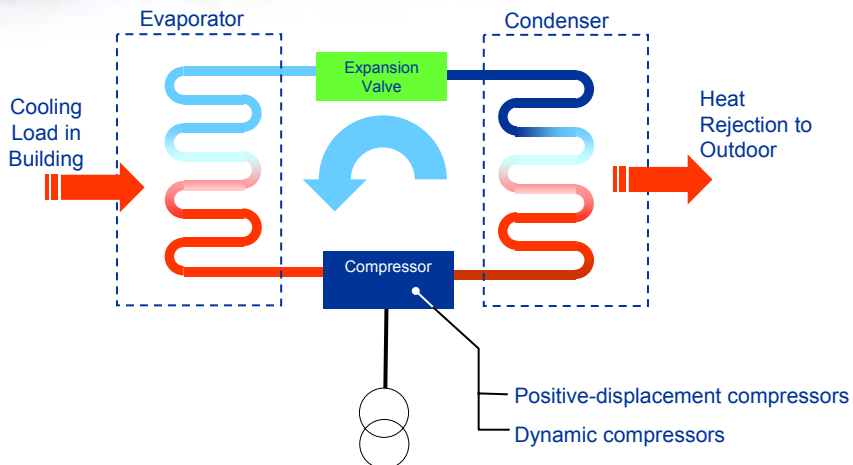
It was roughly estimated that chiller equipment alone consume about 50%-70% electricity of the HVAC system



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The Basic Principle of Chiller



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Type of Compressors

- Positive-displacement compressors increase pressure of refrigerant vapor by reducing the volume of the compression chamber through work applied to the compressors
- Examples include reciprocating, screw, scroll etc.

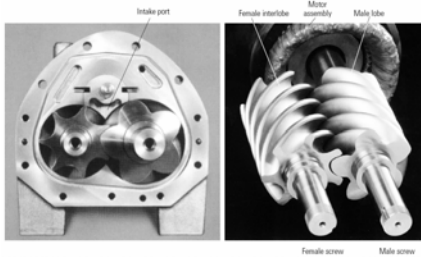


Photo extracted from Esource



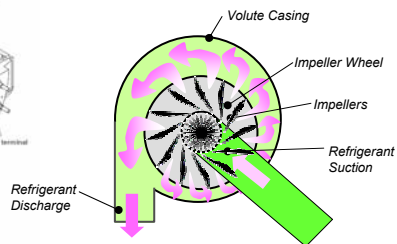
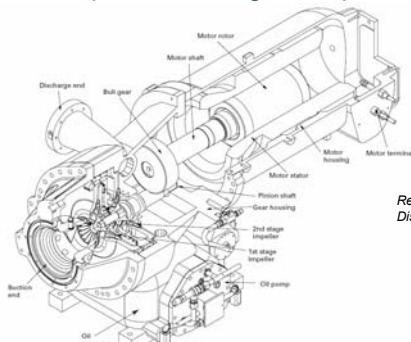
Photo extracted from Air Conditioning and Refrigeration Journal April-June 2000 issue

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Type of Compressors

- Dynamic compressors increase the pressure of refrigerant vapour by a continuous transfer of angular momentum from the rotating member to the vapour followed by the conversion of this momentum into a pressure rise
- Example is centrifugal compressor



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Graphics extracted from Chiller Manufacturer's O&M Manual

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Type of Compressors

Type of Compressor	Typical Size Range	Typical Full-load Chiller COP	Remarks
Centrifugal	100 – 1,500 RT	5 - 7	Mature technology; Subject to surge at low loads; Gear-driven or direct-drive.
Screw	40 – 1,100 RT	5 – 5.8 (water cooled) 2.7 – 3.2 (air cooled)	Wide operating range; Relatively small and light; Response well to reductions in condenser water temp.
Reciprocating	1 – 400 RT	3.5 – 4.4 (water cooled) 2.2 - 2.5 (air cooled)	More moving parts; Vibrations;

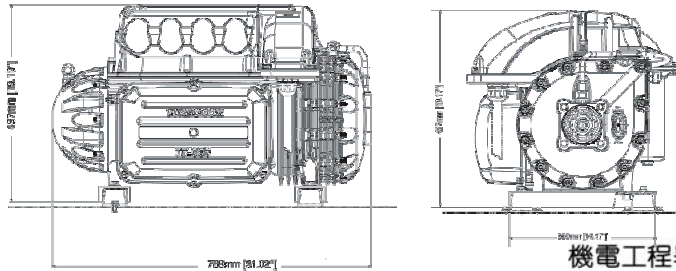
7 Sources: Manufacturer's Data

Innovative Oil-Free Magnetic Bearing Compressor



Innovative Oil-Free Magnetic Bearing Compressor

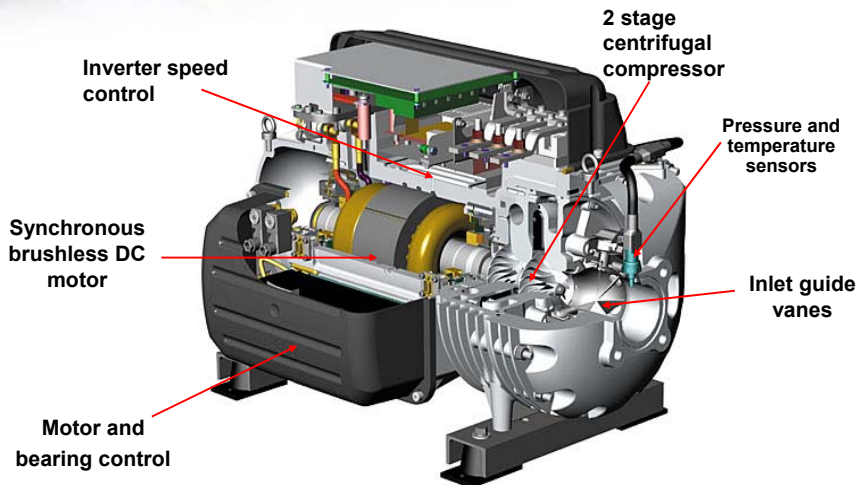
- 2 Stages Centrifugal Type
- Magnetic Bearing – No lubrication oil circuit
- DC Permanent Magnet Motor
- Variable Speed Drive Driven
- Electronics Integration



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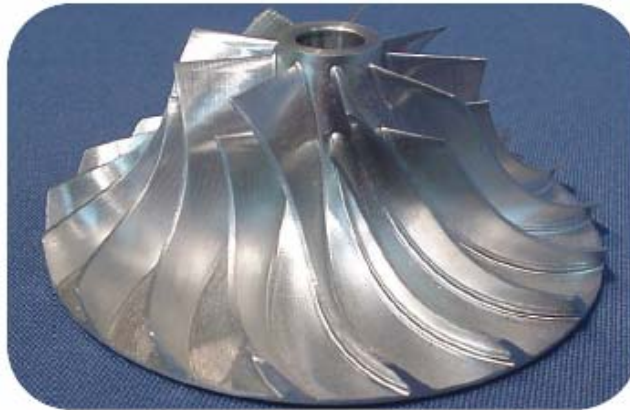
Source: Manufacturer's Literatures

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Centrifugal Design for Small to Medium Size Chiller



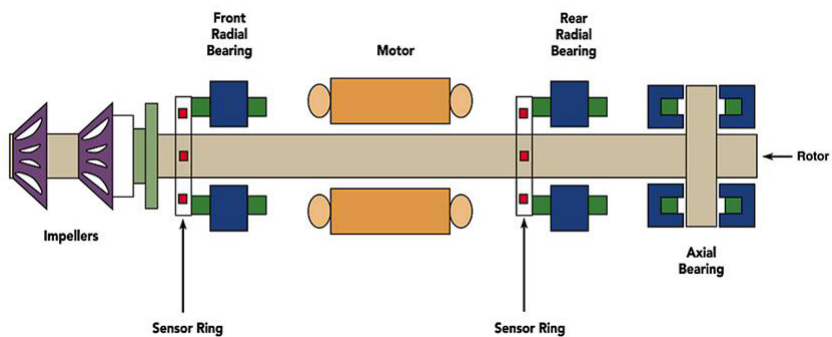
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Source: Manufacturer's Literatures

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Magnetic Bearing System



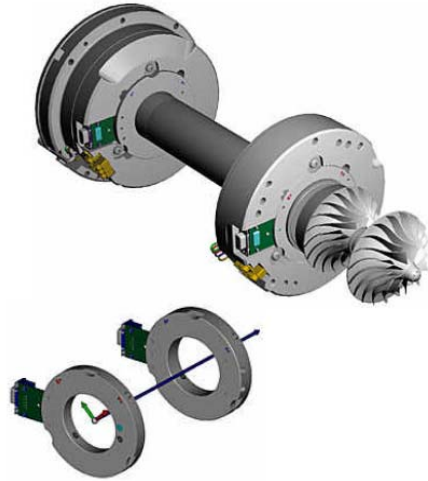
Source: Manufacturer's Literatures

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Magnetic Bearing System



Source: Manufacturer's Literatures

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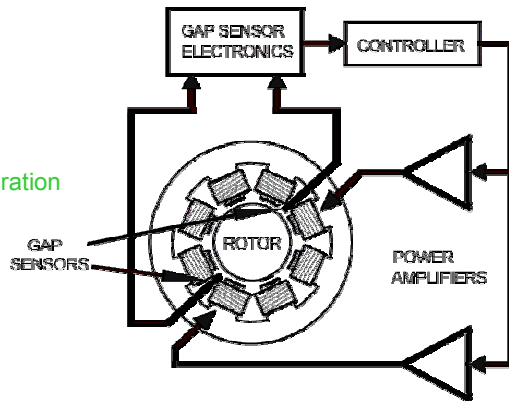
Magnetic Bearing System

Advantages

- No physical contact
- Low and predictable friction
- No lubrication requirement
- Smooth operation
- Suitable for high speed operation

Disadvantages

- Bulky in size
- Expensive



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Innovative Oil-Free Magnetic Bearing Compressor

Magnetic Bearing System

Advantages

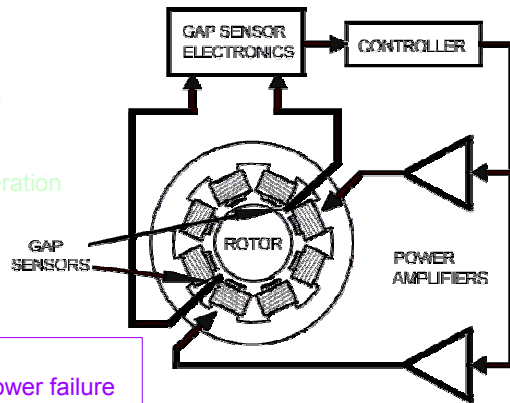
- No physical contact
- Low and predictable friction
- No lubrication requirement
- Smooth operation
- Suitable for high speed operation

Disadvantages

- Bulky in size
- Expensive

Question to think

What will happen if there is a power failure or electronics failure?



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Innovative Oil-Free Magnetic Bearing Compressor

Magnetic Bearing System

Problems associate with Lubrication

- Bulky oil sump in chiller
- Need oil heater to maintain oil temperature at about 40°C
- Maintenance issue
- Regular oil analysis
- Oil migration affecting chiller efficiency
- Oil return problem at low chiller load

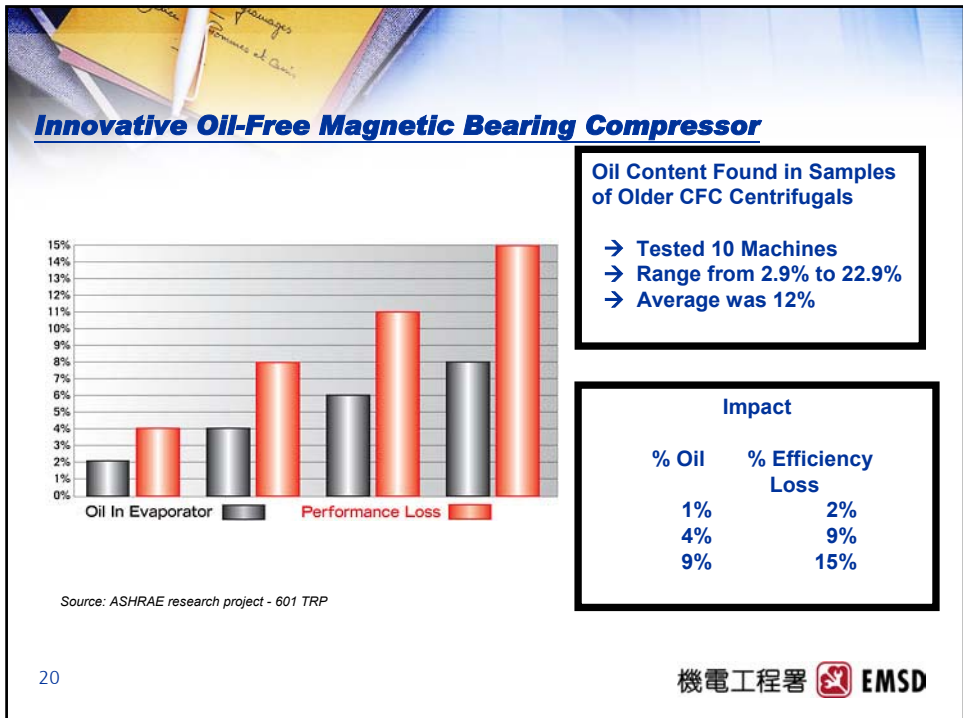
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Results :

Testing Items	Results
1. Moisture content, %	<0.05
2. Kinematic viscosity @ 40°C, cSt	26
3. Total acid number, mgKOH/g	0.06
4. Wear metals :	
Ag, ppm	<1
Al, ppm	1
B, ppm	<1
Ba, ppm	1
Ca, ppm	360
Cr, ppm	<1
Cu, ppm	17
Fe, ppm	15
K, ppm	31
Mg, ppm	16
Mo, ppm	<1
Na, ppm	56
Ni, ppm	<1
P, ppm	2
Pb, ppm	2
Sb, ppm	<1
Sn, ppm	5
V, ppm	<1
Si, ppm	<1
Ti, ppm	<1
Zn, ppm	7

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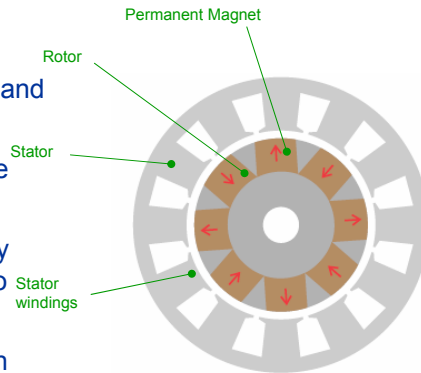
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Permanent Magnetic DC Motor

- More efficient over a wide speed and load range
- Variable speed capability improve load control and precision
- Shows slight advantage for nearly constant operation at moderate to high load
- Large advantage for systems with varying load including significant low-load operation



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Source: ESource

Innovative Oil-Free Magnetic Bearing Compressor

Permanent Magnetic DC Motor

<u>Speed</u>	<u>Load</u>	<u>Induction Motor Eff.</u>	<u>PM DC Motor Eff.</u>
100%	100%	88.0%	89.8%
50%	100%	79.3%	85.4%
100%	50%	87.5%	86.8%
50%	50%	83.3%	85.5%

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Source: ESource

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Variable Speed Drive



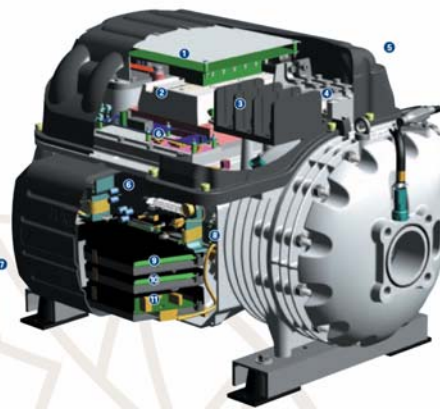
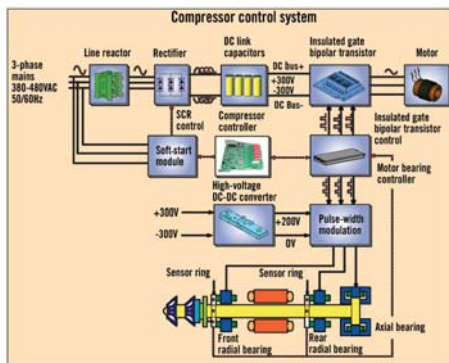
Source: Manufacturer's Literatures

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- Varies the frequency between 300 – 800 Hz
- Compressor running at 18,000 – 48,000 rpm

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Variable Speed Drive



Source: Manufacturer's Literatures

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Variable Speed Drive



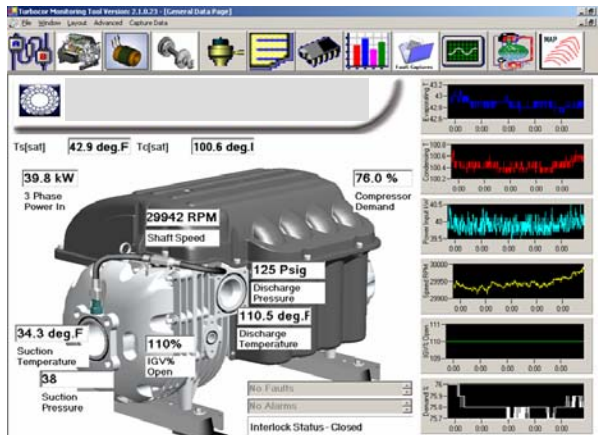
Source: Manufacturer's Literatures

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Variable Speed Drive



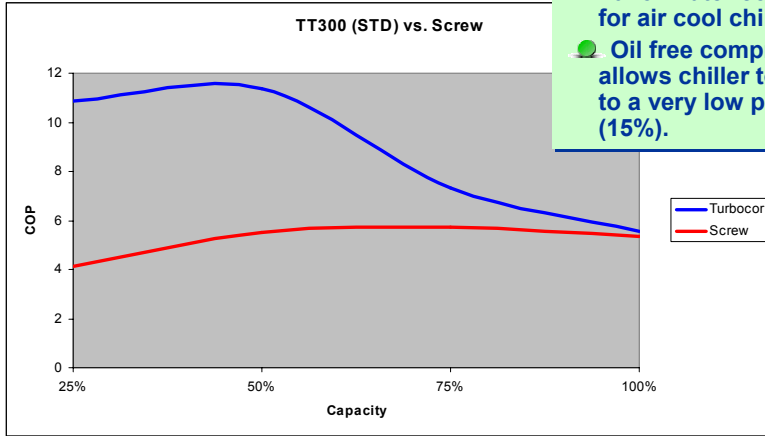
Source: Distributor's Literatures

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Variable Speed Drive



- IPLV COP approaching 10 for water cool and 6 for air cool chillers
- Oil free compressors allows chiller to off load to a very low percentage (15%).

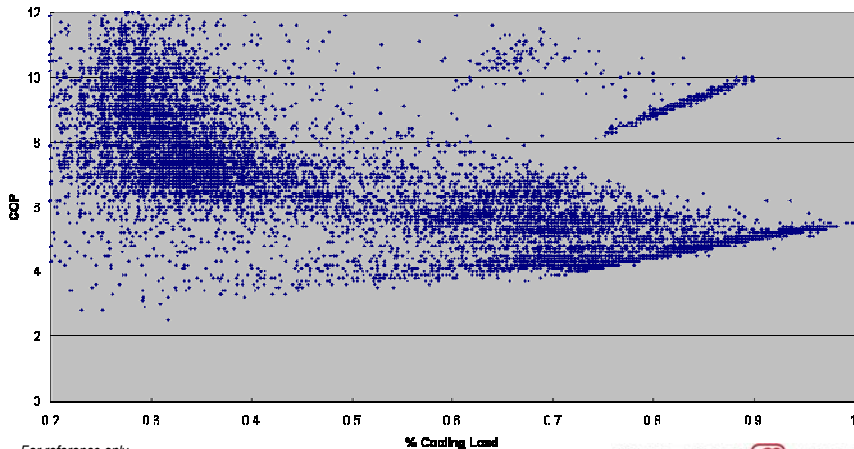
Source: Manufacturer's Literatures

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Variable Speed Drive

COP vs % Cooling Load



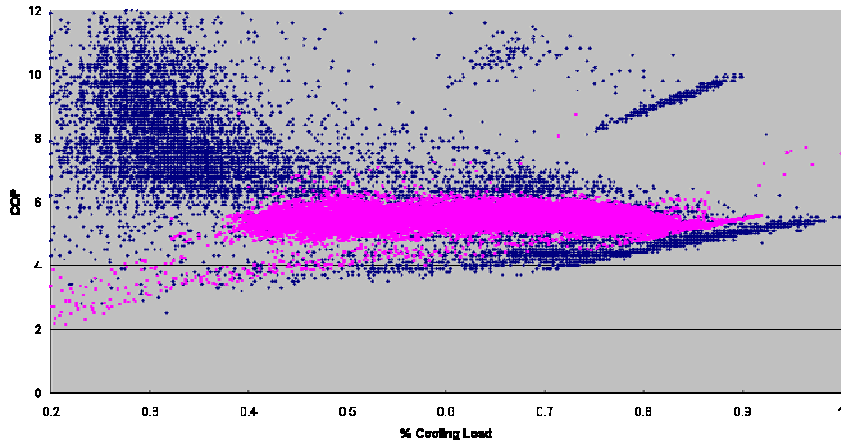
For reference only

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Variable Speed Drive

COP vs % Cooling Load



29 For reference only

• Oil Free Magnetic Bearing Chiller • Conventional Chiller

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Application



Can be used in Air Cooled Chillers or Water Cooled Chillers

Source: Manufacturer's Literatures

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Performance

- Data Logging starts in October 2008.
- Preliminary Results from 1-17 November (for reference only):
 - Average Condensing Water In/Out Temp: 27.4/23.5 °C
 - Average Chilled Water In/Out Temp: 8.0/10.7 °C
 - Average % Loading of Chiller: ~53%
 - Average Chiller COP As Recorded By CCMS: ~5.8 (c.f. ~ 5-6 of a typical conventional centrifugal chiller)
- More data will be collected for evaluation.



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End Of Presentation

