



Advancements in Variable Speed Technology for Centrifugal Chillers

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Enabling Technologies for Efficiencies

Water-cooled, centrifugal chillers are the most versatile class of chillers available, meeting customer needs in capacities > 100 Tons

So how do we improve upon great?

Combine 4 enabling technologies:

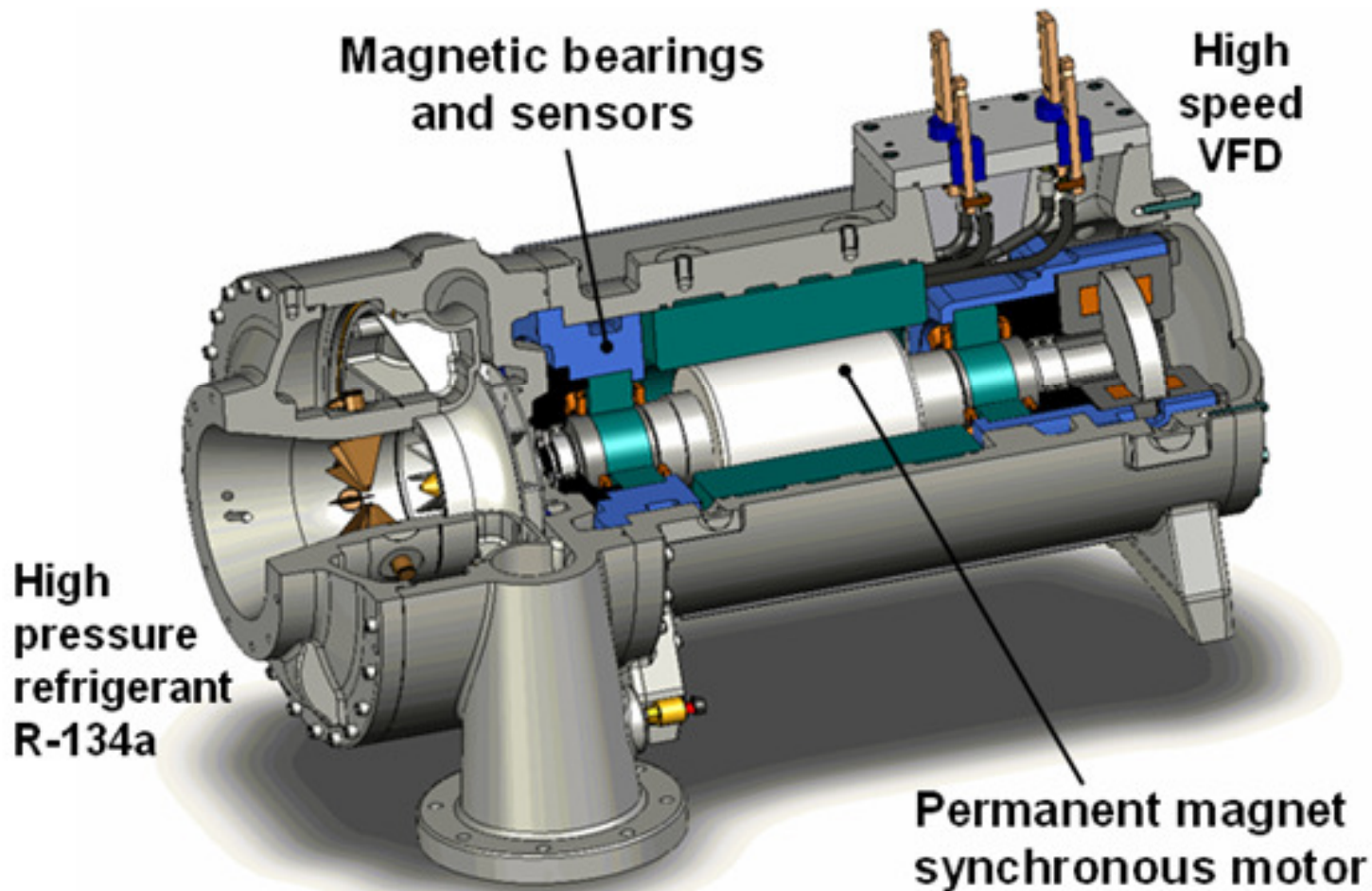
High pressure refrigerant

Permanent magnet (PM) motors

Magnetic bearings

High speed VFDs

Enabling Technologies for Efficiencies



What's really important?

*System Energy Efficiency and Operating Costs
Sustainability and Green*



**High
Efficiency**

+



**Reduced
Maintenance**

+



Sustainability

=



**Lower Total
Cost of
Ownership**

So how do we get there with technology?

Crucial Design Choice

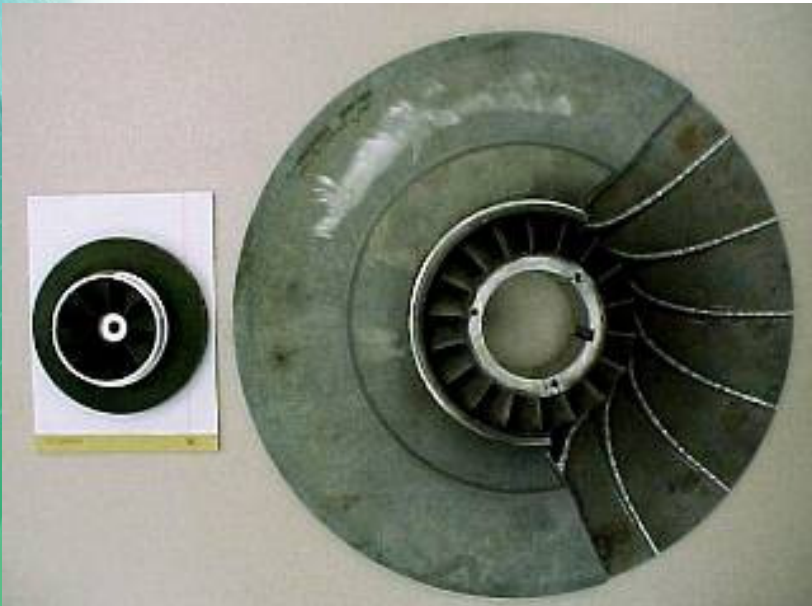
...the right refrigerant

Positive Pressure

Keep contaminants out-not in

Low specific volume

Lower normalized flow rate (cfm/ton)



Refrigerant	Specific Volume, ft ³ /lb	Normalized Flow Rate, CFM/ton
R-123	5.9327	18.33
R-134a	0.9528	2.86

Conditions:

40 °F saturated vapor

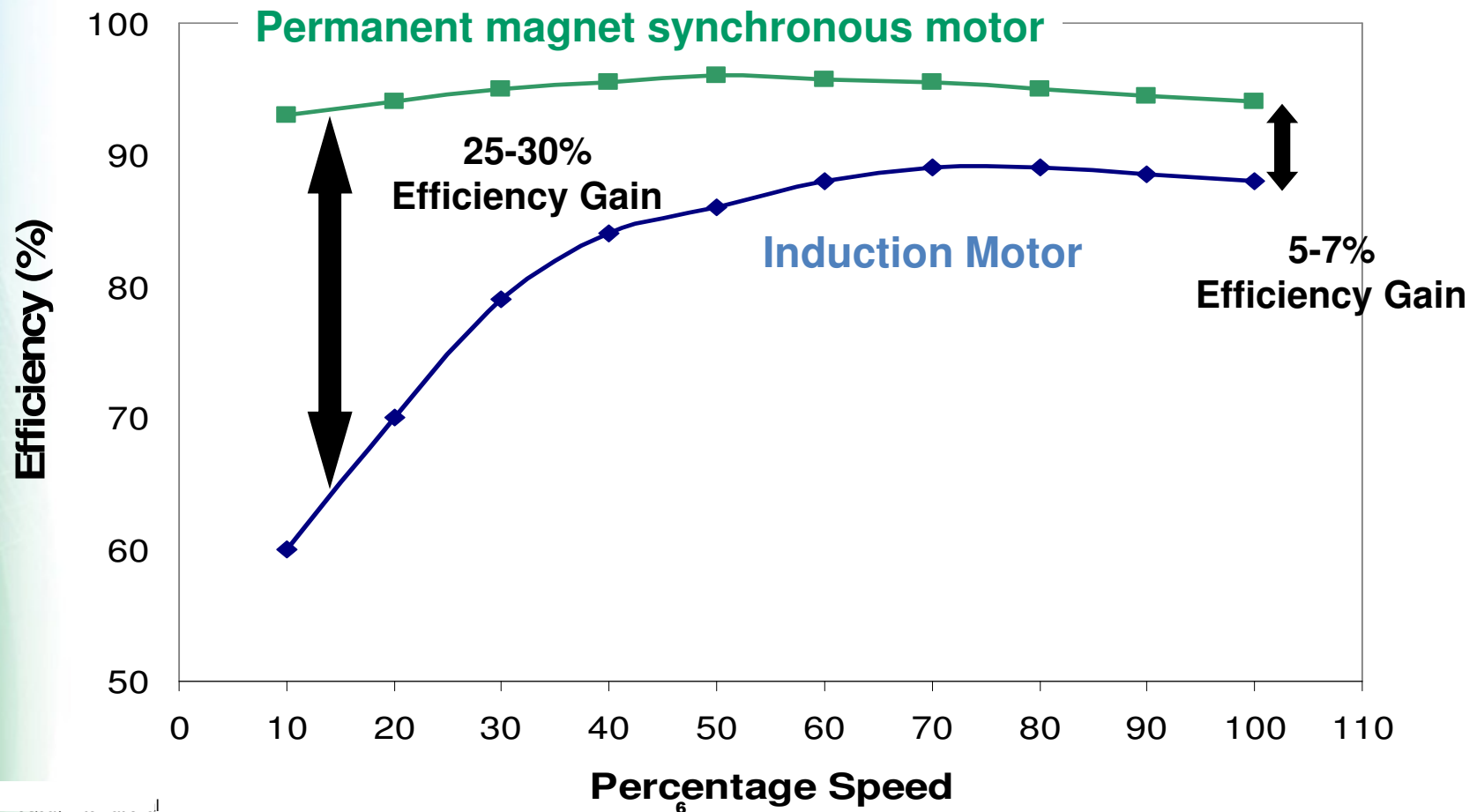
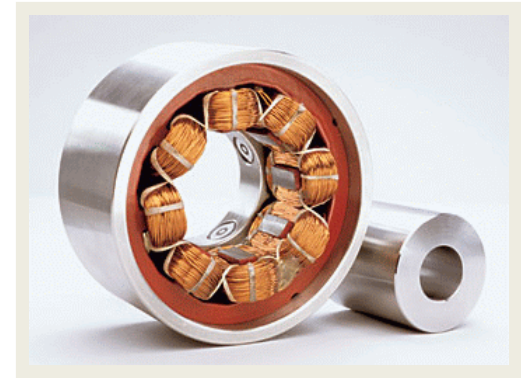
5.78 psia for R-123

49.94 psia for R-134a

100 °F saturated condensing

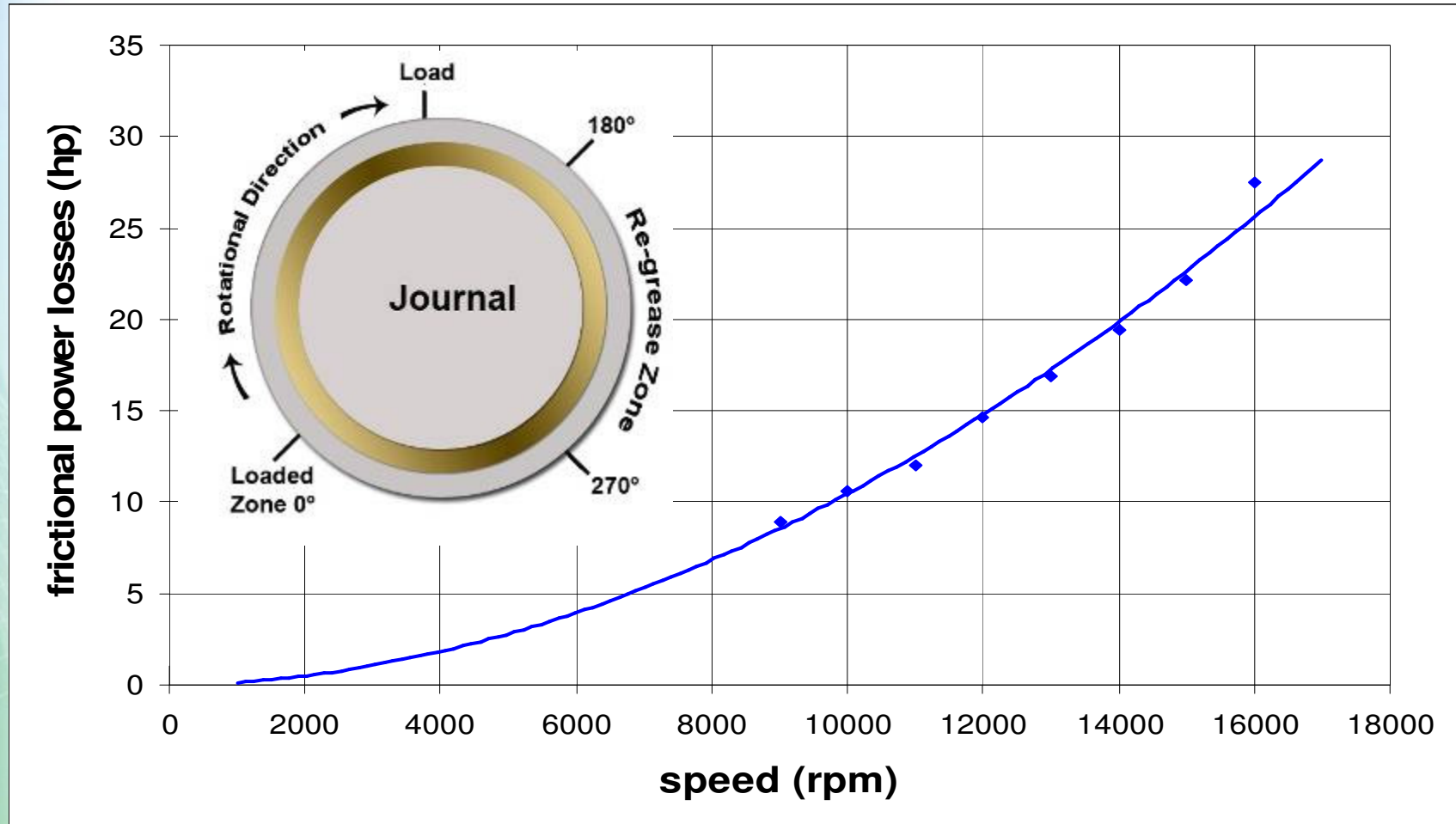
8 °F subcooling and 0.5 °F superheat

Crucial Design Choice ...Motor Type



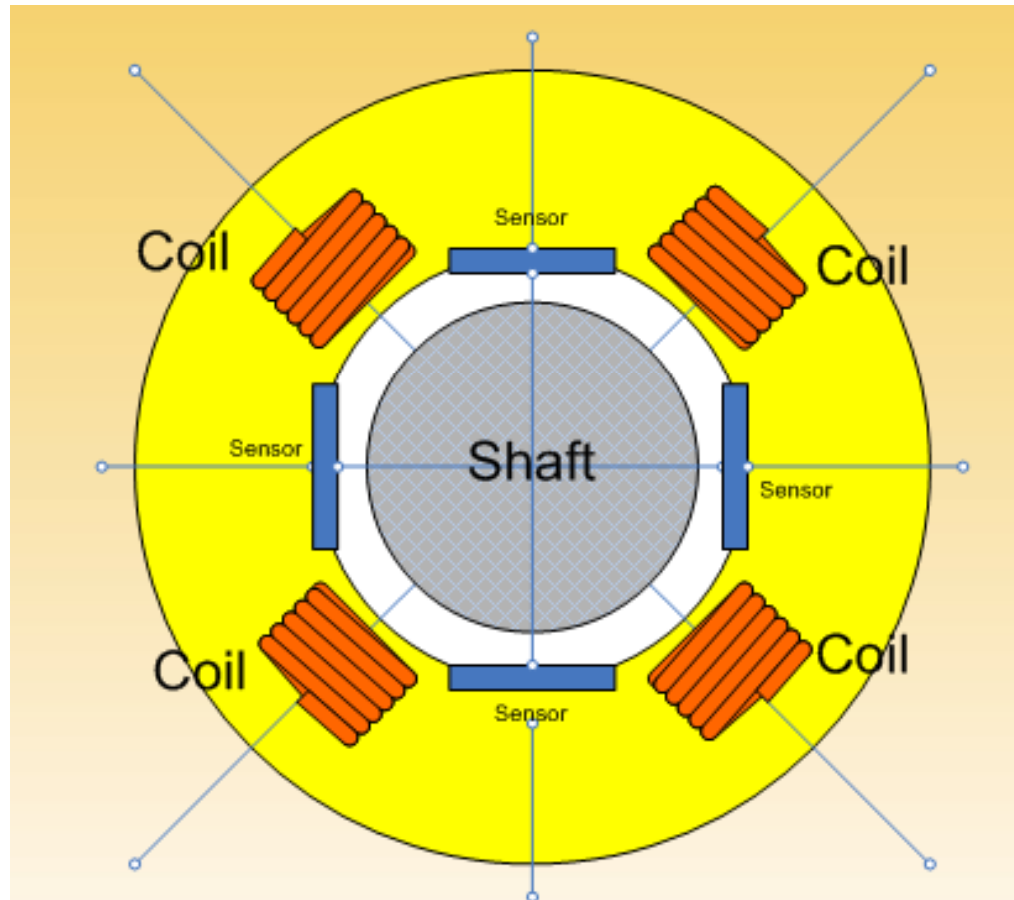
Crucial Design Choice...Bearing Type

Hydrodynamic has significant frictional power losses



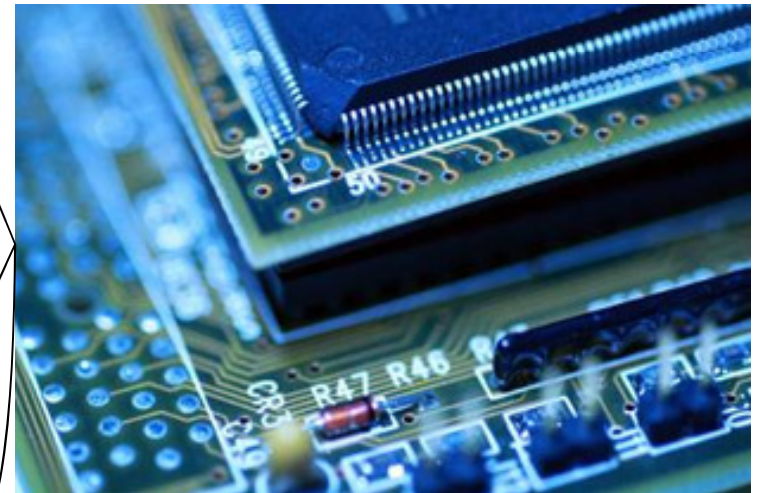
Crucial Design Choice...Bearing Type

Magnetic Bearings-very limited losses

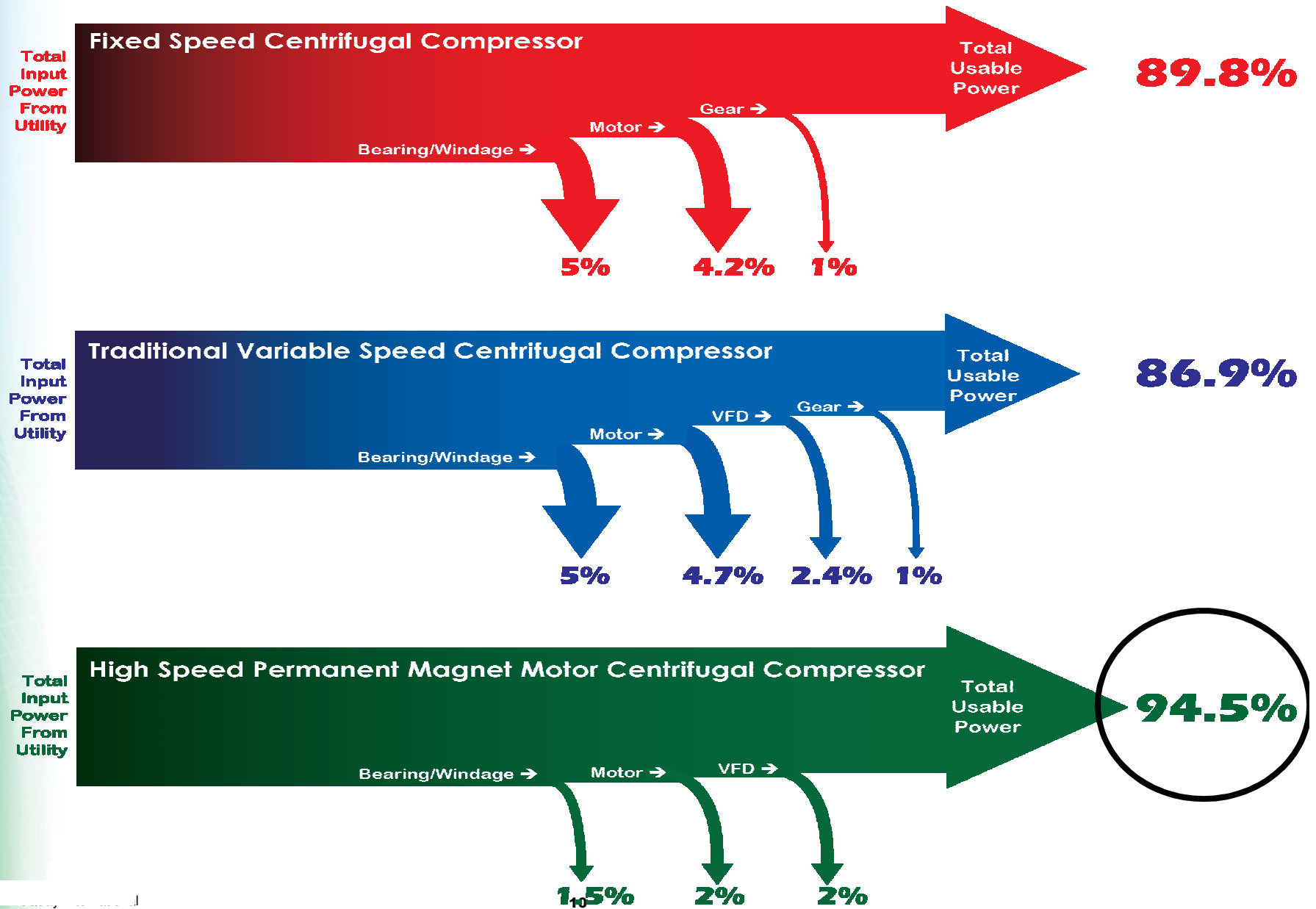


Advancements in Magnetic Bearings

High speed digital processing
Lower cost than 5-10 years ago
High reliability
Standardized design



Comparisons



Controlling the compressor speed ...what works best?

$$\text{IPLV or NPLV} = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}}$$

Full Load 1% →

Where:

A = kW/ton at 100% & 85°F CEWT

B = kW/ton at 75% & 75°F CEWT

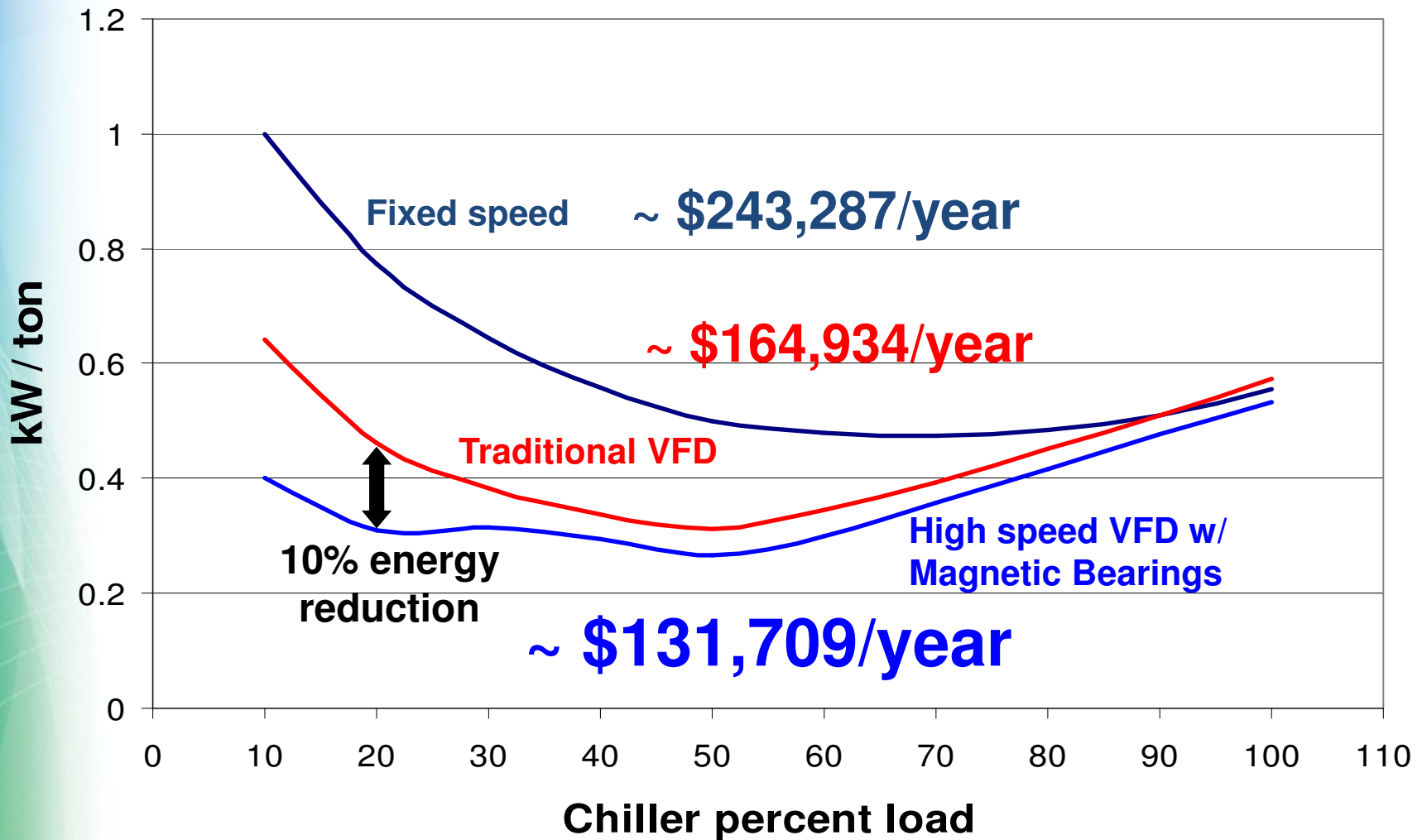
C = kW/ton at 50% & 65°F CEWT

D = kW/ton at 25% & 65°F CEWT

AHRI Standard 550/590-2003, Appendix D

Fixed Speed? Traditional VFD?

High speed VFD w/Magnetic Bearing?



You forgot about Sustainability?

From ASHRAE Research Project 751-RP,
“Experimental Determination of the Effect of Oil on
Heat Transfer with Refrigerants HCFC-123 and
HFC-134a”,

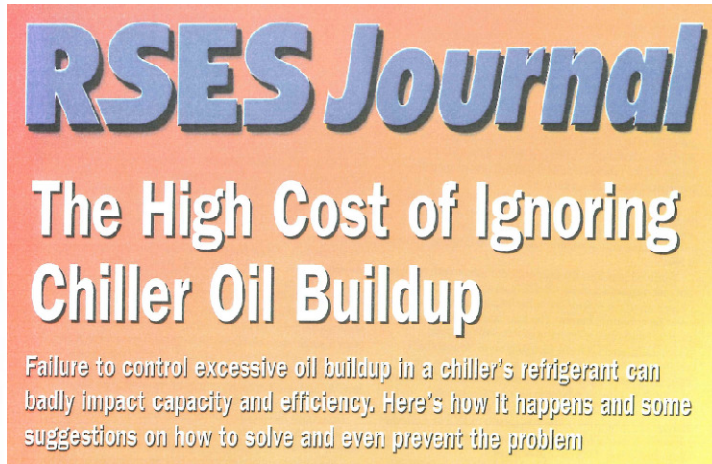
Conclusions and Recommendations:

“The effect of POE oil on the heat transfer coefficient of R-134a flowing across a bundle of Turbo-B2 (HP) tubes is a reduction in heat transfer coefficient. The heat transfer ratio drops steadily with oil concentration and reaches a value of 0.65 [from 1.0 normalized] at an oil concentration of 10%.”



More Sustainability Benefits

Positive pressure, oil-free design eliminates the performance degradation due to non-condensables and oil contamination of the refrigerant



RSES Journal
The High Cost of Ignoring Chiller Oil Buildup
Failure to control excessive oil buildup in a chiller's refrigerant can badly impact capacity and efficiency. Here's how it happens and some suggestions on how to solve and even prevent the problem

Source: *The News*, 04/15/04, by Jack Sine

Oil Contamination

Oil In Evaporator	Performance Loss
1-2%	2-4%
3-4%	5-8%
5-6%	9-11%
7-8%	13-15%



THE HVACR CONTRACTOR'S WEEKLY NEWSMAGAZINE SINCE 1926
Air Conditioning | Heating | Refrigeration
the NEWS
JUNE 5, 2006 WWW.ACHRNEWS.COM A BNP MEDIA PUBLICATION \$3.00
The High Cost of Oil Contamination

More Sustainability Benefits

	<u>Traditional Centrifugal Chiller</u>	<u>Oil-Free Chiller</u>
Oil	YES	NO
+ Oil Heater	YES	NO
+ Oil Cooler	YES	
+ Oil Pump/Starter	YES	
+ Oil Reservoir	YES	
+ Oil Filter	YES	
+ Oil Piping/Valving	YES	
+ Oil Sensors/Controls	YES	
+ Annual Oil Analysis	YES	



= **More things to break, more maintenance, more \$**

No energy losses, no concerns, no annual oil change and disposal, maintenance savings

Other Advantages

- Resistant to Power Line Disturbances
 - Rides through voltage drops
 - Meets semi conductor industry standard SEMI F47



Regenerative power system keeps bearings powered until shaft stops spinning

- Rides through short duration power loss
- Extremely low inrush at Start Up

What Else?

- Low Maintenance
 - no oil in system
- Reliability
- Maximum Equipment Uptime
- Quiet Operation
- Ease of Installation
- Ease of Service

Challenges

- Higher 1st cost. Incentives/Rebates ?
 - ~14% increase from fixed speed to traditional VFD
 - ~42% increase from traditional VFD to high speed VFD w/ magnetic bearings
- Voltages
 - Typically limited to most popular voltages and frequency combinations
- New skills required for servicing

What does the technology mean to owners?



**High
Efficiency**

+



**Reduced
Maintenance
(No oil, No purge)**

=



Sustainability

+



**Lower Total
Cost of
Ownership**



Thank you!

Bibliography

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