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June 16 & 17, 2016 – Chicago

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Industrommercial Part II: NH3

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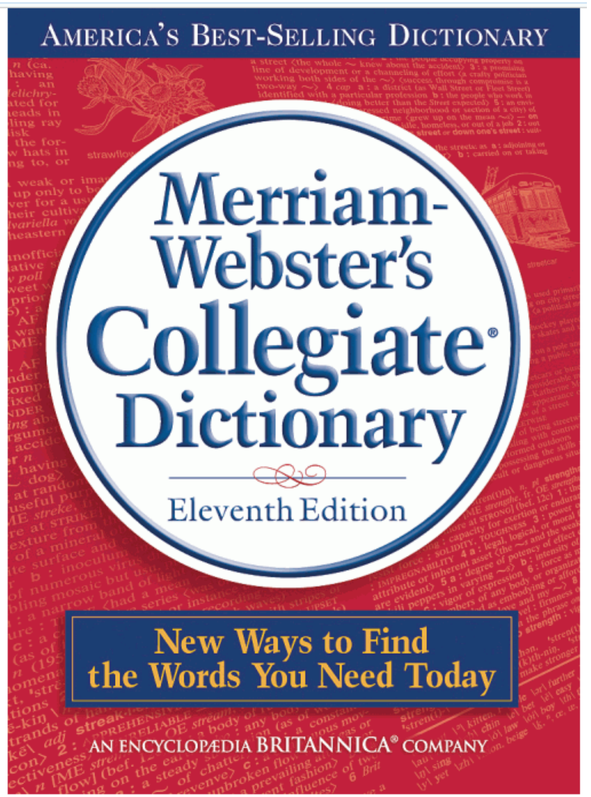
What does Industrommercial mean?

[in-duhs-truh-mur-shuhl]

adjective

1. of, relating to, industrial and commerical markets
2. of, pertaining to, the nature of or resulting from industrial or commerical use
3. suitable or fit for industrial and commerical markets



Technology Decisions:

Commercial (Supermarket) systems applying technology traditionally used in industrial applications

Commercial (Supermarket) vs. Industrial (Cold Storage)

	Commercial	Industrial
Load Size (Tons)	10 to 150	50 to 1,000
Load Size (kBtu/h)	120 to 1,800	600 to 12,000
Load Ratio	Higher Medium Temp	Higher Low Temp
Typical Design Sat. Suction Temps	-28°F to +25°F	-40°F to +25°F
Typical Design Sat. Discharge Temps	115°F to 125°F (Air Cooled)	95°F to 105°F (Water/ Evap Cond)
Piping	Copper	Steel
Refrigerants (Historically)	H(C)FCs	Ammonia

Overlap

Overlap

Commercial (Supermarket) vs. Industrial (Cold Storage)

	Commercial	Industrial
System Technology	Direct Expansion	Liquid Recirculation / Flooded
Compression Technology	Recips [Scrolls / Screw])	Screws [Recips]
Compressor Motor	Semi-Hermetic	External (Open-Drive)
Compressor Units	Racks (>3 in Parallel)	Packs (1 or <3 in Parallel)
Oil Type	Miscible	Non-Miscible
Oil Management	Common Oil Separator (w/System Oil Return)	Individual Oil Separator (w/Oil Pot)
Capacity Control	Comp Staging, Unloaders, VFDs,	Slide Valves, VFDs, Comp

Overlap

Overlap

Commercial (Supermarket) vs. Industrial (Cold Storage)

	Commercial	Industrial
Challenges	GWP / Carbon Footprint (EPA, DOE)	Safety (EPA, OSHA, HSA) Note: EPA next SNAP rule to target industrial?
Future Refrigerant Potential	Carbon Dioxide, HFOs, HFCs blends, Ammonia	Carbon Dioxide, HFC Blends?

Supermarkets:
→ Low margin
→ Relatively high energy consumption
→ CO_2 becoming more efficiency in warmer climate

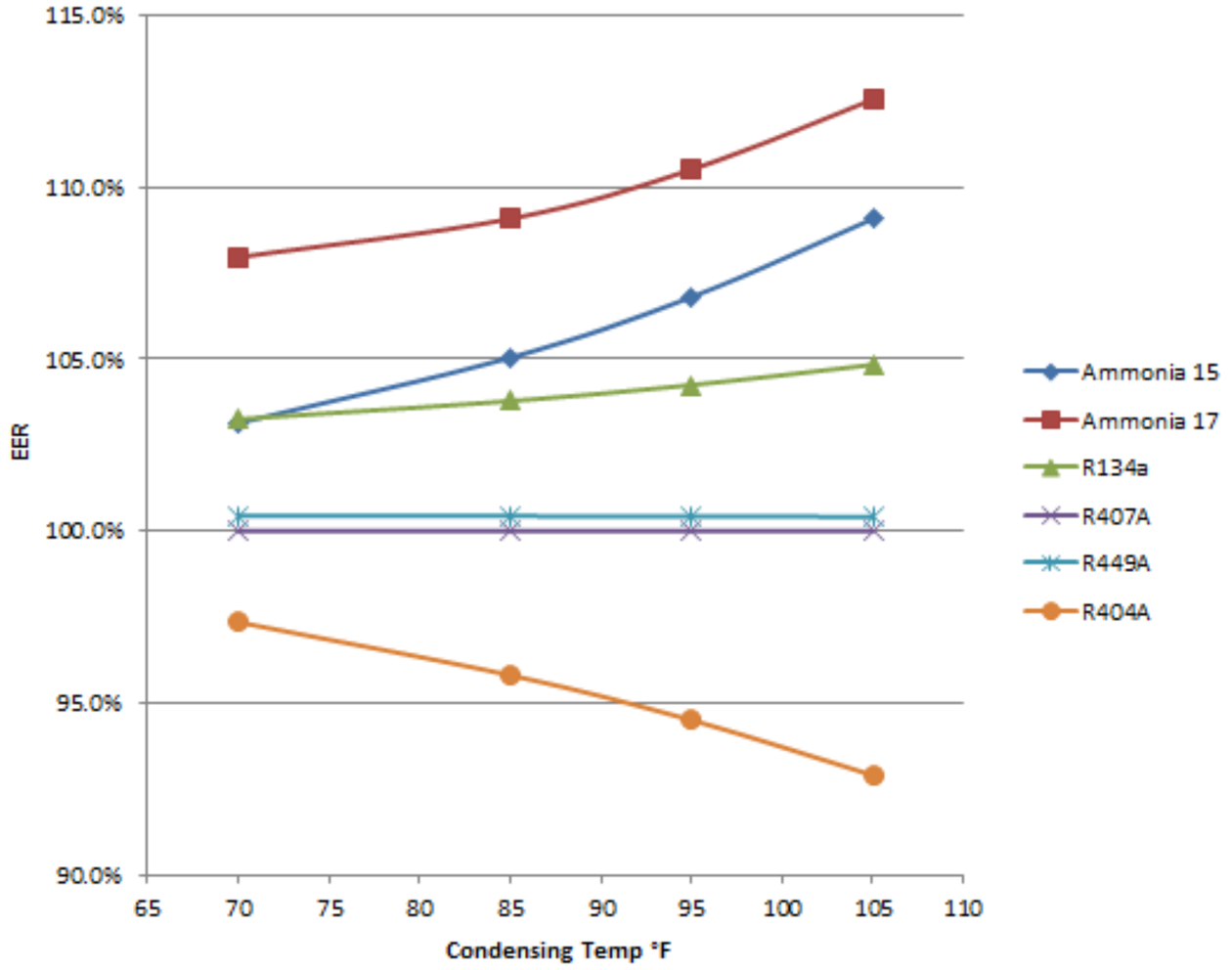
→ Efficiency is critical!

Refrigerant Efficiency Comparison

Typical operating conditions of the high side of CO_2 cascade system:

Saturated Suction Temperature = 15°F
(except Ammonia 17 (17°F)
Superheat = 20°F
Useful superheat = 10°F
Subcooling = 2°F
Isentropic efficiency = 1

Refrigerant Efficiency (Ideal)



Refrigerant Efficiency Comparison

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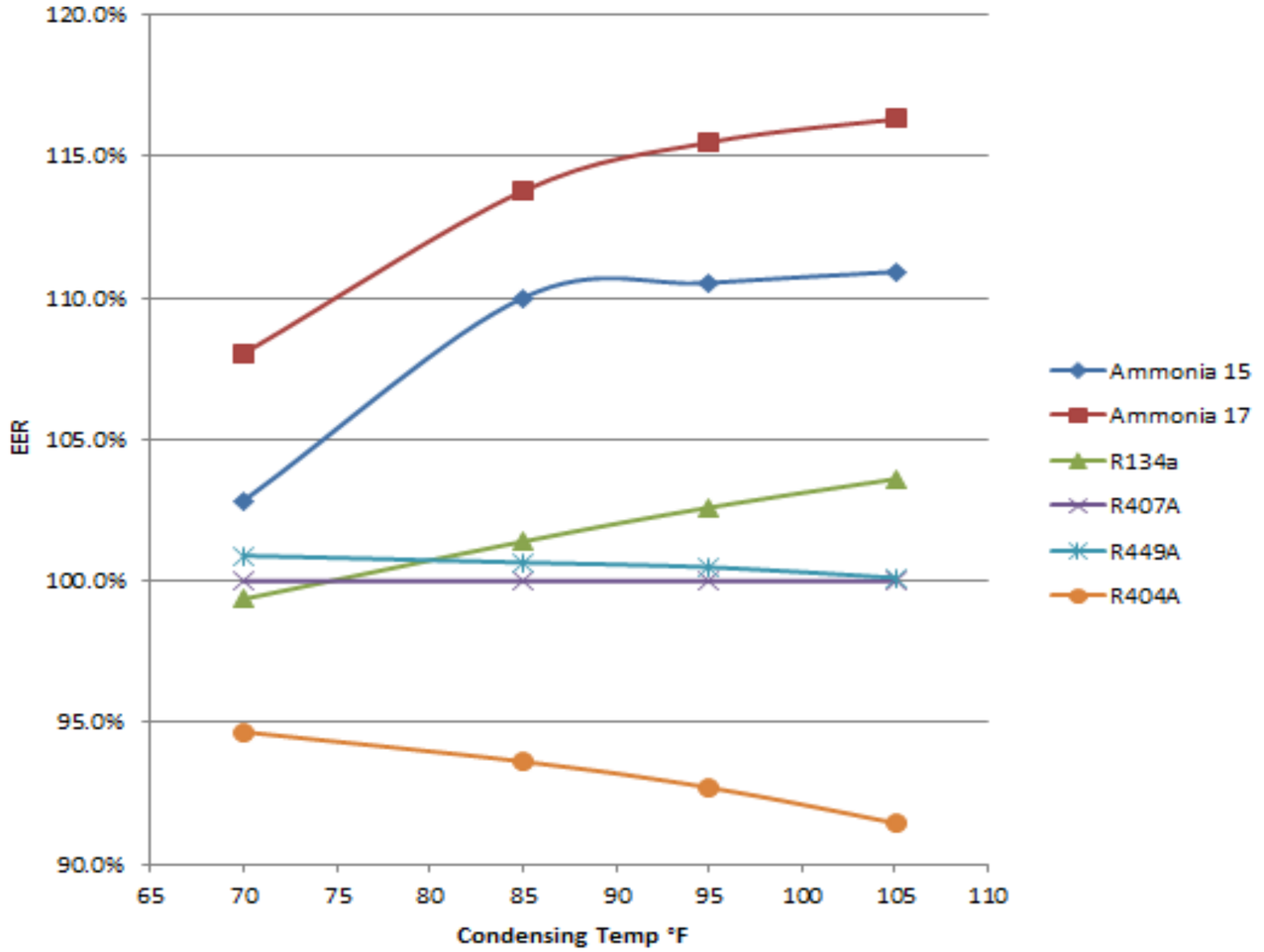
Saturated Suction Temperature = 15°F
(except Ammonia 17 (@17°F))
Superheat = 20°F
Useful superheat = 10°F
Subcooling = 2°F
Ammonia Motor Efficiency = 94%

Refrigerant Efficiency (Compressor Software)



Comparions of Actual Systems

	System A	System B	System C
Style	Parallel Rack	Parallel Rack	Modular Systems
Redundancy	Compressors	Compressor	Systems
Compressor	Recip	Recip	Screw
Evaporation	Flooded	Metered	Metered
Oil Recovery	Automatic	Automatic	Auto/Manual
Condensation	Adiabatic	Water cooled	Water cooled
Charge Size	Low	Very Low	Lowest (per ton)
Estimated Cost	?	?	?
Estimated Efficiency	Highest?*	High	High

*Based on flooded evaporation and no intermediate HX for condensing

Industrial Pack vs. Commercial Rack

	Single Pack	Parallel Rack	Modular Systems
Compressor Redundancy		✓	✓
Heat Exchanger Redundancy			✓
Control Redundancy			✓
Oil management Redundancy			✓
Cost			
High Efficiency at Part Load		✓	✓

→ A compressor pack is a more industrial approach and probably not suitable for supermarkets

→ Modular system is very “industrommercial” but could be costly

Compressor Type: Screw vs. Reciprocating

	Screw	Reciprocating
Cost	Usually higher (oil management)	✓
Oil Management required	2 stages of oil separation, oil cooler, mixing valve, filters	1 oil separator, oil floats ✓
Control	May requires individual controller	✓
Reliability	Much more forgiving! ✓	
Application Range	Much larger ✓	
Serviceability	Out of (most) supermarket technician's scope	Easy to change valve plates ✓
Sizes Available	~20 to 25 HP is lower end	5 to 50HP
Widely used		Much more common ✓

→ Screws have been used successfully in supermarkets for decades:
However, the same decision exists →
More forgiving solution vs. Lower Cost and Complexity

Compressor Capacity (Part Load) Decision

	Screw Pros / Cons	Recip Pros / Cons
Efficiency Full Load	Depends*	Depends*
Efficiency Part Load (VFD)	Better than using slide valve	Improves when slowing down
Efficiency Part Load	Slide valve is good (not always available)	Blocked suction very efficient (not always tight control)

*Speed, Vi, manufacturer, etc.

Using multiple compressor leads to higher part load efficiency →
"most efficient compressor is the one off"

With CO_2 on low side, a stable pressure is challenging:
More compressors / VFDs → more stable pressure → higher average saturated suction → higher efficiency

Oil Management Decisions

	Oil Separation
Recip	Coalescer only
Screw	Primary and with secondary coalescer

	Automatic Oil Recovery	Manual drain pot
Cost	Additional vessels, valves	✓
Complexity	Controls / strategy required	Requires trained technician
Commonly used		Widely used in industrial ref ✓
Ease of use	✓	

→ Why is oil draining out of the scope of the supermarket technician?
*(*and why not oversize oil separator?)

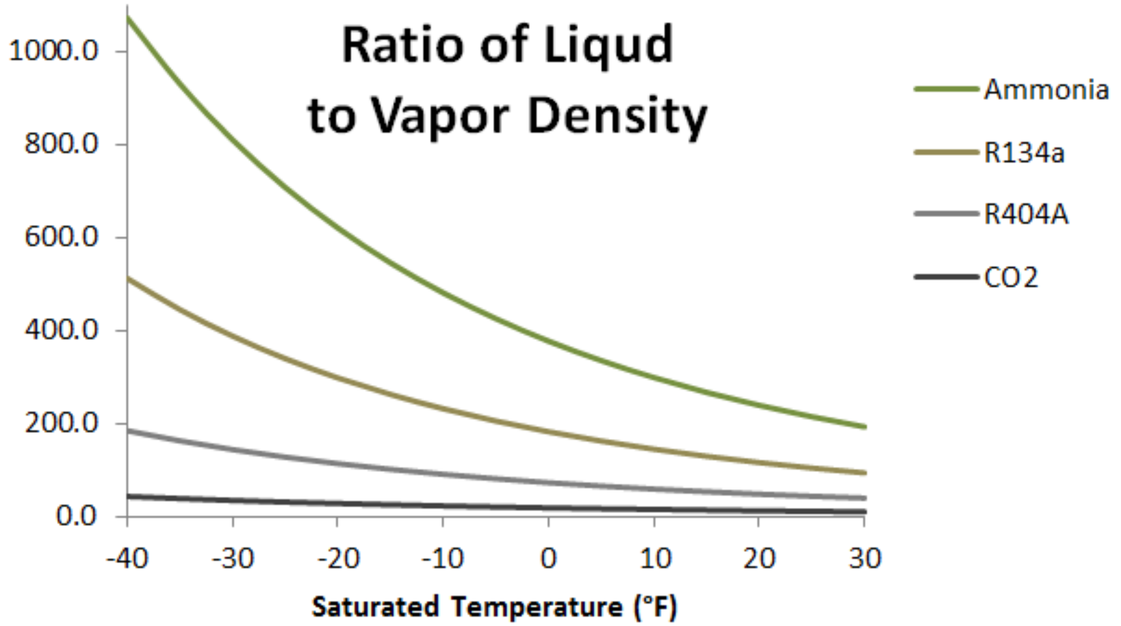
→ Miscible oil with NH_3? (extremely challenging)

Condensing Choices

	Air Cooled	Water Condensing / Cooling Tower	Water Condensing / Dry Cooler	Adiabatic Cond	Evaporator Condenser
Charge Size		✓ (Plate HX)	✓ (Plate HX)	Low w/ Microchannel	
Water consumption	✓		✓	(✓)	
Water Treatment	✓		✓	✓	
Additional Costs	✓	Intermediate HX / Pumps	Intermediate HX / Pumps	Newer technology	
Efficiency		(additional HX)	(additional HX)	(✓)	✓

Evaporation Choices

	Metered (DX)	Flooded
Charge Size	✓	
Efficiency		✓



→ Similar choice as in industrial world
→ Semi-flooded options also possible
→ Must be allow for oil drain

Note: Commercial world must become familiar with Ammonia's unique physical properties

Summary

→ Four extremely different NH_3 / CO_2 systems have been installed in US supermarkets with various approaches

→ High level decisions for end user/OEM to prioritize:

- Charge size
- Efficiency
- Cost
- Maintenance
- Simplicity
- Service

→ There will be no one perfect system in the future

→ Exchanging Information and technologies between Commercial and Industrial will ensure this and other natural refrigerants success

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Thank you very much!

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