NO REFRIGERANT IS GOOD

LESS IS MORE

ERAS OF REFRIGERATION

- Before 1930's – Ammonia absorbers, and various refrigerants-mostly secondary (brine)
- After WWII, Ammonia liquid overfeed – recirculation

  Efficient but large charges; flooded evaporators

- Now and Forward – Ammonia small charge
  1) Ammonia / CO_2
  2) Improved direct expansion
  3) Desiccant
  4) Low pressure receiver

  Charges down to 1 lb/ton

Public Refrigerated Warehouse

- About 80% of the country's Refrigerated Warehouse space
- 92-95% Ammonia, almost all liquid recirculation with

  Large charge 10,000 lbs plus
- All PRWs in New Jersey use R22 – operating engineers requirements – union pressure in the 1920's
- We replaced ammonia with R22 in the mid – 90's
- Misguided regulation determines the refrigerant- look at New Jersey, Northern Europe and Southern Europe – Not rational decision making

National Regulatory Climate

- Last 4 years excess ammonia regulation has been brutal
- Only solution – very small charges
- Investment required, return is fewer operating engineers, lower regulatory and insurance costs

Performance of Refrigerants

Refrigerant COP %	Net Refrigerant Effect BTU/lb	Refrigerant circulated) (lbs/min
Ammonia 4.76 100	474	.12
R22 4.66 98	70	.81
CO_2 2.69 56	57	.51
Propane 4.50 95	120	.47
R507 4.18 88	47	.47

Difficulties with CO_2

- Will not condense above 88°F; need cascade
- Will freeze at −70°F
- Low COP, 49% less than ammonia

Difficulties with R22

- Average leak rate 35%
- Price to replace $23/lb
- A pound of R22 does much less refrigerating than ammonia
- Production banned in 2020, limited by EPA now

Difficulties with R507

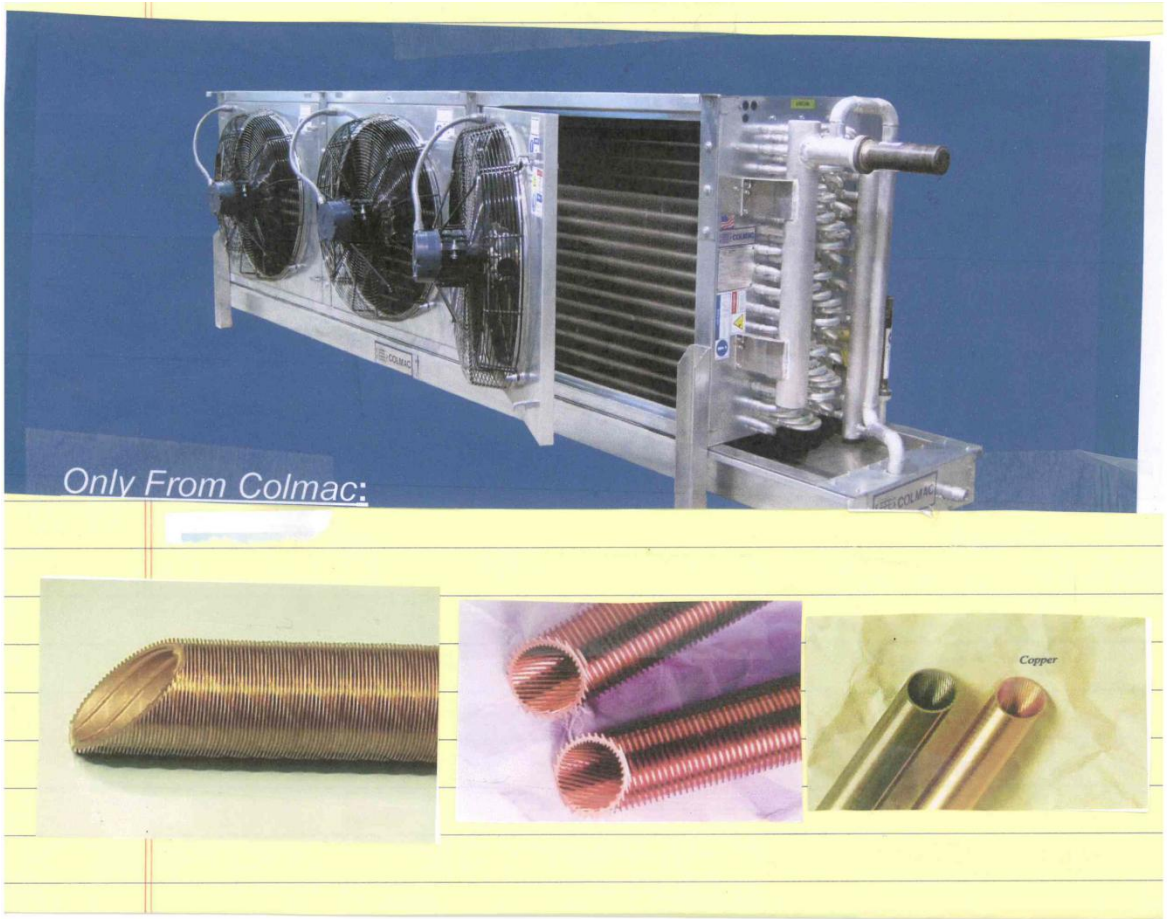
- Will get banned
- 12% lower COP than ammonia
- Leaks more than R22 and costs more

Ammonia is the best industrial refrigerant

Difficulties with Ammonia

- Low density at low temperatures
  required compressor displacement is 7 X CO_2
- 10,000 lbs (5,000 lbs in some states) requires PSM and RMP
- Refrigeration expertise needed for large central systems.

New Direct Expansion Evaporators



Small charge system – improved evaporators Dx not recirculation

Best Solutions – Warehouses

- Small charge ammonia systems (1 to 7 lbs/ton)
- Roof top mounted, factory fabricated and manufactured system 40’ – 140’ in the air. Virtually no exposure to people or product
- As energy efficient as liquid recirculation with virtually no refrigeration engineers