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Choosing the Right R-22 Retrofit

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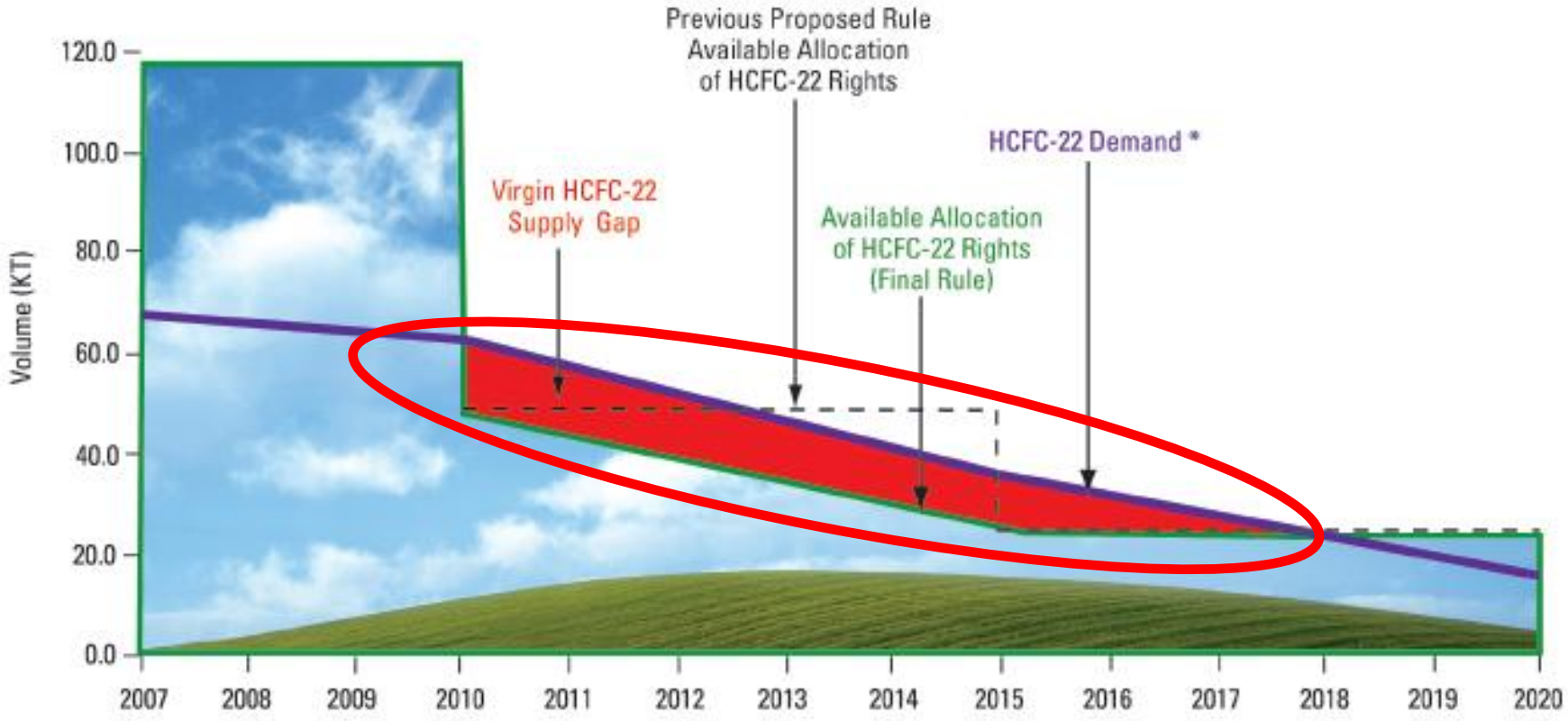
Discussion Topics

- Phase-out / Transition Strategy
- R-22 Retrofits
  - General Retrofit Issues
  - Component Comparisons
  - Functional Considerations
  - Operating Traits Comparison
- Retrofit Recommendations

R-22 Phase-Out Schedule



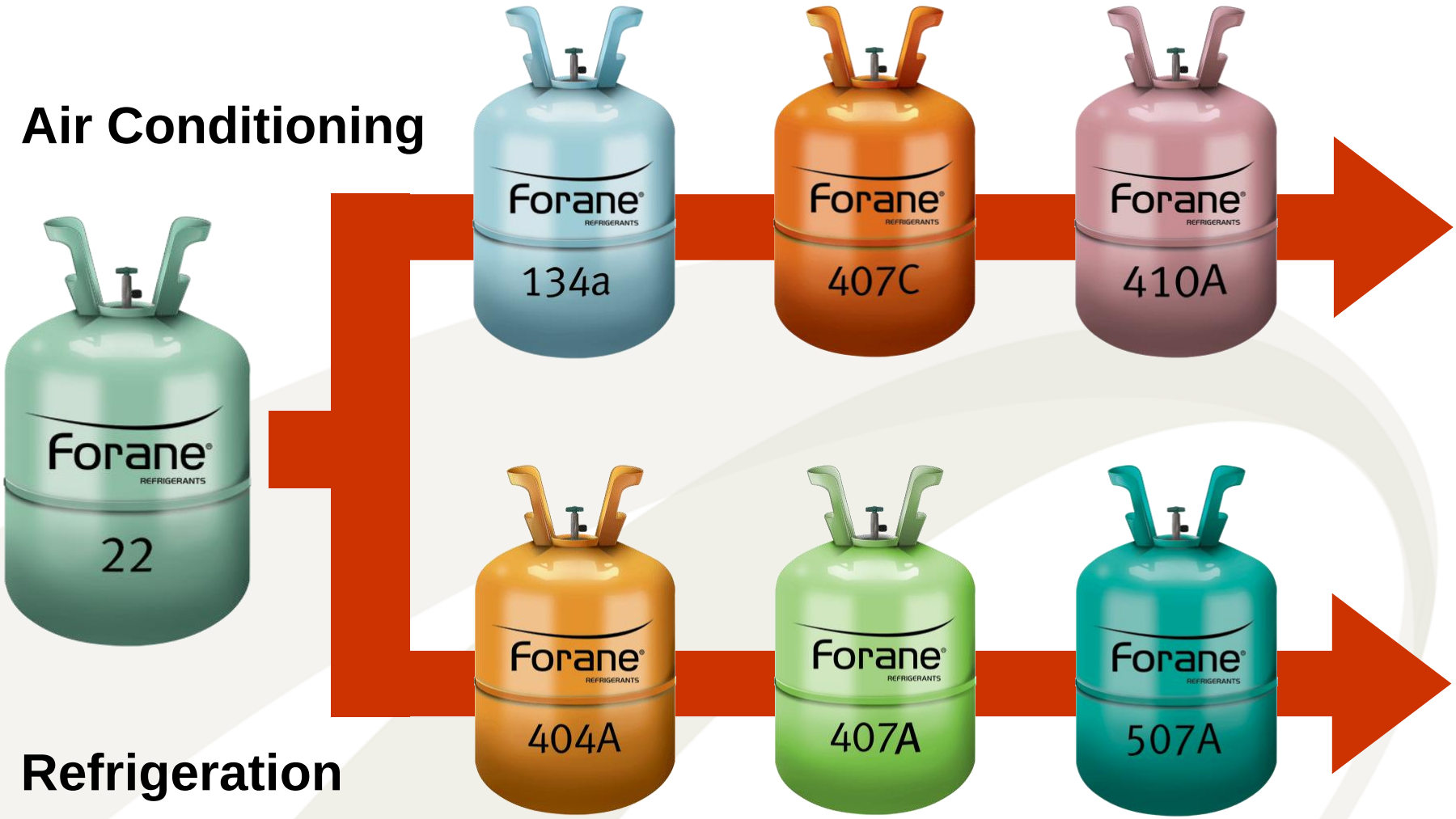
Arkema will supply its customer base through allowances, plus investments in reclaim services and other alternatives.

* Projected HCFC-22 Service Demand "June 2008 Revised Draft Report". Prepared for US EPA. Prepared by ICF International

R-22 Transition Strategy

- Service as usual
  - Refrigerant price / availability
  - Leaks
- Replacement
  - Initial equipment costs
  - Energy savings
  - Refrigerant recovery
- Retrofit
  - Refrigerant / equipment / labor costs
  - Refrigerant recovery
  - Energy costs

R-22 Replacement Refrigerants



The Truth About R-22 Retrofits

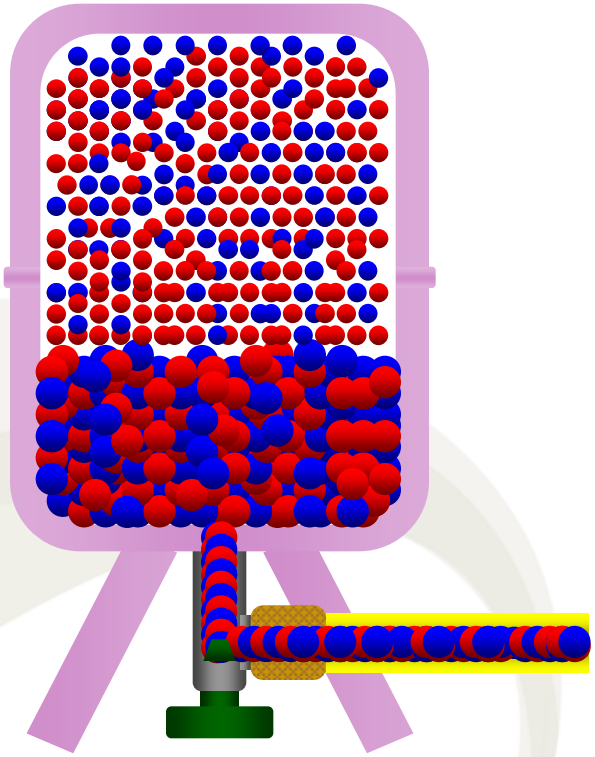
- None work as well as R-22 **OVERALL**
- None are as efficient as R-22 **OVERALL**
- None are “Drop-Ins”
- None are miscible with MO or AB
- None will work in every R-22 system

Elastomer Changes

- R-22 vs. HFCs with elastomers
- May need to change seals during retrofit
  - Schrader valves / caps
  - Ball valves
  - Solenoid valves
  - EPRs
  - Filter-driers
  - Sight glasses
  - Receiver level gages
- Leak check after retrofit

Blend Issues

- Charge all blends as liquid



- Azeotropes / Near-azeotropes

  (R-507A / R-404A)

  - Fractionation from leaks small
  - May be suitable for flooded systems

- Zeotropes
  - Running / dormant systems
  - Typically not suitable for flooded systems

Discharge Temperature Effects

- R-22 suffers from high discharge temps
  - May exceed 300 F,
    @ high ambients / low temp
- Discharge temps of R-22 retrofits lower
  - Most typically < 250 F,
    even @ high ambients / low temp
- Need for liquid injection, desuperheaters, & oil coolers reduced / eliminated
- Improved capacity / efficiency for low temp

R-22 Retrofit Blends

R-404A **R-407A** **R-407C**

R-407F **R-417A** **R-417B**

R-421A **R-421B** **R-422A**

R-422B **R-422C** **R-422D**

R-424A **R-427A** **R-428A**

R-434A **R-438A** **R-507A**

Etc.

Blend Compositions (weight %)

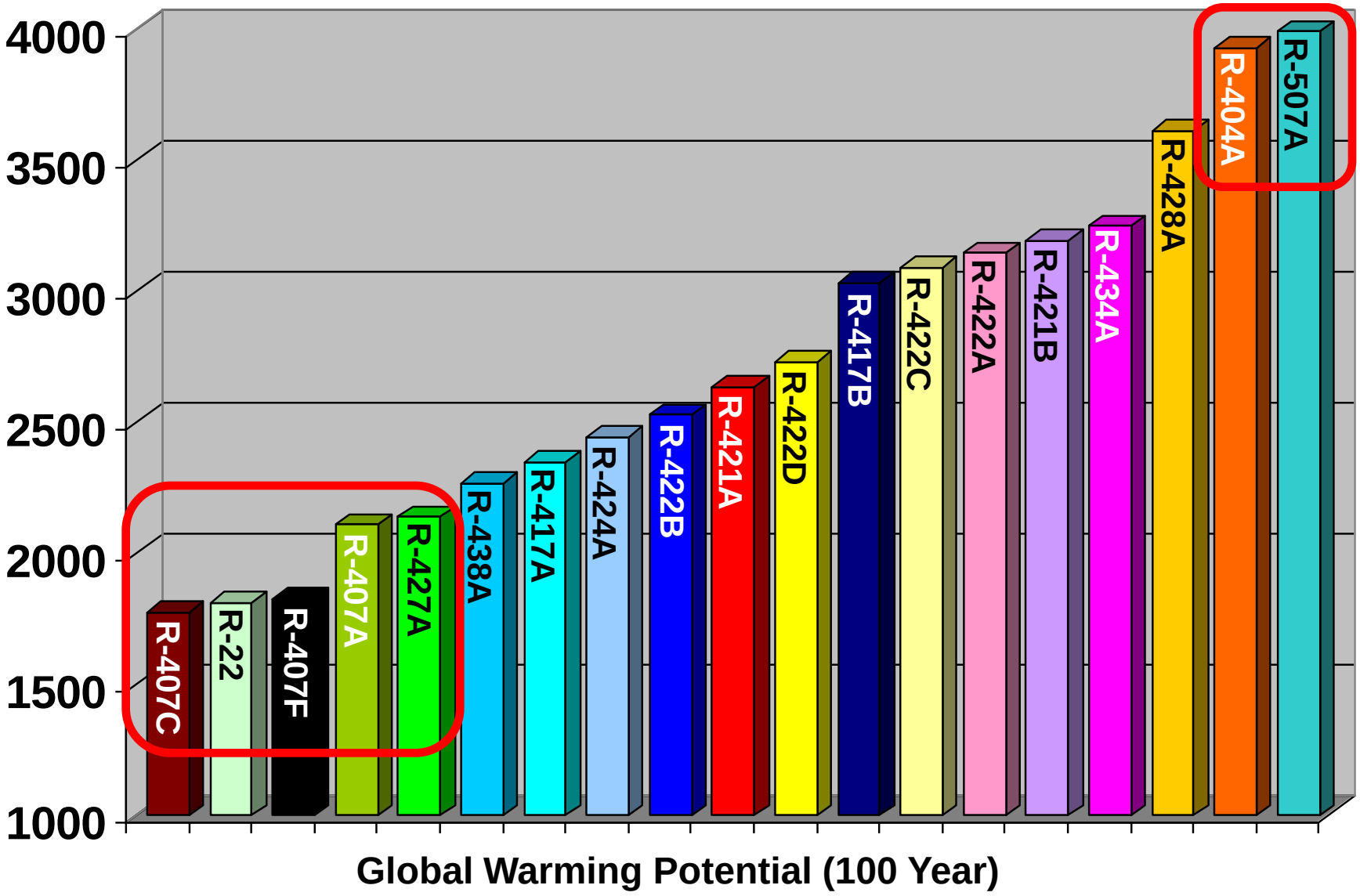
	R-32	R-125	R143a	R-134a	R-290	R-600a	R-600	R-601a	Lubricant
R-404A	-----	44.0	52.0	4.0	-----	-----	-----	-----	-----
R-407A	20.0	40.0	-----	40.0	-----	-----	-----	-----	-----
R-407C	23.0	25.0	-----	52.0	-----	-----	-----	-----	-----
R-407F	30.0	30.0	-----	40.0	-----	-----	-----	-----	-----
R-417A	-----	46.6	-----	50.0	-----	-----	3.4	-----	-----
R-417B	-----	79.0	-----	18.3	-----	-----	2.7	-----	-----
R-421A	-----	58.0	-----	42.0	-----	-----	-----	-----	Added
R-421B	-----	85.0	-----	15.0	-----	-----	-----	-----	Added
R-422A	-----	85.1	-----	11.5	-----	3.4	-----	-----	-----
R-422B	-----	55.0	-----	42.0	-----	3.0	-----	-----	-----
R-422C	-----	82.0	-----	15.0	-----	3.0	-----	-----	-----
R-422D	-----	65.1	-----	31.5	-----	3.4	-----	-----	-----
R-424A	-----	50.5	-----	47.0	-----	0.9	1.0	0.6	-----
R-427A	15.0	25.0	10.0	50.0	-----	-----	-----	-----	-----
R-428A	-----	77.5	20.0	----	0.6	1.9	-----	-----	-----
R-434A	-----	63.2	18.0	16.0	-----	2.8	-----	-----	-----
R-438A	8.5	45.0	-----	44.2	-----	-----	1.7	0.6	-----
R-507A	-----	50.0	50.0	-----	-----	-----	-----	-----	-----

HFC Component Comparison

	R-32	R-125	R-143a	R-134a
Cond. Pressures (%) [1]	+ 62	+ 31	+ 19	- 34
V. R. Capacity (%) [1]	+ 60	+ 7	+ 5	- 38
COP (%) [1]	- 5	- 11	- 7	+ 0.6
Mass Flow Rate (%) [1]	- 36	+ 84	+ 25	+ 8
Discharge Temps (°F) [1]	+ 34	- 51	- 46	- 36
GWP (100 year) [2]	675	3500	4470	1430
Flammability [3]	A2L	A1	A2L	A1
MO / AB Solubility	Very Poor	Very Poor	Poor	Very Poor

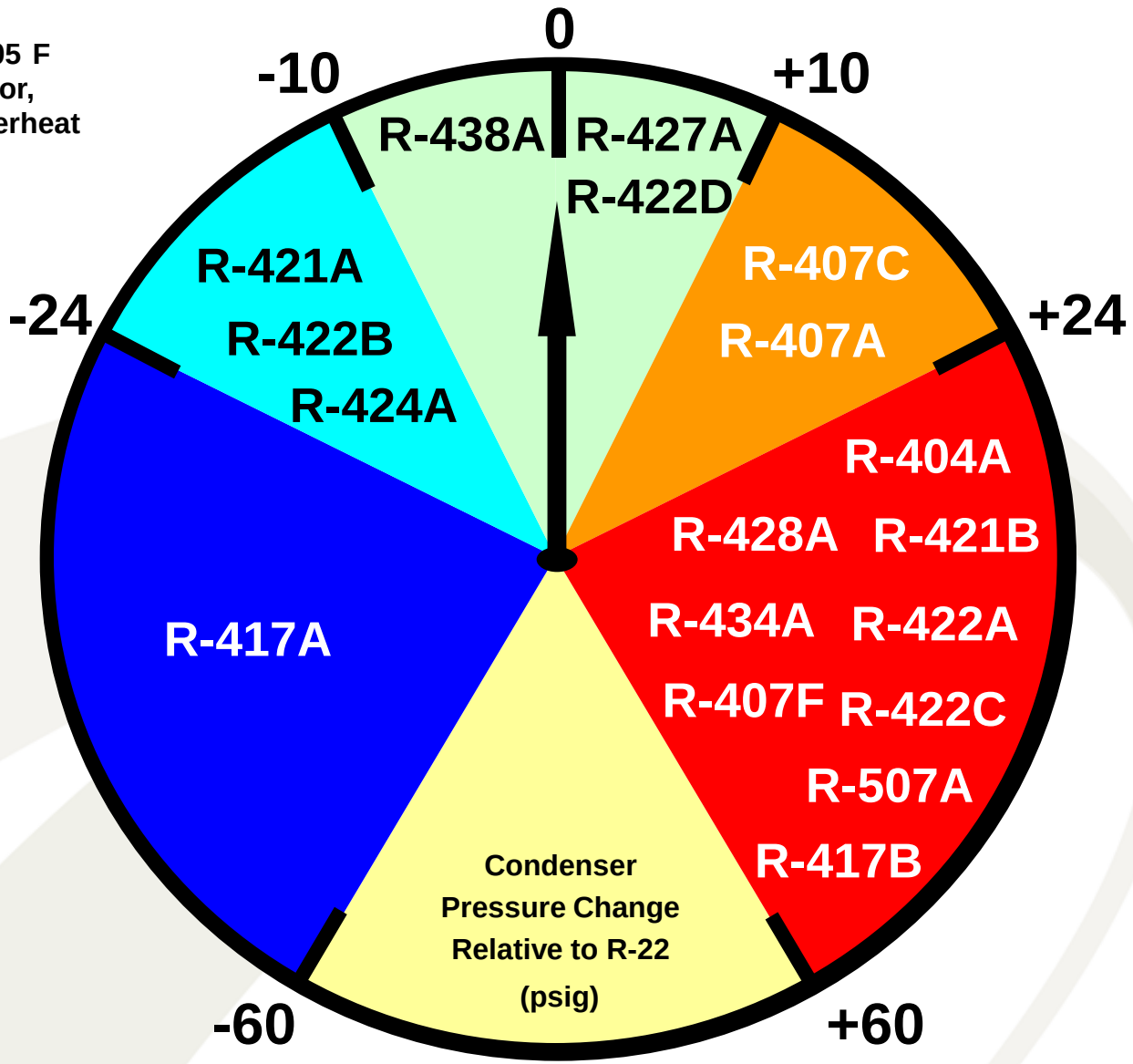
1 – Relative to R-22, Standard Cycle @ 105 F Condenser, 25 F Evaporator, 10 F of Superheat & Subcooling
2 – From the IPCC AR4
3 – L Sub-classification Under Public Review

GWP Comparison



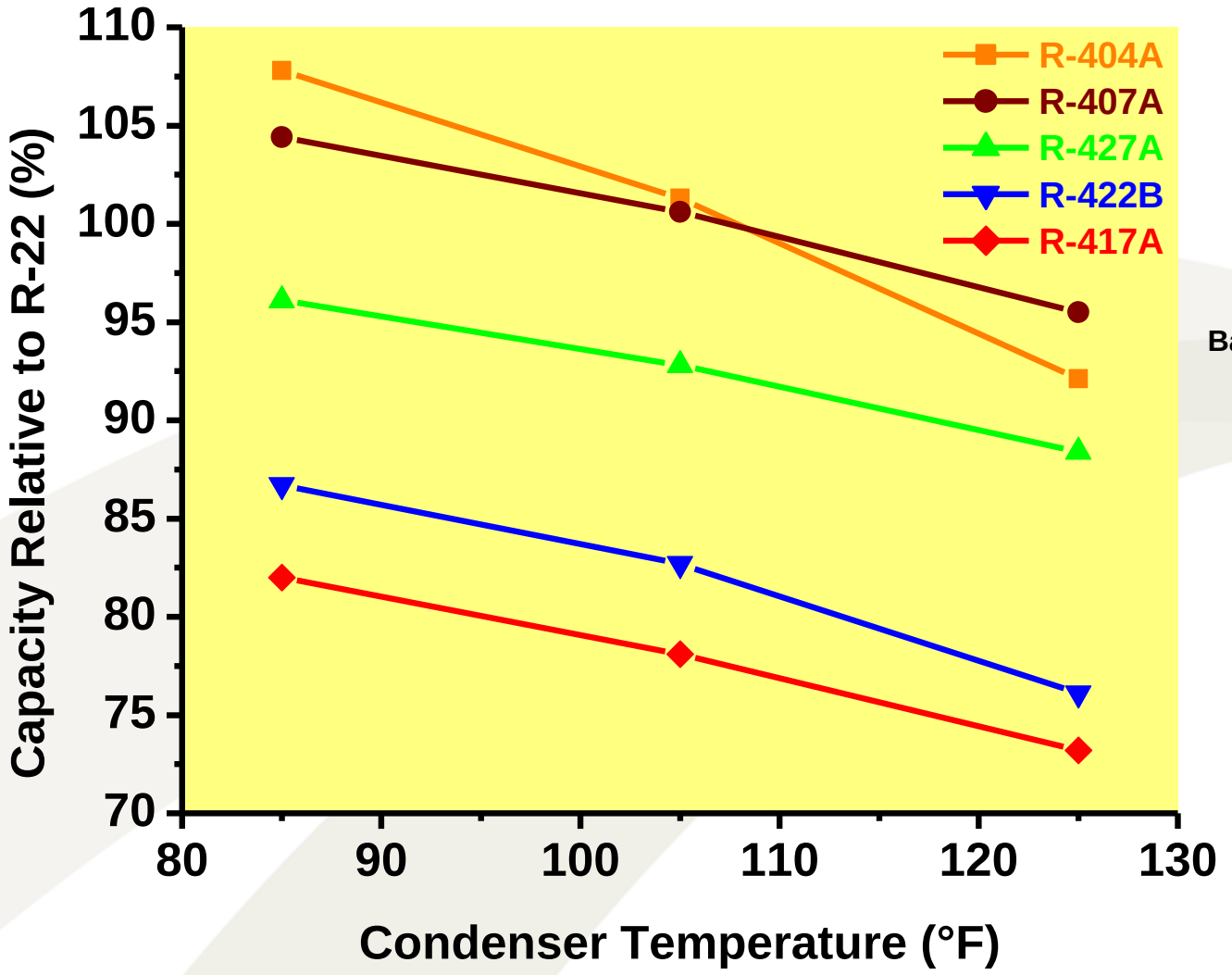
High Side Pressure Comparison

Based on Standard Cycle 105 F Condenser, 25 F Evaporator, 10 F Subcooling & 10 F Superheat



- Much lower pressure
- Lower pressure
- Similar pressure
- Higher pressure
- Much higher pressure

Refrigerant Capacities



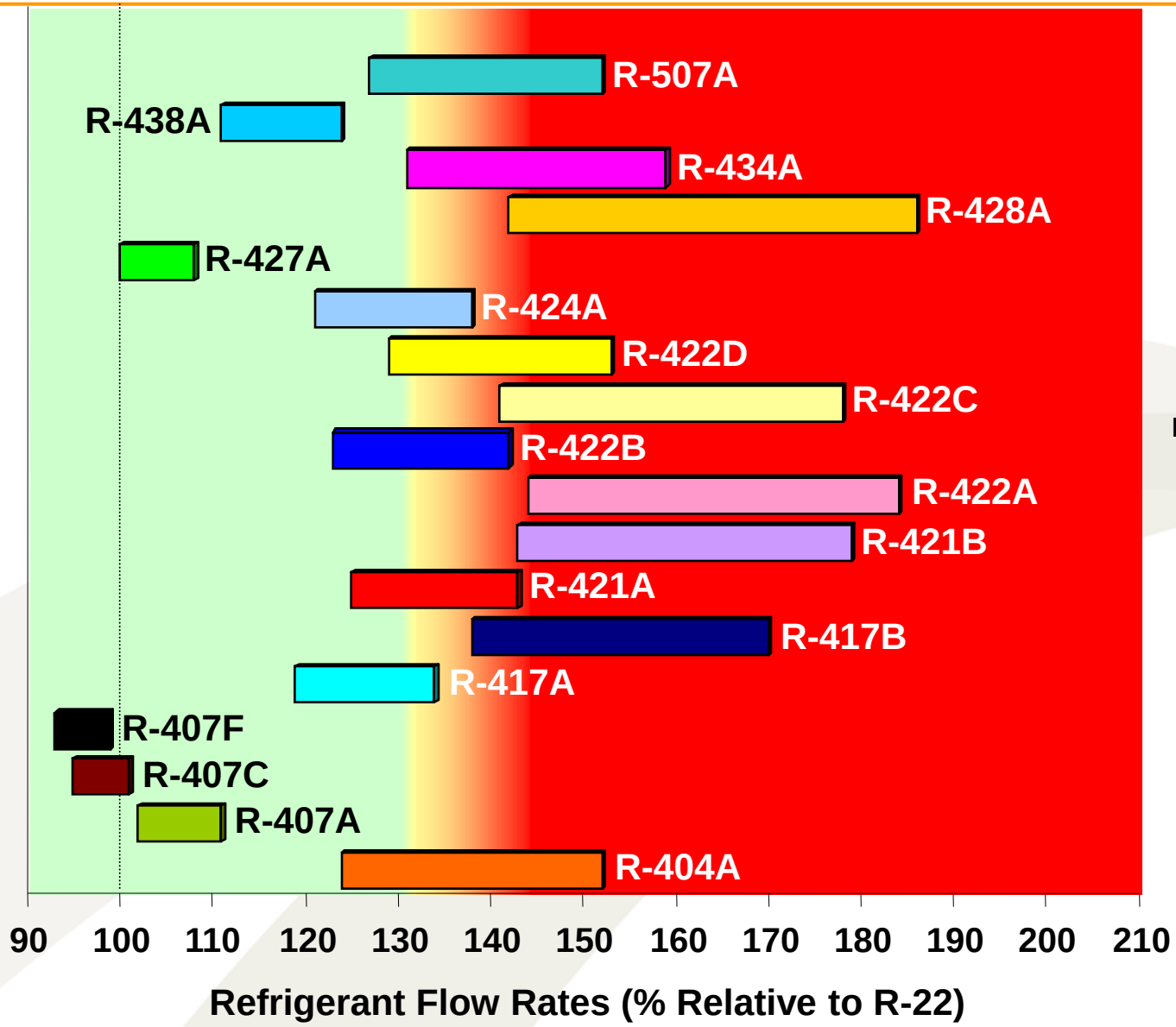
Based on Standard Cycle
25 F Evaporator,
10 F Subcooling
& 10 F Superheat

Refrigerant Flow Rate Issues

- Most R-22 retrofits require significantly higher refrigerant flow rates than R-22

- Flow considerations for retrofit
  - TXVs
  - Pistons, orifices, cap tubes
  - Distributor nozzles
  - Line sets
  - Compressor valve plates

Mass Flow Rates



Based on Standard Cycles
65 - 105 F Condenser,
25 F Evaporator,
10 F Subcooling,
& 10 F Superheat

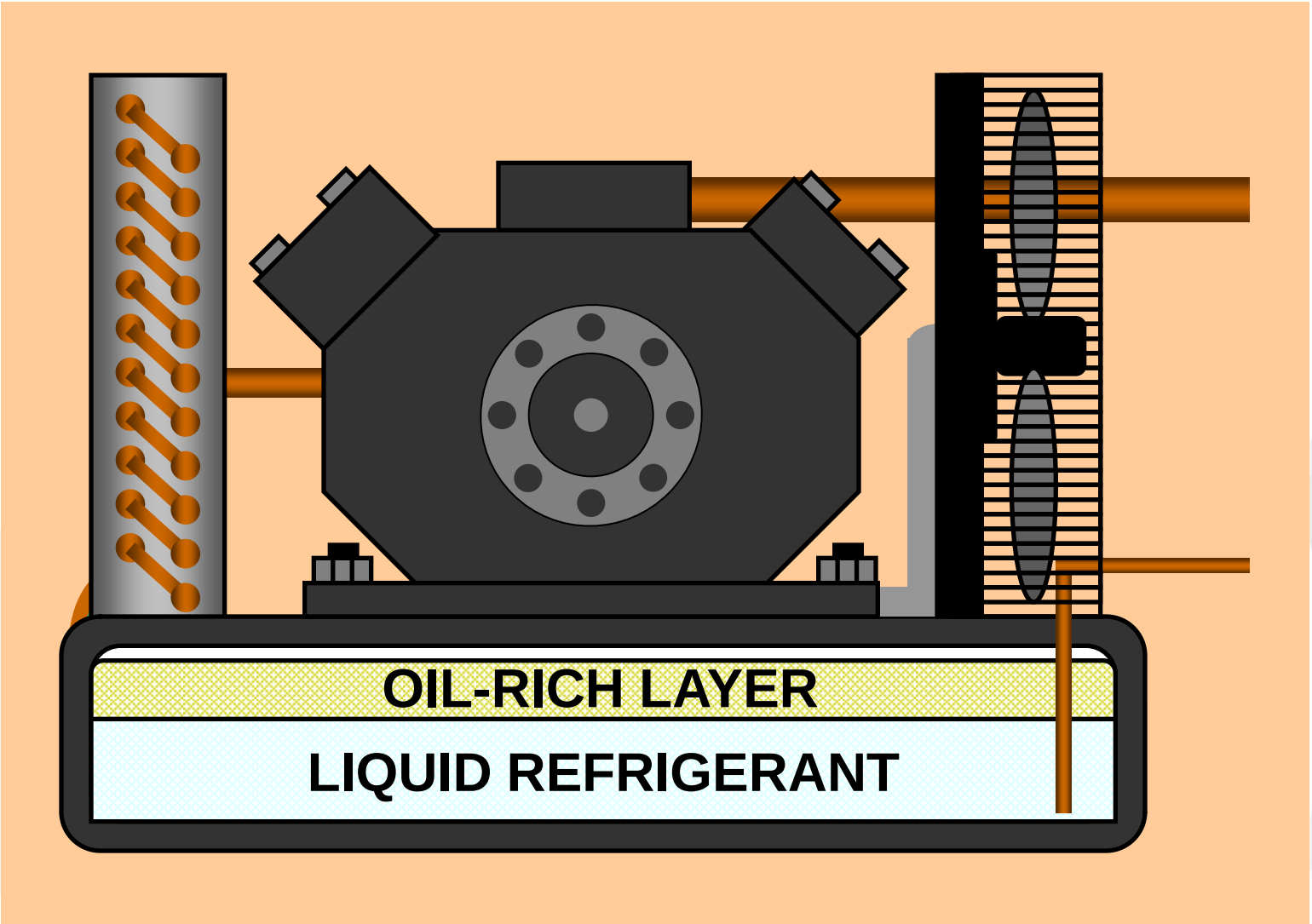
POE Oil Change Issues

- Labor & expense of oil change
  - Retrofit procedures
- Solvency effects
  - Filter changes
  - Elastomers
- Flushes
  - Multiple flushes often not required
    - Oil separators
    - Dirty installations
    - Oil concentration / purity
- Performance improvement

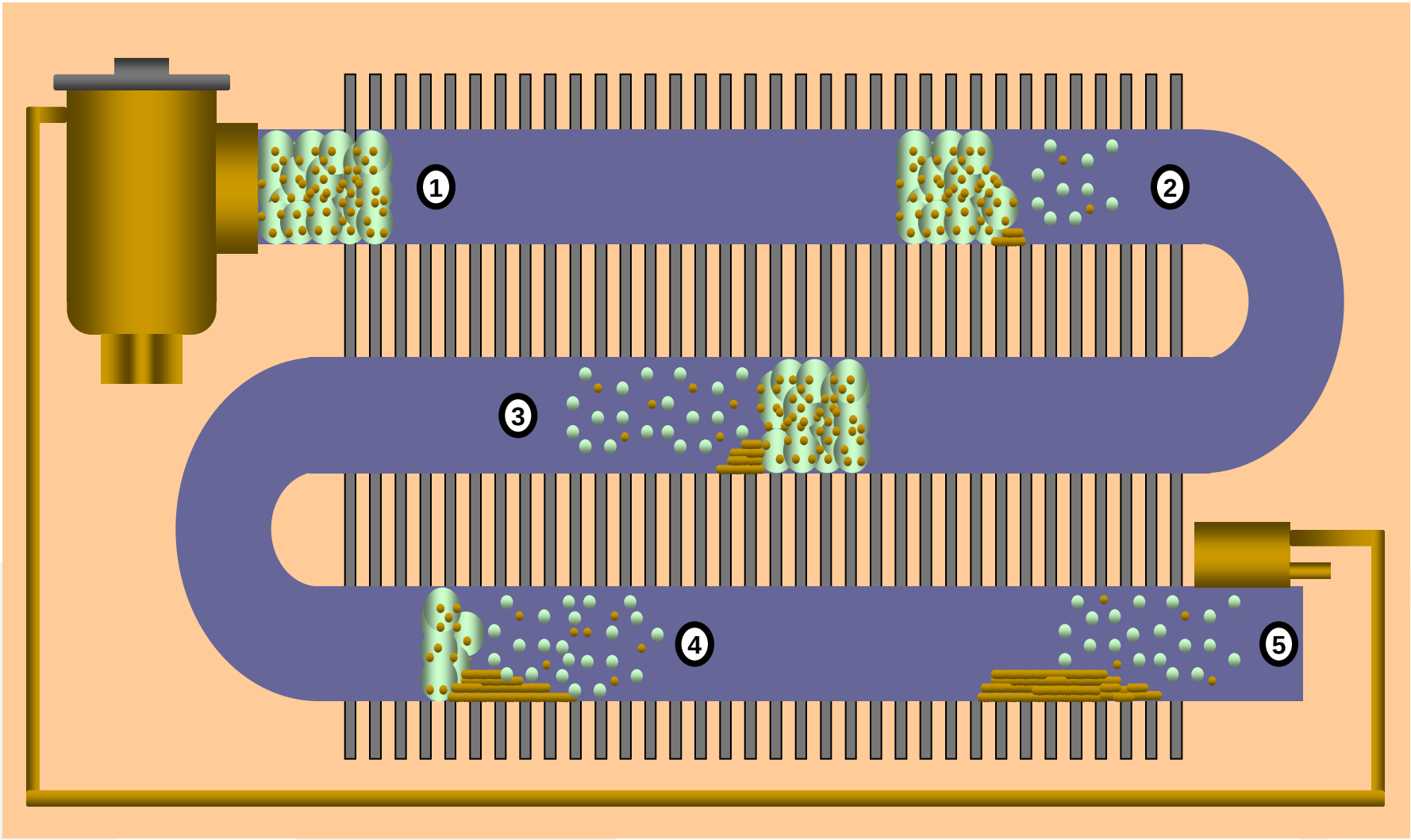
Oil Change Trade-Offs

"No Oil Change"			Oil Change to POE	
R-417A	R-417B	R-421A	R-404A	R-407A
R-421B	R-422A	R-422B	R-407C	R-407F
R-422C	R-422D	R-424A	R-427A	R-507A
R-428A	R-434A	R-438A		
Pros Lower Upfront Cost Quicker Retrofit No "POE Issues"			**Pros** Reduced Oil Logging Reliable Oil Return Best Performance	
% R-32 & R-143a 0 – 20			**% R-32 & R-143a** 20 – 52	

Immiscibility Issues - Oil Hold-Up

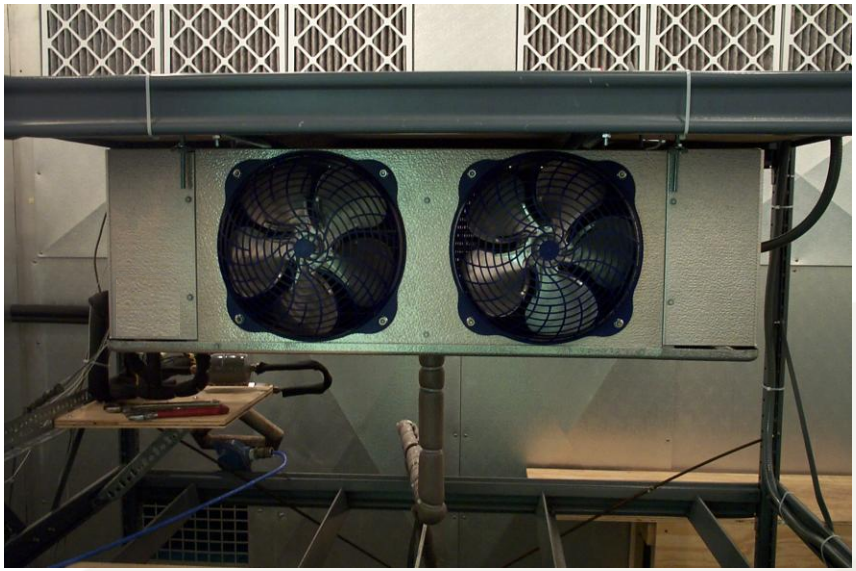


Immiscibility Issues - Oil Logging

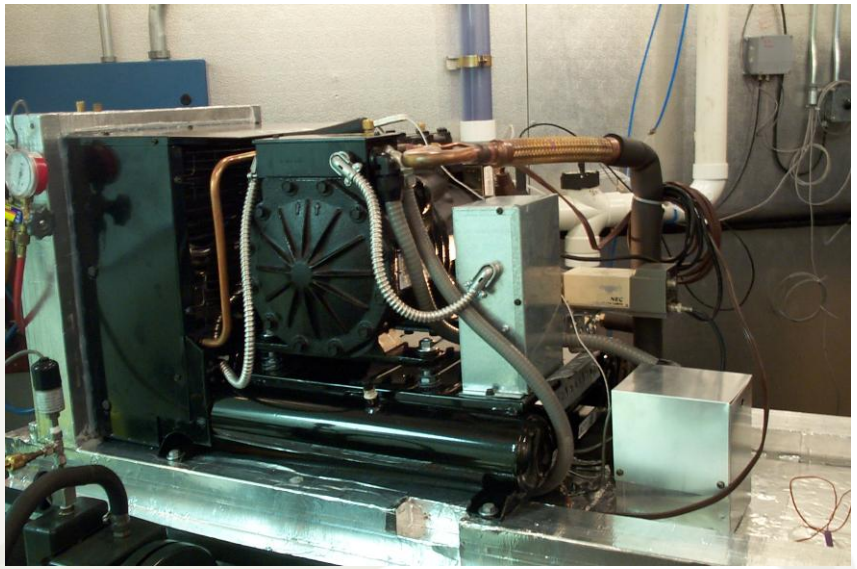


Test Set-Up

Evaporator Unit



Condensing Unit

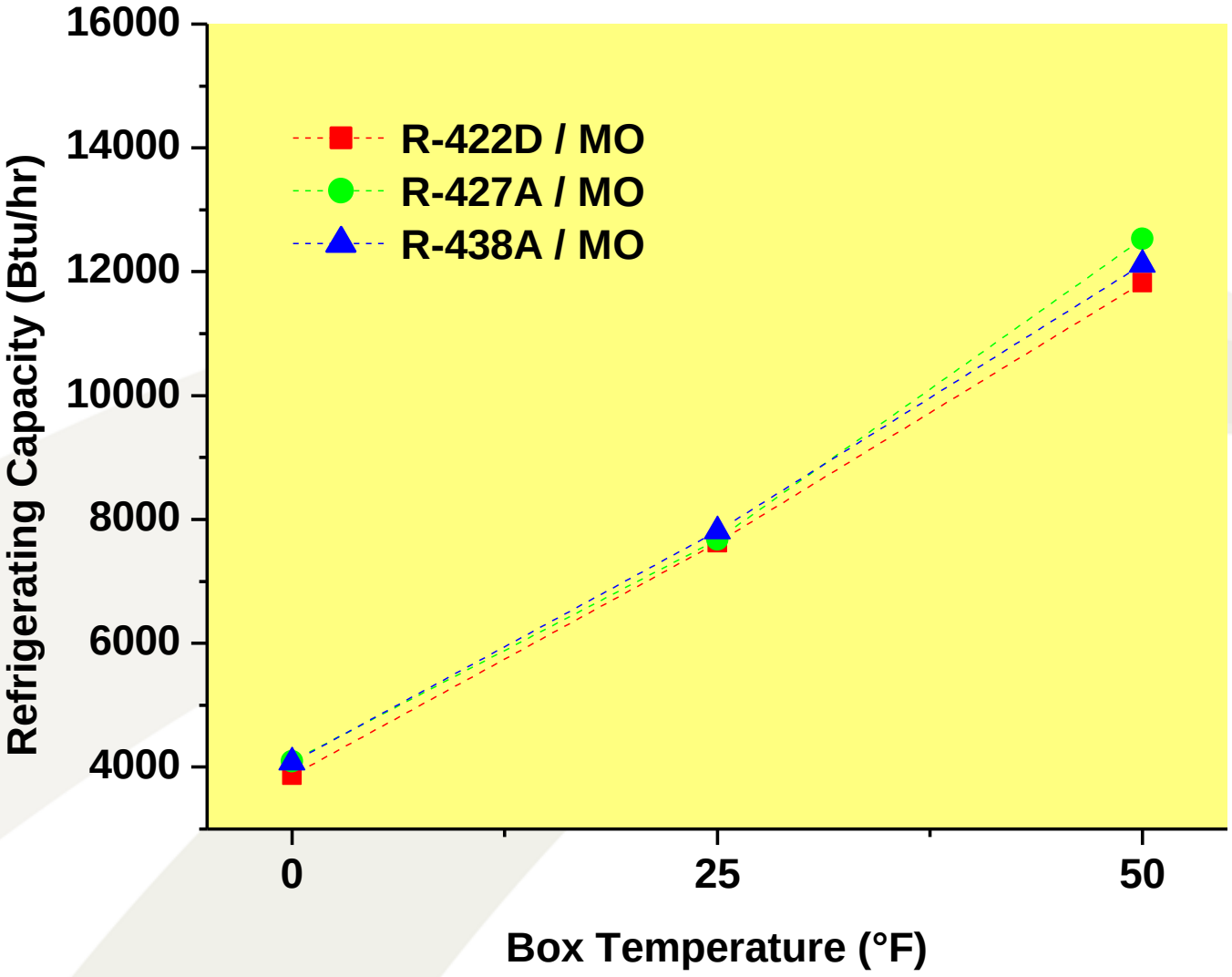


- 1-½ HP R-22 condensing unit / evaporator assembly
- Horizontal line-set sloped down from evaporator → compressor
- Optimized refrigerant charge / adjusted TXV superheat setting
- Ran R-422D, R-427A, and R-438A with MO & POE (camera)
- 100°F Ambient / 0, 25, & 50°F Box Temps – "Dry Coil" tests

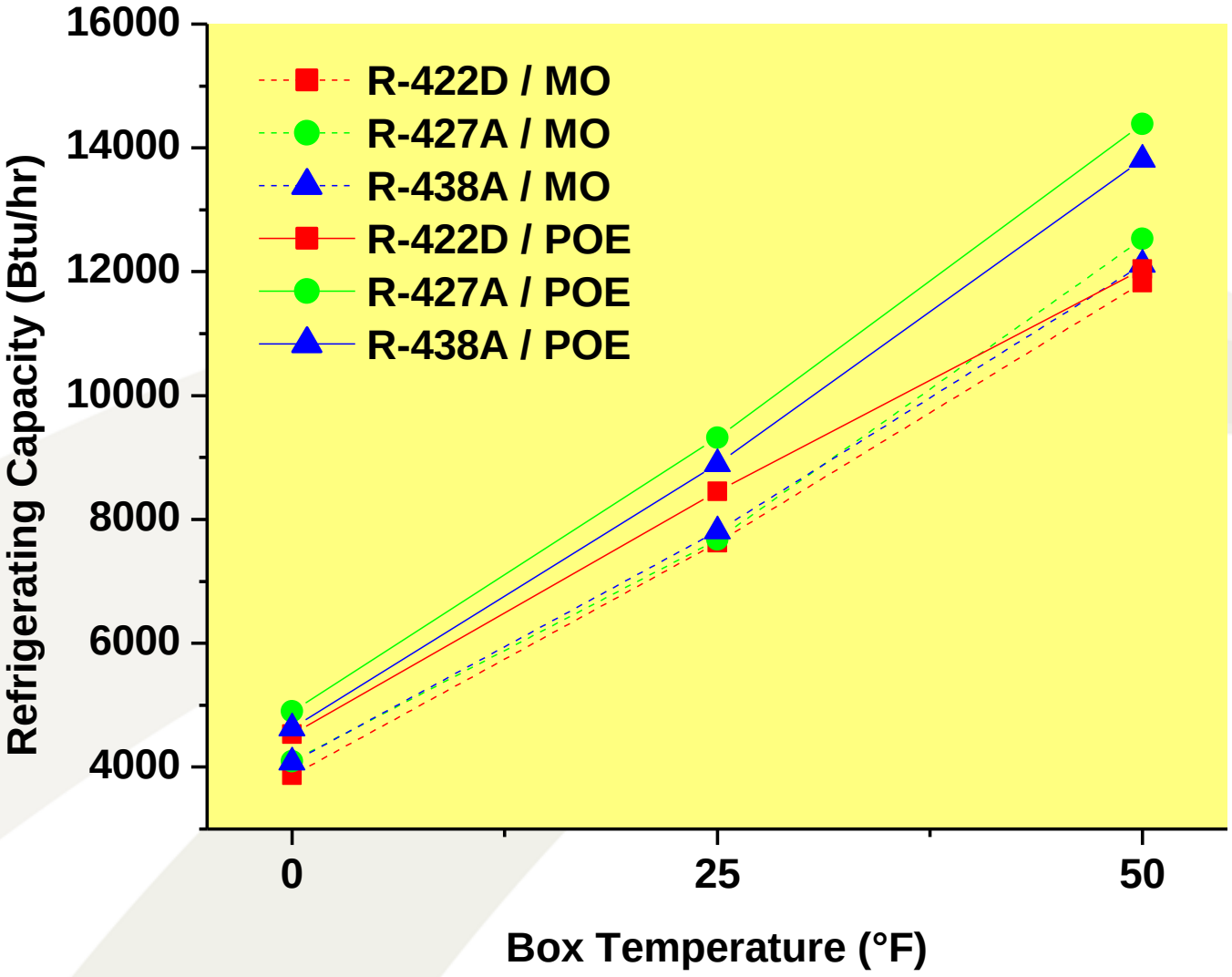
Test Data – Oil Return Results

	MO	POE
R-22	PASS	PASS
R-422D	FAIL	PASS
R-427A	FAIL	PASS
R-438A	FAIL	PASS

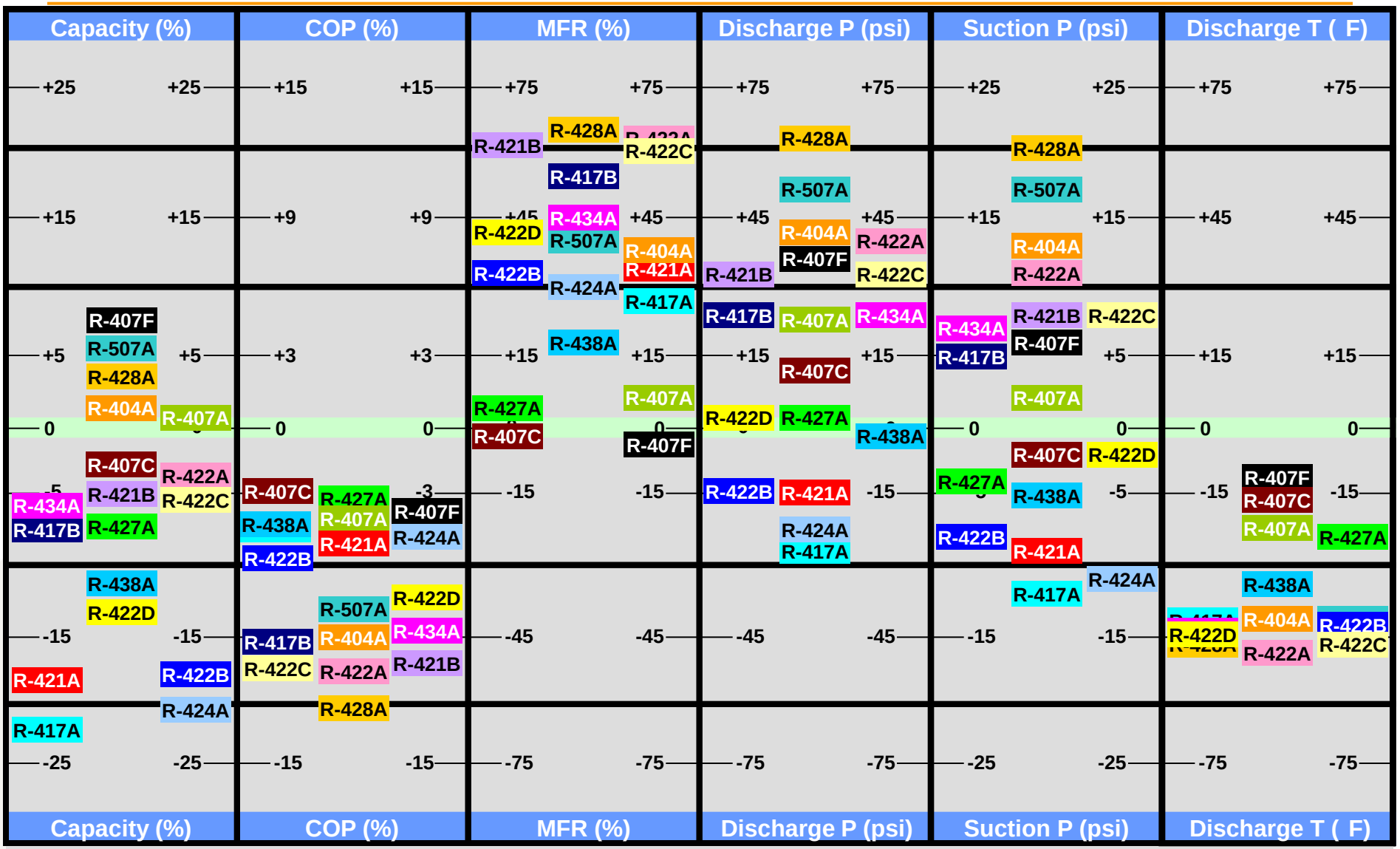
Test Data – MO Runs



Test Data – MO vs. POE Runs

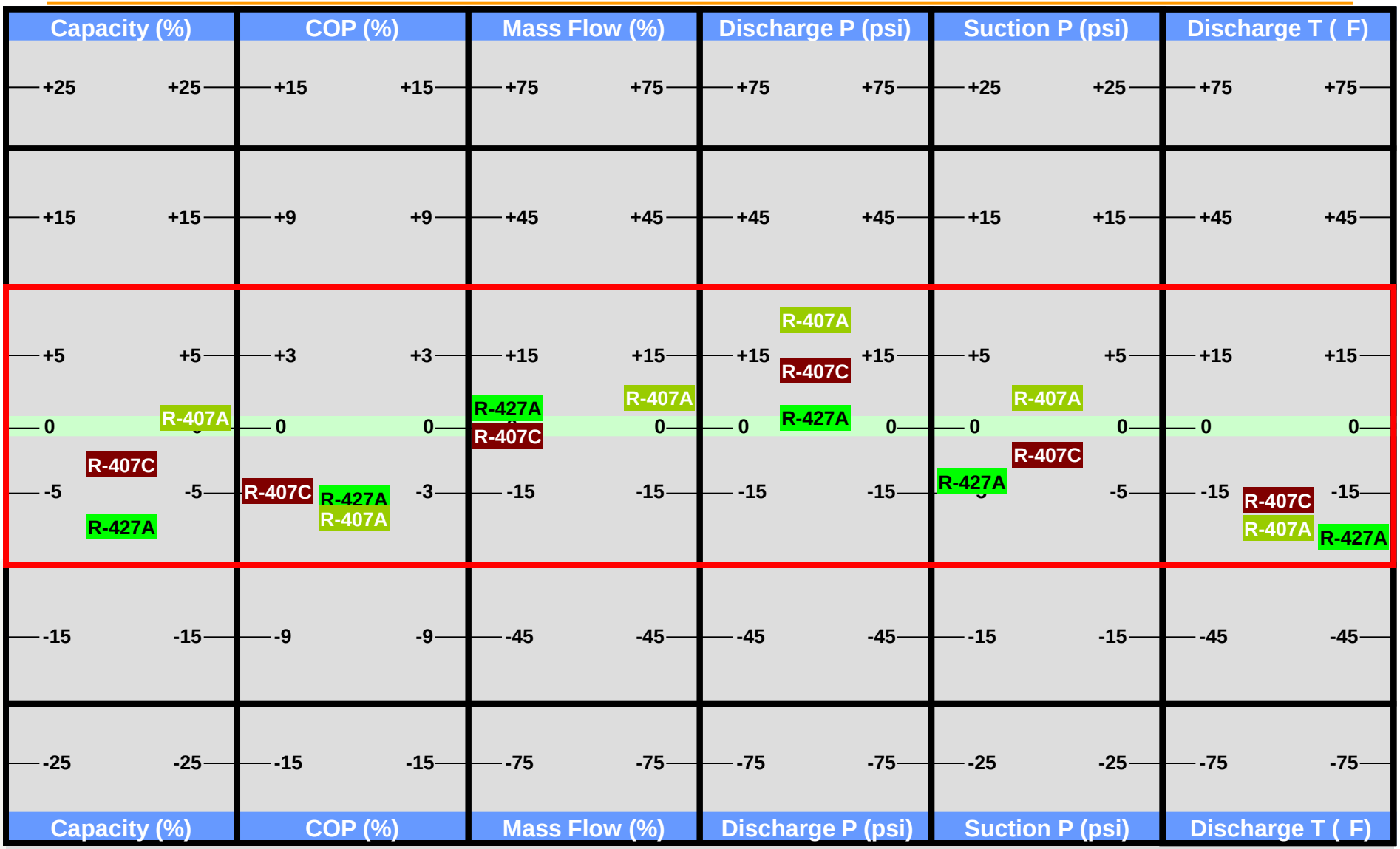


R-22 Retrofit Metrics*



*Standard Cycle 105 F Condenser, 25 F Evaporator, 10 F Subcooling & 10 F Superheat

R-22 Retrofit Metrics*



*Standard Cycle 105 F Condenser, 25 F Evaporator, 10 F Subcooling & 10 F Superheat

R-22 Retrofit Recommendations

	R-407C	R-407A	R-427A
Application	AC, MT	MT, LT	AC, MT, LT
Pros	Closest AC Match No TXV changes Lowest GWP	Closest MT Match No TXV changes Lower GWP	Close pressures No TXV changes Lower GWP
Cons	Moderate Head Pressure ↑	Moderate Head Pressure ↑	Slight Capacity ↓
Oil	POE	POE	POE (MO / AB)*
Limitations	DX Systems Only	DX Systems Only	DX Systems Only

* Successfully used with MO and AB with an Oil Separator

Conclusions

- Need for R-22 retrofits growing
- Many R-22 retrofits
  - No “drop-ins” / No “1 answer”
- Understanding basic HFC components key to differentiating products / advertising claims
- HCs help with oil – immiscibility issues remain
- R-407C, R-407A, & R-427A are good options

Q & A

Thank You!