Retrofit Experience of Alternative Refrigerant R-438A in Air-Conditioning and Refrigeration Systems

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Learning Objectives for Session

- **Describe a high glide refrigerant blend**
- **Explain applications where one refrigerant blend would be preferred over another**
- **Describe when a new refrigerant may require modifications to valves or controls**
- **Identify when an oil change may or many not be required**

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Agenda

- Performance Comparison of HFC Blends in R-22 Retrofits
- Retrofit Procedure & Oil Management Guidance
- Impact of Temperature Glide on:
  - Performance during Leak/Re-Charge
  - Fractionation in the presence of Mineral Oil (Leak/Recharge and Recovery/Recharge)
- Summary & Conclusions

Basics of Common HFC Blends used in R-22 Retrofits

	R-438A	R-407A	R-407C
ASHRAE #	R-438A	R-407A	R-407C
HFC blend	Zero ODP	Zero ODP	Zero ODP
GWP (AR4)	2,264	2,107	1,774
ASHRAE safety	A1	A1	A1
Applications*	LT, MT, & AC	LT & MT	MT & AC

*DX Systems only; Not Recommended for Flooded Evaporators

Comparing HFC Blend Performance vs R-22

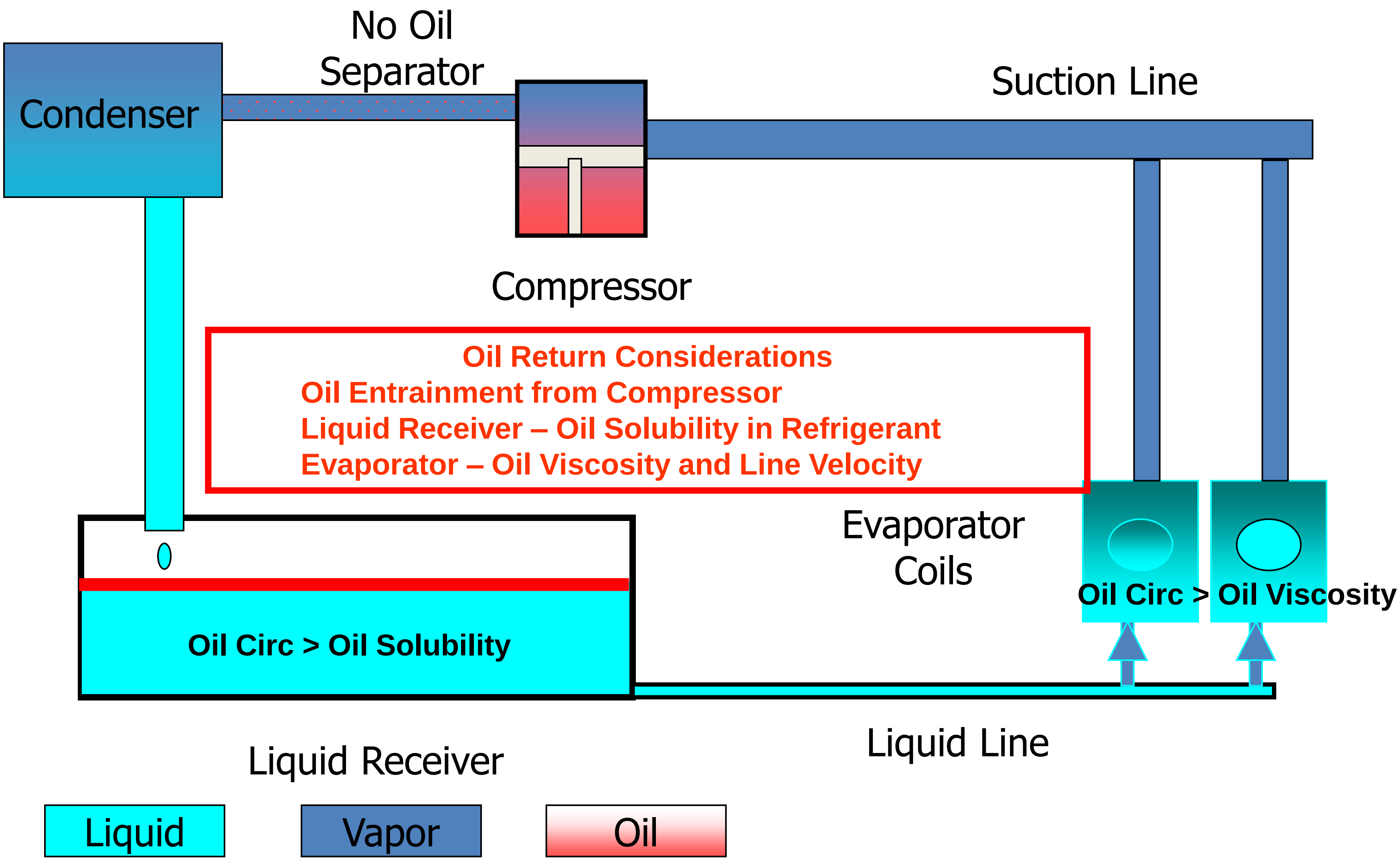
	R-438A			R-407A			R-407C		
Blend	R-32/125/134a/600/601a 8.5/45/44.2/1.7/0.6			R-32/125/134a 20/40/40			R-32/125/134a 23/25/52		
Δ vs R-22	LT	MT	A/C	LT	MT	A/C	LT	MT	A/C
Capacity (%)	- 6	-8	-7	+1	+1			-4	-1
COP (%)	+7	-1	-2	+6	-4			-1	-2
Suction Pressure (psi)	-2	-3	-3	--	+3			-1	+1
Discharge Pressure (psi)	+3	+3	+5	+30	+30			+19	+18
Discharge Temperature (F)	-22*	-41	-30	0*	-27			-29	-18
Temperature Glide (F)	+6	+6	+7	+7	+7			+8	+8
Mass Flow (%)	+12			+10			+1		

Conditions: Avg Evap Temp / Avg Cond Temp / Return Gas Temp / Subcool from Avg Cond Temp
Low Temp (LT): -25°F / 105°F / 65°F /10°F
Med Temp (MT): 20°F / 105°F / 65°F /10°F
Air Conditioning (A/C): 45°F / 115°F / 65°F / 15°F
*Assumes liquid injection to maintain maximum of 275°F discharge T

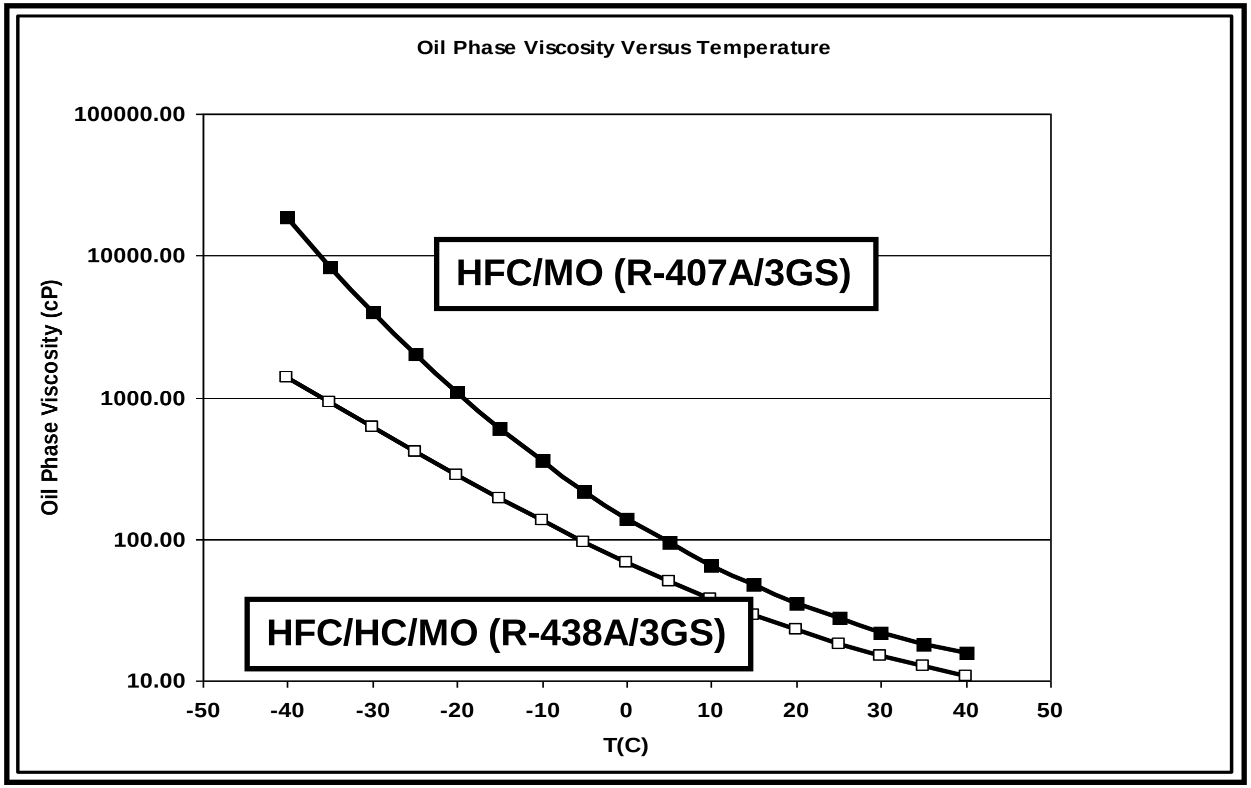
Retrofit Procedure to Convert R-22 to R-438A or R-407A/C

1. Review retrofit guidelines
2. Obtain Baseline Data on R-22
3. Recover R-22
4. Change filter driers/critical elastomeric seals
5. R-438A - no oil change in most systems (see oil management considerations); R-407A/C – lubricant change to POE
6. Evacuate system & leak check
7. Charge with refrigerant (remove as liquid from cylinder) ; Start-up and monitor
8. Leak Check, Label system, and optimize set-points if needed

R-438A Oil Return- w/o Oil Separator



Oil Viscosity vs. Temperature for HFC(HC)/MO



Small % HC in R-438A lowers MO or AB viscosity in cold evaporator enabling oil return.

Summary of R-438A Oil Management Considerations*

System	Guidance
More complex systems with potential for challenging oil return • Long pipe runs and/or poor line velocity design • Liquid receivers but no oil separator present	~20% POE addition
Certain Scroll compressors (see retrofit guidelines for details)	Replace oil in compressor sump with POE
Screw compressors	Detailed system evaluation recommended

*Note: These considerations would apply to any R-400 series blend that claims "mineral oil compatibility"

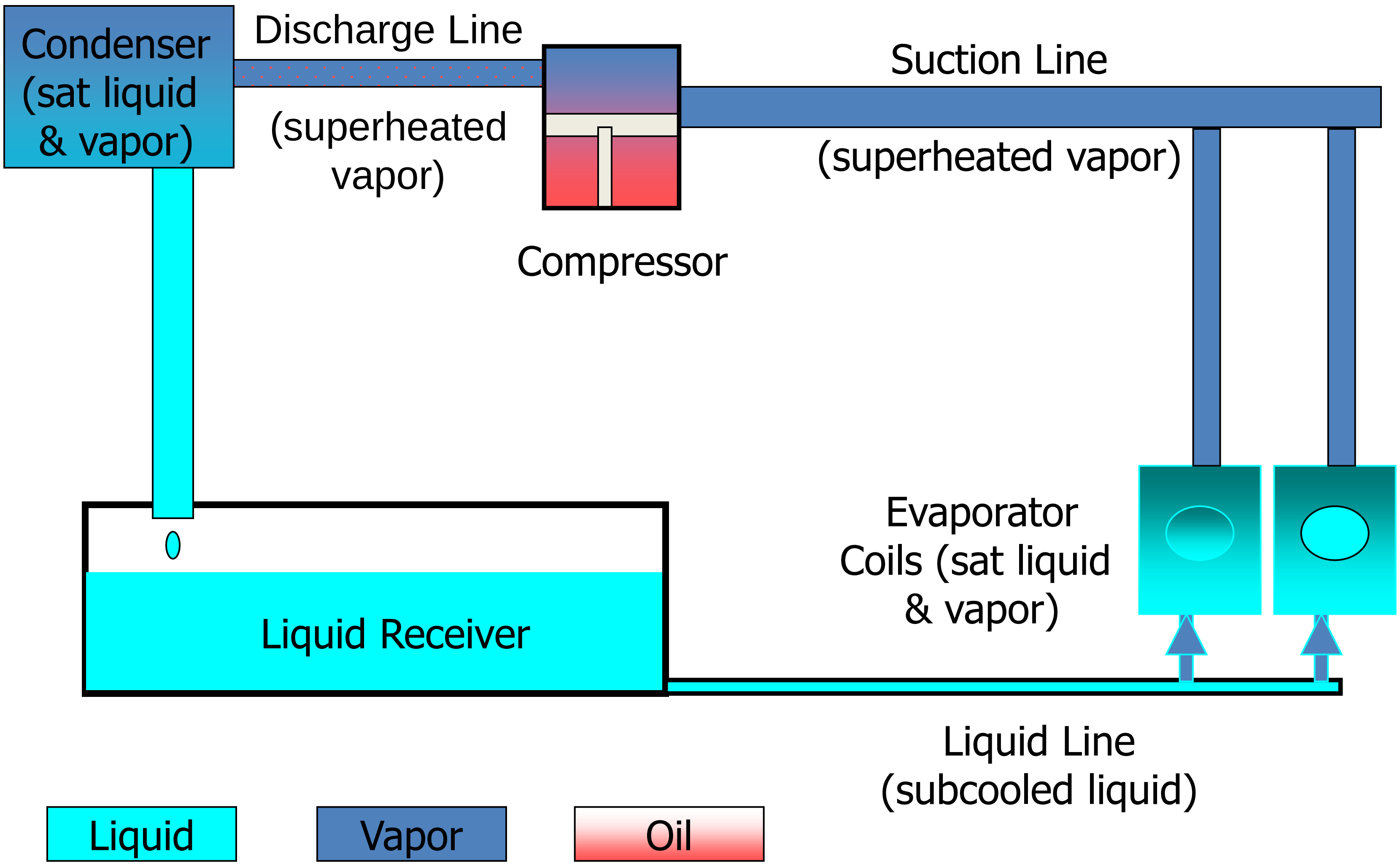
What Impact does Temperature Glide Have on R-438A Performance/Composition?

Take a Closer Look at:

1. Performance During Leak/Recharge

2. Presence of Mineral Oil and Impact on Blend Fractionation during Leak/Recharge and Recovery/Recharge

Composition Change During Leak/Recharge



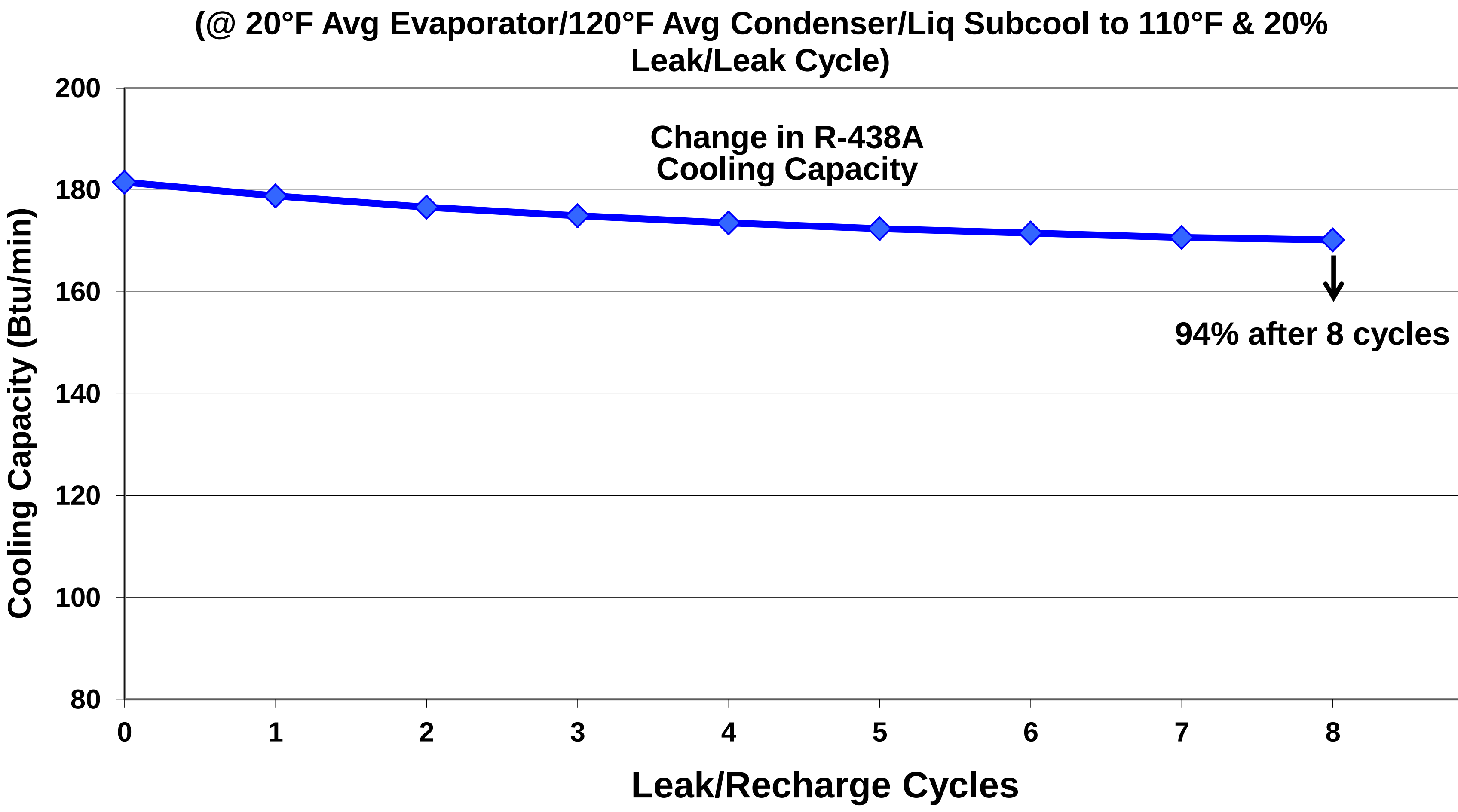
Composition Change of Zeotropic Blends During Equipment Leak Scenarios

- **Need Saturated Vapor/Liquid Present for Composition Change**
  - -Evaporator or Condenser when System Running
  - -System Off

- **Worst Case Composition Change During Slow Vapor Leak**
  - -Entrained Liquid with Vapor reduces Composition Change

- **No Composition Change for Leaks of Superheated Vapor or Subcooled Liquid.**

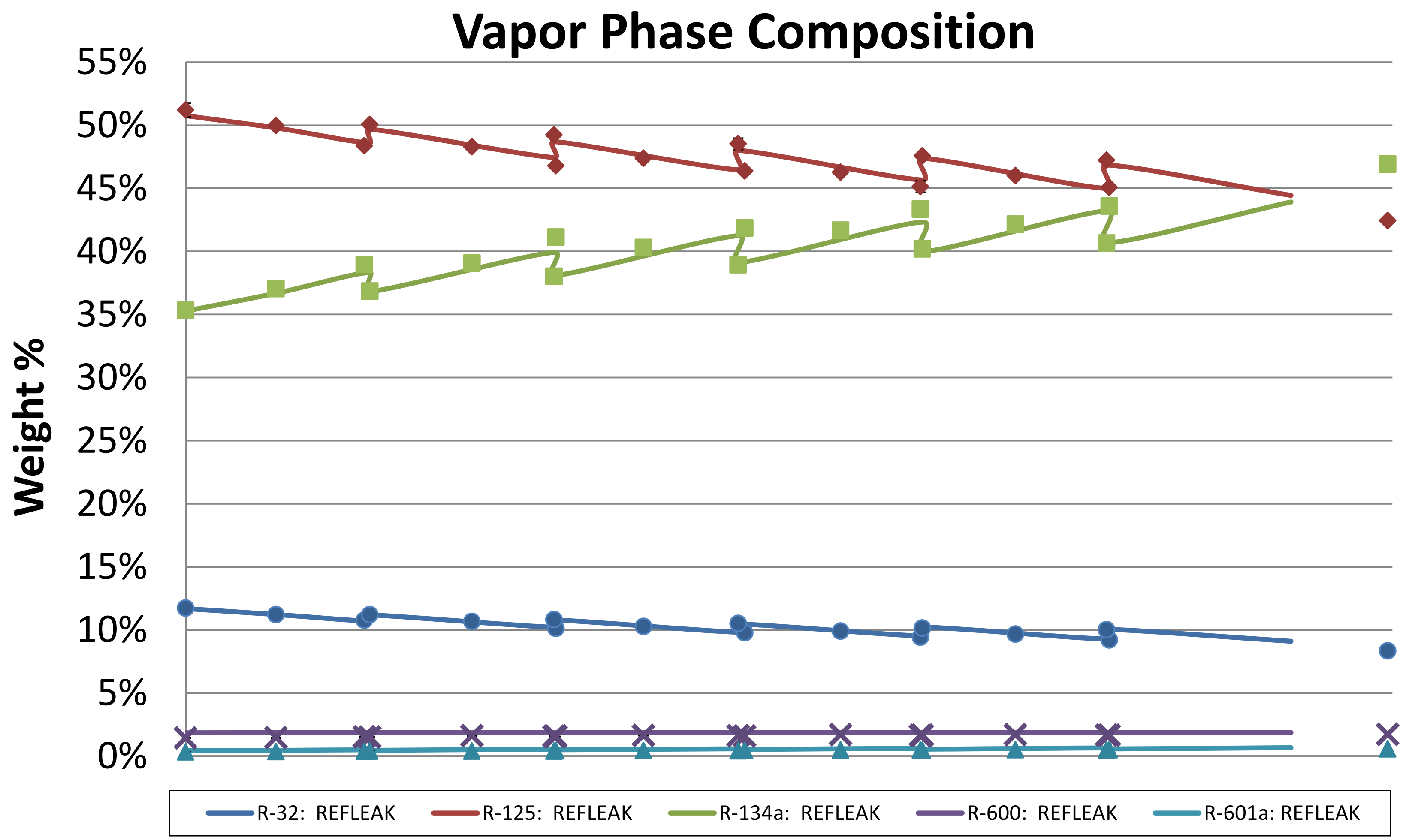
R-438A Performance during Leak/Re-Charge



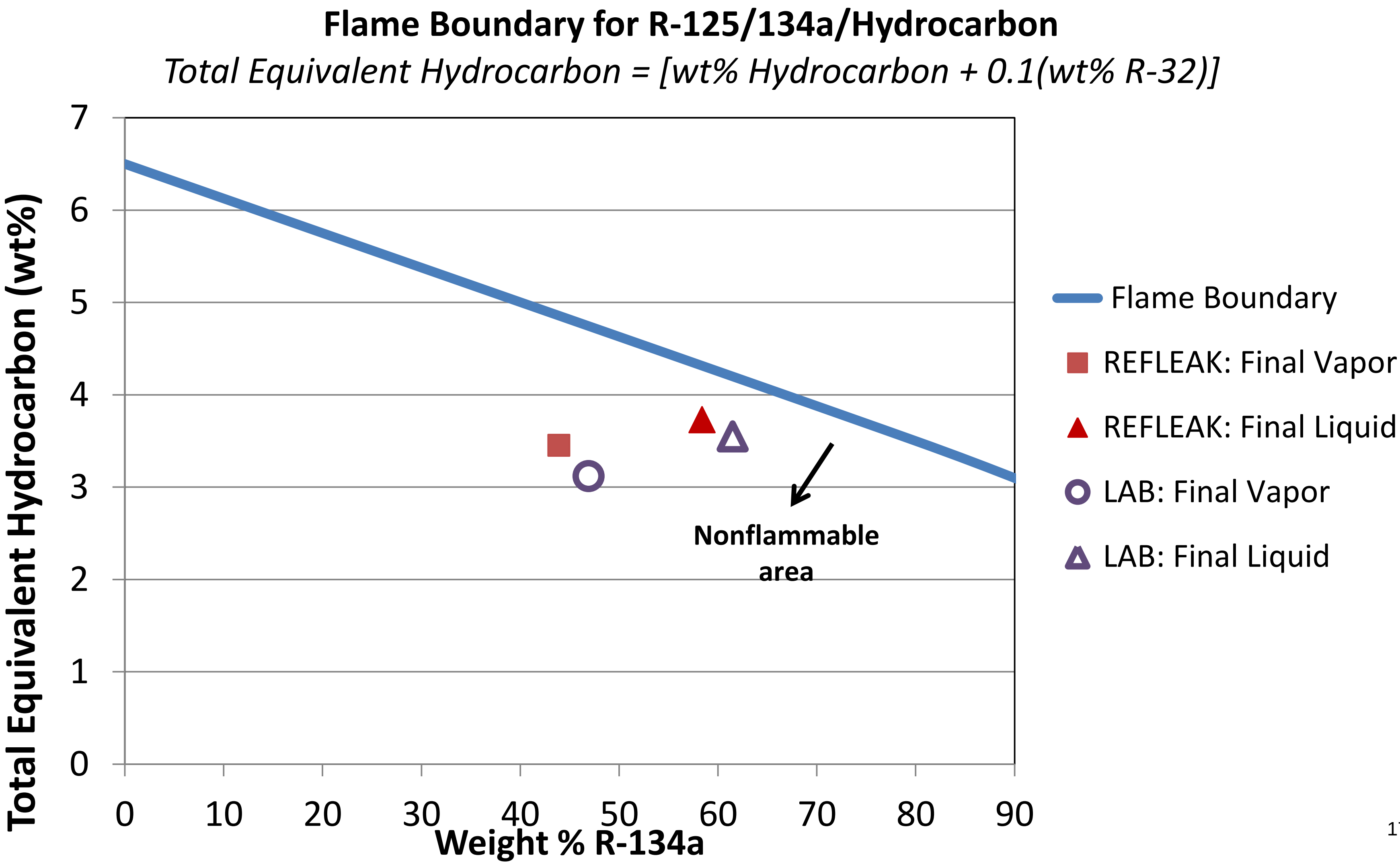
R-438A Fractionation During Leak/Recharge in Presence of Mineral Oil

- Leak/recharge at 15% liquid fill ;
  25% oil/refrigerant charge by weight.
- 2% leak rate/hour, with 20% leak before recharge
- Used WCF composition for R-438A as initial starting composition for leak/recharge

R-438A Fractionation during Leak/Re-Charge In the Presence of Mineral Oil



R-438A Fractionation during Leak/Re-Charge In the Presence of Mineral Oil



Results of R-438A Fractionation During Leak/Recharge in Presence of Mineral Oil

- Hydrocarbon composition does not build up to level that would cause vapor or liquid refrigerant to become flammable

- Experimental results comparable to theoretical leak model results with refrigerant only
  - presence of mineral oil does not alter conclusions from theoretical leak modeling

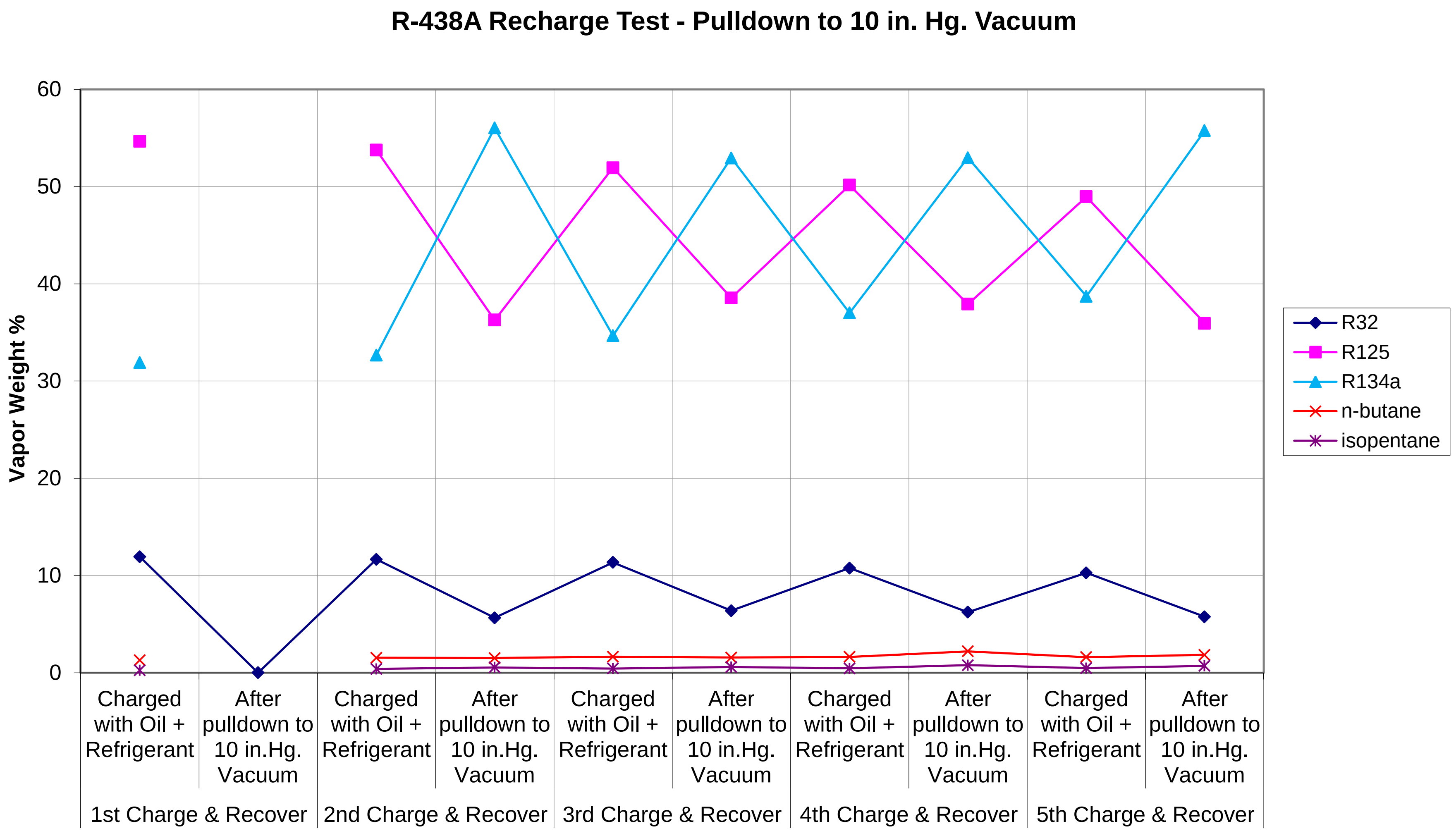
R-438A Fractionation during Recovery/Recharge In the Presence of Mineral Oil

- Worst case test - recovery of refrigerant under slight vacuum (10” Hg) and recharge with virgin refrigerant

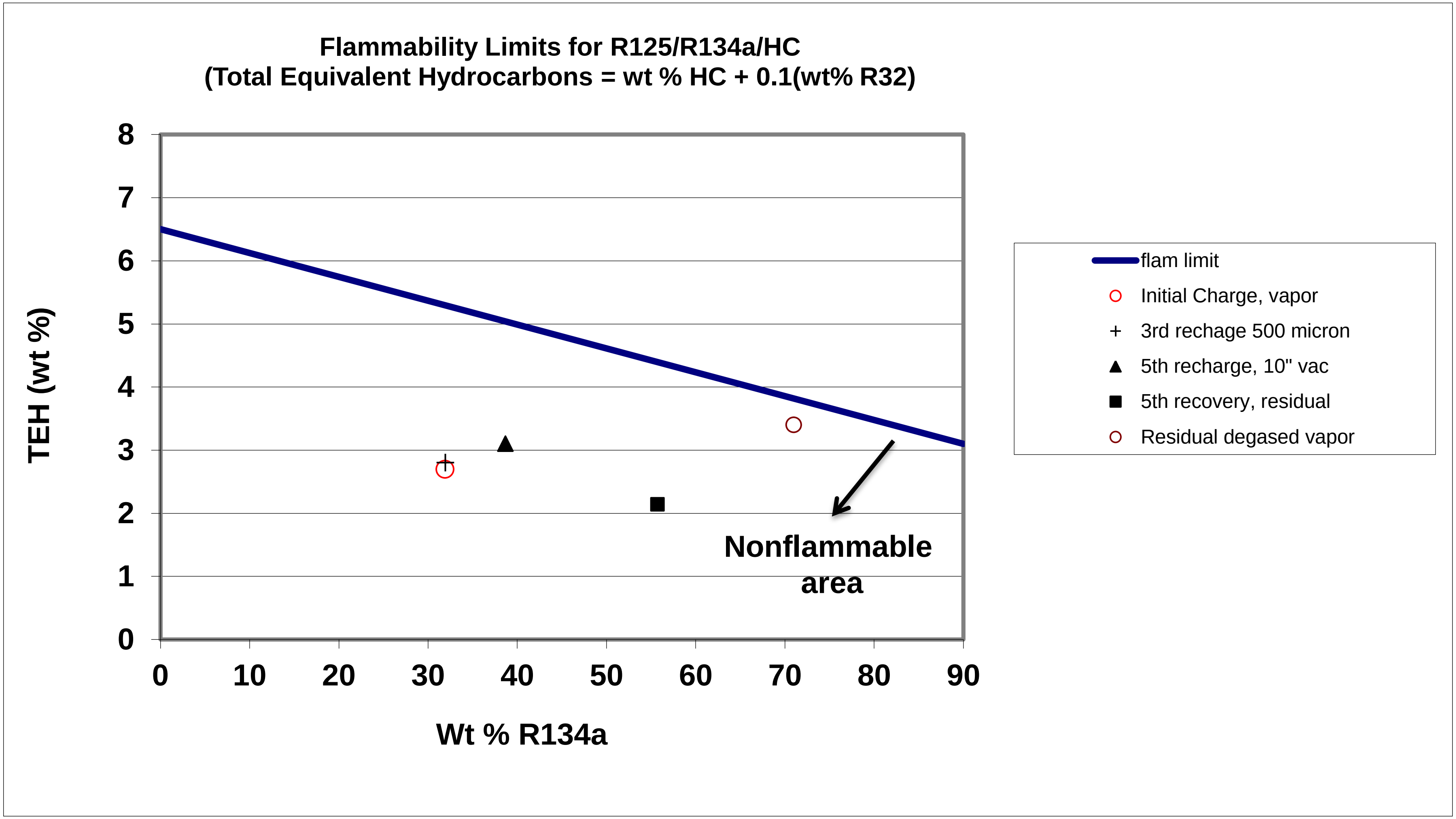
- Measured Vapor composition after each recovery/recharge cycle

- Measured composition of refrigerant in oil at end of test (@ 10” Hg and @ 500 μ)

R-438A Vapor Composition during Recovery/Recharge in the Presence of Mineral Oil



R-438A Vapor Composition during Recovery/Recharge in the Presence of Mineral Oil



Results of R-438A Recovery/Re-Charge Tests in the Presence of Mineral Oil

- Minimal composition change after multiple recovery/recharge cycles
- Hydrocarbon content in refrigerant vapor sample essentially unchanged; no evidence of buildup of hydrocarbon in mineral oil
- No residual refrigerant in oil with pull down to 500 μ (recommended practice)
  - Original oil charge - 217 g
  - Oil weight after pull down to 10” Hg – 495 g
  - Oil weight after pull down to 500 μ – 219 g

Summary & Conclusions

- R-438A, R-407A, and R-407C are excellent alternative refrigerants to replace R-22 in DX systems

  -Performance similar to R-22; no TXV change

  -No oil change needed in most systems with R-438A

- For most zeotropic blends - slight loss of capacity possible during leak/recharge scenarios with slow saturated vapor leak

  -In practice, minimal overall performance impact observed

- R-438A Leak/Recharge and Recovery/Recharge Tests show negligible change in hydrocarbon content in refrigerant and in mineral oil

Thank You!

Questions ?

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