Paper # 2499

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Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings

Effects of Refrigerant-Lubricant Combinations on the Energy Efficiency of a Convertible Split-System Residential Air Conditioner

Chemtura

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Complementary Work

Lubricants Optimized for use with R-32 and Related Low GWP Refrigerant Blends

Paper 2413: HESSELL

Solution Properties Of Polyol Ester Lubricants Designed For Use With R-32 And Related Low GWP Refrigerant Blends

Paper 1491: URREGO

Refrigerant and Lubricant Mass Distribution in a Convertible Split System Residential Air Conditioner

Paper 2502: WUJEK

Effect of Lubricant-Refrigerant Mixture Properties on Compressor Efficiencies

Paper 1507: WUJEK

Background

Regulations drive the HVAC-R industry to develop and commercialize new and alternative refrigerants. Each refrigerant interacts differently with lubricants and this opens up opportunities to develop new products for new refrigerants.

- **Montreal Protocol**
- **Kyoto Protocol**
- **European F-Gas Regulations**

Lubricant-Refrigerant Pairs

1. Miscibility

- Forms one liquid phase at all ratios of oil:refrig
- Observed as a function of temperature
- Primary importance in heat exchangers

2. Solubility

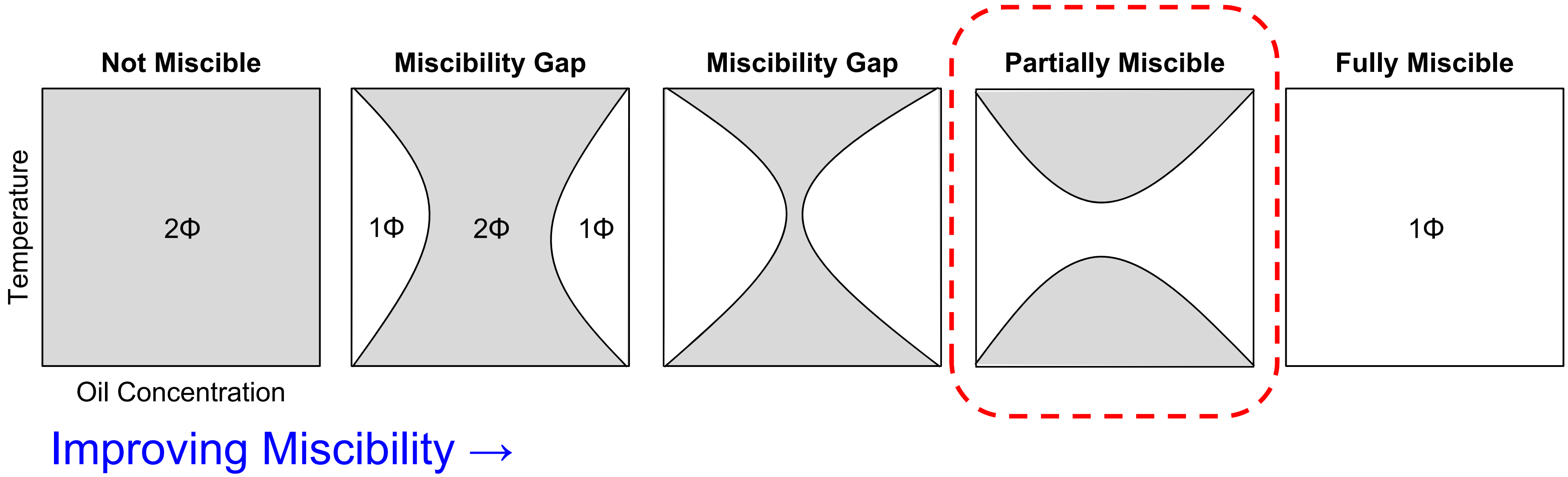
- Tendency for the refrigerant to dissolve into the lubricant
- Lowers the working viscosity of the fluid
- Temperature and pressure changes can cause foaming

3. Working Fluid Viscosity

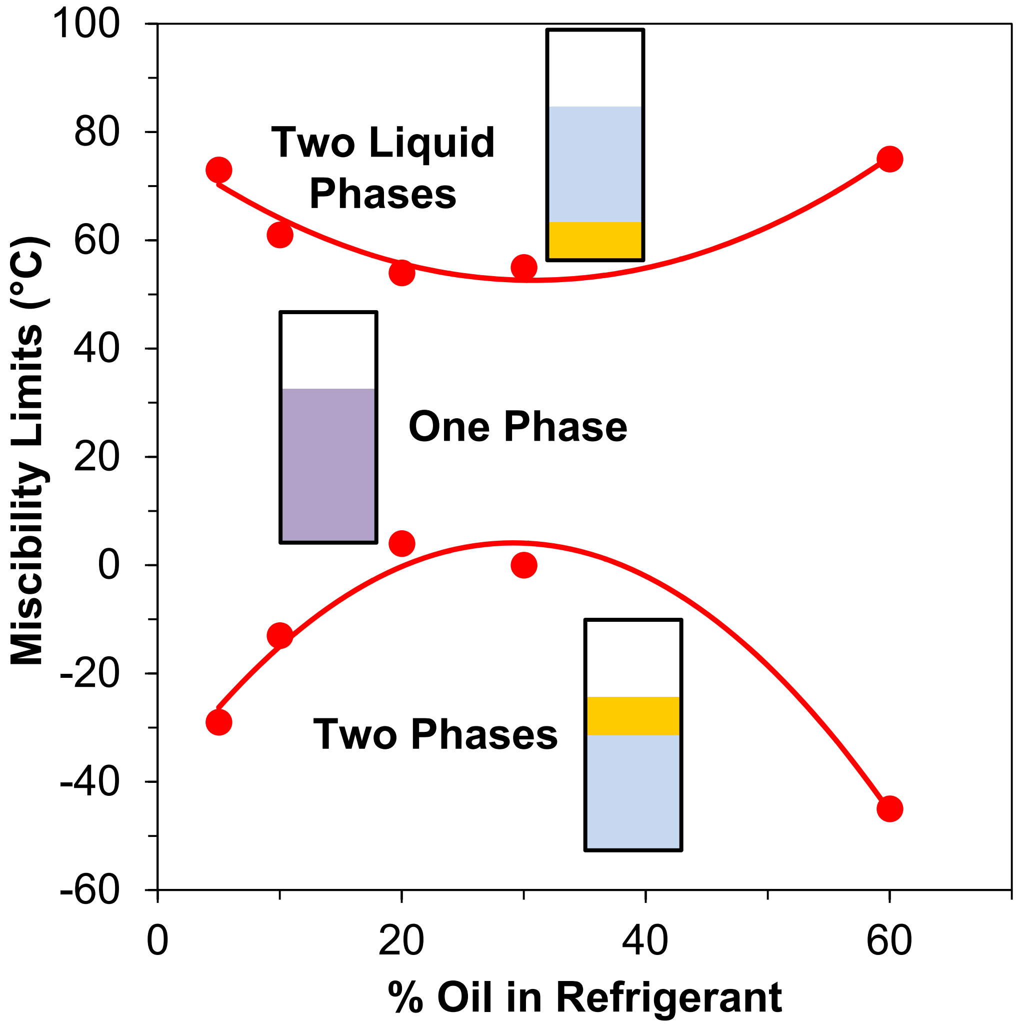
- Always lower than the neat oil due to refrigerant
- Changes as a function of T, P, dissolved refrigerant

Miscibility

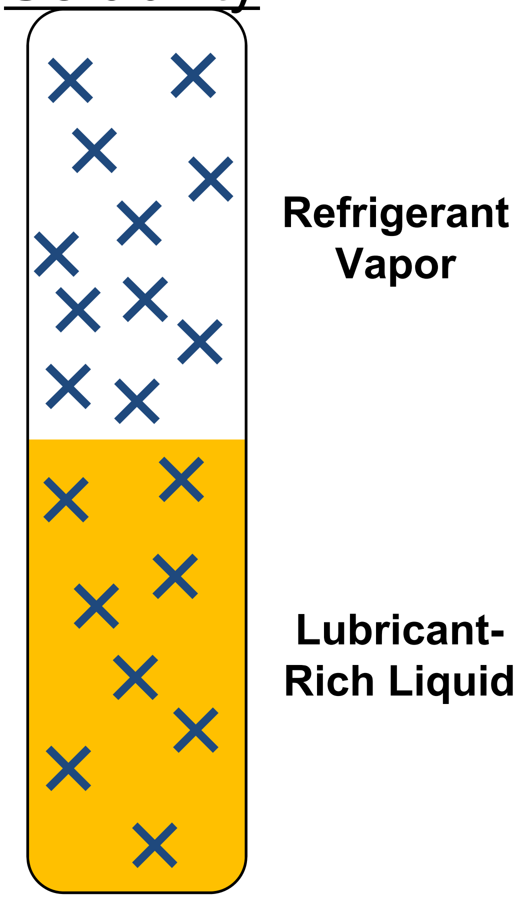
In today's systems, it is desirable to have a lubricant with controlled miscibility, since this behavior affords working fluids (oil + refrig) that provide good lubrication without negatively impacting the system as a whole.



Miscibility and Solubility

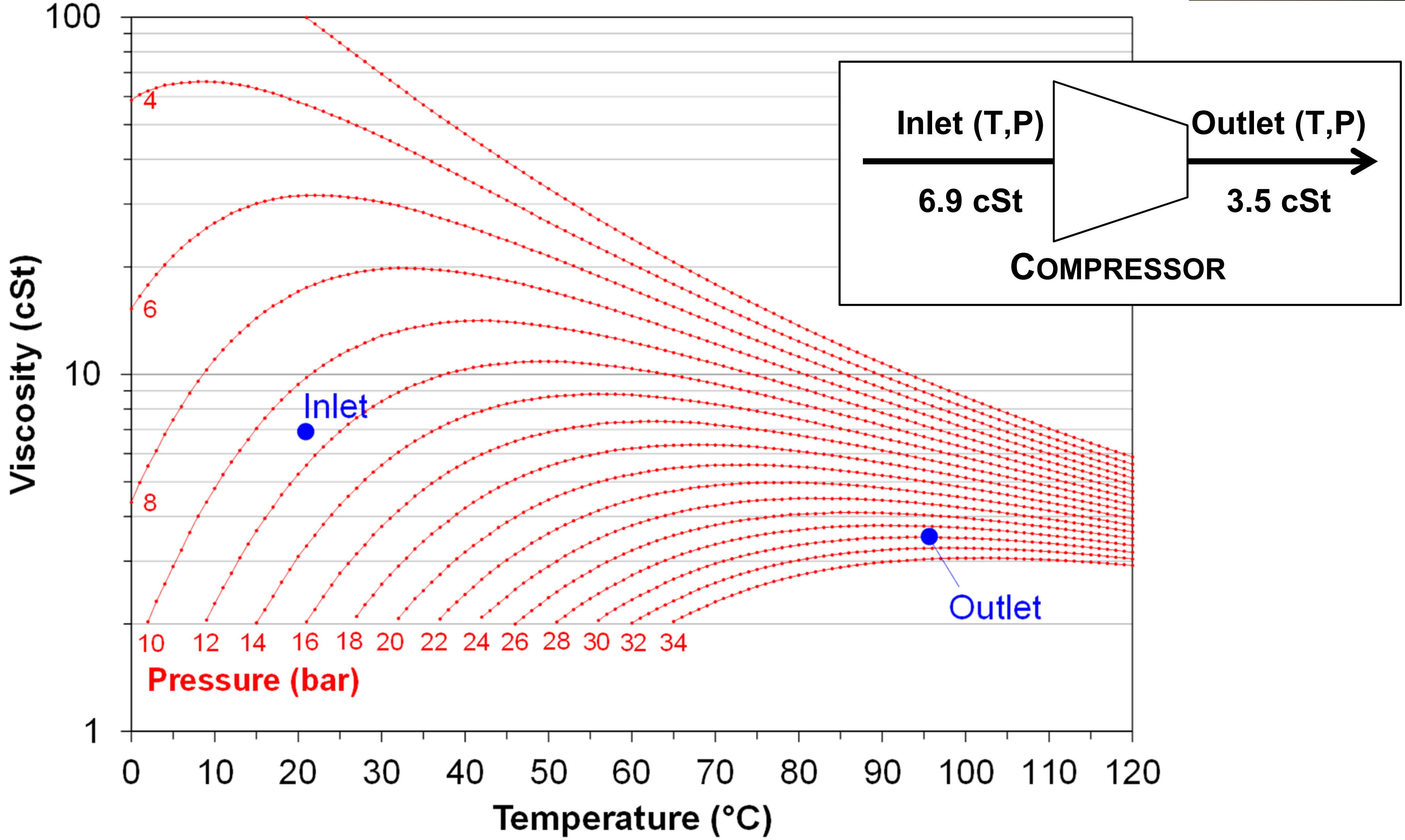


Solubility

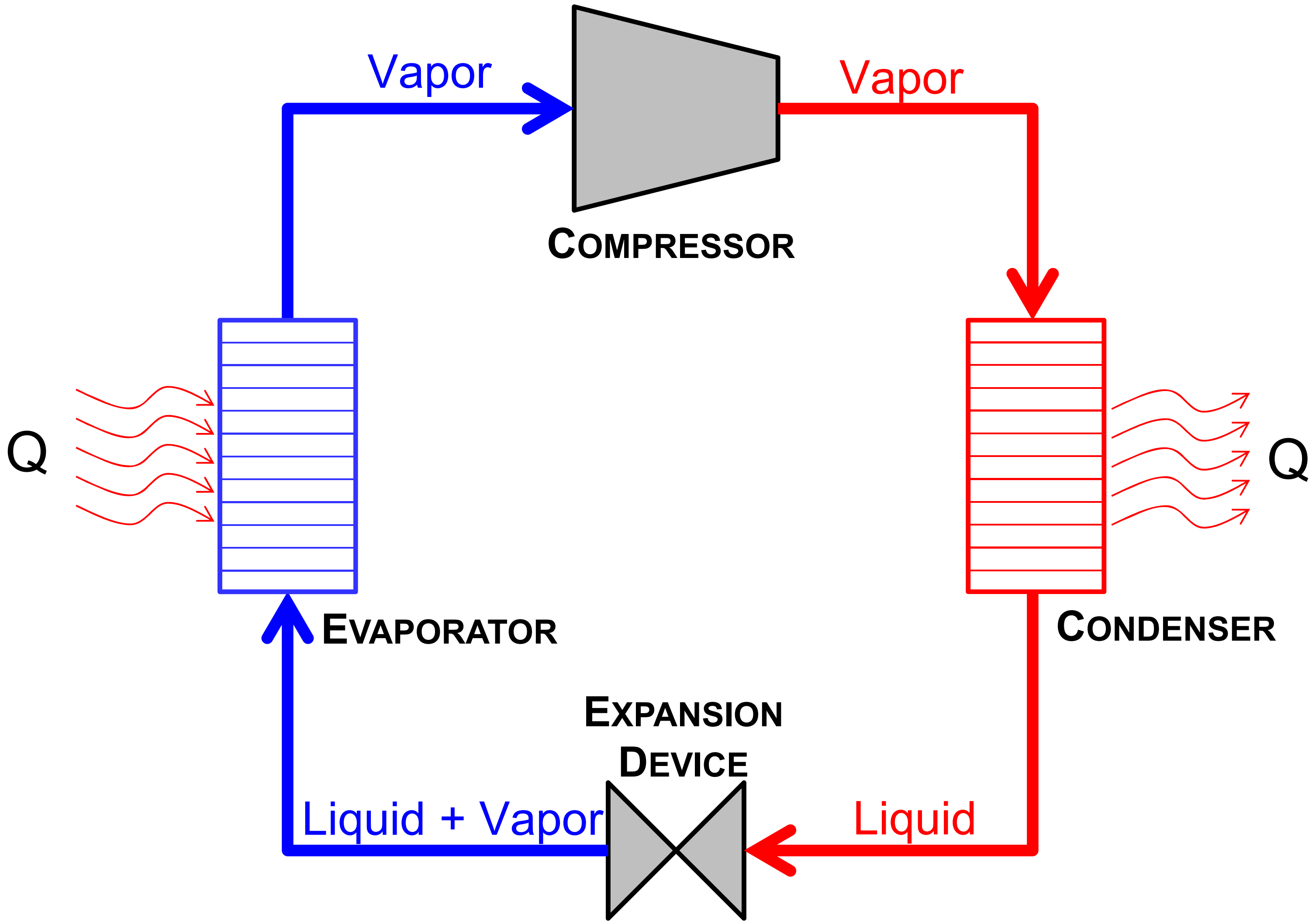


Dissolved Refrigerant Lowers Viscosity of the Lubricant

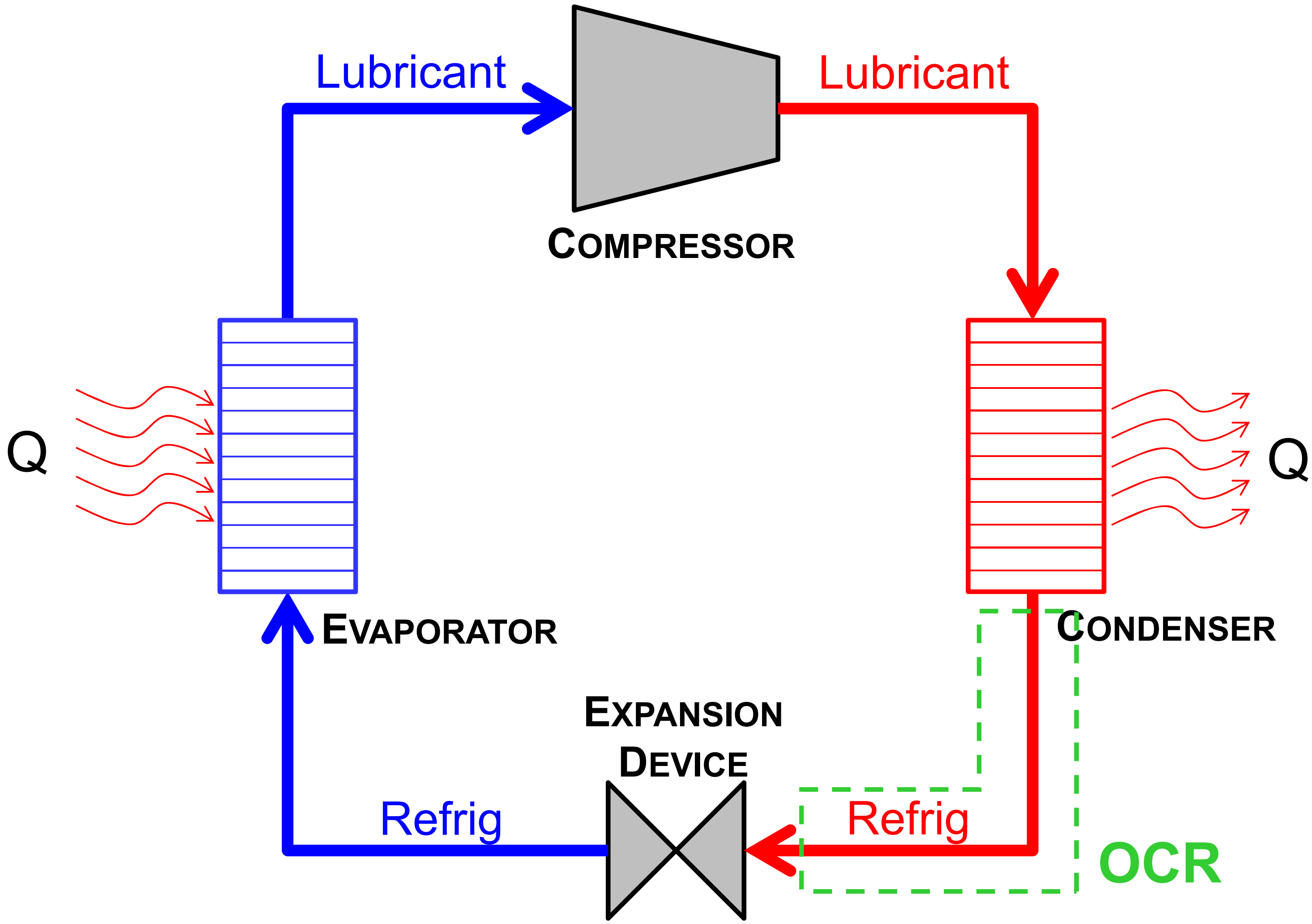
Working Fluid Viscosity



Overall Flow Composition



Liquid Phase Compositions



Possible Lubricant Effects

Build-up in components
Adversely affects energy balances
Saturation temps implied from pressure measurements
Two-phase pressure drops
Altered heat transfer coefficients
Reduces log-mean temperature difference
Lowered capacity

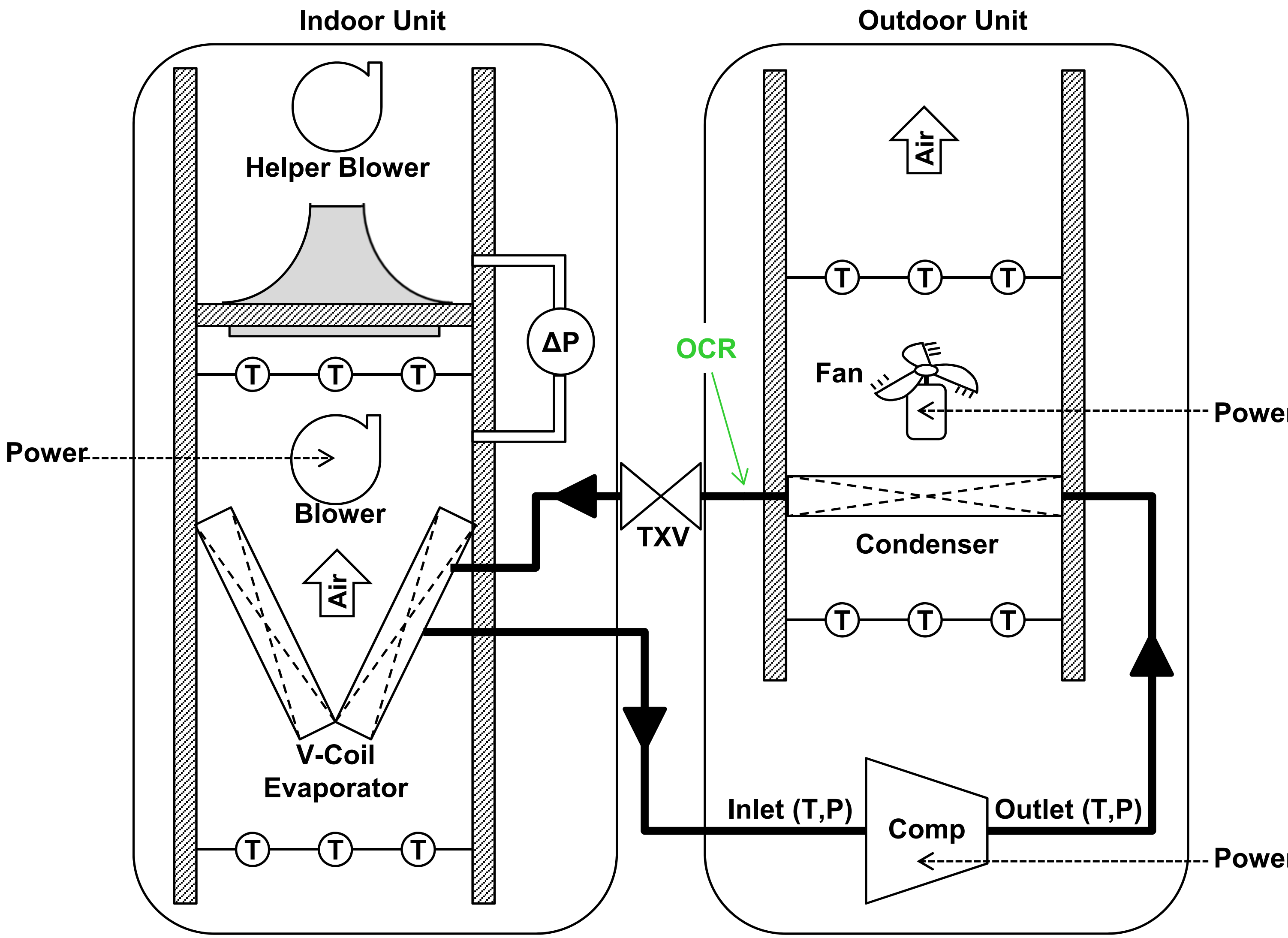
Improved wetting at low vapor quality
Nucleation of boiling
Foaming
Coating of microchannels

Lubricant-Refrigerant Pairs Tested

ID#	Type	ISO	R-410A		R-32		L-41b	
1	Commercial	32	?	?	?	?		?
2	Commercial	68	?	?	?	?	?	?
3	Developmental	32		?	?	?	?	?
4	Developmental	46		?	?	?	?	?
5	Developmental	68	?	?	?	?		?
6	Developmental	80		?	?	?	?	?

ü **Tested in Full System**
? **Good Miscibility**
? **Poor Miscibility**

Experimental Setup



Test Conditions

AHRI Condition	Mode	Indoor Air T (°C)		Outdoor Air T (°C)	
		Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb
A	A/C	26.7	19.4	35.0	-
B	A/C	26.7	19.4	27.8	-
C	A/C	26.7	-	27.8	-

Evaporator Energy Balance

$$\dot{Q}_{evap} = \dot{m}_{air} c_{p,air} \left(T_{in} - T_{out}\right) = \dot{m}_{refrig} \left(h_{out} - h_{in}\right)$$

Coefficient of Performance (COP)

$$COP = \frac{\dot{Q}_{evap}}{\dot{W}_{in}} = \frac{\text{Cooling Effect}}{\text{Power Input}}$$

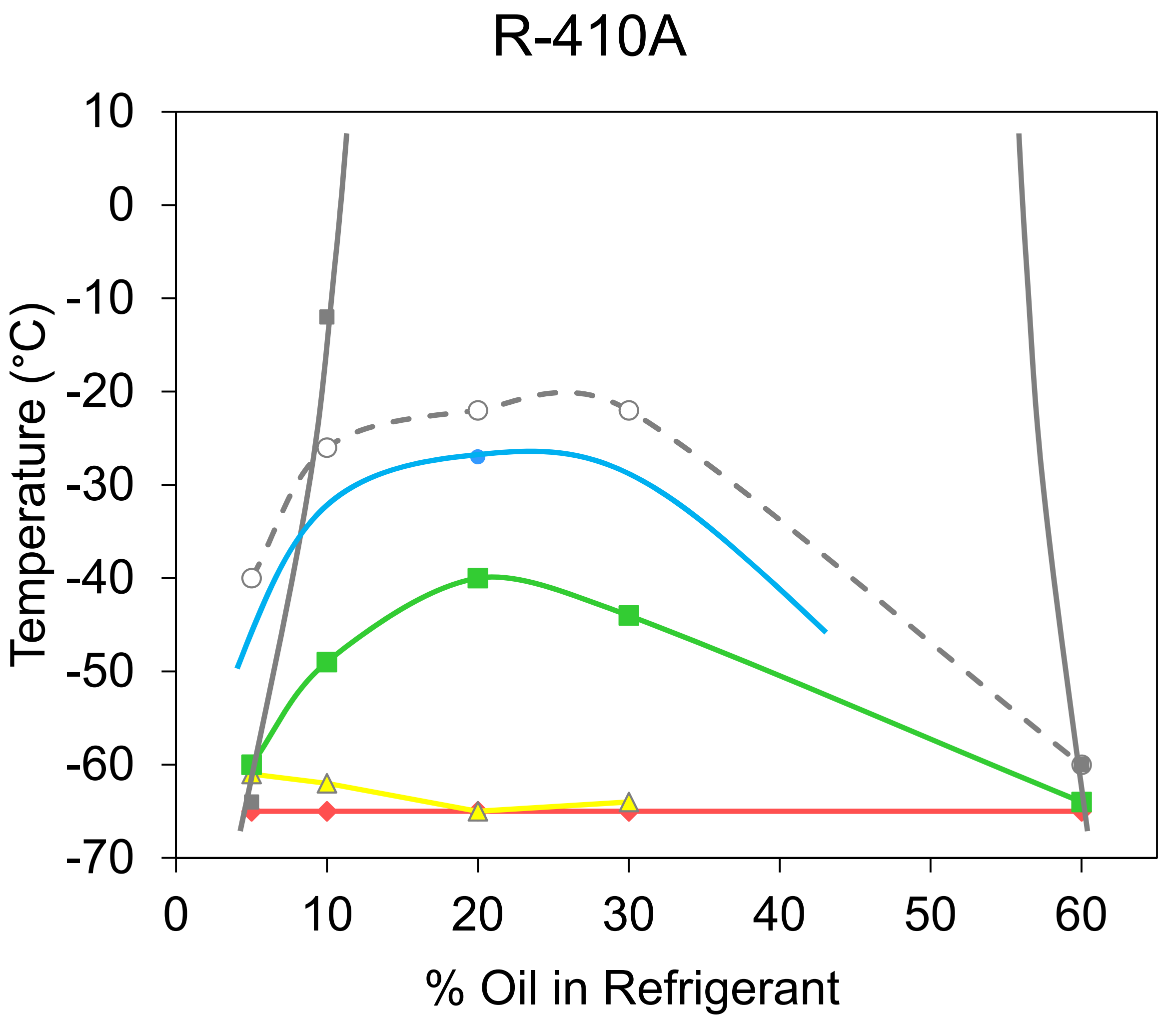
Optimized Lubricant Properties

Benchmark is Lubricant 1 (ISO 32) + R-410A, but this standard lubricant is not miscible with R-32.

Lubricant CTQs:

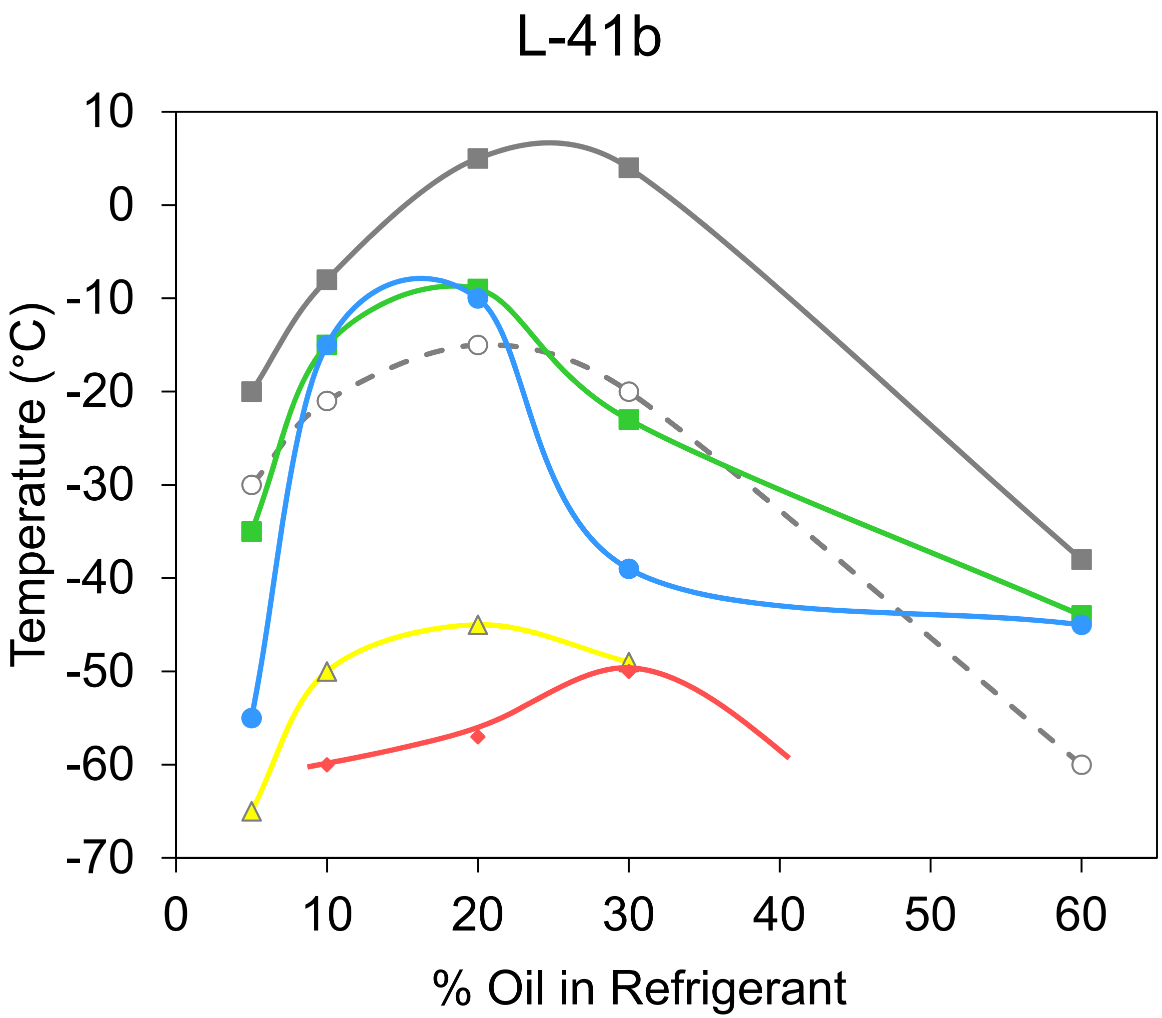
1. Good miscibility profile; no miscibility gap
2. Match working fluid viscosity in new refrigerants to that of the benchmark combination
3. Show no performance degradation when switching to higher viscosity grade oils

Miscibility Profiles



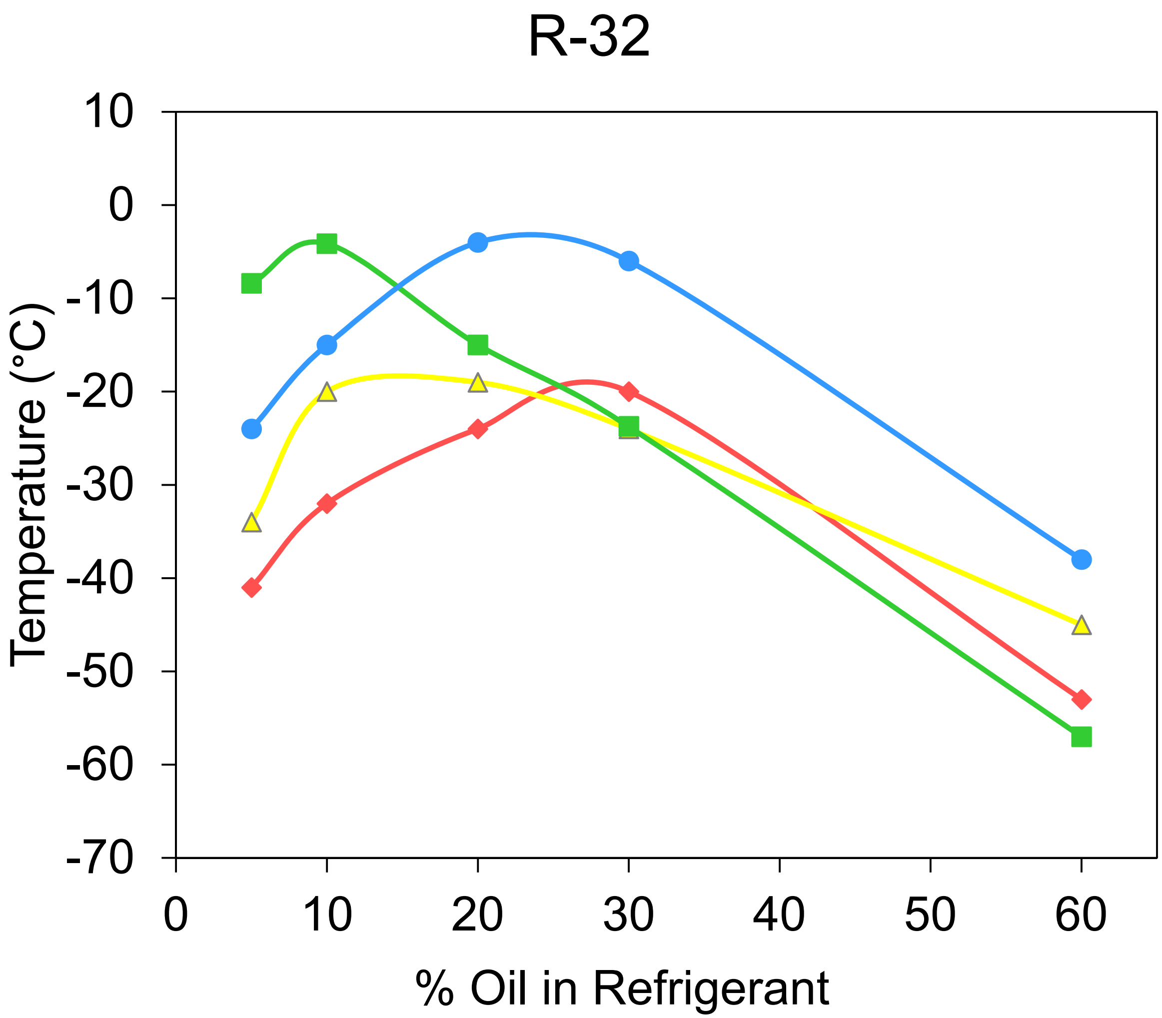
ID#	ISO	R-410A
1	32	?
2	68	?
3	32	?
4	46	?
5	68	?
6	80	?

Miscibility Profiles



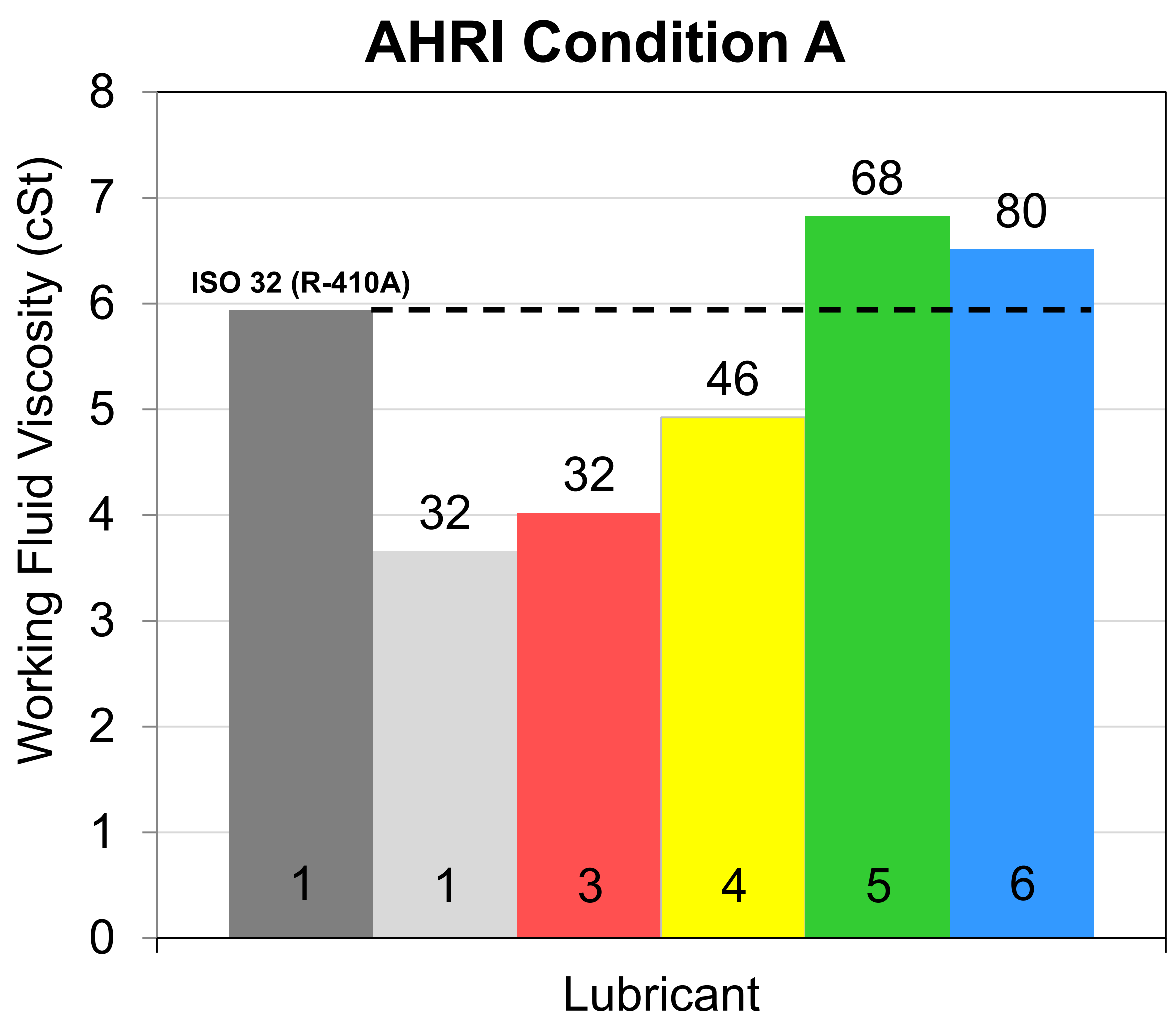
ID#	ISO	L-41b
1	32	?
2	68	?
3	32	?
4	46	?
5	68	?
6	80	?

Miscibility Profiles

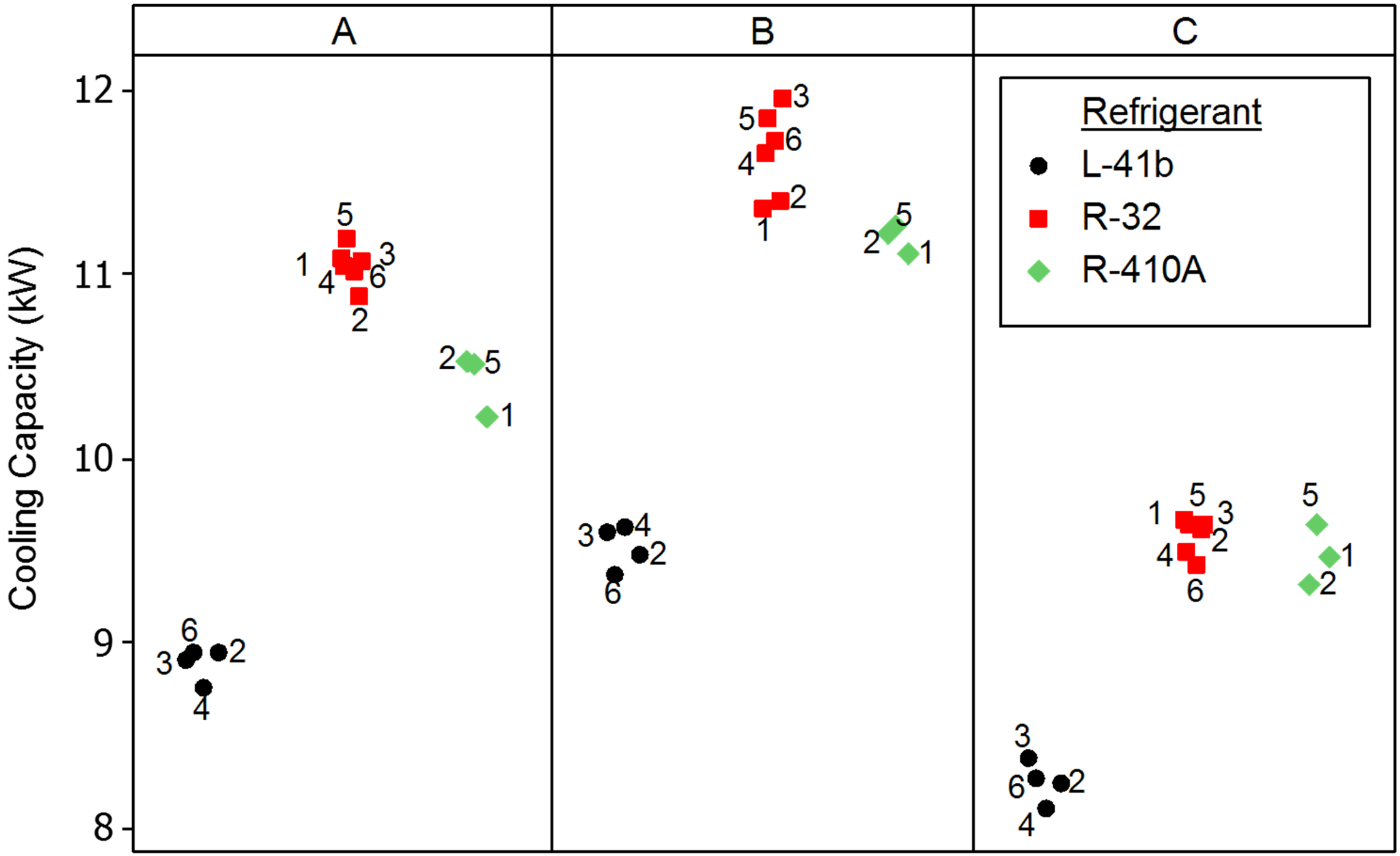


ID#	ISO	R-32
1	32	?
2	68	?
3	32	?
4	46	?
5	68	?
6	80	?

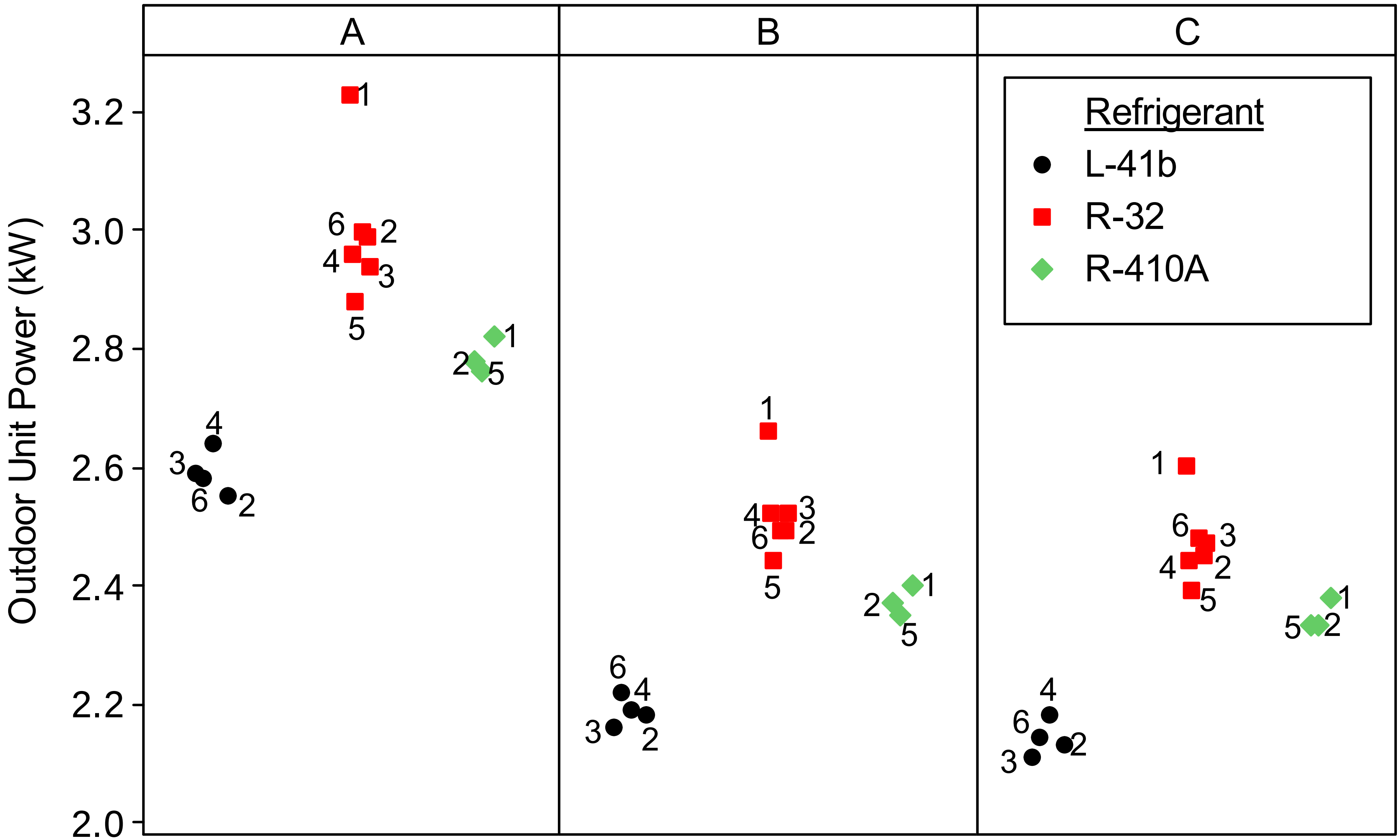
Working Fluid Viscosity



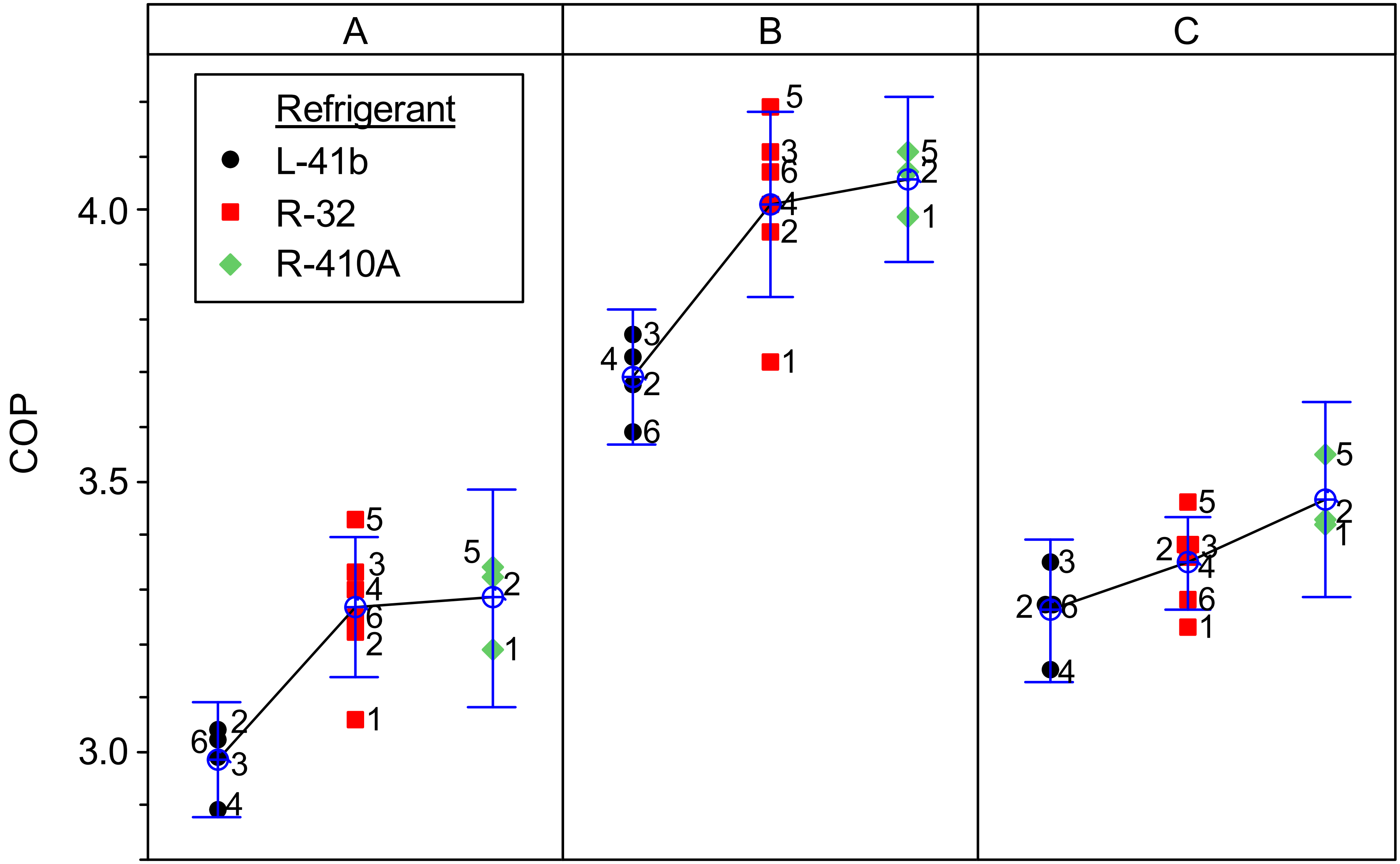
Cooling Capacity



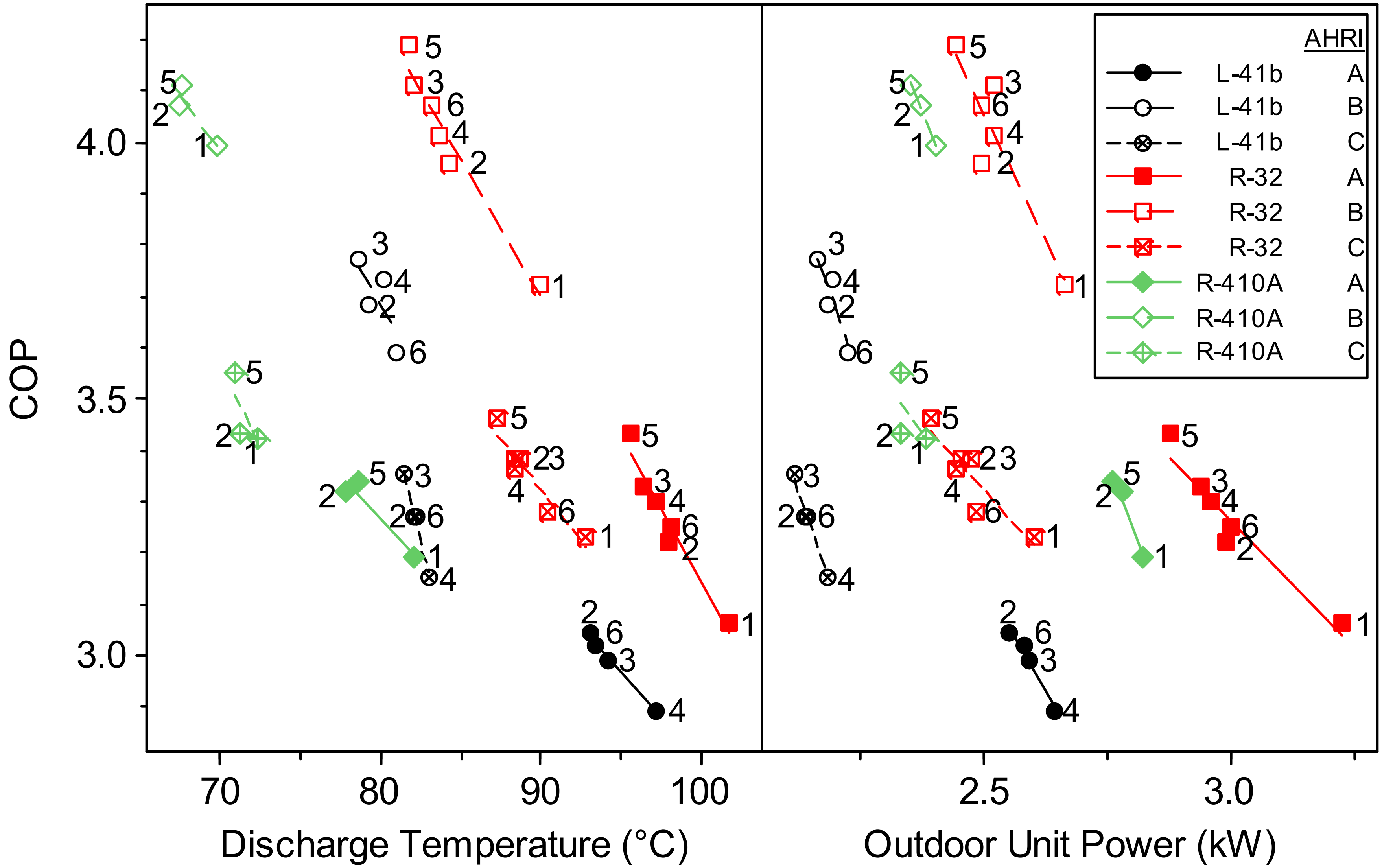
Compressor Power



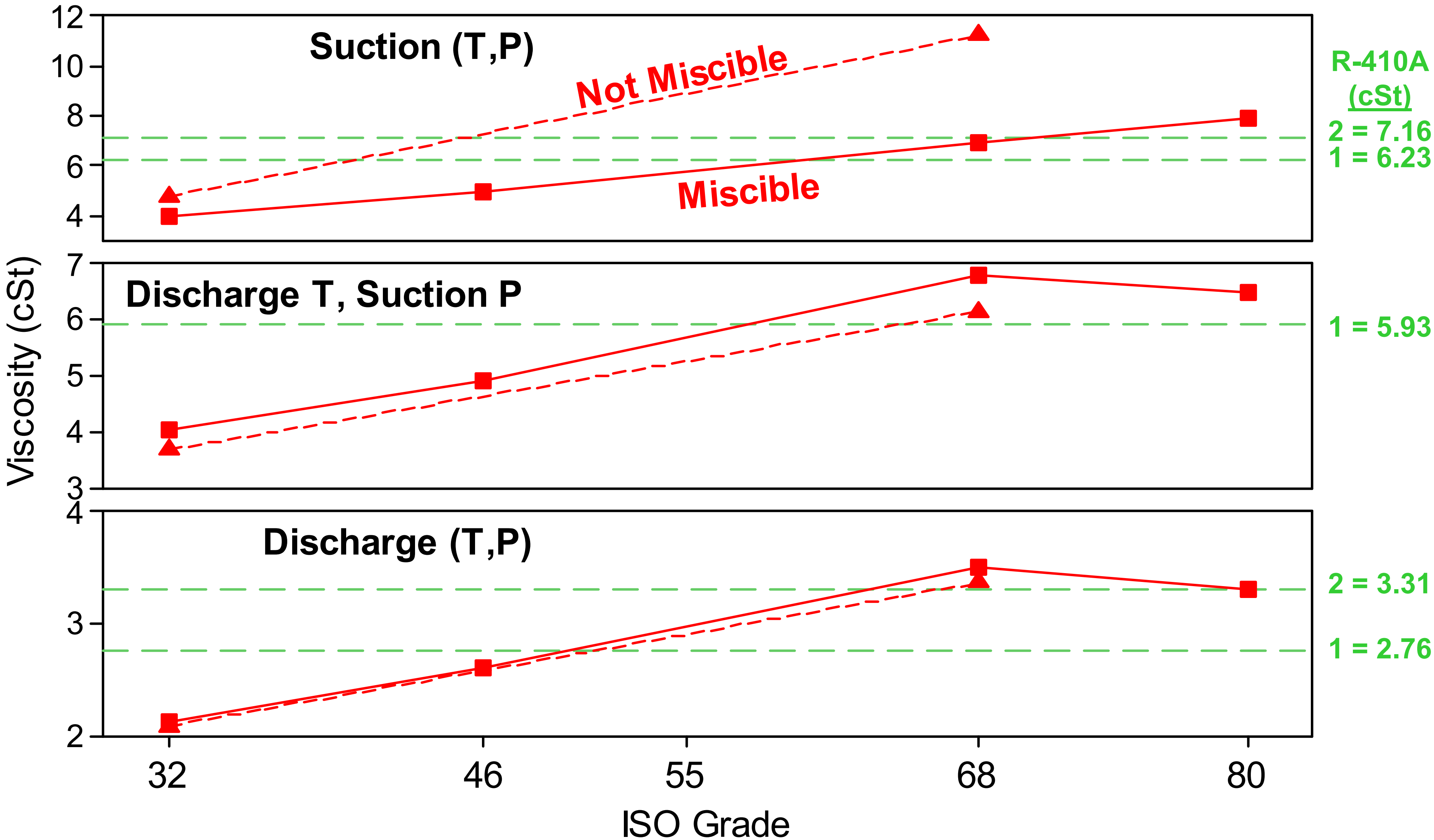
Lubricant Effects on COP



Lubricant Effects on Compressor



R-32 vs. R-410A Viscosities



Conclusions

- Higher ISO grade lubricants are required for R-32 & L-41b
- R-32: Immiscible lubricant 1 gave lowest COP in all cases while optimized lubricant 5 afforded the highest COP
- L-41b: Similar working viscosity trends to R-32

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