

Polyalkylene Glycols for Alternative Refrigerant R-152a for Automotive Air Conditioners

Myrna Serrano

Mike Miller

Dow Automotive Fluids R&D/TS&D



Dow Automotive

Outline

- Introduction
- Experimental Section: Description
- Functional Requirements for Mobile A/C
- PAG Miscibility: f (refrigerant type, oil type, T, x)
- PAG Thermal Stability = f (metals (Al, Cu, Steel), refrigerant type)
- Extreme Pressure Properties = f (refrigerant type, oil type)
- Summary

Hydrofluorocarbon Alternative Refrigerant

R-134a

1,1,1,2-tetrafluoroethane

HFC CH_2FCF_3

MW = 102

GWP = 1300

d = 1.202 g/cc

ODP = 0

R-152a

1,1-difluoroethane

HFC CH_3CHF_2

MW = 66

GWP = 150

d = 0.911 g/cc

ODP = 0

Flammable

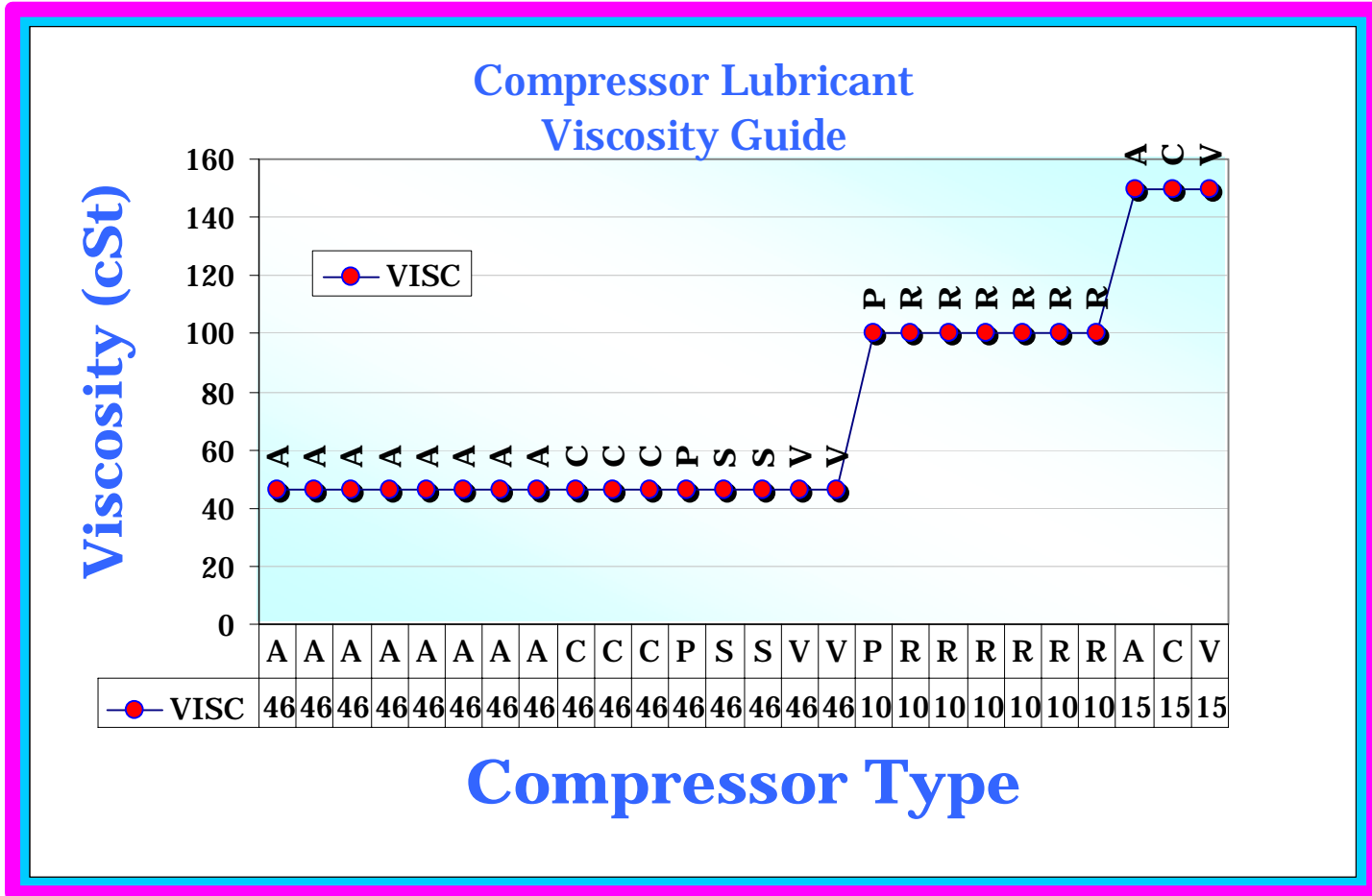
Hermetic Falex Pin and Vee Block

	Condition1	Condition2	Condition3	Condition4	Condition5
Pin	Steel (AISI3135)	Steel (AISI3135)	Steel (AISI3135}	Steel (AISI3135)	Steel (AISI3135)
V Block	Steel (AISI1137)	Steel (AISI1137)	Steel (AISI1137)	Steel (AISI1137)	Steel (AISI1137)
Rotating Speed	290	290	290	290	290
Load (lbs)				300	300
T (C) - initial	RT	RT	RT	RT	RT
P (psi)	72	72	72	72	72
Oil (gm)	95	95	95	95	95
Refrigerant	none	R-134a	R-152a	R-134a	R-152a
Testing	EP	EP	EP	Wear	Wear

Functional Requirements for Mobile A/C

- Miscibility in the Refrigerant
- Good Lubricity: Inherent polarity & affinity metal surfaces
- High VI
- Chemical and Thermal Stability: R-152a, Metals
- Material Compatibility Elastomers (HNBR, Neoprene)
- Low Pour Points ($< -30\text{ }^{\circ}\text{C}$)
- Flash Point ($> 150\text{ }^{\circ}\text{C}$ (CCC), $> 200\text{ }^{\circ}\text{C}$ (COC))
- Low Toxicity
- Viscosity Range: 50 – 150 cSt @ $40\text{ }^{\circ}\text{C}$

Compressor Type and Viscosity

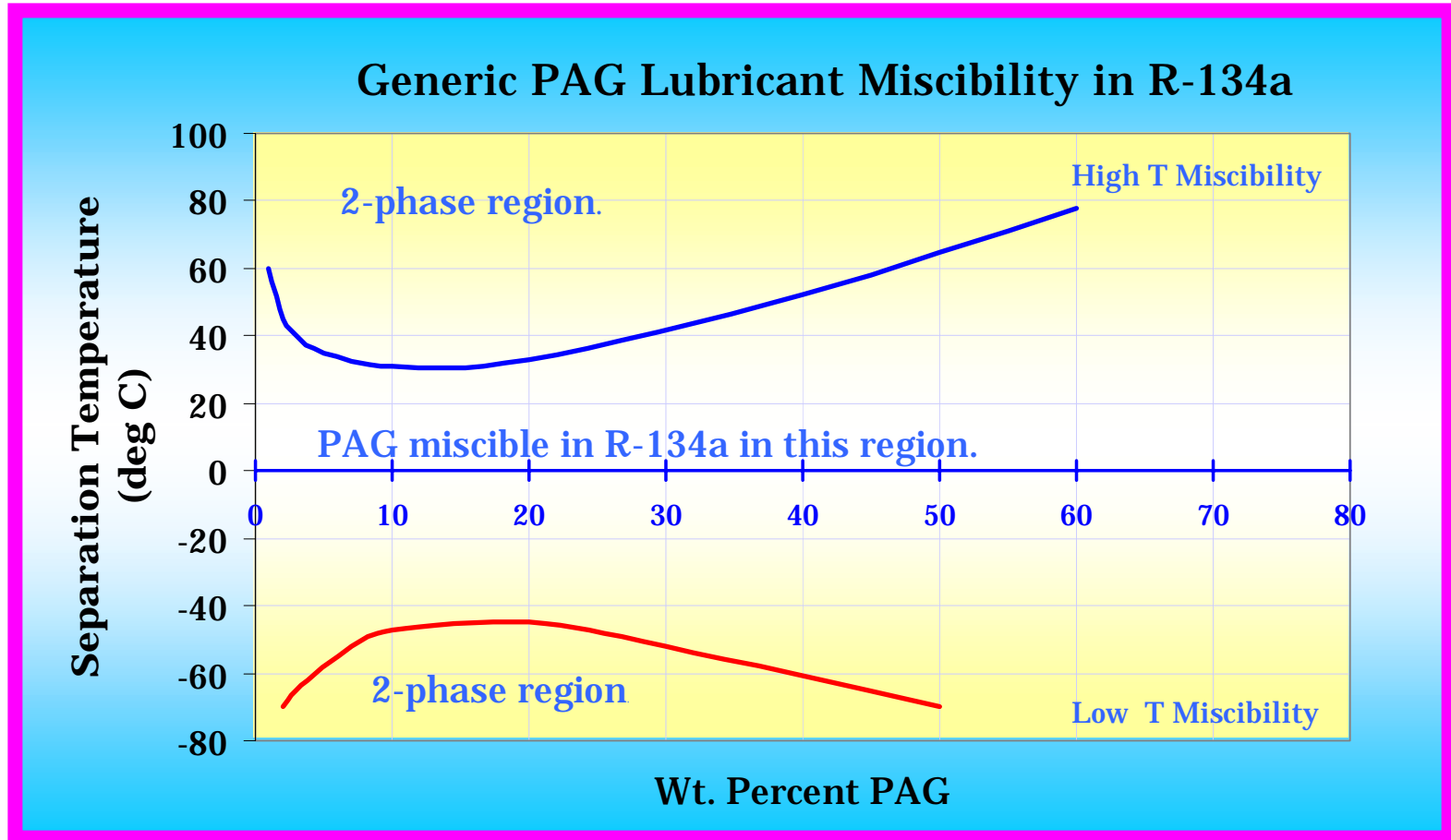


A=Axial Plate
 C= Crankshaft 6
 P= Planetary Socket Plate

R=Rotary
 S=Scroll
 V= Variable



Generic PAG Miscibility Diagram: R-134a



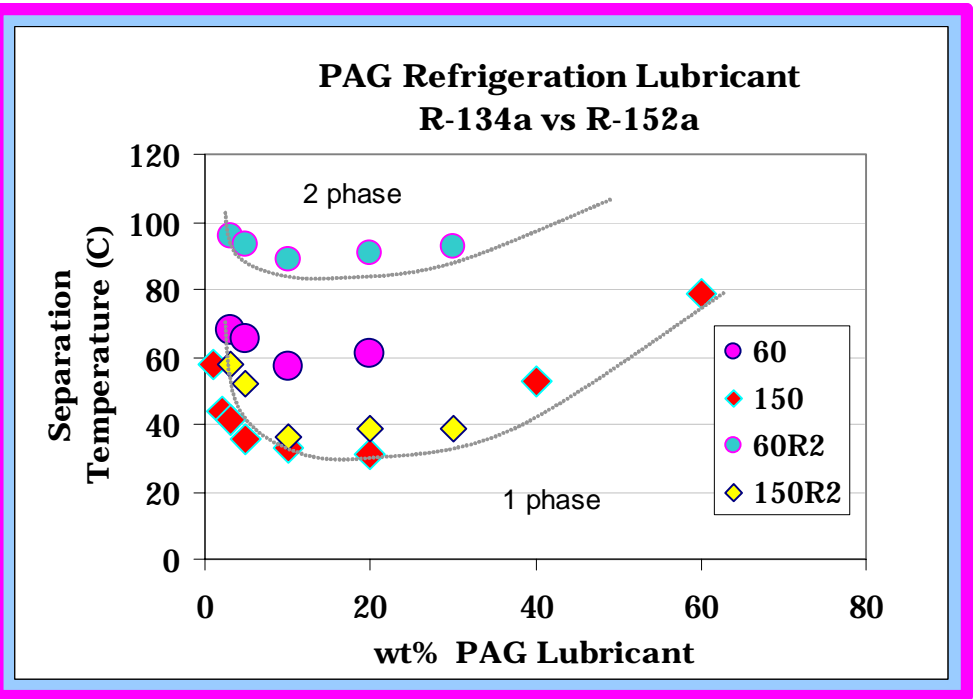
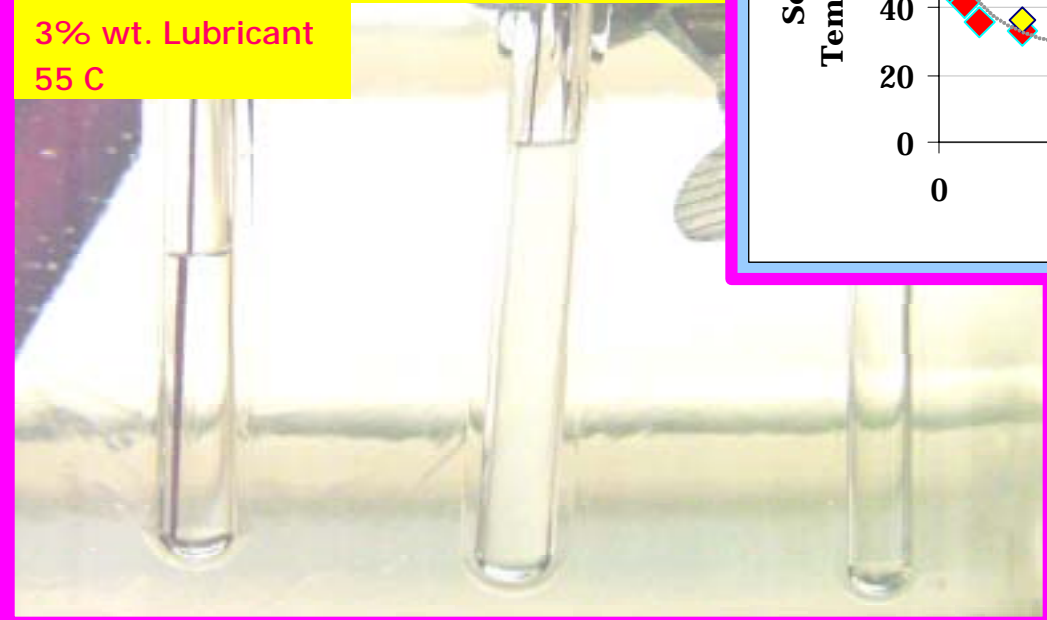
Miscibility of R-134a vs R-152a



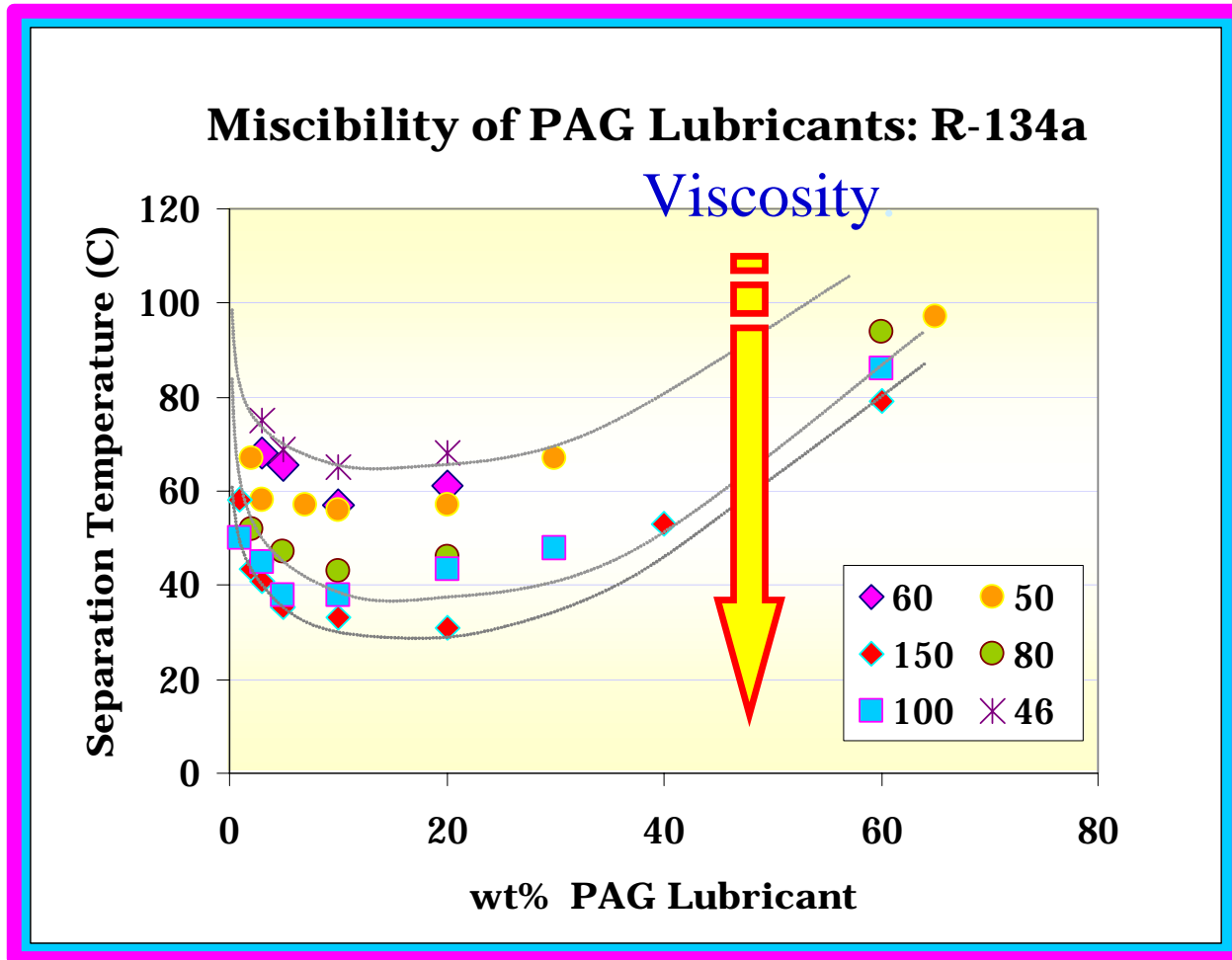
PAG Miscibility Alternative Refrigerant: R-134 vs R-152a

60R1 150R2 60R2

3% wt. Lubricant
55 C

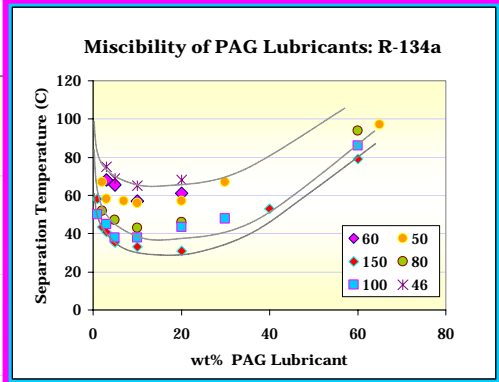
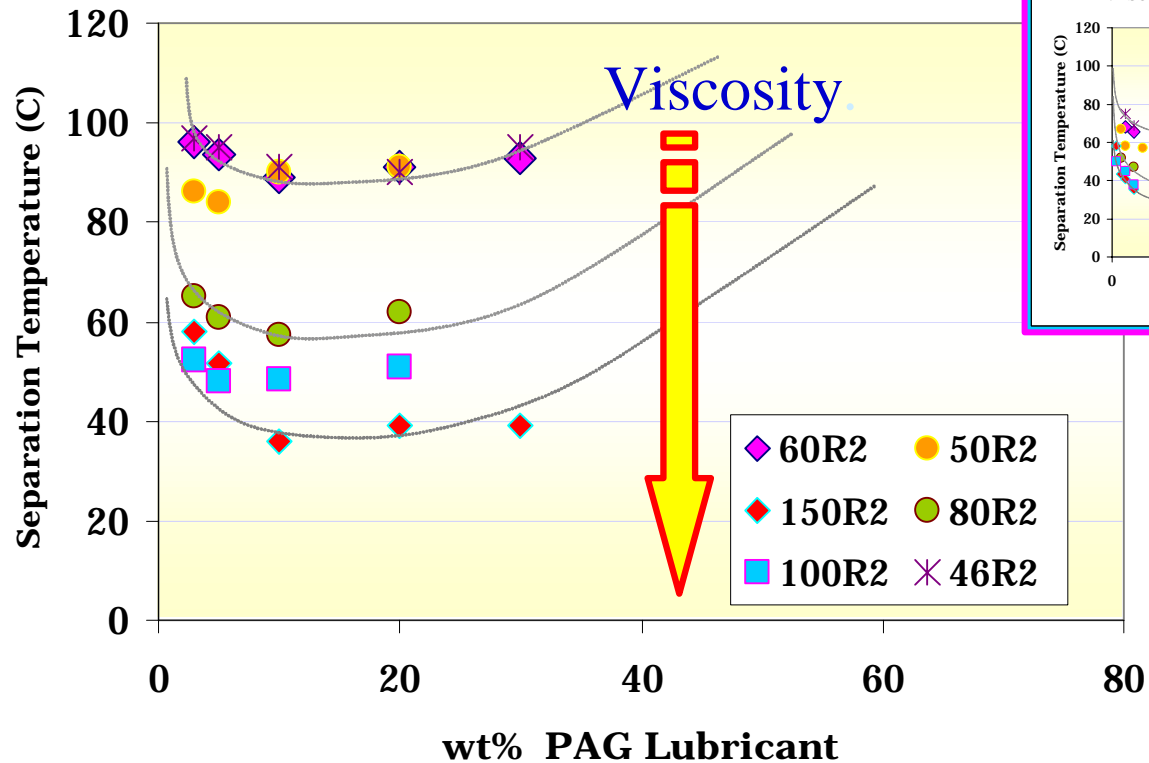


PAG Miscibility in Refrigerant R-134a

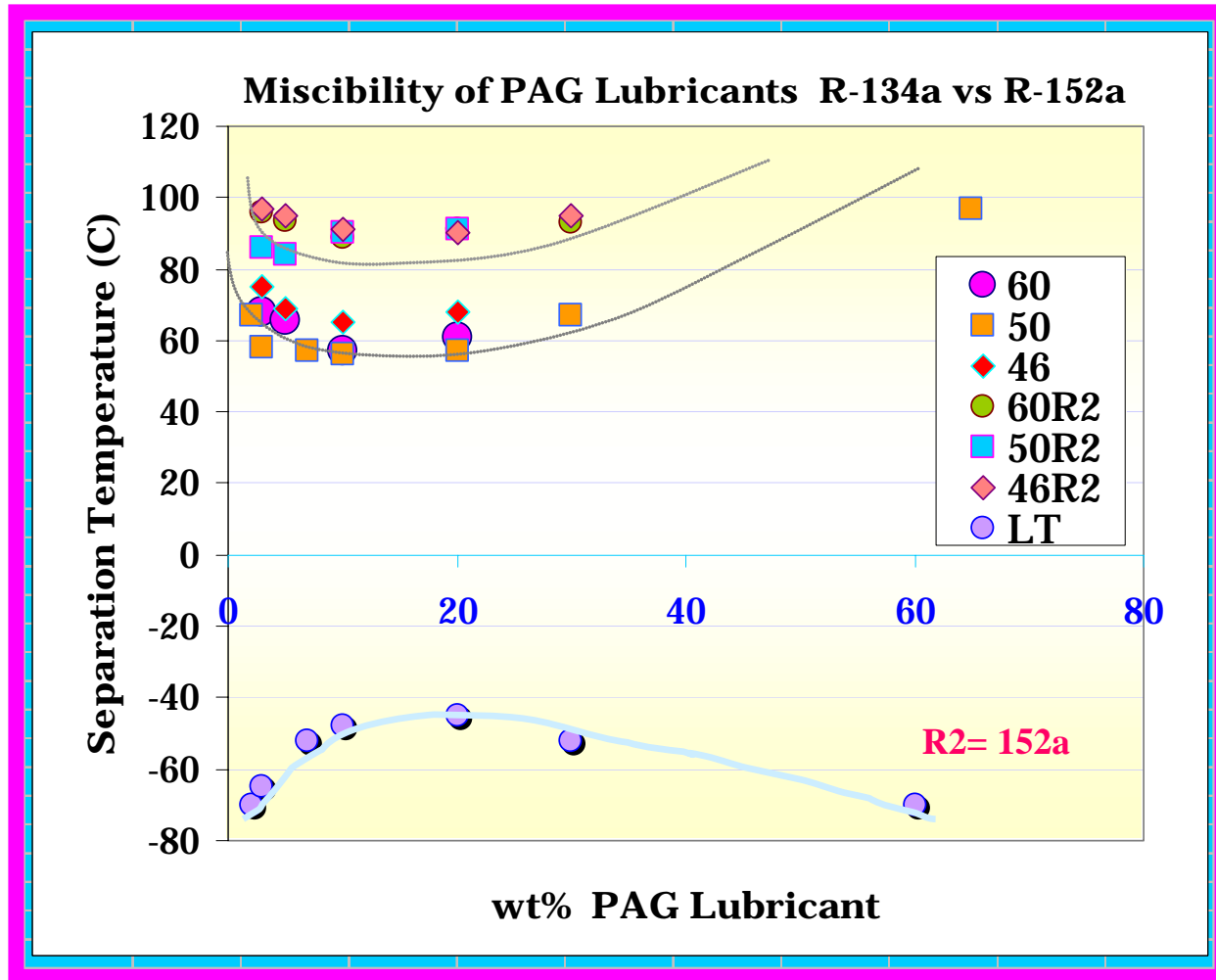


PAG Miscibility in Refrigerant R-152a

Miscibility of PAG Lubricants: R-152a



PAG Miscibility: R-134a vs R-152a



Miscibility of PAG Lubricants

- The miscibility of the PAG oil varies depending on oil chemistry specifics: EO and PO content and/or ratios, viscosity, MW.
- The *lower viscosity* oils showed more shift toward higher separation temperature compared to the higher viscosity.
- There are differences in miscibility behavior by switching from R-134a to R-152a, the trend is toward *higher* miscibility.

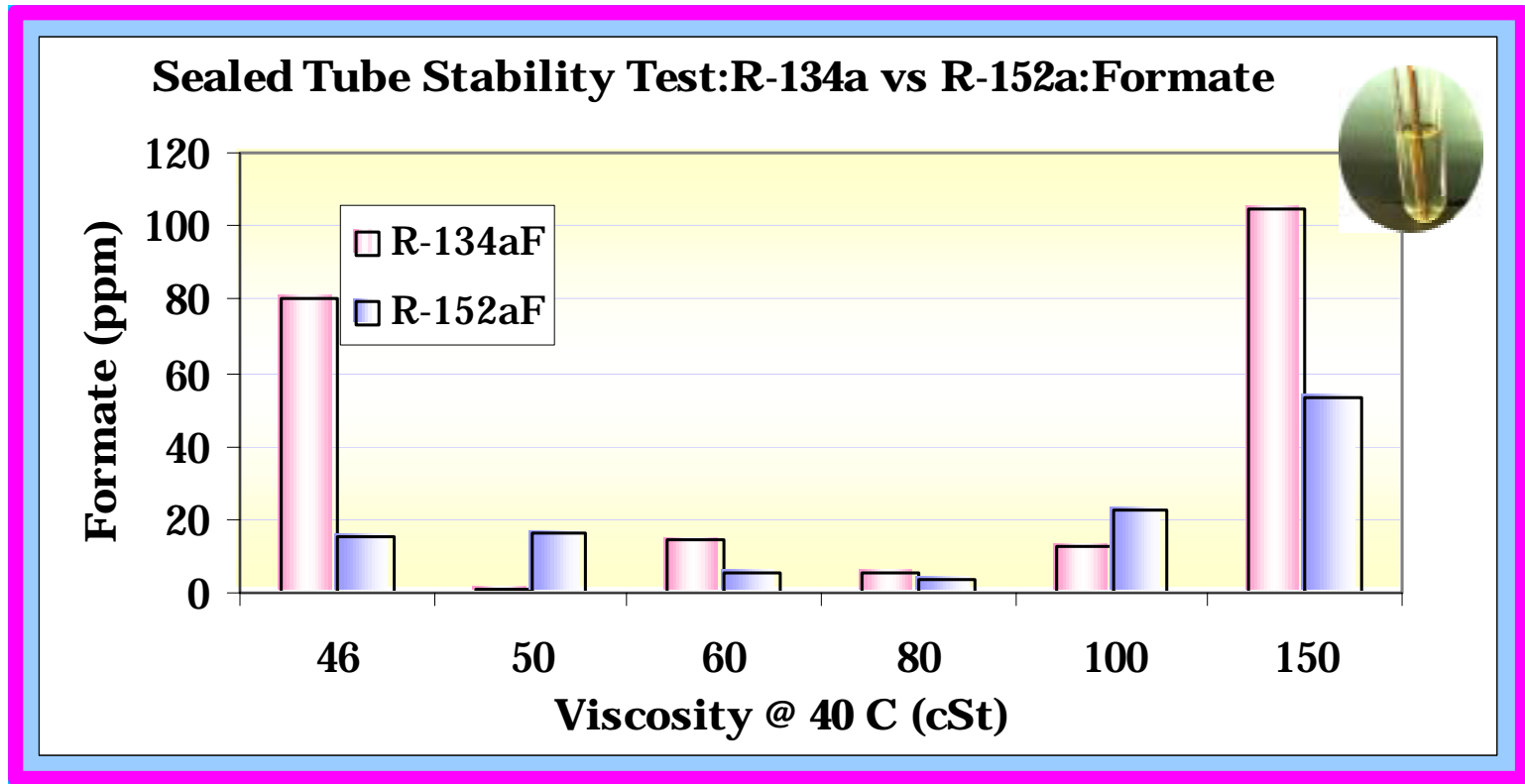
Thermal Stability Comparison

- Compare PAG and Refrigerant Type
- FTIR – no PAG degradation around the 1700 cm⁻¹
- ICP (< 10 ppm) - Cu, Al, Fe
- IC = F, Acetate, Formate
- Visual determination - all clear, colorless, fluid. No precipitates. All metals shiny.

175 C 14 days
Cu, Al, Fe
50/50 wt % Oil/Ref



Thermal Stability – R-134a vs R-152a

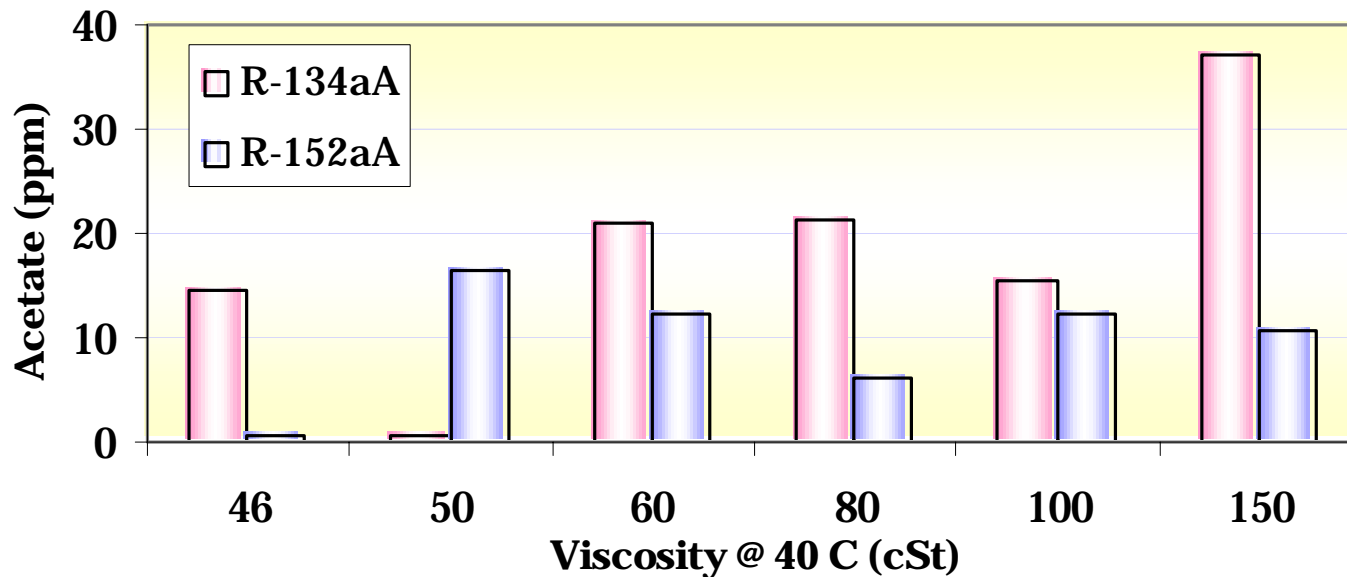


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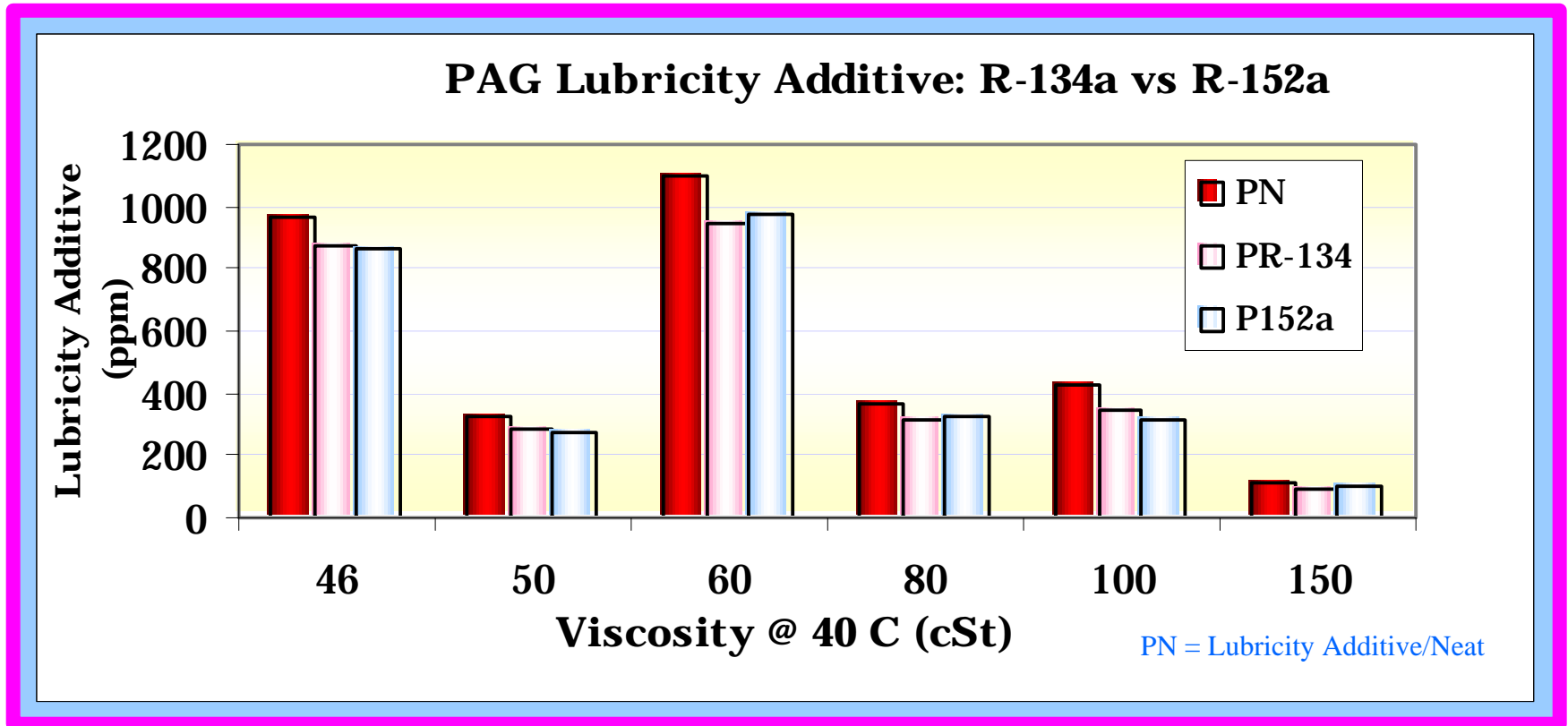
Thermal Stability: R-134a vs R-152a



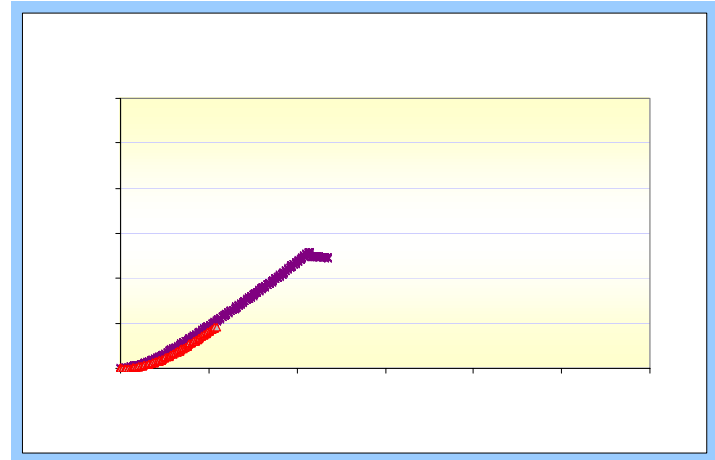
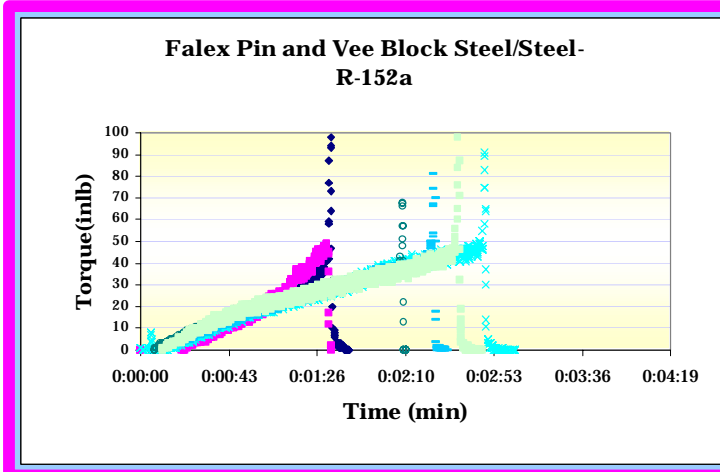
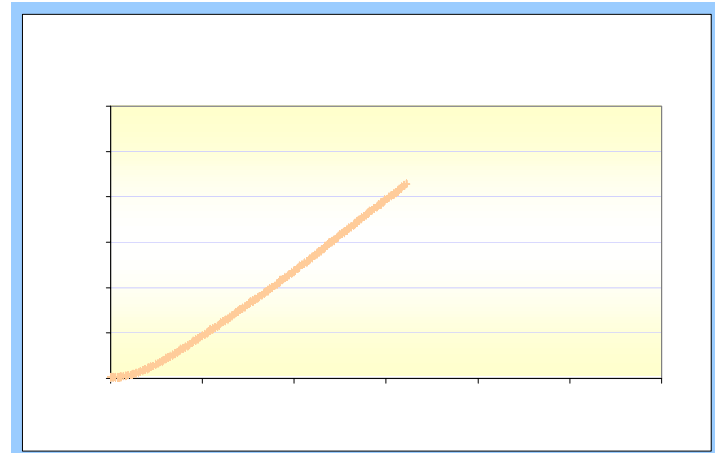
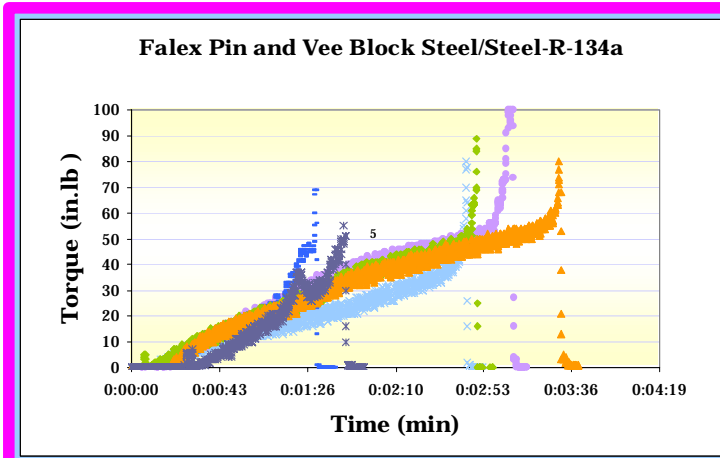
Sealed Tube Stability Test: R-134a vs R-152a: Acetate



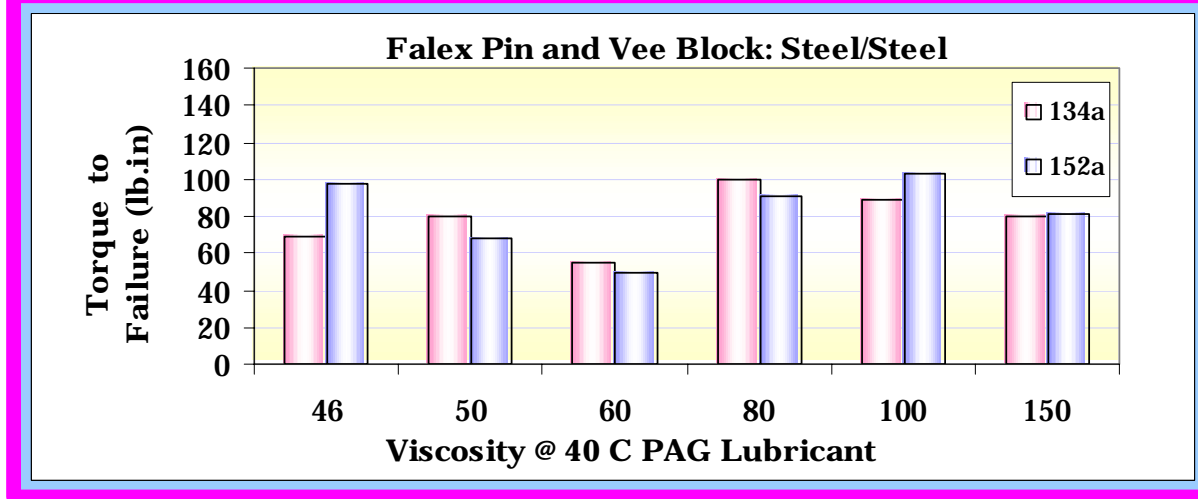
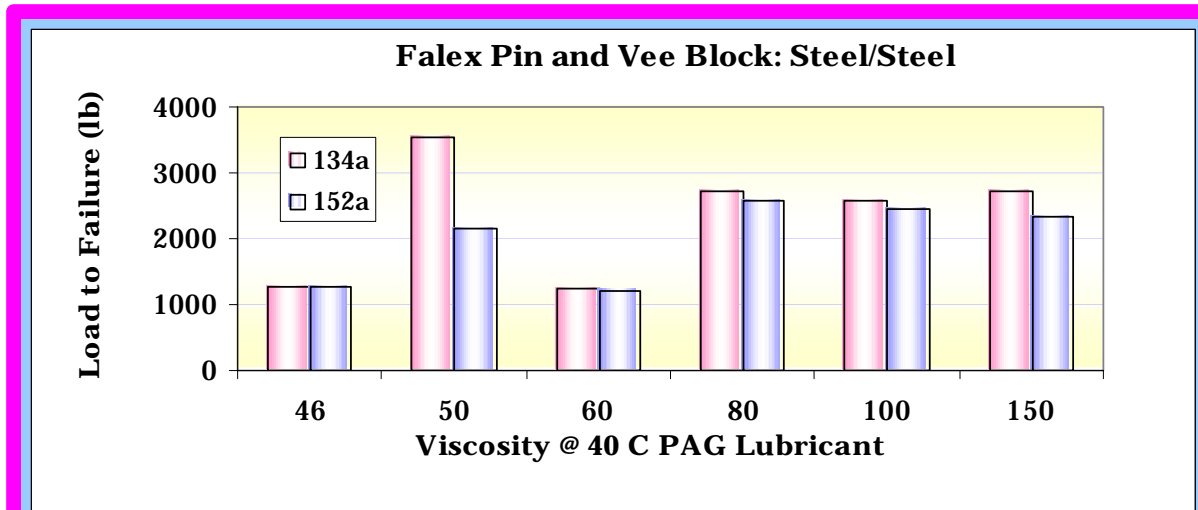
Lubricity Additive: Thermal Stability



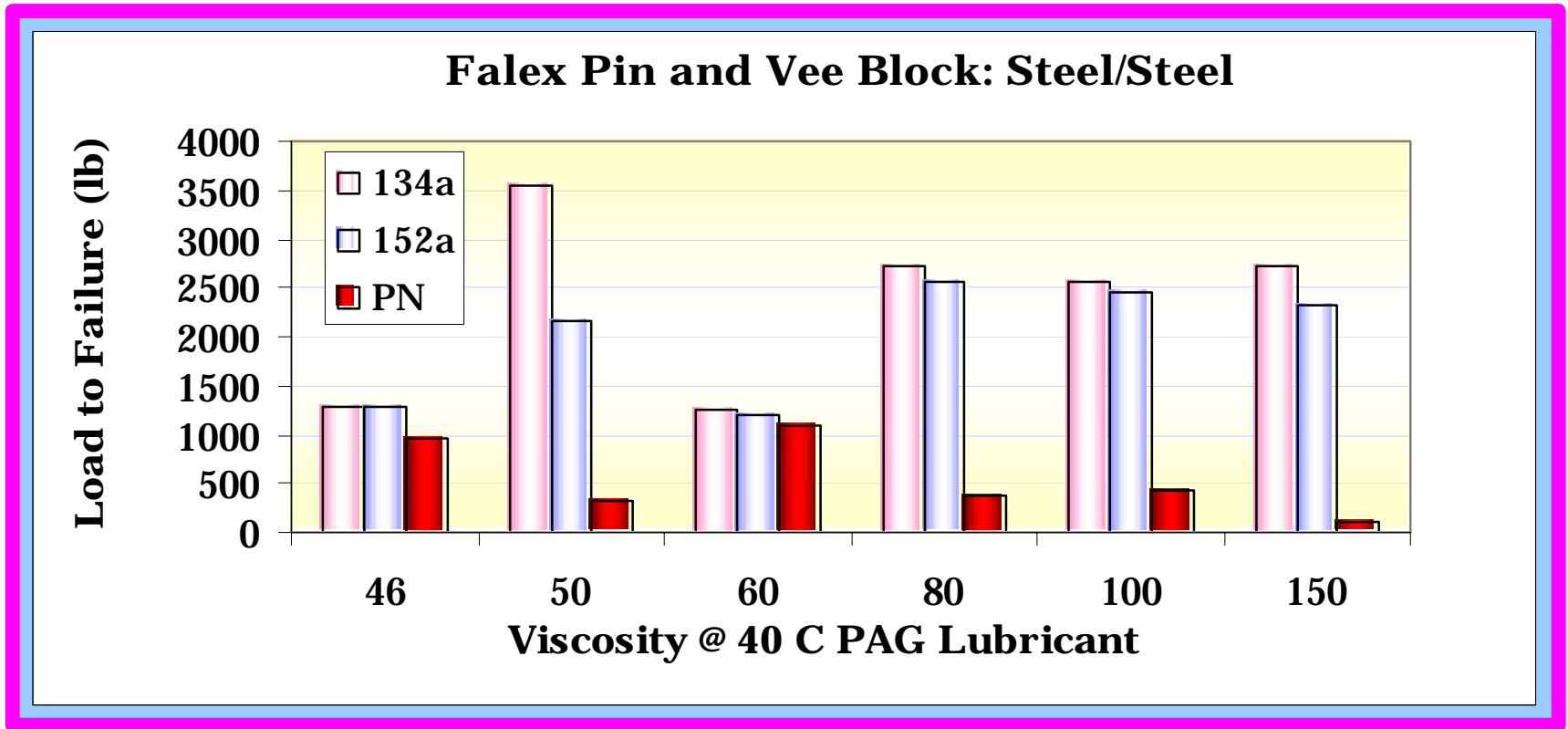
Extreme Pressure: Falex Pin and Vee Block



Extreme Pressure Falex Pin and Vee Block

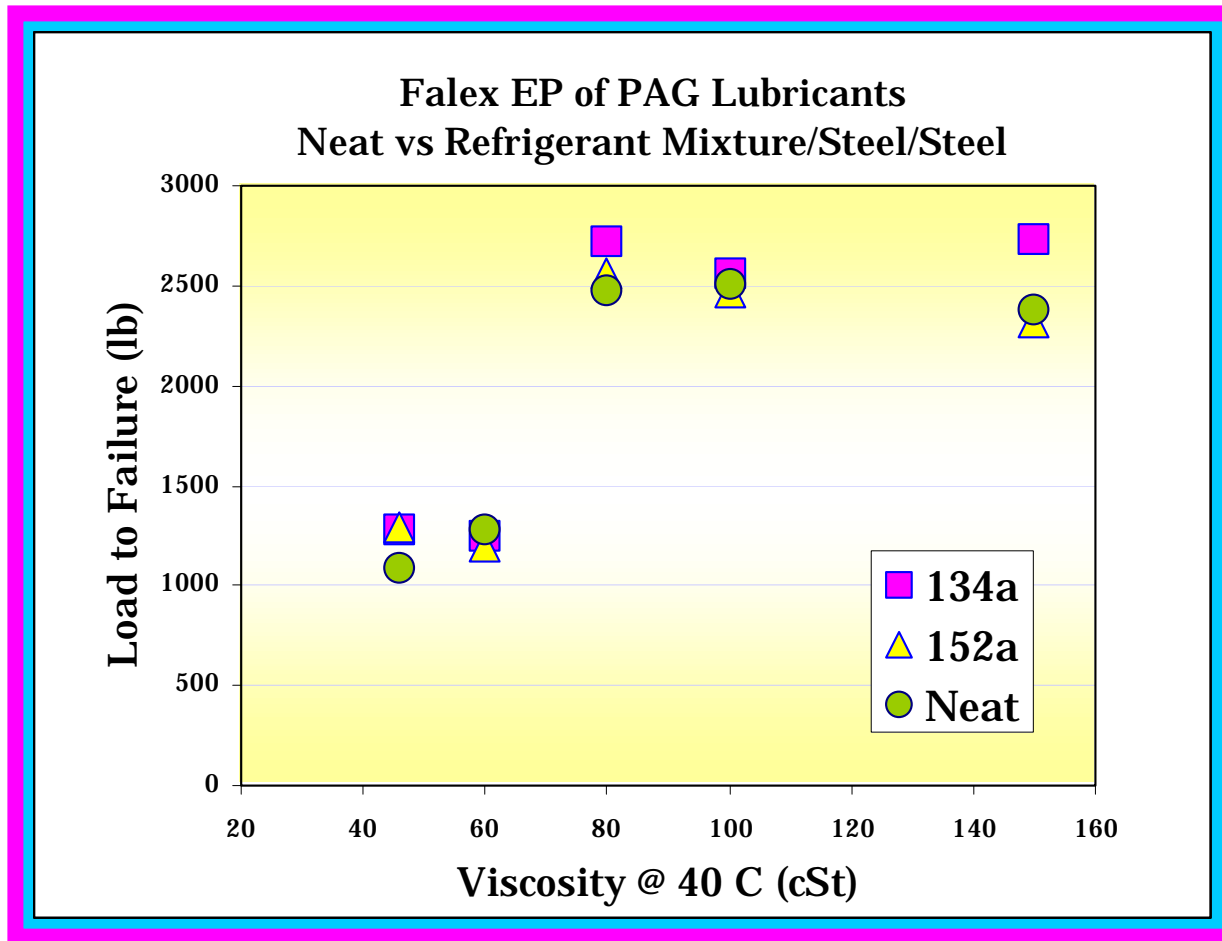


Falex Pin and Vee Block: Steel/Steel



Comparison of PAG Extreme Pressure

Neat vs Refrigerant Type: R-143a vs R-152A



Summary

- PAG Monol Lubricants for Mobile Air Conditioners have been shown to have good thermal stability with R-134a and Alternative Refrigerant R-152a.
- The miscibility of the PAG oil varies depending on chemistry specifics: EO and PO content and/or ratios, viscosity, MW.
- There are differences in miscibility behavior by switching from R-134a to R-152a, the shift is toward higher miscibility.
- The main differences in Falex Extreme Pressure (Steel/Steel) lubrication were a result of the differing PAG's structure, less effect due to the refrigerant type.
- For the series of PAG analyzed (46-150 cSt) there was not a direct correlation between lubricity additive content and Falex Pin and Vee Block load to failure.

Future Work

- Complete Extreme Pressure Steel Pin/Al Block vs. Refrigerant Type
- Test for Wear Steel/Steel and Steel/Al Falex Pin and Vee Block vs. Refrigerant Type.
- Conduct hydrolytic stability via sealed tube tests and compare R-134a vs R-152a.

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