Chillventa Specialist Forums 2024
Chillventa Fachforen 2024

CONNECTING EXPERTS.

Natural Refrigerant Gases and their Effects on Lubricant Properties

NEXT LUBRICANTS

BOOTH 7-111

Key Properties of a Refrigeration Lubricant

- Provides minimum viscosity for lubrication
- Good cold temperature properties
- Immiscibility/Miscibility with Refrigerant
- Seal compatibility
- Protects against corrosion
- Reduces heat

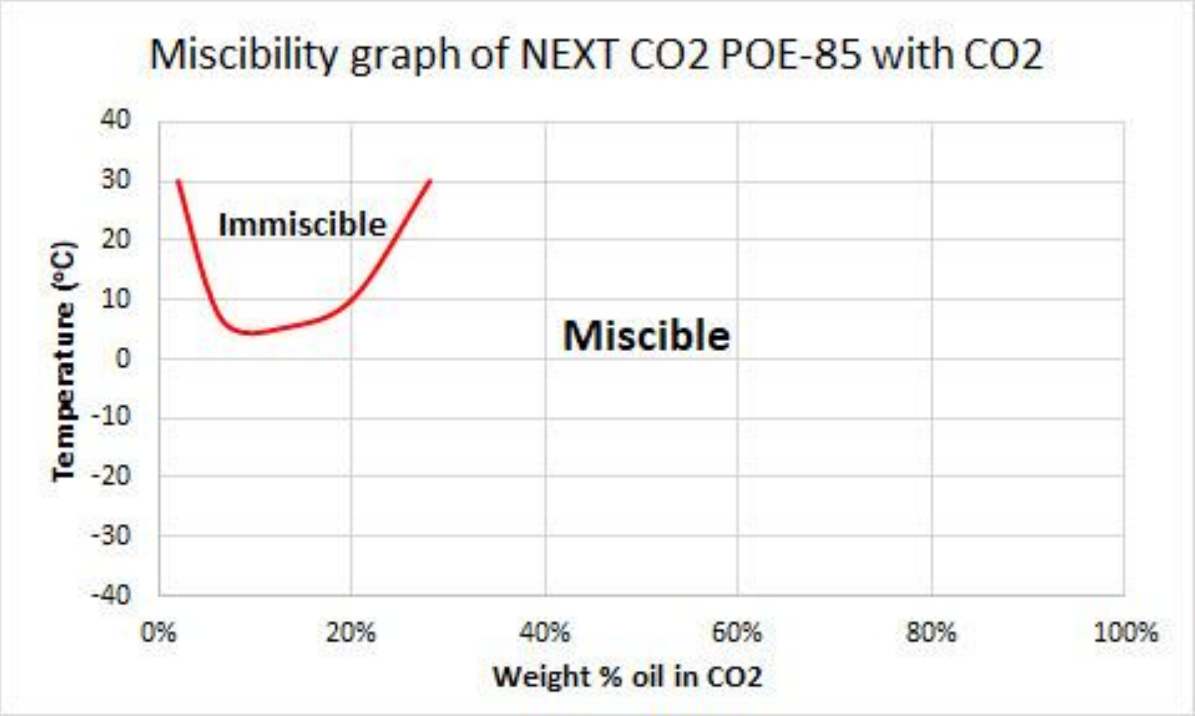
Miscibility vs Solubility

- Miscibility: The ability of a refrigerant to completely mix with a lubricant. Depending on the type of refrigerant and lubricant mixture there is often a maximum concentration of refrigerant that can be dissolved into a lubricant

- Solubility: The extent to which a refrigerant can dissolve in a lubricant. In refrigeration lubricant solubility is typically referenced when determining the effect that a refrigerant will have on the properties of a lubricant

Miscibility

- Miscibility is dependent on temperature.
- Within the miscible regions the lubricant/refrigerant will form a homogeneous mixture
- Outside the miscible regions the lubricant will separate from the refrigerant.



Non-Miscible Systems

- These systems avoid miscibility
- Lubricant that escapes into the refrigeration system reduces system efficiency
- Theses systems use separator-coalescer to separate the refrigerant from the lubricant
- Separator-coalescers cannot remove oil vapour
- Oil return system is often necessary
- Ammonia systems are typically non-miscible systems

Miscible Systems

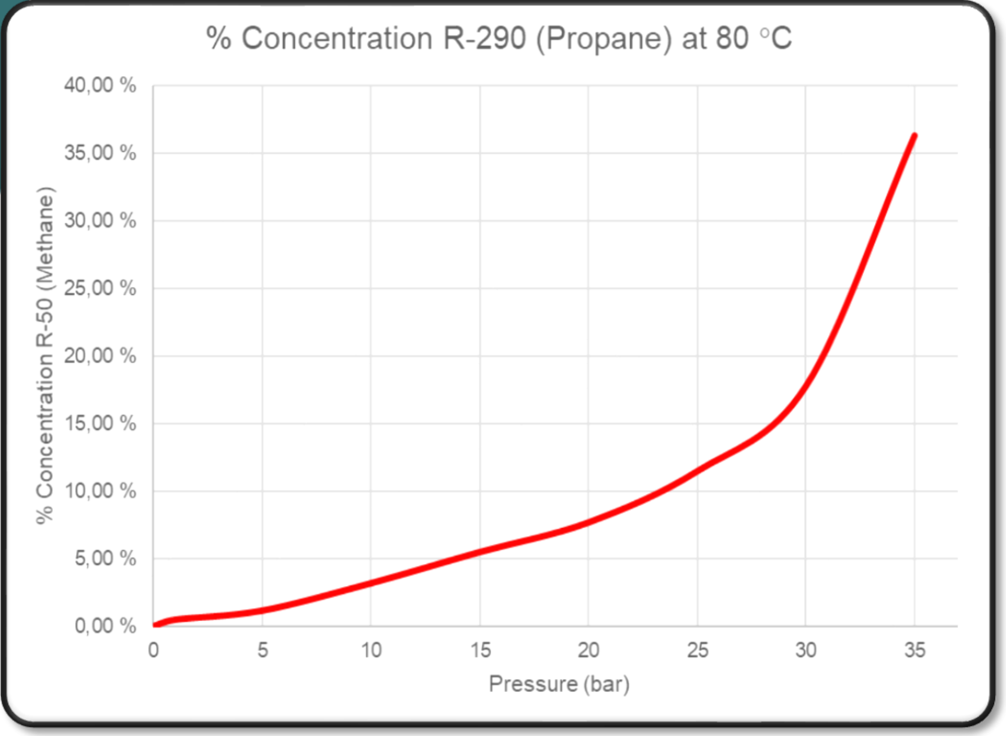
- Required in DX systems
- This is necessary as there are no mechanical means of separating the lubricant from the refrigerant
- The refrigerant substantially reduces the viscosity of the oil, this improves flow at low temperatures
- If the refrigerant and oil are not miscible then the oil will collect at the cold points of the system and act as an insulator

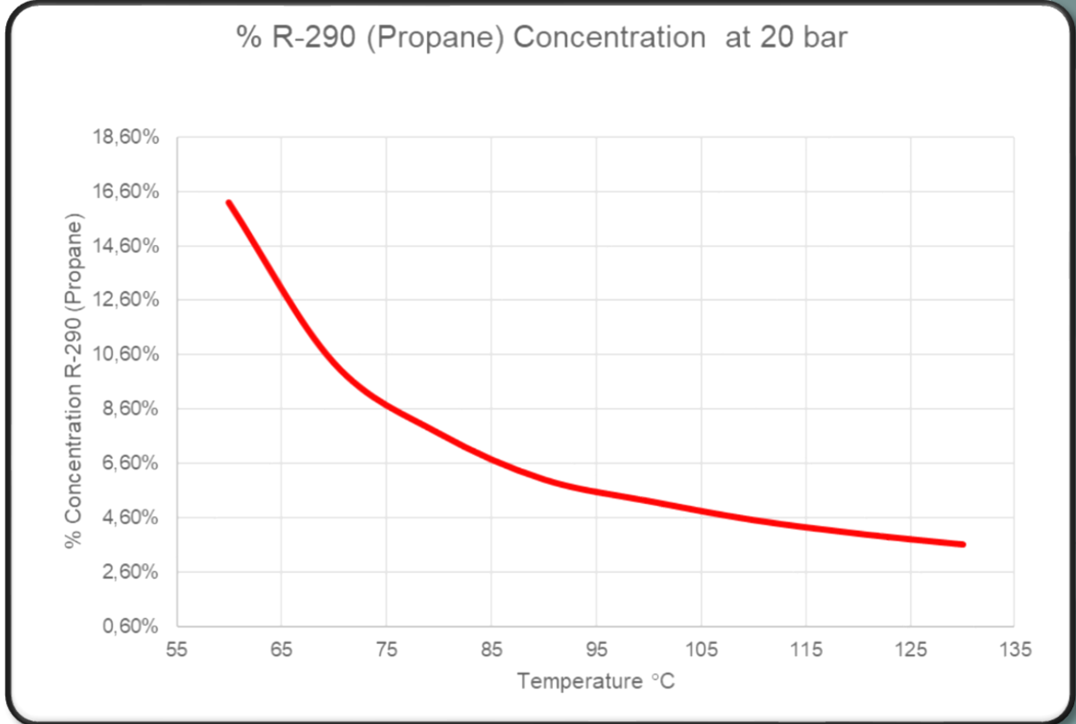
What Controls Solubility

- Refrigerant lubricant solubility is influenced by
    - Pressure
    - Temperature
    - Polarity of gas and lubricant
    - Molecular weight of gas
      and (average) molecular weight of lubricant

Pressure and Temperature Relationship

- Refrigerant lubricant solubility increases with increasing pressure
- Refrigerant lubricant solubility decreases with increasing temperature



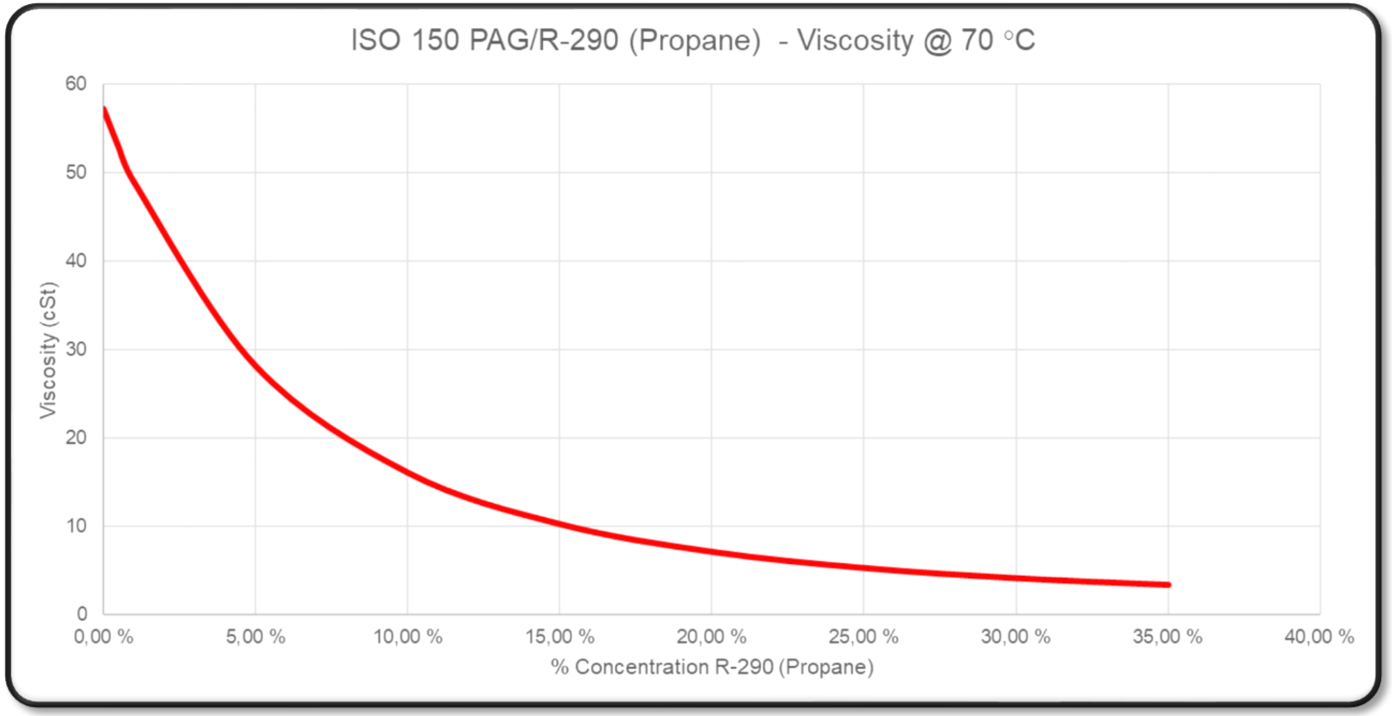


NEXT LUBRICANTS

BOOTH 7-111

Effect of Solubilized Refrigerant - Viscosity

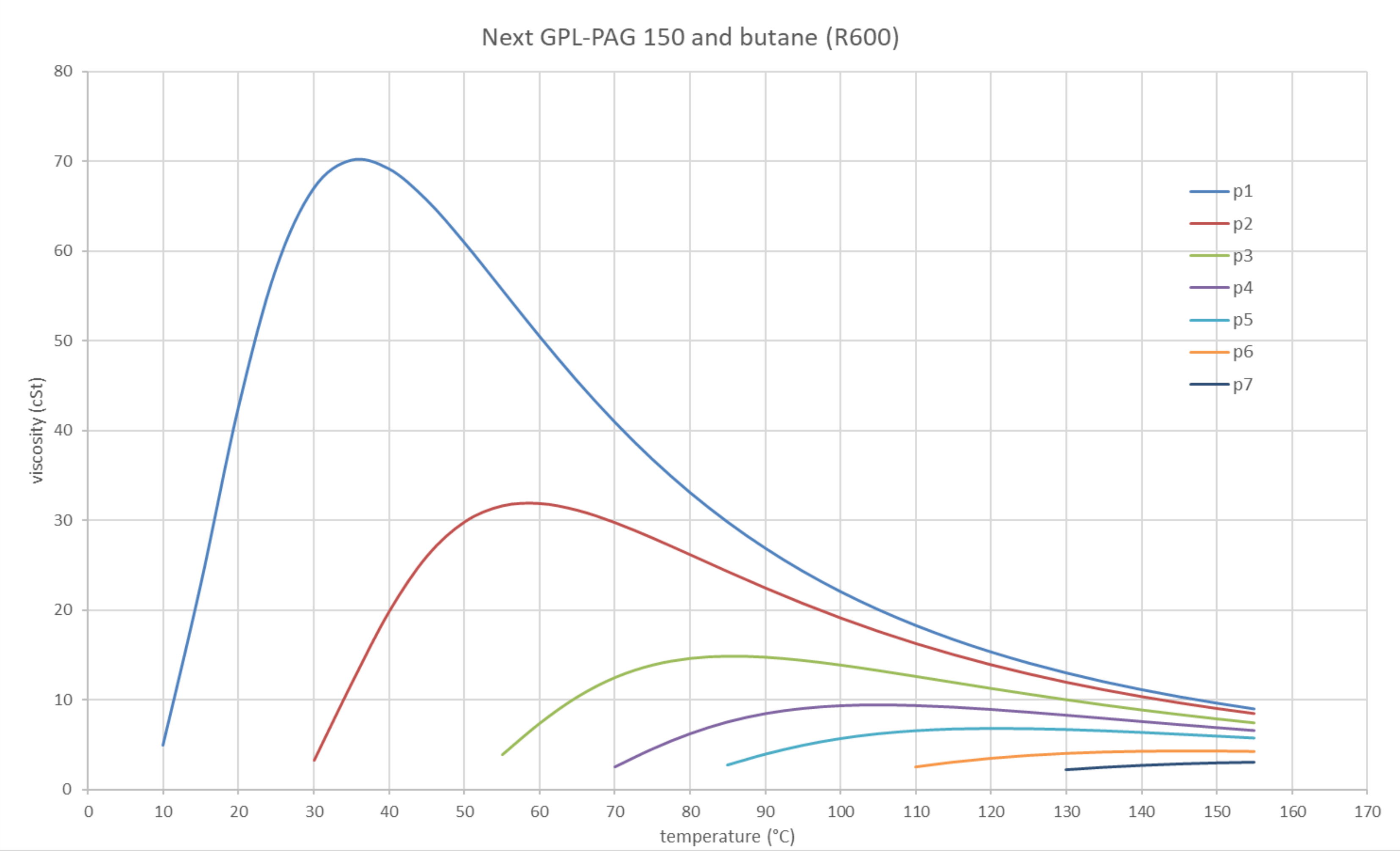
- Solubilized refrigerant can substantially reduce a lubricants viscosity
- To provide proper lubricity the lubricant viscosity must not decrease below minimum operating levels.
- If the diluted viscosity of the oil is too low a higher viscosity lubricant may be required or an alternatively a lubricant with a reduced refrigerant affinity should be selected



BOOTH 7-111

Effect of Solubilized Refrigerant - Viscosity

- The temperature/solubility relationship can override the normal viscosity temperature relationship

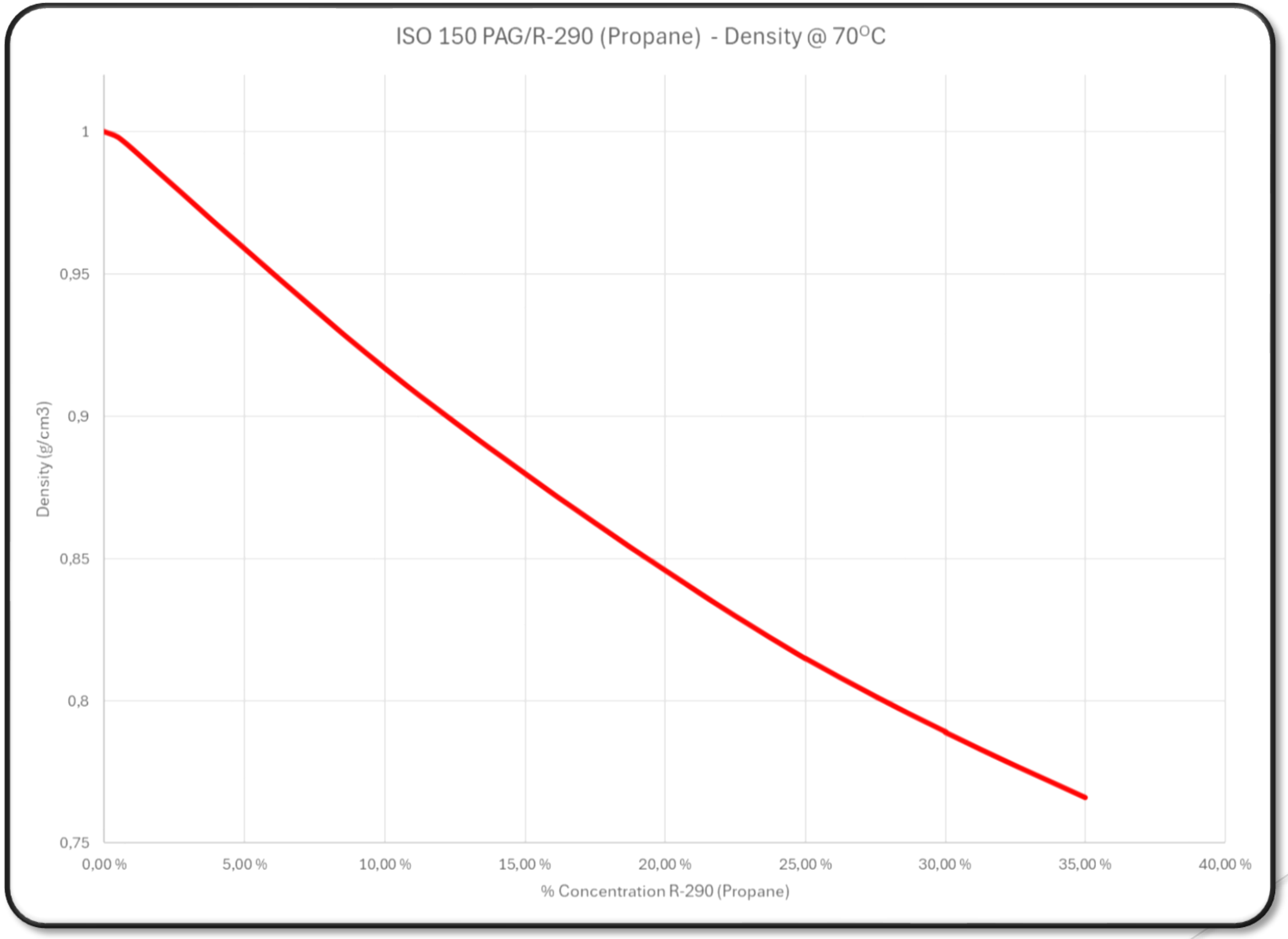


NEXT LUBRICANTS

BOOTH 7-111

Effect of Solubilized Refrigerant - Density

- Dissolved refrigerant will also decrease the density of a lubricant
- Changes in density can affect oil collection

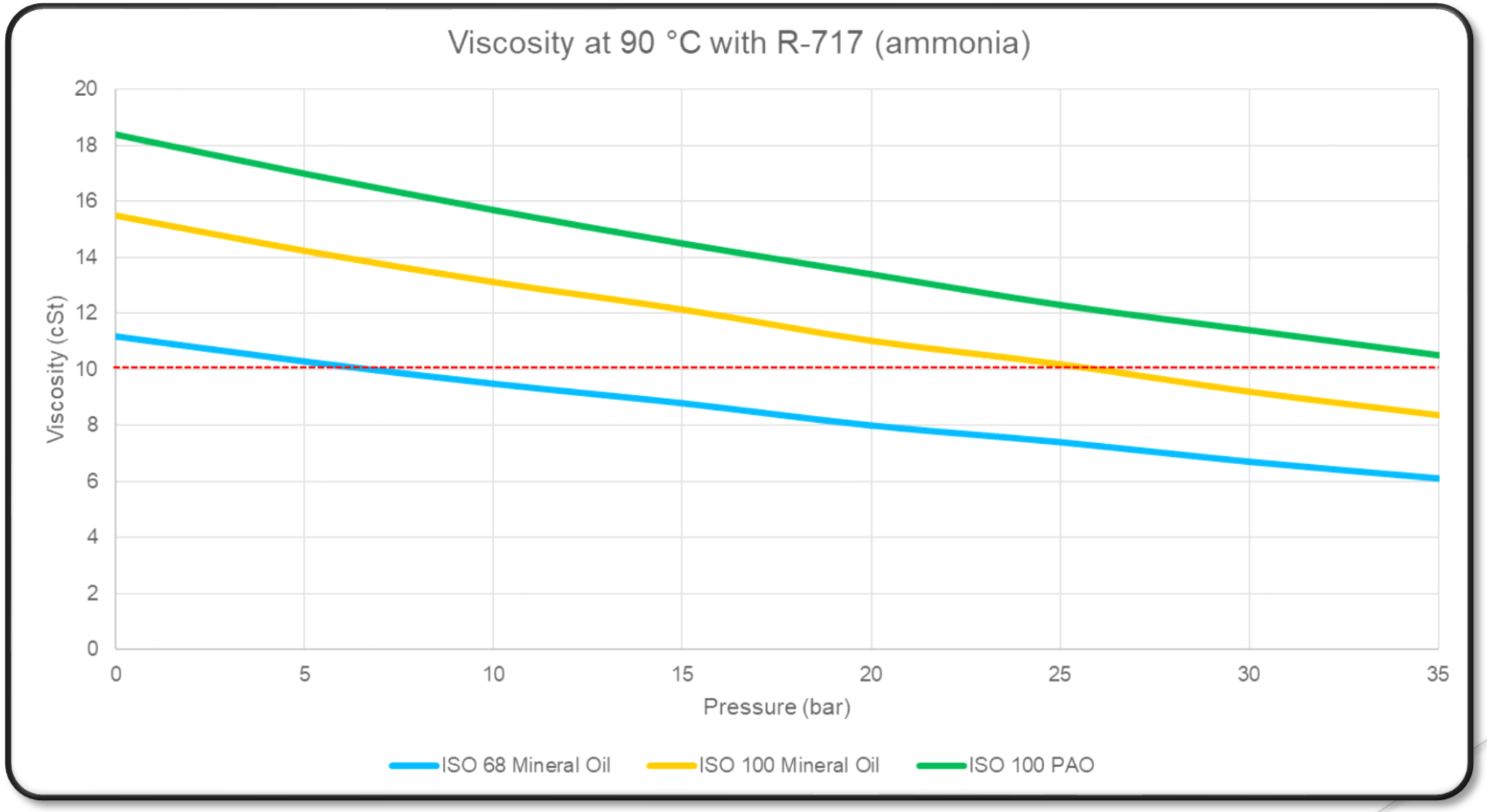


NEXT LUBRICANTS

BOOTH 7-111

Effect of Solubilized Refrigerant - Viscosity

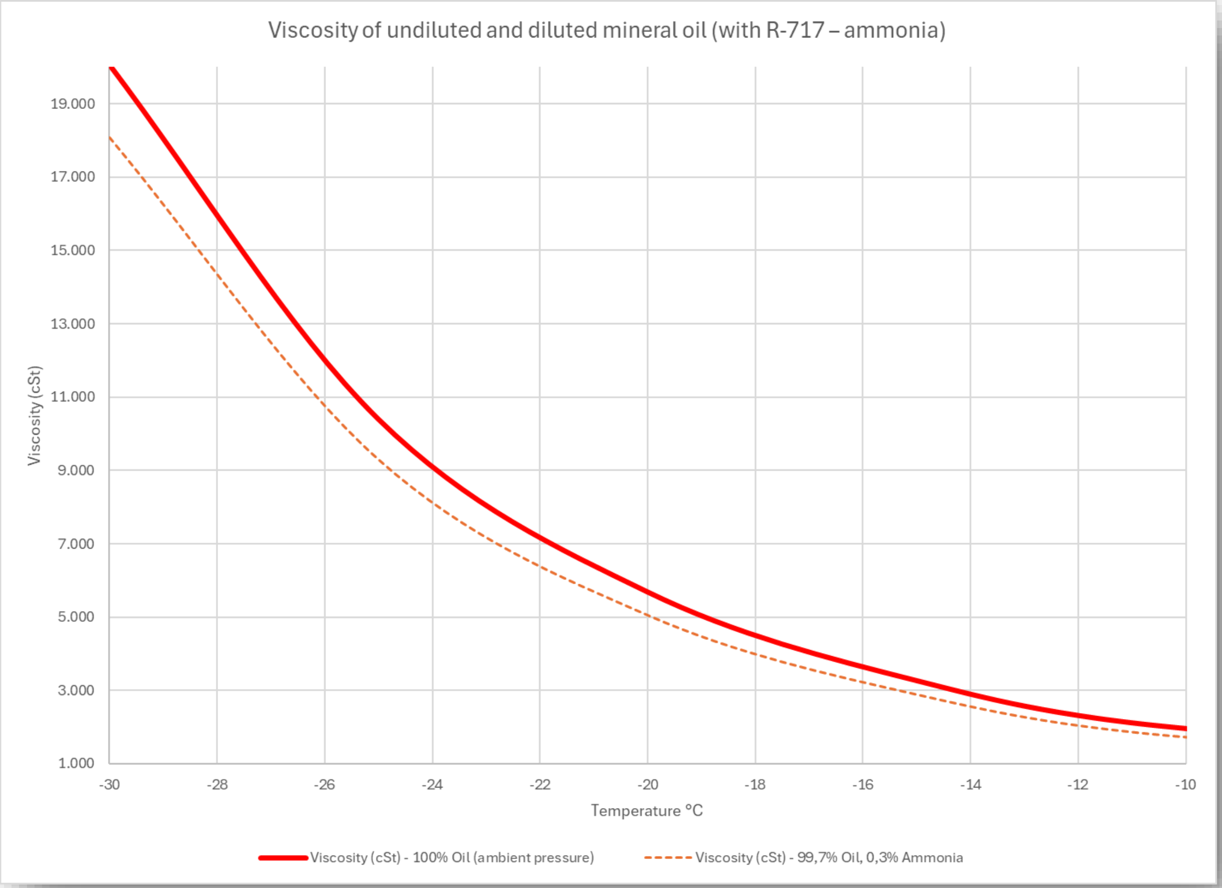
- To provide proper lubricity the lubricant viscosity must not decrease below minimum operating levels (typically 10 cSt)
- If the diluted viscosity of the oil is too low a higher viscosity lubricant may be required or an alternatively a lubricant with a reduced refrigerant affinity should be selected



BOOTH 7-111

Effect of Solubilized Refrigerant – Low Temp Viscosity

- Viscosity dilution can be beneficial as at low temperatures it can promote oil return.
- Even in immiscible systems ammonia can lower the viscosity.

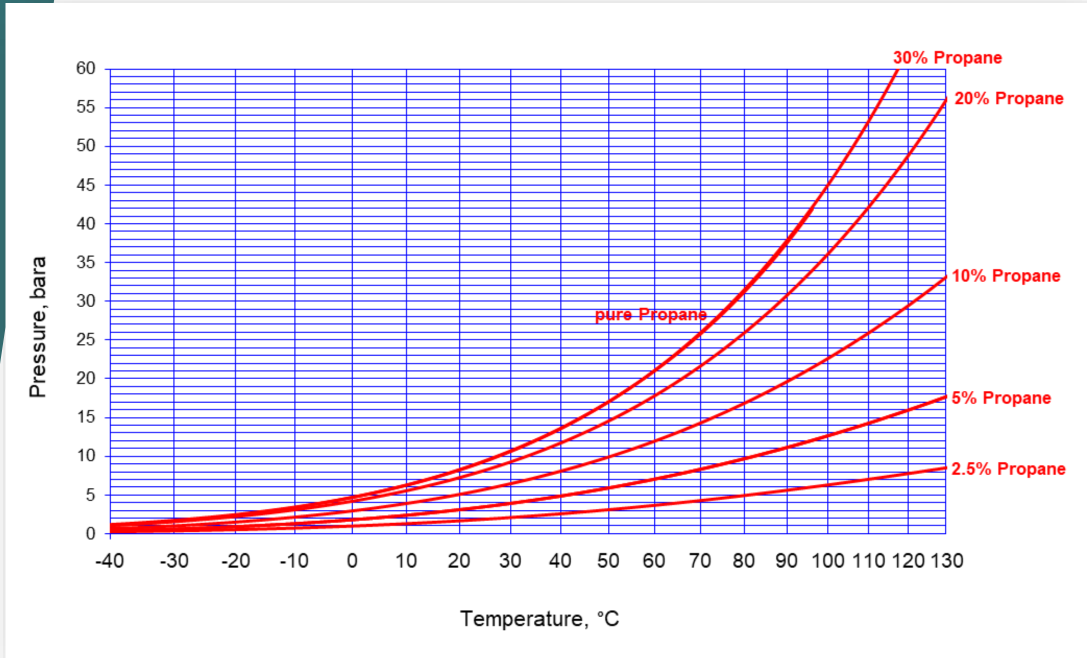


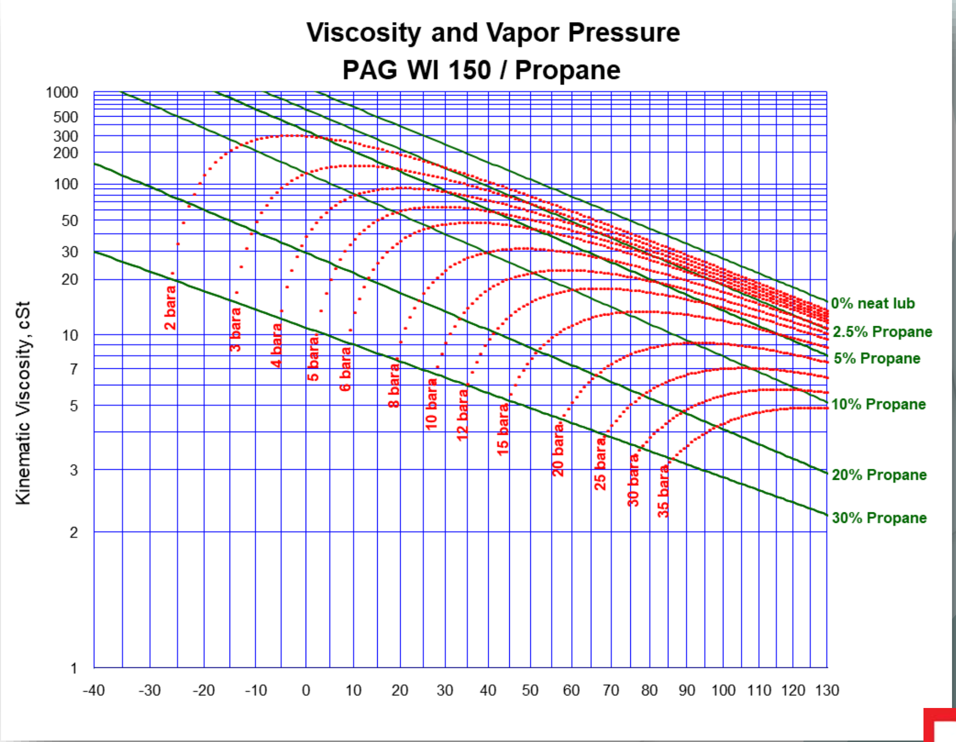
Condition	Viscosity (cSt) at -35ºC
Ambient	41.160
0,3 % Ammonia	37.452

Condition	Pour Point ºC
Ambient	-42
0,3 % Ammonia	-45

Determining the Right Viscosity

- Pressure vs Temperature (PVT) charts are provided by manufactures and can be used to predict the amount of refrigerant that will dissolve into the oil and the resulting diluted viscosity
- Example: A pressure of 17 bar at 85 °C = >10% butane – 11 cSt
  (from 38 cSt, 71% reduction in viscosity)





NEXT LUBRICANTS

BOOTH 7-111

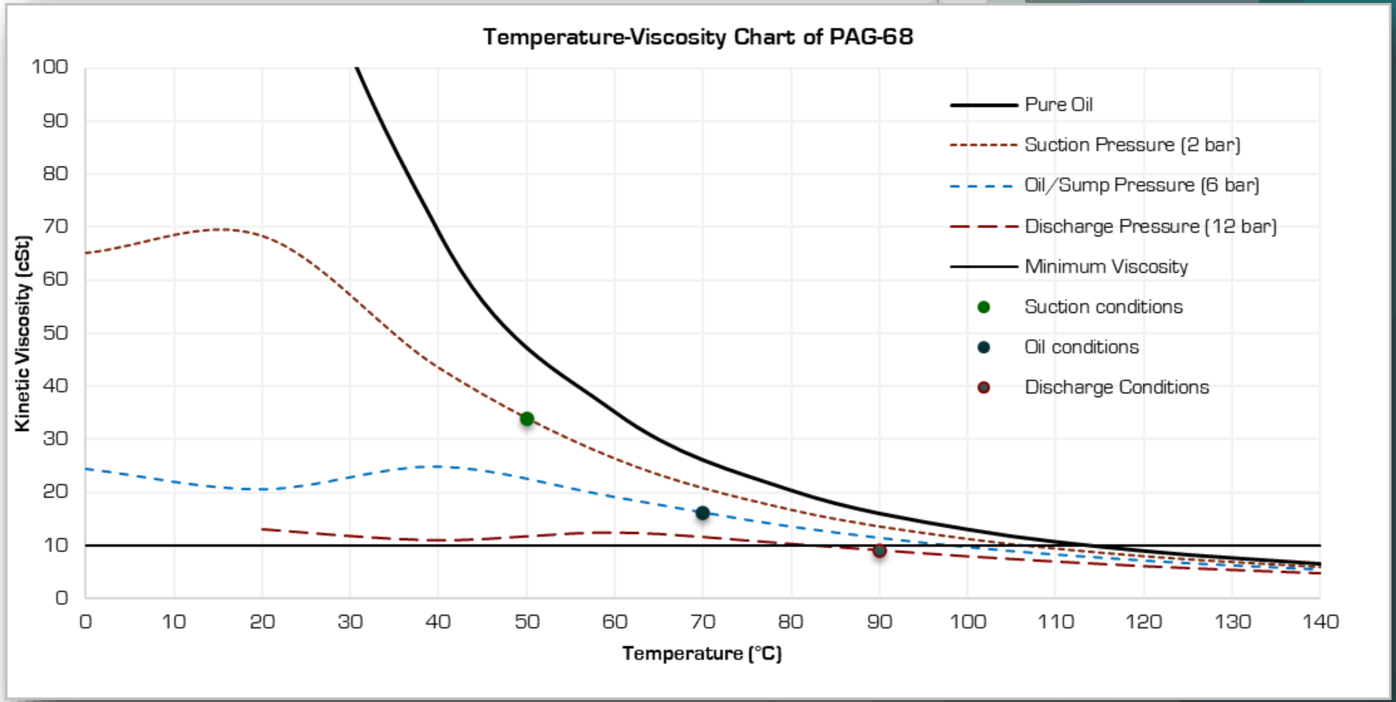
Determining the Right Viscosity

- Calculator tools can more accurately predict the quantity of dissolved refrigerant and resulting viscosity dilution
- It is also possible to more easily predict the resulting dilution over a wider temperature range

Compressor Brand and Model:	Chillventa
Compressor Type: (reciprocating, screw,scroll,certifugal, etc)	Conference
Compressor Serial Number:	2024-10

Compressor Suction Temperature (°C):	50
Compressor Suction Pressure (bar):	2
Compressor Discharge Temperature (°C):	90
Compressor Discharge Pressure (bar):	12
Operation Oil Temperature (°C): Sump Temperature / Oil Injection Temperature	70
Operating Oil Pressure (bar): Sump pressure	6
Minimum required viscosity (cSt):	10

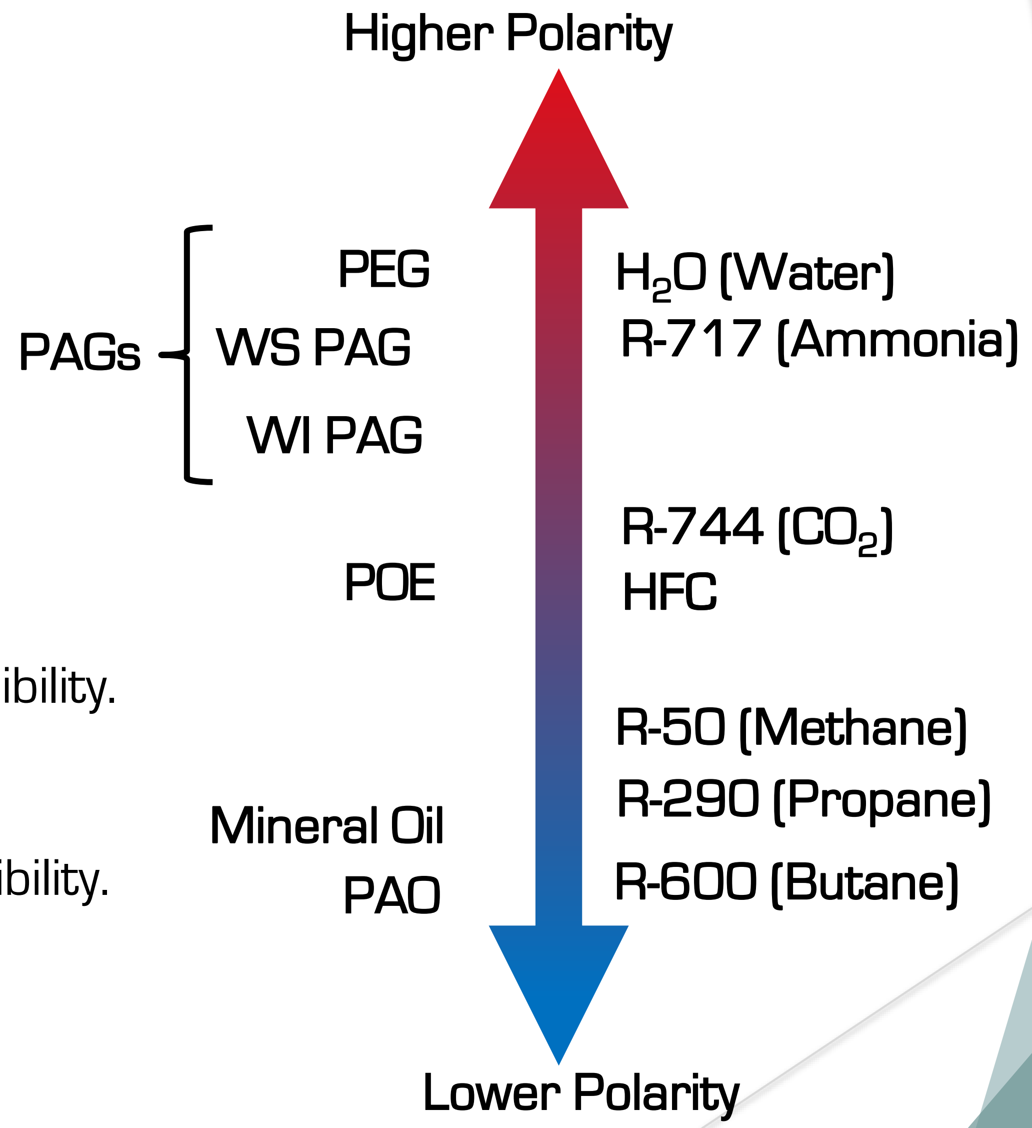
Gas composition	Mol %
Methane	20,00%
Ethane	40,00%
Propane	20,00%
Isobutane	
n-Butane	10,00%
Isopentane	
n-Pentane	5,00%
Hexanes	
C7+	
Carbondioxide	5,00%
Hydrogensulfide	
Nitrogen	
Oxygen	
Helium	
Hydrogen	
Water Vapor	
TOTAL %	100,00%



BOOTH 7-111

Affinity of lubricants with refrigerants

- Typically determined by polarity
- Lubricants and refrigerants with similar polarity have greater miscibility.
- Lubricants and refrigerants with opposite polarity have lower miscibility.



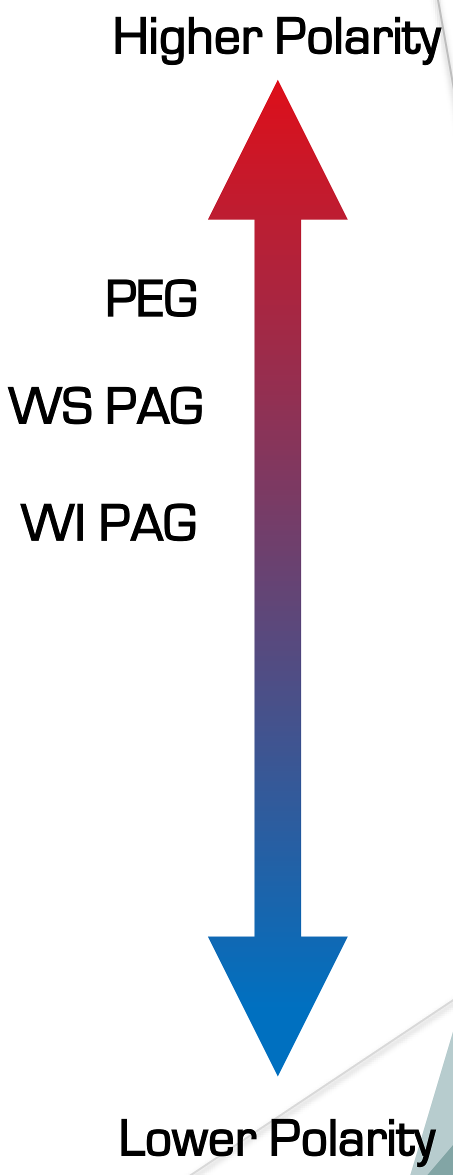
BOOTH 7-111

Types of PAGs

- Water Insoluble PAG (WI PAG)
  - Composed of solely propylene oxide
  - Most typical PAG base oil for hydrocarbon refrigeration systems
  - Good miscibility with hydrocarbon refrigerants and suitable for DX-systems

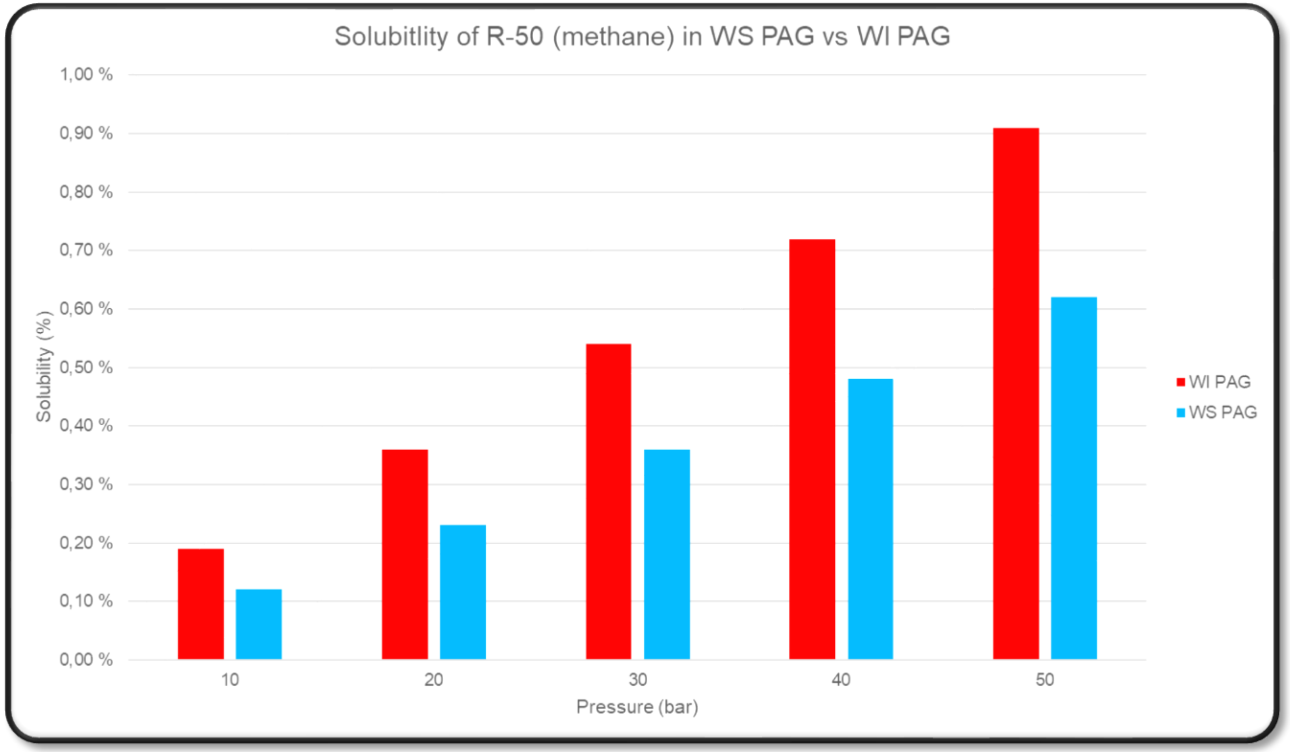
- Water Soluble PAG (WS PAG)
  - Composed of a mixture of propylene and ethylene oxide (typically 50/50)
  - Higher density
  - Recommended for gas compression for heavier hydrocarbons
  - Lower dilution with hydrocarbon gasses than WI PAGs

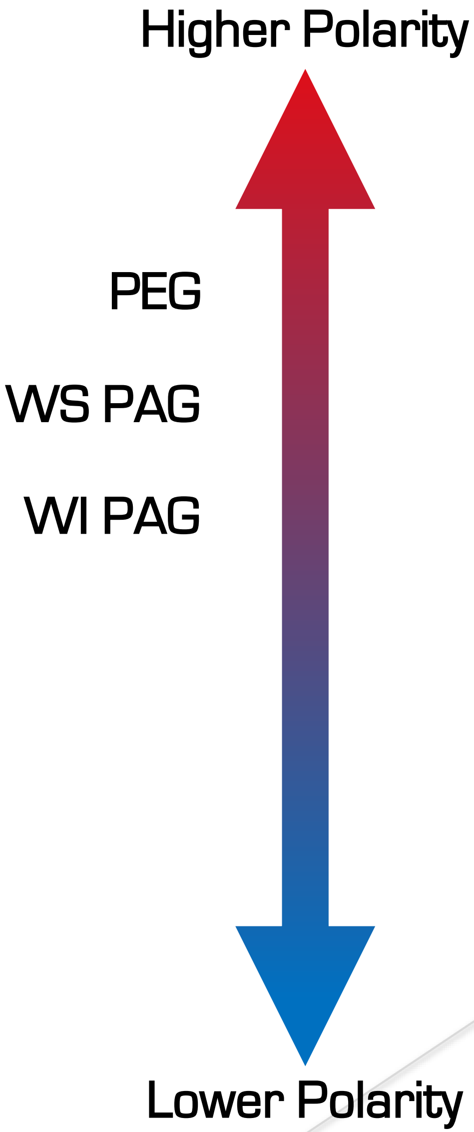
- Poly Ethylene Glycol (PEG)
  - Composed of solely ethylene oxide
  - Negligible viscosity dilution with hydrocarbon gases
  - Ideal for non-miscible hydrocarbon refrigeration systems



BOOTH 7-111

Types of PAGs





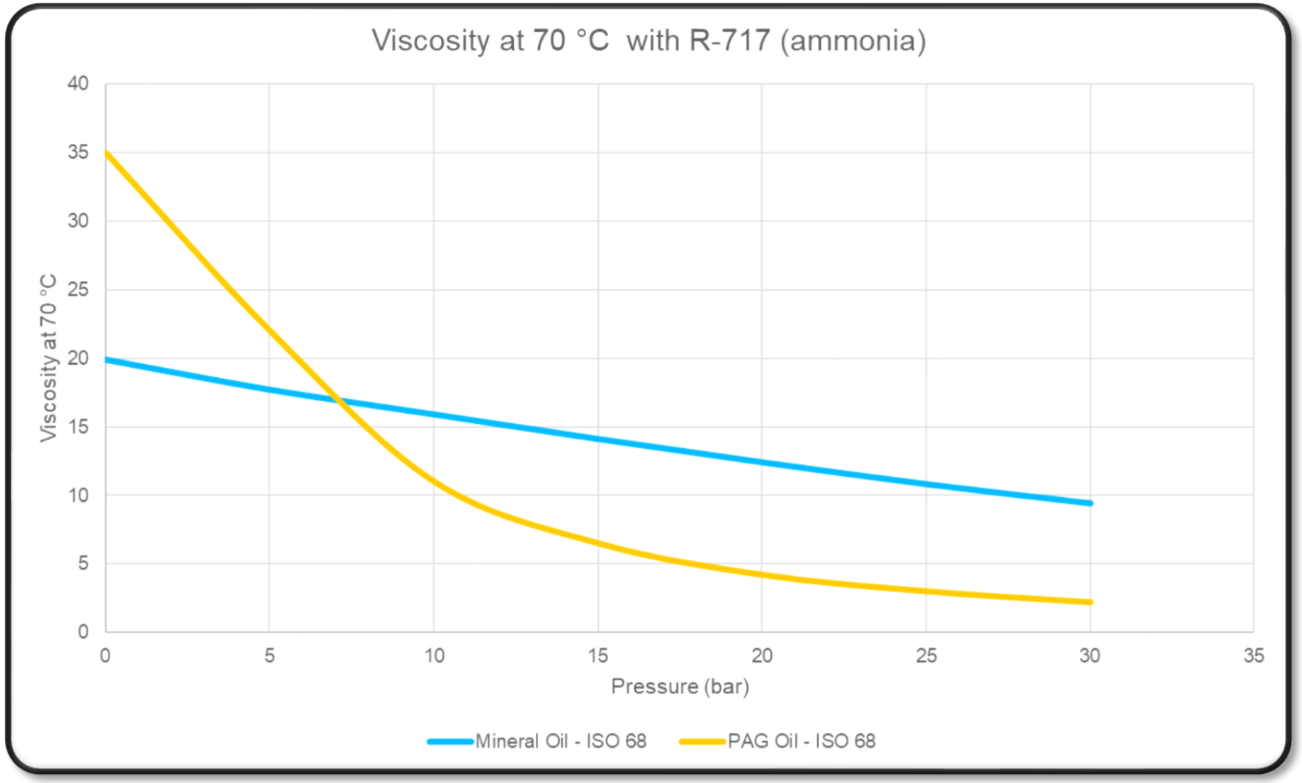
Recommended Lubricant

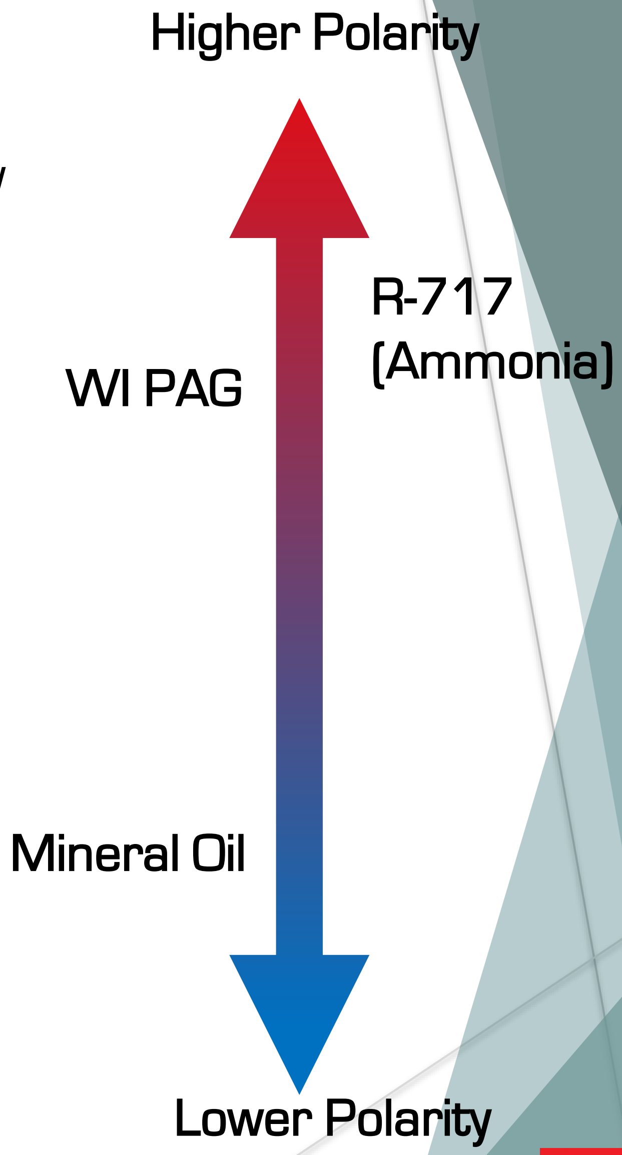
- The choice of lubricant is dependent on whether or not miscibility is required
- A compromise is necessary between miscibility and viscosity dilution

	Immiscible Systems	Miscible Systems
R-717 (ammonia)	Mineral or PAO	DEC PAG (WI-PAG)
R-744 (CO_2)	Mineral or PAO	POE or DEC PAG (WI-PAG)
R-290 (propane)	WS PAG or PEG	PAO, POE or WI PAG
R-600 (butanes)	WS PAG or PEG	PAO, POE or WI PAG
R-601 (pentanes)	WS PAG or PEG	WI PAG

Solubility with Ammonia

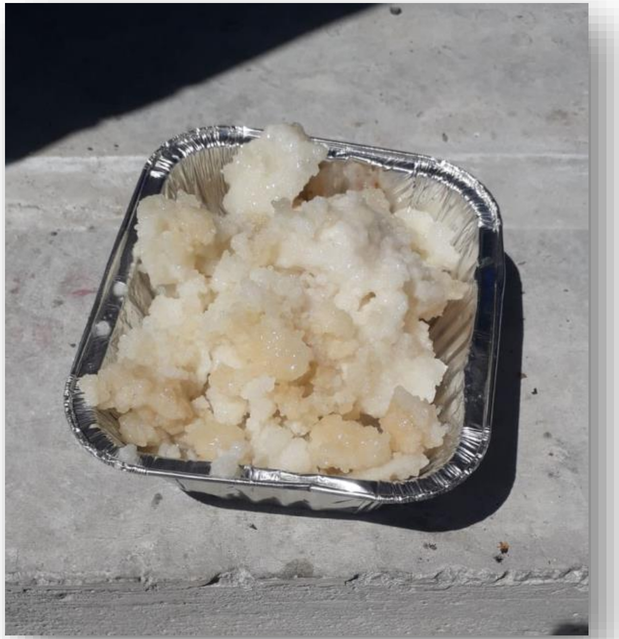
- Mineral oils are highly immiscible with ammonia. Viscosity dilution is minimal at normal operating pressures
- PAG base oils are highly miscible with ammonia. This is a critical function for DX systems as they help promote oil return





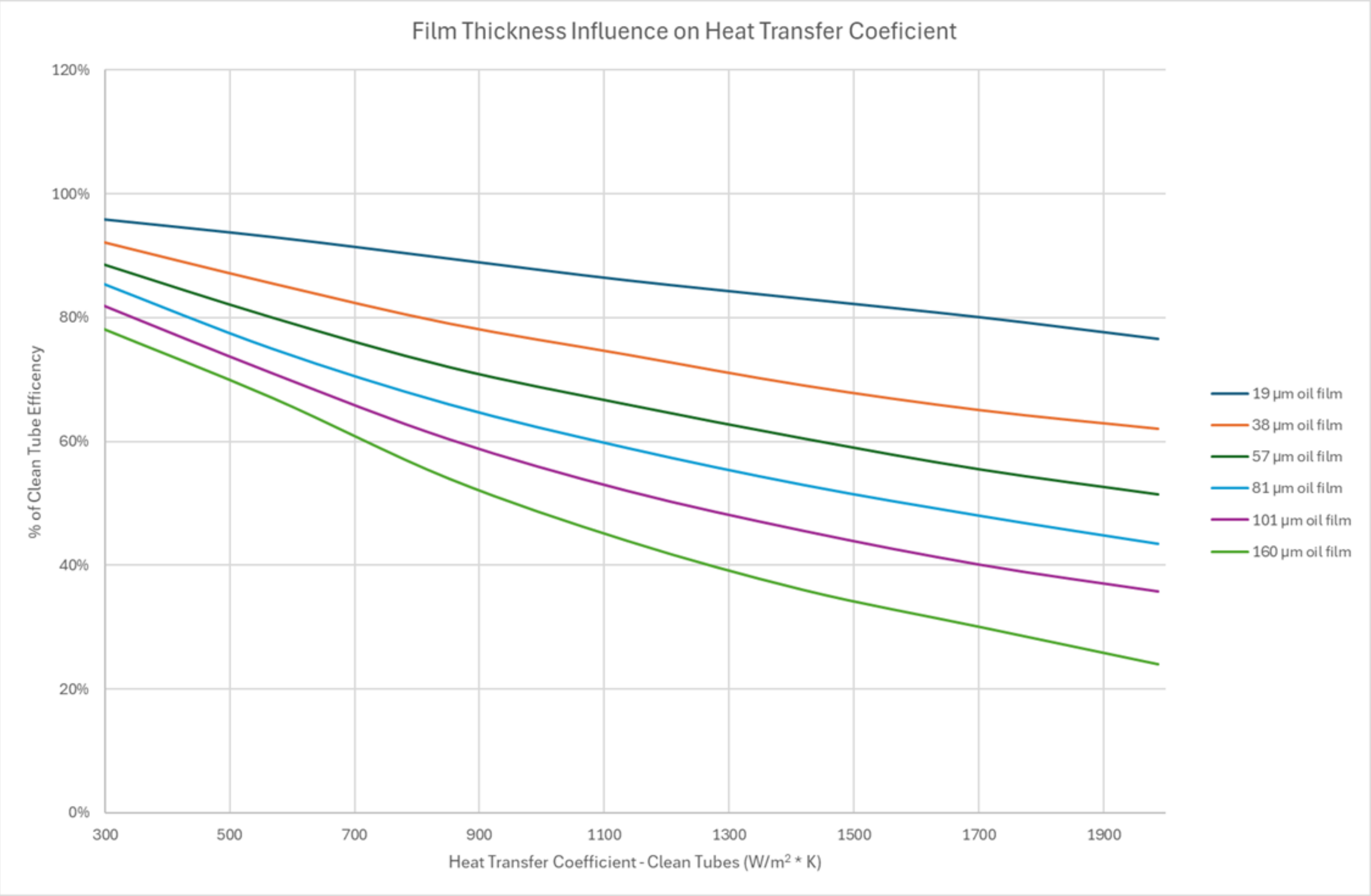
Compatibility with Refrigerants

- The compatibility between the lubricant and the refrigerant needs to be confirmed
- Esters (e.g. POE) should never be used in an ammonia refrigeration systems!
- Esters react with ammonia to form amides and fully degrade the lubricant
- These amides can be solids and are extremly difficult to remove from a refrigeration system



Effect of Lubricant on Efficiency

- The lubricant can act an insulator which will reduce thermal transfer efficiency



Thomas T.S. Wan, “”Oil and Lubricants”, 3 September, 2008

Summary

- Solubilized refrigerant can decrease lubricant viscosity and density
- Lubricant/Refrigerant solubility is affected by pressure, temperature and refrigerant/lubricant affinity

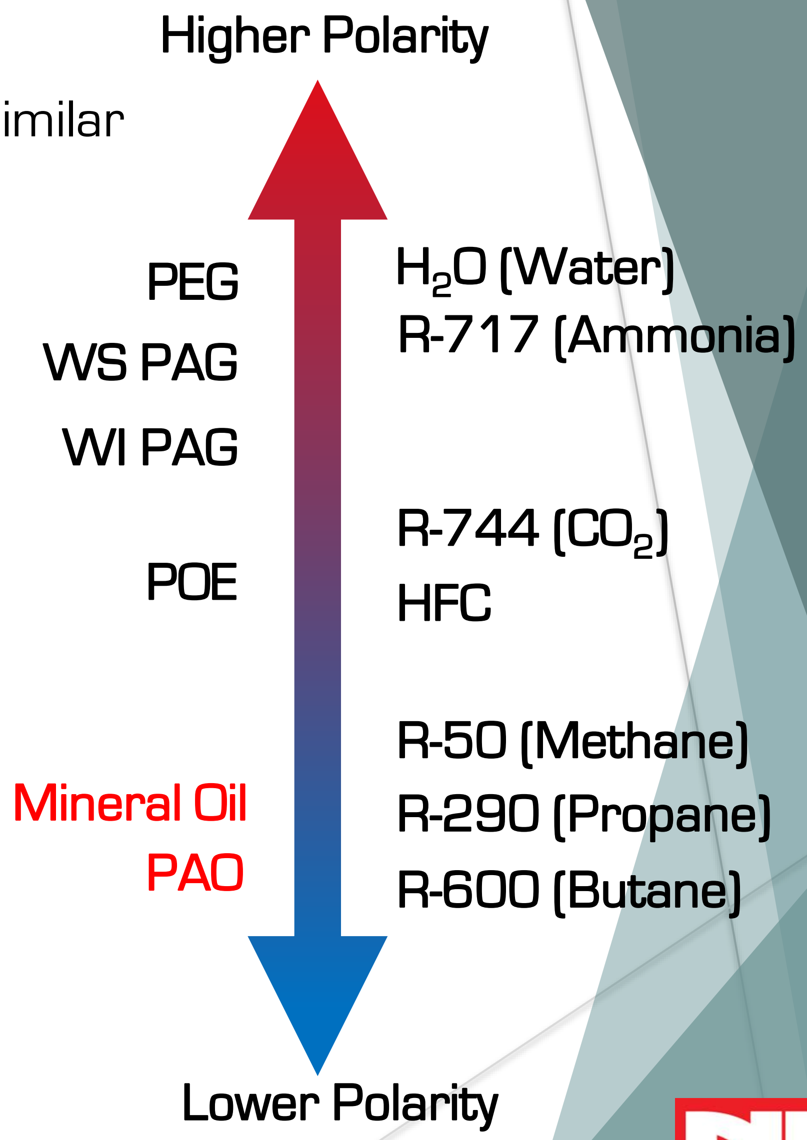
Condition		Solubilty
Pressure	↑	↑
Temperature	↑	↓

Summary

- Lubricants want to solubilize in refrigerants with similar polarity

Mineral/PAO Oil

Refrigerant	Solubility Potential
R-717 (ammonia)	Very low
R-744 (CO_2)	Low
R-50 (Methane)	High
R-290 (Propane)	Very High
R-600 (Butane)	Very high



NEXT LUBRICANTS

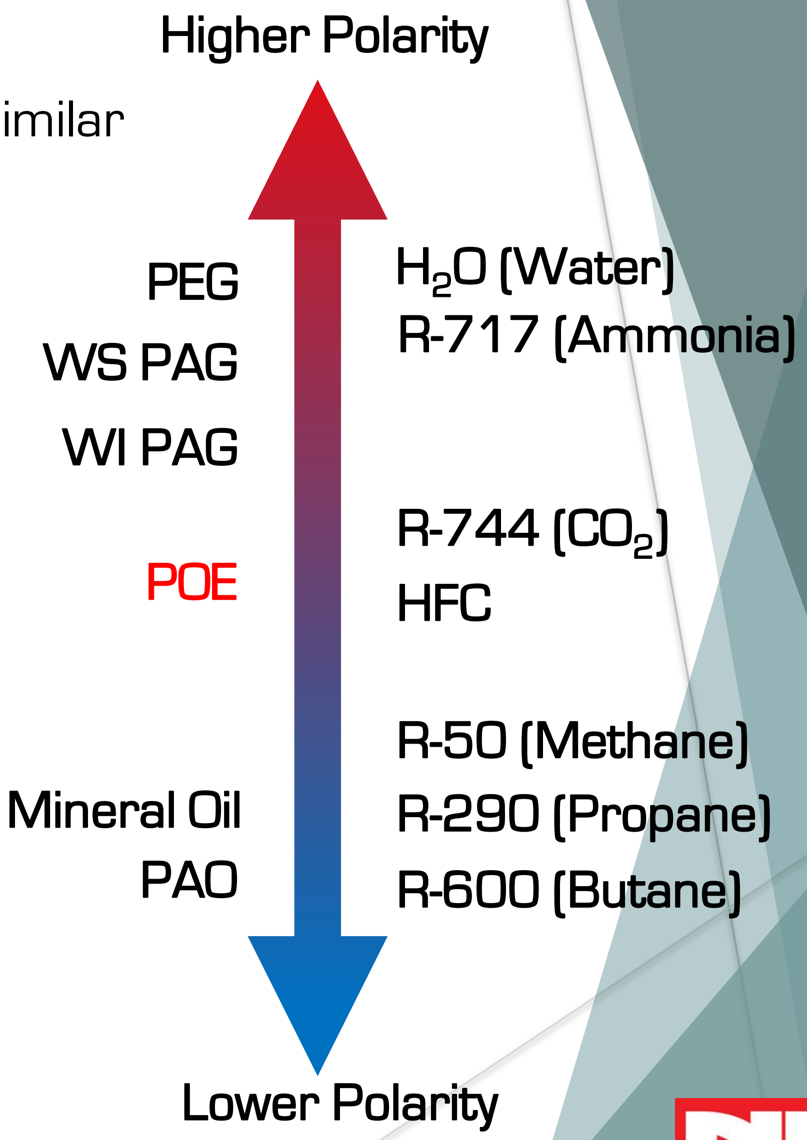
BOOTH 7-111

Summary

- Lubricants want to solubilize in refrigerants with similar polarity

POE

Refrigerant	Solubility Potential
R-717 (ammonia)	DO NOT USE
R-744 (CO_2)	High
R-50 (Methane)	High
R-290 (Propane)	High
R-600 (Butane)	Very high



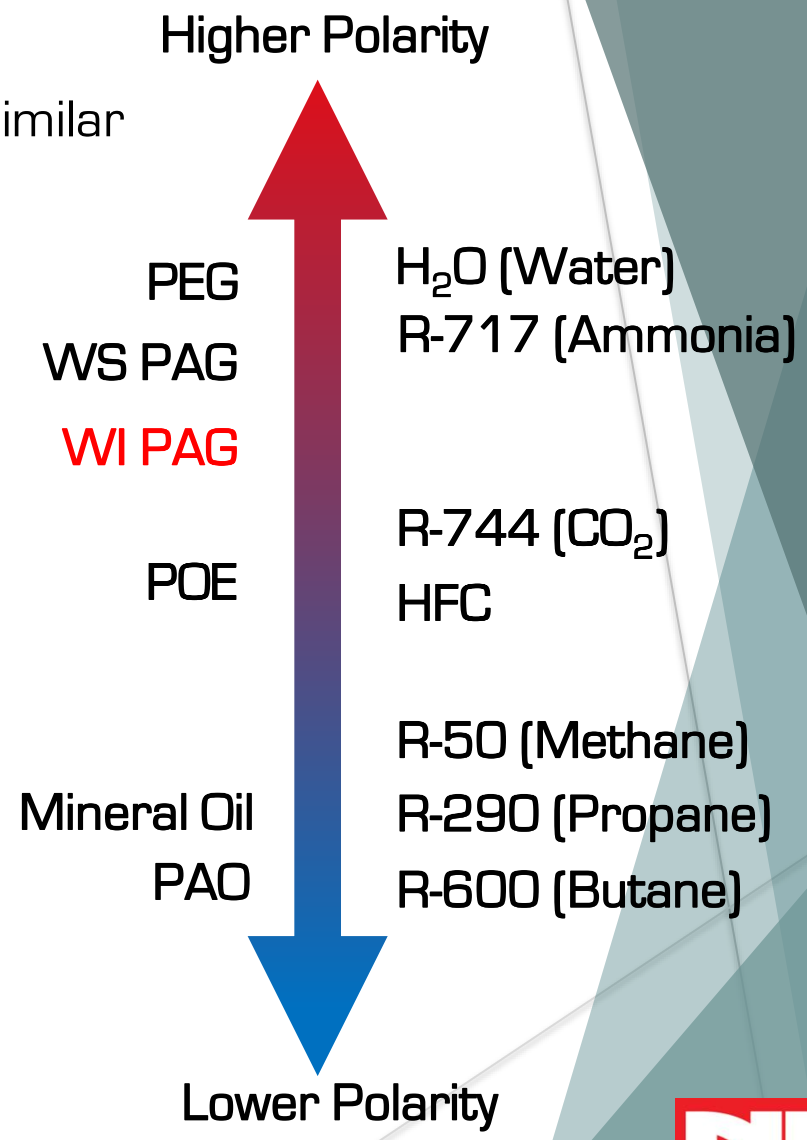
BOOTH 7-111

Summary

- Lubricants want to solubilize in refrigerants with similar polarity

WI-PAG

Refrigerant	Solubility Potential
R-717 (ammonia)	Very high
R-744 (CO_2)	High to moderate
R-50 (Methane)	Low
R-290 (Propane)	Moderate
R-600 (Butane)	Moderate



NEXT LUBRICANTS

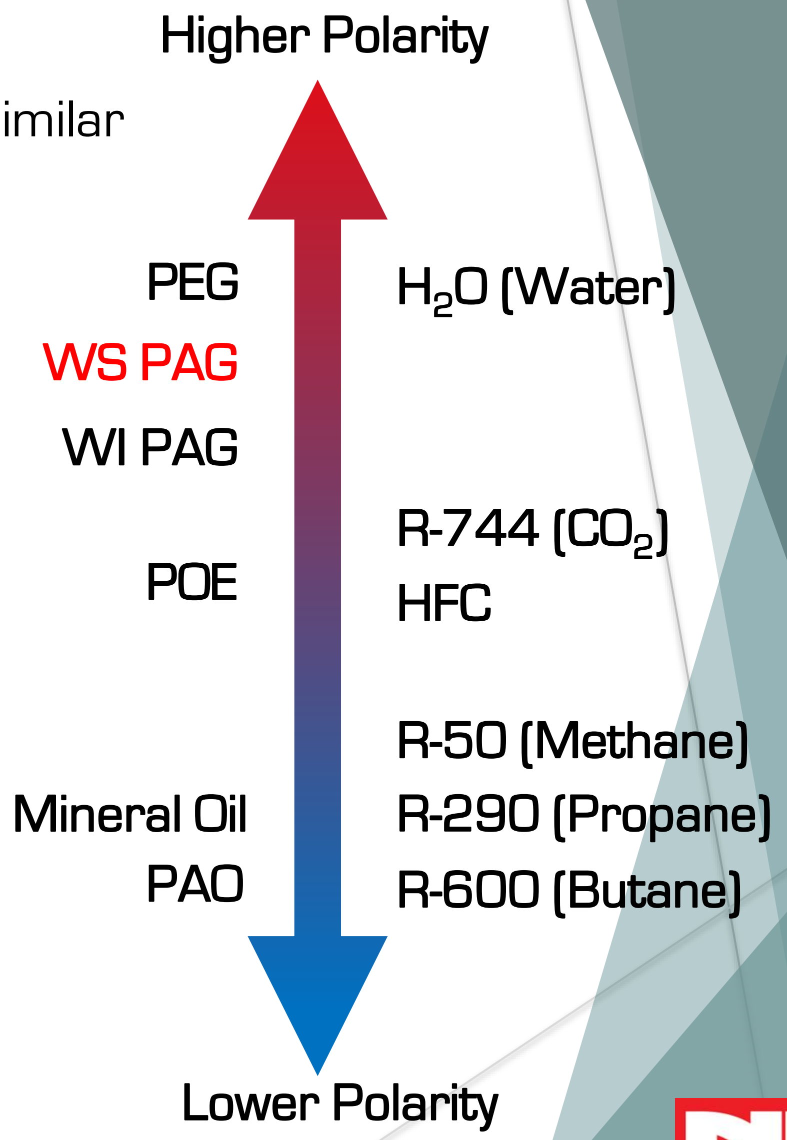
BOOTH 7-111

Summary

- Lubricants want to solubilize in refrigerants with similar polarity

WS-PAG

Refrigerant	Solubility Potential
R-717 (ammonia)	Very high
R-744 (CO_2)	Low
R-50 (Methane)	Very low
R-290 (Propane)	Low
R-600 (Butane)	Low



Questions?

Please visit us at booth 7-111

Hall 8

CHILLVENTA

Chillventa Specialist Forums 2024
Chillventa Fachforen 2024

CONNECTING
EXPERTS.