

# China Refrigeration Roadshow



## Selection of Lubricants for Lower GWP Refrigerants 低GWP制冷剂的润滑油选择

Great Chemistry

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# Agenda 内容提要



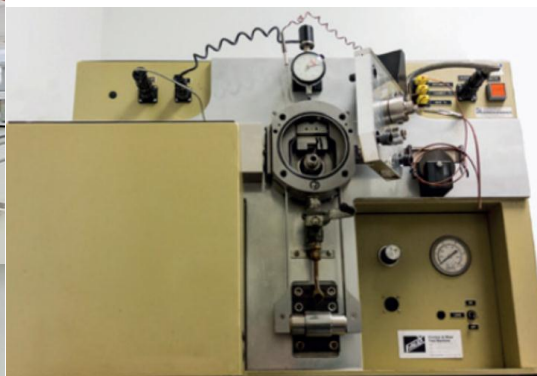
- Shrieve Technology
  - Refrigerant Changes
  - Lubricant Options
    - R404A Replacements
    - R134a replacement
    - R32
  - HFO Stability Data
  - Electrical Properties
  - Conclusion
- 瑞孚技术
  - 制冷剂变化
  - 润滑油选择
    - R404A替代
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  - 结论

# Shrieve Technology

Technical capabilities



Two **Global** Laboratories 两个研发实验室  
– Houston & Shanghai



- 150+ years experience in oil field and gas compression  
研发人员在油田和气体压缩领域的经验加在一起超过150年
- Focus on lubricant/gas interactions  
聚焦在润滑油/气体相互作用
  - Stability 稳定性
  - Miscibility 混溶性
  - PVT 压力-温度-粘度关系
  - Materials Compatibility 材料兼容性
- Research and Development 研发
  - Unique Chemistries 独特的化学结构
  - Additive Response 添加剂
  - Performance Benefits 应用性能评估

# Potential Lower GWP (<750) Options to Replace HFC/HCFC Refrigerants

## 替代HFC/HCFC的低GWP制冷剂的可选方案



R134a	R404A	R410A	R22	Other
R600a *	R290 *	R32 ***	R32 ***	R1233zd *****
R290 *	R455A **	R290 *	R290 *	R514A *****
R1234yf **	R454A **	R452B **	R444B **	R1336mzzz **
R1234ze(E) **	R744*****	R447B **	R454C **	
R450A **		R454B **		
R513A **				
R744*****				


- \* Hydrocarbon (A3)
- \*\* HFO or HFO based (A1 to A2L)
- \*\*\* HFC (A1 to A2L)
- \*\*\*\* Chloro/Fluoro Olefin (A1)
- \*\*\*\*\* HFO/Chloro Olefin (A1)

- The List Keeps Growing  
清单还在继续增加
- Challenges Still Exist with Some Applications and Regions  
对于某些应用及某些区域挑战仍然存在

# Common Refrigeration Lubricant Chemistries

## 常用制冷润滑油



	Mineral Oils矿物油 & PAOs	Alkyl benzene烷基苯	POE	PAG	PVE
HCFC	✓	✓	✓	Not Recommended 不推荐	Not Recommended 不推荐
HFC	Not Recommended 不推荐	Only in special cases 特殊情况下	✓	special design considerations 特殊设计考虑	✓
HC	✓	✓	✓	✓	✓
NH <sub>3</sub>	✓	✓		✓	Not Recommended 不推荐
CO <sub>2</sub>	Not Recommended 不推荐	Not Recommended 不推荐	50/50	✓	50/50
HFO and Blends	Not Recommended 不推荐	Probably not 可能不合适	Under development 开发中	Under development 开发中	Maybe? 也许?

# HFO/HFC Blends – Lubricant Optimization

## HFO/HFC混合冷媒 – 润滑油优化



- Optimizing lubricant interaction to improve performance and potential cost reductions.

优化润滑油以提高性能以及可能带来成本降低

- Base lubricant viscosity ranges 15 to 60 cSt

基础油粘度范围从15到60cSt

### New Chemistries and Blends 新结构及其混合物

**A** **B** **C** **D** **E**

	10%	20%	10%	20%	10%	20%	10%	20%	10%	20%
Upper	45C	45C	40C	40C	45C	45C	45C	40C	35C	30C
Lower	<-60C	<-60C	<-60C	<-60C	-45C	-45C	-50C	-45C	-50C	-50C

### Existing Chemistry Blends 现有结构混合物

**F** **G** **H** **I** **J** **K** **L**

	20%	20%	20%	20%	20%	20%	20%
Upper	>60C	>60C	>60C	>60C	>60C	>60C	>60C
Lower	-25C	-20C	-20C	5C	-20C	30C	0C

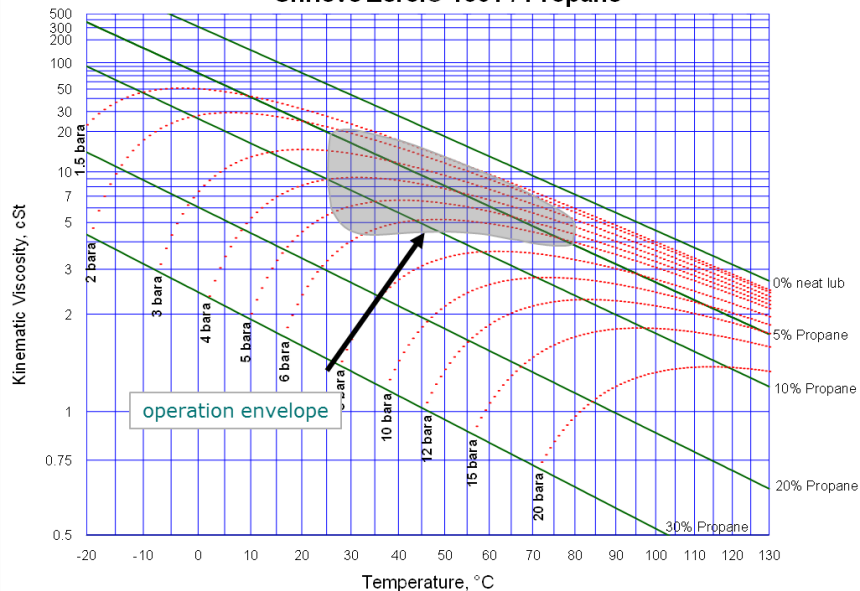
# R404A Replacement

## – R290 Example – Smaller Commercial

## R404A替代 – R290为例 – 轻商应用

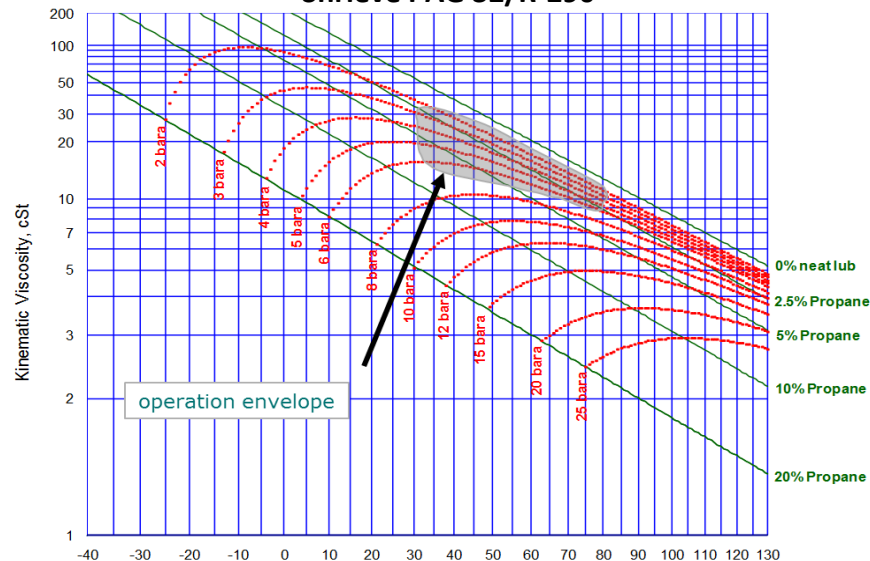


Shrieve Zerol® 150T / Propane



- ☐ 45°C / 6 bar
  - ✓ 10% Dilution 稀释
  - ✓ 5 cSt
- ☐ Shrieve Zerol 150T lubricant offers cost benefits
- 瑞孚Zerol 150T 润滑油性价比高

Shrieve PAG 32/R-290



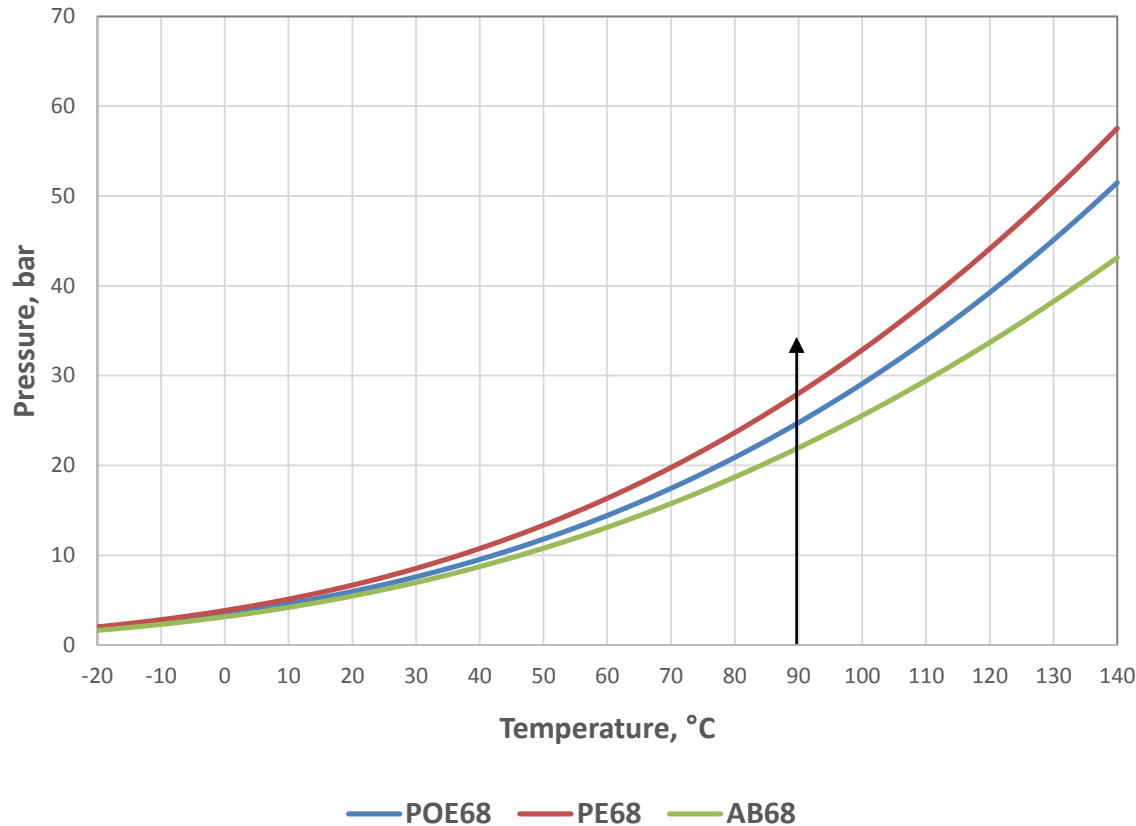
- ☐ 45°C / 6 bar
  - ✓ 5% Dilution 稀释
  - ✓ 15 cSt
- ☐ Shrieve PAG 32 lubricant offers lower dilution rate
- 瑞孚PAG 32润滑油降低制冷剂溶解度



# R404A Replacement

## – R290 Example – Larger Commercial

## R404A替代 – R290为例 – 大型商用



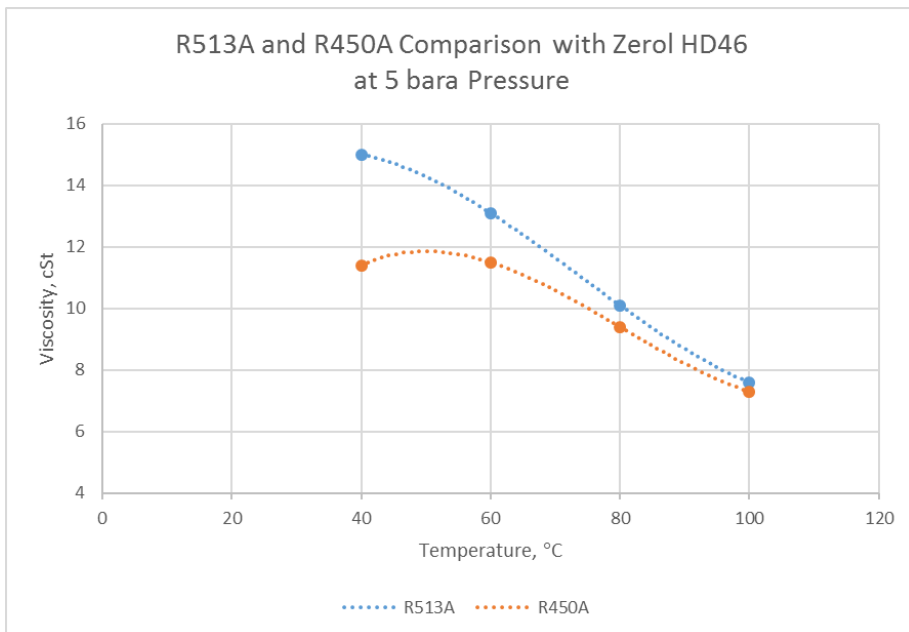
Pressure Diff. at 90°C 压力差	Bar	% Increase
AB68	22.0	-----
POE68	24.8	12.7
PE68	28.0	27.3; 12.9

- Higher Pressure translates to less solubility of the refrigerant into the lubricant  
更高压力意味着润滑油中制冷剂溶解度更低
- Less solubility allows for optimizing compressor design and system operation.  
低溶解度为压缩机设计和系统运行的优化带来可能



# R134a Replacement Examples R134a替代举例

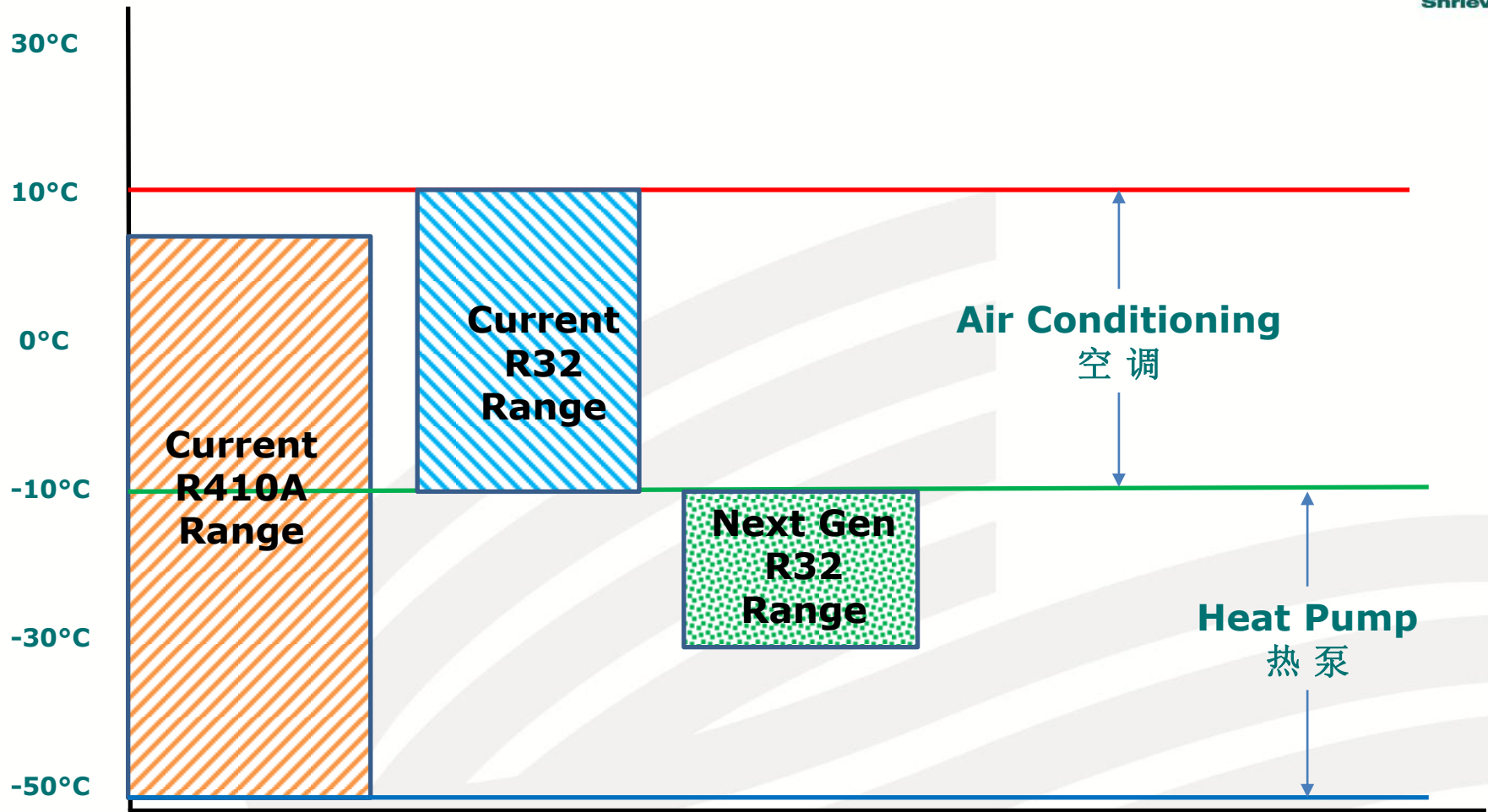
## R-1234ze(E) and R513A/R450A



- R-1234ze(E) has high dilution with lubricants including POE  
R1234ze(E)对含POE的润滑油稀释率高
- Other lubricant chemistries can offer lower dilution and can be optimized for viscosity  
其它类型的润滑油可降低稀释率，并可优化粘度
- R450A can have greater dilution than R513A and viscosity may need to be adjusted  
R450A比R513A的稀释率高，可能需要对粘度进行优化

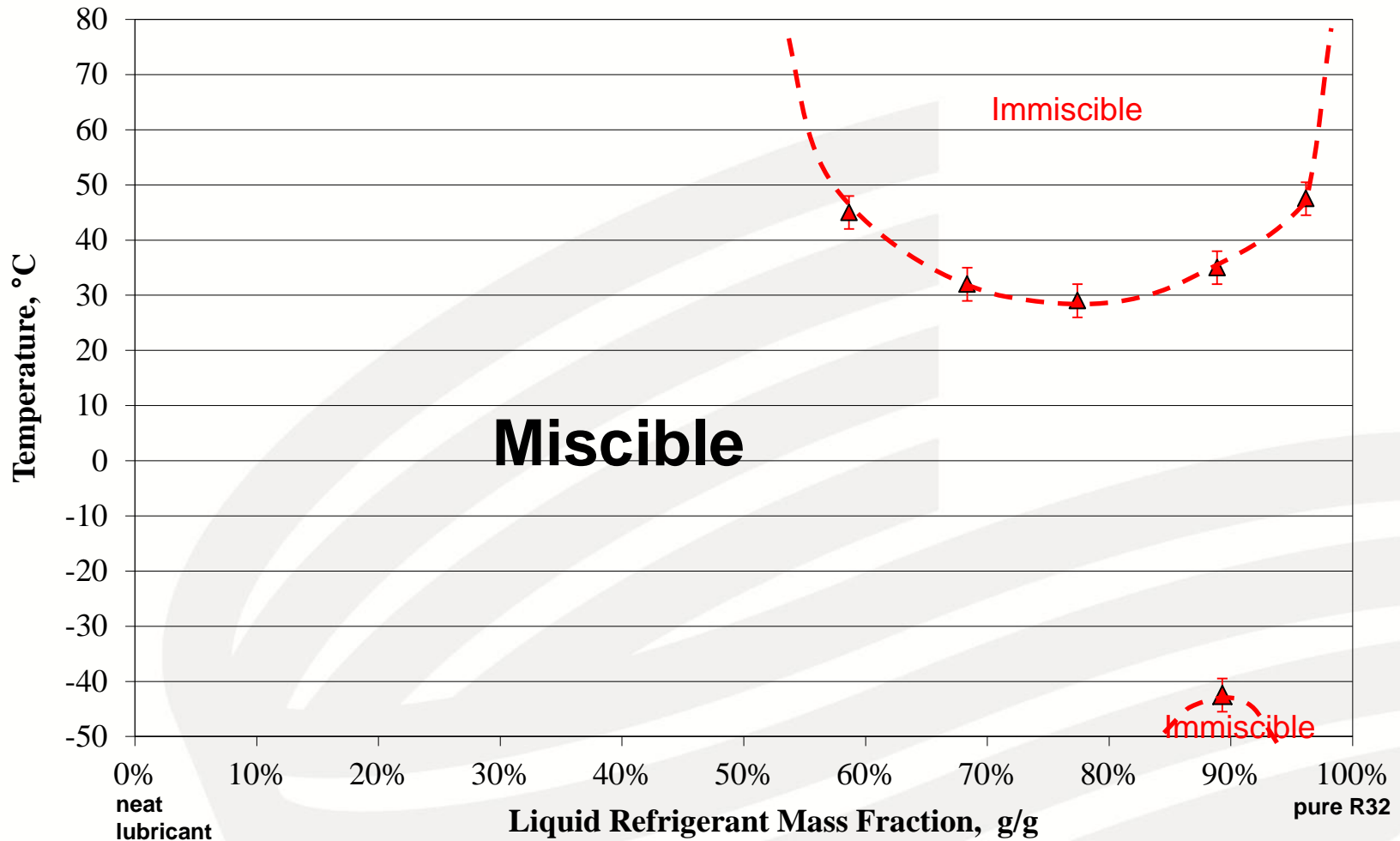
Dilution, % at 5 bara	R450A	R513A
40°C	21.1	15.1
60°C	11.6	8.7
80°C	7.2	5.7
100°C	4.9	4.0

# R32 Work – Miscibility 相溶性



# R-32 Miscibility – New Lubricant Chemistry

## R-32相溶性 – 新结构润滑油



# R32 Work - PVT



R-32 Lubricant R-32润滑油

Dual Purpose Lubricant for R-32 and R-410A

同时覆盖R-32和R-410A



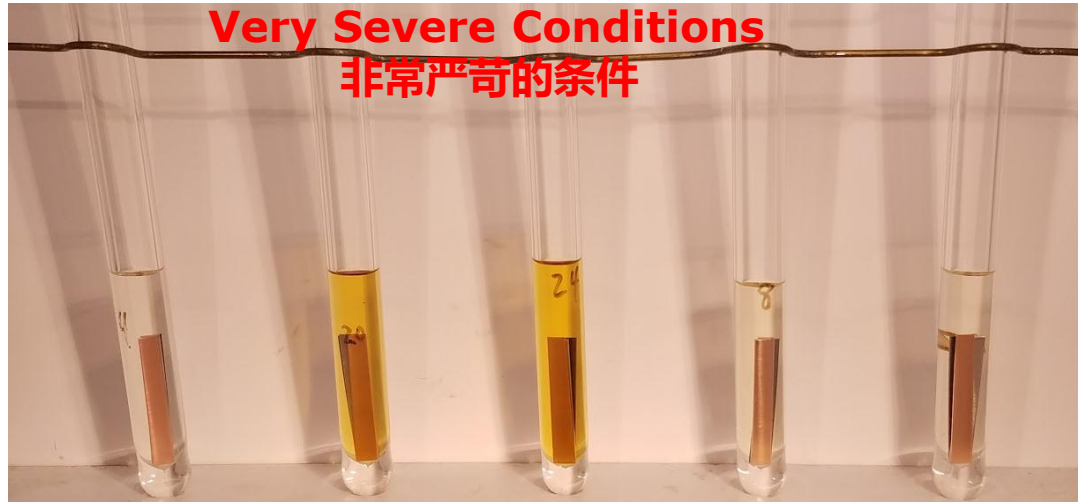
	T °C	P Bar	Refrigerant %	Viscosity cSt	UCST(20% lubricant) °C	
R-410A/POE	39	12.5	18%	7.2	-25	Low-side Compressors 低背压压缩机
R-32/New	41	13.0	15%	9.4	-25	
R-410/New	39	12.5	20%	8.7	-50	
R-410A/POE	80	34.4	22%	3.0	-25	High-side Compressors 高背压压缩机
R-410A/PVE			20%	3.3	-50	
R-32/New	85	35	18%	3.2	-25	
R-410/New	80	34.4	24%	3.0	-50	

# Stability Challenges for HFOs & HFO blends

## HFO及其混合物所面临的稳定性挑战



SGT – 14 days at 175°C; ~ 200 ppm Moisture; 1000 ppm Air



R134a

R1234yf

R1234zeE

R1234yf

R1234zeE

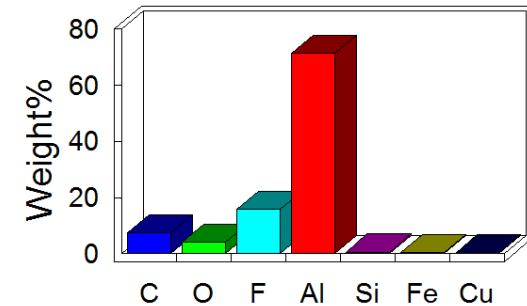
Major OEM oil  
Millions of compressors  
主要OEM用油，几百万台压缩机

Shrieve POE  
瑞孚POE

Effect of Air, Moisture and Additive Chemistry needs to be evaluated with some HFO based refrigerants. 需要评测空气，水分以及添加剂对基于HFO的制冷剂的影响



Quantitative results

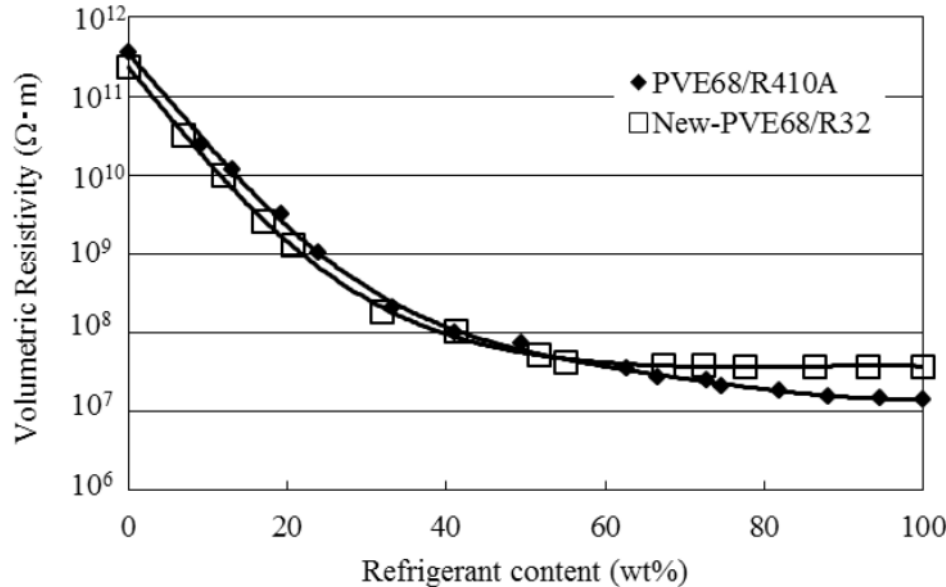


Chemistry Differences	TAN mgKOH/gOil
Example 1	5.0
Example 2	3.1
Example 3	0.8

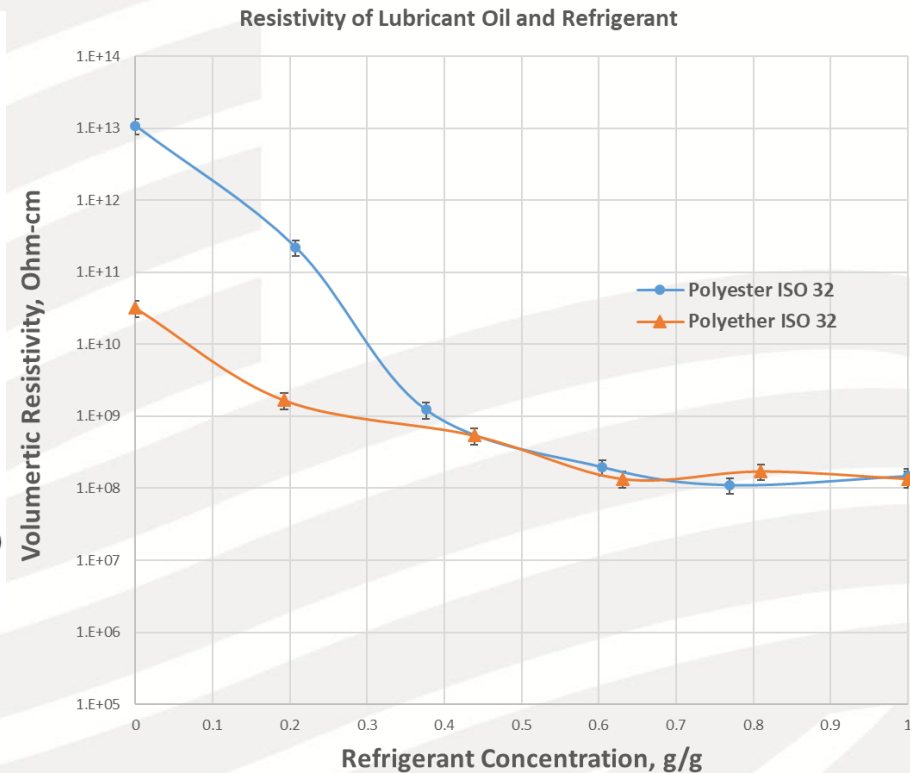
# Interactions - Volume Resistivity 体积电阻率



- Evaluation of electrical properties is usually performed on just the lubricant.  
电性能测试通常只是针对对润滑油。
- The refrigerant can have lower volumetric resistivity and can dictate the electrical property interaction with the compressor motor.  
制冷剂的电阻率可能比油低，从而主导对压缩机马达的电绝缘性的影响。



Matsumto, T. Development of PVE Refrigeration Lubricants for R32. International Refrigeration and Air Conditioning Conference 2014. Paper 1556.



## Conclusion 结论

- ❑ Lower GWP refrigerants will be the next generation of refrigerant options.  
低GWP的制冷剂将会是下一代制冷剂的选择
- ❑ Which lower GWP Refrigerant is still in question.  
具体采用哪一种低GWP制冷剂仍为完全定论
- ❑ New refrigerant options brings opportunity for new investigations of properties.  
新的制冷剂选择带来了新的研究机会
- ❑ Some new refrigerant could present some stability challenges.  
有些制冷剂会的使用带来稳定性方面的挑战
- ❑ Shrieve is evaluating current lubricants and new lubricant options.  
瑞孚公司正在评估一系列使用过的润滑油以及全新的润滑油





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