



Shrieve

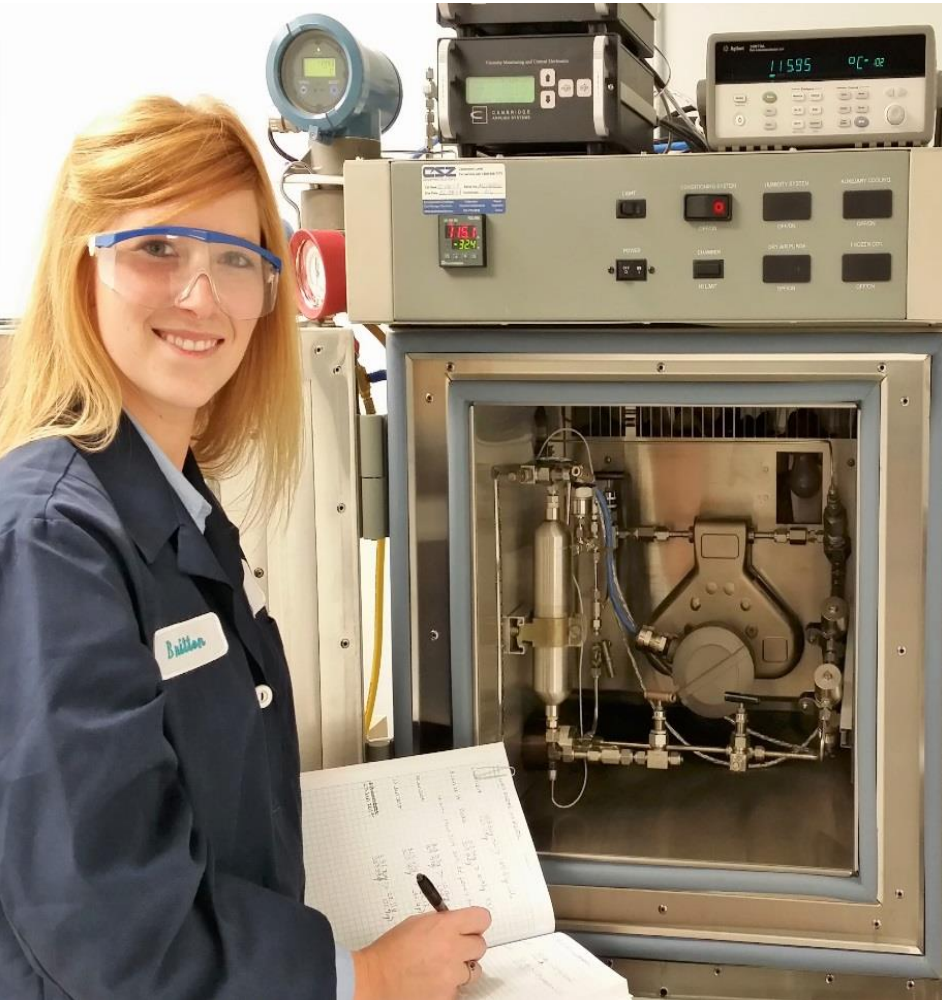
Lubricant Solutions for Next Generation Refrigerants

下一代制冷剂的润滑油解决方案

Joe Karnaz – Technical Director 技术总监

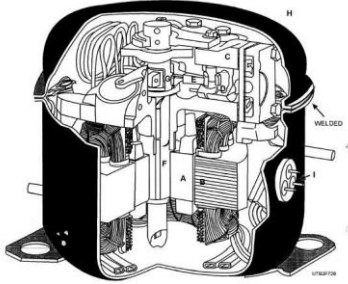
Great Chemistry

Agenda 内容提要



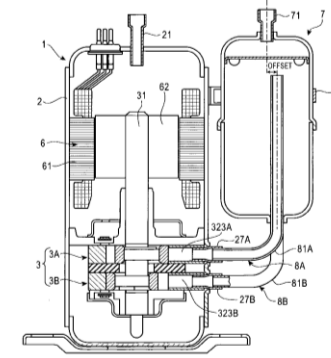
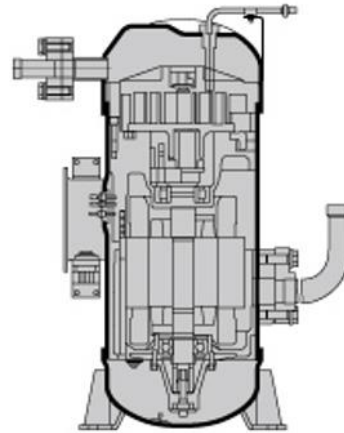
- Understanding Refrigeration Lubricant
制冷润滑技术简介
- New Lubricant Technology for R-32
用于R-32的新型润滑油
- Lubricants for Hydrocarbon Refrigerants
用于碳氢制冷剂的润滑油
- Lubricants for HFO and Other Refrigerants
用于HFO及其它制冷剂的润滑油
- Summary
总 结

Understanding Refrigeration Lubricant 制冷应用润滑技术



Design around the **Compressor**
润滑油设计需要考虑的**压缩机**问题

- ✓ Type of Compressor 压缩机类型
- ✓ Type of Bearing 摩擦副类型
- ✓ Bearing Material 摩擦副材料
- ✓ Oil Distribution to Bearing 摩擦副供油
- ✓ Temperature and Pressure 温度和压力
- ✓ Bearing Tolerances 摩擦副配合间隙
- ✓ Inner Conditions 内部条件
- ✓ Stability 稳定性
- ✓ Efficiency 效率



Design around the **Refrigerant**
润滑油设计需要考虑的**制冷剂**问题

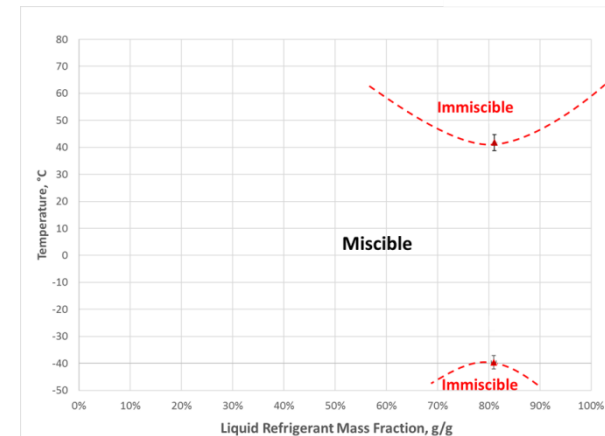
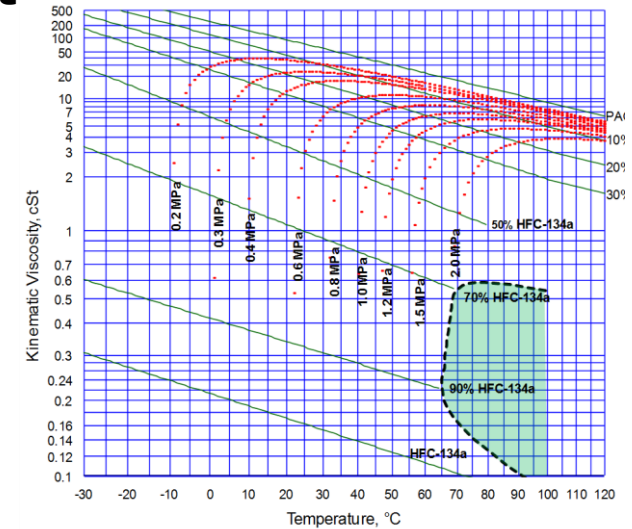
- ✓ Type of Refrigerant 制冷剂类型
- ✓ Pressure Conditions 压力
- ✓ Solubility in the Lubricant 在油中的溶解度
- ✓ Miscibility with the Lubricant 混溶性
- ✓ Stability 稳定性
- ✓ Working Viscosity 工作粘度
- ✓ Compatibility 制冷剂与润滑油的兼容性
- ✓ System Thermodynamics 系统热力学
- ✓ Efficiency 效率

Understanding Refrigeration Lubricant 制冷应用润滑技术

Most Important Testing for Refrigeration Lubricant Development

制冷润滑油开发中最重要的测试：

- Dynamic PVT testing (Daniel Charts) 动态PVT测试
 - -60~150 °C, 175 bar, electric resistivity 在线电阻率
- Miscibility Studies 混溶性
 - Lubricant/refrigerant critical solution temperature 测定润滑油和制冷剂的临界共溶温度
 - Evaluate oil return and potential system heat transfer losses 评价压缩机回油和可能的系统换热损失
- Material Compatibility 材料兼容性 - ASHRAE 97
 - Glass tube or metal vessel 玻璃管或者高压釜
 - Bench study lubricant and refrigerant stability 测定润滑油和制冷剂稳定性



Refrigeration Lubricant Chemistry

Mineral Oil –

- Naphthenic and Paraffinic Based
- Potential Applications; HC, HCFC, NH_3
- Less cost but also less stability

Alkylbenzene –

- Linear and Branched Formulations
- Potential Applications; HC, HCFC, NH_3
- Provides added stability over mineral oils

矿物油

- 环烷基和石蜡基
- 可以用于： HC, HCFC, NH_3
- 较便宜但稳定性差

烷基苯

- 直链以及支链
- 可以用于： HC, HCFC, NH_3
- 比矿物油稳定性更好

Refrigeration Lubricant Chemistry

Polyol Ester –

- Reaction of various polyfunctional alcohols and carboxylic acids
- Potential Applications; HC, HFC, HFO, CO₂
- Good miscibility but poor hydrolytic stability

Polyalkylene Glycol –

- EO/PO based with various initiators and capping
- Potential Applications; HC, HFC, HFO, CO₂, NH₃
- Good stability and versatility

POE - 多元醇酯

- 多元醇和羧酸的反应产物
- 可以用于: HC, HFC, HFO, CO₂
- 混溶性良好, 但水解稳定性差

PAG – 聚醚

- 基于EO/PO, 不同的起始剂和封端
- 可以用于: HC, HFC, HFO, CO₂, NH₃
- 良好的稳定性和性能多样性

New Lubricant Technology for R-32

用于R32的新型合成润滑油



- Taking advantage of Shrieve's knowledge and understanding of refrigeration lubricant properties.
充分利用瑞孚对于润滑油特性的知识和深度理解
- Understanding the interaction of R-32 with refrigeration lubricants and potential issues.
充分了解R-32与润滑油的相互作用和潜在的问题
 - Poor miscibility when compared to R-410A/Lubricant
与R410A相比，R32和油的混溶性差
 - Reduction in working viscosity to bearings
工作温度高导致润滑油的工作粘度降低
- Development of new chemistry focused on lubricant-refrigerant interaction parameters.
新型润滑油的开发聚焦在润滑油/制冷剂的相互作用参数上
- Make backwards compatible with R-410A refrigerant.
同时考虑新型润滑油可适用于R410A系统

New Lubricant Technology for R-32

用于R32的新型合成润滑油



Comparison to R-410A/ISO 32 POE to R-32/ISO 32 POE 比较R410A和R32

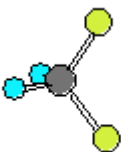
(Evaluating a typical condition for Scroll Compressor Operation 典型的涡旋压缩机工况下不同制冷剂/润滑油)

	T °C	P Bar	Refrigerant 制冷剂%	Viscosity 粘度 cSt		UCST(20% lubricant) °C	
R-410A/POE	39	12.5	18%	7.2	😊	-25	😊
R-32/POE	41	13.0	13%	6.8	😐	10	😞
R-32/ISO 32 POE (Reformulated)	41	13.0	14%	5.8	😞	-15	😐
R-32/ISO 56 POE (Reformulated) 😞	41	13.0	15%	9.1	😊	-15	😐

➤ POE is not always the best choice for R32 refrigerant 对于R32，POE不是最好的选择

New Lubricant Technology for R-32

用于R32的新型合成润滑油



Other Considerations 其它选择

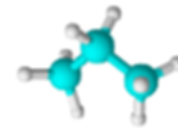
Dual Purpose Lubricant for R-32 and R-410A 同时适用于R-32和R-410A的PAG润滑油

	T °C	P Bar	Refrigerant 制冷剂 %	Viscosity 粘度 cSt		UCST(20% lubricant) °C	
R-410A/POE	39	12.5	18%	7.2	😊	-25	😊
R-32/New(新)	41	13.0	15%	9.4	😊	-25	😊
R-410/New(新)	39	12.5	20%	8.7	😊	-50	😊

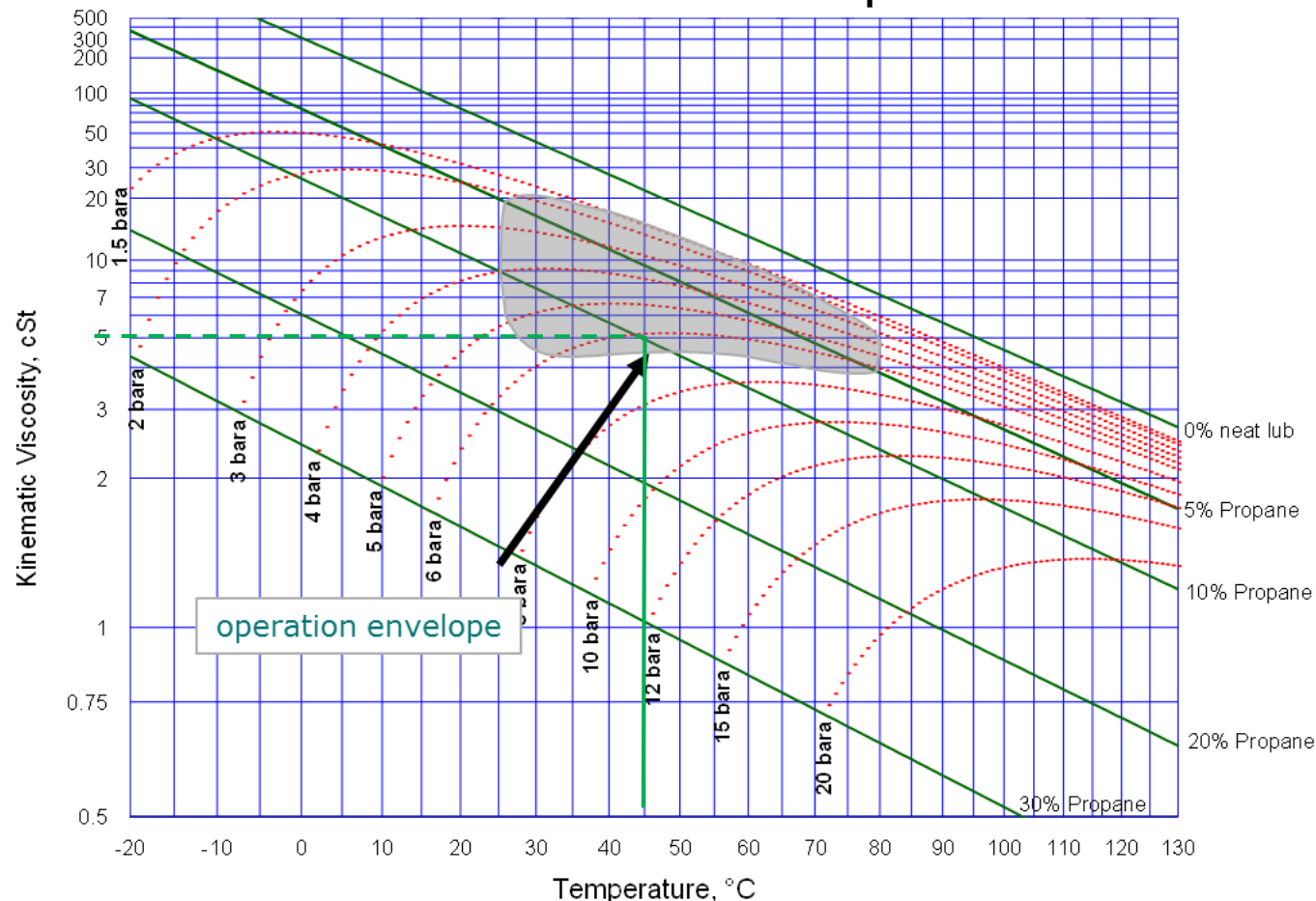
- This chemistry can also be used for rotary compressor operations typically using ISO 68 lubricants.
新型润滑油同时适用于通常使用粘度为68#的转子式压缩机
- Typical ISO 68 rotary lubricants are challenged with maintaining adequate miscibility with R-32. New Synthetic Technology for R-32 will maintain miscibility since structure does not vary when going to higher viscosities.
典型的68#转子式压缩机用油与R32的混溶性较差，新型R32润滑油可以维持良好的混溶性。

Lubricants for Hydrocarbon Refrigerants 适用于碳氢制冷剂的润滑油

R-290



Shrieve Zerol® 150T / Propane

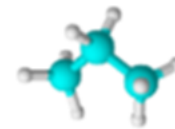


- Compressor oil sumps may contain up to 15% dissolved hydrocarbon in the lubricant.
压缩机油池中溶解的制冷剂量高达15%
- 45°C & 6 bar
 - 10% Dilution 制冷剂含量10%
 - 5 cSt
- Alkylbenzene Lubricants can be optimized with starting base oil viscosity to provide performance benefits.
烷基苯润滑油可以通过基础油粘度优化以达到最佳性能

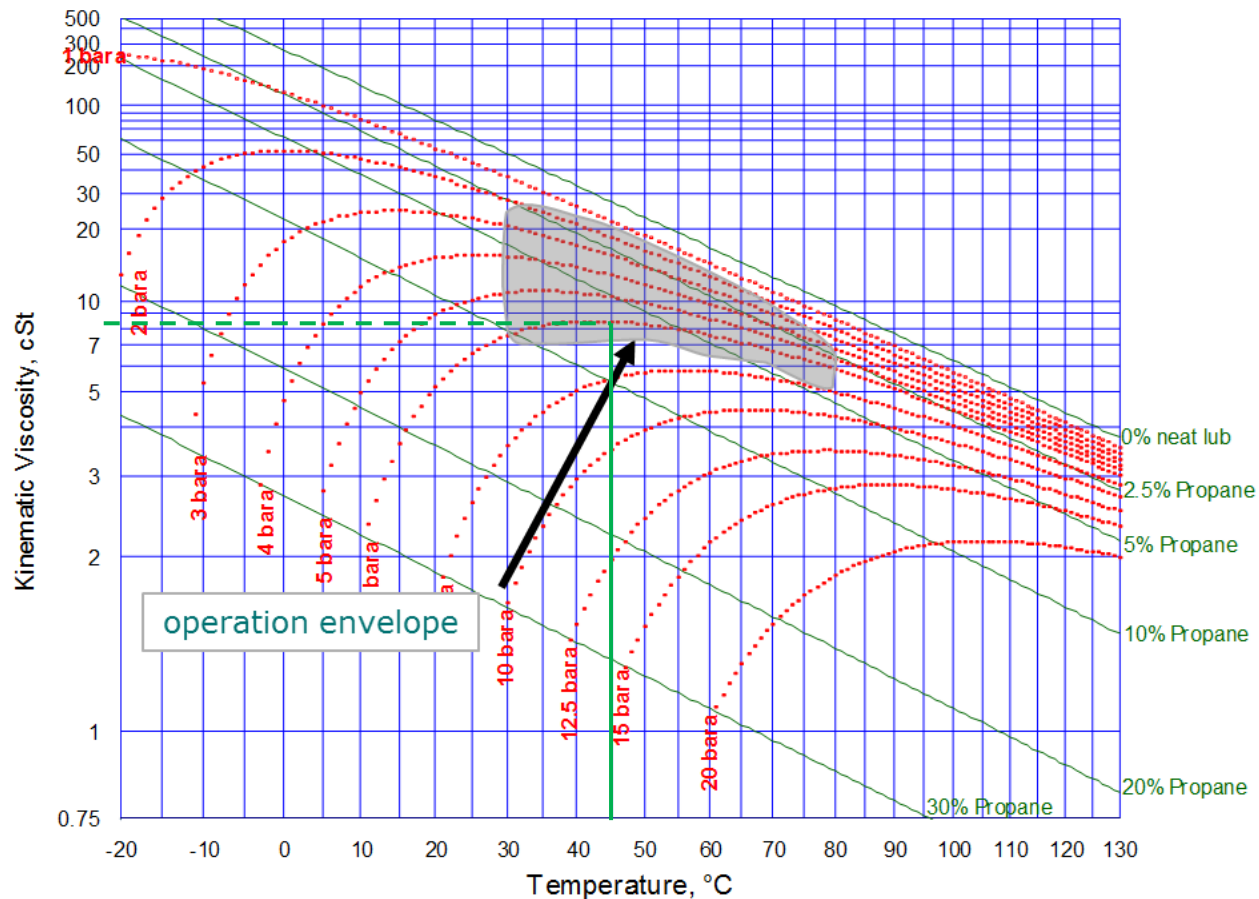
Lubricants for Hydrocarbon Refrigerants

适用于碳氢制冷剂的润滑油

R-290



Zerol® ESTER 32 / Propane

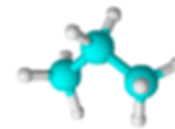


- Compressor oil sumps may contain up to 10% dissolved hydrocarbon in the lubricant.
压缩机油池中溶解的制冷剂含量高达10%
- 45°C & 6 bar
 - 7% Dilution 制冷剂含量7%
 - 8 cSt
- POE lubricants start to provide some dilution reduction and increase in working viscosity.
POE稀释效应有所减小，工作粘度增加

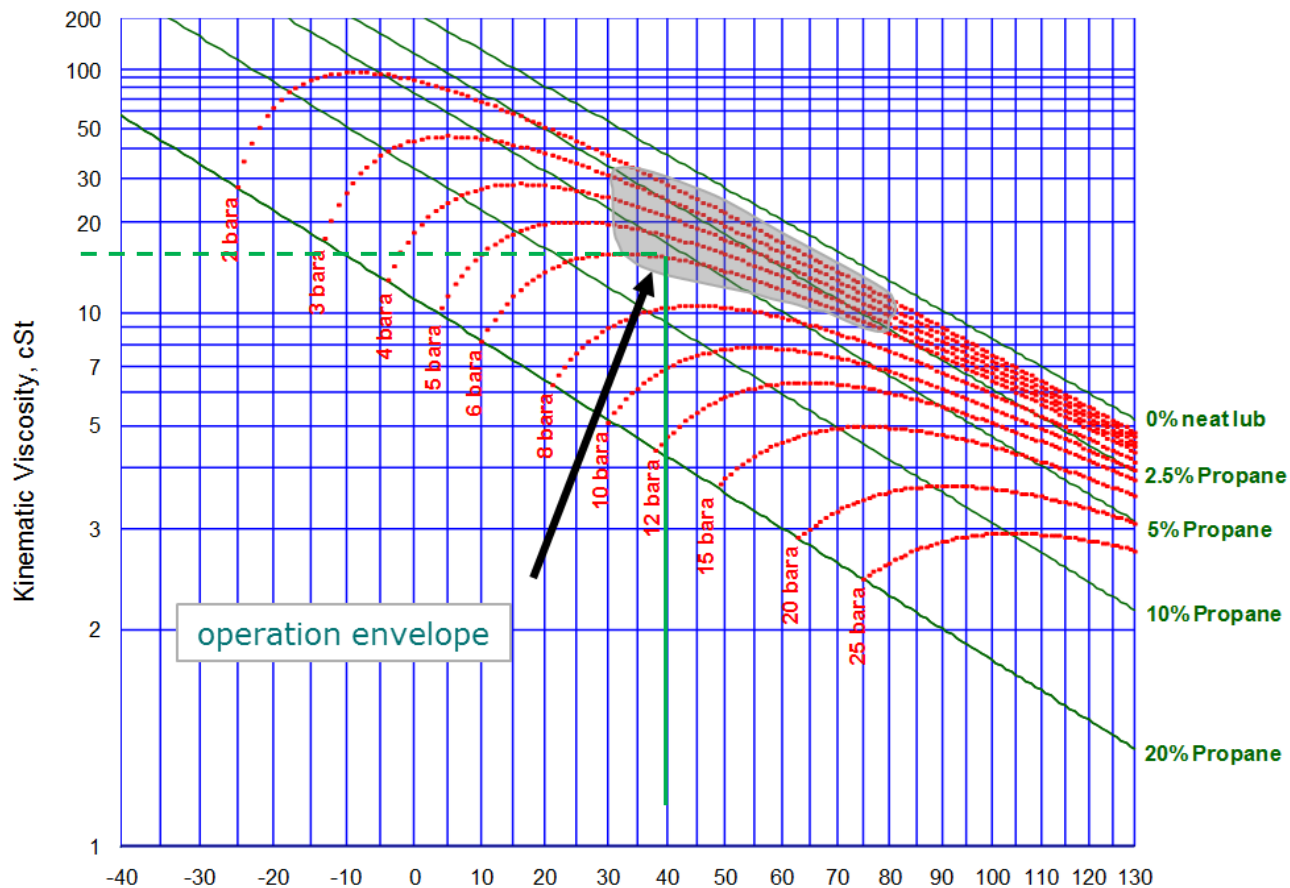
Lubricants for Hydrocarbon Refrigerants

适用于碳氢制冷剂的润滑油

R-290



Shrieve Zerol® PAG 32

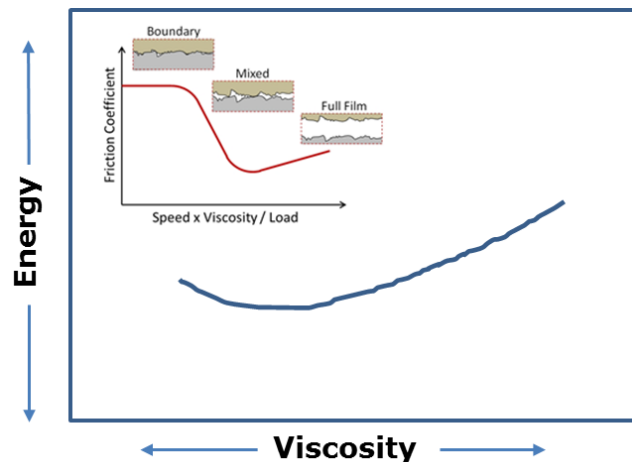
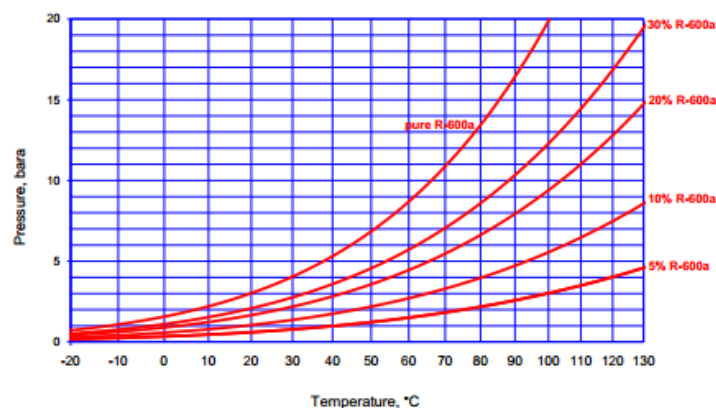
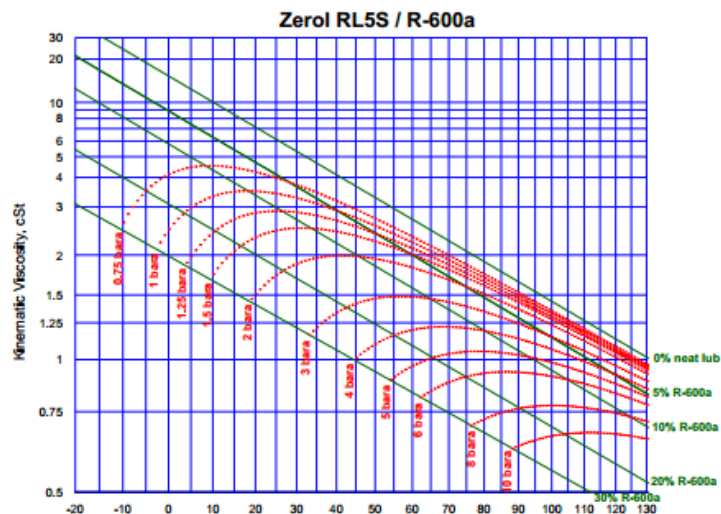
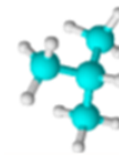


- Compressor oil sumps may contain up to ~5% dissolved hydrocarbon in the lubricant.
压缩机油池中溶解的制冷剂量高达5%
- 45°C & 6 bar
 - ✓ 5% Dilution 制冷剂含量5%
 - ✓ 15 cSt
- PAG lubricant lower dilution rate can be a benefit to regulated charge limitations. Lubricant base chemistry and viscosity can be optimized for best performance.
R290在PAG润滑油中的溶解度较小，可以利用这一特性降低冷媒充注量。基础润滑油的结构和粘度还可以进一步优化以达到最佳性能。

Lubricants for Hydrocarbon Refrigerants

适用于碳氢制冷剂的润滑油

R-600a



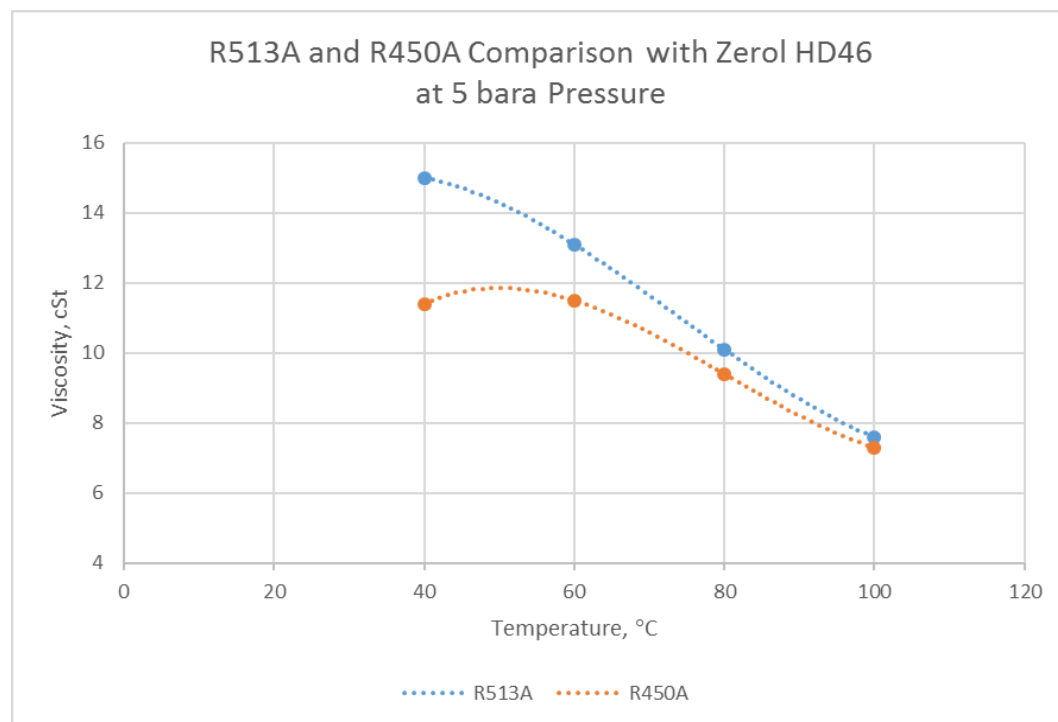
- Global Appliance Market is predominately using R-600a refrigerant.
全球家电市场基本是R-600a主导
- Mineral Oils are sometimes the typical choice of lubricant for these applications, but as demand for lower viscosities is being requested for improvements in energy efficiency, flash point and high dilution of the refrigerant in the oil becomes a challenge.
矿物油是一种典型的润滑油选择，但是随着能效要求的提高，润滑油粘度要求越来越低，低闪点以及高的制冷剂溶解度成为矿物油面临的挑战
- Alkylbenzenes based on linear alkylate (LAB) technology have become an alternate source to provide better system performance.
直链烷基苯技术能够提供比矿物油更好的性能
- Shrieve has LAB products ranging from 10 cSt to 2 cSt to meet various demands for optimized performance and energy efficiency advances.
瑞孚提供从10cSt到2cSt范围的低粘度直链烷基苯，以满足不同能效及润滑性能的需求

Lubricants for HFO and Other Refrigerants

适用于HFO及其它制冷剂的润滑油



- R-1234yf 和R-1234zeE HFO 已被广泛用于替代R134a.
- 但由于其“弱可燃性”，其和R134a的混合物被考虑用作R134a的“不可燃”替代品以降低GWP
- 其中两个混合物是R-450A (GWP=600) 和 R-513A (GWP=630)



- R-1234yf and R-1234zeE HFO refrigerants are being evaluated as replacements for refrigerants like R-134a.
- But since these refrigerants have mild flammability blends of these refrigerants with R-134a are being investigated as lower GWP non-flammable options
- Two particular options are R-450A (GWP=600) and R-513A (GWP=630)

Viscosity reduction of R450A over R513A is most likely due to the fact that R450A uses R1234zeE which has more dilution potential than R513A which uses R1234yf. Both products are blended with similar amounts of R134a.

R450A比R513A粘度低的主要原因是因为R450A含有R1234zeE, 其溶解度比R1234yf好, 因而对润滑油的稀释效应更强, 导致粘度降低。

Lubricants for HFO and Other Refrigerants

适用于HFO及其它制冷剂的润滑油



- ✓ The HVAC&R market in regards to refrigerants is in transition due to environmental concerns, various regulations and demand for improvements in energy efficiency.
- ✓ Shrieve has worked to develop lubricant options to meet the requirements of other alternative refrigerants and certain challenges associated with these refrigerants.
- ❖ Various R-404A substitutes: HFO Blends and various R407 Series – POE lubricants and PAG lubricants for higher discharge temperatures.
- ❖ Carbon Dioxide – Addressing concerns of high refrigerant dilution in certain lubricant chemistries with PAG lubricants
- ❖ Ammonia – Products designed for higher stability, less lubricant carryover and lower pour point temperatures, AB lubricants. More miscible products designed for direct expansion applications, PAG lubricants.
- ✓ 由于环保及能效要求，HVAC&R行业正在经历制冷剂的换代
- ✓ 瑞孚已经在为满足新制冷剂的使用要求开发润滑油方案
- ❖ 各种R-404A替代物：HFO混合冷媒以及407系列，POE和PAG以满足更高的排气温度
- ❖ CO₂ – 用PAG润滑油解决其它种类的润滑油可能面临的制冷剂对润滑油稀释严重的问题
- ❖ NH₃ – 烷基苯润滑油具有更高稳定性，更少润滑油夹带，更低倾点即更好的低温性能；另一方面，相溶性PAG润滑油可以应用到直膨式系统。

Summary 总结

- ✓ Specific equipment and test capabilities are essential for routine and advanced studies of lubricant and refrigerant interaction properties.
- ✓ R-32 refrigerant presents certain challenges when it comes to identifying an optimal lubricant.
- ✓ Shrieve has designed lubricant products to be used with R-32 in multiple compressor and system designs.
- ✓ Hydrocarbon refrigerants can be better served with various synthetic lubricant options.
- ✓ Shrieve is developing lubricants for all refrigerant options.
- ✓ 特殊的测试设备对常规润滑油测试及进一步深入研究制冷剂及润滑油相互作用是必不可少的
- ✓ R32制冷剂给选择理想的润滑油带来了一些挑战
- ✓ 瑞孚已开发出用于多种压缩机及系统的R32润滑油
- ✓ 合成润滑油更适合于碳氢制冷剂
- ✓ 瑞孚正在为所有新兴制冷剂开发润滑油解决方案