



Icematic

Lubricant Selection for Low GWP Refrigerants

低全球增温潜势（GWP）制冷剂配套润滑剂的选择

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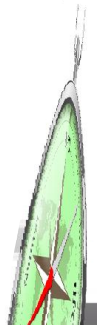
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Refrigerant Overview & Industry Trends

制冷剂简介和行业趋势



GWP Reduction from a Lubricant Perspective

Direct Global Warming Potential

- Reduce Refrigerant GWP
 - Enable use of low GWP refrigerants
- Reduce Opportunity for Refrigerant Leaks
 - Contribute to reliable, low-maintenance equipment design

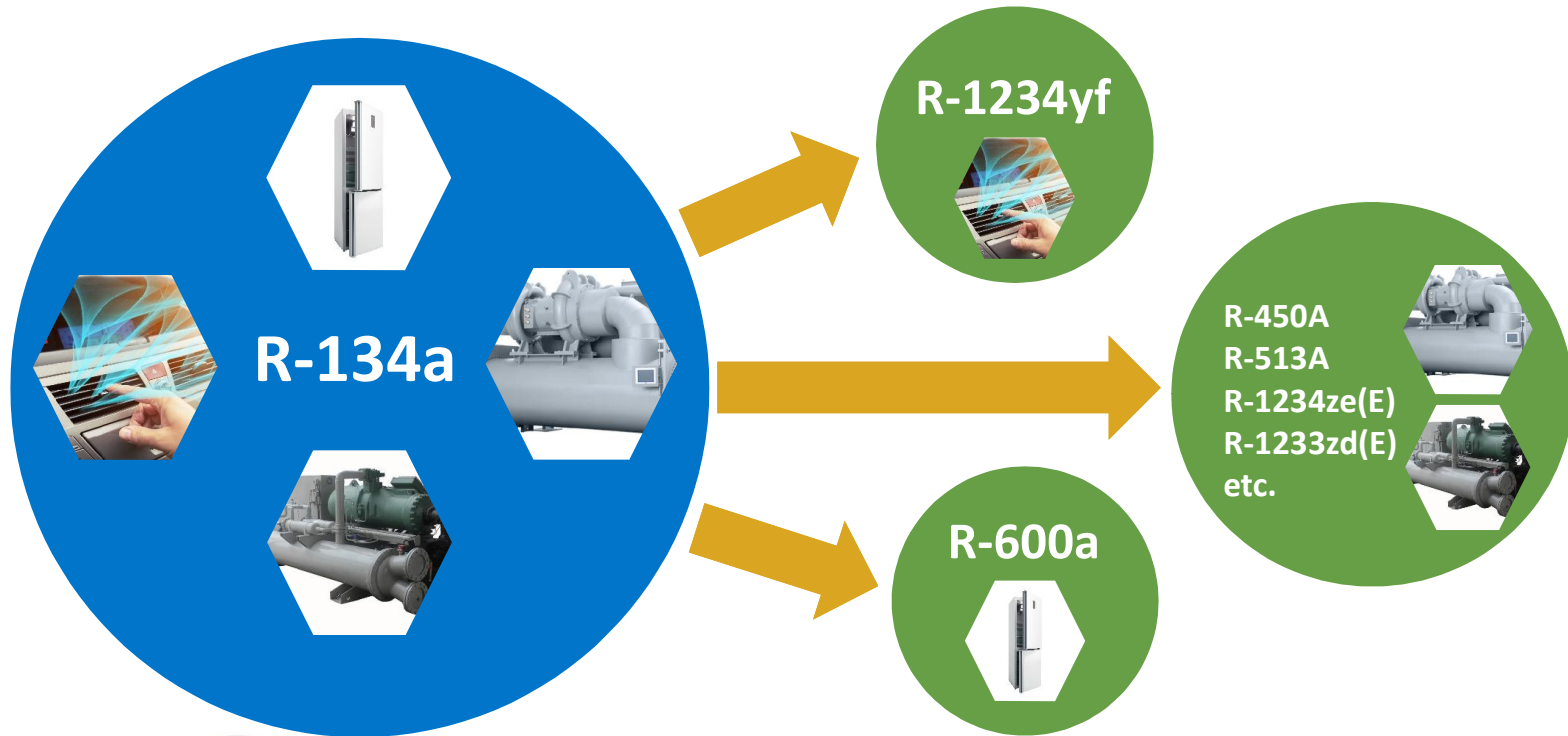
Indirect Global Warming Potential

- Reduce Energy Consumption
 - Contribute to compressor and system efficiency improvements

间接全球增温潜势（Indirect GWP）对环境的影响约为直接全球增温潜势（Direct GWP）的十倍以上。



Industry Trends – Low Pressure (R-134a)



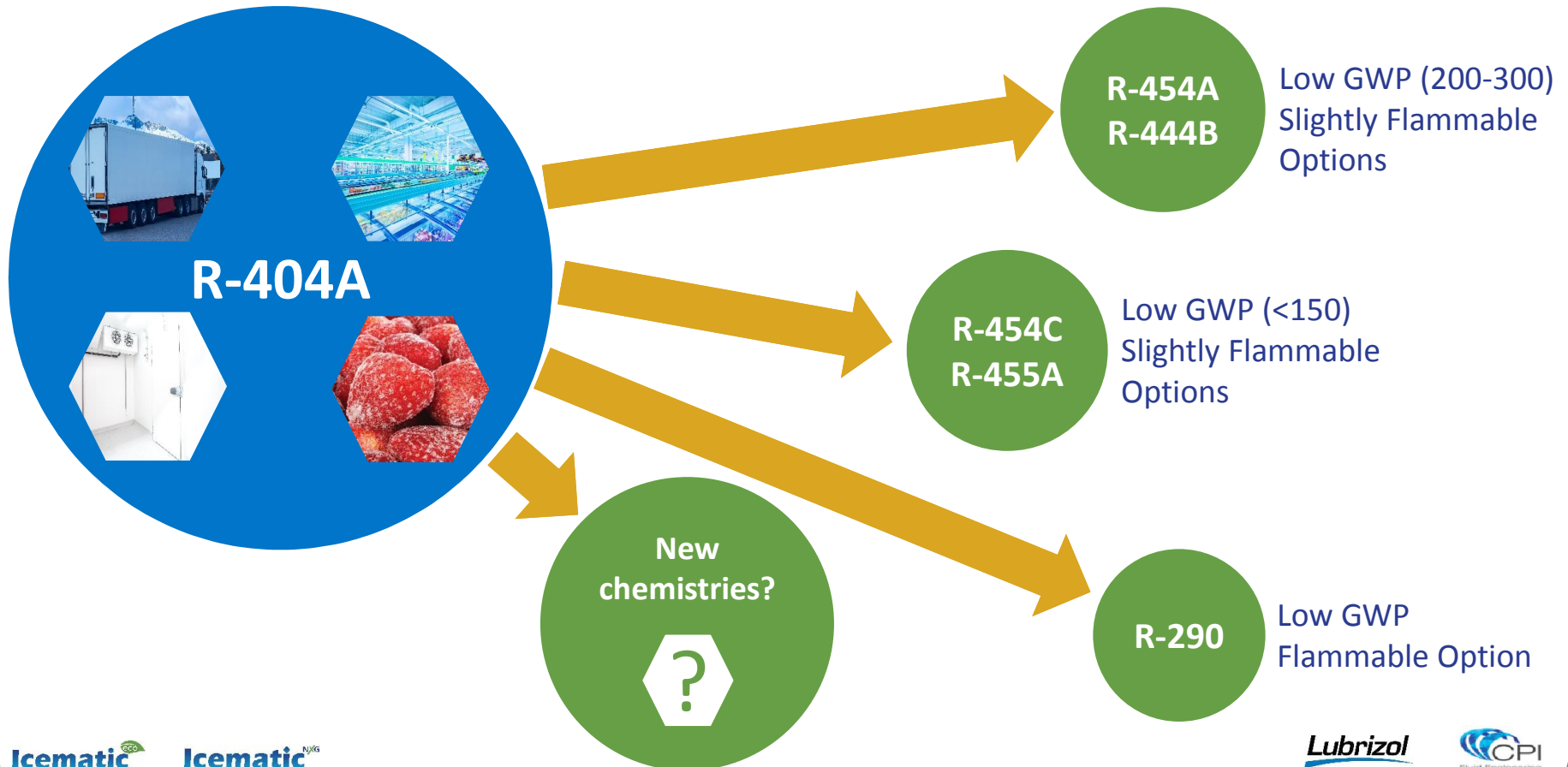
Multiple refrigerants are filling the application spaces previously occupied only by R-134a.

多种制冷剂正在许多应用领域取代R-134a。



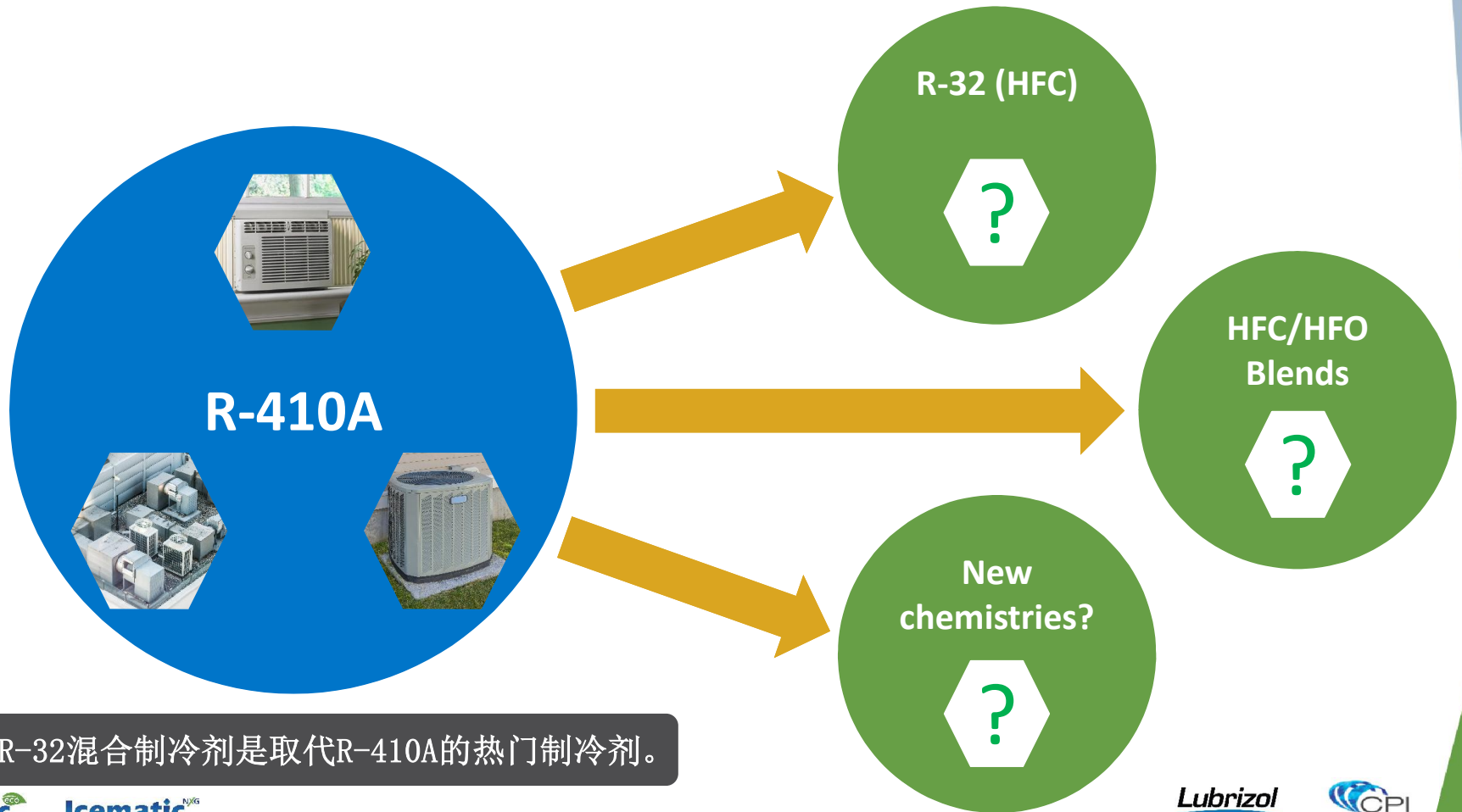
Industry Trends – Medium Pressure (R-404A)

就中压制冷剂而言，现已有多种低GWP制冷剂可以选择。





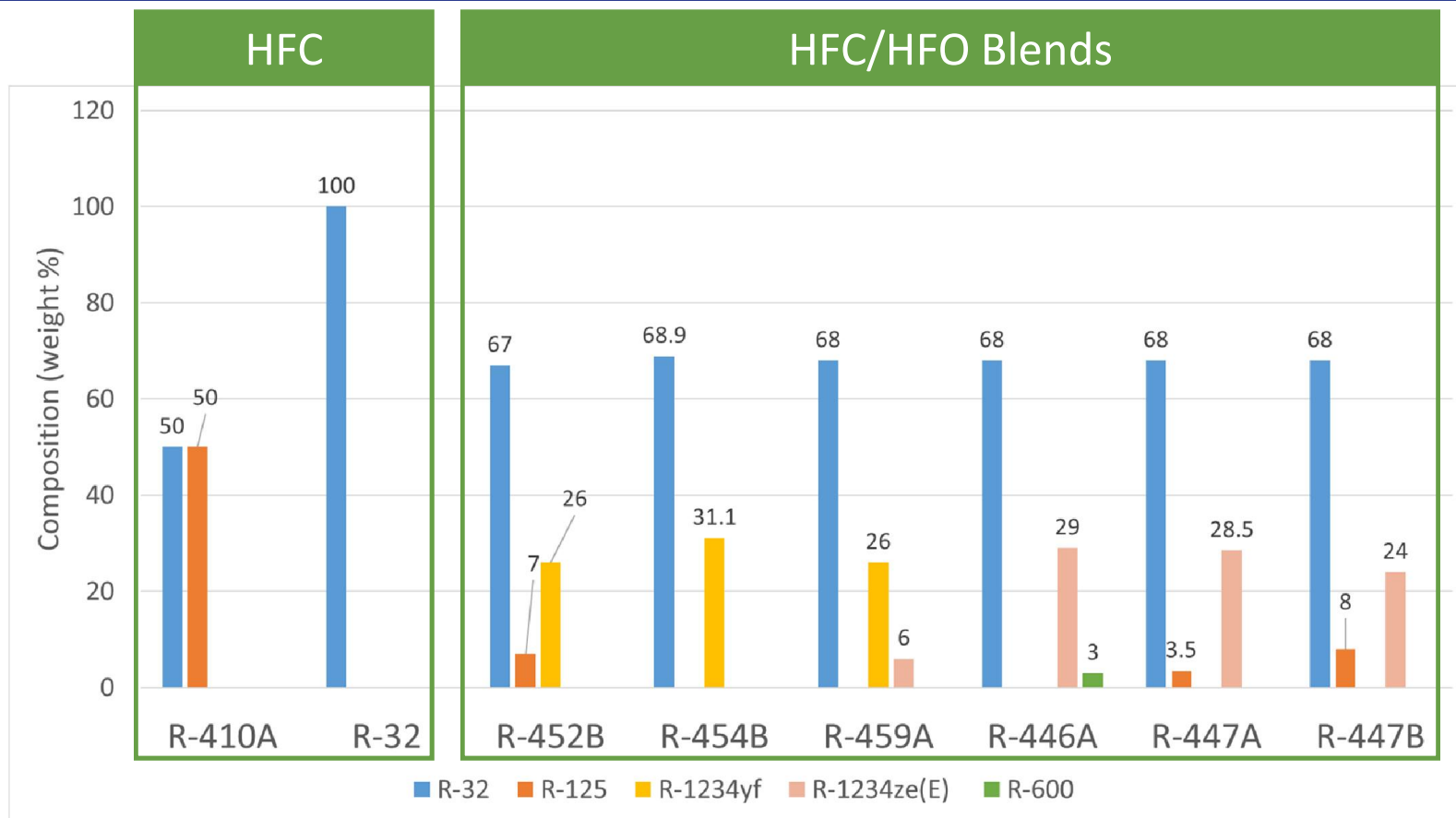
Industry Trends – High Pressure (R-410A)



R-32和R-32混合制冷剂是取代R-410A的热门制冷剂。



Selection of R-410A Alternatives

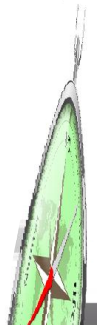


所有R-410A的替代品均属轻微易燃物。



Industry Trends Summary

- Direct GWP impacts on the environment are small relative to Indirect GWP impacts.
 - Lubricant innovation enables
 - Direct GWP reduction
 - Facilitating the transition to low GWP refrigerants
 - Contributing to the design of reliable equipment (lower leaks)
 - Indirect GWP reduction
 - Efficiency improvements
- Multiple refrigerant alternatives (5-10) are being applied or considered as replacements for each incumbent refrigerant
 - New or optimized lubricant technologies are necessary for some alternatives
- Implementation timing is driven by regulatory, regional, and technology/capability readiness factors



Lubricant Selection Criteria & Examples

润滑油选择的标准和实例



Lubrication Considerations for Low GWP Refrigerants

- ☐ Miscibility
- ☐ Solubility
- ☐ Working Viscosity
- ☐ Chemical Stability
- ☐ Target Application

Low GWP Refrigerants Impact Lubricating Properties - Lubricants will be Optimized to Meet Desired Property Targets



为保证符合应用要求，理解制冷剂与润滑油的相互作用非常必要。



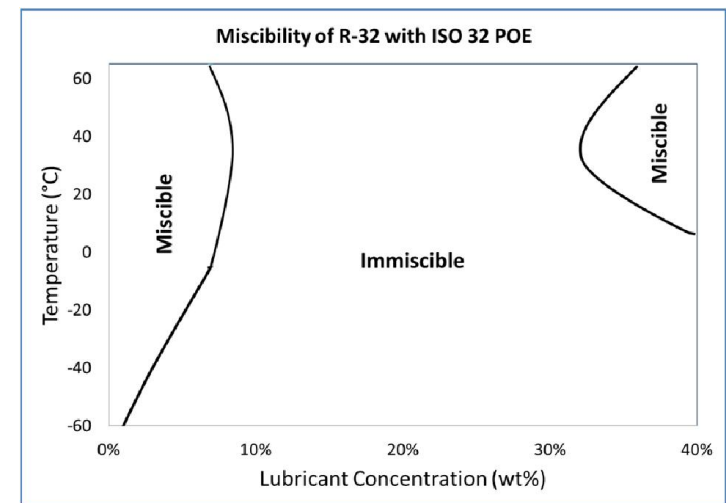
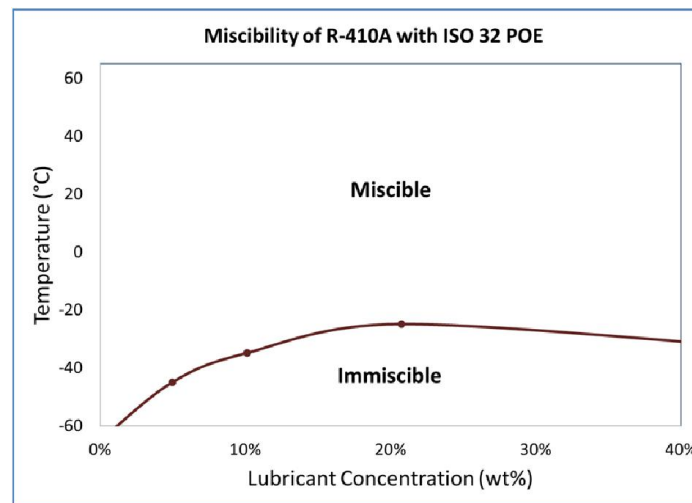
Miscibility

R-410A compared to R-32



Miscible

Immiscible

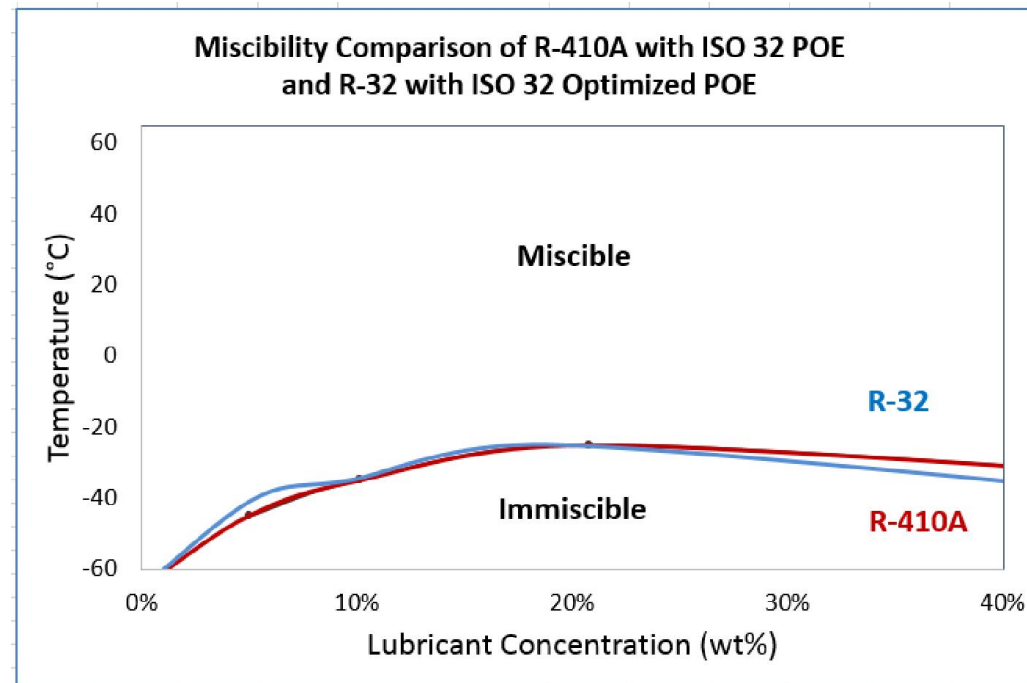


R-32 has miscibility challenges and requires optimized lubricants to ensure good oil return to the compressor.

R-32不易混溶，需配方经过优化的润滑油保证压缩机回油良好。



Lubricant Optimization to Address Miscibility Challenge



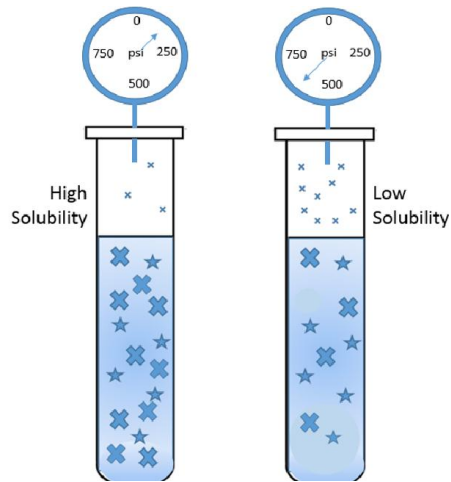
Lubricant chemistry may be modified to achieve similar miscibility performance between new refrigerants and the baseline.

解决混溶难题或需调整润滑油配方。

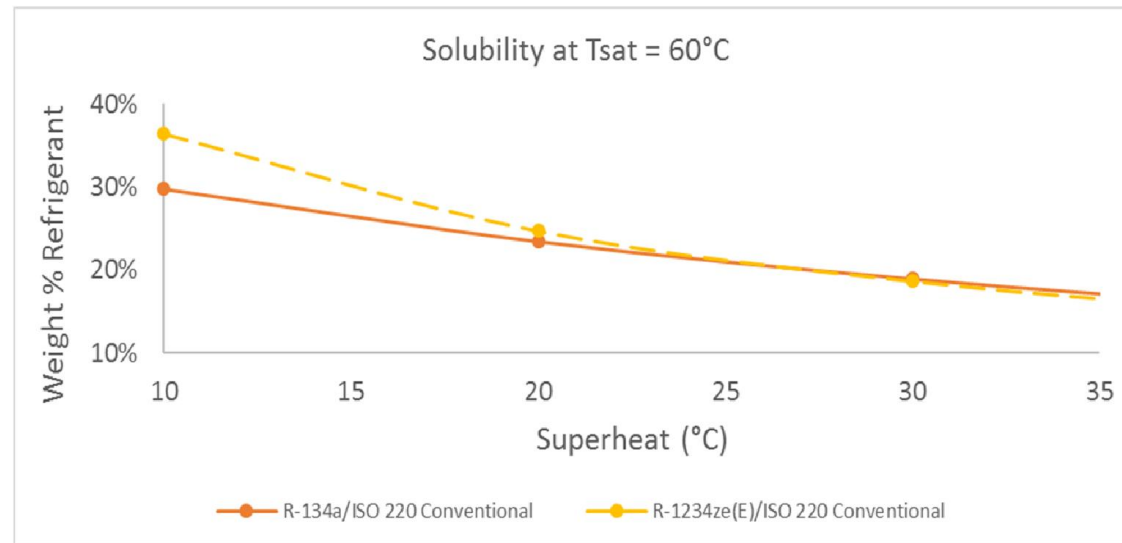


Solubility and Working Viscosity

R-134a compared to R-1234ze(E)



- × = Refrigerant Vapor
- × = Refrigerant
- ★ = Lubricant

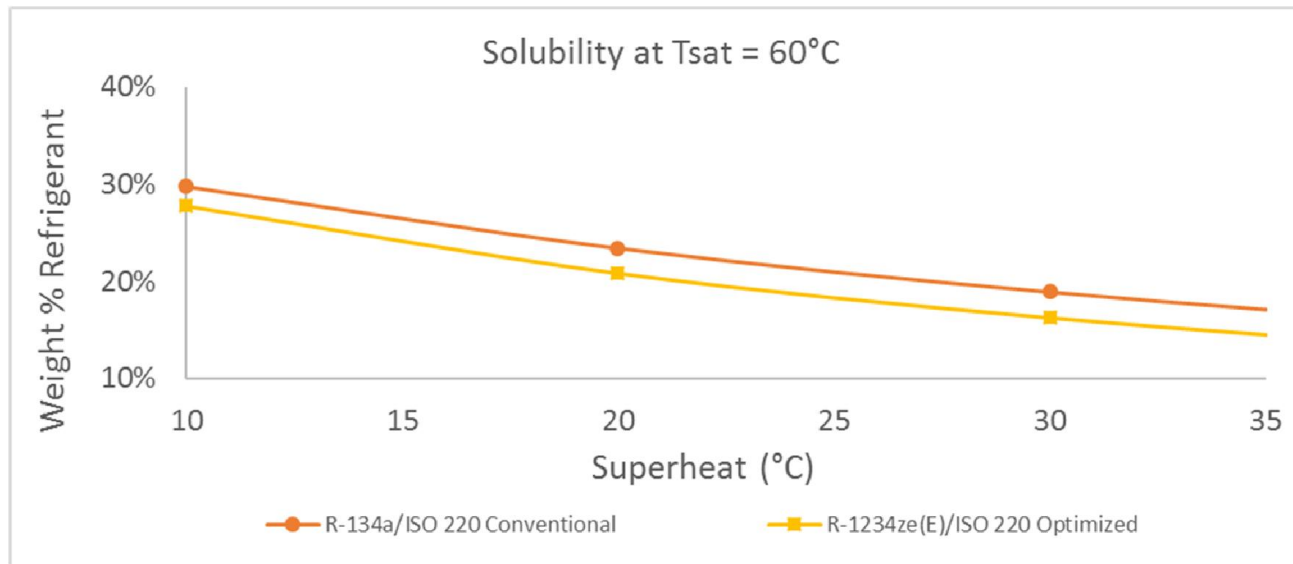


R-1234ze(E) has higher lubricant solubility compared to R-134a, resulting in lower working viscosity. A lower working viscosity could negatively impact bearing reliability.

R-1234ze (E) 比R-134a在润滑油中更易溶解，工作粘度更低。



Lubricant Optimization to Address Solubility Challenge



Lubricant chemistry may be modified to achieve similar or better solubility performance for new refrigerants relative to the baseline.

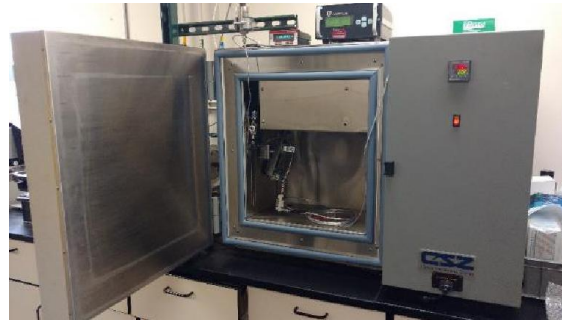
解决溶解度和工作粘度的难题或需调整润滑油配方。



Chemical Stability



Refrigerant, lubricant,
& materials of
construction placed in
a glass tube and sealed



Typically aged for 14
days at 175°C



No Additive



Additive



Post-exposure
assessments of fluids &
catalysts



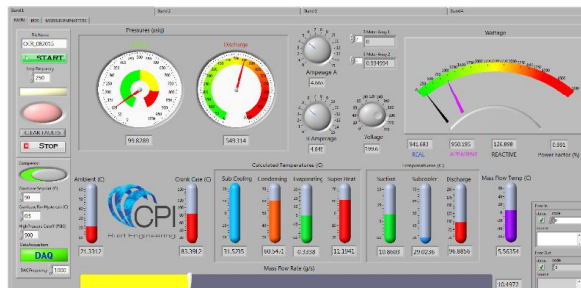
**Lubricant formulations may be modified to address
chemical stability concerns of new refrigerants.**

为消除对新制冷剂化学稳定性方面的疑虑，或需调整润滑油配方。



Target Application – Performance & Reliability

- Ultimately, performance & reliability in the target application must be validated.
 - Laboratory component or compressor testing
 - Laboratory system testing
 - Field experience
- Evaluation of equipment performance, reliability, & efficiency
- Evaluation of fluid integrity & key components



润滑油在目标应用上的表现及完好性需加以验证。



Target Application – Performance & Reliability

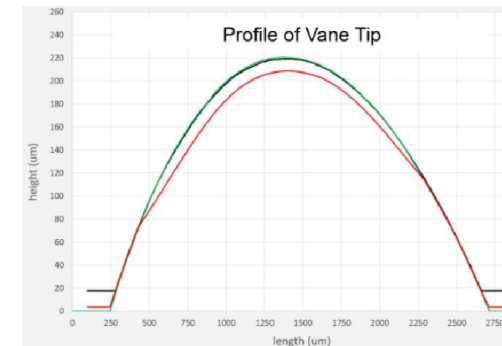
Advanced analytical techniques are useful for understanding

1) Impact of fluids on equipment:

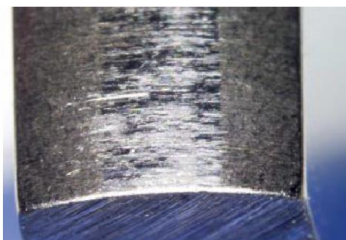
- Additive performance, component or system reliability

2) Impact of operating conditions on the fluids

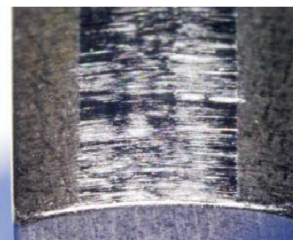
- Lubricant & refrigerant integrity, additive usage



New



State-of-the-Art

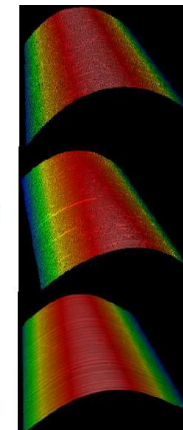


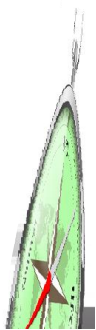
No Additive

Baseline

State-of-the-Art

New





Lubricant Options for Low GWP (<700) Refrigerants

低GWP (<700) 制冷剂配套润滑油的选择



Refrigeration Industry | Lubricant Selection Criteria

STAGE 1: END-USER TARGET

- Desired refrigerant
- System operating conditions
- Target miscibility
- Desired working viscosity
- Efficiency targets



STAGE 2: OIL RECOMMENDATION

- Typical properties
- Miscibility in refrigerant
- PVT in refrigerant
- Material compatibility
- Global regulatory review
- Formulated to meet customer needs/targets



Lubricant properties are modified for a perfect fit!

为和制冷剂完美配合，润滑油的性质或需调整。



Lubricant Options for R-32

- R-32 optimized lubricants have been developed that match R-410A performance.
- R-32 optimized lubricants are compatible with R-410A and HFC/HFO blend refrigerants including R-452B and R-454B.
- R-32 optimized lubricants are available in a range of viscosity grades to meet the needs of various applications.



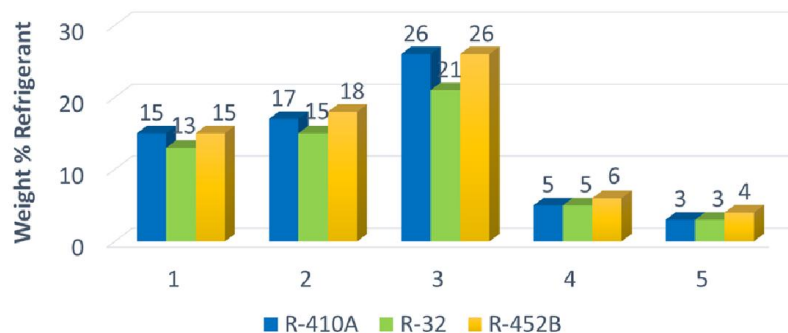
Lubricants have been developed to manage the uncertainty associated with R-410A alternatives.

润滑油研制出来是为解决R-410A替代品相关的不确定性问题。

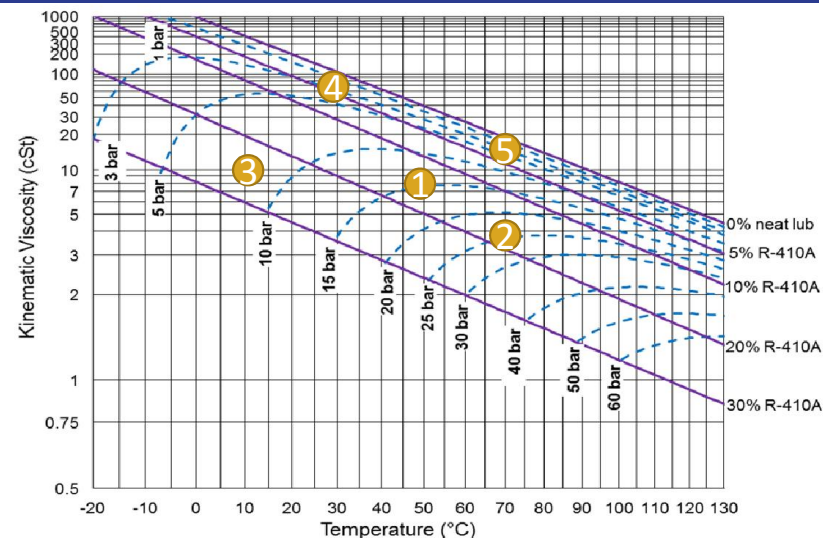
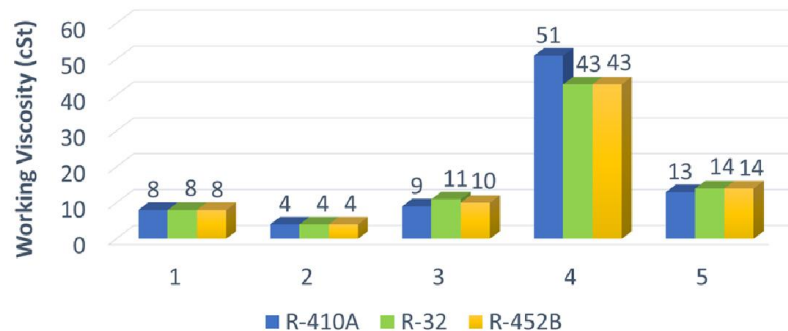


Solubility & Working Viscosity – R-410A & R-452B with POE and R-32 with Optimized POE

Solubility Comparison of ISO 68 POE with R-410A and R-452B, and New ISO 68 POE with R-32



Working Viscosity Comparison of ISO 68 POE with R-410A and R-452B, and New ISO 68 POE with R-32



New R-32 lubricant options match R-410A & R-452B solubility and working viscosity.

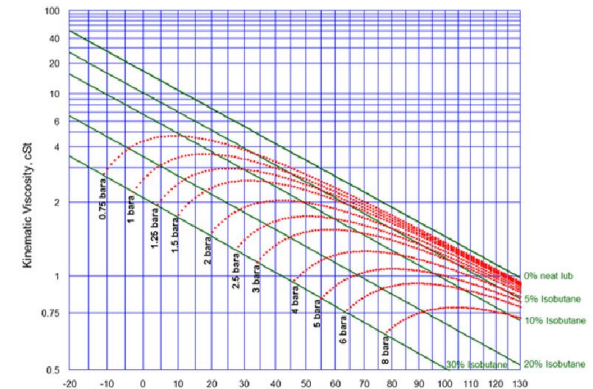
Point	Temp.	Pressure
1	50°C	14.4 bar
2	70°C	24.2 bar
3	10°C	8.0 bar
4	30°C	4.0 bar
5	70°C	5.0 bar

新R-32润滑油产品满足R-410A与R-452B溶解度和工作粘度的要求。



Lubricant Options for R-600a

- Current refrigerant charge size limitations define the application space.
- R-600a optimized lubricants have been developed to meet performance and commercial targets in today's application space and with future considerations in mind.
 - Standard efficiency
 - High efficiency
- R-600a optimized lubricants are available in several viscosity grades.



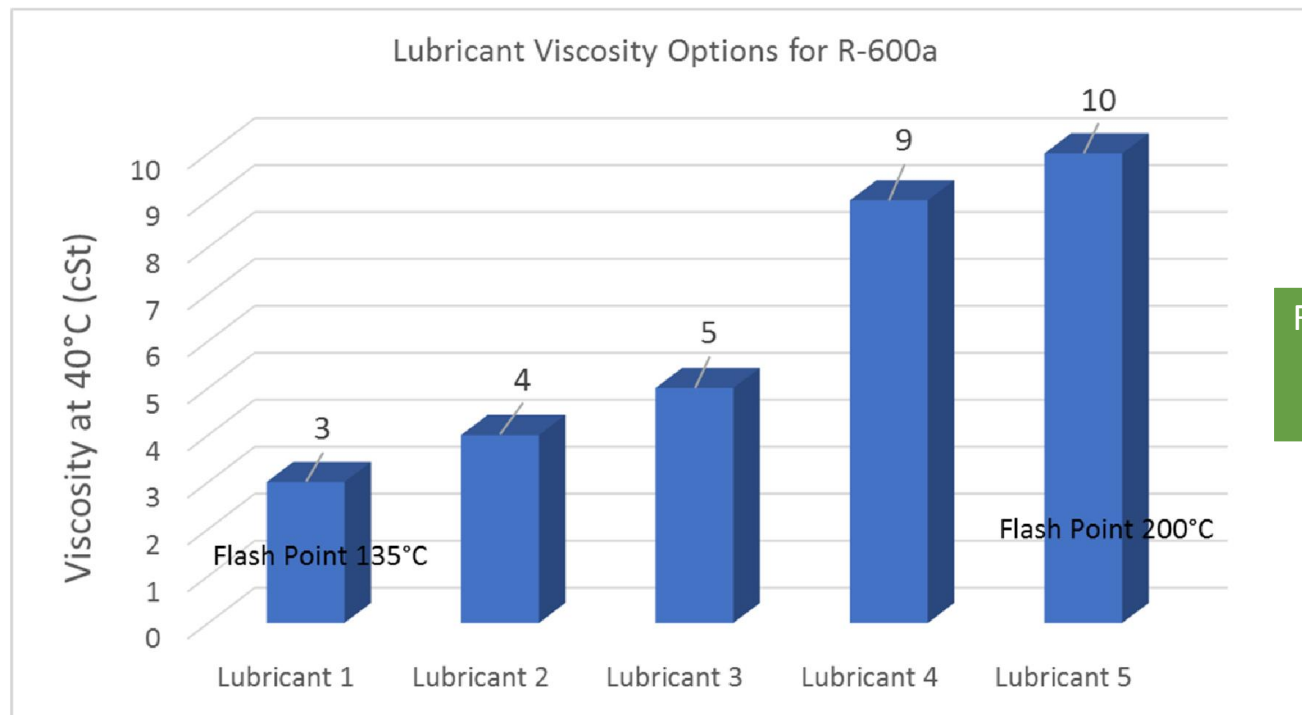
Daniel plot for an ISO 4 lubricant optimized for R-600a.

Multiple lubricant options have been developed to enable the application of R-600a.



Lubricants for R-600a

Viscosity and Flash Point



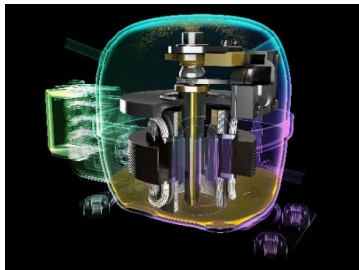
Flash point is a consideration as lubricants move to lower viscosity grades.

润滑油粘度低，需要考虑其闪点也低。



Lubricants for R-290

- ❑ High solubility impacts lubricant choice.
- ❑ Synthetic lubricants improve performance and efficiency vs standard mineral oils.
 - ❑ Users should consider cost vs performance.
- ❑ Regulatory concerns on charge size will shape this market space.
- ❑ Multiple lubrication options available.

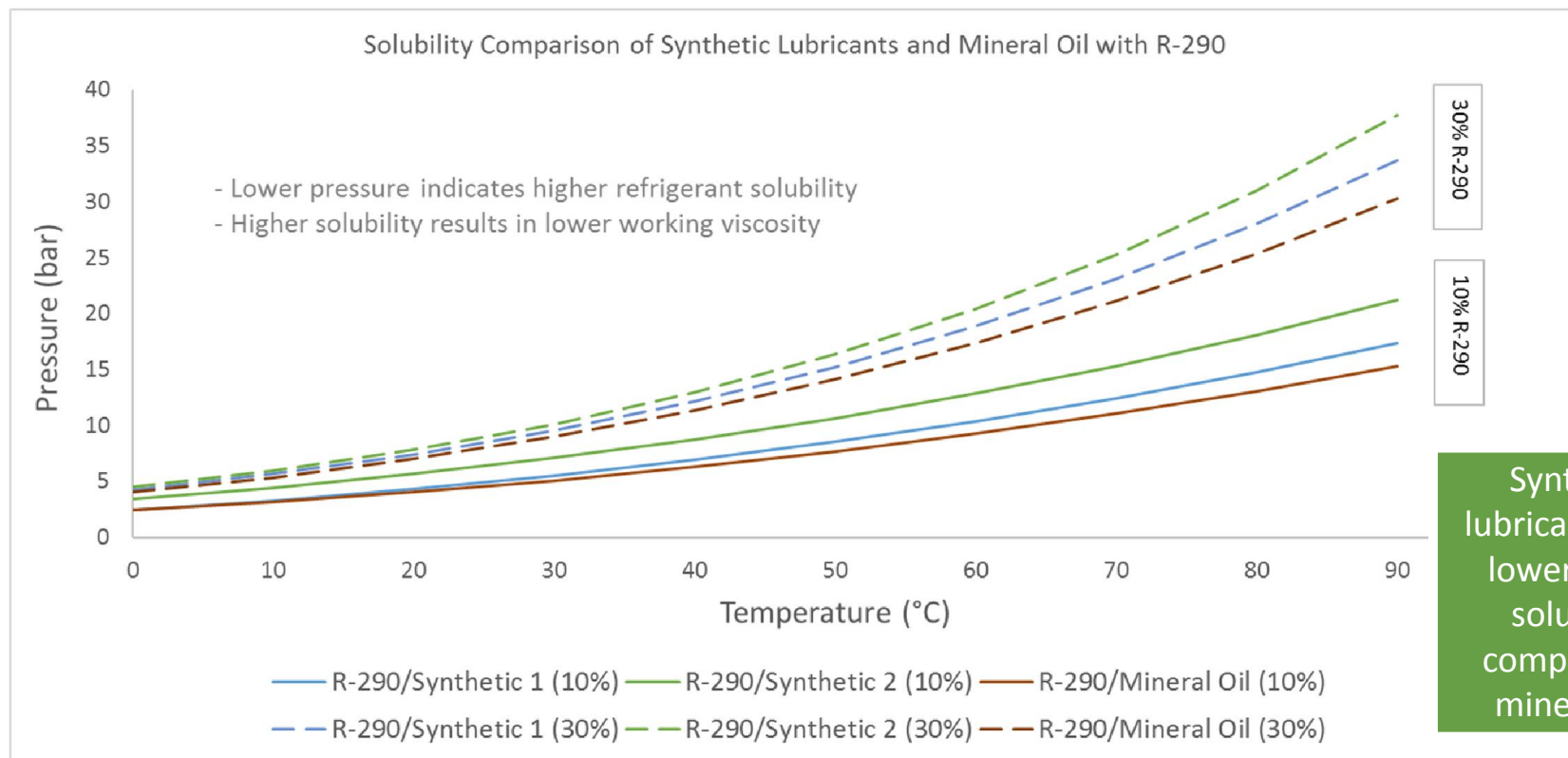


R-290有多种润滑油可供选择。



Lubricants for R-290

Solubility Comparison

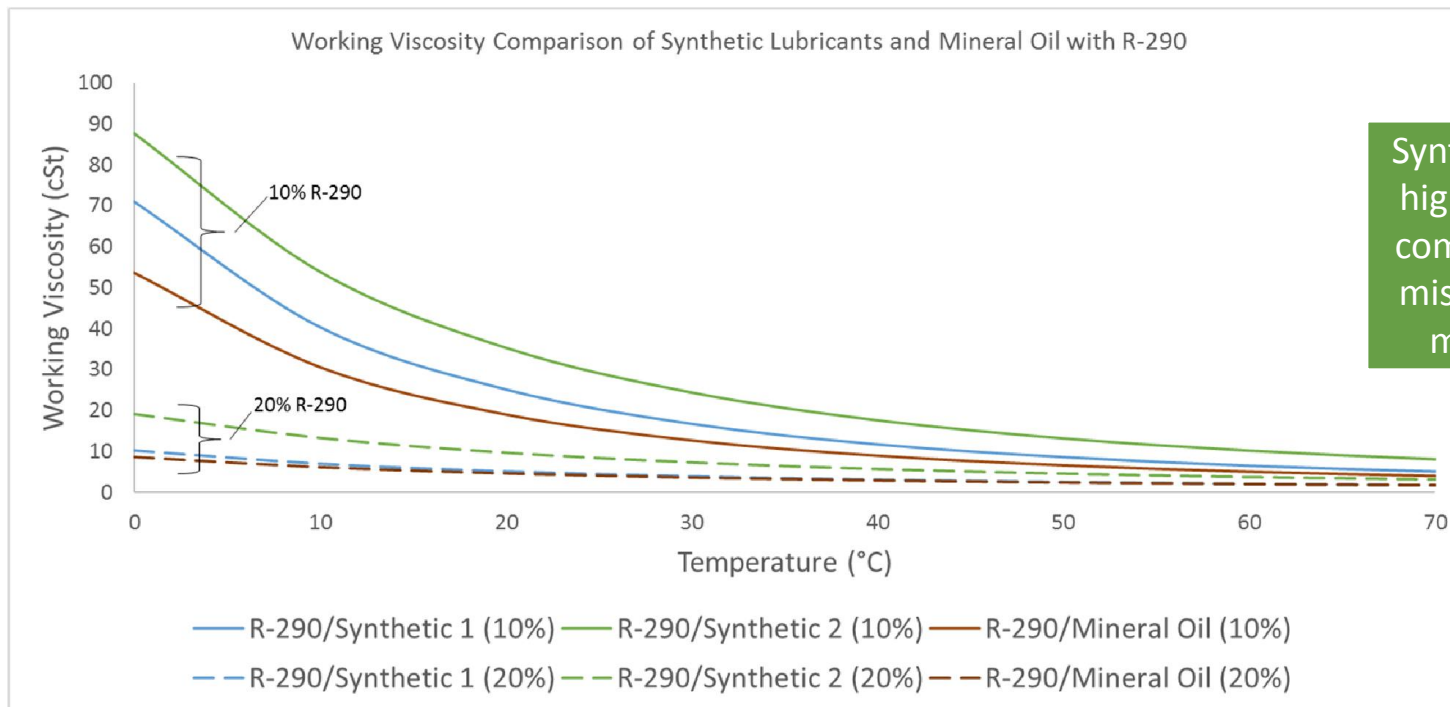


合成润滑油在R-290中的溶解度一般比矿物油低。



Lubricants for R-290

Working Viscosity Comparison (ISO 100)



Synthetic lubricants have higher working viscosity compared to mineral oil; miscibility requirements must be considered.



Lubricant Reliability & Longevity

- Programs with OEMs to Analyze Lubricant and Refrigerant Samples Over Time.
 - Use Data to Build Predictive Longevity Models
- Lubricants Developed as Fill for Life
 - Field Data Backs up Performance Targets
- Compressor Tear Downs
 - Wear Performance and Lubricant Integrity Evaluated
- Performance Data Looks Good with Lubricant / Low GWP Refrigerant Recommendations!





Conclusions

Regulatory uncertainty requires the industry to be prepared for alternate futures.

- ❑ Lubricant solutions have been/can be developed to manage the uncertainty.

R-32 requires optimized lubricants to address the miscibility changes relative to R-410A.

- ❑ New, compatible lubricants have been developed.

Many HFOs and HFO blends are compatible with today's lubricants; in some cases, optimized lubricant formulations are required to maximize performance & reliability.

- ❑ Low solubility lubricants developed for R-1234ze(E) and blends with R-1234ze(E).

A range of lubricant options exist for R-600a and R-290.

- ❑ Optimized for standard efficiency and high efficiency applications.



Lubricants are a key contributor to direct and indirect GWP reduction targets.

润滑油对降低直接GWP和间接GWP有巨大作用。



THANK YOU!

QUESTIONS ?

Lubrizol

XIE XIE!

有问题要问吗？

CPI
Fluid Engineering