Refrigerants Management & Retrofits

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Emerson Climate Technologies
Agenda

- Refrigerant Landscape and Proposed Regulation Review
- Life Cycle Climate Performance
- Refrigerant Phase-Down Approach
- Retrofit Options
- Retrofit Guidelines
- Q & A
Alternatives for Refrigeration and AC Applications

Pressure or Capacity

R-410A Like
- R410A
- R32/HFO Blends
- R407A
- R407C
- R407F
- R452A = XP44

R404A & R407/22 Like
- NH3
- R290
- HDR110 DR3
- R444B = L20 L40, DR7
- R32/HFO Blends

R134a Like
- HFC 1234yf
- HFC 1234ze

R123-Like (V.Low Pr.)
- DR2, N12, ARC 1

GWP Level
- A1 – Non Flammable
- A2L – Mildly Flammable
- A3 – Flammable
- B2L – Toxic, Mildly Flam.

Qualitative Chart – Not to Scale

E360
## EPA’s Proposed Rule on Delisting HFCs by Application

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Supermarket*</th>
<th>Condensing Units*</th>
<th>Standalone Self Contained Comm. Ref. Eqpt*</th>
<th>Vending Machines*</th>
<th>Foam</th>
<th>Auto AC</th>
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<td>Direct</td>
<td>Sec.</td>
<td>(field charged)</td>
<td>(factory charged sealed systems)</td>
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<td>2017 Model (New)</td>
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* New And Retrofit Only; Service Is Allowed
** Check EPA Documents For Details
Aerosol Application Not Shown In Above Table
Industrial, Ice Making Heads, Warehouses and Transport Applications Are Not Included In This NOPR But Comments Have Been Requested
North American Proposal for HFC Phase-Down

GWP Weighted Cap (% of Baseline)

Year

0%
20%
40%
60%
80%
100%
120%

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055

A5 Countries (Asia, etc.)

Non-A5 Countries (U.S.)
Only a Holistic Evaluation Process Can Minimize “Unintended Consequences”

- **Safety**
  - Toxicity, Flammability
  - Working Pressures

- **Performance**
  - Physical Properties
  - Capacity, Energy (Annual/Peak Energy)
  - Technology Changes

- **Economics**
  - Total Cost of Ownership

- **Environment**
  - Regulatory Requirements
  - Life Cycle Climate Performance — LCCP (GWP/TEWI)
LCCP — Accounts for Energy and GWP

LCCP (Life Cycle Climate Performance) = Direct Global Warming + Indirect Global Warming

Holistic Approach:
- Safety
- Performance
- Environment
- Economics

Refrigerant Leakage:
- Leak during life
- End of life recovery leak
- Leak during production

Energy Consumption:
- Energy used during life
- Source of energy
- Embodied energy of all material used for manufacturing of fluid
Three System Architectures Offer Lowest LCCP* Choices in Supermarket Applications

* LCCP — Life Cycle Climate Performance
Sample Refrigerant Phase-Down Analysis (Using Minimum LCCP Systems)

- 100-Store Chain
- Builds Two New Stores/Year
- Baseline: 80% R404A and 20% R22 in Centralized Systems
- System Architectures and Refrigerants Changes
  - Retrofits: Four Refrigerant Retrofits/Year to R407A for Five Years (Eliminate R22) Then Four Retrofits to N40/Year for 20 Years (Reduce R404A)
  - Remodels: Two Remodels/Year to Secondary N40
  - New Construction: Two Stores/Year to N40 Secondary or CO₂ Booster
LCCP and Weighted GWP
Weighted GWP Refrigerant Purchase

Significant decrease in GWP weighted refrigerant purchase possible
Other Methods to Reduce Weighted GWP Refrigerant Purchase

- Reduce Leak Rates
- Convert Out of R404A Sooner
- Change to Architectures That Use Less Refrigerant or Natural Refrigerants
- Increase Use of Refrigerants Like R717, R744, R290
- Monitor and Manage Refrigerant Use
Refrigerants Retrofit Options & Best Practices
Current Retrofit Options

- **R12**
  - R134a*
  - R401A, R401B, R409A

- **R502**
  - R404A*, R507*
  - R402A, R408A

- **R22**
  - R404A*, R407A/C/F
  - R422A/D*, R438A, R427A, R507*

*EPA proposed to delist in certain applications
<table>
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<tr>
<th>Refrigerants</th>
<th>Similar to</th>
<th>Application</th>
<th>Preferred</th>
<th>Alternate #1</th>
<th>Alternate #2</th>
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<td>L,M</td>
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<td>POE-32</td>
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<td>Discus = L,M</td>
<td>POE-32</td>
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<td>A8</td>
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<td>PAG</td>
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<td>Trans-critical</td>
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<td>POE-32</td>
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# Mid-Point Theoretical Refrigerant Comparison

(0SC, 20F Compressor SH, 10 Evaporator SH)

| Refrigerant     | GWP AR4 | Pressure (psia) @130F | LT Evap EER | Theo Evap Cap LT | Disch Temp (-25/105) | MT Evap EER | Theo Evap Cap MT | Dish Temp (20/120) | Glide (@120F) |
|-----------------|--------|-----------------------|-------------|------------------|----------------------|--------------|------------------|-------------------|----------------|}
| R134a           | 1430   | 213.4                 | 100%        | 100%             | 146.7               | 100%        | 100%             | 150.0             | 0              |
| R401A (MP39)    | 1193   | 214.4                 | 105%        | 122%             | 174.5               | 104%        | 116%             | 168.5             | 7.62           |
| R437A (MO49)    | 1805   | 232.0                 | 97%         | 110%             | 143.8               | 97%         | 109%             | 148.6             | 4.65           |
| R12             | 10,900 | 195.2                 | 104%        | 114%             | 152.2               | 104%        | 103%             | 153.7             | 0              |
| 1234yf          | 4      | 209.7                 | 91%         | 96%              | 119.1               | 92%         | 92%              | 131.8             | 0              |
| 1234ze          | 6      | 161.2                 | 98%         | 70%              | 125.2               | 99%         | 73%              | 134.9             | 0              |
| R450A (N13)     | ~600   | 186.5                 | 98%         | 85%              | 134.1               | 99%         | 86%              | 141.5             | 1.11           |
| R513A (XP10)    | 631    | 221.7                 | 96%         | 100%             | 130.6               | 95%         | 103%             | 139.4             | 0.01           |
| R404A           | 3922   | 368.2                 | 100%        | 100%             | 140.4               | 100%        | 100%             | 149.2             | 0.52           |
| R22             | 1810   | 311.6                 | 121%        | 109%             | 198.1               | 121%        | 110%             | 185.4             | 0              |
| R402A (HP80)    | 2796   | 386.8                 | 104%        | 114%             | 150.6               | 104%        | 113%             | 155.9             | 1.41           |
| R407A           | 2107   | 341.8                 | 112%        | 102%             | 165.2               | 112%        | 108%             | 164.9             | 7.22           |
| R407C           | 1774   | 321.3                 | 115%        | 98%              | 171.5               | 115%        | 105%             | 168.7             | 8.30           |
| R407F           | 1825   | 357.1                 | 114%        | 111%             | 177.9               | 114%        | 116%             | 173.3             | 7.31           |
| R448A (N40)     | ~1300  | 343.2                 | 112%        | 105%             | 166.0               | 112%        | 110%             | 165.8             | 7.81           |
| R449A (XP40)    | 1397   | 343.3                 | 112%        | 105%             | 164.2               | 112%        | 109%             | 164.6             | 7.70           |
Theoretical Refrigerant Comparison

Medium Pressure, Low Temp, -25/105/20SH/0SC/10ESH

Low Pressure, Low Temp, -25/105/20SH/0SC/10ESH

Medium Pressure, Medium Temp, 20/120/20SH/0SC/10ESH

Low Pressure, Medium Temp, 20/120/20SH/0SC/10ESH
# Guidelines for Refrigerant Conversions

Guidelines available online at [www.emersonclimate.com](http://www.emersonclimate.com) under the Online Product Information link

<table>
<thead>
<tr>
<th>GUIDELINES FOR REFRIGERANT CONVERSIONS</th>
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<tr>
<td>-1284 Switching Refrigerants in Field Installations</td>
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<tr>
<td>-2006ECT-54 Refrigerant Changeover Guidelines HCFC R-22 to HFC R-404A/R507</td>
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<td>-2007ECT-13 Refrigerant Changeover Guidelines HCFC R-22 to HFC R-422A/D</td>
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<td>-2010ECT-19 Refrigerant Changeover Guidelines HCFC R-22 to HFC R-438A for Medium and Low Temperature Applications</td>
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<td>-90-02 Refrigerant Changeover Guidelines CFC-12 to R-401A</td>
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<td>-90-03 Refrigerant Changeover Guidelines CFC-12 to R-401B/R-409A</td>
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<td>-90-05 Refrigerant Changeover Guidelines R-502 to R-402A/R-408A</td>
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<td>-95-14 Refrigerant Changeover Guidelines R-22- R-407A,C,F /R-427A</td>
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Refrigerants and Lubricants
Frequently Asked Questions (FAQ)

Question: Can I mix different oils?
Answer: Yes. Refer to publication 92-11 from Emerson Climate Technologies, Inc.

Question: Can I use different weight oils?
Answer: Yes. Refer to publication 93-11 from Emerson Climate Technologies, Inc.

Question: Can I use R22 with POE?
Answer: Yes. Refer to publication 93-11 from Emerson Climate Technologies, Inc.

Question: Can I add an additive to the oil in my system?
Answer: No. Additives are not permitted. Refer to Application Engineering Bulletin 17-1282.

Question: When we are assembling the system it is open to the air for several hours. What effect will this have on POE oil?
Answer: Exposure to ambient air will cause moisture to be absorbed in the POE oil. Refer to various HFC refrigerant retrofit guidelines published by Emerson Climate Technologies, Inc.

Question: Will too high of an oil level cause the compressor to trip on oil failure?
Answer: No. It may result in a motor protector trip due to high amps.

Question: What is the viscosity of POE oil?
Answer: The viscosity of oils used in Copeland™ compressors is selected by the design of the compressor and varies from 22 to 32 cst (centistokes). Refer to the Emerson Climate Technologies, Inc. publication 92-11 for further details.

Question: What should the oil level be in the sight glass of a Copeland compressor?
Answer: Typically ½ sight glass of oil is required in Copeland compressors; some models are different. Refer to Application Engineering Bulletin 4-1281 for further details.

Question: Where can I find what refrigerants are approved for Copeland compressors?
Answer: Approved refrigerants can be found in the Emerson Climate Technologies, Inc. publication 93-11.

Question: What is centistokes and what is the difference between 22 CC and 32 CC?
Answer: Centistokes (cst) is the unit of measure for viscosity of the oil. 22 CC oil has a viscosity of 22 cst at standard conditions and 32 CC oil has 32 cst.

Question: What percent mix of oils is acceptable?
Answer: Refer to the refrigerant changeover guidelines from Emerson Climate Technologies, Inc.

Question: What would be the effect if I topped off the compressor with the wrong oil?
Answer: Emerson recommends topping with approved oils as listed in publication 93-11. Use of non-approved oils may result in oil management and lubrication issues that could lead to system inefficiencies and compressor failure.

Question: Are all POE refrigerant oils the same?
Answer: No. Oils vary in viscosity, formulation, etc. and are designed for different applications in different compressors.

Question: What acid test kit does Emerson Climate Technologies recommend?
Answer: Emerson Climate Technologies recommends the Emerson™ Universal Acid Test Kit, product code 064427.

Question: What will happen if I use Mineral oil or Alkylbenzene oil with an HFC refrigerant?
Answer: Emerson recommends using oils approved as listed in publication 93-11. Use of non-approved oils may result in oil management and lubrication issues that could lead to system inefficiencies and compressor failure.

Question: How long can I leave POE oil exposed to the atmosphere before contamination occurs?
Answer: Exposure to ambient air will cause moisture to be absorbed in the oil. Refer to the various HFC refrigerant retrofit guidelines published by Emerson Climate Technologies, Inc.

Question: Will warranty be affected if I used the wrong oil and refrigerant combination?
Answer: Yes.

Question: How can I determine what oil is in a compressor?
Answer: A complete chemical analysis will confirm the identity of the oil. However, if there is doubt as to the oil in the compressor, we recommend changing the oil to what is approved in the Emerson Climate Technologies publication 93-11.

Question: Does Emerson Climate Technologies analyze oil from failed compressors?
Answer: Investigation of failed compressors generally requires oil analysis.

The Frequently Asked Questions bulletin is available at the “Online Product Information” (OPI) site under section 28 of the Application Engineering Bulletins.
Why Retrofit Refrigerants?

- Facilitates Compliance With Environmental Regulations
- Potential to Upgrade Compressor Technologies = Increased Efficiencies
- Enables Accelerated Transition Away From Ozone-depleting Refrigerants
- Provides Opportunity to Promote Environmental Leadership
- Provides Potential for Improved Compressor Reliability and Lifespan
- Avoid Premature Obsolescence of Equipment
- Avoids Costly Equipment Replacement / Improve Life Cycle Cost of Equipment
- Enables Continued Use of Existing Equipment With Minimal Downtime for Retrofit
Considerations Prior to Retrofit

- Are the Current Compressors and System Components Compatible With the New Refrigerants and Oils? Will Additional Cooling be Required?

- Will the System Require a “Flush” to Remove Excess Amounts of Mineral Oils When Converting to POE Oil?

- Are the Compressor Capacities With the New Refrigerant Similar to the Existing Refrigerant?

- Will the Sizing of the Thermal Expansion Valves Need to be Addressed or will the Valves Need to be Adjusted to Maintain Proper Super Heat? Remember, Many of the New Refrigerants Are Blends and May Have a Glide up to 8 °F.

- Filter Driers Will Need to be Changed, and Ensure That the Drier Type and Design Are Compatible With the New Refrigerant and Oils. Will Seals and Gaskets Need to be Replaced.

- Pressure Switches and Controls Should be Verified and Adjusted for the New Refrigerant.

- Is there an Opportunity to Upgrade System Performance? Digital or Modulated Compressors, Floating Head Pressures Down, Reduce Number of Compressors on Rack?

- How Will You Manage System Downtime?
Eight Easy Steps for Refrigerant Retrofit

*Always Follow Recommended Safety Guidelines and Procedures*

1) Establish a Performance Baseline With the Existing Refrigerant in the System.

2) Leak Check and Repair All Leaks Prior to Changing Refrigerants.

3) Remove Mineral Oil From Compressors (if applicable), and Recharge With the Appropriate Oil. Will the System Require a Flush to Remove Residual Oils?

4) Remove Existing Refrigerant / Weigh the Refrigerant Recovered From the System.

5) Change Filter Driers and Other Components, as Required. Verify Pressure Settings on Controls and Safeties.

6) Evacuate System Down to 250 Microns; Verify System Is Leak-Free.


# Mid-Point Theoretical Refrigerant Comparison

(0SC, 20F Compressor SH, 10 Evaporator SH)

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>GWP AR4</th>
<th>Pressure (psia) @130F</th>
<th>LT Evap EER</th>
<th>Theo Evap Cap LT</th>
<th>Disch Temp (-25/105)</th>
<th>MT Evap EER</th>
<th>Theo Evap Cap MT</th>
<th>Dish Temp (20/120)</th>
<th>Glide (@120F)</th>
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<td>R134a</td>
<td>1430</td>
<td>213.4</td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td>146.7</td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
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<td>214.4</td>
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<td><strong>100%</strong></td>
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<td>103%</td>
<td>139.4</td>
<td>0.01</td>
</tr>
<tr>
<td>R404A</td>
<td>3922</td>
<td>368.2</td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td>140.4</td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td>149.2</td>
<td>0.52</td>
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<tr>
<td>R22</td>
<td>1810</td>
<td>311.6</td>
<td>121%</td>
<td>109%</td>
<td>198.1</td>
<td>121%</td>
<td>110%</td>
<td>185.4</td>
<td>0</td>
</tr>
<tr>
<td>R402A (HP80)</td>
<td>2796</td>
<td>386.8</td>
<td>104%</td>
<td>114%</td>
<td>150.6</td>
<td>104%</td>
<td>113%</td>
<td>155.9</td>
<td>1.41</td>
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<tr>
<td>R407A</td>
<td>2107</td>
<td>341.8</td>
<td>112%</td>
<td>102%</td>
<td>165.2</td>
<td>112%</td>
<td>108%</td>
<td>164.9</td>
<td>7.22</td>
</tr>
<tr>
<td>R407C</td>
<td>1774</td>
<td>321.3</td>
<td>115%</td>
<td>98%</td>
<td>171.5</td>
<td>115%</td>
<td>105%</td>
<td>168.7</td>
<td>8.30</td>
</tr>
<tr>
<td>R407F</td>
<td>1825</td>
<td>357.1</td>
<td>114%</td>
<td>111%</td>
<td>177.9</td>
<td>114%</td>
<td>116%</td>
<td>173.3</td>
<td>7.31</td>
</tr>
<tr>
<td>R448A (N40)</td>
<td>~1300</td>
<td>343.2</td>
<td>112%</td>
<td>105%</td>
<td>166.0</td>
<td>112%</td>
<td>110%</td>
<td>165.8</td>
<td>7.81</td>
</tr>
<tr>
<td>R449A (XP40)</td>
<td>1397</td>
<td>343.3</td>
<td>112%</td>
<td>105%</td>
<td>164.2</td>
<td>112%</td>
<td>109%</td>
<td>164.6</td>
<td>7.70</td>
</tr>
</tbody>
</table>
Future Retrofit and Alternative Options

- **R134a**
  - R450A, R513A
  - *HFO1234yf, *HFO1234ze
  - Others?

- **R404A**
  - R407A/C/F, R448A, R449A
  - *R290, *R744 (CO$_2$), HFO Blends?

- **R410A**
  - *R32
  - *HFO Blends???

*R290 and R744 (CO$_2$) are not applicable for retrofit, and many of the blends are considered mildly flammable.*
Thank You!

Questions?

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