Refrigerants Technology
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Agenda

- Introduction to Refrigerants
  - Refrigerants Technology Evolution
- HCFC-22 Replacements
  - Air Conditioning
  - Refrigeration
- Next Generation Low GWP Refrigerants
  - Auto AC applications: HFO-1234yf
  - Low GWP refrigerants for Stationary applications
- Final Comments
Regulatory Requirements Driving Change

- Montreal Protocol / Ozone Depletion Concerns
- Kyoto Protocol / Global Warming Concerns

CFCs → HCFCs → HFCs → HFOs

- CFC Phase-out
- HCFC Phase-out
- EU F-Gas Regulation

- Ozone
- Global warming

R12 → R134a → R1234yf

- Simple Chemistry
- Enhanced Chemistry
- New Molecule Development
- Advanced Molecules Development + Complex Chemistry
The major HFC refrigerants (by volume):

- **R-410A**: 50/50 mixture of 32 and 125 which is industry choice to replace R-22 in residential and light commercial a/c.
- **R-134a**: Used in mobile a/c, large chillers, & small refrigeration applications.
- **R-404A**: 44/52/4 mixture of 125, 143a, and 134a &
- **R-507**: 50/50 mixture of 125 & 143a. Both are used in commercial (supermarket) and industrial refrigeration.
New Hydro-Fluoro-Olefins have been developed:

- **Solstice™ 1234yf (R-1234yf)** has been identified as replacement for R134a by the automotive industry.
  - It has an atmospheric life of only 11 days (12 years for HFC-134a) and an extremely low GWP~0 (1430 for R-134a).
  - R-1234yf is mildly flammable, ASHRAE Safety Classification A2L
  - Can also be used in refrigerant blends

- **Solstice™ 1234ze(E)**, is currently replacing R-134a for one-component foam applications and looks promising for centrifugal chillers.
  - This molecule has a very short atmospheric lifetime with a GWP=1
  - R-1234ze is nonflammable at room temp but ASHRAE A2L
  - Can also be used refrigerant blends

- **Solstice™ 1233zd(E)** is also being commercialized
  - Intended refrigerant application is low pressure centrifugal chillers.
  - It has a GWP of 1 and is non-flammable, likely AHSRAE A1
Refrigerant Stability

Thermal Stability:
- Sealed tube tests using 1234ze and 1234yf with lower viscosity POE oils ISO-10 and ISO-7.
- Test Conditions: 2-week duration; 2 temperatures (175°C and 200°C); 2 moisture levels (<50 ppm and 1000 ppm).
- Both 1234yf and 1234ze show excellent stability: Clear color and very low TAN numbers.
Refrigerants: Flammable Gas Definitions

- **ASHRAE Standard 34** (for a single component refrigerant)
  - ASTM E681-01: 12 liter flask, spark ignition, 1 atmosphere, air RH (50% at 23°C) 60°C
    - **Class 1**: no flame propagation
    - **Class 2**: $< 19,000 \text{ kJ/kg}$ and $> \text{ LFL } 0.10 \text{ kg/m}^3$
      - Safety Group 2 is subdivided into 2 and 2L
      - 2L refrigerants have a **Burning Velocity** less than 10 cm/sec (less flammable)
    - **Class 3**: $\geq 19,000 \text{ kJ/kg}$ or $\leq \text{ LFL } 0.10 \text{ kg/m}^3$

- **Japan Definition**
  - Flammable if the LEL $< 10 \text{ vol.}%$
  - Flammable if the difference UEL-LEL $> 20 \text{ vol.}%$
  - Measurement temperature and apparatus not clearly defined.

- **ISO 817 (Standard is published but not yet approved)**
  - Flammability classification is essentially the same as ASHRAE Standard 34 (test temperature is 60°C)
Flammability is evaluated by ‘Chance of Flame occurring’ and ‘Effect of Flame occurring’

- Effect of Flame occurring -> Burning Velocity, Heat of Combustion

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**Damage Potential**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Burning Velocity, cm/s</th>
<th>Heat of Combustion, MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R152a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFO-1234yf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R134a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ASHRAE Classes**

- ASHRAE Class 3
- ASHRAE Class 2
- ASHRAE Class 2L

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**Increasing Impact**
Probability of Ignition

Flammability is evaluated by ‘Chance of Flame occurring’ and ‘Effect of Flame occurring’

- Chance of Flame occurring -> Lower Flame Limit, Minimum Ignition Energy

![Graph showing flammability of different substances]

- Methane
- R-152a
- Acetylene
- Propane
- Iso-Butane
- Gasoline
- HFO-1234yf
- R-32
- Ammonia

Increasing Flammability:
> 5000 times more energy to ignite!
Ignition/Deflagration of 2L Refrigerants

- **1234yf (BV=1.5)**: Flame covers ~15% of the volume

- **R32 (BV=6.7)**: Flame covers ~100% of the volume

- **R152a (BV=23)**: Strong pressure rise

- **R600a (BV~40)**: Strong pressure rise
Practical Application - Refrigerator Test

For an Homogeneous distribution, 1234yf is not in the flammable range.

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Vapor Density (23°C, 1 Atm)</th>
<th>Leaked Refrigerant (80% of Charge)</th>
<th>Volume Occupied by Refrigerant</th>
<th>C-vol</th>
<th>LFL - UFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFO-1234yf</td>
<td>4.801</td>
<td>0.111</td>
<td>0.02312</td>
<td>3.3%</td>
<td>6.2% - 12.3%</td>
</tr>
<tr>
<td>R152a</td>
<td>2.779</td>
<td>0.089</td>
<td>0.03202</td>
<td>4.5%</td>
<td>3.9% - 16.9%</td>
</tr>
<tr>
<td>Isobutane</td>
<td>2.458</td>
<td>0.055</td>
<td>0.02237</td>
<td>3.2%</td>
<td>1.8% - 8.4%</td>
</tr>
</tbody>
</table>
Air Conditioning
<table>
<thead>
<tr>
<th>Segment</th>
<th>Regional use</th>
<th>Refrigerant</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unitary AC</td>
<td>US</td>
<td>410A</td>
<td></td>
</tr>
<tr>
<td>Heat Pump</td>
<td>US, AS, LA</td>
<td>410A</td>
<td></td>
</tr>
<tr>
<td>Window Unit</td>
<td>EU, AS, LA, MX</td>
<td>22 &gt; 410A</td>
<td></td>
</tr>
<tr>
<td>Ductless Split (mini-split)</td>
<td></td>
<td>22, 410A, 407C</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaged Rooftop</td>
<td>Global</td>
<td>22, 410A</td>
<td></td>
</tr>
<tr>
<td>PTAC</td>
<td>Global</td>
<td>22 &gt; 410A</td>
<td></td>
</tr>
<tr>
<td>Chillers</td>
<td>Global</td>
<td>123, 134a, 22, 407C, 410A</td>
<td></td>
</tr>
</tbody>
</table>
# Primary Replacements for HCFC-22 in A/C

<table>
<thead>
<tr>
<th>Product</th>
<th>Primary Application</th>
<th>Lubricant</th>
<th>Segregation Potential</th>
<th>Retrofit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-410A</td>
<td>Unitary A/C</td>
<td>POE</td>
<td>Very Low</td>
<td>NO</td>
</tr>
<tr>
<td>R-407C</td>
<td>Unitary A/C</td>
<td>POE</td>
<td>High</td>
<td>YES</td>
</tr>
<tr>
<td>R-134a</td>
<td>Chillers</td>
<td>POE</td>
<td>None</td>
<td>NO</td>
</tr>
</tbody>
</table>

There were few good candidates to replace R-22 in A/C
## System/Refrigerant Interaction

<table>
<thead>
<tr>
<th>Efficiency Effect (%)</th>
<th>R-134a</th>
<th>R-407C</th>
<th>R-410A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermodynamics</td>
<td>+2</td>
<td>-4</td>
<td>-7</td>
</tr>
<tr>
<td>Compressor</td>
<td>-3</td>
<td>-1</td>
<td>+5</td>
</tr>
<tr>
<td>Heat Exchangers</td>
<td>-6</td>
<td>-2</td>
<td>+5</td>
</tr>
<tr>
<td>Lines</td>
<td>-2</td>
<td>0</td>
<td>+2</td>
</tr>
<tr>
<td>Total (Net)</td>
<td>-9</td>
<td>-7</td>
<td>+5</td>
</tr>
</tbody>
</table>
Why R-410A?

• Higher system efficiency despite lower thermodynamic efficiency
• More compact equipment
• Better heat transfer
• Lower delta P impact

Evaporation Pressure at 45° F & Condensing Pressure at 115° F
# Retrofitting HVAC Systems

## Refrigerant Options

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Best capacity and efficiency match to R-22</th>
<th>The most efficient R-22 retrofit option in the marketplace</th>
<th>A change to POE lubricant is recommended. If existing MO is used, the addition of some POE to the system is required for proper oil return</th>
<th>Requires a minimum of 20% POE for close-coupled A/C systems</th>
<th>No TXV change required</th>
<th>Lowest GWP (1774) among R-22 replacements</th>
<th>Lower discharge temperatures than R-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-407C (HFC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-422D (HFC)</td>
<td>No oil change* or TXV change** in most installations</td>
<td>Satisfies customers looking for a “drop-in” option</td>
<td>Slightly less capacity and efficiency but lower discharge temperatures</td>
<td>Can be used with AB, MO, POE lubricants* when short connecting lines are used</td>
<td>Lower discharge temperatures than R-22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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* System designs vary and the addition of POE may be required to assured proper oil return

** The mass flow of R-422D is higher than that of R-22 and an evaluation of the expansion device is recommended
Refrigeration
Honeywell
Refrigeration Equipment Segments

- Convenience Store Coolers (MT)
- Restaurant Refrigerators (MT)
- Iced Cream Dispensing (LT)
- Supermarket/Deli Cases (MT)
- Supermarket Freezer Cases (LT)

- R-134a
- R-404A
- R-507
- R-134A

## Centralized DX System

<table>
<thead>
<tr>
<th>Features</th>
<th>Pros</th>
<th>Cons</th>
<th>Current</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Compressor rack in</td>
<td>- Convenient installation in most</td>
<td>- Larger refrigerant charge</td>
<td>R22, R404A,</td>
<td>N40</td>
</tr>
<tr>
<td>machine room far from</td>
<td>machine room far from cases</td>
<td>- Higher leak rates</td>
<td>R407A, R407F</td>
<td></td>
</tr>
<tr>
<td>cases</td>
<td>- Long connecting lines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Convenient installation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in most buildings – in</td>
<td>- Very familiar to store owners and contractors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>common practice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Very familiar to store</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>owners and contractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Distributed DX System

<table>
<thead>
<tr>
<th>Features</th>
<th>Pros</th>
<th>Cons</th>
<th>Current</th>
<th>Future</th>
</tr>
</thead>
</table>
| - Condenser in rooftop and compressor at store level closer to cases  
- Short connecting lines | - Lower refrigerant charge (about 1/2 of centralized systems)  
- Lower leak rates since condensing units are factory assembled  
- Potentially more efficient than centralized – better match of suction groups, shorter lines | - Not always feasible in some buildings | R22  
R404A  
R407F | N40 |
Selection Criteria for Supermarket Refrigeration

- **Capacity**: Is there enough capacity to keep the food at required temperatures?
- **Efficiency**: How much does the refrigerant add to the total and peak power consumption of the system? (include all powered systems)
- **Oil Return**: Is refrigerant miscible with oil so that oil returns and protects the compressor?
- **Mass Flow**: Higher mass flow means more refrigerant moving through the system. Different mass flow requires changes to TXV valves.
- **Superheat**: Need to protect compressors and ensure full use of refrigerating capacity.
- **GWP**: Lower is better. (possible future GWP tax)

Key Selection Criteria for New Installations and Retrofits
Performance Comparison

LT matches the Capacity and has the Highest Efficiency

% Relative to R22

Genetron Performax™ LT
R407A (2107)
R427A (2526)
MO-99 (2138)
R422B (2264)

CONDITIONS: -25°F Suction Temp., 15°F Entering Compressor, 10°F Superheat, 105°F condensing, 10°F subcooling

Genetron Performax™ LT Outperforms Alternatives
# R22 Options - Summary

<table>
<thead>
<tr>
<th>Importance Factor</th>
<th>22</th>
<th>407F</th>
<th>407A</th>
<th>422B</th>
<th>427A</th>
<th>MO99</th>
</tr>
</thead>
<tbody>
<tr>
<td>No TXV changes or adjustments</td>
<td>![important]</td>
<td>![not important]</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![important]</td>
</tr>
<tr>
<td>No oil change/Oil Return</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![important]</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![neutral]</td>
</tr>
<tr>
<td>Maintain System Performance (Capacity)</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
</tr>
<tr>
<td>Minimize Electrical Costs (efficiency)</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
</tr>
<tr>
<td>Minimize GWP Based Taxes</td>
<td>![important]</td>
<td>![important]</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![neutral]</td>
</tr>
<tr>
<td>Maintains Superheat</td>
<td>![neutral]</td>
<td>![neutral]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
<td>![important]</td>
</tr>
</tbody>
</table>

### Why Does This Matter?
- **TXV changes and adjustments add significant cost**
- **One oil change required for 407F. Mineral oil not fully miscible with refrigerants like MO99**
- **Key system performance item. Better capacity keeps food fresh and reduces system run time**
- **KWH cost of operating the system**
- **At $10.00/MT CO2E, every 100 GWP pts = $0.45/lb. in Taxes**
- **Prevents floodback issues and protects compressors**

### Project & Ongoing Costs
- **No TXV changes or adjustments**
- **No oil change/Oil Return**
- **Maintain System Performance (Capacity)**
- **Minimize Electrical Costs (efficiency)**
- **Minimize GWP Based Taxes**
- **Maintains Superheat**

### Refrigerant Alternatives
- **R22**
- **407F**
- **407A**
- **422B**
- **427A**
- **MO99**

### GWP Value
- **1810**
- **1824**
- **2107**
- **2526**
- **2138**
- **2264**
Better than 95% Capacity

Commercial Options:
16 Refrigerants

407A, 407C, G.P. LT
421A, 422A, 422B
422C, 422D, 417A
427A, 424A, 428A,
507A, 404A, 434A
R438

Commercial Options:
5 Refrigerants

407F
407A
428A
404A
507A

No TXV
Change GWP < 2000
Efficiency
(95% + relative to
R-22)

Commercial Solution:
1 Refrigerant

R407F Performax™

The capacity, mass flow, efficiency, GWP, superheat & oil return solution
ASDA Hunts Crossing Case Study

- Case study by ASDA, Copeland, local utility, Honeywell, refrigeration contractor and consultants
- Identical MT systems
- The R404A system had a 7% over consumption vs. the R407A system
- After retrofit to Performax LT, system is using 13% less power than the R407A system and around 20% less than the R404A performance
- Why? The extra capacity of Performax LT allowed for more compressor down time vs. 407A

Performax consumed 13% less energy than 407A
Next Generation
Low GWP Refrigerants
Solstice™ 1234yf for MAC Applications

The Product
- Global Warming Potential of <1
- >99% Reduction in Greenhouse Gases
- Performance Similar to R-134a
- Effective Cooling in All Climates
- Developed Specifically for MAC Systems
- Familiar Serviceability
- Reliable Technology

The Properties
- GWP of <1 is Significantly Below the MAC Directive
- High Performance with Lower Fuel Consumption and CO₂ Emissions
- Near Drop-in Solution, Minimal Re-design Required
- Global Solution
- Easy Implementation for Aftermarket
- Cost-Effective

A Global Solution to Benefit the Environment and Industry
**Drivers**

- **Europe:** Regulates Use of Refrigerant with GWP Below 150 for New Vehicle Types
- **US:** Trade-off with CAFE Tailpipe Emission for LGWP Refrigerant Replacement
- **Asia:** Conversion for Vehicles Exported to EU and U.S.
- **Demand:** Global Annual Light Vehicle Builds Expected to Grow from 67M to 94M by 2019

**Superior Environmental Performance**

- R-134a
- HFO-1234yf (Honeywell Technology)
- CO2 (Competing Solution)

~30% Lower Emissions vs. CO2 Alternative
# Honeywell’s Solstice™ Low GWP Refrigerants

<table>
<thead>
<tr>
<th>Solstice™ HFO’s</th>
<th>Non Flammable</th>
<th>Mildly Flammable (ASHRAE A2L)</th>
<th>Examples of Possible Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC-134a GWP=1300</td>
<td></td>
<td>Solstice yf GWP=0</td>
<td>Auto A/C, Vending, Refrigerators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solstice ze GWP=1</td>
<td>Chillers, CO₂ Cascades Refrigerators</td>
</tr>
<tr>
<td>R-123 GWP= 79</td>
<td>Solstice zd GWP = 1</td>
<td></td>
<td>Centrifugal Chillers</td>
</tr>
</tbody>
</table>

Note: All GWP values use the latest assessment from the ICCP, “AR5”

**Solstice™ HFO’s for Low and Medium Pressure Applications**
### Honeywell’s Solstice™ Low GWP Refrigerant Blends

<table>
<thead>
<tr>
<th>Current Product</th>
<th>Solstice™ N Series</th>
<th>Solstice™ L Series</th>
<th>Examples of Possible Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFC-134a GWP=1300</td>
<td>N-13 - GWP=547</td>
<td></td>
<td>Chillers, Med-temp Refrigeration</td>
</tr>
<tr>
<td>HCFC-22 GWP=1760</td>
<td>N-20 - GWP=891</td>
<td>L-20 - GWP=295</td>
<td>Stationary A/C, Refrigeration</td>
</tr>
<tr>
<td>R-404A GWP=3943</td>
<td>N-40 - GWP=1273</td>
<td>L-40 - GWP=285</td>
<td>Low-Temp Refrigeration</td>
</tr>
<tr>
<td>R-410A GWP=1924</td>
<td></td>
<td>L-41 – GWP=461 GWP=572</td>
<td>Stationary A/C Applications</td>
</tr>
</tbody>
</table>

**Note:** All GWP values use the latest assessment from the ICCP, “AR5”

**Solstice™ HFO Blends for Medium & High Pressure Applications**
Evolution of Replacements in Air Conditioning

System redesign necessary if using refrigerants with higher operating pressures

<table>
<thead>
<tr>
<th>Operating Pressures</th>
<th>ODP = 0</th>
<th>ODP = 0 Low GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCFC 22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC 407C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFC 410A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L-41 HFC32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blend L-20+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydro Carbons</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- Non-flammable GWP = 2088 Properties enable cost-effective efficient system
- Non-flammable GWP = 1824 Utilizes R22 design
- Very high pressure Major changes needed Low efficiency GWP = 1
- Mildly flammable GWP = 675 (R32) GWP < 500 (L41) R410A Performance R32 - high discharge T
- Mildly flammable GWP < 350 Utilizes R22 Designs
- Highly flammable GWP < 20
R410A and R22 Replacements in AC Systems

L-41
HFC-410A Replacement

- After recovering capacity, **L-41** offers excellent performance and a significant GWP reduction.
- It enables compact high efficiency systems in many regions.
- No problems with high discharge temperatures.

L-20
HCFC-22 Replacement

- **L-20** replaces R-22 in AC systems without significant design changes.
- With a **GWP of 295**, it reduces significantly environmental impact.
- It performs well at high ambient temperatures.

*Used 11% larger displacement compressor*
All options offer significantly improved efficiency & GWP reduction compared to R-404A
**Solstice™ Low GWP Replacements for Chillers**

**Solstice™ ze**
- Equal (or better) efficiency compared to R-134a
- 99.7% reduction in GWP

**Solstice™ N-13**
- Comparable efficiency to R-134a and is non flammable. Potential for retrofit.
- ~60% reduction in GWP

**Solstice™ zd**
- Higher efficiency than R-123 – the current efficiency leader.
- 94% reduction in GWP

*HFOs Offer Large GWP Reductions & High Efficiency*
Star Chiller with Solstice™ ze

- Star Chiller Installed at Honeywell’s Research Center

Solstice™ ze Shows 7 to 12% Higher COP than R-134a
Commercial Status of Solstice™ Products

- **Solstice™ yf**
  - In commercial use by auto industry now
  - Sample quantities available today for stationary applications

- **Solstice™ ze**
  - Commercially available today
  - Announced world scale plant for 2013

- **Solstice™ zd**
  - Commercial plant on stream 2nd quarter 2014
  - Sampling for chiller, foam and solvent applications

- **Solstice™ Blends**
  - Contains Solstice ze and/or yf blended with other products
  - Recently announced availability of Solstice™ L-41
  - Currently sampling to OEM’s, compressor mfrs, and AREP

*Working with Industry to Commercialize Solstice™*
Final Comments

- Reduced and Low GWP replacements have been identified for all major refrigerant applications.

- GWP reductions of 50 to 99% are possible
  - Solstice™ 1234yf for Mobile Air Conditioning
  - HFO blends for Commercial Refrigeration and Stationary A/C
  - Performax™ LT to replace R-22 and R-404A in new and existing equipment
  - Solstice™ 1234ze(E) and Solstice™ 1233zd(E) for Medium and low pressure chillers, respectively

- Some of the lowest GWP options are mildly Flammable but much safer the HC’s