BNL Refrigerant Overview

Presentation to the BER and CAC

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Background…

- **Evaporation** is a cooling process.
- **Condensation** is a heating process.
- **Refrigeration** is an engineered “cycle” where the refrigerant is made to evaporate in the area you want cooled – and condense in the area you want heated.
  - Heat flows naturally from hot (high temperature) to cold (low temperature).
  - To make heat flow from cold to hot, we must do work (add energy) to the cycle.
- **Refrigerants** are the “working fluids” in refrigeration, air conditioning and heat pumping systems
  - They absorb heat from one area (office/house or refrigerator) and reject it into another (outdoors or kitchen air)
Refrigeration Cycle

Diagram showing the refrigeration cycle with labels: Warm Vapor, Low Pressure, Compressor, Hot Vapor, High Pressure, Room Air, Outside Air, Condenser, Expansion Valve, Cold Liquid, 40°F, Low Pressure, Cold Liquid, 110°F, High Pressure, 275 psi.
Refrigerant Selection

- Refrigerant selection involves compromises between desirable / undesirable properties:
  - Thermal / physical properties (Boiling point? Freezing point? Heat of vaporization? Pressure range? Molecular weight?)
  - Transport properties (Thermal conductivity? Viscosity?)
  - Chemical stability (Stable? Corrosive? Compatible with oil? Compatible with metals, gaskets, seals?)
  - Safety (Flammable? Explosive? Toxic? Asphyxiant?)
  - Environmental consequences of leakage (Ozone depleting? Greenhouse gas?)
Refrigerant History

- Early air conditioners and refrigerators employed flammable and toxic gases.
  - Ammonia, sulfur dioxide, methyl chloride, propane.
  - Leaks resulted in fires, explosion, injuries and fatalities.
- Thomas Midgley, Jr., working for GM, invented the first “safe” chlorofluorocarbon gas, Freon, in 1928. [R-12]
  - Freon is a trademark of DuPont for any chlorofluorocarbon (CFC), hydrogenated CFC (HCFC) or hydrofluorocarbon (HFC).
- 1970s – concerns arise about CFC impacts on environment.
  - Lovelock measures CFC residuals in the atmosphere at 60 ppt.
  - Rowland & Molina show UV breaks down CFCs – and free chlorine depletes earth’s ozone layer.
- 1989 – Montreal Protocol begins phase-out and regulation of CFCs, and later, HCFCs due to atmospheric ozone depletion.
- 1990s – CFC, HCFC, and HFC refrigerants are recognized to be significant greenhouse gases (GHGs).
Refrigerants Use Today

- U.S. manufacture of “Phase I” CFCs ended in 1996.
- U.S. manufacture of “Phase II” HCFCs is being phased out with complete phase-out by 2030.
- Recycled / reclaimed CFC and HCFC refrigerants can continue to be used for servicing existing systems.
  - Protects the huge investment in existing refrigeration and air conditioning equipment.
  - Minimizes refrigerant releases to the atmosphere through careful servicing, recovery, recycling and economical re-use.
BNL Refrigerants

- BNL has over 17,000 tons of installed refrigeration capacity with about 35,000 pounds of refrigerant charge.

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Type</th>
<th>BP °F</th>
<th>ODP</th>
<th>GWP\textsubscript{100}</th>
<th>Used in Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-11</td>
<td>CFC</td>
<td>75</td>
<td>1</td>
<td>4750</td>
<td>Older centrifugal chillers (&gt;200 tons)</td>
</tr>
<tr>
<td>R-12</td>
<td>CFC</td>
<td>-20</td>
<td>1</td>
<td>10900</td>
<td>Old refrigerators and vehicle A/C</td>
</tr>
<tr>
<td>R-13</td>
<td>CFC</td>
<td>-115</td>
<td>1</td>
<td>14400</td>
<td>Cold boxes, environmental chambers</td>
</tr>
<tr>
<td>R-22</td>
<td>HCFC</td>
<td>-41</td>
<td>0.06</td>
<td>1810</td>
<td>Freezers, reciprocating A/C mach.</td>
</tr>
<tr>
<td>R-123</td>
<td>HCFC</td>
<td>81</td>
<td>1.3</td>
<td>77</td>
<td>Newer centrifugal chillers (&gt;200 tons)</td>
</tr>
<tr>
<td>R-134a</td>
<td>HFC</td>
<td>-15</td>
<td>0</td>
<td>1430</td>
<td>Refrigerators, vehicle A/C, large chillers</td>
</tr>
<tr>
<td>R-410a</td>
<td>Zeo.</td>
<td>-55</td>
<td>0</td>
<td>2100</td>
<td>Repl. R-12 &amp; R-22 in small A/C machines</td>
</tr>
<tr>
<td>R-502</td>
<td>Azeo.</td>
<td>-49</td>
<td>0.25</td>
<td>4700</td>
<td>Cold boxes, environmental chambers</td>
</tr>
<tr>
<td>R-718</td>
<td>Water</td>
<td>212</td>
<td>0</td>
<td>N/A</td>
<td>Steam-driven absorption chiller</td>
</tr>
</tbody>
</table>
BNL Refrigeration Management Plan

- Details how BNL complies with Sections 608 and 609 of the Clean Air Act Amendments (40 CFR 82) regulations.
- The BNL Refrigeration Management Plan incorporates:
  - **Introduction** - refrigerant and environmental issues overview
  - **Regulations** - requirements, references, enforcement
  - **Compliance Management** - responsibilities, self assessment, craft qualifications, refrigerant recovery, recordkeeping, disposal, testing, inventory process
  - **Operating Procedures** - refrigerant recovery, labeling, avoiding contamination, handling used refrigerants, blends, lubricants, other processes, documenting accidental releases, safety
  - **Appendices** - glossary, references
Is refrigerant ever replenished or replaced?

Yes. Refrigeration and air conditioning equipment can lose charge through leaks and normal losses.

R/AC engineers add charge, as required, and track weight of refrigerant added on equipment record (we use Refrigerant Compliance Manager™ software).

Refrigerant charge is also evacuated, stored, and re-used when equipment is opened for repair using refrigerant recovery equipment.

Refrigerant is not normally changed out (like oil in a car).
How does BNL handle and store its refrigerants?

Refrigerants are managed in accordance with BNL’s Refrigerant Management Plan [FM-PLAN-REFRIG-001]. Refrigerants may only be ordered by EPA-certified technicians (BNL AC shop supervisors).

Refrigerant inventory is stored under lock and key in refrigerant storage (steel) container.

Note: R-11 drums are kept in secondary containment (due to 75°F boiling point).

Static and bulk refrigerant inventory is kept in the BNL Chemical Management System (all BNL chemicals).
BNL Operational Q&A

Does BNL use environmentally friendly refrigerants in its new facilities and equipment?

Yes. BNL specifies environmentally friendly refrigerants in all new facilities & equipment (such as R-22, R-123, R-134a, R-410a).

- 14 new large chillers have been installed since 2000 (35% of the “fleet”).
- BNL buys replacement small air conditioners and refrigerators manufactured with “environmentally friendly refrigerants”.
Questions?