

# BNL Refrigerant Overview

## Presentation to the BER and CAC

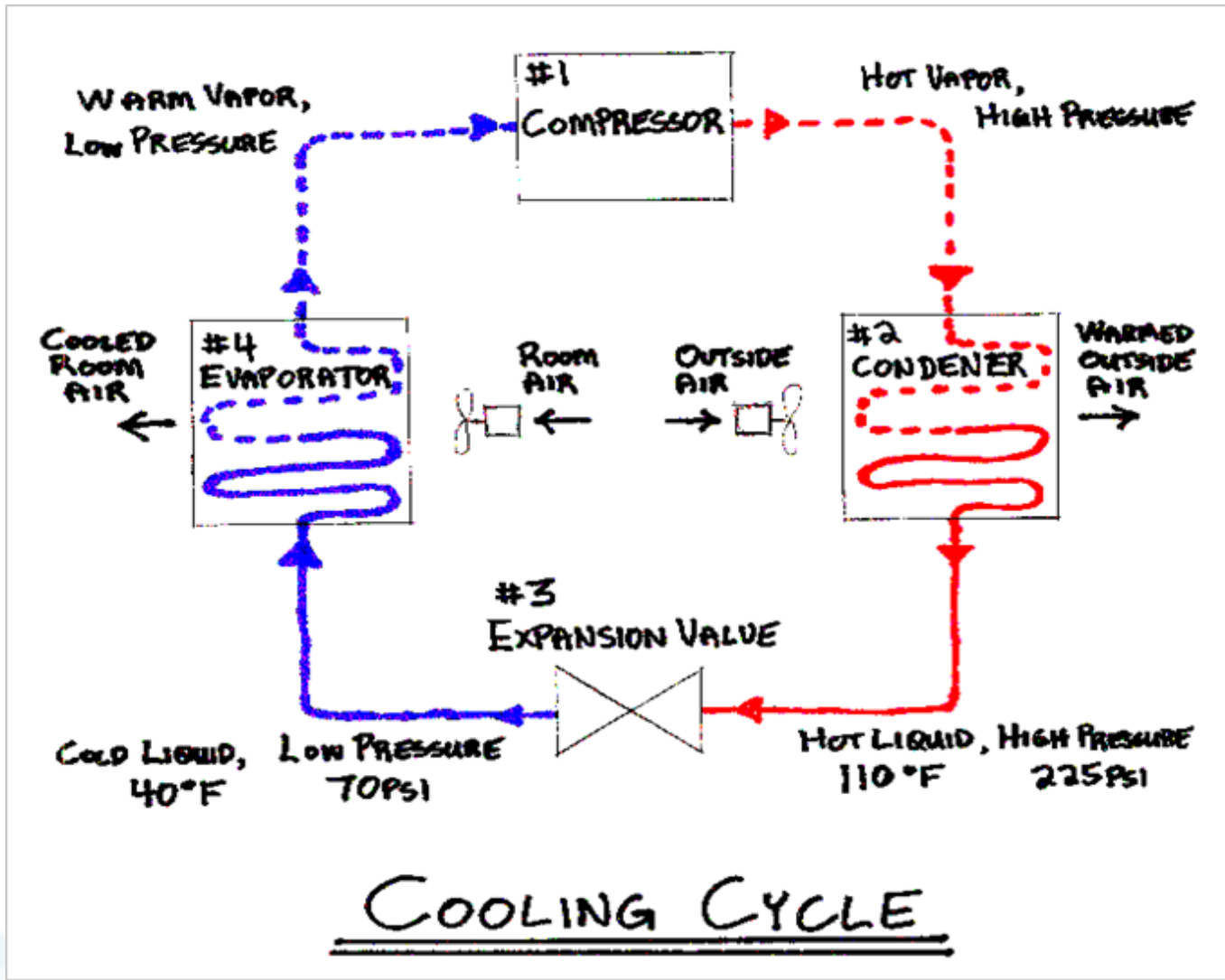
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# Background...

- **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



# 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

- 2009 ASHRAE Handbook currently lists 55 refrigerants and 56 refrigerant blends (zeotropes and azeotropes).
- 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.

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

# 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



# BNL Operational Q&A

- **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).



R-11 refrigerant recovery equipment

# BNL Operational Q&A

- **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?