This Program is made Possible through the Code Officials Education & Training Fund. Revenue for the Fund comes from Assessments on Building Permits.

Please turn down cell phones and put pagers on vibrate.

Thank you

2003 International Mechanical Code

Chapter 11

Refrigeration

Section 1101 General Defines
The Scope Of The Chapter

- **The Chapter Governs**
  - *Design, installation, construction & repair of refrigeration systems, including*
    - *Piping and permanently installed systems & components*
- **Highlights:**
- *1101.2 Factory-Built Equipment*
- *1101.4 Water Connection*
- *1101.6 General*

Maintenance??

- **1101.7 Maintenance**
  - *Systems shall be maintained*
    - *Proper operating condition*
    - *Free of accumulation of*
      - *Oil*
      - *Dirt*
      - *Waste*
      - *Corrosion & Debris*

Change Of Refrigerant Type

To

- **When Is It Necessary To Notify The Building Official Of Change Of Refrigerant Types?**
  - *Section 1101.8*
    - *If more than 220 pounds of Group A-1*
    - *30 pounds of any other group*
      - *No change in refrigerant without*
        - » *Prior notification to the code official is necessary*

Section 1102
System Requirements

- **Sets up determinations for system coordination and application by:**
  - *(Classification, Quantity, Location, Pressure)*
    - *Section 1102.1*
- **Refrigerants**
  - *(New, Existing, Recovered, Recycled & Reclaimed)*
    - *Section 1102.2*

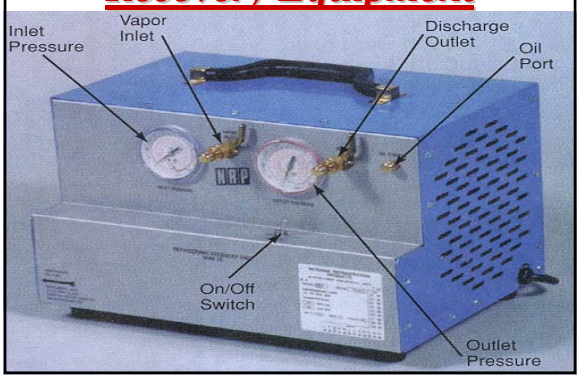
Can Refrigerants Be Mixed???

- **Mixing – Section 1102.2.1**
  - *No mixing of refrigerants including*
    - *Designations from ASHRAE 34*
  - *Exception*
    - *Allowed when permitted by MFG to improve oil return*
- **Purity – Section 1102.2.2**
  - *Refrigerants used to be*
    - *New, recovered or reclaimed*

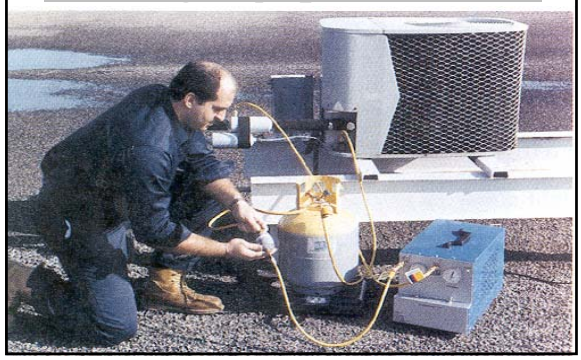
Recovery

- **"To remove refrigerant from a system and store it in an external container."**

Recovery Equipment



Recovery Equipment In Use



Recycling

- **"To clean refrigerant for reuse by oil separation and single or multiple passes through devices capable of reducing moisture, acidity and matter."**

Portable Recovery-Recycling Unit

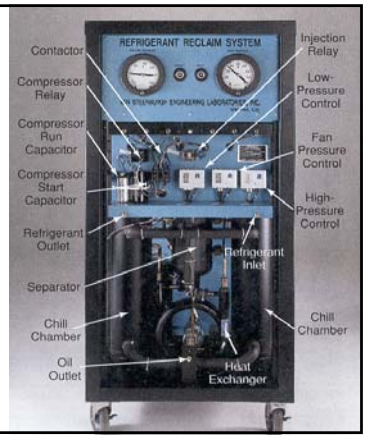
Typical Field Unit

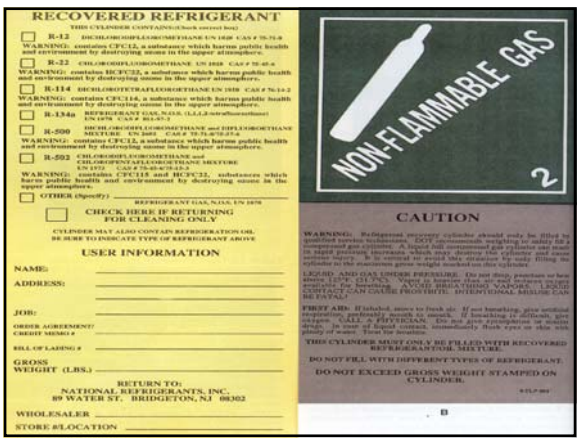
Reclaim

- **To reprocess refrigerant to new product specifications by means which may include distillation. This process must be capable of meeting the standards set by *ARI-700***

Refrigerant Reclamation System

Unit Shown Is A Portable System





Recovery, Recycling, Reclaiming History

- **Cause**
  - *– CFC's & HCFC's breakdown the ozone layer*
- **Montreal Protocol**
  - *– Led to the Federal Clean Air Act*
    - *Which set deadlines*
      - *– Starting with the phase out of CFC's*
      - *– With eventual phase out of HCFC's*

Clean Air Act Deadlines

1992	July 1	—	Venting ban of class I and II substances during maintenance, service, repair, or disposal of appliances or industrial process refrigeration equipment.
	Nov. 15	—	No nonessential class I substances designated by the EPA may be sold or distributed in interstate commerce.
1993	May 15	—	Containers of class I or class II substances and products containing class I substances must have warning labels.
		—	Warning labels may be required for products manufactured with class I substances or that contain class II substances.
		—	All requirements of CAA Title VI must be met by U.S. government procurement regulations.
	Nov. 11	—	As of this date, EPA will enforce warning label requirements.
1994	Nov. 15	—	Products releasing class II substances that are designated nonessential by the CAA or EPA cannot be sold or distributed in interstate commerce.
1995	Nov. 15	—	Ban on venting of substitutes for class I and II substances during maintenance, service, repair or disposal of appliances or industrial process refrigeration equipment, except for substitutes the EPA deems as not harmful to the environment.
2015	Jan. 1	—	All products containing class II substances sold or distributed in interstate commerce must have warning labels attached.
	May 15	—	All products manufactured with class I or class II substances that are sold or distributed in interstate commerce must have warning labels.

STATE OF CONNECTICUT ✦ DEPARTMENT OF CONSUMER PROTECTION

Be it known that

John Q. Public

has been certified by the Department of Consumer Protection as a licensed

HEATING, PIPING & COOLING LIMITED JOURNEYPERSON

TYPE: D2

License # 0000000000

Effective: 09/06/2001
Expires: 08/31
2002

James T. Fleming, Commissioner

Refrigeration System Classification

- **Section 1103**
  - *Classifications are in accordance with ASHRAE 34*
  - *Dependent upon*
    - *Occupancy classification - 1103.2*
    - *System classification - 1103.3*

Classification Of Refrigerants

ASHRAE 15-94

Section 1103.1

INCREASING FLAMMABILITY	SAFETY GROUP	
HIGHER FLAMMABILITY	A3	B3
LOWER FLAMMABILITY	A2	B2
NO FLAME PROPOGATION	A1	B1
	LOWER TOXICITY	HIGHER TOXICITY

INCREASING TOXICITY

TABLE 1103.1

REFRIGERANT	CHEMICAL FORMULA	CHEMICAL NAME OR BLEND	HAZARD CATEGORIES	REFRIGERANT CLASSIFICAION	DEGREES OF HAZARD[b]	[m] amount of refrigerant per occupied space: Pounds per 1000 cubic feet	ppm	g/m³	TLV-TWA (ppm)
R-11	CCl_3F	Trichlorofluoromethane	OHH	A1	2-0-0	0.39	1,100	6.2	C1000
R-12	CCl_2F_2	Dichlorodifluoromethane	CG,OHH	A1	2-0-0	5.6	18,000	90	1000
R-410B	Zeotrope	R-32/125 (45/55)	CG,OHH	A1	2-0-0[c]	11	58,000	180	-
R-413A	Zeotrope	R-218/134a/600a (9/88/3)	CG,F,OHH	A2	-	-	-	-	-
R-600	$CH_3CH_2CH_2CH_3$	Butane	CG,F,OHH	A3	1-4-0	-	-	-	-
R-717	NH_3	Ammonia	CG,C,F,OHH	B2	3-3-0[d]	0.022	500	0.35	25
R-1270	$CH_3CH=CH_2$	Propene (propylene)	CG,F,OHH	B3	1-4-1	0.37	3,400	5.0	660

NOTE: Slide is representative of Table 1103.1

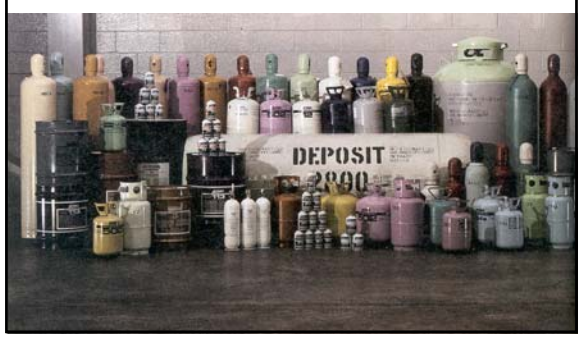
Example Problem For Table 1103.1

- *How much R-22 is permitted for a building of open floor plan, one floor, 10,000 sq. ft. with a 10 foot ceiling?*

»Solution

- **10,000 sq. ft. X 10 ft. = 100,000 cu. Ft.**
- **R-22 = 5.5 LB. Per 1,000 cu. Ft.**
- **100,000 X 5.5 / 1000 =**
  - **550 Pounds Of R-22**

Refrigerant Classification



Occupancy Classification
Section 1103.2

- Classification Considerations
  - *Potential exposure to refrigerant*
  - *Equipment outside & 20 feet or more*
    - *From buildings and openings*
- Occupancy Classifications
  - *Institutional*
  - *Public Assembly*
  - *Residential Occupancy*
  - *Commercial Occupancy*
  - *Large Mercantile Occupancy*
  - *Industrial Occupancy*
  - *Mixed Occupancy*

Section 1103.3
System Classification

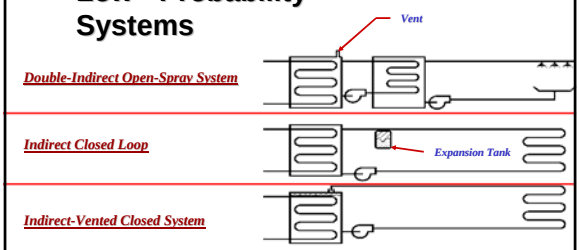
What Are The Chances Of Leakage?

Could Refrigerant Enter The Occupied Space?

Location Of Components?

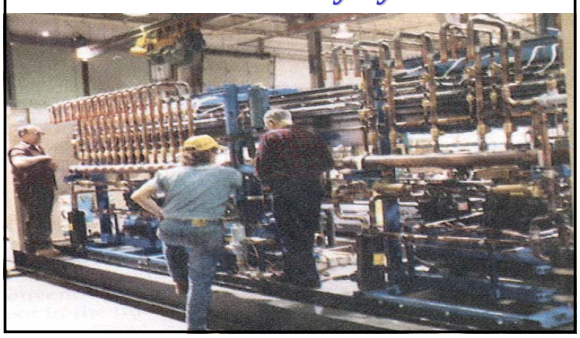
Refrigeration System Classification
Section 1103.3.1

Low - Probability Systems



Low - Probability System ???

Machinery Room
Low-Probability System



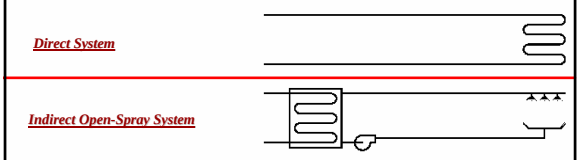
Section 1103.3
System Classification

1103.3.2 High-Probability Systems

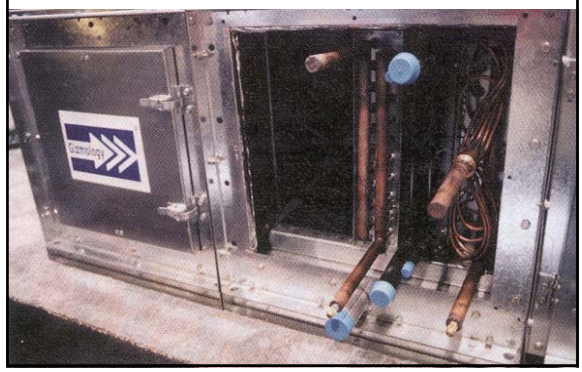
Refrigeration System Classification

Section 1103.3.2

High - Probability Systems

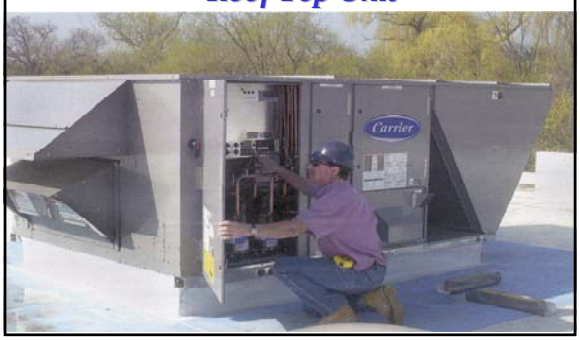


High - Probability Air Handler



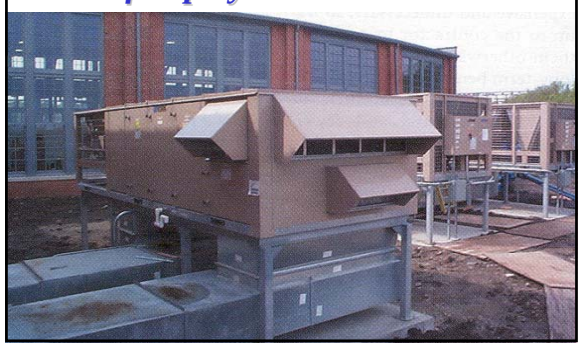
High – Probability

Roof Top Unit

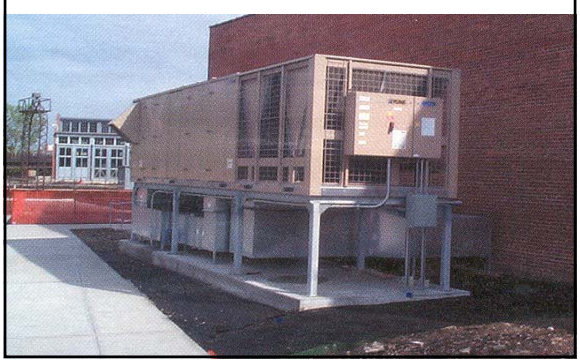


High-Probability

Roof Top System & Duct Work



High - Probability



Refrigerant Blends

- **Section 1104.1 General**
  - *Blends may be assigned a dual classification*
  - *Use the worst classification*
    - *When worst case fractionation can occur*
    - *IE*
      - *Classification is A1 / A2*
- **What is Fractionation?**
  - *Chemical separation of blended refrigerants*
    - *Resulting compounds having a different*
      - *Flammability & toxicity from original blend*

Alternative Refrigerants ??
BLENDS?????

Azeotropics

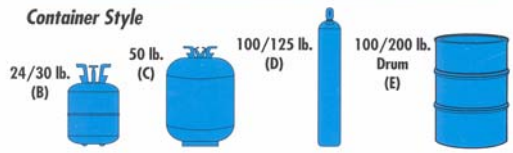
Zeotropics

TYPE	COLOR CODE	SIZES NET LBS.
R-134a (CF_3CH_2F)	Light Blue	30 (B), 125 (D)

Other Forane® Alternative Refrigerants

TYPE	COLOR CODE	SIZES NET LBS.
R-22 ($CHClF_2$)	Green	30 (B), 50 (C), 125 (D)
R-123 ($CHCl_2CF_3$)	Lt. Blue Grey	100 (E), 200 (E)
R-404A	Orange	24 (B), 100 (D)
R-408A (FX-10)	Medium Purple	24 (B), 100 (D)
R-409A (FX-56)	Tan	30 (B), 125 (D)

Container Style



Zeotropic Refrigerants

- **A refrigerant blend, comprised of various refrigerants, that changes in volumetric composition and saturation temperature when used**

  – Zeotropic Refrigerants would be the:

  –R - 400 Series

R-410A: Fact And Fiction

By Mark Spatz and David Metcalf
For *The News*

[**Authors' note:** *The information presented in this article addresses several specific safety aspects of refrigerants, but should not be used as a substitute for proper training or following of a manufacturer's safety instructions. Honeywell recommends that technicians be fully trained and read all relevant safety instructions before using any refrigerant products or working on any systems containing pressurized refrigerants. Readers should not assume that all safety measures are indicated, or that other measures may not be required.*]

There are over a dozen brands of R-410A-based air conditioners and heat pumps available today, and more coming on to the market each season.

R-410A has different physical properties than R-22 and technicians should be aware of the differences. But there are also a higher than R-22, the systems, components, service tools, and refrigerant cylinders (both new and recovery) are all designed to safely handle this pressure with a safety margin similar to that for other refrigerants, such as R-22. With over a million R-410A-based *coming to replace R-22.*

For new equipment, this is unlikely to be the case. Every major manufacturer of air conditioners and heat pumps in the United States and Japan has introduced R-410A systems or has selected R-410A as the replace-

Properties Of R-410A

Type: Azeotropic mixture, HFC

Replaces: R-22

Lubricant: Polyolester

Applications: New equipment. Widely accepted by OEMs.

Comments: High efficiency. Equipment redesign required.

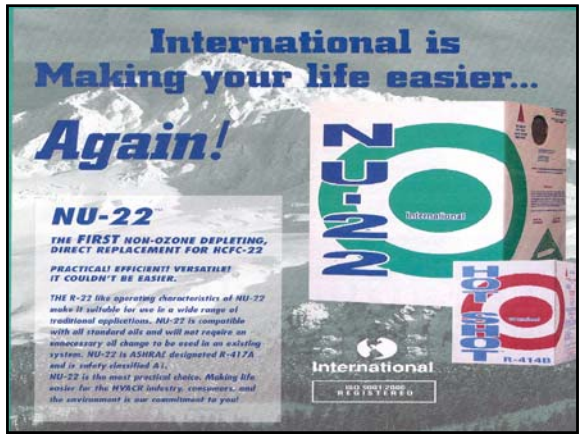
Figure 1. Guide to alternative refrigerants. *(Courtesy of Honeywell Genetron.)*

Azeotropic Refrigerants

- **A liquid mixture having constant maximum and minimum boiling points. Refrigerants comprising the azeotropic mixture do not combine chemically, yet the mixture provides constant characteristics.**

  – Azeotropic Refrigerants would be of the:

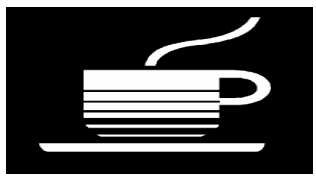
  –R-500 Series



No Matter How It Is Advertised

Cost Factor Is The Number 1 Trap

Coffee Break



1104.2
Machinery Room

- **Refrigerant Quantities Exceed Table 1103.1**
  - *Components to be located outdoors or in machinery room*
  - *Combined blends*
    - *Not to exceed 69,100 ppm by volume*
- ***Institutional & Industrial Occupancies***
  - *Follow their own standards*

Institutional & Industrial

- **Section 1104.2.1 Institutional Occupancies**
  - *Quantities from Table 1103.1 to be*
    - *Reduced by 50%*
  - *A2, B2, A3 & B3 Totals*
    - *Not to exceed 550 pounds*
- **Section 1104.2.2 Industrial Occupancies**
  - *Applies to*
    - *Manufacturing, Food Prep, Meat Cutting, Processes & Storage*
  - *No machinery room necessary if all of*
    - *Seven requirements are met*

Refrigerant Restrictions

- **Section 1104.3.1 Air-Conditioning for Human Comfort**
  - *In other than industrial occupancies*
    - *B1, B2, & B3 not to be used*
      - *In High-probability systems*
- **Section 1104.3.2 Non-industrial Occupancies**
  - *A2 & B2 not to be used in High-probability systems*
    - *If exceeding Table 1104.3.2*
  - *A3 & B3 not to be used*
    - *Exception:*
      - *Laboratories with 100 sq ft / person or larger*

Use of Table 1104.3.2

TABLE 1104.3.2
MAXIMUM PERMISSIBLE QUANTITIES OF REFRIGERANTS

TYPE OF REFRIGERATION SYSTEM	MAXIMUM POUNDS (kg) FOR VARIOUS OCCUPANCIES			
	Institutional	Assembly	Residential	All other occupancies
Sealed absorption system				
In exit access	0(0)	0(0)	3.3(1.5)	3.3(1.5)
In adjacent outdoor locations	0(0)	0(0)	22(10)	22(10)
In other than exit access	0(0)	6.6(3)	6.6(3)	6.6(3)
Unit systems				
In other than exit access	0(0)	0(0)	6.6(3)	6.6(3)

For SI: 1 pound = 0.454 kg.

All Occupancies

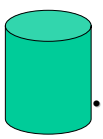
- **Section 1104.3.3**
  - *Total of all Group A2, A3, B2, B3*
    - *Other than R717 Ammonia*
  - *Not to exceed 1,100 pounds*
    - *Except where approved*
      - *Approved meaning safety specialists within the industry*

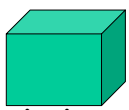
A2	B2	A3	B3
R – 32	R – 717	R – 170	R - 1270
R – 152a	(OTHER THAN)	R – 290	
R – 406A		R – 600	
R – 411A & B		R – 600A	
		R - 1150	

Refrigerant Decomposition

- **Section 1104.3.4**
  - **Protection From Refrigerant Dec**
    - *No open flame or surface temp of 800 degrees F or higher*
      - *Within a room with more than 6.6 pounds*
  - *If greater than*
    - *Hood and exhaust to be provided*
  - *Exceptions for hood and exhaust*

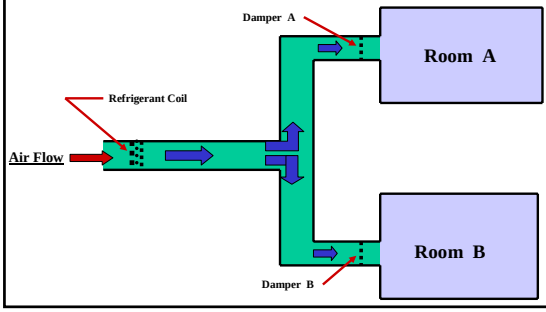
Volume Calculations



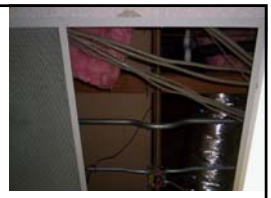


- **Section 1104.4.1 Non-communicating Spaces**
  - *System parts in one or more Non-communicating spaces*
    - *Use the volume of the smallest space*
- **Section 1104.4.2 Communicating Spaces**
  - *Volume of the smallest enclosed space served*
    - *Shall be used for determination of maximum refrigerant quantity*
  - *See Exception*

Exception To
Section 1104.4.2



Plenums

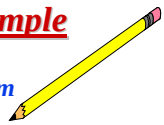


- **Section 1104.4.3**
  - *Suspended ceiling space being used for*
    - *Supply or return air plenum*
  - *The suspended ceiling space*
    - *Must be included within the volume calculation for refrigerant quantity*

Example Problem

- **Problem:**
  - *A 15,000 square foot open floor plan office building is to be served by a cooling system having an R-123 chiller. Chilled water coils are employed with a ceiling return air plenum.Ceiling height is 8 feet and height to roof deck is 10 feet.*
- **Find:**
  - *What are the requirements and limitations for this system?*

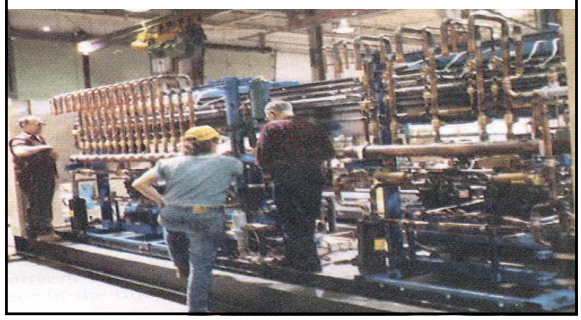
Working Out Example



- *Determine refrigeration system classification*
  - » *Indirect Low Probability*
- *Determine refrigerant classification*
  - » *B1*
- *Determine building occupancy*
  - » *Commercial (business)*
- *Determine maximum allowable refrigerant quantity*
  - » *525 pounds*

Machinery Room, General Requirements

Section 1105



Incidental Use Areas
IBC 302.1.1

- **Table 302.1.1**
  - *Addresses Refrigerant Machinery Rooms*
    - *Providing for room enclosure & fire suppression*

TABLE 302.1.1
INCIDENTAL USE AREAS

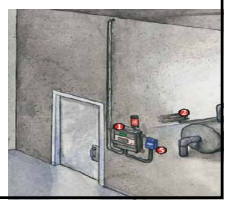
ROOM OR AREA	SEPARATION[a]
Furnace room where any piece of equipment is over 400,000 Btu per hour input	1 hour or provide automatic fire-extinguishing system
Rooms with any boiler over 15 psi and 10 horsepower	1 hour or provide automatic fire-extinguishing system
Refrigerant machinery rooms	1 hour or provide automatic sprinkler system
Parking garage (Section 406.2)	2 hours; or 1 hour and provide automatic fire-extinguishing system
Hydrogen cut-off rooms	1-hour fire barriers and floor/ceiling assemblies in Group B, F, H, M, S and U occupancies. 2-hour fire barriers and floor/ceiling assemblies in Group A, E, I and R occupancies.

Section 1105.2
Openings

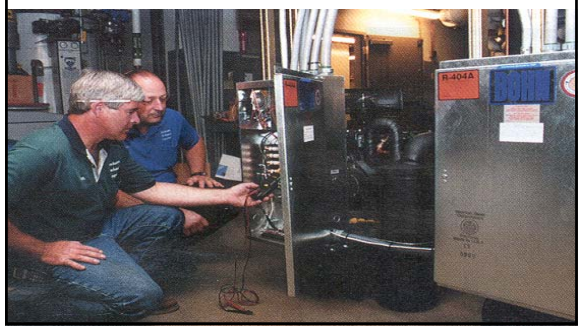
Detection

Section 1105.3 Refrigerant Detector

- *Shall be provided as per the*
  - *IFC*
- *See CFSC or IFC*
  - *Section 606 Mechanical*
  - *Section 606.8*
    - *Refrigerant Detector*



Tests
Section 1105.4



What About Open Flames That Use Combustion Air??

Can They Be Used Within Machinery Rooms??

Machinery Room Ventilation
Section 1105.6

Machinery Room Ventilation

- **Makeup Air - 1105.6.2**
  - *Must be supplied to replace exhaust air*
- **Quantity Of Normal Ventilation - 1105.6.3**
  - *Must be equal to the larger of two conditions*
- **Quantity Of Emergency Ventilation - 1105.6.4**
  - *Must actuate upon refrigerant detection*

Relief Valve Termination
Section 1105.7

Ammonia R717

- **Section 1105.8 Ammonia Discharge**
  - *Pressure relief as per*
    - *ASHRAE 15*
- **Also Covered Within**
  - *IFC & CFSC*
    - *Section 606.11.3*

Machinery Room Special Requirements Section 1106

- **This Section Provides Specifications For Special Machinery Rooms As Required By**
  - *1106.1 General*
    - *Referenced to Sections*
      - *1104.2, 1105 & 1106*
    - *Also for refrigerants*
      - *A2, A3, B2, B3*

Special Requirements For Ammonia Absorption Systems

- **1106.3 Ammonia Room Ventilation**
  - *Ventilation system to operate*
    - *Continuously*
  - *Exceptions*
    - *Vapor detector system on alarm actuation*
      - *Starts ventilation system*
    - *Class 1, Division 2 conformance*

Remote Controls Section 1106.5

Are They Required???

What Is Required???

Where Are They Required???

Remote Controls

- **Section 1106.5.1 Refrigeration System**
  - *Break glass type switch*
    - *Off – Only Control / Clearly Identified*
      - *Not for detectors or ventilation system*
      - *As per IFC / CFSC 606.9.1*
- **Section 1106.5.2 Ventilation System**
  - *Break glass type switch*
    - *On – Only Control / Clearly Identified*
      - *As per IFC / CFSC 606.9.2*

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Standard Break Glass with Audible Alarm

Emergency Signs

- **Section 1106.6 Emergency Signs & Labels**
  - *"…Systems shall be provided with approved emergency…"*
    - *Signs, Charts & Labels*
  - *In accordance with the IFC / CFSC*
    - *Section 606.7*

606.7 **Emergency signs.** Refrigeration units or systems having a refrigerant circuit containing more than 220 pounds (100 kg) of Group A1 or 30 pounds (14 kg) of any other group refrigerant shall be provided with approved emergency signs, charts, and labels in accordance with NFPA 704. Hazard signs shall be in accordance with the *International Mechanical Code* for the classification of refrigerants listed therein.

Means Of Egress

- Section 1014.4 (of the IBC)
  - *Refrigeration Machine Rooms*
    - *1000 sq ft or larger*
      - *2 exits or exit access doors*
- Section 1014.5 (of the IBC)
  - *Refrigerated Rooms or Spaces*
    - *1000 sq. ft. or larger*
    - *Containing refrigerant evaporator & below 68 degrees F.*
      - *2 exits or exit access doors*

Refrigerant Piping
Section 1107

- The Section Addresses The Material And Installation Requirements For Refrigerant Piping, Joints And Joining Methods
- Section 1107.2 Pipe Enclosures
  - *Enclosures or ducts shall be used when soft drawn copper tubing is used for other than*
    - *Group A1 or B1 Refrigerants*
- Section 1107.3 Condensation
  - *Protection must be provided from condensation due to temperatures below the dew point*

Refrigerant Piping Materials
Section 1107.4

- What Materials Can Be Used?
  - *All material used must be compatible with the refrigerant being used*
    - *R717 Ammonia is not used with copper or brass*
- Section 1107.4.1 Steel Pipe
  - *Schedule 80 for*
    - *A2, A3, B2, B3*

Piping And Tubing

- Copper Tube – Section 1107.4.3
  - *ACR Type – ASTM B 280*
    - *K, L, or M*
  - *Annealed not over 2 inch*
  - *Mechanical joints*
    - *7/8 or smaller*

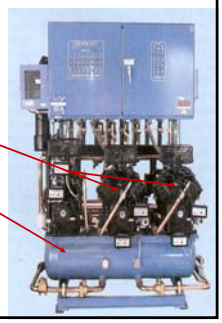
- Copper Tubing Joints Section 1107.4.4
  - *A2, A3, B2, B3*
    - *Shall be brazed*

Parts In Air Ducts

- Section 1107.5 Joints & Refrigerant Containing Parts In Air Ducts
  - *Supplying conditioned air to or from*
    - *Occupied space*
  - *Shall be constructed to withstand*
    - *Pressure 150% higher than design*
      - *Or pressure relief setting*

Valves & Receivers

- **Section 1107.7 Stop Valves**
  - *Positive displacement unit*
    - *With greater than 6.6 pounds*
  - *Inlet and discharge stop valves must be used*
  - *Exception*
    - *Pumpout capability*
- **Section 1107.7.1 Liquid Receiver**
  - *100 pounds or more*

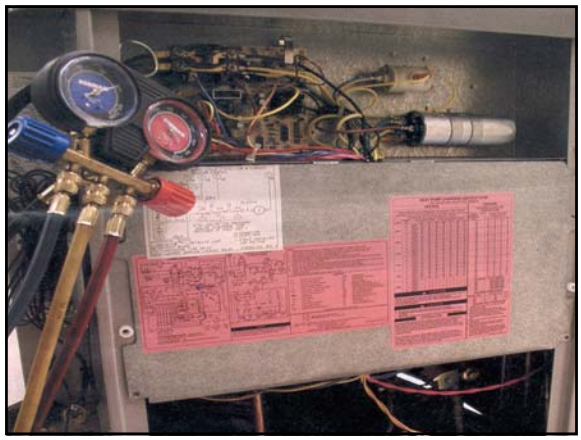


Mounting & Identification

- **Section 1107.7.2 Copper Tubing**
  - *Soft tubing or hard drawn 7/8 inch or smaller*
    - *To be securely mounted*
- **Section 1107.7.3 Identification**
  - *If intended purpose is not obvious*
    - *Valves to be labeled*

Field Testing
Section 1108

- **Section 1108.1 General**
  - *Every part erected on site that contains refrigerant*
    - *Shall be leak tested*
  - *Factory assembled components, factory tested*
    - *Are excluded*
  - *Testing*
    - *Testing is to be at the lower of*
      - *Design pressure*
      - *Pressure Relief Setting*



Test Gases & Test Apparatus

- **Section 1108.2 Test Gases**
  - *Inert dry gas most commonly used*
    - *Nitrogen & Carbon Dioxide*
  - *Do not use*
    - *Oxygen, Air or Combustible Gases*
- **Section 1108.3 Test Apparatus**
  - *Pressure limiting or*
    - *Pressure reducing device to be used*
  - *The gauge is to be on the outlet side*

Section 1108.4

DECLARATION

Certificate Of Test

Periodic Testing

- **Section 1109.1 Testing Required**
  - *The following Emergency Devices & Systems*
    - *Shall be tested periodically*
      - *Treatment & Flaring systems*
      - *Valves & devices for emergency refrigeration control box operation*
      - *Emergency ventilation equipment*
      - *Detection & alarm systems*

Summary

- *Recovery, recycling & reclaiming*
  - *Is a part of the refrigeration chapter*
- *Table 1103.1 sets up refrigerant classification*
  - *Maximum Quantity of refrigerant*
    - *Per cubic foot of occupied space*
- *Refrigerant quantity, classification & application*
  - *Will determine need for machinery room*
- *Machinery rooms & equipment are covered by*
  - *Three codes*
    - *IMC, IFC / CFSC, IBC*