Refrigeration

Chapter 11 NCMC
Part 1 Occupancy and Classification

Reggie Hucks – Director of Inspections, City of High Point

What is a Refrigerant?

Nomenclature of Refrigerants

- Refrigerants are named using an "R" followed by a two-to-four-digit number.
- Some refrigerants have letter prefixes or suffixes that specify the chemical makeup.
- It can be classified into 10 series. These are shown in below table:

Series	Description
000	Methane Based
100	Ethane Based
200	Propane Based
300	Cyclic Organic Compounds
400	Zoetropes'
500	Azeotropes
600	Organic Compounds
700	Inorganic Compounds
1000	Unsaturated Organic Compounds

- The first four series of refrigerants (000, 100, 200, 300) usually contain Carbon (C), Hydrogen (H), and Florine (F) mixed with some other elements.

A **refrigerant** is the working fluid in refrigeration and air-conditioning systems. In vapor refrigeration cycles, refrigerants absorb heat from the load side at the evaporator and reject heat at the condenser. In addition to suitable thermodynamic properties, the selection of a refrigerant must also take into consideration **chemical stability, flammability, toxicity and environmental compatibility**. Refrigeration is a result of the physical laws of vaporization (evaporation) of liquids. The evaporation of liquid refrigerant is an endothermic process and condensing of vapors is an exothermic process. **Basically, refrigerants undergo a repeated phase transition from a liquid to a gas and back again in a refrigerant system.**

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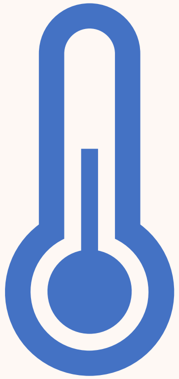

How does refrigeration work?

Refrigeration is the process of removing heat from an enclosed space or from a substance for the purpose of lowering the temperature.

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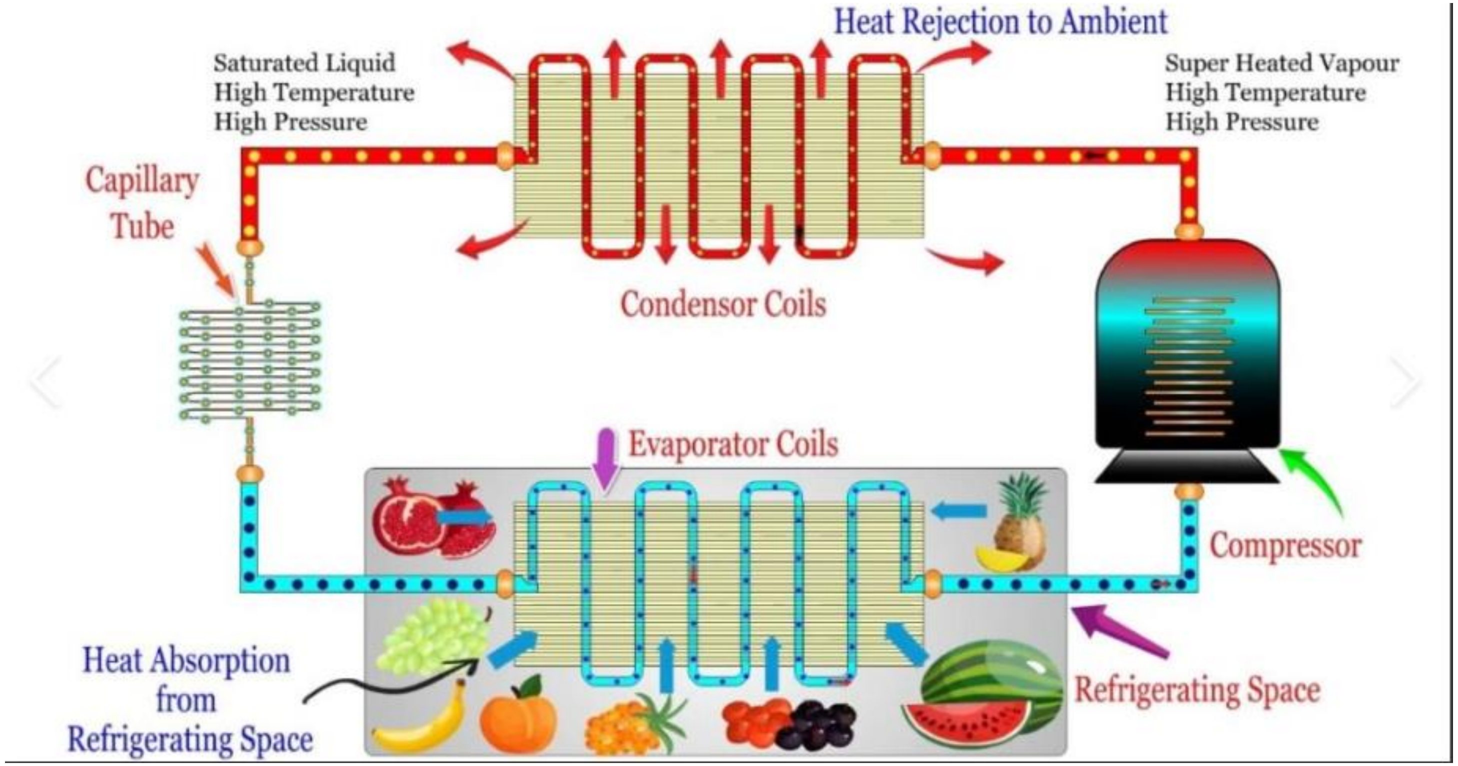
Fundamental Operation of a Refrigerant System



Refrigeration as a Building System

If a building is maintained so that all exits are clear, accessibility is compliant, and all structural envelopes (roof and exterior walls) remain weatherproof, a life safety problem with the building is minimized. However, building systems can affect life safety by improper maintenance or malfunction. **Refrigeration systems** can have an immense impact on life safety if improperly installed, poorly maintained, ruptures, or is damaged.

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WHAT ARE THE USES OF REFRIGERATION?

WHAT ARE THE HAZARDS TO BUILDING OCCUPANTS?

WHAT ARE THE HAZARDS TO THE ENVIRONMENT?

Examples of Refrigeration Uses

Industrial Process (hardening of metals)

Environmental Cooling

Preservation of Meat and Diary Products

Transporting fruits and vegetables (preservation)

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Hazards to Building Occupants

The risks associated with the use of refrigerants in refrigeration and air-conditioning equipment can include toxicity, flammability, asphyxiation, and physical hazards. Although refrigerants can pose one or more of these risks, system design, engineering controls, and other techniques mitigate this risk for the use of refrigerant in various types of equipment.

Refrigerant Hazards

Hope, Arkansas CNN —

Mimi Perkins’ job on the graveyard shift at a Tyson Foods poultry plant started like any other night: hosing down the blood, guts, and stray feathers left behind by hundreds of thousands of dead chickens. Then, she heard a single loud pop.

A pipe weld in the plant had ruptured, filling the room with a white cloud of ammonia gas – a chemical used to refrigerate meat that can be deadly in high doses. As other workers fled, Perkins lost consciousness and was trapped inside the plant for about forty minutes while the gas ravaged her eyes, throat, and lungs.

When a colleague finally dragged her outside, Perkins had red chemical burns on her face and leg. She heard a paramedic refer to her as “DOA” – dead on arrival. In the years since the 2016 accident, Perkins has undergone multiple throat surgeries and two cornea transplants, takes six kinds of eye drops, and suffers from chronic coughing fits that make it difficult to breathe, she said.

Hazards to the Environment

The ozone in the upper stratosphere forms a crucial layer that absorbs ultraviolet sunlight. Scientists measure the thickness of this layer of "good" ozone in Dobson units, named after British physicist Gordon Miller Bourne Dobson, a pioneer in the study of ozone. One Dobson unit is defined as a thickness of 0.01 millimeters (0.0004 inches) at standard temperature and pressure, which is 0 degrees Celsius (32 degrees Fahrenheit) and 1 atmosphere.

Refrigerants containing chlorine (CFC) reacts with the ozone and decrease the volume in the ozone layer. They have been phased out since 2010. They were replaced with HFC's.

Global Warming Potential is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2).

Hydrofluorocarbons (HFC) Refrigerants increase global warming are now being phased out. New refrigerants are on the market that are replacing them.

A typical food retail store leaks an estimated 25% of refrigerant, or approximately 1,000 pounds, annually. In addition to being costly, leaks have significant impacts on the environment, because most refrigerants are greenhouse gases, and some are also ozone-depleting substances.

Refrigerant	Global Warming Potential	Ozone Depletion Potential
R11	4750	1
R22	1810	0.055
R410A	2088	0
R407C	1770	0
R134A	1430	0
R32	675	0
$C0_2$	1	0
R1234yf	4	0

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Chapter 11 is intended to minimize the hazards to the building **occupants** and the **environment** by requiring that all refrigeration systems be designed, constructed and installed incompliance with the provisions of this chapter.

Purpose continued…

Chapter 11 contains regulations pertaining to the life safety of building occupants. These regulations establish minimum requirements to achieve the proper design, construction, installation and operation of refrigerating systems. This chapter establishes reasonable safeguards for the occupants by defining and mandating practices that are consistent with the practices and experience of the industry.

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ASHRAE Standard 15, Safety Standard for Refrigeration Systems, sets forth requirements to help protect people and property where refrigeration facilities are located. Further information is available in the current edition, **ANSI/ ASHRAE Standard 15-2019.**

Personal injury and property damage can result from a number of origins, such as rupture of a part with flying debris, release of refrigerant from a fracture or fire resulting from or intensified by burning, or deflagration of escaping refrigerant or lubricant. In addition, personal injury can result from the accidental release of refrigerants in inadequately ventilated spaces; narcotic and cardiac sensitization effects; toxic effects of vapor or the decomposition products due to vapor contact with flames or hot surfaces; corrosive attack on the eyes, skin, or other tissue; or freezing of tissue by contact with liquid.

1101.6 General. Refrigeration systems shall comply with the requirements of this code and, except as modified by this code, **ASHRAE 15.** Ammonia-refrigerating systems shall comply with this code and, except as modified by this code, **ASHRAE 15, IIAR 2, IIAR 3, IIAR 4 and IIAR 5**.

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International Institute of Ammonia Refrigeration

ASHRAE®

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Technical Requirements

This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle. Refrigerant piping design and installation, including pressure vessels and pressure relief devices, shall conform to this code. Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

Refrigerants

1102.2 Refrigerants. The refrigerant shall be that which the equipment or appliance was designed to utilize or converted to utilize. Refrigerants not identified in Table 1103.1 shall be *approved* before use.

*Existing equipment may have to be converted to a different type of refrigerant or charged with refrigerant recovered from it or another system; however, it would be an unnecessary risk to charge new equipment with any refrigerant other than that specified by the equipment manufacturer.

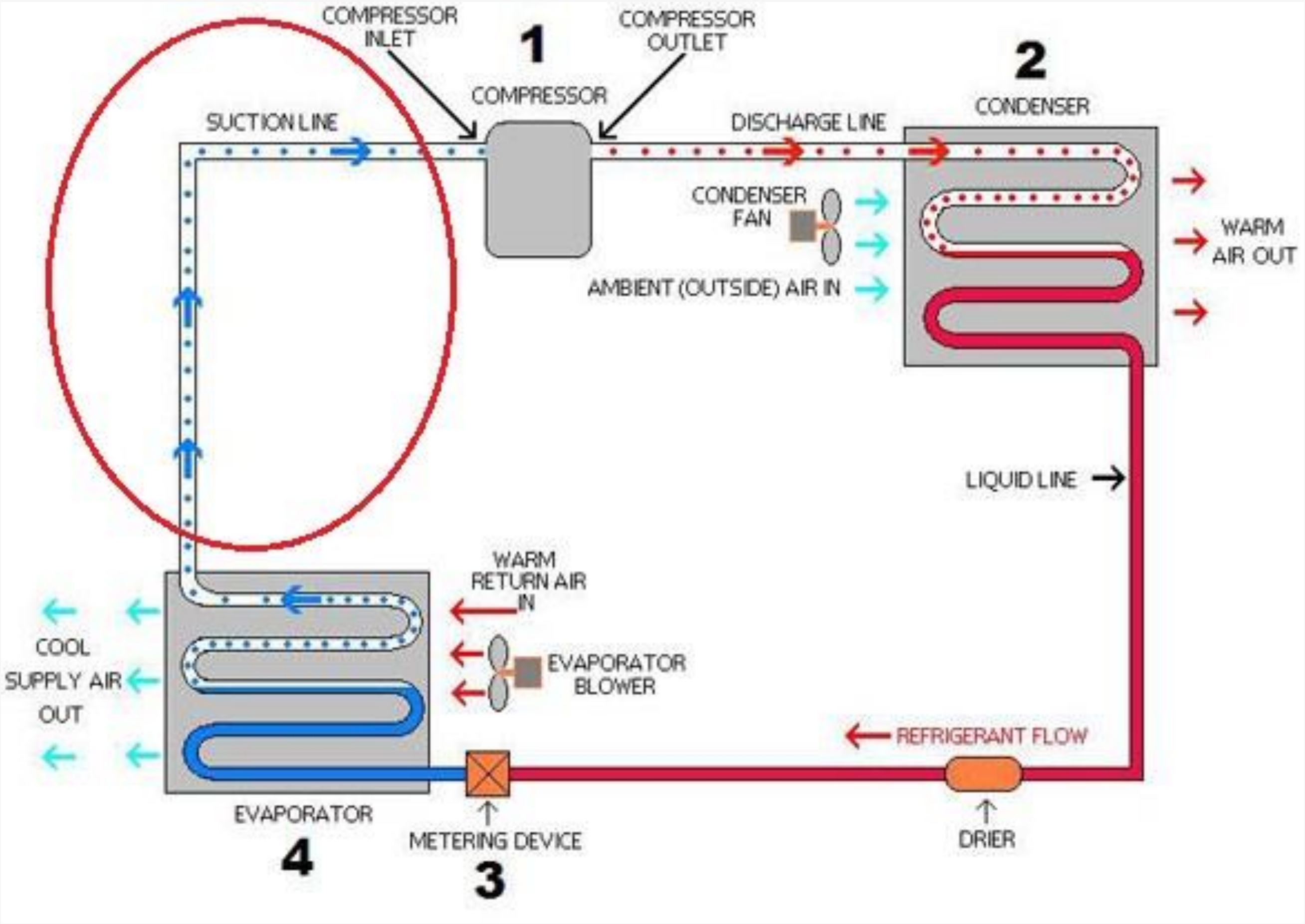
Refrigerants not listed in Table 1103.1 are prohibited unless approved in accordance with Section 105. Because of constantly evolving technology and a never-ending search for better and safer refrigerants, new types of refrigerants will likely be entering the marketplace regularly. Once these new products are classified in accordance with ASHRAE 34, the code official can evaluate them based on their properties and comparisons to those refrigerants listed in Table 1103.1.

What is a Refrigeration System as Defined in the Code?

REFRIGERATING SYSTEM. A combination of interconnected refrigerant-containing parts constituting one closed refrigerant circuit in which a refrigerant is circulated for the purpose of extracting heat.

REFRIGERATION SYSTEM, MECHANICAL. A combination of interconnected refrigeration-containing parts constituting one closed refrigerant circuit in which a refrigerant is circulated for the purpose of extracting heat and in which a compressor is used for compressing the refrigerant vapor.

REFRIGERATION SYSTEM, ABSORPTION. A heat operated, closed-refrigeration cycle in which a secondary fluid (the absorbent) absorbs a primary fluid (the refrigerant) that has been vaporized in the evaporator.



Mechanical Refrigeration Cycle

Refrigerating system – code definition:

A combination of interconnected refrigeration-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat and in which a compressor is used for compressing refrigerant vapor.

Rotary screw

Centrifugal

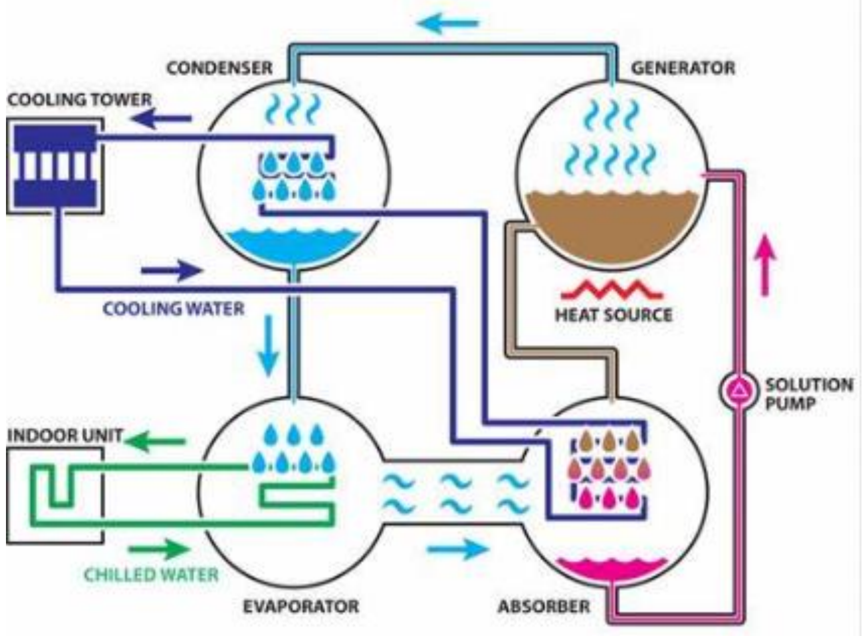
Reciprocating

These systems use different methods of mechanical compression

Mechanical Chillers

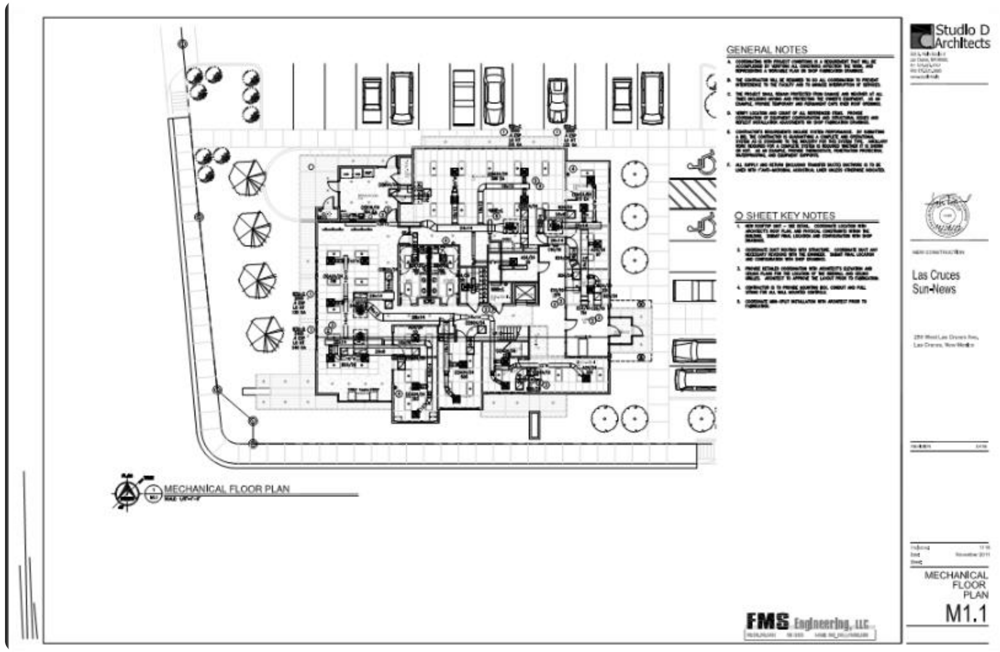
Absorption Refrigeration Cycle

Common systems use ammonia (refrigerant) / water (absorber) or water (refrigerant) / lithium bromide (absorber). The heat source that drive these systems can vary and include waste heat. Both systems have their drawbacks and new suitable refrigerant – absorbent pairs are being researched.



Absorption Chiller

Mountain Farms Site – Siler City NC



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So how does a mechanical engineer or contractor determine what type of refrigerant / system can be safely used in specific buildings such as a hospital, an industrial plant, or a mixed-use office building based on ASHREA 15 and 34, IIAR, and Chapter 11 of the NCMC?

The three components used to determine the application of a refrigerant system in a building are:

- **Refrigerant Classification** – What type of refrigerant should be considered based table 1103.1, the occupancy classification, and refrigerant system classification.
- **Occupancy Classification** – What is the building use per the listed ASHRAE occupancies.
- **Refrigerant System Classification** – How the system is designed based on the first two components and the probability that occupants will be exposed to refrigerant in the event of a leak?

Refrigeration - Chapter 11

Note* This section contains general requirements regarding the purity and compatibility of refrigerants, serves to coordinate the provisions of Chapter 11 and includes basic user guidance for the application of those provisions. Items 1 through 4 provide logically ordered instruction on the application of the interdependent Sections 1103, 1104, 1105 and 1106.

SYSTEM REQUIREMENTS

1102.1 General. The system classification, allowable refrigerants, maximum quantity, enclosure requirements, location limitations, and field pressure test requirements shall be determined as follows:

1. Determine the **refrigeration system's classification**, in accordance with Section 1103.3.
2. Determine the **refrigerant classification** in accordance with Section 1103.1.
3. Determine the **maximum allowable quantity of refrigerant** in accordance with Section 1104, based on type of refrigerant, system classification and occupancy.
4. Determine the **system enclosure requirements** in accordance with Section 1104.
5. Refrigeration equipment and appliance location and installation shall be subject to the **limitations of Chapter 3.**
6. **Nonfactory-tested, field-erected equipment and appliances shall be pressure tested** in accordance with Section 1108.

Designation and Safety Classification of Refrigerants

	Safety group	
Higher Flammability	A3	B3
Lower Flammability	A2 A2L*	B2 B2L*
No flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

*A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤ 10 cm/s

SAFETY GROUP

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

INCREASING TOXICITY

The Next Big Policy Change: A2L Refrigerants

On the immediate horizon, the United States and dozens of nations globally are transitioning from the high global warming potential (GWP) refrigerants traditionally used in air conditioning systems and heat pump water heaters to more environmentally friendly coolants with dramatically lower GWP. The most common low GWP alternatives are classified by ASHRAE as mildly flammable, or A2L. The switch to A2Ls goes into effect on January 1, 2025.

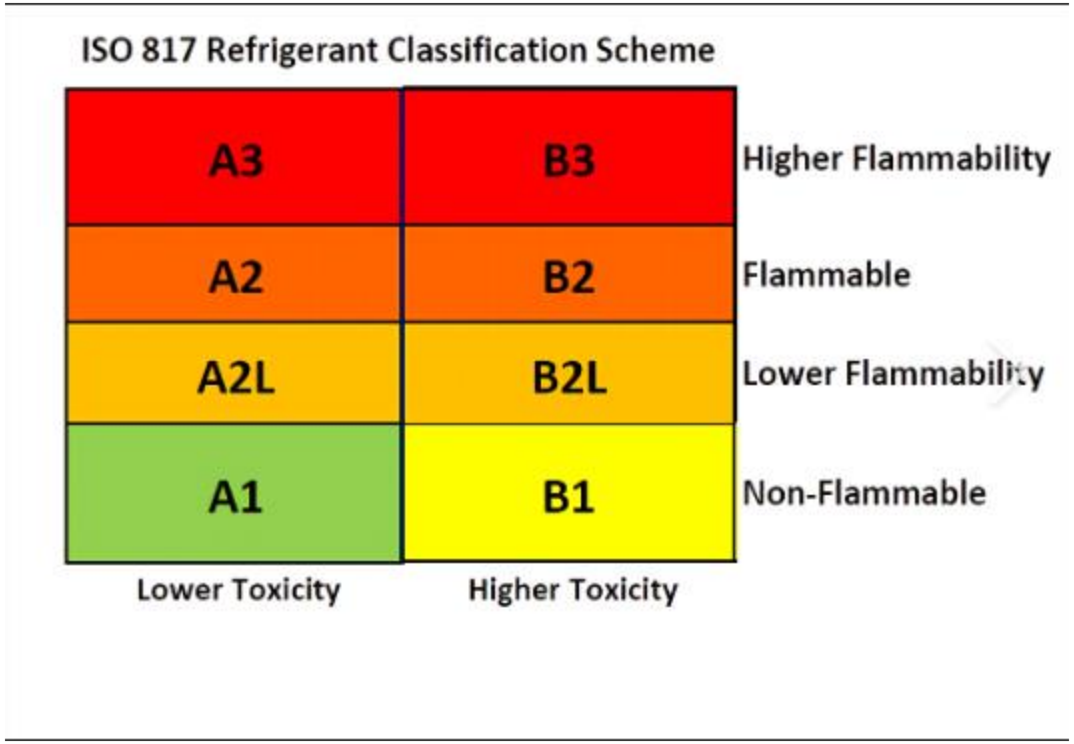


Table 1103.1 – Chapter 11

What are the "Degrees of Hazard"?

Footnote A - Degrees of hazard are for health, fire, and reactivity, respectively, in accordance with NFPA 704.

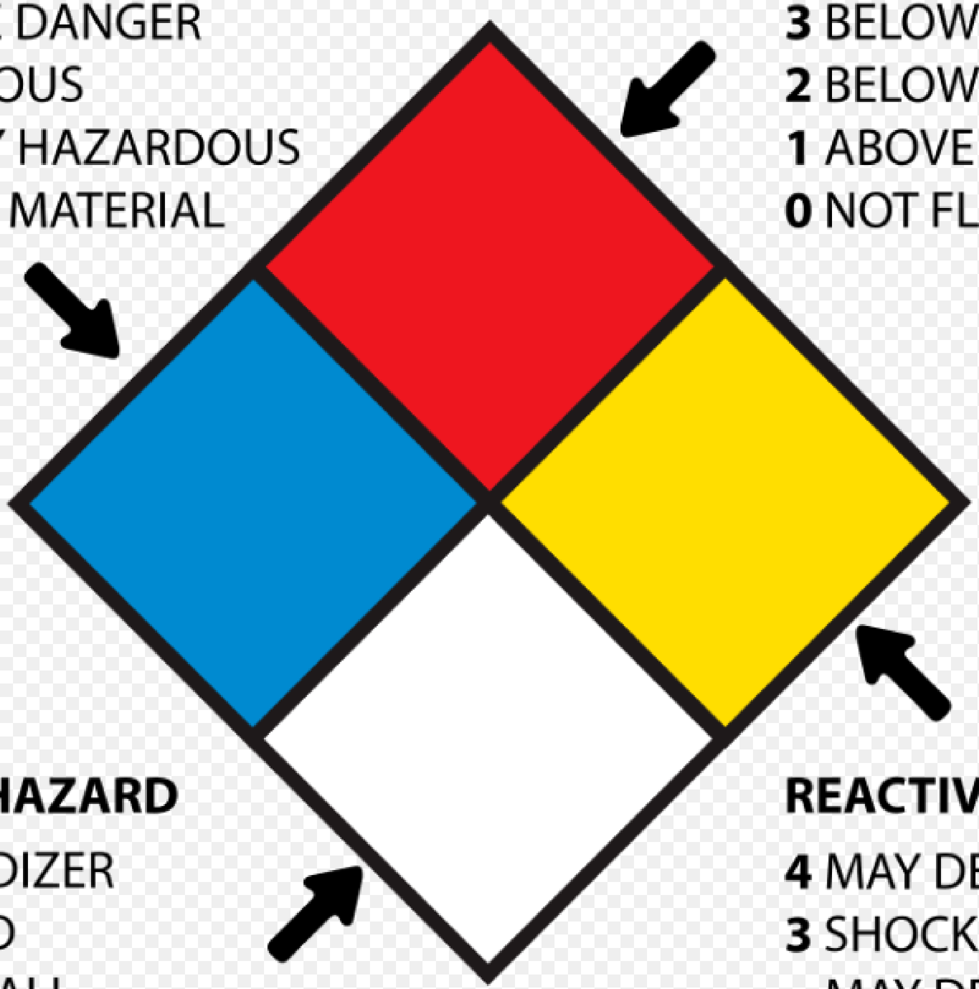
Footnote B - Reduction to 1-0-0 is allowed if analysis satisfactory to the code official shows that the maximum concentration for a rupture or full loss of refrigerant charge would not exceed the **IDLH**, considering both the refrigerant quantity and room volume.

HEALTH HAZARD

4 DEADLY
3 EXTREME DANGER
2 HAZARDOUS
1 SLIGHTLY HAZARDOUS
0 NORMAL MATERIAL

FIRE HAZARD

4 BELOW 25 °C
3 BELOW 37 °C
2 BELOW 93 °C
1 ABOVE 93 °C
0 NOT FLAMMABLE



SPECIFIC HAZARD

OXY	OXIDIZER
ACID	ACID
ALK	ALKALI
CORR	CORROSIVE
☢	RADIOACTIVE
~~W~~	USE NO WATER

REACTIVITY

4 MAY DETONATE
3 SHOCK + HEAT MAY DETONATE
2 VIOLENT REACTION
1 UNSTABLE IF HEATED
0 STABLE

Table 1103.1 – Chapter 11

What does IDLH mean?

Immediately Dangerous to Life and Health –

The concentration of airborne contaminants that poses a threat of death, immediate or delayed permanent adverse health effects, or effects that could prevent escape from such an environment. This contaminant concentration level is established by the National Institute of Occupational Safety and Health (NIOSH) based on both toxicity and flammability. It is generally expressed in parts per million by volume (ppm v/v) or milligrams per cubic meter (mg/m3).

TABLE 1103.1 REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	AMOUNT OF REFRIGERANT PER OCCUPIED SPACE				[F] DEGREES OF HAZARD[a]
				Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]	
R-11[d]	CCl_3F	trichlorofluoromethane	A1	0.39	1,100	6.2	C1,000	2-0-0[b]
R-12[d]	CCl_2F_2	dichlorodifluoromethane	A1	5.6	18,000	90	1,000	2-0-0[b]
R-13[d]	$CClF_3$	chlorotrifluoromethane	A1	—	—	—	1,000	2-0-0[b]
R-13B1[d]	$CBrF_3$	bromotrifluoromethane	A1	—	—	—	1,000	2-0-0[b]
R-14	CF_4	tetrafluoromethane (carbon tetrafluoride)	A1	25	110,000	400	1,000	2-0-0[b]
R-22	$CHClF_2$	chlorodifluoromethane	A1	13	59,000	210	1,000	2-0-0[b]
R-23	CHF_3	trifluoromethane (fluoroform)	A1	7.3	41,000	120	1,000	2-0-0[b]
R-32	CH_2F_2	difluoromethane (methylene fluoride)	A2[f]	4.8	36,000	77	1,000	1-4-0
R-113[d]	CCl_2FCClF_2	1,1,2-trichloro-1,2,2-trifluoroethane	A1	1.2	2,600	20	1,000	2-0-0[b]
R-114[d]	$CClF_2CClF_2$	1,2-dichloro-1,1,2,2-tetrafluoroethane	A1	8.7	20,000	140	1,000	2-0-0[b]
R-115	$CClF_2CF_3$	chloropentafluoroethane	A1	47	120,000	760	1,000	—
R-116	CF_3CF_3	hexafluoroethane	A1	34	97,000	550	1,000	1-0-0
R-123	$CHCl_2CF_3$	2,2-dichloro-1,1,1-trifluoroethane	B1	3.5	9,100	57	50	2-0-0[b]
R-124	$CHClFCF_3$	2-chloro-1,1,1,2-tetrafluoroethane	A1	3.5	10,000	56	1,000	2-0-0[b]
R-125	CHF_2CF_3	pentafluoroethane	A1	23	75,000	370	1,000	2-0-0[b]
R-134a	CH_2FCF_3	1,1,1,2-tetrafluoroethane	A1	13	50,000	210	1,000	2-0-0[b]
R-141b	CH_3CCl_2F	1,1-dichloro-1-fluoroethane	—	0.78	2,600	12	500	2-1-0

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	Pounds per 1,000 cubic feet	ppm	g/m^3	OEL[e]	[F] DEGREES OF HAZARD[a]
R-401B	zeotrope	R-22/152a/124 (61.0/11.0/28.0)	A1	7.2	30,000	120	1,000	2-0-0[b]
R-401C	zeotrope	R-22/152a/124 (33.0/15.0/52.0)	A1	5.2	20,000	84	1,000	2-0-0[b]
R-402A	zeotrope	R-125/290/22 (60.0/2.0/38.0)	A1	17	66,000	270	1,000	2-0-0[b]
R-402B	zeotrope	R-125/290/22 (38.0/2.0/60.0)	A1	15	63,000	240	1,000	2-0-0[b]
R-403A	zeotrope	R-290/22/218 (5.0/75.0/20.0)	A2	7.6	33,000	120	1,000	2-0-0[b]
R-403B	zeotrope	R-290/22/218 (5.0/56.0/39.0)	A1	18	70,000	290	1,000	2-0-0[b]
R-404A	zeotrope	R-125/143a/134a (44.0/52.0/4.0)	A1	31	130,000	500	1,000	2-0-0[b]
R-405A	zeotrope	R-22/152a/142b/C318 (45.0/7.0/5.5/2.5)	—	16	57,000	260	1,000	—
R-406A	zeotrope	R-22/600a/142b (55.0/4.0/41.0)	A2	4.7	21,000	25	1,000	—
R-407A	zeotrope	R-32/125/134a (20.0/40.0/40.0)	A1	19	83,000	300	1,000	2-0-0[b]
R-407B	zeotrope	R-32/125/134a (10.0/70.0/20.0)	A1	21	79,000	330	1,000	2-0-0[b]
R-407C	zeotrope	R-32/125/134a (23.0/25.0/52.0)	A1	18	81,000	290	1,000	2-0-0[b]
R-407D	zeotrope	R-32/125/134a (15.0/15.0/70.0)	A1	16	68,000	250	1,000	2-0-0[b]
R-407E	zeotrope	R-32/125/134a (25.0/15.0/60.0)	A1	17	80,000	280	1,000	2-0-0[b]
R-407F	zeotrope	R-32/125/134a (30.0/30.0/40.0)	A1	20	95,000	320	1,000	—
R-408A	zeotrope	R-125/143a/22 (7.0/46.0/47.0)	A1	21	95,000	340	1,000	2-0-0[b]
R-409A	zeotrope	R-22/124/142b (60.0/25.0/15.0)	A1	7.1	29,000	110	1,000	2-0-0[b]
R-409B	zeotrope	R-22/124/142b (65.0/25.0/10.0)	A1	7.3	30,000	120	1,000	2-0-0[b]
R-410A	zeotrope	R-32/125 (50.0/50.0)	A1	26	140,000	420	1,000	2-0-0[b]
R-410B	zeotrope	R-32/125 (45.0/55.0)	A1	27	140,000	430	1,000	2-0-0[b]
R-411A	zeotrope	R-127/22/152a (1.5/87.5/11.0)	A2	2.9	14,000	46	990	—
R-411B	zeotrope	R-1270/22/152a (3.0/94.0/3.0)	A2	2.8	13,000	45	980	—
R-412A	zeotrope	R-22/218/142b (70.0/5.0/25.0)	A2	5.1	22,000	82	1,000	—
R-413A	zeotrope	R-218/134a/600a (9.0/88.0/3.0)	A2	5.8	22,000	94	1,000	—
R-414A	zeotrope	R-22/124/600a/142b (51.0/28.5/4.0/16.5)	A1	6.4	26,000	100	1,000	—

R-509A	azeotrope	R-22/218 (44.0/56.0)	A1	24	75,000	390	1,000	2-0-0[b]
R-510A	azeotrope	R-E170/600a (88.0/12.0)	A3	0.87	7,300	14	1,000	—
R-511A	azeotrope	R-290/E170 (95.0/5.0)	A3	0.59	5,300	9.5	1,000	—
R-512A	azeotrope	R-134a/152a (5.0/95.0)	A2	1.9	11,000	31	1,000	—
R-600	$CH_3CH_2CH_2CH_3$	butane	A3	0.15	1,000	2.4	1,000	1-4-0
R-600a	$CH(CH_3)_2CH_3$	2-methylpropane (isobutane)	A3	0.59	4,000	9.6	1,000	2-4-0
R-601	$CH_3CH_2CH_2$ CH_2CH_3	pentane	A3	0.18	1,000	2.9	600	—
R-601a	$(CH_3)_2CHCH_2CH_3$	2-methylbutane (isopentane)	A3	0.18	1,000	2.9	600	—
R-717	NH_3	ammonia	B2[f]	0.014	320	0.22	25	3-3-0[c]
R-718	H_2O	water	A1	—	—	—	—	0-0-0
R-744	CO_2	carbon dioxide	A1	4.5	40,000	72	5,000	2-0-0[b]
R-1150	$CH_2{=}CH_2$	ethene (ethylene)	A3	—	—	—	200	1-4-2
R-1234yf	$CF_3CF{=}CH_2$	2,3,3,3-tetrafluoro-1 propene	A2[f]	4.7	16,000	75	500	—
R-1234ze(E)	CF3CH=CHF	trans-1,3,3,3-tetrafluoro-1 -propene	A2[f]	4.7	16,000	75	800	—
R-1270	$CH_3CH{=}CH_2$	Propene (propylene)	A3	0.1	1,000	1.7	500	1-4-1

For SI: 1 pound = 0.454 kg, 1 cubic foot = 0.0283 m^3.

a. Degrees of hazard are for health, fire, and reactivity, respectively, in accordance with NFPA 704.
b. Reduction to 1-0-0 is allowed if analysis satisfactory to the code official shows that the maximum concentration for a rupture or full loss of refrigerant charge would not exceed the IDLH, considering both the refrigerant quantity and room volume.
c. For installations that are entirely outdoors, use 3-1-0.
d. Class I ozone depleting substance; prohibited for new installations.
e. Occupational Exposure Limit based on the OSHA PEL, ACGIH TLV-TWA, the AIHA WEEL or consistent value on a time-weighted average (TWA) basis (unless noted C for ceiling) for an 8 hr/d and 40 hr/wk.
f. The ASHRAE Standard 34 flammability classification for this refrigerant is 2L, which is a subclass of Class 2.

https://www.osha.gov/chemical-hazards

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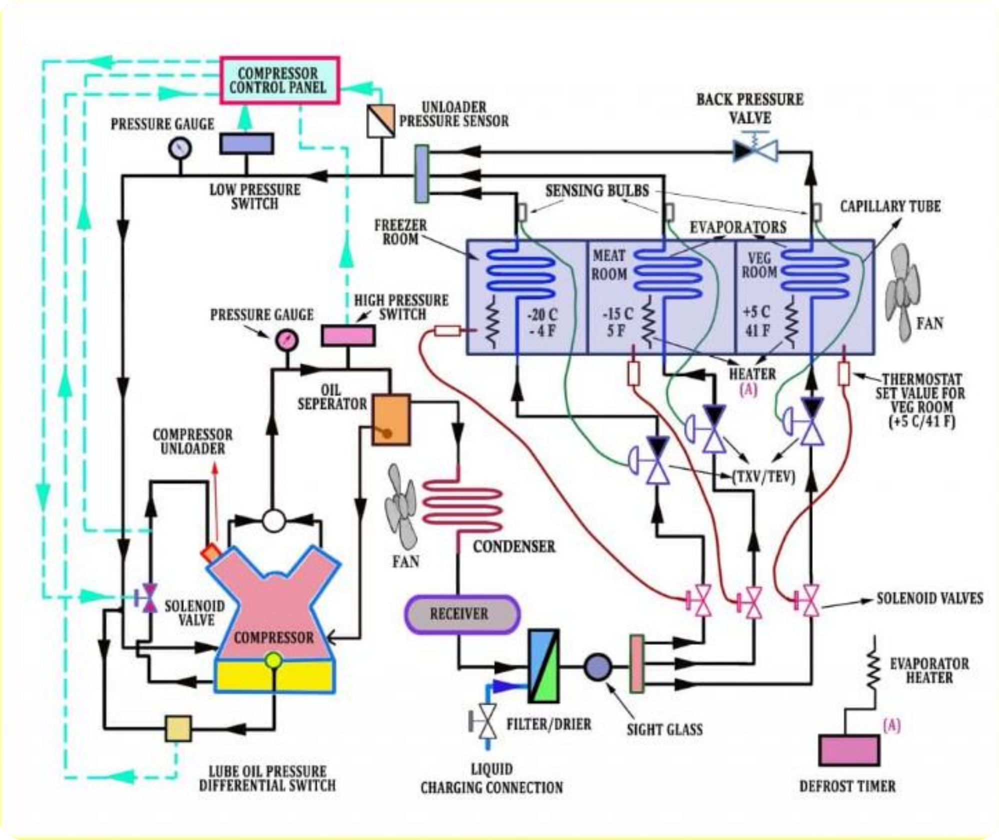


To apply the refrigerant-per-volume requirements of Table 1103.1, the method of determining occupied space volume must be known. Human occupants could be directly exposed to refrigerant if any refrigerant circuit leaks. The amounts given [pounds per 1,000 cubic feet (kg/28 m), volume percent or grams/ cubic meter] are the maximum allowed in the largest single circuit in a given space, assuming that only one circuit is likely to leak refrigerant at any given time.

Section 1103.2

Occupancy classification. Locations of refrigerating systems are described by occupancy classifications that consider the ability of people to respond to potential exposure to refrigerants. Where equipment or appliances, other than piping, are located outside a building and within 20 feet (6096 mm) of any building opening, such equipment or appliances shall be governed by the occupancy classification of the building.

Refrigerant poisoning happens when someone is exposed to the chemicals used to cool appliances. Refrigerant contains chemicals called fluorinated hydrocarbons (often referred to by a common brand name, "Freon"). Freon is a tasteless, mostly odorless gas. When it is deeply inhaled, it can cut off vital oxygen to your cells and lungs.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Institutional occupancy is that portion of premises from which occupants cannot readily leave without the assistance of others because they are disabled, debilitated or confined. Institutional occupancies include, among others, hospitals, nursing homes, asylums and spaces containing locked cells.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Public assembly occupancy is that portion of premises where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly occupancies include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants and theaters.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Residential occupancy is that portion of premises that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking and sanitation. Residential occupancies include, among others, dormitories, hotels, multiunit apartments and private residences.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Commercial occupancy is that portion of premises where people transact business, receive personal service or purchase food and other goods. Commercial occupancies include, among others, office and professional buildings, markets (but not large mercantile occupancies) and work or storage areas that do not qualify as industrial occupancies.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Large mercantile occupancy is that portion of premises where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.

Note – According to the NASRC, the average food retail system contains 3500 pounds of refrigerant that leaks 25% each year.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

Industrial occupancy is that portion of premises that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process or store goods such as chemicals, food, ice, meat or petroleum.

REFRIGERATION SYSTEM CLASSIFICATION – Not Building Code Occupancies

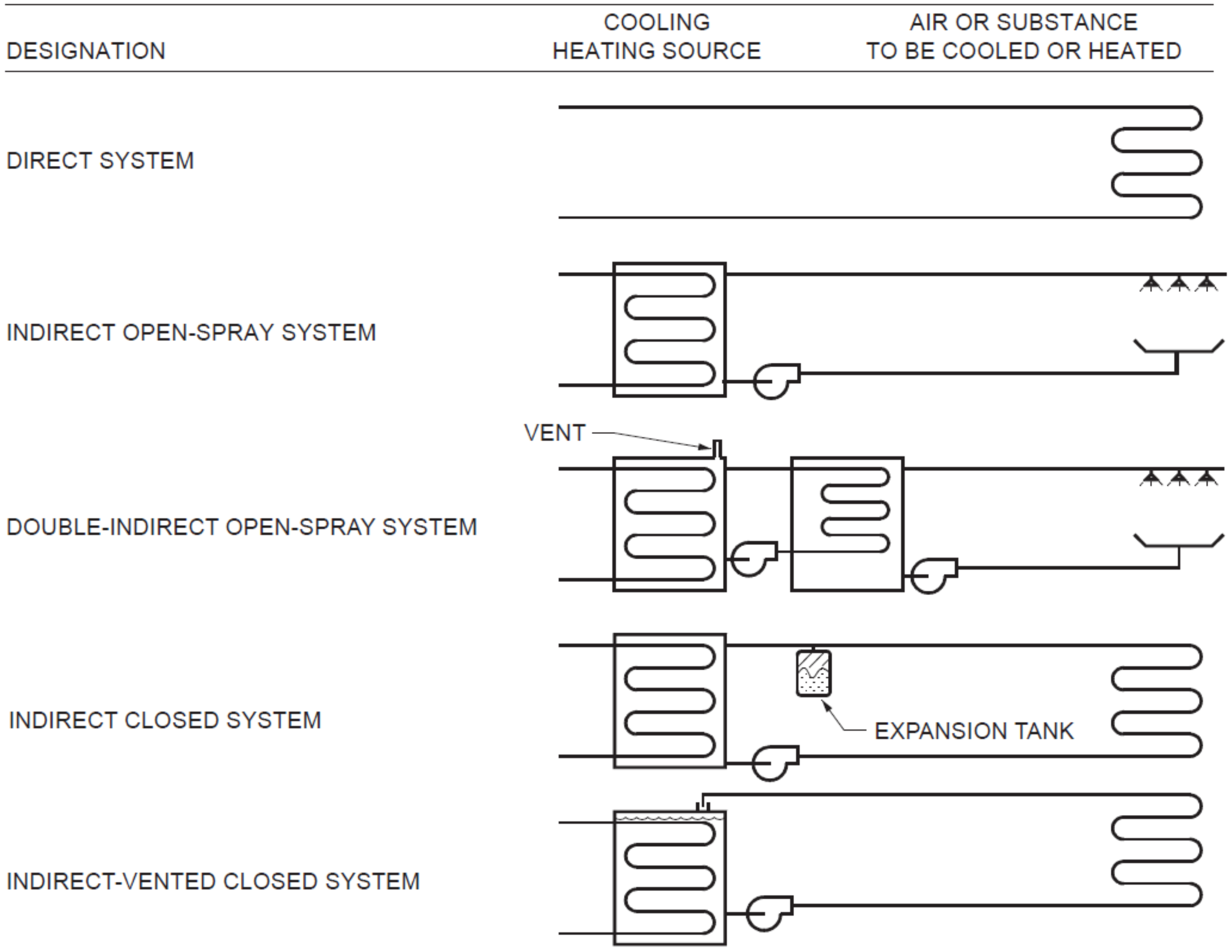
Mixed occupancy occurs where two or more occupancies are located within the same building. Where each occupancy is isolated from the rest of the building by tight walls, floors and ceilings and by self-closing doors, the requirements for each occupancy shall apply to its portion of the building. Where the various occupancies are not so isolated, the occupancy having the most stringent requirements shall be the governing occupancy.

Refrigerant System Classification – System Classification

Refrigeration systems shall be classified according to the degree of probability that refrigerant leaked from a failed connection, seal or component could enter an occupied area. The distinction is based on the basic design or location of the components.

Low Probability Systems - The nature of low-probability systems makes refrigerant leakage into occupied areas unlikely.

High Probability Systems - In a high-probability system, chances are good that system leakage would expose building occupants to a refrigerant



Commentary Figure 1103.3.1
REFRIGERATION SYSTEM CLASSIFICATION
(Source: ASHRAE 15-89)

In refrigeration systems, open and closed spray systems are two types of cooling systems. The main difference between the two is that **open spray systems** are used in **low-probability refrigeration systems** to cool the refrigerant, while **closed spray systems** are used in **high-probability refrigeration systems** to cool the refrigerant [1].

In an **open spray system**, the refrigerant is cooled by direct contact with a spray of water or other coolant. The coolant is then evaporated, and the refrigerant is cooled by the resulting heat transfer. Open spray systems are classified as low-probability systems when they use **double-indirect open-spray systems, indirect closed systems and indirect-vented closed systems** [1]. Open recirculating cooling systems also use spray ponds to cool process equipment [2].

In a **closed spray system**, the refrigerant is cooled by indirect contact with a spray of water or other coolant. The coolant is then circulated through a heat exchanger, where it cools the refrigerant. Closed spray systems are used in high-probability systems because they are more reliable and less prone to leaks than open spray systems

Package Chiller – High or Low Probability System?

Package Heat Pump – High or Low Probability System?

Chiller and Cooling Tower

System Application Requirements

Whereas Section 1103 addresses the classification of systems, **Section 1104** deals with specific requirements based on these classifications. This includes when a machinery room is required to house refrigeration equipment (Section 1104.2) and when equipment can be located outside of machinery rooms (Section 1104.2.2). The requirements in Section 1104 parallel ASHRAE 15, referenced in Section 1101.6, and have become a part of the code for ease of reference. Before the specific application requirements of Section 1104 can be applied, the system must be classified in accordance with Section 1103.

1104.2.1 Institutional occupancies. The amounts shown in Table 1103.1 shall be reduced by 50 percent for all areas of institutional occupancies except kitchens, laboratories and mortuaries. The total of all Group A2, B2, A3 and B3 refrigerants shall not **exceed 550 pounds** (250 kg) in occupied areas or machinery rooms.

Because of the danger to people who may be incapable of self-preservation, the table 1103.1 limits are cut in half for institutional occupancies. The cumulative amount of the more hazardous refrigerants (A2, B2, A3, B3), even for systems located in machinery rooms, is also limited to 550 pounds. Systems that require greater amounts of refrigerants than 550 pounds would have to be located **outdoors**.

1104.2.2 Industrial occupancies and refrigerated rooms. This section applies only to rooms and spaces that: are within industrial occupancies; contain a refrigerant evaporator; are maintained at temperatures below 68F (20C); and are used for manufacturing, food and beverage preparation, meat cutting, other processes and storage. Where a machinery room would otherwise be required by Section 1104.2, a machinery room shall not be required where all of the following conditions are met:

1. The space containing the machinery is separated from other occupancies by tight construction with tight-fitting doors.

2. Access is restricted to authorized personnel.

3. Refrigerant detectors are installed as required for machinery rooms in accordance with Section 1105.3.

See Exceptions…

Machinery Room – A room meeting prescribed safety requirements and in which refrigeration systems or components thereof are located (NCMC). A machinery room provides a buffer between building occupants and the system, so that if something goes wrong, the hazard will be isolated from normally occupied areas. Section 1105 requires protected openings, refrigerant detectors and special ventilation for the room.

1104.2 Machinery room. Except as provided in Sections 1104.2.1 and 1104.2.2, all components containing the refrigerant shall be located either outdoors or in a machinery room where the quantity of refrigerant in an independent circuit of a system exceeds the amounts shown in Table 1103.1.

Machinery rooms required by this section shall be constructed and maintained in accordance with Section 1105 for Group A1 and B1 refrigerants and in accordance with **Sections 1105 and 1106** for Group **A2, B2, A3 and B3 refrigerants.**

NCBC Machinery Room Requirements

TABLE 509
INCIDENTAL USES

ROOM OR AREA	SEPARATION AND/OR PROTECTION
Furnace room where any piece of equipment is over 400,000 Btu per hour input	1 hour or provide automatic sprinkler system
Rooms with boilers where the largest piece of equipment is over 15 psi and 10 horsepower[a]	1 hour or provide automatic sprinkler system
Refrigerant machinery room	1 hour or provide automatic sprinkler system

1006.2.2.2 Refrigeration machinery rooms. Machinery rooms larger than 1,000 square feet (93 m2) shall have not less than two *exits* or *exit access doorways*. Where two *exit access doorways* are required, one such doorway is permitted to be served by a fixed ladder or an *alternating tread device*. *Exit access doorways* shall be separated by a horizontal distance equal to one-half the maximum horizontal dimension of the room.
All portions of machinery rooms shall be within 150 feet (45 720 mm) of an *exit* or *exit access doorway*. An increase in *exit access* travel distance is permitted in accordance with Section 1017.1.
Doors shall swing in the direction of egress travel, regardless of the *occupant load* served. Doors shall be tight fitting and self-closing. (NCBC)

Option to a Refrigeration Machinery Room Section 1104.2

1104.4 Volume calculations in accordance with table 1103.1. This determines if a refrigeration room is required.

1104.4.1 Noncommunicating spaces. Where the refrigerant containing parts of a system are located in one or more spaces that do not communicate through permanent openings or HVAC ducts, the volume of the smallest, enclosed occupied space shall be used to determine the permissible quantity of refrigerant in the system.

1104.4.2 Communicating spaces. Where an evaporator or condenser is located in an air duct system, the volume of the smallest, enclosed occupied space served by the duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

Exception: If airflow to any enclosed space cannot be reduced below one-quarter of its maximum, the entire space served by the air duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

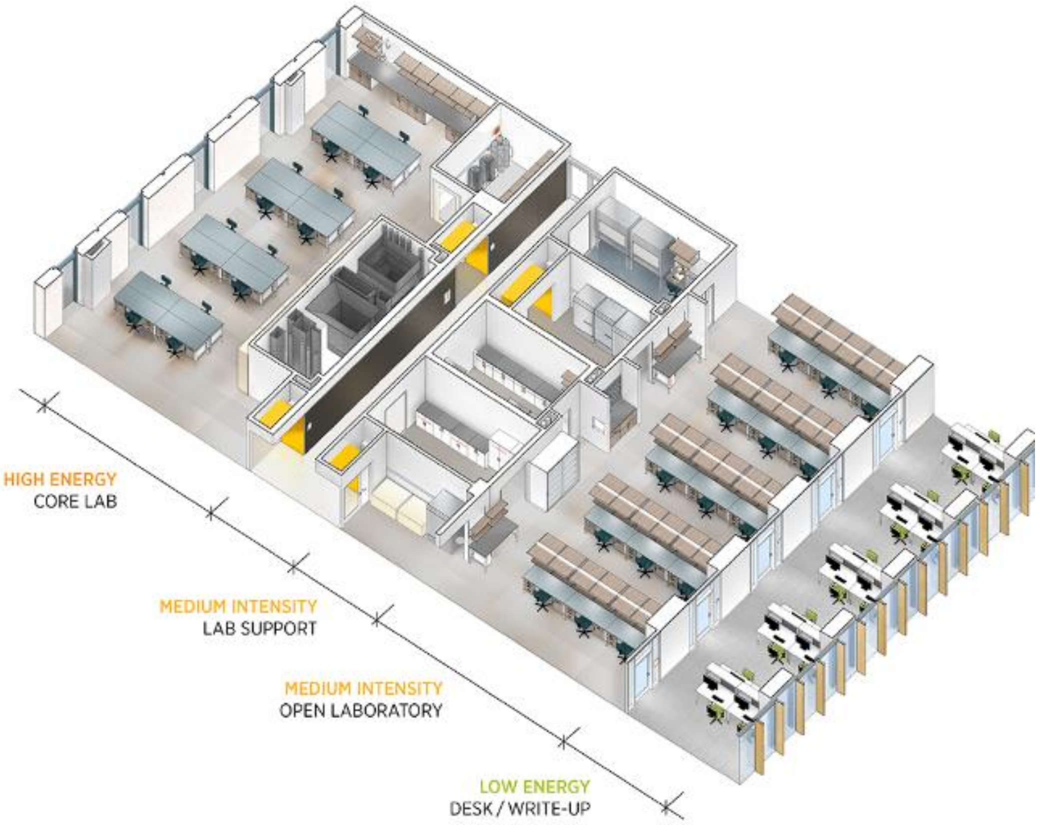


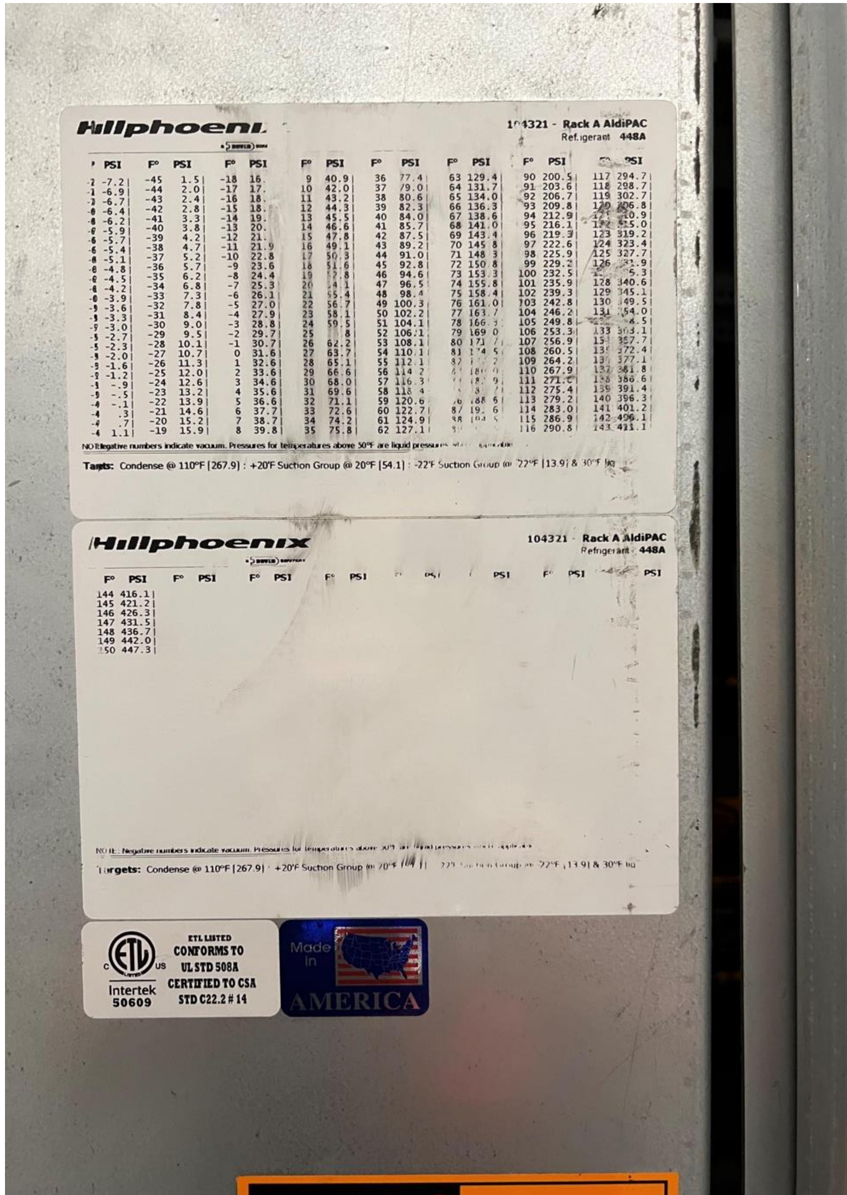
TABLE 1104.3.2
MAXIMUM PERMISSIBLE QUANTITIES OF REFRIGERANTS

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

For SI: 1 pound = 0.454 kg.

Refrigeration Machinery Room Section 1105- General Requirements


Aldi Inc.
Store ID: 28
Hillphoenix
102554

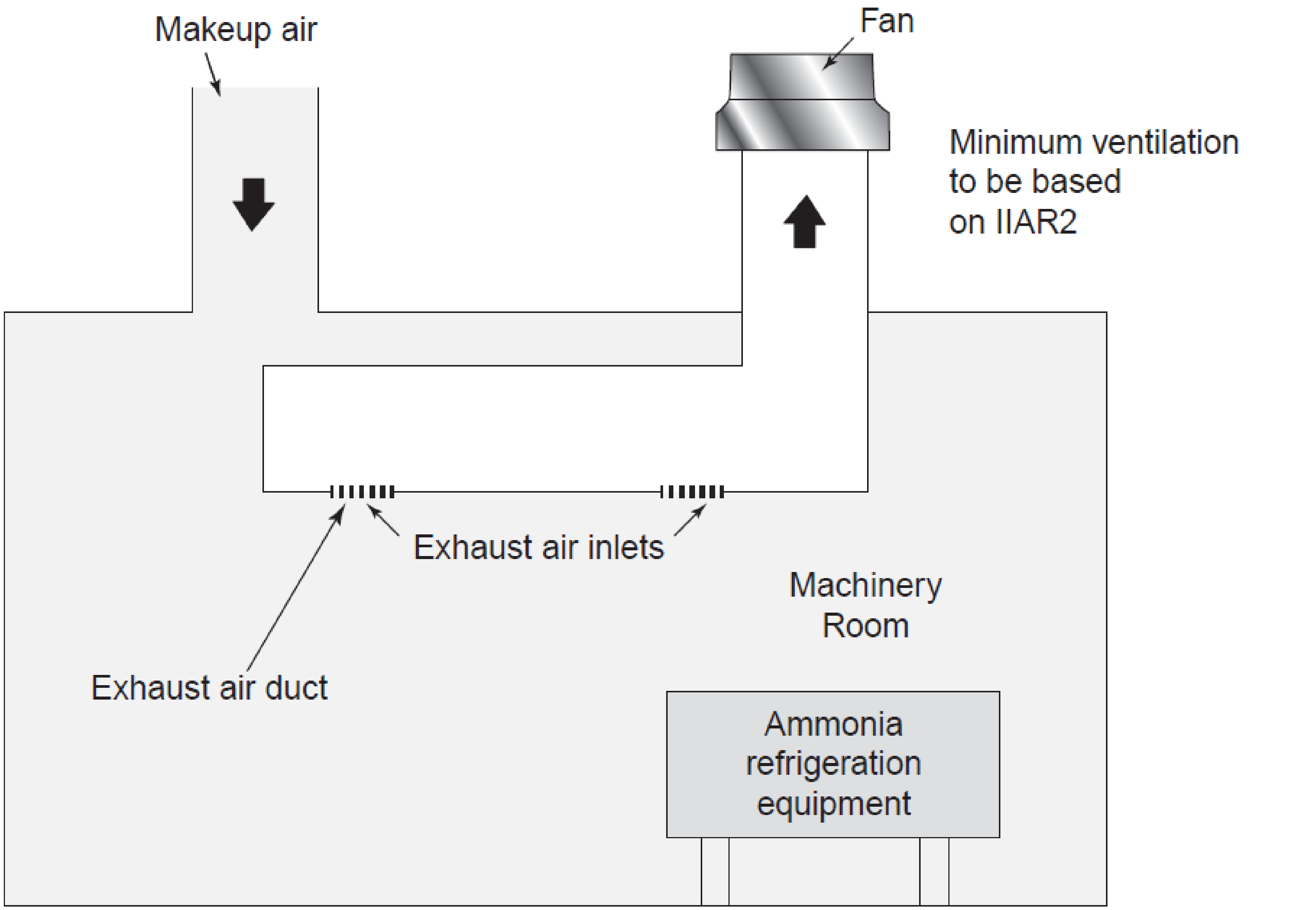

Hillphoenix
104321 - Rack A AldiPAC
Refrigerant 448A
Hillphoenix
104321 - Rack A AldiPAC
Refrigerant 448A
F° PSI
144 416.1
145 421.2
146 426.3
147 431.5
148 436.7
149 442.0
150 447.3
Targets: Condense @ 110°F [267.9]
ETL LISTED
CONFORMS TO
UL STD 508A
CERTIFIED TO CSA
STD C22.2 # 14
Intertek
50609
Made in
AMERICA

Section 1105.5 - **No** Fuel Burning Appliances in a Machinery Room – except….

Exceptions:

1. Where the refrigerant is carbon dioxide or water.

2. Fuel-burning appliances shall not be prohibited in the same *machinery room* with refrigerant-containing *equipment* or appliances where *combustion* air is ducted from outside the *machinery room* and sealed in such a manner as to prevent any refrigerant leakage from entering the *combustion* chamber, or where a refrigerant vapor detector is employed to automatically shut off the *combustion* process in the event of refrigerant leakage.



Commentary Figure 1105.6.3
THE MINIMUM EMERGENCY VENTILATION RATE FOR AMMONIA IS 30 ACH PER IIAR2

1105.6.3.1 Quantity—normal ventilation. During occupied conditions, the mechanical ventilation system shall exhaust the larger of the following:

1. Not less than 0.5 cfm per square foot of machinery room area or 20 cfm per person.

2. A volume required to limit the room temperature rise to 18°F (10°C) taking into account the ambient heating effect of all machinery in the room.

1105.6.3.2 Quantity—emergency conditions. Upon actuation of the refrigerant detector required in Section 1105.3, the mechanical ventilation system shall exhaust air from the machinery room in the following quantity:

(Equation 11-2)

Q= 100 X the square root of G

Q = The airflow in cubic feet per minute.

G = The design mass of refrigerant in pounds (kg) in the

largest system, any part of which is located in the machinery room.

Sections 1105.6.1 and 6.2 - Discharge and make-up air for machinery room ventilation

Section 1105.3 – Refrigerant Detectors

For specific requirements, see section 606.8 of the NC Fire Code

SAFETY RELIEF VALVE

Type SRH1, SRH2, SRH3, SRH4, & SRH5

Suitable For: Ammonia, R22, R502, R404A, R717 and Other Common Refrigerants

FEATURES

- ANSI / ASHRAE 15 Complaint
- Excellent Repeatability / Unaffected by Vibration
- All Stainless Steel Internal Parts
- PTFE Seat
- Capacity Rating for Vapor Only
- Pressure Settings 150 to 400 psi

DESCRIPTION

The Type SRH High Capacity Safety Relief Valves are

Bulletin 72-00D

September 2007

Installation, Service, and Parts Informtion

Section 1105.7 – Termination of Relief Devices

YORK	YK Refrigerant Relief Valve Vent Sizing	
APPLICATION DATA	Supersedes: 160.73-AD1	Form 160.73-AD1

The ASHRAE-15 Safety Standard for Refrigeration Systems provides guidelines for sizing refrigerant relief valves and vent piping. Without attempting to provide a complete and thorough interpretation, this document provides the necessary data to properly determine piping requirements.

Relief Valve Sizing

YORK YK Mod F units are supplied with pressure relieving devices which are properly sized, selected, and installed on each unit. Owners, facility managers, or consulting engineers need relief valve rated discharge capacities [Cr] to adequately size relief vent piping from the chiller. ASHRAE 15-2004, Section 9.4, provides guidelines for selecting the type of pressure-relief protection (relief valves, rupture discs, or fusible plugs) and Section 9.7 provides the criteria for properly sizing the relief valve and vent piping from the chiller.

Section 9.7.5 defines the **minimum required discharge capacity [C]** of the relief device as:

$$C = f\,DL \quad \text{[lbs. of air per minute (kg/s)]} \qquad \text{Eq. 1}$$

Where:

f = factor dependent upon type of refrigerant {= 1.6 for R-134a},
D = outside diameter of vessel in feet (m), and
L = length of vessel in feet (m)

Notes: 1) When combustible materials are used within 20 ft. (6.1 m) of a pressure vessel, multiply the value of f (or C as provided in tabular form) by 2.5.
2) The formula is based on fire conditions. Other heat sources shall be calculated separately.

When one pressure-relief device or fusible plug is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.

The rated discharge capacities [Cr] for relief valves on York YK modification level F equipment are provided in Table I.

Section 9.7.6 specifies that the rated discharge capacity of each relief device shall be determined in accordance with the ASME Boiler and Pressure Vessel Code (paragraph UG-131, Section VIII, Division I) and that pipe and fittings between the pressure-relief valve and the parts of the system it protects shall have at least the area of the pressure-relief valve inlet area. Section 9.7.2.3 requires vessels or systems with refrigerant capacity greater than 10 cubic feet be provided with one or more rupture member(s) or a dual relief valve assembly. A single relief valve is adequate for all vessels less than 10 cubic feet and low side vessels equipped with isolation valves. Additionally, every pressure vessel containing liquid refrigerant and that is capable of being isolated by stop valves requires over-pressure relief protection (Section 9.7.2).

Section 1105.7 – Termination of Relief Devices

Table II -- Maximum Length [feet] of Discharge Piping.

Rated Relief Valve Capacity, Cr (lb. air / min.)	Relief Valve Pressure Setting, PSIG											
	180						235					
	Nominal pipe size, inches (calculations based on sch. 40 pipe)											
	1-1/4	1-1/2	2	2-1/2	3	4	1-1/4	1-1/2	2	2-1/2	3	4
43.5	30	79	324	847								
55.9							24	68	289	761		
71.4	4	20	108	300	976							
87.0		9	67	194	648							
91.8								15	93	265	876	
112								5	55	169	576	
143			13	57	220	994			25	93	340	
148									22	85	315	
173			3	31	141	666						
179									8	49	204	940
184									7	45	191	887
204									1	32	148	712
235										17	103	524
255										10	82	438
291										1	55	324
321											38	258
357											24	199

Table III - Steel Pipe Dimensions (Sch. 40)

	Nominal Pipe Size (in)								
	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6
I. D. (in)	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	6.065
Friction Factor	0.0225	0.0209	0.0202	0.0190	0.0182	0.0173	0.0163	0.0155	0.0149

Refrigeration Machinery Room Section 1106- Special Requirements

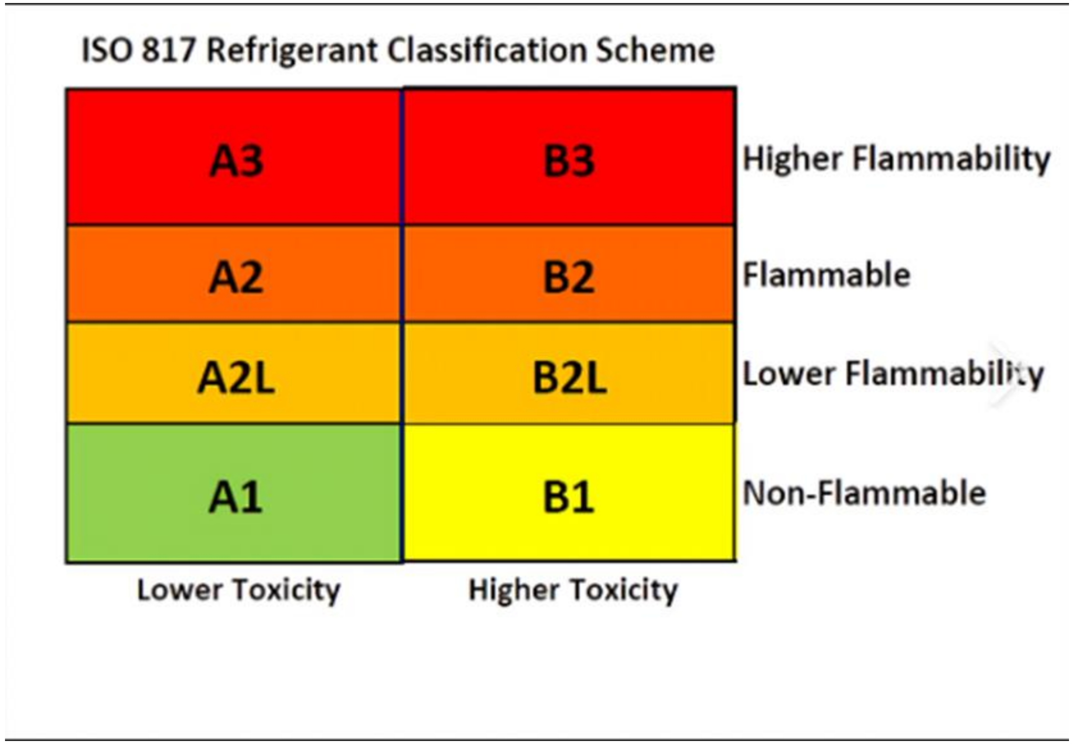
ISO 817 Refrigerant Classification Scheme

Lower Toxicity	Higher Toxicity	
A3	B3	Higher Flammability
A2	B2	Flammable
A2L	B2L	Lower Flammability
A1	B1	Non-Flammable

1106.4 Flammable refrigerants. Where refrigerants of Groups A2, A3, B2 and B3 are used, the machinery room shall conform to the Class 1, Division 2, hazardous location classification requirements of NFPA 70.

Exceptions:

1. Ammonia machinery rooms that are provided with ventilation in accordance with Section 1106.3.
2. Machinery rooms for systems containing Group A2L refrigerants that are in accordance with Section 1106.5.



1106.2 Elevated temperature. There shall not be an open flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.

❖ The presence of any open flame or a hot surface could create a fire or explosion hazard where refrigerants are flammable. Also, as discussed in Sections 1104.3.4 and 1105.5, exposing refrigerant to high temperatures can produce dangerously toxic and corrosive chemicals.

Section 1106.5.1

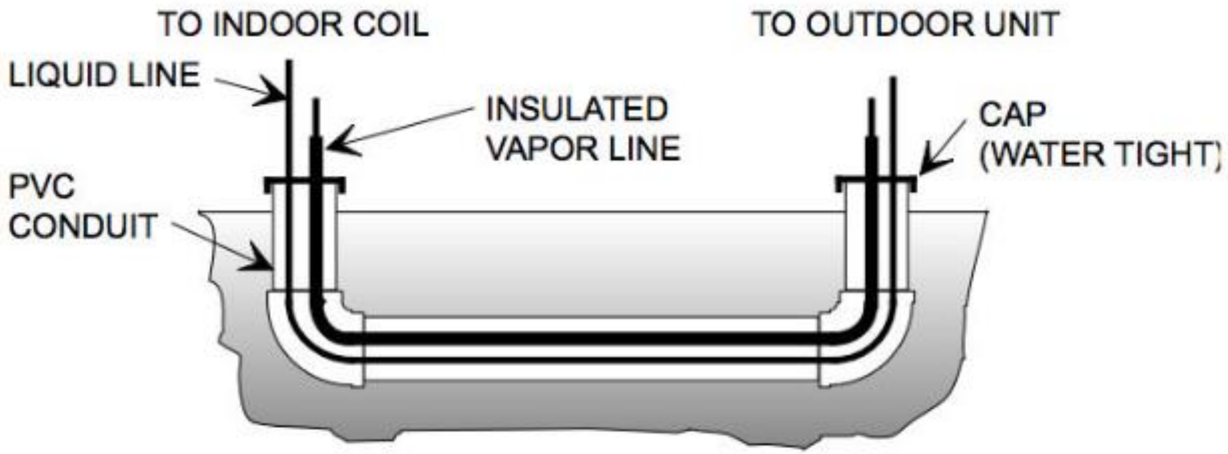
NCMC Section 1106.5.2Ventilation System

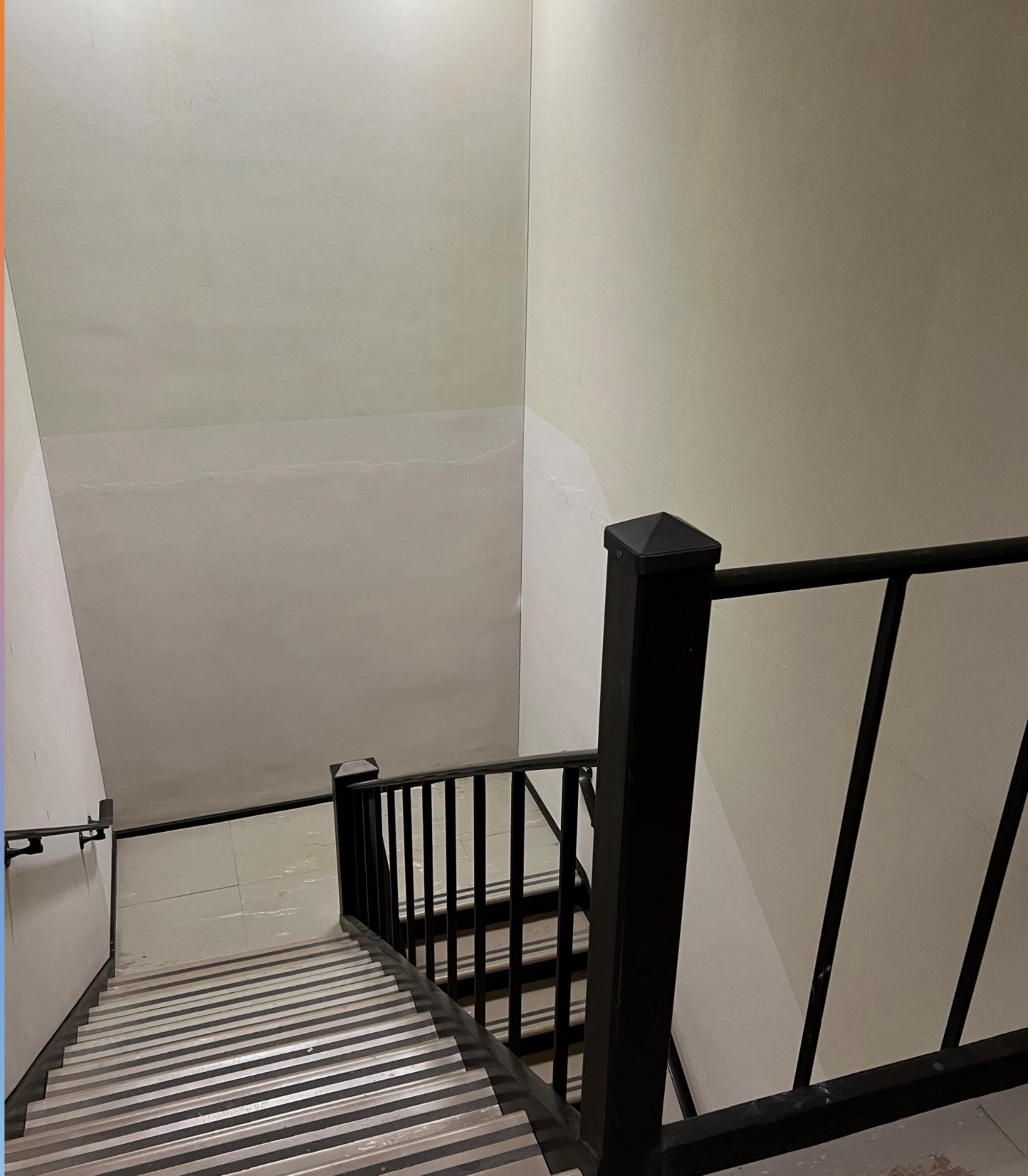
1106.7 Emergency signs and labels. Refrigeration units and systems shall be provided with approved emergency signs, charts, and labels in accordance with the North Carolina Fire Code.

Section 605 of the NCFC requires emergency signs and labels in accordance with NFPA 704 on refrigeration units or systems containing **more than 220 pounds (100 kg) of Group A1** or more than **30 pounds (13.6 kg) of any other refrigerant group.** These signs must be prominently displayed at each entrance to the machinery room and should show, at a minimum, the hazard classification of the refrigerant in accordance with Section 11.

Refrigerant Piping – Section 1107

Piping in concrete floors. Refrigerant piping
installed in concrete floors shall be encased in pipe ducts. The piping shall be isolated and supported to prevent damaging vibration, stress and corrosion.





1107.2 Piping location. Refrigerant piping that crosses an open space that affords passageway in any building shall be not less than 7 feet 3 inches (2210 mm) above the floor unless the piping is located against the ceiling of such space. Refrigerant piping shall not be placed in any of the following:

1. A fire-resistance-rated exit access corridor.
2. An interior exit stairway.
3. An interior exit ramp.
4. An exit passageway.
5. An elevator, dumbwaiter or other shaft containing a moving object.
6. A shaft that has one or more openings into a fire-resistance-rated exit access corridor, interior exit stairway or ramp or exit passageway.

1107.2.2 Refrigerant penetrations. Refrigerant piping shall not penetrate floors, ceilings or roofs.

Exceptions:

1. Penetrations connecting the basement and the first floor.

2. Penetrations connecting the top floor and a machinery penthouse or roof installation.

3. Penetrations connecting adjacent floors served by the refrigeration system.

4. Penetrations by piping in a direct system where the refrigerant quantity does not exceed Table 1103.1 for the smallest occupied space through which the piping passes.

5. In other than industrial occupancies and where the refrigerant quantity exceeds Table 1103.1 for the smallest space, penetrations for piping that connects separate pieces of equipment that are either:

5.1. Enclosed by an approved gas-tight, fire resistive duct or shaft with openings to those floors served by the refrigeration system.

5.2. Located on the exterior of the building where vented to the outdoors or to the space served by the system and not used as an air shaft, closed court or similar space.

1107.3 Pipe enclosures. Rigid or flexible metal enclosures or pipe ducts shall be provided for **soft, annealed copper tubing** and used for refrigerant piping erected on the premises and containing **other than Group A1 or B1** refrigerants. Enclosures shall not be required for connections between condensing units and the nearest riser box(es), provided such connections do not exceed 6 feet (1829 mm) in length.

Material for Refrigerant Piping and Tubing

The following materials are allowed as refrigerant piping:

Steel Pipe

Copper and Brass Pipe

Copper Tube

Aluminum tube (in some cases)

Steel pipe. Carbon steel pipe with a wall thickness not less than Schedule 80 shall be used for **Group A2, A3, B2 or B3 refrigerant** liquid lines for sizes 1.5 inches (38 mm) and smaller. Carbon steel pipe with a wall thickness not less than Schedule 40 shall be used for **Group A1 or B1 refrigerant liquid lines 6 inches (152 mm) and smaller**, Group A2, A3, B2 or B3 refrigerant liquid lines sizes 2 inches (51 mm) through 6 inches (152 mm) and all refrigerant suction and discharge lines 6 inches (152 mm) and smaller. Type F steel pipe shall not be used for refrigerant lines having an operating temperature less than -20°F (-29°C).

❖ This section requires a heavier wall pipe for liquid lines conveying the more hazardous refrigerant groups. The smaller a pipe is, the more susceptible it is to physical damage. Type F steel pipe is defined in ASTM A53 as furnace butt-welded pipe. Type F steel pipe is not intended for flanging and could be susceptible to stress failures at low temperatures.

1107.5.3 Copper tube.

Type ACR tube is designed for air-conditioning and refrigeration applications and is factory cleaned, dehydrated and shipped with end caps or plugs to prevent internal contamination. It is available in rigid or bending temper. If approved by the **code official,** Type K, L or M copper water tube can be used; however, this is rarely done because water tube is not protected from contamination in shipping and storage, as is Type ACR. Also, Type M tube has less wall thickness than the almost exclusively used Type L tube. **Note that ASHRAE 15 prohibits the use of copper and its alloys in systems with ammonia refrigerant.** The larger a soft (annealed temper) tube is in diameter, the more difficult it is to work with, form and join. Also, larger sizes tend to be "out of round," making it difficult to achieve a good seal with mechanical joints.

Section1107.5.5 Aluminum tube. Type 3003-0 aluminum tubing with high-pressure fittings shall not be used with methyl chloride and other refrigerants known to attack aluminum.

* Type 3003-0 alloy of aluminum is susceptible to chemical corrosion when used with refrigerant R-40. Piping, tubing, fittings and refrigerant-containing components must be compatible with and unaffected by the refrigerant used. ASHRAE 15 prohibits the use of aluminum, zinc, magnesium and any alloys of these metals in systems with methyl chloride refrigerant. ASHRAE 15 also states that magnesium alloy materials must not be used with any of the halogenated refrigerants.

SECTION 1108

FIELD TEST

1108.1 General. Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, vessels, evaporators, safety devices, pressure gauges and control mechanisms that are listed and factory tested, shall be tested and proved tight after complete installation, and before operation. Tests shall include both the high and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit nameplate, as required by ASHRAE 15.

1108.4 Declaration. A certificate of test shall be provided for all systems containing 55 pounds (25 kg) or more of refrigerant. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and the low side of the system. The certification of test shall be signed by the installer and shall be made part of the public record.

❖ The test certificate can be in whatever form is acceptable to the code official. This documentation must be filed with the permit and inspection records.

SECTION 1109
PERIODIC TESTING

[**F**] 606.6.1 Testing required. The following emergency devices and systems shall be periodically tested in accordance with the manufacturer’s instructions and as required by the code official:

1. Treatment and flaring systems.
2. Valves and appurtenances necessary to the operation of emergency refrigeration control boxes.
3. Fans and associated equipment intended to operate emergency ventilation systems.
4. Detection and alarm systems.

Required by the NCFC and deleted from the NCMC. Periodic testing is as required by the **fire code official**.

As stated earlier in the presentation, The HVACR industry is undergoing another refrigerant transition, as HFCs such as R-410A and R-404A are being phased down in favor of new, lower-GWP refrigerants, such as R-32 and R-454B. Unlike the last transition, which shifted from the use of one nonflammable (A1) refrigerant to another, many of these new refrigerants are mildly flammable (A2L), so additional care will need to be taken in order to safely use them. This will require code changes due to the slightly flammable nature of the newer refrigerants. The 2024 Code will have new language that addresses some of these changes.

<ins>But what about thermo-acoustic refrigeration?</ins>

Sound powered refrigeration…

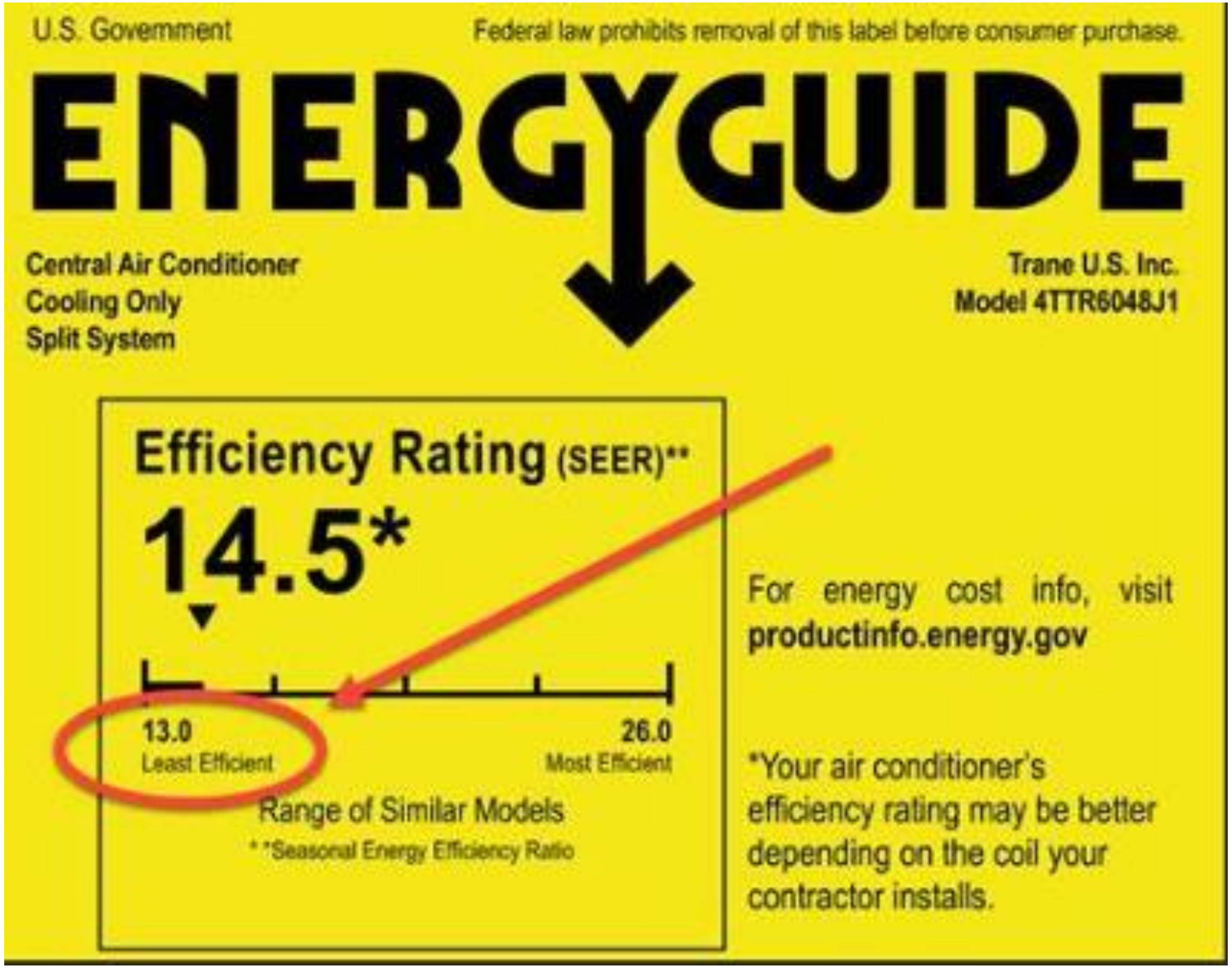
[SoundEnergy – Thermo acoustic cooling technology]

New federal efficiency ratings - SEER 2 VS SEER

Currently, the existing SEER conditions overlook the effect of ductwork on a unit's external static pressure. In effect, this results in ratings that are not as accurate as they ought to be.

Thus, with the implementation of SEER 2, most units undergoing testing may end up with lower ratings that are more accurate. This applies to split system ACs, split system heat pumps, and single packaged units.

For instance, under the new SEER 2 requirements, residential central AC systems with a BTU less than 45,000 should have a SEER 2 rating of 14.3 (an equivalent of 15.0 SEER). Systems with a BTU higher than 45,000 should have a SEER2 rating of 13.8 (an equivalent of 14.5 SEER).



New energy code acronyms

MINIMUMS FOR RESIDENTIAL AIR CONDITIONING AND HEAT PUMPS

Today - Appendix M	All	North	South	South West	
Type	HSPF	SEER	SEER	SEER	EER
AC	-	13	14	14	12.2/11.7*
Heat Pump	8.2	14	14	14	-
Packaged Units	8.0	14	14	14	11

**11.7 EER limit for equipment ≥ 45K BTU/Hr*

2023 - Appendix M1	All	North	South	South West	
Type	HSPF2 (HSPF)	SEER2 (SEER)	SEER2 (SEER)	SEER2 (SEER)	EER2 (EER)
AC < 45K BTU/Hr	-	13.4 (14)	14.3 (15)	14.3 (15)	11.7 (12.2) / 9.8* (10.2)
*New AC > 45K BTU/Hr	-	13.4 (14)	13.8 (14.5)	13.8 (14.5)	11.7 (12.2) / 9.8* (10.2)
Heat Pump	7.5 (8.8)	14.3 (15)	14.3 (15)	14.3 (15)	-
Packaged Units	6.7 (8.0)	13.4 (14)	13.4 (14)	13.4 (14)	10.6 (11)

**9.8 EER2 limit for equipment ≥ 15.2 SEER2*

Questions
Comments
Concerns?