



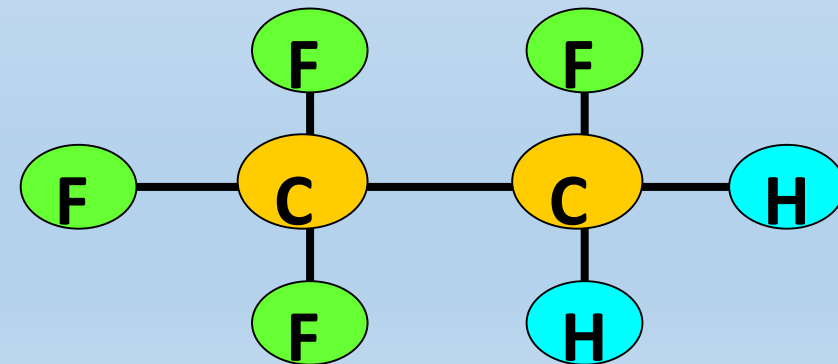
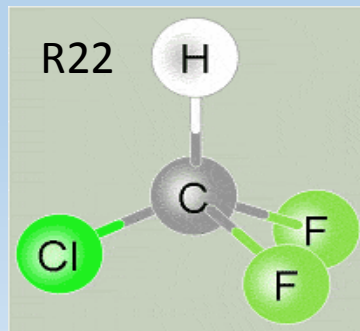
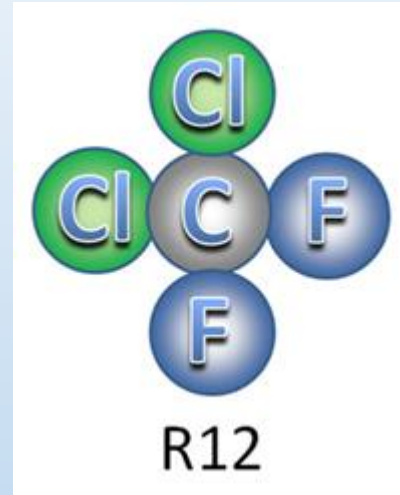
ALTERNATIVES TO HCFC AND THEIR CHARACTERISTICS

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Classes of Refrigerant In Use Today

- Refrigerants are colorless and odorless
- Most refrigerants are composed of or a combination of:
 - Chlorine, fluorine, carbon (CFC)
 - Hydrogen, chlorine, fluorine, carbon (HCFC)
 - Hydrogen, fluorine, carbon (HFC)
 - Hydrogen, carbon (hydrocarbon)
 - Hydrogen, oxygen (CO₂)



HCFCs AND HFCs REFRIGERANTS

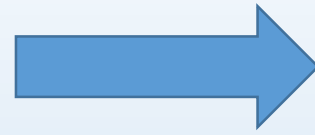
Example of HCFCs: R22, R402a

Example of Pure HFCs: R134a R32

Example of Blends HFCs: R407C, R410A, R404A



HCFC Refrigerant



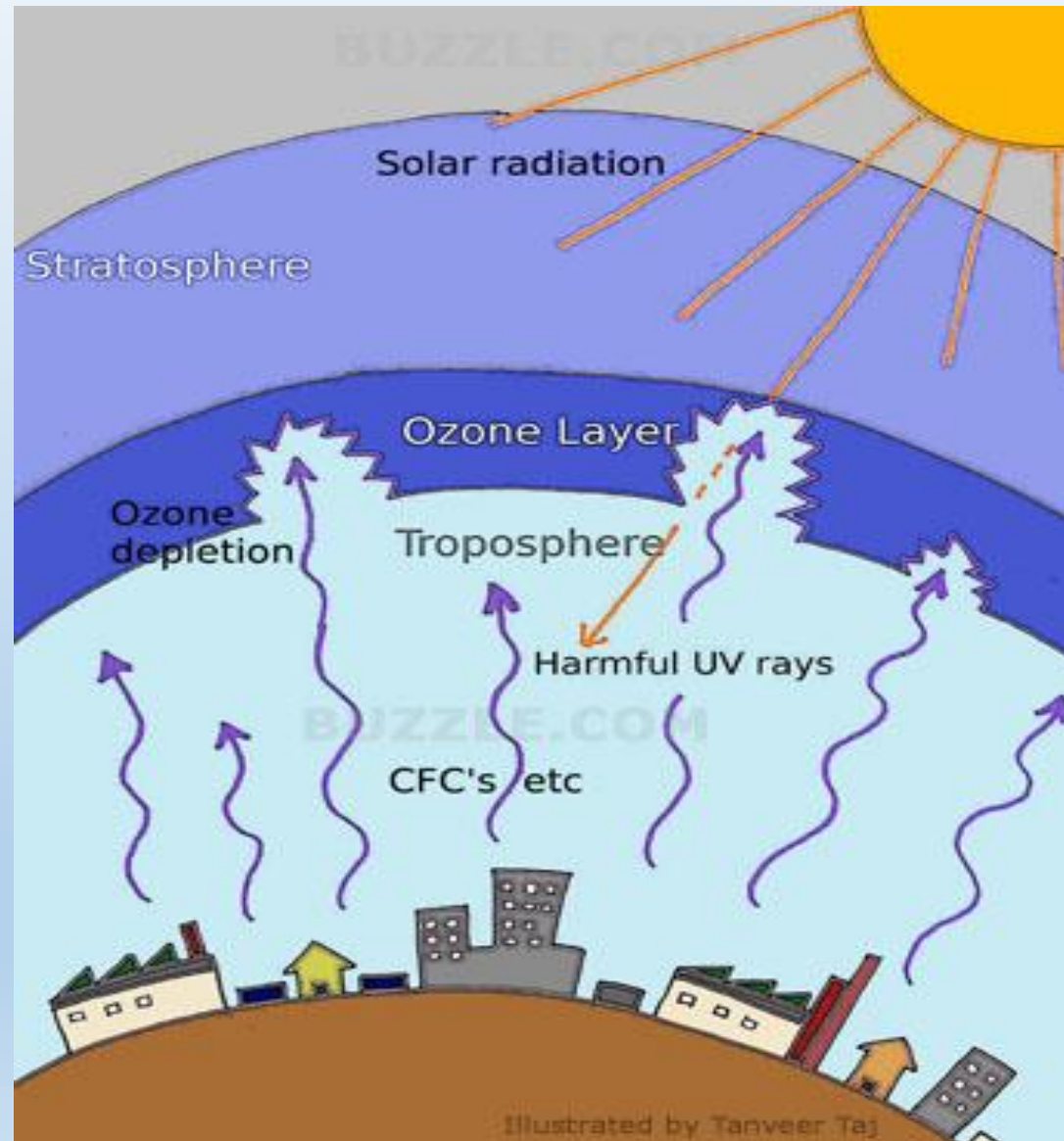
HFC Refrigerant



OTHER COLOUR CODE OF R32 CYLINDER.



Ozone Depletion

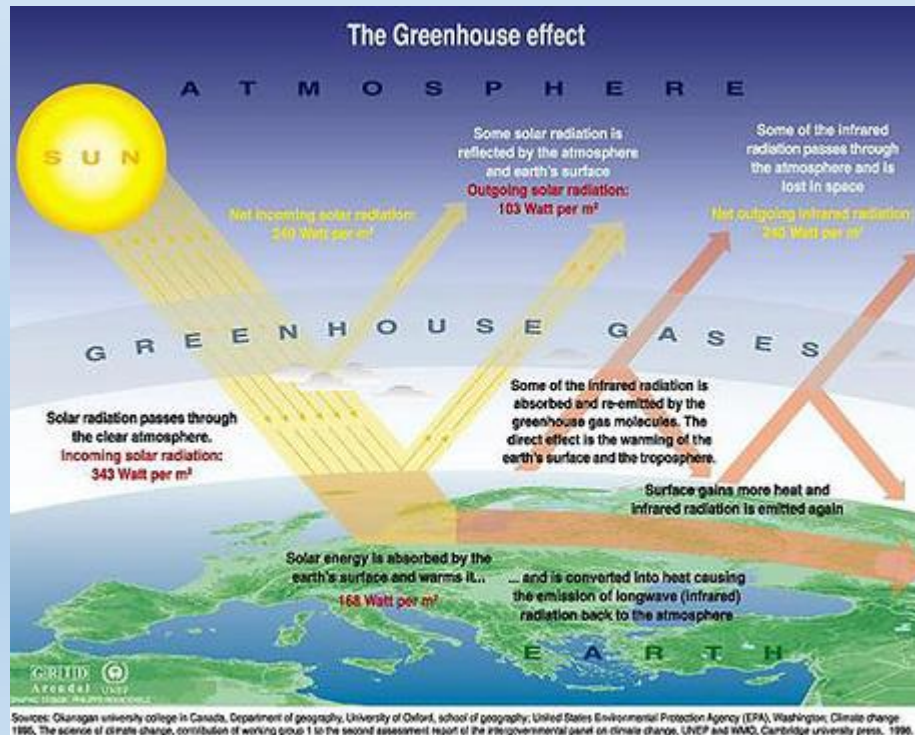


Ozone Depletion Potential (ODP)

- CFC refrigerants have high ozone depletion potentials.
- HCFC refrigerants have lower ozone depletion potentials.
- HFC and HC refrigerants have an ozone depletion potential of zero.

Global Warming

- Also referred to as the greenhouse effect.
- Earth's inability to release heat by radiation back to the atmosphere.



Global Warming Potential (GWP)

- CFC refrigerants have high global warming potentials.
- HCFC & HFC refrigerants have lower global warming potentials..
- HC refrigerants have very low global warming potentials.

Refrigerant Environmental Properties

Refrigerant	Group	Atm. life	ODP	GWP	Class	Typical Uses
R11	CFC	45	1	4750	A1	Centrifugal compressors, large commercial plants
R12	CFC	100	1	10900	A1	Reciprocating comp. small unit & Automobiles
R22	HCFC	11.9	.055	1790	A1	Widely used AC&R
R134a	HFC	13.4	0	1300	A1	Automobiles
R404A	HFC	16	0	3700	A1	Low temp refrigeration
R410A	HFC	16	0	2100	A1	AC equipment
R507A	HFC	130	1	3300	A1	Low temp refrigeration
R717	NH ₃	-	0	<1	B2L	Low temp
R744	CO ₂	-	0	1	A1	Cascade
R290	HC	0.041	0	20	A3	Commercial refrigerator
R600a	HC	0.016	0	20	A3	Domestic refrigerator
R1234yf	HFO	0.029	0	<4.4	A2L	Automobiles

S.O.P : RECOVERY OF REFRIGERANT.

4 way Manifold gauge



CLOSE

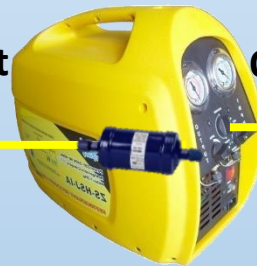
Vapour



Liquid

Input

Output



Recovery Machine

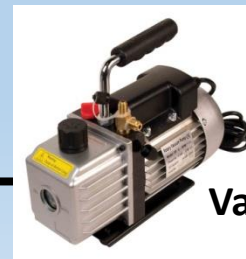
Recovery Tank



Scale



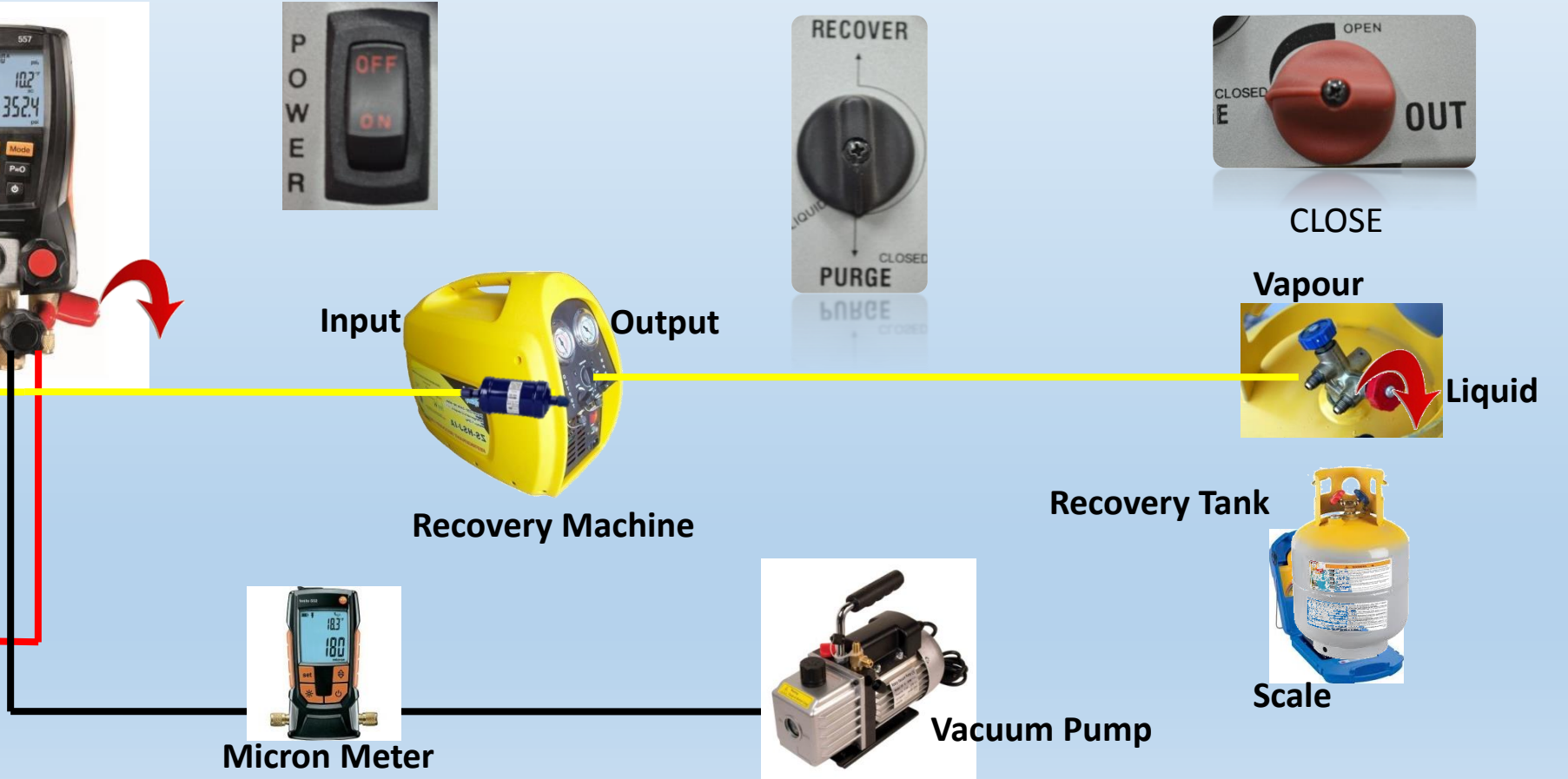
Micron Meter



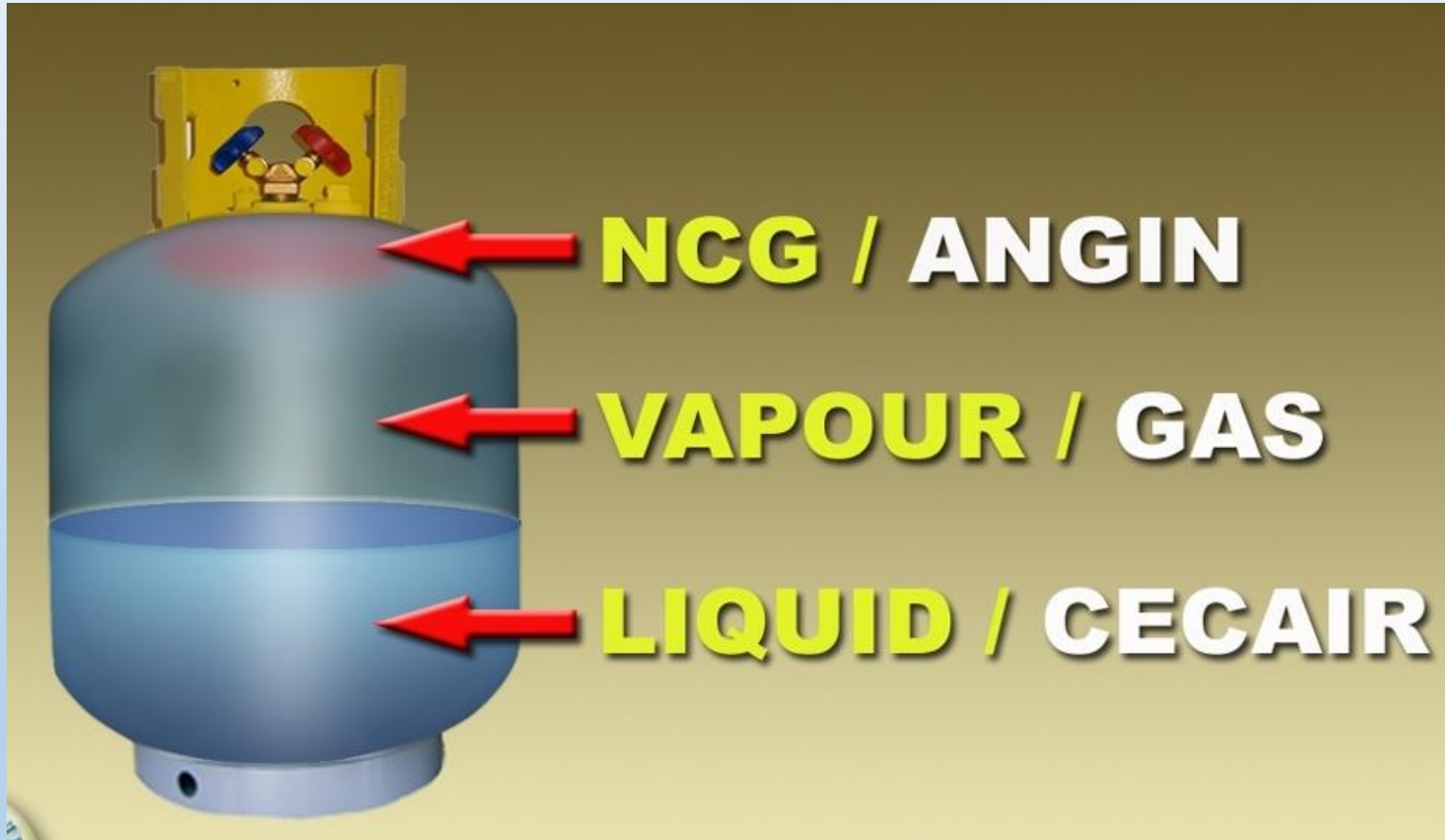
Vacuum Pump



Condenser unit



Refrigerant Air Contamination



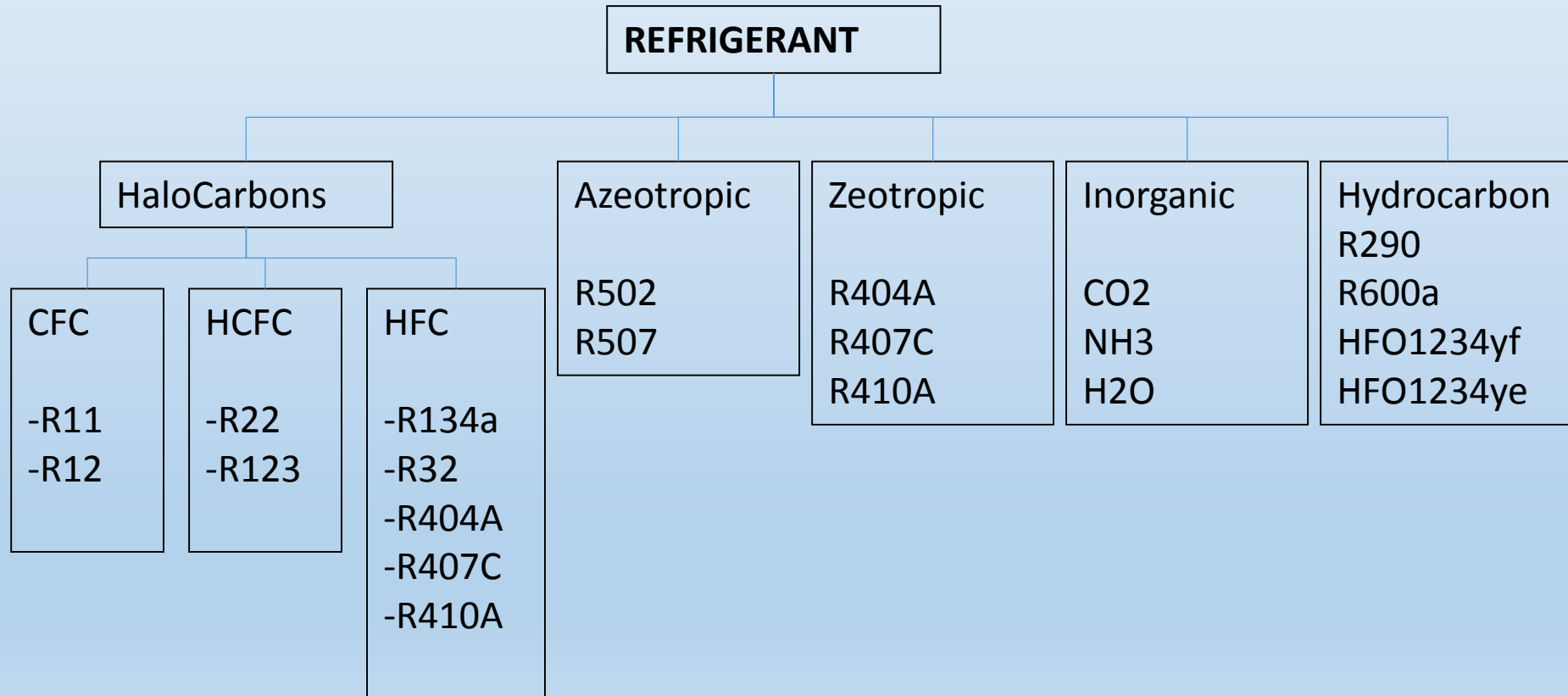
***Removal of Non-condensable gases (air)**

PRESSURE TEMPERATURE CHART

Temperature		R12	R134a	R22	R410A	R407C	R417A
°F	°C						
-15	-26.1	2.4	0.6	13.2	31.7	17.6	12.2
-10	-23.3	4.5	1.9	16.5	36.8	21.3	15.2
-5	-20.6	6.7	4.0	20.1	42.5	25.4	18.5
0	-17.8	9.2	6.5	24.0	48.6	29.9	22.0
5	-15.0	11.8	9.1	28.2	55.2	34.7	25.9
10	-12.2	14.6	11.9	32.8	62.3	39.9	30.0
15	-9.4	17.7	15.0	37.7	70.0	45.6	34.5
20	-6.7	21.0	18.4	43.0	78.3	51.6	39.3
25	-3.9	24.6	22.1	48.8	87.3	58.2	44.5
30	-1.1	28.5	26.1	54.9	96.8	65.2	50.8
35	1.7	32.6	30.4	61.5	107	72.6	56.0
40	4.4	37.0	35.0	68.5	118	80.7	62.4
45	7.2	41.7	40.1	76.0	130	89.2	69.2
50	10.0	46.7	45.5	84.0	142	98.3	76.4
55	12.8	52.0	51.3	92.6	155	108	87.2
60	15.6	57.7	57.5	102	170	118	95.7
65	18.3	63.8	64.1	111	185	129	105
70	21.1	70.2	71.2	121	201	141	114
75	23.9	77.0	78.8	132	217	153	124
80	26.7	84.2	86.8	144	235	166	134
85	29.4	91.8	95.4	156	254	180	146
90	32.2	99.8	104	168	274	195	157
95	35.0	108	114	182	295	210	170
100	37.8	117	124	196	317	226	183
105	40.6	127	135	211	340	243	197
110	43.3	136	147	226	365	261	211
115	46.1	147	159	243	391	280	225
120	48.9	158	171	260	418	300	241
125	51.7	169	185	278	446	321	258
130	54.4	181	199	297	476	342	275
135	57.2	194	214	317	507	365	293
140	60.0	207	229	337	539	389	312
145	62.8	220	246	359	573	-	-
150	65.6	234	263	382	608	-	-

Pressure-Temperature Chart

Types of Refrigerant



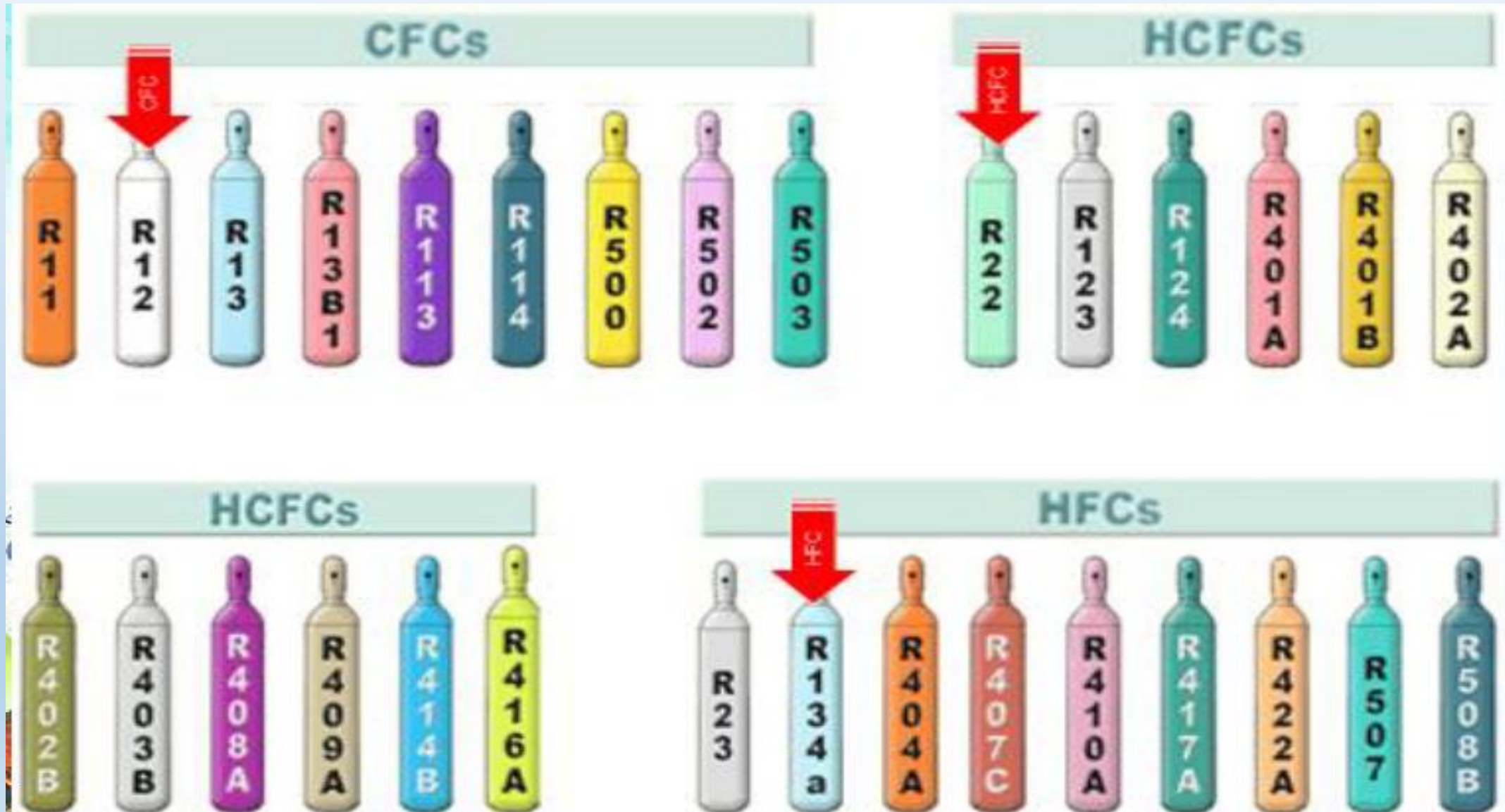
Halocarbon Refrigerant

Halocarbon Refrigerant are all synthetically produced and were developed as the Freon family of refrigerants.

Examples :

- CFC's : R11, R12, R113, R114, R115
- HCFC's : R22, R123
- HFC's : R134a, R32, R404A, R407C, R410A

Halocarbon Refrigerant



Azeotropic Refrigerants

A stable mixture of two or several refrigerants whose vapour and liquid phases retain identical compositions over a wide range of temperatures.

Examples :

- R-500 : 73.8% R12 and 26.2% R152
- R-502 : 8.8% R22 and 51.2% R115
- R-503 : 40.1% R23 and 59.9% R13

Azeotropic Refrigerants

An azeotropic mixture acts like a single component refrigerant over its entire temperature/pressure range. An azeotrope does not have a temperature glide.

➤ Example: R-500, R-502, R-507



Zeotropic Refrigerants

A zeotropic mixture is one whose composition in liquid phase differs to that in vapour phase. Zeotropic refrigerants therefore do not boil at constant temperatures unlike azeotropic refrigerants.

Examples :

- R404A : R125/143a/134a (44%,52%,4%)
- R407C : R32/125/134a (23%, 25%, 52%)
- R410A : R32/125 (50%, 50%)
- R413A : R600a/218/134a (3%, 9%, 88%)

Zeotropic Refrigerant

A blend of two to three different refrigerants and **DO NOT** has specific pressure for each temperature. They exhibit fractionation and temperature glides.

➤ Example: R404A, R407C, R-410A



Introduction to HC's

- HC refrigerants were first used in the late 1800's/early 1900's
- They are naturally occurring
- They have zero ODP and Minimal GWP
- They are compatible with most lubricants
- They are 'more' compatible with materials normally used in the industry
- HC's can reduce/eliminate acids forming

Hydrocarbon Refrigerants

- Good substitutes for CFC's, HCFC's, and HFC's.
- Drop in solution
- Compatible with copper
- A third of original charge only is required when replacing halocarbons refrigerant in existing equipment
- Energy saving : up to 20% due to lower molecular mass and vapour pressure

Drawback :

- Flammable

Hydrocarbon Refrigerants

Many hydrocarbon gases have successfully been used as refrigerants in industrial, commercial and domestic applications.

Examples:

- R170, Ethane, C_2H_6
- R290, Propane C_3H_8
- R600, Butane, C_4H_{10}
- R600a, Isobutane, C_4H_{10}
- HFO1234yf
- Blends of the above Gases



Carbon Dioxide as Refrigerant

- Non Flammable
- Non toxic
- Inexpensive and widely available
- Its high operating pressure provides potential for system size and weight reducing potential.



Drawbacks:

- Operating pressure (high side) : 80 bars
- Low efficiency



Carbon Dioxide (CO₂)



Carbon Dioxide Refrigerants are used in Industrial Refrigeration System and Heat-Pump.

Ammonia – A Natural Refrigerant

NH_3 (Ammonia) has been used as refrigerant for more than a century in industrial and larger refrigeration plants. It has no ozone depletion potential and no direct global warming potential.



Ammonia (NH₃)



Ammonia is environment friendly. It does not cause Ozon Depletion and Global Warming. Ammonia is used in big commercial refrigeration system .

Properties of Ammonia

Concentration (ppm)	Effect
5	Noticeable by smell
25	Irritation noticeable
50	Irritation of nose, mouth and throat; acclimatization after a while
500	Immediate irritation of mucous membranes, respiration difficult
3500	Lethal after a short period of exposure
20000	Causes blisters and chemical burns
Lower explosion limit	16 % by volume in air
Higher explosion limit	25 % by volume in air
Ignition temperature	650 °C
Ignition energy required	0.01 to 1 Joule

Advantages of using Ammonia as Refrigerant

- ODP = 0
- GWP = 0
- Excellent thermodynamic characteristics: small molecular mass, large latent heat, large vapour density and excellent heat transfer characteristics
- High critical temperature (132°C) : highly efficient cycles at high condensing temperatures
- Its smell causes leaks to be detected and fixed before reaching dangerous concentration
- Relatively Low price

Some Drawbacks of Ammonia as Refrigerant

- Toxic
- Flammable (16 – 28% concentration)
- Not compatible with copper
- Temperature on discharge side of compressor is higher compared to other refrigerants



Refrigerant Classification

CLASS A:

Refrigerant with lower toxicity, and with a weighted Threshold Limit Value (TLV) over time higher than 400 ppm.

CLASS B:

Refrigerant with higher toxicity and with weighted Threshold Limit Value (TLV) over time lower than 400 ppm.

How to Evaluate Refrigerants – Safety: Flammability

Consideration on the use of 2L refrigerants classified by ASHRAE 34 and ISO 817

ASHRAE 34: Class 1 = Non flammable, Class 2L Mildly flammable Class 2= Flammable, Class 3 = Highly Flammable

Class 1 (No flame propagation)	Class 2L (Lower flammable with low burning velocity)	Class 2 (Lower flammable with high burning velocity)	Class 3 (Higher flammability)
CO2(R744) R410A R22	HFO 1234yf R32 Ammonia (Toxic)	R152a	Propane (R290)

1. Flammability of Class 2L is similar to ammonia. Consideration is ongoing to clarify the safety requirements to use 2L refrigerants
2. Commercial refrigeration and MAC (wrong use) which employed R290 caused fire accidents in the field
3. ASHRAE 34 recently reclassified R32 & HFO 1234yf down to new Class 2L (Lower flammability, low burning velocity)

Beer cooler incident in Australia

10/19/95, CA: charging while engine was still hot

8/18/96, MS: low pressure hose from evaporator blew off

9/27/96, AR: torch used on truck AC unit after venting refrigerant




Source: US-EPA in Bogota 2008

Propane explosion in a
New Zealand supermarket.



Source: EFCTC newsletter

Fire accidents in case of HC use for cooking & heaters : ave.68/yr, death: ave.1.3/yr (01-06) ;,Source METI Japan

FLAMMABILITY	 3	R-600a(isobutane) R-290(propane)	R-1140 (vinyl chloride)
	 2	HFC-32 HFC-143a HFC-152a	R-717 (Ammonia)
	 2L	HFC-32 (Proposed) HFO-1234yf (Proposed)	
	1	CFC-11 CFC-12 HCFC-22 HFC-125 HFC-134a	HCFC-123
	CATEGORY	A Lower Toxicity	B Higher Toxicity
TOXICITY			
ASHRAE 34 Matrix with some Refrigerant Examples			

Safety precaution - Conversion

- **“Conversion”** = When applying a flammable refrigerant to a system that ordinarily uses a non-flammable refrigerant. A switch from a non-flammable to a flammable refrigerant should be considered in terms of an entire conversion of the equipment, not just a change of refrigerant.
- **“re-fill”, “drop-in” and “retrofit”**. = a non-flammable refrigerant (such as R12) is replaced by another non-flammable refrigerant (such as R134a),

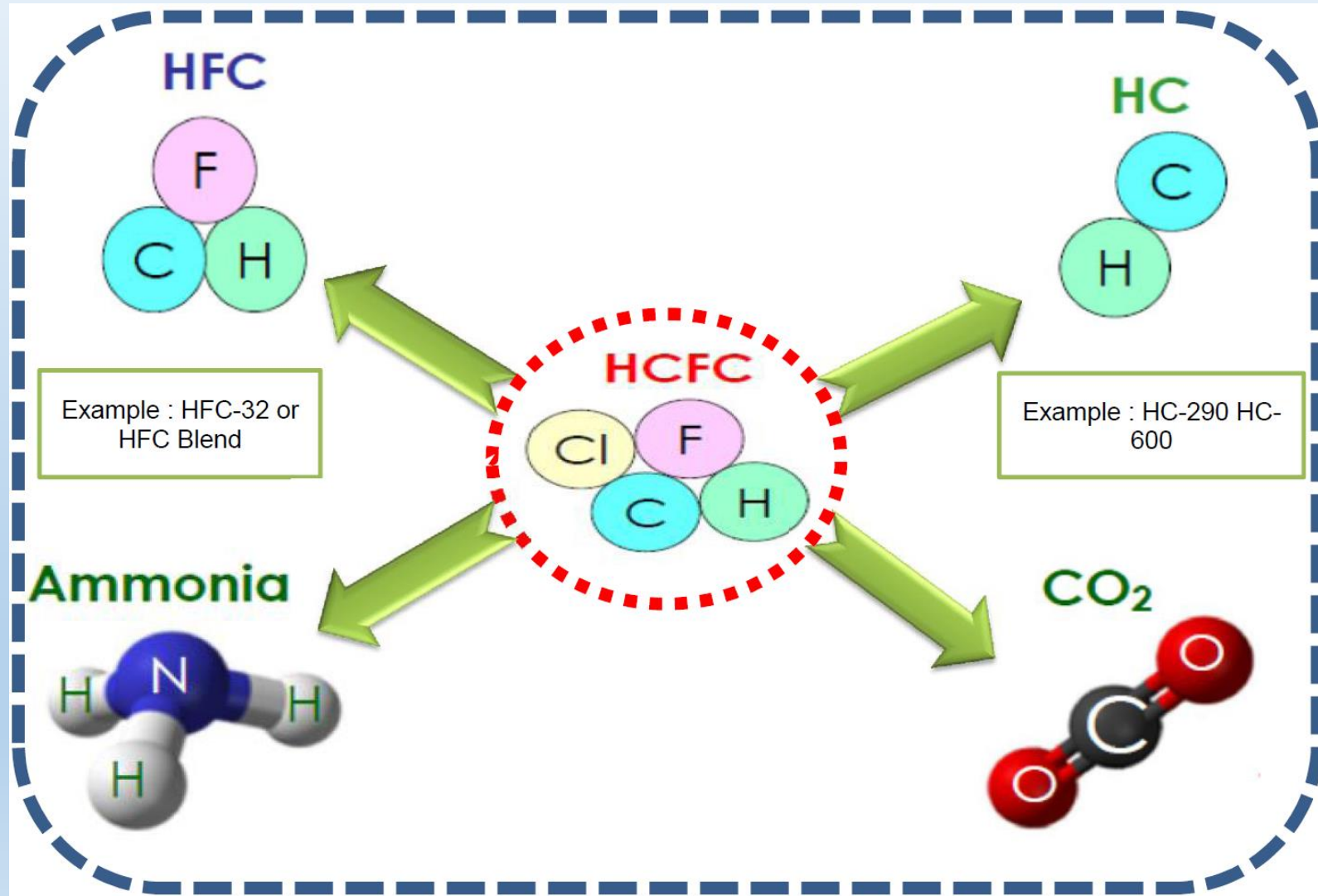
Modifications of Electrical Equipment

- Faulty components.
- Poor, corroded, loose, or dirty electrical connections.
- Missing or broken insulation which could cause arcing/sparks.
- Friction sparks, like a metal fan blade hitting a metal enclosure.
- Modifications must meet local regulations and standards

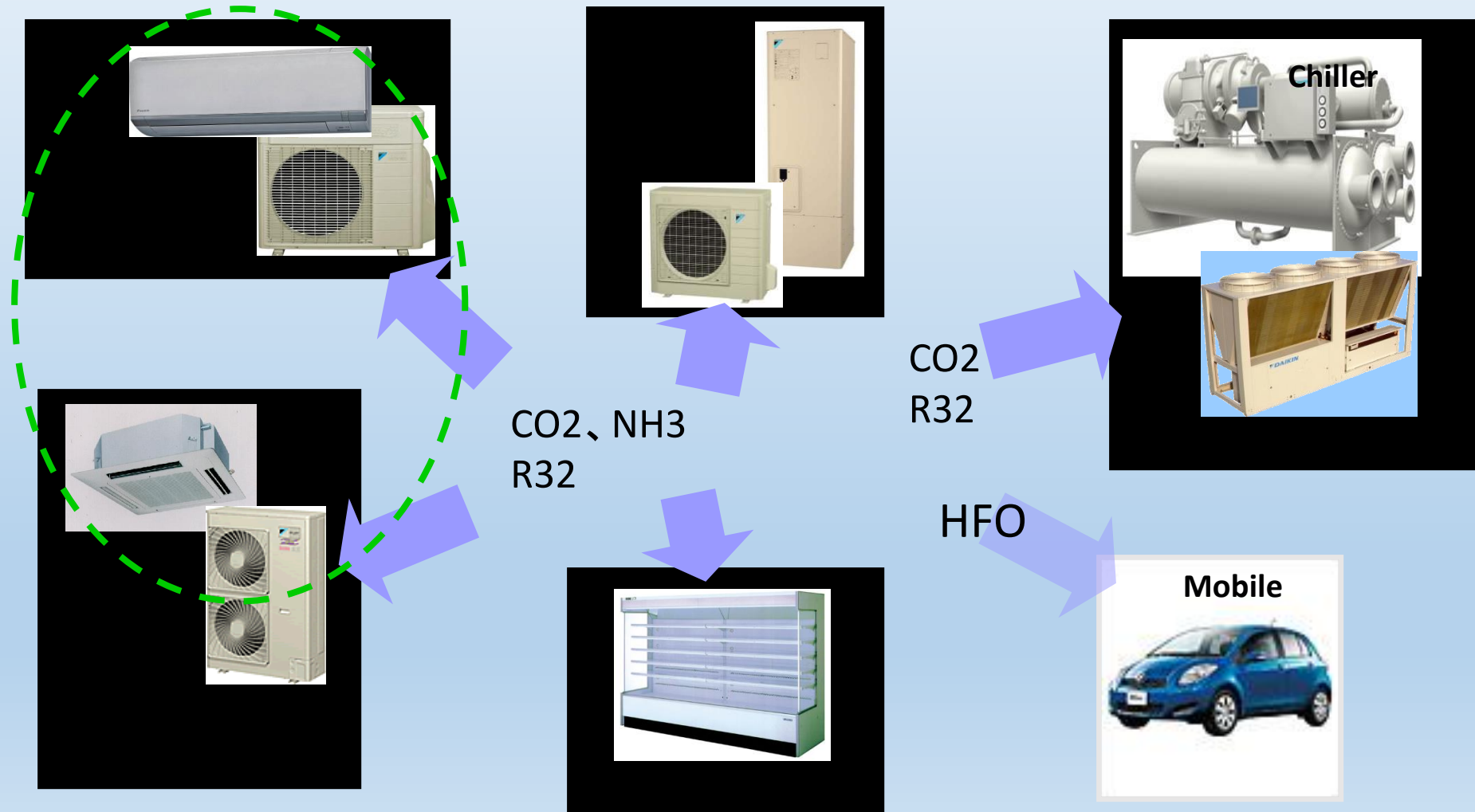
Modifications of Electrical Equipment

- Replaced with solid state equivalents
- Sealed to ensure that any sparks do not come into contact with leaking gas
- Relocated to a position where the component would not come into contact with leaking gas

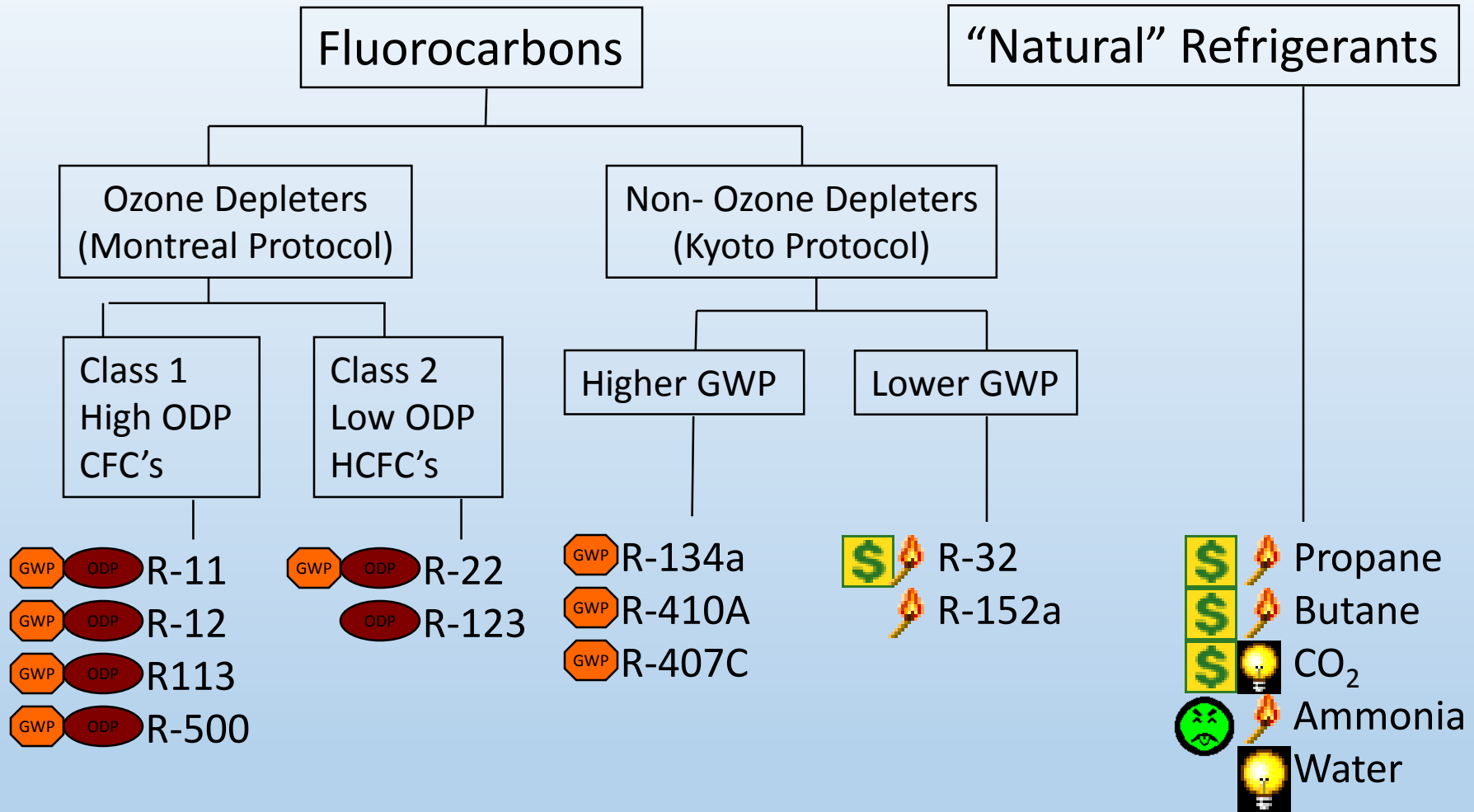
ALTERNATIVES TO HCFCs









ALTERNATIVE OF HCFC IN REFRIGERATION SYSTEM



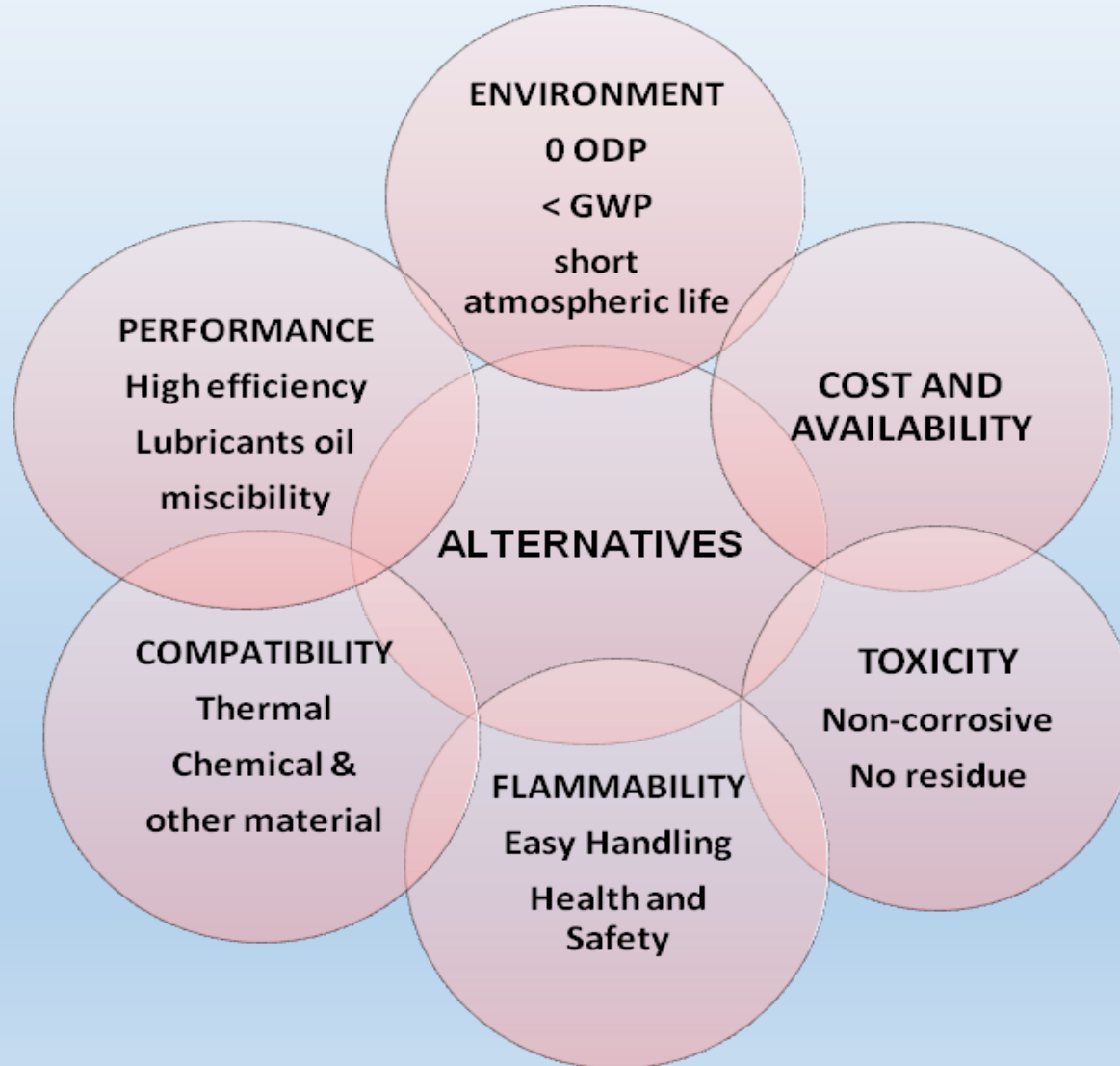
HVAC Refrigerants



 -ODP Concerns
 -GWP Concerns
 - Flammable

 -Toxicity Concerns
 -Efficiency Concerns
 -Cost Concerns

SELECTING THE REFRIGERANT



Conclusion

- Evolving policy is stressing on selecting environment-friendly refrigerants
- Environmental regulations are moving toward low GWP refrigerants
- Energy Efficiency will be encouraged
- Cost and safety remain important

THANK YOU