

REFRIGERANTS

A refrigerant is the working substance in a refrigeration system and is generally a volatile substance which can remain in liquid phase at the evaporator pressure, although gaseous refrigerants may find application if the conditions favour.

Refrigerants can be classified as :

(i) primary

(ii) secondary

#Primary refrigerants include organic substances such as hydrocarbons (HCs), ChloroFluoroCarbons (CFCs), HydroChloroFluoroCarbons (HCFCs), HydroFluoroCarbons (HFCs), brominated compounds, various isomers, azeotropes, zeotropes and unsaturated compounds (like ethylene), and inorganic substances like ammonia, water, carbon-dioxide, sulphur dioxide, etc. CFCs, HCFCs, HFCs and some brominated compounds are derived mainly from the saturated hydrocarbons methane (CH₄) and ethane (C₂H₆) by substituting chlorine/bromine or fluorine in place of hydrogen atoms.

#Secondary refrigerants include brines (calcium chloride, sodium chloride), glycol solutions (ethylene glycol and propylene glycol), water, air and other substances.

*****ASHRAE NAMING*****

#For SATURATED HYDROCARBONS and compounds derived from saturated hydrocarbons with the chemical formula: C_mH_nF_pCl_q

$$n+p+q=2m+2$$

Designation: R(m-1)(n+1)(p).

EXAMPLE: methane (CH₄) is R050 or R50, ethane (C₂H₆) is R170, propane (C₃H₈) is R290, monochlorodifluoromethane or CHClF₂ is R22, dichlorodifluoromethane or CCl₂F₂ is R12, trichloromonofluoromethane or CCl₃F is R11, dichlorotrifluoroethane or CHCl₂CF₃ is R123 or HCFC123, tetrafluoroethane or CH₂FCF₃ is R134a or HFC134a, etc.

Hydrocarbons with the number of hydrogen atoms exceeding 8 result in double digits as in, for example, R(3)(11)(0) for butane C₄H₁₀. To avoid this problem, such hydrocarbons are given arbitrary numbers. For example R600 is normal or n-butane and R600a is isobutane.

#Brominated compounds are designated by adding the number of bromine atoms displacing the chlorine atoms to the designation of the original refrigerant CF₃Br is R13B1, since CF₃Cl is R13.

#Isomers, i.e., compounds with the same chemical formula but with differing molecular structure, are designated by adding the alphabets a, b, c, etc.

#Azeotropes (refrigerant mixtures which behaves like a pure refrigerants, evaporating and condensing at constant pressure/temperature) are designated by 500 series numbers, e.g., R500, R502, R503, R507A, etc.

#Zeotropes (also called Non-azeotropic refrigerant mixtures NARMs or blends NARBs) are refrigerant mixtures which do not behave like a pure refrigerant. When they boil, the more volatile component is released first and when they condense, the higher boiling point component condenses first. Zeotropes are designated by 400 series numbers,

e.g., R401A, R413A, R401B, R410A, R407A, R407B, R407C, R417A, R402A,

#Unsaturated compounds, i.e., compounds with the chemical formula $C_mH_nF_pCl_q$

where $n+p+q=2m$, the designation is 1 prefixed to the usual designation $R(m-1)(n+1)(p)$. Thus ethylene (C_2H_4) is R1150.

#Inorganic substances are designated by writing the molar mass after 7, as in, for example, R717 for ammonia (NH_3), R718 for water (H_2O), R744 for carbon dioxide (CO_2), R764 for sulphur dioxide (SO_2), etc.

IMPORTANT REFRIGERENT AND ITS APPLICATION:

#CFC11 (CCl_3F ; NBP = $23.80^\circ C$): Air-conditioning of large buildings requiring hundreds of kW of refrigerating capacity, industrial process water and brine cooling, with single or multi-stage centrifugal compressors, as a brine in indirect low-temperature systems (down to $-100^\circ C$).

#CFC114 (CCl_2F_2 , NBP= $3.80^\circ C$): Small fridges and drinking water coolers with rotary compressors; air conditioning of buildings, industrial process water and brine cooling with multistage centrifugal compressors.

#CFC12 (CCl_2F_2 , NBP= $-29.80^\circ C$): Automotive AC, household refrigerators, water coolers, ice cream and frozen food cabinets, food locker plants, industrial process water and brine cooling, with reciprocating, rotary and centrifugal compressors.

#R500: R500 is an azeotropic mixture consisting of 73.8% CFC12 and 26.2% HFC152a and is used in medium temperature systems. These systems, if charged with HCFC22, give about 35% higher refrigerating capacity.

#HCFC22 (CHClF₂, NBP = - 40.8oC): Room and central AC, heat pumps, industrial and commercial low temperature systems, with reciprocating and rotary compressors.

#R502: R502 is an azeotropic mixture. Results in good capacity and lower compressor discharge temperature in commercial and low temperature applications with single- and two-stage reciprocating compressors; home freezers, display cases, frozen food and ice cream cabinets, environmental test chambers and heat pumps.

#CFC13 (CClF₃, NBP= -81.4oC) and R503: R503 is an azeotropic mixture .Applications of CFC13 and R503 are industrial very low-temperature cascade systems, with reciprocating or rotary compressors.

!!## NEW & PREVIOUS YEARS PROBLEMS: (#NEW also comes from these above notes only if you follow properly)**

1. Environment friendly refrigerant R134a is used in the new generation domestic refrigerators. Its chemical formula is:

- a) CH ClF_2 (b) $\text{C}_2 \text{Cl}_3 \text{F}_3$ (c) $\text{C}_2 \text{Cl}_2 \text{F}_4$ (d) $\text{C}_2 \text{H}_2 \text{F}_4$

2. Match List-I (Refrigerant) with List-II (Principal application) and select the correct answer using the codes given below the lists:

List-I

A. Air

B. Ammonia

C. Carbon dioxide

D. Refrigerant-11

List-II

1. Direct contact freezing of food

2. Centrifugal compressor system

3. Large industrial temperature installation

4. Automotive air-conditioners

5. Aircraft refrigeration

Codes: A B C D

(a) 3 4 1 2

(c) 2 4 3 5

A B C D

(b) 5 3 1 2

(d) 5 3 2 1

3. In conventional refrigerants what is the element responsible for ozone depletion?

(a) Chlorine

(b) Fluorine

(c) Carbon

(d) Hydrogen

4. Match List-I (Refrigerant) with List-II (Chemical constituent) and select the correct answer using the codes given below the lists:

List-I

A. R-12

B. R-22

C. R-717

D. R-113

List-II

1. Trichlorotrifluoroethane ($\text{CCl}_2\text{FCClF}_2$)

2. Difluoro monochloro methane (CHF_2Cl)

3. Ammonia (NH_3)

4. Difluoro dichloro methane (CCl_2F_2)

Codes: A B C D

(a) 3 2 4 1

(c) 3 1 4 2

A B C D

(b) 4 2 3 1

(d) 4 1 3 2