FDE 447
COLD PRESERVATION TECHNOLOGY

Content

Components of mechanical compression system- **Refrigerants**

WHAT IS REFRIGERANT?

- Refrigerant is the fluid used for heat transfer in a refrigerating system that absorbs heat during evaporation from the region of low temperature and pressure, and releases heat during condensation at a region of higher temperature and pressure.

CLASSIFICATION REFRIGERANTS

Primary refrigerants

Secondary refrigerants

Properties of primary refrigerants

Primary refrigerants should have certain properties:

1) Physical properties
   * Boiling and condensing temperatures and pressures
   * Freezing temperature, critical temperature and outlet temperature
   * Specific heat and latent heat
   * Compression ratio
   * Density and viscosity
2) Chemical properties
   * Toxicity
   * Combustion and explosion
   * Smell
   * Fat and water soluble

Properties of primary refrigerants

- It should have low condensing pressure.
- The latent heat of evaporation should be high.
- It should not be chemically active. It should not affect the installation material, should not be corrosive, and should not change the properties of the lubricating oil.
- It should not be flammable, explosive and poisonous.
- It should be of a feature that allows the leak to be easily detected.
- It should be cheap.
- It should have high thermal conductivity.

Classification of primary refrigerants

- Halo-carbon refrigerant
- Hydro-carbon refrigerant
- Inorganic refrigerant
- Azeotrope refrigerant

Halocarbon refrigerants

- Halocarbon refrigerants are all synthetically produced and were developed as the Freon family of refrigerants.
- They are fluorocarbons of methane and ethane series
- They contain 1 or more of these halogens (chlorine, bromine, fluorine)
- Non-toxic, non-flammable, non-explosive, non-corrosive, non-irritant to human body and eyes.
- Odourless, colourless
- Will not react with food product stored in the refrigerated space.
- Will not react with lubricating oil.
- Has excellent thermodynamic properties
- Only disadvantage is ozone layer is damaged.

Examples:

* CFC's: R11, R12, R113, R114, R115 Chlorofluorocarbons
* HCFC's: R22, R123 Hydrochlorofluorocarbons
* HFC's: R134a, R404a, R407C, R410a Hydrofluorocarbons

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Hydrocarbon refrigerants

Hydrocarbon refrigerants	No.	Chemical name	Formula
	R170	Ethane	C_2H_6
	R290	Propan	C_3H_8
	R600	**Butane**	**C4H10**
	R600a	**Isobutane,**	**C4H10**
	Blends of the above gases		

Inorganic refrigerants

	No.	Chemical name	Formula
Inorganics	717	Ammonia	NH_3
	718	Water	H_2O
	729	Air	-
	744	Carbon dioxide	CO_2
	764	Sulphur dioxide	SO_2

Ammonia (NH_3) R-717

- Used for commercial purposes. Mainly in cold stored and ice plants.
- The boiling temperature of NH3 at atmospheric pressure is -33°C and melting point from solid is -78°C.
- The low boiling points makes it possible to have refrigeration considerably below 0°C without using pressure below atmospheric in the evaporator.
- Its latent heat of vaporization at -15°C is 1315 kJ/kg
- It is colorless gas with a sharp pungent smell.
- Has good thermodynamic properties.
- It is neutral to all metals, highly soluble in oil.
- Volatile and non toxic but in higher concentration.

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Sulphur dioxide (SO_2)

- Previously used in houshold refrigerators.
- Toxic, non-explosive and non-flammable, non-corrosive
- Irritant to human body
- Non mixable with oil
- Has pungent odour and low latent heat value.

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SECONDARY REFRIGERANTS

- Ethylene glycol
- Propylene glycol Calcium chloride (29.5%,-51.1°C) much preferred and expensive
- Sodium chloride (23%, -21.6°C)

DESIGNATION OF REFRIGERANTS:

- Since a large number of refrigerants have been developed over the yeaars for a wide variety of applications, a numbering system has been adopted to designate various refrigerants.
- From the number one can get some useful information about the type of refrigerant, its chemical composition, molecular weight etc.
- All the refrigerants are designated by «R» followed by a unique number.

FULLY SATURATED, HALOGENATED COMPOUNDS

- These refrigerants are derivatives of alkanes (C_nH_{2n+2}) such as methane (CH4), ethane (C2H6).
- These refrigerants are designated by R XYZ, where:
- X-1 indicates the number of Carbon (C) atoms
- Y+1 indicates number of Hydrogen (H) atoms
- Z indicates number of Fluorine (F) atoms
- Only 2 digits indicates that the value of X is zero

Ex: R22 ($CHClF_2$)	R134 (C2H2F4)
X= 1-1 = 0	X= 2-1= 1
Y= 1+1= 2	Y= 2+1=3
Z= 2	Z= 4

2) INORGANIC REFRIGERANTS

- These are designated by number 7 followed by molecular weight of the refrigerant.
- Ex: Ammonia (NH3): Molecular weight is 17.
- The designation is R 717

Carbon dioxide (CO2): Molecular weight is 44.

The designation is R 744

Water (H2O): Molecular weigt is 18.

The designation is R 718

Physical characteristics of refrigerants

- Boiling and condensing temperature and pressures
- Freezing temperature
- Critical temperature
- Discharge temperature
- Latent heat of vapourisation
- Specific heat
- Density
- Viscosity

Environmental and safety properties

- At present the environment friendliness of the refrigerant is a major factor in deciding the usefulness of a particular refrigerant. The important environmental and safety properties are:
- a) Ozone Depletion Potential (ODP): According to the Montreal protocol, the ODP of refrigerants should be zero, i.e., they should be non-ozone depleting substances. Refrigerants having non-zero ODP have either already been phased-out (e.g. R 11, R 12) or will be phased-out in near-future(e.g. R22). Since ODP depends mainly on the presence of chlorine or bromine in the molecules, refrigerants having either chlorine (i.e., CFCs and HCFCs) or bromine cannot be used under the new regulations

Environmental Effects of Refrigerants

Global warming :

Refrigerants directly contributing to global warming when released to the atmosphere

Indirect contribution based on the energy consumption of among others the compressors (CO_2 produced by power stations)

Environmental and safety properties

- b) Global Warming Potential (GWP): Refrigerants should have as low a GWP value as possible to minimize the problem of global warming. Refrigerants with zero ODP but a high value of GWP (e.g. R134a) are likely to be regulated in future.
- c) Total Equivalent Warming Index (TEWI): The factor TEWI considers both direct (due to release into atmosphere) and indirect (through energy consumption) contributions of refrigerants to global warming. Naturally, refrigerants with as a low a value of TEWI are preferable from global warming point of view.

Environmental and safety properties

- e) Flammability: The refrigerants should preferably be non-flammable and non-explosive. For flammable refrigerants special precautions should be taken to avoid accidents.
- f) Chemical stability: The refrigerants should be chemically stable as long as they are inside the refrigeration system.
- g) Compatibility with common materials of construction (both metals and non-metals)
- h) Miscibility with lubricating oils: Oil separators have to be used if the refrigerant is not miscible with lubricating oil (e.g. ammonia). Refrigerants that are completely miscible with oils are easier to handle(R12).

Environmental and safety properties

- Ease of leak detection: In the event of leakage of refrigerant from the system, it should be easy to detect the leaks.

Ozone Depletion

The health and environmental concerns caused by the breakdown of the ozone layer include:

- Increase in skin cancers
- Suppression of the human immune response system
- Increase in cataracts
- Damage to crops
- Damage to aquatic organisms
- Increase in global warming