Desirable Properties of Refrigerants

Properties of Refrigerants

Refrigerants are widely used in Refrigeration cycle where cooling effect below the atmospheric temperatures are needed. Whenever we choose them for particular use Properties of Refrigerants also plays a vital role in economic and environmental friendly application. Here are some of the desirable properties of refrigerant explained in detail.

Physical Properties of Refrigerants

Low Freezing Point
Refrigerants should have low freezing point than the normal operating conditions. It should not freeze during application. Water for example cannot be used below 0 Deg C.

Low Condensing Pressure
The lower the condenser pressure the power required for compression will be lower. Higher condenser pressure will result in high operating costs. Refrigerants with low boiling points will have high condenser pressure and high vapor density. The condenser tubes have to be designed for higher pressures which also give raise to capital cost of the equipment.
If Boiling Point is Low, High Condenser Pressure – Reciprocating Compressor is used. Eg: Ammonia, R22, R12 etc
If Boiling Point is High, Low Condenser Pressure – Centrifugal Compressor is used. Eg: R11, R13 & R114 etc

High Evaporator Pressure
This is the most important property of refrigerant. In a negative pressure evaporator Atmospheric air or Moisture will Leak into the system. The moisture inside the system will starts freezing at low temperature zones and clogs and chokes the system.
Atmospheric air ingress into the system will occupy the heat transfer area and results in poor heat transfer rates. Presence of air will reduce the partial pressure of refrigerant and the condensation temperature will rise. It increasers the condenser pressures and thereby the power consumption for the compressor will also rise.
Atmospheric air ingress inside the system may sometime results in explosions if the flammability values of the refrigerants are in wide range.
Due to the above disadvantages, Positive evaporator pressure is preferred. Leak outside the system results in refrigerant loss and it can be identified easily and refrigerant loss can be topped up. Moderately high evaporator pressure boosts the compressor suction pressure thus reduces the power costs.
High Critical Pressure
Critical pressure of the refrigerant should be higher than the condenser pressures. Otherwise the zone of condensation decreases and the heat rejection occurs.

High Vapor Density
Refrigerants with high vapor density/low specific volume will require a smaller compressor and velocity can be kept small and so the condenser tubes used will also be in smaller diameter.

High Dielectric Strength
In hermetically sealed compressors refrigerant vapor contacts with motor windings and may cause short circuits. Therefore dielectric strength should be high to avoid short circuits.

High Latent Heat of Vaporization
Higher latent heat of vaporization of the refrigerant will result in lower mass flow rates according to the Heat transfer equation. If the mass flow is very small it is difficult to control the flow rates. Therefore ammonia cannot be used for small refrigeration systems.

High Heat Transfer Coefficient
Higher heat transfer coefficient requires smaller area and lower pressure drop. This makes the equipments compact and reduced the operating cost.

Chemical Properties
Toxicity
Toxicity is the important properties of refrigerants. The refrigerants should be non poisonous to humans and food stuff. The toxicity depends upon the concentration and exposure limits.
**Oil Solubility**
The lubricating oils must be soluble in Refrigerants. If the oil is not miscible in the refrigerant used and it is heavier it will settle down in the evaporator and reduces the heat transfer. Therefore oil separators are to be employed. If the oil density is less than the refrigerant used and if it is immiscible, the oil will float on the surface of the refrigerant. Therefore overflow drain is to be provided to remove oil. If the refrigerant velocity is not sufficient, then it cannot carry all oil back into the compressor. It may accumulate in evaporator. This phenomenon is called Oil logging.

**Low Water Solubility**
Most of the refrigerants form acids or bases in the presence of water. This will cause corrosion and deteriorates valves, Seals and Metallic parts. Insulation of windings in hermatic compressors will also get damaged. The free water apart from the dissolved water in refrigerant freezes below 0 Deg C and chokes the narrow orifice of expansion valve. This may also cause bursting of the tubes.

**Reactivity**
The refrigerants should not react with the materials used in refrigeration cycle like evaporators, condenser tubes, compressors, control valves etc. Ammonia reacts with Copper and Cuprous alloys and forms copper complexes. CH₂Cl reacts with Aluminium. Most of the refrigerants form acids with water. CCl₂F₂, CH₂Cl can form HCL with water which dissolves the copper from condenser tubes and deposits them on compressor pistons and deteriorates the life of the machinery.

**Environmental Effects of Refrigerants**

**Leakage Detection**
Ammonia and SO₂ can be detected by their characteristic smell. Strong smelling chemicals like acrolein may be added to refrigerant for easy leak detection.
Freon leak can be detected by a halide torch. It consists of an alcohol lamp that emits a blue flame. If Freon is present blue flame turns into green. This test is based on Beilstein Test for Chlorine.
Ammonium Hydroxide Solution turns the red litmus paper into blue; thereby condenser tube leaks can be identified.
SO₂ can be detected with NH₃ H₂O Solution. It makes white fumes of ammonium sulfide.
Electronic detectors, Ultrasonic leak detectors may also be used to detect the leaks.

**Flammability**
The refrigerant should not make combustion mixture in Air. Freon, Carbon Dioxide, SO₂ are non flammable. Methane, butane and other hydrocarbons are flammable. Ammonia will form explosive mixture when the concentration in air is between 16 to 25 %.

**ODP**
The ozone depletion potential (ODP) of a refrigerant is the relative amount of depletion to the ozone layer it can cause. ODP of R11 is fixed as the maximum value of 1.0. R-22 for example, has an ODP of 0.055.
GWP
Global Warming Potential (GWP) is a relative measure of how much heat a refrigerant traps in the atmosphere. GWP of Carbon Dioxide is 1.0. For Methane GWP is 72, it means that if the same mass of CH₄ and CO₂ were introduced into the atmosphere, that methane will trap 72 times more heat than the carbon dioxide. It is normally mentioned as 20 years or 100 years period.

STEL
Short Term Exposure Limit is the maximum concentration to which one can be exposed up to maximum of 15 minutes.

TWA
Time weighted Average is the concentration to which repeated eight hour exposures for five days in a week which is considered to be safe.

Economics of Refrigerants

Cost of refrigerants
The quantity of refrigerant used in any industry is very small. Therefore cost of the refrigerants is normally high when compared to other chemicals. Similarly if it is very low industry professional will not take necessary action to control the leaks.

Availability
Refrigerants should be readily available near the usage point. It must be sourced and procured within a short span of time to enable the user in case of leaks, maintenance schedules etc.

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