**DEPARTMENT OF AEROSPACE ENGINEERING**

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**UNIT III - CRYOGENIC ENGINEERING**

## CATEGORIES OF INSULATION MATERIALS

Insulation materials may be categorized (Turner and Malloy, 1981) into one of five major types 1) Cellular, 2) Fibrous, 3) Flake, 4) Granular, and 5) Reflective.

- Cellular insulations are composed of small individual cells either interconnecting or sealed from each other to form a cellular structure. Glass, plastics, and rubber may comprise the base material and a variety of foaming agents are used.

- Cellular insulations are often further classified as either open cell or closed cell Generally, materials that have greater than 90% closed cell content are considered to be closed cell material

- Fibrous insulations are composed of small diameter fibers that finely divide the air space. The fibers may be organic or inorganic and they are normally held together by a binde

- Flake insulations are composed of small particles or flakes which finely divide the air space. These flakes may or may not be bonded together. Vermiculite, or expanded mica, is flake insulation

- Granular insulations are composed of small nodules that contain voids or hollow spaces. These materials are sometimes considered open cell materials since gases can be transferred between the individual spaces. Calcium silicate and molded perlite insulations are considered granular insulation. Spray Foam Insulation The Spray Foam System is developed to improve insulation efficiency, minimize maintenance and reduce application time. Our Spray Foam System is based on a long experience from working with polyurethane foam for LPG, LEG and LNG

## TYPES OF INSULATIONS

1. expanded foams,
2. gas-filled powders and fibrous material,
3. vacuum alone,

(1) Expanded-foam insulations.

Expanded-foam insulations have cellular structure formed by evolving gas during the manufacture of the foam. some examples of foam insulation include polyurethane foam, polystyrene foam, rubber silica, and glass foam. The thermal conductivity of the foam insulations depends upon the gas used to foam the insulation plus a contribution due to internal radiant heat transfer and solid condition

(2) Gas-filled powders and fibrous insulations

. Porous insulations include fiber glass, powdered cork, perlite, Santocel, rock wool, and Vermiculite. The primary mechanism for insulation in gas-filled powders and fibrous materials is the reduction or elimination of convection due to the small size of the voids within the material. in addition, for the case of very fine powders, the distance between the powder particles may become smaller than the mean free path of the gas within the insulation

(3) Vacuum insulation Vacuum insulation

alone is used extensively for small laboratory-size Dewars. The use of vacuum insulation essentially eliminates two components of heat transfer solid conduction and gaseous convection. Heat is transferred across the annular space of a vacuum-insulated vessel by radiation from the hot outer jacket to the cold inner vessel and by gaseous conduction through the residual gas within the annular space. In addition to the heat transferred by radiation, energy is transmitted by gaseous conduction through the residual gas in the vacuum space. If the pressure of the gas is low enough that the mean free path of the gas molecules is greater than the distance between the two surfaces, the type of conduction differs from the usual continuum-type conduction at ambient pressure.


## IMPORTANT PROPERTIES OF CRYOGENIC INSULATION

Thermal conductivity (k) the value of thermal conductivity should be as low as possible. The value of thermal), type and structure of particles and pores, conductivity depends on various factors. i.e. temperature (T), density (moisture content and the type of gas contained in pores. The value of thermal conductivity increases with increase All rights Reserved 15 temperature and moisture content. Material of lower thermal conductivity (k) permits the use of lower thickness for a given heat leak. Also, it reduces the external surface area of the insulated system. Which ultimately reduce the material cost as well as heat in- leak.

Moisture permeability This is very important parameter in cryogenic engineering as high moisture permeability can ruin the thermal conductivity of the insulation. i.e., increase of moisture permeability to 10% from dry state in perlite doubles the thermal conductivity of perlite

**Co-efficient of linear expansion:** A lower thermal co-efficient of linear expansion reduces shrinkages and cracking of the insulating material during cooling.

**Specific heat:** The specific heat of all solids decreases with temperature and tends to zero at 0 k. since most cryogenic insulation have a finely dispersed structure, they are capable of absorbing large amount of air at low temperature. The heat evolved by adsorption raises the apparent specific heat of the material. The quantity of heat adsorbed depends on the structure of the material and the gas pressure.

**Cost factor:** After considering other technical properties the cost cannot be ignored. The cost factor consideration is to calculate the payback period for profit through cold conservation and proportionate investment cost. For example, pay -back period for foam

**Advantages**

Insulation System

- The risk of voids in the insulation iseliminated by the spray method
- No joints in the foam, hence increasedtightness
- Increased insulation efficiency
- Complete bonding to all surfaces
- No space for moisture accumulation
- Excellent corrosion protection