2.2 INSULATINGMATERIALS

Definition: An insulation material is one that provides thermal insulation, or the reduction of heat transfer between objects.

Requirements

- ✓ High insulation resistance to avoid leakage current.
- ✓ High dielectric strength to avoid electrical breakdown of the cable.
- ✓ High mechanical strength to withstand the mechanical handling of cables.
- ✓ Non-hygroscopic i.e., it should not absorb moisture from air or soil. The moisture tends to decrease the insulation resistance and hastens the breakdown of the cable.
- ✓ Non-inflammable.
- ✓ Low cost so as to make the underground system a viable proposition.
- ✓ Unaffected by acids and alkalies to avoid any chemical action.

2.2.1 GLASS

Glass is an amorphous, hard brittle, transparent or translucent, super-coolant obtained, by fusing a mixture of a number of metallic silicates. Most commonly silicates of Na, Ca and Pb are used it possesses no sharp melting point, crystalline structure and definite formula, Glass may be represented as $xR_2O.yMO.6SiO_2$,

Where , R = monovalent alkali metals like Na, K

M = Divalent metals like Ca, Pb, Zn etc, x & y = whole numbers

Approximate composition of ordinary glass (Soda lime glass) is $Na_2O.CaO.6SiO_2$

In some glasses SiO_2, may be replaced by Al_2O_3. B_2O, P_2O_5, etc.

2.2.2 General Properties of Glass

- ✓ It is amorphous
- ✓ It has no definite melting point.
- ✓ It is very brittle
- ✓ It softens on heating
- ✓ It can absorb, reflect or transmit light
- ✓ It is a good electrical insulator
- ✓ It is affected by alkalis
- ✓ It is not affected by air, water or acids or chemical reagents, but soluble in HF, which converts its silica into SiF_4
- ✓ Since it has no crystalline structure, no slippage between planes can occur. It possesses high compressive strength.
- ✓ It is light, because it has homogeneous internal structure similar to liquids.

2.2.3 Manufacture of Glass

Manufactureofglassinvolvesthefollowing4steps

1. Melting

The raw materials, in proper proportions, (eg, sand, soda ash and lime stone for commonglass) are mixed and finely powdered. The homogeneous mixture (known as

Batch) is fused withsome broken glass, called "Cullet" in the pot (or) tank of the tank furnace, in which beating is donebyburning producesgasandairmixtureoverthecharge.

The culler melts at a comparatively low temperature and assists in melting the rest of thecharge. During melting the following series of reactions occurleading to theformationof various silicates.

$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2\uparrow$

$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2\uparrow$

2. Working of molten glass

The molten glass is then worked into articles of desired shapes by either blowing or moulding or pressing between rollers

3. Annealing

Glass articles are then allowed to cool gradually to room temperature (sudden cooling must beavoided, because cracking occurs). The longer the annealing period, the better is the quality of theglass.

4. Finishing

The glass articles, after annealing period, are subjected to finishing process such as cleaning, polishing, cutting, sand-blasting, etc.

2.2.4 Types of Glasses

1. Soda-lime(or)Soft glass

Raw Materials: Silica (sand), Calcium carbonate and soda ash. **Composition**: The approximate composition is $Na_2O.CaO.6SiO_2$ **Properties:**

- ✓ They are low cost.
- ✓ It is resistant to water.
- ✓ It is attacked by common reagents like acids.

Uses

They are used as window glasses, electric bulbs, bottles, plate-glasses, jars, cheaper table wares, where high temperature-resistance and chemical stability are not required.

2. Lead glass or flint glass

Raw Materials: Lead oxide (instead of calcium oxide) and Silica are fused.

For dense optical glasses, as much as 80% of PbO is incorporated. In addition, K_2O is used, instead of sodium oxide.

Composition: The approximate composition is $K_2O.PbO.6SiO_2$

Properties:

(i) It is bright, lustrous and possesses high specific gravity (3 to 3.3).

(ii) It is more expensive to manufacture, than the ordinary lime-soda glass.

(iii) It has a lower softening temperature than soda-glass.

(iv) It has higher refractive-index and excellent electrical properties.

Uses

(i) Lead glasses are used for high-quality table wares, neon sign tubings, optical purposes (like lenses, etc), electrical insulators.

(ii) High lead content glasses are used for extra-dense optical glasses for windows and shields to protect personal from X-rays and gamma-rays in medical and atomic energy fields respectively.

3. Potash lime or hard glass

Raw Materials: Silica (sand), Calcium carbonate and Potassium carbonate.

Composition: The approximate composition is $K_2O.CaO.6SiO_2$

Properties

(i) Potash-lime possess high melting point, so, it will not fuse easily.

(ii) It is less acted upon by acids, alkali and other solvents than ordinary glasses.

Uses

(i) These glasses are used for manufacturing combustion tubes, chemical apparatus, etc,

(ii) Boro Silicate glass (or) Pyrex glass or Jena glass

Raw Materials: Silica, boron with a small amount of alumina and some oxides.

Composition: A typical formula for the glass is SiO_2 (80.5%), B_20_3(13%), Al_2O_3 (3%), K_2O (3%) and Na_2O (0.5%)

Properties

(i) The substitution of alkali (Na_2O) and basic alkaline earth oxides (CaO) of the soda glasses by boron and aluminium oxides results in a low thermal coefficient of expansion and high chemical resistance.

(ii) It possesses very high softening points and excellent resistivity (shock proof).

Uses:

It is used in industry for pipelines for corrosive liquids, gauge glasses, superior laboratory apparatus, kitchen wares, television tubes, chemical plants, electrical insulators, etc.

5. Alumino Silicate glass

Raw Material: It contains 5% or more of alumina. Addition of alumina makes the glass heat resistant.

Composition: The composition of this glass is SiO_2 (55%), Al_2O, (23%), B_2O, (7%), MgO (9%), CaO (5%), $Na_2O + K_20$ (1%)

Properties

They possess exceptionally high softening temperatures.

Uses

They are used in high-pressure mercury discharge tubes, chemical combustion tubes, certain domestic equipments, etc..

6. Optical (or) Crookes glass

Raw material: Contain phosphorus and lead silicate together with a small amount of cerium oxide. Cerium oxide is capable of absorbing UV light (which is injurious to eyes).

Properties

(i) Optical glasses have low melting-points and are relatively soft.

(ii) Chemical-resistance and durability of optical glasses are lower than those of ordinary glasses.

Uses

Optical glasses are used for making lenses.

7. Quartz glasses

Raw Material: Crystalline silica. It is fused at 1900°C under vacuum.

Properties

Quartz glasses possess outstanding resistance to thermal shock and chemicals.

Uses

They are used in the manufacture of special lab ware, crucibles, reaction tubes etc..

8. Opal glasses

Raw Material: NaF (or) CaF, (or) $Ca_3(PO_4)_2$ (or) SnO_2

Properties

They are translucent white or milky glasses. They are transparent, when they are in liquid, but becomes opalescent, when they are cooled, because of inclusions.

9. Glass Wool

Glass wool is a fibrous wool-like material, composed of intermingled fine threads (or) filaments of glass. They are completely alkali free.

The glass filaments are obtained by forcing molten glass through small orifices. The average diameter of the orifice is 0.0005 to 0.007 min. Then the filaments, so obtained, are thrown over a rapidly rotating drum to get wool-like materials.

Properties

(i) It is a very good fire-proof and heat proof material.

(ii) Its electrical conductivity and thermal conductivity is low.

(iii) It is a resistant to water and most chemicals.

(iv) Its tensile strength is about eight times that of steel.

Uses

(i) It is used for heat-insulation purposes eg, in domestic and industrial appliances like oven, motors, vacuum-cleaners, insulation of metal pipelines, walls and roofs of houses.

(ii) It is used for electrical and sound insulation

(iii) It is used in filtration of corrosive liquids like acids.

(iv) It is also used for manufacturing fibre-glass, by blending with plastic resins.