Electrical Engg. Material

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Introduction

The materials which are used for storing of electrical energy are classified as dielectric materials. Dielectric materials are essentialy insulating materials. the material to be used as dielectric must have properites some of which may not be answered by a materials ordinary used as an insulating material.

Dielectric Constant or Permiativity

two insulated conducting plates forming a capacitor having air gap in between them. the value of a capacitance be Co we can put a piece of another dielectric, say glass, is introduced in the space between the two plates. then we obsered that the value of the capacitance increase. the charging capacity it is obvious that the charge storing capacity of the condenser increase when an air is replaced by another dielectric.

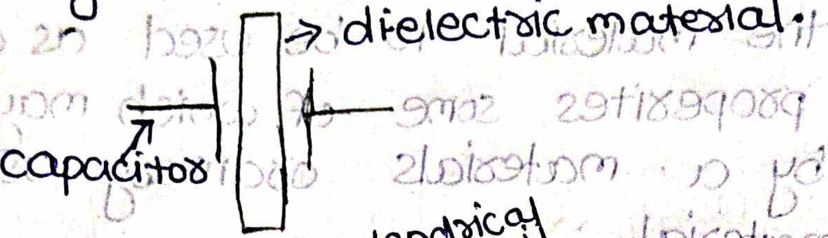
The ratio of the capacitance using a material as the dielectric to the capacitance when air is substituted for the material is called the permittivity or dielectric constant of that material.

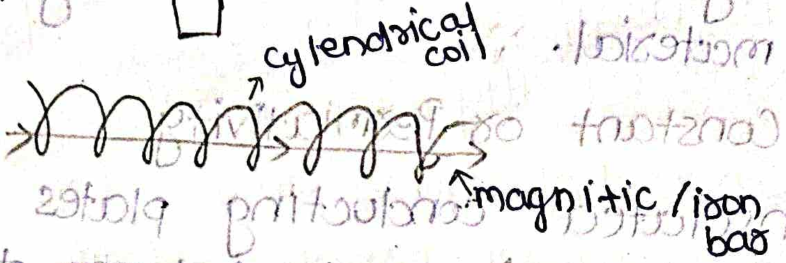
Permittivities of dielectric other than air are more than 1.

Permitivity of a dielectric is analogous to permeability of a magenetic material. consider the case of an air-cored solenoid. when a voltage is applied across the solenoid it will set up a certain amount to Polex due to the current flowing through the solenoid. If a piece of magnetic material is introduced or placed inside the solenid oil, the amount of flux set up increase.

Note⇒ A cylindirical coil of wire acting as a magnet when carrying electric current that is called solenid.

like that in the case of a capacitor the value of the capacitance increases as the permiability of the path for electric flux increase by introducing an appropriate dielectric.





when a magnetic material or iron bar is placed inside the solenoid an additional amount of flux is setup because of the orientation of the magnetic dipoles in the magnetic material.

Magnetisation :-
A magnetic material is said to be magnetized when its magnetic dipoles get oriented in parti-cular direction in the influence of an externally applied magnetic field. This process is called magnetisation.

Magnetic Matrial
↓
Magnetized
↓
Magneticdipole in particular direction
↓
External applied Magnetic Field.

Permeability of magnetic material is different for different magnetic materials. like that Permittivity is also different for different dielectric.

Important points of polarization:-

→ The degree of polarization in case of electronic polarization largely depend upon the density of the material.

→ Gasous dielectric have very little electronic polarization due to their extremely low density.

→ In many dielectric the molecules of dielectric possess an electric dipole moment even in the absence of an external electric field.

→ So that the mole have positive and negative charges displaced with respect to each other and form a dipole.

→ the stronge the feild, the greater will be the number of dipoles pointing in the direction of the feild.

→ whether the molecules of an dielectric are non-polar or polar, the net effect of an external field on the dielectric is the same.

→ the result of polarization said that the presence of electric feild the dipole line up in the direction of the applied feild.

→ Negative charges apper on the surface of the dielectric facing positive plate.

→ Positive charges apper on the surface of the dielectric facing negative plate.

So the electric field which will induced within the dielectric due to polarization will be in oppsite direction to the applied field.

the field is opposite to main field due to votage applied across the two plates. so the resultant field weakend.

As the field is weakend. the potential different appering across the plates will be reduced.

when the plates are connected across a battery more charge will be stored in the capacitor.

Di-electric loss :-

In case of electronic polarization the electrons charge very less / little displacement and remain with in the limits as of their atom or ions.

Electronic polarization \ setup for small time.

Electron displacement is the type of polarization is elastic in nature.

when polarization Field is with drawn removed the electrons to their original position

- All the energy absorved in selling up the Electric Field which was responsible for ionic polarization e.g. the energy required for changing a capacitor is completely released on its discharge. while the electric Feild collapse.

- In case of polar dielectric the orientation of dipole in the electric Field is not a pure elastic displace-ment process.

→ In individual overcoming of certain internal Friction Force on which certain amount of energy is expanded.

So, lame amount of energy is irreversible and wasted as heat in the dielectric.

This wastege of energy is known as dielectric loss.

Application of Dielectric:-

→ The Function of a dielectric is to store energy.

→ There are various type of capacitor avilable in market they are generally:-

Classified → according to the kind of dielectric used in them.

(i) capacitor that use vaccum, air or other gasses as dielectric.

(ii) capacitor in which the dielectric is a meneral oil.

(iii) capacitor which is combination of solid and liqued Di-electric losses, → paper, Glass, mica, meneral oil silicon.

the dielectric losses in vaccum air and other gasian dielectric are very small such capacitor are use in radio Frequency ckt and in low Frequency measuring ckt.

capacitor, using oil as a dielectric are use in were a large value of capacitor is required.

Mica a solid dielectric is used in making standers capacitor for laboratories because it dielectric constant Doesnot change with temp. veriation and with time.

Electro lighting Capacitor:- (450V, 1000uF)

→ Electro lighting capacitor are fixed value capacitor they are polarised divies with high capacitience; normally used for bi-pass coupling and motor starting application.

→ Tantalum oxide in comparision to Aluminium oxide is more suitable in electro lighting capacitor but it is costlyer. Boric acid is also used in electro lighting capacitor.

→ This capacitor are used of the high capacitance type and have high value of dielectric constant.

→ The capacitor which all electro light have capacitance of 3×10^5 uF the value of dielectric constant for Aluminium oxide is 7 and Tatalum oxide is 11.

Electrical conductivity of dielectric and their break down:-

Gaseous Di-electric:-

→ Air is most commonly used gasous di-electric the primary constituents of air are nitrogen and oxygen.

→ The natural ionization gives rise to equal number of free electrons and positive charge appearing at the same time.

→ Natural ionizing factors are unable to ionize all the air molecules because ionization of new molecule is counter-balanced by recombination of previously formed ion whenever the continues random thermal motion of the gas particles brings ion close enough to a free electron.

→ Free electron will move towards the positive plate where as the positive ions will attracted towards to the negative plate.

→ If the applied electric field is very mild the random motion of the free charge will be predominant over their directed motion due to the applied field.
So, in weak electric field, the leakage current will be negligible.

→ If the voltage applied is increased ~~function~~ further the free charge will acquire sufficient energy to knock out electrons from other neutral atom by collision.

→ Each newly free electron gets accelerated to a very high speed due to the applied electric field and this is turns knocks out an electron from other gas atom and ionizes them, the process is known as ionization.

→ due to ionazation by collision the number of free charge increase in geometric progressive and strength of leakage current increase.

Liquid Di-electric:-

All liquid di-electric
↓
easily get contaminated
↓
hydroscopic liquide
↓
All these contaminant give rise to conductivity.
↓
impurity conductivity.

→ The basic molecules of a liquid dielectric get dissocited under the infulence of an electric field
∴ Dissociation of molecule cause conductivity.

→ Neutral molocule are less capable of Dissociation than polar mole-cule. that is why dielectric having low values of permitivity have low conductivity.

And dielectric having high value of permittivity show considerable conductivity.

- Contaminants in liquid dielectrics can increase the conductivity under the action of an applied electric field.

when the dielectric is placed in an electric field the contaminants be come electrically charged and may act a current carrier.

→ A breakdown in a contaminated liquid dielectric may occur due to the formation of conductive bridge between the electrode by the contaminents drawn into the enter-electrode space by the applied electric feild.

→ There may be breakdown of the di-electric through the bridge thus formed at of the place where breakdown occurs. Some amount of heat will be produced which will result in convention flow of the liquid di-electric. this will break any bridge and dielectric strength will restore.

But after some time another conducting will be formed causing break down again.

→ uncontaminated liquid can not formed conducting bridge. Break down of uncontaminat liquid dielectric is caused due to the ionization of the gases of present in the liquid.

→ Applied electric field ionizes the gas present in di-electric and places in a di-electric where the gas exists to electric field intensity increases.

Solid dielectric :-

→ electrical condutivity of solid di-electric also depends upon the presence of various contaminats or impurity.

→ In most di-electric these impurities dissociate to form ions and free electrons than the di-electric containing them.

→ In low temperature the voloume of electrical conductivity of solid dielectric wholly due to the impurities.

→ In increased temperature the magnitude of leakage current depend upon the contribution of free ions of the basic dielectric to electric conduction.

→ Break down in solid dielectric either electro thermal or electrical depending upon prevailing conditions.

→ Electro thermal breakdown is caused by destructions of the dielectric due to heating produced by dielectric losses.

→ solid di-electric are poor conductors of heat. Dielectric loss in these dielectric increases very sharply with increase in temperature.

→ If heat generated not conducted away rapidly through the dielectric then there will be thermal breakdown of dielectric occur.

Voltage applied
↓
Dielectric do not Radiate
↓
heat generated due to dielectric loss.

→ If applied voltage is kept for long period the material will be melted so short circuit of electrode occures.

Insulating Material

→ Any material that is able to insulate to prevent the flow of electricity through it when a potential difference applied across it that is called insulator.

→ The electric wiring which are use for general purpose comprises conductor made of copper and aluminium and insulating covering of some sort of plastic rubber or some sort of varnished cotton or cambric tape, electric iron comprises high resistance conducting wire. For heat generation

→ mica or abestos insulation to prevent flow of current in the outer body of the carbon.

→ The electric fan comprises a single phase motor having winding on the stator made of copper conductor in that case varnishe cotton or cambric covering as insulation.

→ In overhead conductor the streets. For a distribution of electricity comprise aluminium or steel cored aluminium as conductor and air between the conductor as working as insulator.

→ there are important factor which must be consider while selecting a insulating material. these factors are i- ease of fabrication
ii- availability.
iii - cost.

Various propertie of insulating material is secondly the most powerful tool while tackling the problem of section of a right material.

The different properties are
- i- Electrical properties
- ii- visual "
- iii- Mechanical "
- iv- Thermal properties
- v- Chemical "
- vi- ageing properties.

→ Every application imposes its own demand as regard the priority given to the different properties.

→ The Top most priority properties are electrical and mechinacal properties.

→ The primary function of insulating material is to insulate the electricity but to a acomplish in any practical application it has to discharge other function like mechanical function and the function of heat transfer.

→ Properties like thermal ablity, chemical resistance, mastuse resistance and ageing also important depending on the specific Engineering application.

~~Introduction~~ → The charge of the insulating material:
It must have high dielectric strength the material is highly resistive for preventing the flow of likeage current from the conductor to earth.

→

→ The material is non corros and free from impurity.
→ The electrical propertie of material should not be affected by temperature.

→ This is a property by which matrial resists flow of electric current.
→ when subject to electrical pressure there will be a very little flow of current is presence.
→ An insulator to which a voltage 'v' is applied will have a small current (I) flowing through it.
→ The insulation resistance (R) is said to be

$R = \frac{V}{I}$

Insulation Resistance are two type
i = Voloume R.
ii = Surface R.

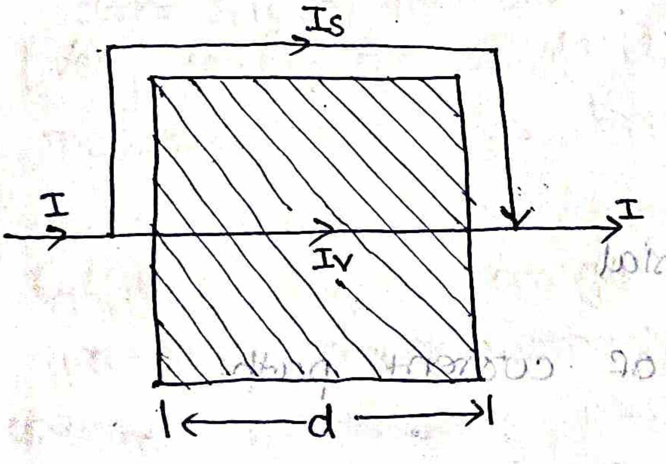


Fig-01
(Volome R.)

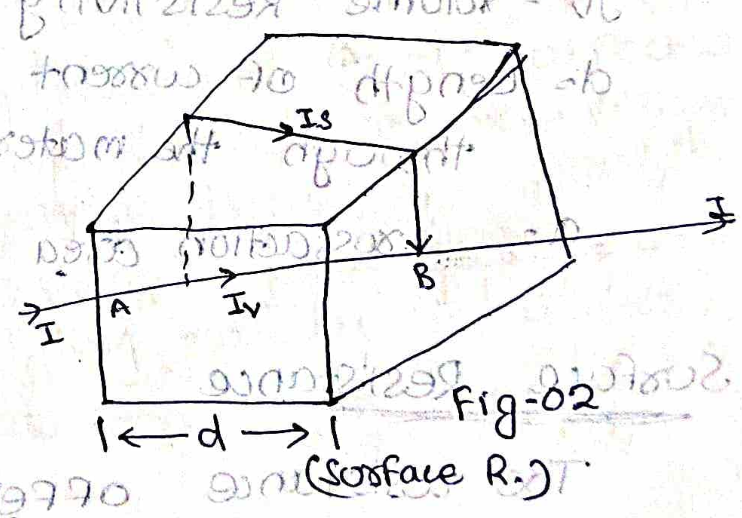


Fig-02
(Surface R.)

If a potential difference is applied across the faces 'a' and 'b', A current will flow this current is lightly two take a path which straight through the material and around the material over the surface.

→ The current that flows right through the material is denoted by Iv.

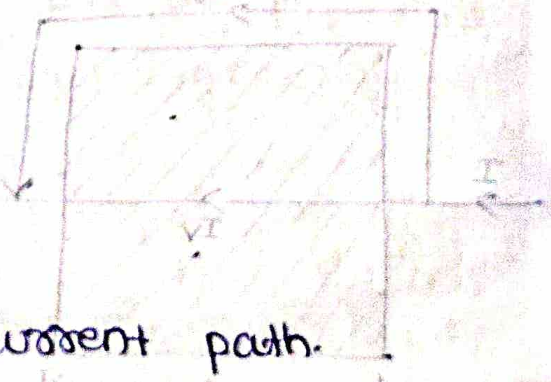
→ The current that flows over the surface is denoted by Is.

→ The possibility of current Is flowing over the surface of material is due to the presence of moisture or other atmospheric or surrounding impurities

Volume resistance

It is offered to current Iv which flows through the material, is called volume resistance for a cube of unit dimensions & this is called volume resistivity. this resistivity is the resistance offered to the flow of current through the body of the material. and that is expressed as resistivity of a conducting material. So the volume resistance of an insulating material expressed as

$$R_v = \rho_v \cdot \frac{d}{a}$$



ρ_v = Volume Resistivity

d = Length of current through the material

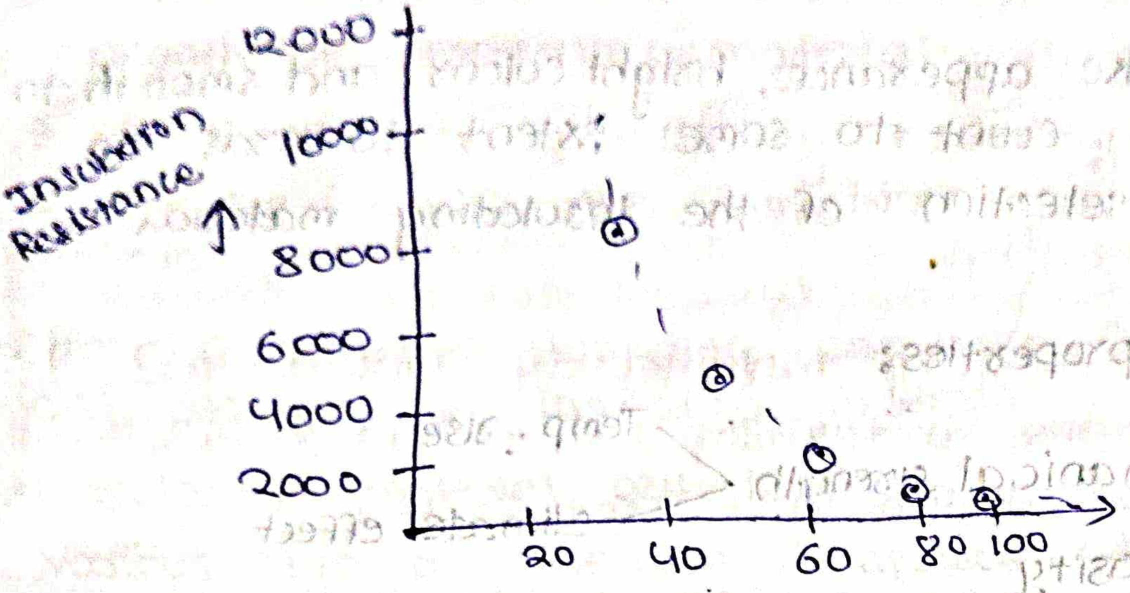
a = crossection area of current path.

Surface Resistance

The resistance offered to current Is which flows over the surface of the Insulating material. is called surface resistance.

surface resistivety depend upon the humidity.

Affects of various Factors :-



Variation of Insulation resistance with temp. for oil. Impegnated paper Insulation.

1- Insulation resistance is very much affected by temp. varition.

2> in application where the insulation is exposed to atmo sphere this factor beome very important as it is very important as it is found to be one major reason for breakdown.

3. The value of insulation resistance is also affected by the applied voltage and to a small extent by the direction in which the voltage is applied.

4. The resistance of insulating material decrease with age so ageing of insulating material is a factor which contributes towards the life of apparatus in which it is used.

Ex> life span of underground cable is 40 to 60 years.

visula properties of insulating materials are
→appearance
• colour
• crystallinity

→ factors like apperance, bright colour, and smooth to mat surface count to some extent towards the coustomer selection of the Insulating material.

Mechanical properties:

a. mechanical strength < Temp. rise / climate effect
b. visosity
c. porosity
d. solubility
e. Machinability and Mouldability.

Mechanical Strength :-

Most of the solid Insulator have to withstand various loads during manufacture as well as, during operation when it use in equipment.

Ex→ strings of suspanded porcelain insulator. have to bear a good amount of load, rotor winding of motors and generator have to bear centrifugal force of revolving rotors, plugs and socket for domestic application have to withstand repeated operation.

The mehanical strength of insulating material depends upon Temp. rise and climate effect.

a. Temp. rise - Temp. rises as a result of heat generation in the conductor and the dielectric loss in the insulator.

→ High Temp. can also effect the mechanical strength of insulating material.

→ so when we are selecting insulating material we must consider the temp. rise properties of the material.

b. Climatic affect - Humidity can also affect mechanical strength of insulating material.

→ Insulating material are likely to to be subjected to various type of mechanical stresses which are tension, compression, resistance to absorbtion, tear, shear and impact.

Viscocity.

viscocity in liquid dielectric affect manufacturing process.

Ex → In paper insulated cable the temp. at which the oil will penitrated through paper will depend on its viscocity.

The method to be use to purify the insulating oil usein transformer and other application will depend on the viscocity of the oil.

Porosity :-

High porosity insulating material are the mousture holding capacity and it also affet the electrical propertiey.

But in some application porcity is advantage and desirable as for when pape will to ~~our~~ impregnata oil.

Solubility

In certain applications insulation can be applyed only after it is dessilvdd in some solven.

In such cases the insulating material should be Soloubie in certain appropreate solvents.

Some insulation should not dissolve and be washed out in fluids it comes in contact with during operation.

if the insulating material is soloubie in water than moisture in the atmosphere will always be able to remove the applied insulation and caused break down

Machinability and mouldability:-

These properties are impotaint form the point of view of economy mass production.

Thermal properties:-

if the under ground cable are under operation than these cables are recomandad for operation with certain limitation. of voltage and current.

suppose voltage is increase if it involved insulating material is able to with stand the higher voltage stress, the cange will cause increase of dielectric losses that will increase heat generation. so the temp. of insulation will increase. so that insulator startes lossing its insulating properties ultimately break dow will occur.

If the I_c will increase in the cable, increase I^2R losses will Increase, it results once again increase heat generat-ion and also failure occur.

i. The voltage rating and up to what safe limit the voltage can be raised and for hom much period without breakdown. it will stay.

ii. loading and over loading current limitations.
iii. Ambient temp. and maximum temp an insulation can with stand

Temp. affect such diverse and important properties and as electrical properties mechanical pro., hardness, viscosity, solubility

Dielectric Losses :-

when a perfect insulation is subjected to alternating voltage it is like applying alternating voltage to a perfect capacitor.

In such a case There is no consumption of power. only vaccum and purified gasses takesplace in that capacitor.

There is a definite amount of dissipation of energy when an insulator is subjected to alternating voltage. that dissipation of energy is called dielectric loss.

Factor affecting dielectric loss.

i. The loss increases as increasing with the frequency of applied voltage.
ii. presence of humidity increases the loss.
iii. Temperature rise normally increase the loss.
iv. voltage increase causes increased dielectric loss.

* dielectric loss is an engineering problem involving heat generation and heat dissipation.
* every application of insulation requirs proper understanding of the blance between the two factor.

Melting point, flash point, volability.

melting point assumes importance in some cases like non-draining compound impregnated paper insulated cables.

flash point will impose restriction in many factoring process to avoid possible hazards of apparatus catching fire.

volatility assumes importance from the fact that when a trapped gas is evolved from a volatile insulating material subjected to voltage stress the break down is very rappid. so a volatile material cannot be a good insulator.

* Thermal Conductivity :-

→ Heat generated due to I^2R losses and dielectric losses will be dissipated through the insulator itself.

> How effectively this flow of heat takes place, depend on the thermal conductivity of the insulator.

→ An insulator with better thermal conductivity will not allow temp rise because of effective heat transfer through it to the atmosphere.

> This property assumes grate importance in high voltage apparatus where thickness of the insulator is more.

* Thermal expansion :-

→ A insulator whith high coefficient of expansion poses problem.

> when there are two insulating material involved to form an insulation system. different coefficient of Expansion of the two material will increase.

This will be measus causes of the insulation causes of breakdown.

→ Thermal expansion is an significant important where heavy current are involved.

*** Heat Resistance :-**

→ This is the property where desire that a dielectric should withstand temp. variation with in desirable limits, without damaging in others impotance properties.

→ Heat resistance also defind as how much heat a insulating material cand sustaind with out any break down.

Chemical properties

Chemical Resistance

→ Presence of gases, water, acids, alkalis and salts affect different insulator differently.

→ Chemically a material is a better insulator if it resists chemical action

→ plastics have replaced paper insulation. In many application because of the former being chemicaly inert and groscopic.

→ chemical resistance requirment of insulations used in underground cable which are likely to operate under severe. chemical condition due to water, salt, acids or alkali will be more demanding.

→ In high voltage installastions "ozone" resistance assumes great importance because of richness of the ozone

Hygroscopicity :-

→ Many insulator comes in contacts with atmosphere either during manufacture or operation or both.

→ The contact of insulation with atmosphere is often complet that the less chemically aggrassive atmosphere can prove a . the smooth running of apparatus.

→ Moisture due to high humidity atmosphere can affect a insulator in two ways.

i- it acts on the surface of insulation.

ii- It may be absorbed by the insulation.

→ There are insulating material like paraffins, polythene, polytetra-flouroethylen which are non hygrosopic.

Effect of contact with other Materials :-

→ insulation remains invariable in contact with different types of material like air, gases, moisture, conducting material etc.

→ the conducting materials have little effect due to contact with the insulation.

→ Some time. rubber contact with copper when chemical action take place. to avoid the chemical action a couting on of the applied to copper be fore pouting on the rubber insulation.

→ In capacitor using synthic ~~capacitting~~ insulating oil, the oil react with the inner wall of the tank causing iron particles to mix with the oil. This can adversely affect the insulating properties of the oil.

Ageing :- Ageing is the long time effect of
i - heat
ii - chemical action
iii - voltage application

These factor decide the natural life of an insulator

Class	Maximum working Temperature	Materials or combination of Materials
Y	90°C	cotton, silk, paper, press board, wood pvc with or without plasticizers vulcanized natural rubber etc.
A	105°C	Cotton, silk and paper when impregnated or immersed in a liquid dielectric such as oil.
E	120°C	Materials possesing a degree of thermal stability allowing them to be operated at temp. 15°C higher than class A materials.
B	130°C	Mica, glassfiber abestoes, etc.. with suitable bonding substance
F.	155°C	Mica, glass fibre, absestoes, etc; with, suitable bonding substance as well as other materials not necessarily inorganic, which by expirience or accepted at 155°C.
H.	180°C	Material such as silicon elastomer and combinations of materials such as mica glass fiber, abestoe etc. with suitable bonding substance such as appropriate silicon resins.
C.	above 180°C	Mica, porcelin, glass and quartz with or without an inorganic binder.

Insulating material - classification, properties and applications.

An ideal insulating material should posess:

(i) dielectric strength as good as that of mica

(ii) volume and surface resistivity equal to that of sulphur.

(iii) Mechanical strength as good as that of steel.

(iv) crushing resistance as goods as that of granite

v. Ease of machining as good as that of wood.

vi- fire proofing qualities as good as that of silica

vii- chemical inertness equal to that of platinum.

viii- surface finish like that of ebonite

ix- water proofing quality as good as that of paraffin wax.

Classification of insulating material on the basic of physical and chemical structure.

insulating material on the basic of their physical and chemical structure may be classified in various categories as follows:

i- Fibrous materials;

ii- Impregnated fibrous materials.

iii- Non resinous materials.

iv- Insulating ~~materials~~ liquids

v- ceramics.

vi- mica and mica products.

vii- Asbestos and abestos products

viii- Glass

ix- Natural and synthetic rubbers.

x- Insulating resins and their products

xi- laminates , Adhesives , Enamels and varnishes.

Fibrous Materials

→ Fibrous Material are either derived from animal origin or from cellulase which is the major solid constituent of vegetable plants.

→ The majority of material are form cellulose in certain materials the cellulose Fibres are clearly visible as in cloth, tape, yarn, thread etc.

→ In certain other materials like paper, wood, cardboard and The fibre is of the order of 25mm length and 0.015 mm thickness.

The different fibrous materials are wood, paper and card board , insulating textile, cotton, silk jute.

Impregnated Fibrous Material

It is by proper impegnation that limitation like hygroscopicity and thermal and chemical degradition of unimpregnated fibrous material are over come.

* Oil paper dielectric

Among all fibrous material used as insulator this class contributes the maximum.

The techeneqe of impegnated is complicated. oil used for this purpose selected carefully depending or requirment.

paper insulation are usuly provided on the conductor with out impregnation after the conductor with all impereghate After the unimpregnated paper is placed in position in any apparatus the semi finish apparatus is put through the impregnation process.

> Steps involve in impregnation process:-

i. Extracting most of the air and misture before alloying any contact with impregnating oil these require indirect heating of the apparatus in vaccume for complet removal of misture.

ii- The oil which is already dehydrated separately is allowed to impregnate through the paper.

iii- Colling process is carried out before exposeing the insolation to the atmosphere. So that oil doesnot flow out of the paper which may make it once again vulnereable to absorb moisture.

iv. If the insolation is to used for high voltage a proper sealling of the apparatus after impregnated is very essential.

Main features of I. Paper insolation

1- Good mechanical pro.

2- Good chemial stability

3- Ability to withstand high temp.

4- Diekelectric constant varying betn 2.25 and 6.35

5- comparatively less dielectric loss.

6- Non-inflammable.

Application of impregnated papers:-

Major application of impregnated paper are in

* Cables:- In all type of cable that is under ground power cable, mining cable and submarine cable in the operating voltage range of 220V to 400k.v.
* Transformers:- paper dielectric is frequently used in high voltage power transformer.
* Capacitors:-

B. Varnished or impregnated textiles:-

cotton or silk textiles can be varnished by two types of varnish:- i. oilvarnishes and (ii) oleobituminous varnishes. commonly used thickness of varnished textile vary between 0.08 mm to 0.25 mm. This material is belongs to class A insulating material.

Important features of varnished textiles are:

i - Good mechanical strength
ii - Good dielectric strength
iii - Low hygroscopicity.
iv - Low resistance to organic solvents.
v - Limiting working temp. of 105°c
vi - olebituminous varnished textiles are not resistant to oil.

Application of varnished or impregnated textiles:-

This insulation is widely used for winding in electric machine of low and medium rattings. it is also used in cables as wrappers and liners.

Nonresinous Materials

Solid or semisolid insulation which are directly available in nature and that are organic based fall under this class. These materials are mineral waxes asphalts, bitumens, and chlorinated naphthalene.

→ main defect in such material is that in the insulation system where these materials are apply there are always gas pockets in the system. These defect restricts the use of this class of materials to low voltage systems only.

Nonresinous materials are classified into follows:-

A- Bitumens.
B- waxes:
 i- parafin and micro-crystaline waxes.
 ii- Natural waxes.

A. Bitumens :-

These are solid or semisolid materials obtain by refining crude petroleum.

Special features of bitumens are:

i- highly soluble in minirol and synthetic oils.
ii- Easily oxidized.
iii- Resistant to misture penetration
iv- Poor insulation property
v- Acid and alikali resistance.
vi- Specific gravity is about one.

Applications of bitumens :-

* Bitumens is normally used in electric engineering because of its outstanding property of being water resistant. Bitumens is very cheap.

→ Bitumens find wide application in underground cable for the protection of lead and steel armour against corrosion.

B. Waxes

a. paraffin and Microcrystalline waxes :- These waxes are obtained by the process of distillation of minral petroleum oil. These waxes are hydrocarbon in composition.

* special feature of these waxes are :

→ Easily soluble in minral and synthetic insulating oil

→ Mehanically weak.

→ Poor electrical properties which become poorer when heated.

→ parafin waxes get oxidized when they are heated beyond melting point.

→ Application of paraffin and microcrystalline waxes

Micro crystaline waxes having high melting point are used as a constituent material to make non-draining Impregnated compound which is used For Mind (Mass Impregnated Non Draining) paper cables. These cables are used in INDIA For transmission in urban area

Natural waxes

→ These waxes are avalibale in Nature. Natural waxes are often used after processing in the form of chlorinated parafin wax.

→ The dielectric property of Natural waxes are satisfactory. Its Dielectric constant range betn 2 and 3.

→ The melting point of natural waxes may be upto 130°C depending upon its type.

Ceramic

→ Ceramics are material made by high temp. Firing treatment of natural clay and inorganic matters.

→ Structurally ceramic are crystal bonded together.

→ A simple manufacturing process for ceramic involved mixing finely ground clay and metal oxide with water just ~~surface~~ sufficient to make a paste which is shapes according to requirement.

→ This mould is finally dried and fired at a temp. ranging betn 1200°C to 1700°C.

Main Features of ceramics :-

i - ceramics are hard and strong.

ii - Not affected by chemical action except by stronge acid and alkalies.

iii - stronger in compression than in tension.

iv - stability at high temp. ~~likely~~

v. Excellent dielectric properties;

applications of ceramics :-

The capacity to withstand high temp., immunity to misture, good electrical properties, excellent compressive strength, mouldability are the properties which make ceramic.

a - porcelain insulator

b - line Insulator

c - other ceramic material like oxide free ceramic ~~of~~ titante, Alumina exe.

Piezo Electric Ceramic Transduser elements:-

It based on lead zirconate and lead titanate composition. They have good efficiency for electrical to mechanical Energy conversion. These are 3 type

i> lower power ceramic material

ii> High " " "

iii> The third grade is stabilished grade

Soldering Materials

→ Alloy of two or more Metals of low Melting point used for base metal is known as soldering.

→ Alloy used for joining the metals is called solder.

→ Most commonly solder is compared of 50% of Lead and 50% of tin.

→ Melting point is 185°C.

→ Tensile strength is 385 kg/cm².

→ Electrical conductivity is about 10% of copper.

→ solders are of two types
- → soft solders → composed of Lead and tin
- → Hard solder → melting point above than lead-tin solder

→ common hard solder are → silver hard solder, Aluminium, copper, zinc.

* Most imp. application of soft solders is in electronic Devices.

* Hard solders is power apparatus for making permanent connections.

Thermo copuled Material

→ when two wire of different metals are joined together an emf exist across the junction which is depend on types of metal or alloys.

→ when one tries to measure e.m.f. more junction are to made. which also give rise to emf.

→ Resulatent emf propertaional to temp. Difference of jonction is called thermo copuled.

→ E.m.f produced by T.C. is very small, it is measure by sensitive moving coil.

→ Tc. are made of Different material material used will depend upon temp.

Application

To measure temp. proper material to be chosen

materials	Temp. Range	emf at 500c mv.
copper	-200 to 400	27.6
Iron	0 - 900	26.7
Nickel	0-1100	10.0
platinum	500-1400	4.5

Bimetals

→ Made of two metalic strip, with diff cofficent of thermal expansion.

→ Bimetals is heated directly / indirectly.

→ Alloys of iron and nickel with low cofficent of thermal expansion are used as one element of Bimetalic strip.

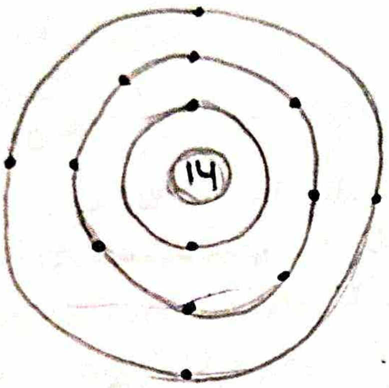
→ Bimetalic

Semi-Conductor :-

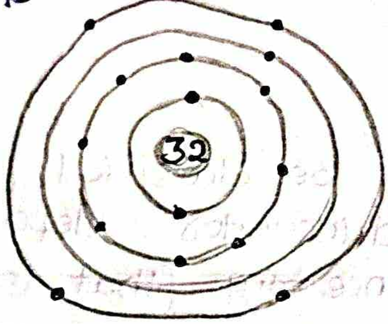
A semiconductor is indicates, a good conduction and nor good insulator typical semi conductor meterial germanium and silicon each of which have four valence electron.

Atomic structure Si and Ge :-

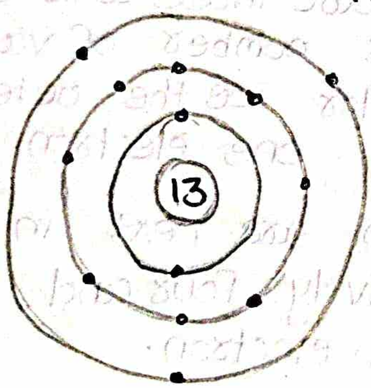
Si



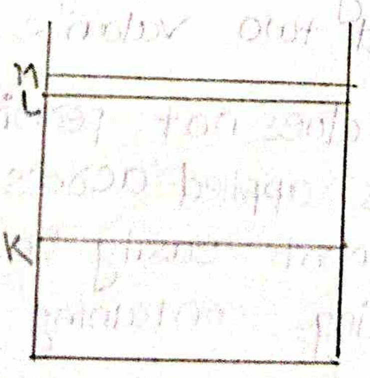
Ge



a. The Bohr model of an Aluminium atom



b. Simplified energy level



Representation of the shell.

electron revolving around the nucleus of an atom has potential energy. centrifugal energy rotational. and magenetic energy, all of which to gether determine the total energy or the energy level of an electron. This value is measured in electron volts eV.

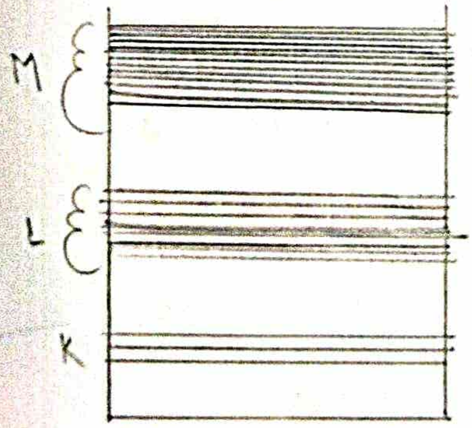
The electron volts defind as that amount of energy gained or lost when an electron moves with or aginst a potential difference of one volt.

The large of the orbit in which an electron revolves The gether is its an energy. Electrons with least energy are on the k level that is orbit closest to the nucleus. Each succeeding level contain electron higher energies if we consider and individual atom then all the atom in a given level shall passess the same energy Fig-A and Fig-B.

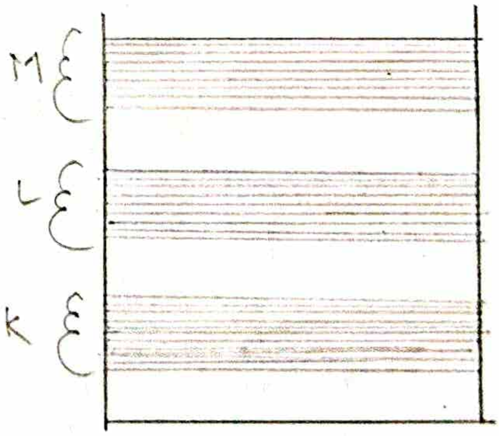
each level or shell is divided into subshell, each subshell having a difference energy level.

according to Fig a> The actual energy level of an aluminium atom : each electron now occupies an energy level different from any other.

b> They are also called Forbidden zones, since no electron can have an energy represented by these areas.



(Electron eV)
energy level of typical atom



Energy level group as Bonds.

Excitations of ATOMS :-

when each electron in an atom is in its normal orbit the atoms is said to be an unexcited state.

To move an electron Further away from the nucles additional energy. The additional energy can be obtained From any of the Following source.

- Light
- Heat
- Electrostatic
- Magnetic
- Kinetic.

if a required amount of heat energy is absorbed by electron it will Jump to a higher energy level. the atom is said to be in an excited state.

when required amount of light or heat energy is absorbed by avalance electron. it will leavs the valance band and may move up to the inoization level.