

**Recent Advances in Transmission Insulators**  
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**Module No # 01**  
**Lecture No # 03**  
**Manufacturing process for Polymeric Insulator**

Good morning we were discussing about the manufacturing of ceramic disc insulator used for high voltage transmission various methods or flow chart which was used for the manufacture was discussed in detail. We will now look into the importance of glass insulator how the glass insulators are manufactured in the industry.

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### 2. Glass Suspension Insulators

- Good contamination performance due to self cleaning properties
- Good for remote areas with no gun shooting & helicopter patrols
- Outer glass surface under higher tension than inside glass
- Damage to outer surface causes violent shattering of shell
- Spontaneous failures
- Attractive to shoot because the shell “ explodes when hit
- Shattered glass is a safety hazard
- Not popular in US, used in Europe, Canada & Brazil



So the suspension glass insulators are used like a porcelain or a ceramic insulator for transmission and distribution purposes these insulators have very good contamination performance because of the self-cleaning or cleaning properties this glass insulators are very good for remote areas in particularly where gun shooting or helicopter patrols are not of regular or activity is not there.

So here in the glass insulator so the outer glass surface is normally under higher tension and compared to the inside glass sheds. For any damage caused to the outer surface could cause

violent shattering of the shell with the spontaneous failures in the line. Glass insulators are very attractive to shoot because the shell explodes when heat.

So some people take it as a fun to shoot the gas insulator and shatter the insulators again the shattered glass is a safety hazard these insulators for transmission or distribution or not so popular in the united states they are popular in Europe, Canada, Brazil and many other country. In our country there are also several lines which we have used glass insulator for the extra high voltage and dry voltage transmission system.

When you carefully look into the glass insulator you can see the similar to a porcelain insulator a glass insulator also has metallic end fittings on a pin and a cap and a glass shell of petty coat depending upon the crepe age length. You can see various types of glass insulators this are normally without the petty coat sheds usually used in desert areas where high wind could damage the petty coats of the porcelain or glass shell.

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#### Manufacture of Glass insulators - Process



- Raw materials for glass insulators are:  
Soda ash, feldspar, cullett (small pieces of glass) and minor amounts of other agents
- Materials are crushed to powder, screened, measured and put in storage towers
- This mixture is fed to electric furnace - undergo melting phase and then fining phase.
- Glass is drawn at a rate dependent on heat input and input feed of raw materials - Molten glass is at 1400 degree celcius.
- At exact temperature glass drops into cast iron mold & immediately pressed to shape
- Molded shell is transferred to heat tempering followed by thermal shock where shells are dropped into water.
- Shells not tampered properly or contains defects are collected and are inspected.
- Alumina is cemented, insulators are proof tested mechanically.
- Various conformance tests are performed according to applicable ANSI or IEC or IEEE or National standards
- Crated for shipment

So we will be looking into how the manufacturing of glass insulators this also very important to know that. So manufacturer of glass insulator again is a similar process like the porcelain or the ceramic insulator but here the materials which are employed of the manufacture of glass are basically the soda ash a feldspar then the cullett small pieces of glasses with minor amounts of other agents which are used.

So these materials are crushed to a powdered form properly screened and measured and later on put into a storage towers. So the mixtures which is available in the storage towers is fed to the electric furnace this under goes a melting phase and then the fining phase what is known. Here the glass is at the molten stage where it is around 1400 degree Celsius and the glass can be drawn at a known rate depending upon the heat input and input feed to the feed of the raw materials.

So at known temperature whatever specified temperature the glass is normally the molten glass is normally dropped into the cast iron mold and immediately this is pressed to the required shape. So depending upon the shape whether it is a normal insulator or used for a normal conditions or the anti-fog type with the sheds different sheds and for the higher crepe age length or the insulators which are used for desired condition basically known as hero foil with the known sheds.

So such mold is already prepared and molten glass is drawn and this is fed and to the cast iron mold and immediately it is pressed to the required shape which is to be obtained. So the molded shell later on it is transferred to heat tempering a followed by the thermal shock where shells are normally dropped into the water basin. So where water so this shells which are not tampered properly or not being having some defects during this above process are observed usually and are collected and normally inspected and further process will never be done for these defected insulators.

We should know that alumina is normally cemented and later on used to cementing and insulator further are sent for proof testing both mechanically and further electrically. So various testing are carried out at the factory which are known as the routine type of the test which we will be discussing in the future discussions. So this conformal test will be done according to the applicable standards could IEC, IEEE or national or European standards and the insulators are tested.

Further after the testing confirmation this insulators are put up in the form a crate where number of insulators are put in a crate and or in ship to the desired location of to the utility. This is how the manufacturing process of the glass insulators takes place.

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#### Glass insulator hardware

- Metal components cemented to glass shells provide means of transmitting mechanical load - applies to suspension insulators or post insulators for substations.
- Malleable and ductile iron and forged steel protect against corrosion are used
- After annealing casting is done by grinding or machining and galvanising. Surface in contact with cement is coated with bituminous paint
- Steel forging are employed for pins of suspension insulators
- Steel components are galvanized & coated with bituminous paint for more strength.
- For limited applications aluminium alloys are used as are not economical.

#### Glass insulator cement

- Aluminous cement in neat form (no sand, aggregate or filler in cement mix) is used in assembly of glass insulators
- In curing  $Al_2O_3$  alumina is liberated from monocalcium aluminate phase ( $Al_2O_3 \cdot CaO$ )
- Portland cement is used in assembly of porcelain insulators in which lime ( $CaO$ ) is liberated during curing
- No chemical reaction takes place with galvanized insulator. So need to coat the hardware with bituminous layer
- Alumina has high compression strength, adequate mechanical strength is developed after 24 hours curing in water for mechanical proof test.



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So what are the material hardware which are used along with the silica glass and other materials which we have discussed these are basically the end fittings how important is like the ceramic we were discussing about the Portland cement the end fittings and so on for the porcelain insulators. Similar to that the metal components are to cemented to the glass shell which have been obtained this provide a means of transporting mechanical load which may apply to suspension insulators or post insulators or the insulators which are used in a for the substation equipment production.

So usually valuable and ductile iron and forged steel protect usually again is the corrosion are normally used for the hardware of pin and cap. So these are initially nailed properly and the casting is done by either grinding or machining and galvanizing. So the surface in contact with the cement is properly coated with the bituminous paint. Further steel forging is normally carried out for pins of the suspension glass insulators.

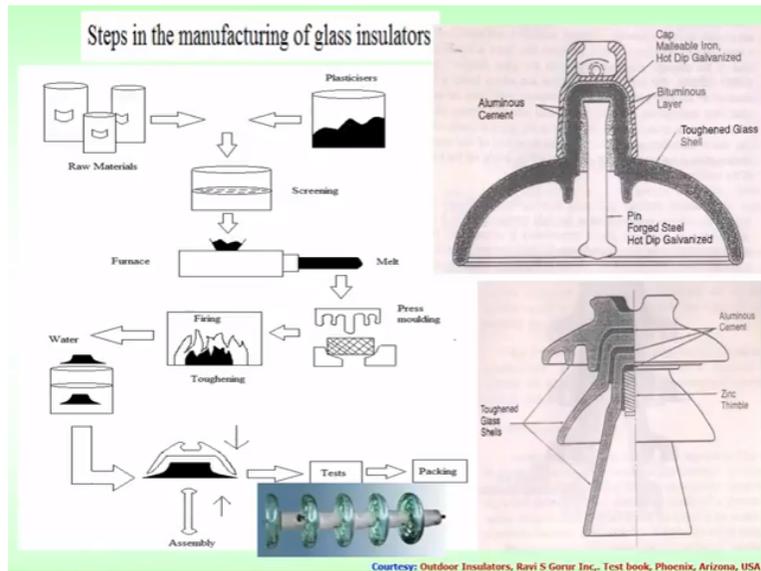
This steel components are further galvanized and further coated with bituminous paint to obtain more strength. So this is important that is one of the reasons where galvanizing and coating where bituminous paint is carried out to obtain carried out more strength. For some limited applications the manufacture also apply aluminum alloys which are used but these are again not very economical.

So depending upon the usage and important so aluminum alloys are being used. So cement similar to the porcelain or ceramic insulator here alumina cement in a very clear form in a neat form where it contains no sand aggregate or fillers made mix is basically used for the assembly of glass insulators. So in curing aluminum tri oxide into the alumina is liberated in from mono calcium aluminate phase.

So earlier in the Portland cement was employed for the porcelain or a ceramic insulator there lime was liberated during for curing purposes. So here it is alumina usually is liberated for mono calcium aluminate phase in case of glass insulator. And there are no chemical reaction which takes place because of galvanized insulator. So there is need to coat the hardware with a bituminous layer that is the layer where a bituminous layer is ported.

And the alumina which has a very high combustion strength adequate mechanical strength is developed after 24 hours after the curing in water and for that to mechanical proof test. So this is how the insulating cementing or insulator hardware are fixed to the glass shells on manufacturing stage.

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This is again the flow chart of the discussion which we have just talked about various manufacturing stages. so this shows the entire manufacturing process of the glass insulators

where you can see the raw materials are collected and stored further this are powdered using the screening mechanism.

So further to the screening it is sent to the furnace where it is melted at a temperature after the melting of the temperature these are carefully molded using the mold cast iron moldings for different shapes or a required shapes further this toughening to be made it is sent for the firing and after the firing the insulator are dropped in the chamber containing water this further shells are taken out and are further assembled along with the cap and the pin using a suitable coatings and other aluminous cement.

Further after finishing the product the glass insulators undergo various mechanical and electrical test at the factory which is best as known as the routine test and further the inspection and the quality measures are made these insulators are packed properly in crates and dispatched to the required locations. This is how steps in manufacturing of glass a very important process for the glass manufacturer.

So with in carefully look here this is how the shell or insulator cut section of the glass insulator looks through typical schematic of the glass insulator where you can see the cap the cap again is the valuable iron hot and dip galvanized iron which is used. You can see here the bituminous layer is coated and alumina cement is used here for the jointing of both the cap and the glass shell.

So toughen glass which is obtained from the molten state at a different temperature you can see various types of shells are normally employed. Further there is again alumina cement which is connected to the pin of the insulators. So the cap and pin of the insulator with the glass shell is embedded with the alumina cement coated with the bituminous layer this is how the glass insulator looks. This is again a pin type of insulator normally employed for a lesser voltages.

Here again you can see the different pin insulators are jointed with the help of alumina cement and toughened glass shells which are two three glass shells which are jointed depending upon the voltage and the crepe age requirement and you have zinc thimble which is basically to used for the having thread arrangement and used to mount on the poles. So you have a

threaded arrangements this insulators could be mounted on the platform of the pole of the where ever the insulator are to be placed.

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**Development of Composite/Polymeric/Silicon rubber/Non-Ceramic Insulators**

- The first polymers used for electrical insulation were bisphenol and cycloaliphatic epoxy resins introduced in mid 1940s.
- Cycloaliphatic epoxy's (CE) were introduced in 1957, for outdoor insulation in 1963 in England later in France, Italy, and the U.S.
- In Germany, units for field testing were done 1967. In early 1970s, manufacturers introduced first generation of commercial polymeric transmission insulators

**Table 1**  
**First Generation Commercial Polymeric Transmission Line Insulators**

<u>Company</u>	<u>Housing Material</u>	<u>Year</u>	<u>Country</u>
Ceraver	EPR*	1975	(France)
Ohio Brass	EPR	1976	(USA)
Rosenthal	SIR**	1976	(Germany)
Sediver	EPR	1977	(USA)
TDL	CE	1977	(England)
Lapp	EPR	1980	(USA)
Reliable	SIR	1983	(USA)

\* EPR Ethylene Propylene Rubber  
\*\* Silicone Rubber



Zhejiang Ruijun Co., Ltd.

HISTORY AND BIBLIOGRAPHY OF POLYMERIC INSULATORS FOR OUTDOOR APPLICATIONS, IEEE Trans on Power Delivery, Vol. 8, No. 1, January 1993

So further we have discussed about the manufacturing of the porcelain or ceramic insulator the glass insulator both are electrically and mechanically stable a very good are being used for a very long period of time more than a century old technology lot of changes have do happened in both the ceramic and glass insulator pertaining to the voltage level and crepe age distances, the shapes have under gone several changes and are being used.

Now we will discuss about the recent or decade or two or three decades since the polymer or development of composite polymeric or silicon rubber insulators sometimes known as non-ceramic insulator. So I will be using the terminologies either a composite polymeric silicon rubber or non-ceramic during the discussion.

So this insulators are basically organic in nature and where first used somewhere in 1940's the first polymers tried out for the electrical insulations where bisphenol and cycloaliphatic epoxy resins which are introduced in mid-40's to 50's. Later on cycloaliphatic however introduced in late 50's particularly for outdoor installation. These were used in 60's are late 60's in England later in France, Italy and US.

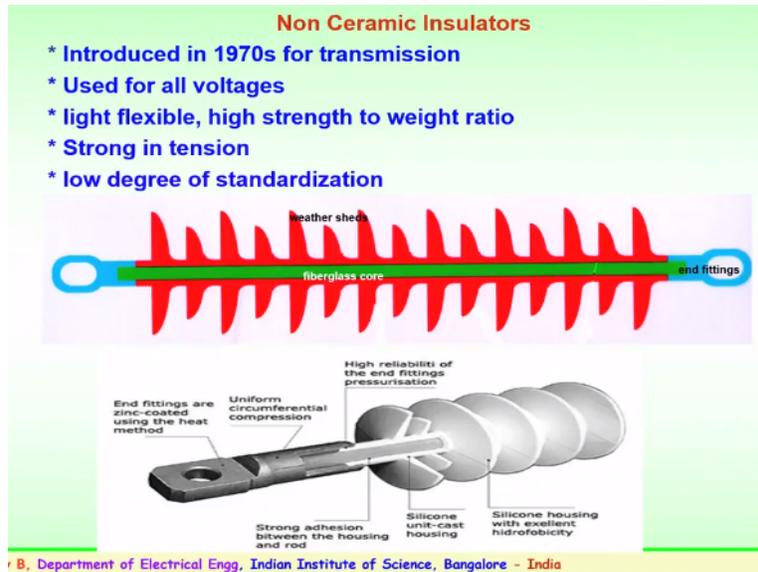
So lot of research activity as gone into this there are several advantages for going in this insulation. So in Germany this unit were initially tested for in the field during the late 70's sorry 60's and in early 70's. So initially the manufacturers introduced the first generation polymers and commercial polymeric transmission insulators or were back in 1970's which are known the first generation commercially available or polymeric transmission line insulator used for both transmission and distribution initially tried out.

So several companies are available most of the companies do exist right like a Ceraver which used the housing material EPR is ethylene, propylene, rubber somewhere in 1975 this is in France. Then Ohio brass and Rosenthal, Sediver, TDL, LAPP, Reliable so several of this companies are started during similar the period of 1975 to 1983 using either ethylene, propylene rubber or the silicone.

So this materials which are organic in nature where being tried out in the initially stages where the silicon rubber insulator are looks like this you have a metal end fittings you have a silicon rubber housing and from the metal fitting inside there is fiber glass rod which is again on the fiber glass rod this silicon rubber or the ethylene propylene rubber has been fixed. So this is how the polymer insulator looks so we will look into how important is the composite or a polymeric or silicon rubber insulator.

How easy or a is it to manufacture and the proper care which is to be employed for manufacture and transportation and so on.

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Now as mentioned non ceramic insulators were introduced in 70's particularly for transmission because of advantages many people many industry started the business of polymeric or the composite or non-ceramic insulators and these part were to be used for all the voltages the main advantages for the polymer or non-ceramic insulators weighing very light in weight, flexible having high mechanical strength to weight ratio.

This sign insulator shown a strong intention and also low degree of standardization so very important so several advantages for both manufactures and the utility. So this is how a typical (()) (19:11) the insulators you have a metal and fitting inside connecting from the metal end fittings is the fiber glass rod then on the fiber glass rod the weather sheds or the silicon rubber or the composite material which is embedded on this rod.

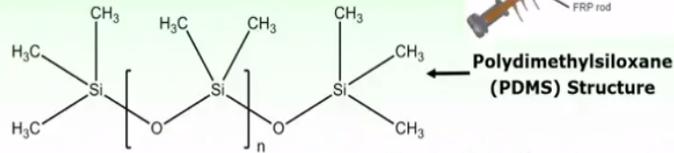
So end fittings are properly crimped to the metal to the fiber glass rod and this is how the insulators looks. So you have a uniform circumferential compression near this end fittings you have high reliability of end fittings pressure which is again taking care of fiber glass rod here strong adaptations between the housing and the rod as to be done there is a paint which is being made and also the silicon units cast housing is done.

Silicon housing with which is an excellent hydrophobicity is normally used so this is how typical non ceramic or a polymer insulator looks.

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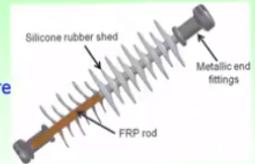
## Manufacture of Silicone Rubber

Main composition of silicone rubber used for Insulators are



**CH<sub>3</sub>** - is methyl group an alkyl derived from methane, containing one carbon atom bonded to three hydrogen atoms

- ❖ Polydimethylsiloxane with different functional groups (-OH, -C=CH<sub>2</sub>, -H and others).
- ❖ Fillers (pyrogenic or precipitated silica, quartz powder and others).
- ❖ Vulcanisers (peroxides, H-siloxane).
- ❖ Catalysts (platinum compounds, tin compounds and others).
- ❖ Additives (adhesive agents, softening agents, pigments and others).
- ❖ Carbon blacks (pigment types, conductivity types and special types).
- ❖ Aluminium trihydrate, aluminium hydroxide (ATH).



How it is the silicon rubber insulator are manufactured so we have a previously discussed about the manufacture of the glass and the ceramic or a porcelain insulator we will look now into the importance and how the manufacturers of silicon rubber and what is the care to be taken during the manufacture and during the transportation.

So before going into the manufacturing stage what is the main composition of the silicon rubber or the composite material which are used for the transmission material which are important and the composite material which are used for the transmission insulators are important. So this compound which is I mentioned as organic compound basically consist of a polydimethylsiloxane which is known as PDMS structure.

So poly in the sense several chains of this dimethylsiloxane structure is shown here basically the silicon again which is consisting of oxygen and methyl group this again a methyl group is an (C) (1:3) which is derived from methane which contains one carbon and three hydrogen atoms which are bonded. So this is how the structure and there are N number of structures in silicon rubber PDMS structure.

So polydimethylsiloxane with different functional groups that is OH, C, CH<sub>2</sub>, H and other level are consist of this groups. So here apart from the silicon rubber PDMS there are fillers which are employed this fillers could be of pyrogenic or a precipitated silicon quartz powder and

others. So the vulcanizes which are used are per oxides and silicon so catalyzed for the material used are platinum compounds, tin compounds and some others.

So what are the additives for this compound again they have adhesive agents or softening agents are various pigment this is for coloring of the insulators and other. So carbon blacks the pigment types conductive types and also the special types. So aluminum dehydrate, aluminum dioxide which is known as ATH which is normally used as the filler materials for this silicon rubber. So the percentage of the various fillers and the PDMS is decided by the manufacturer and each manufacturer they have special composition of the manufacturing of this compound.

So basically as mentioned earlier the polymer insulators consist of metal layer and fittings as shown here this is the silicon rubber material and fiber glass around which is embedded here. Again silicon rubber initially is the sheds are important uniform sheds where absorbed during the manufacture later on because of the advantages this sheds are of uneven in nature or being employed.

That we will be trying to discuss the future when it comes to the testing and the performance of this silicon rubber insulators.

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#### Stages involved in the manufacturing process of a polymer insulator

1. **Raw Materials:** raw materials used for the manufacture of polymer insulator include:-

Silicone rubber, FRP rods, Metal end fittings

2. **Ultrasonic Cleaning process:**

Metal fittings are dipped into a liquid (evapo-rust) for 15 minutes, are free from any kind of impurities present over the surface.

3. **End Metal Fitting- Crimping /Swaging:** step by step process of the crimping method:

- **Selection of the material:** Appropriate cleaned metal fittings, FRP rods are selected
- **Component setting:** Cleaned metallic end fittings are inserted over identified FRP rods. The metal to metal distance (lip to lip distance) is maintained as per prescribed gauge by inserting rubber or poly propylene cushion to ball side or socket side metal fittings.
- **Jaw setting:** Suitable jaws are selected which suits diameter of the crimping portion and crimping length which is mounted in the crimping cavity.
- **Initial zero setting:** Initially trial run to check for complete alignment of all jaws at zero position
- **Dimension Knob setting:** The knob settings are made in such a way that the crimping diameter is to be reduced by 1mm.
- **Crimping pressure setting:** Crimping pressure is set as per the standard.
- **Crimping mode setting:** Crimping apparatus can be either manual/semi-automatic/automatic.

Composite insulators manufactured in range of 90kN to 160kN. For traction insulators crimping jaws adjusted to dia 45mm, length 40mm, holding time 6secs, crimping pressure of 150kg/cm<sup>2</sup>.

What are the steps involved in the manufacturing process of a silicon rubber composite or polymer insulator. So as mentioned raw materials we discussed used for this insulator are basically silicon rubber the fiber glass rod and the metal end fittings. So this metal end fittings which are employed for the insulator are to be cleaned with the help of ultrasonic cleaning process where the metal end fittings are dipped into a liquid for a known time.

And are left for any kind impurities present over the surface of cleaning of the impurities of the metal are very important fittings. So this end fittings again under go crimping and swaging which is the step by step process of crimping method. So how the selection of material is done is to see that appropriate cleaned metal fitting above which is done using the ultrasonic cleaning process and fiber glass rods are also selected and this cleaned metallic fittings are inserted into the identified of fiber glass or known dimensions of known length.

The metal to metal distance which is also known as lip to lip distance is maintained as per the prescribed engage by inserting rubber or polyprolin cushion to ball side or socket side metal fittings. So that the damage is not caused during the crimping process so jaw setting usually done by using the suitable jaws which are selected according to the diameter of the crimping portion and the crimping length which is mounted on the crimping cavity.

So there are various settings which are done for the crimping from the initial conditions and to various crimping pressure crimping mode and crimping knob settings. So this are done are a proper pressure and as per the standards available for a particular a dimension of the paper glass roll. So crimping mode settings can be either manual semi-automatic and automatic. So the composite insulator which are presently being manufactured in the range of 90 kilo Newtons to 160 kilo Newtons or more.

And for a traction insulation crimping jaws are normally adjusted to a dia of 45 milli meter length of 40 millimeter and which for at 6 seconds time and a crimping pressure somewhere around 115 KG per centimeter this is typical example for the traction insulators of a particular length so this stages of crimping is also very important to be considered.

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#### **4. Surface Preparation:**

The surface of FRP rods is made smooth. The coating of diluted primer chemlok 608(20% diluted) is applied so that sheds or housings are properly attached to FRP rod surface. The coating also helps to maintain hydrophobicity so that there is no erosion or surface flashover takes place - after applying the coating, rod along with end fittings are heated in an oven.

#### **5. Injection Moulding:**

suitable mould is selected. for injection moulding is 160°C. no. of sheds, silicone volume, pressure, curing time are provided in according to user specification.

Moulding is done in three stages. Bed of machine is cleaned by using valve lapping compound and later by a jet of compressed air.

Curing process is done so that it becomes hard, rods are now housed using silicone rubber by using this process.

Generally alternate type of sheds is preferred because in case of rain the continuous stream of water is discretised into droplets reducing the frequency of flashover.

#### **6. De-flashing:**

The insulator is placed on the racks or stacked in the wooden supports. After the component has cooled to ambient temperature the sticking extra flash material is removed manually or by knife.

In case of traction insulators three types: Bracket insulator for inclined purposes, Nineton insulator to be used for maintaining horizontal and Stray arm insulator to be used for horizontal purposes.

#### **7. Testing:**

Routine tests are performed during production process prior to crating and shipment. These tests will eliminate defective insulators which might otherwise fail immediately upon installation and energisation. 1. Mechanical, 2. Electrical & 3. Bending tests are performed.

Further service preparation the surface of fiber glass rod is to be made very smooth and the surface is coated by using the diluted primer which is at commercial normally available is chem lock where it is applied to the sheds or housing and are proper attached the properly fiber glass Harold. These coatings helps to maintain hydrophobicity so that there is no erosion of the material surface or flash over which takes place.

So the applying of the material along with the end fittings and also heating in a oven to a temperature will help in the proper surface which further goes for the molding so where various molds molding arrangements where tried out. Presently the injection molding is normally employed this is suitable and this injection mold is normally operated at 160 degrees and number of sheds the volume pressure the curing time are normally provided and are the standard does specification for a the particular product.

So the molding is done usually in three stages where the bed of the machine is cleaned by using a ball lapping compound and later by the jet of compressed air. So here again the curing process is done so that this becomes hard and rods are now housed using silicon rubber by the process. So generally alternated type of sheds are preferred so earlier i have mentioned the point by the importance of alterative type of sheds this is mainly to see in case of rain the continuous stream of water is discretized into droplets reducing the frequency of flashover.

So if the sheds are uniform because of the rain and the flash over because of the water droplets could form and reduces the crepe age length. So to ensure that the sheds are of alternative type bigger and smaller are normally used. Then after the inspection molding it goes for the insulator goes for the de-flashing here is the insulator is placed on the racks or staged in the wooden supports after the compounds has cooled to ambience temperature.

And some further sticking extra material silicon rubber material which is extra is removed manually or by using (( )) (29:59) in case of traction insulator three types we have bracket insulator which is for incline purposes nineton insulator which is to maintain the horizontal position and also has to make it horizontal so the weight of the nineton is used and a stray arm insulators to be in the horizontal are normally used.

So testing routine test after the insulators are ready these have to undergo the routine test in the factory performed during the production before the crating and shipment is done. So these test mechanical or electrical or thermo or mechanical test will eliminate defective insulators which might either otherwise fail immediately upon installation and energization, So in the factory before the dispatch mechanical electrical and other mechanical bending test or usually performed before the insulators are dispatched.

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• **Mechanical Tensile Strength Test:**

The testing fixtures with insulator are placed on mechanical test bed connected to form a string.

The number of insulators per string together will decide the amount of load to be applied, the stress applied is 60% of the total mechanical strength of insulator string for 1 minute. The load is then released and observed for withstand or failure.

• **Electrical Test:**

Appropriate high is applied for a period of 1 minute. If there is no flashover during this period then the insulator has passed this test.

• **Bending Test:**

After completion of mechanical and electrical tests, Some insulators are randomly selected and mounted on test bed one after another for ultimate breaking load is determined and the value of breaking stress is calculated.

**8. Dispatch:**

After clearance from the quality department, the insulators are stored horizontally on fixtures with proper packing. It is ensured that undue load is not exerted on polymer sheds during storage.

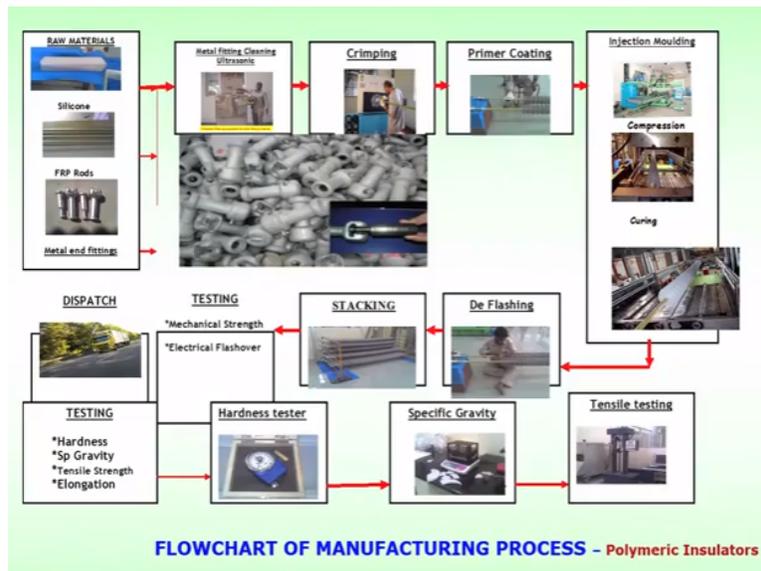
So mechanical in tensile strength we will be discussing several of the test this is just to give a brief introduction about the mechanical test usually here the testing fixture which insulators

are placed on the mechanical test is connected in the form of the string the number of insulator again will be decided by the amount of load are to be applied of the stress which is to be applied where is a 60% to total mechanical of the insulator string of a time frame of the minute.

So the load is generalized and also in for with stand and for failure in the factory similarly appropriate electrical test are carried out for period of one minute and in case of flash or this insulator seems to be cleared the particular test. Bending test the again completion of mechanical and electrical test some are randomly selected and mounted to test bed for ultimate breaking load and determine the value of breaking stress is usually calculated and formed.

So after the electrical mechanical and bending test which are routine in nature the insulators from the quality section is cleared for this batch where after clearance for the insulators are normally stored horizontally in the grates properly with packing and fixing and ensure that and you load is not exerted on the polymer sheds where they could damage if it is not properly taken care.

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So this is how the process of polymer insulator happens the similar flow chart is shown here where it gives the metal end fittings fiber glass rod, silicon compound raw material the raw material silicon compound, fiber glass rod, metal end fittings are the required raw materials.

These metal fittings as mentioned are cleaned with the ultrasonic arrangement where the impurities are completely eliminated.

Further the crimping of the metal end fitting and the fiber glass rod is done and the coating primer coating is mentioned is done to the insulator surface to see a proper attachment of the silicon rubber is done on this. Then these are sent to the injection mold where in the injection molding you have various types of insulators which are to be used could be for distribution transmission or traction suitable temperature and the compound is being fed where depending upon the sheds this injection molding is being done.

And it is compressed further the curing of the insulators is done and it is sent for various deflating and various testing aspects both mechanical and electrical bending arrangements. So this apart from this there are some other chemical and test which are normally carried out it could be the specific gravity hardness testing tensile strength elongation of the rubber so all this test apart from the electrical mechanical bending.

So the chemical and the surface changes which could takes place are carried out and finally this material upon the clearance after undergoing the mechanical electrical testing's these are normally these are dispatched to the utilities of our using in the transmission distribution or in the traction purposes.

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#### **(1) Porcelain /Ceramic**

- During transportation or in field porcelain insulators may cause damage from time to time result in rough handling
- Heavier insulator like line post require handling. Drooping crates of suspension or pin type insulators from truck at field are common reason for damage
- Utilities factor 2% damage rate when estimating the cost
- Insulators that are extensively damaged are easily spotted.
- Hairline crack or internal damage are not easily detected

#### **Vandalism**

- Compared to glass insulators, porcelain insulators are not much attractive
- Each hit will remove a small portion of the shell there by marginally reducing the flashover strength.
- If a dedicated vandal removes sufficient porcelain from each insulator of the string flash over occurs at the first onset of wetting
- Compact line designs using porcelain post insulators are vulnerable to line drops result in gunshot.
- A single hit can cause line post to shatter.

So we have till now discussed about the various procedures or various process involved in the manufacturing of the ceramic glass and the recent insulators which are being used for transmission the composite or the polymer insulators. So various stages of the manufacturing have to be taken care impurities which could be present during the manufacturing stage if left unnoticed could have a series consequences in the field.

So every stage of manufacturing process has to be carefully taken care and see the product is manufactured without any defects impurities and so on. Further after the manufacturing of the insulators may be the ceramic porcelain glass or composite insulators handling of this is a very important task handling or managing of this overhead insulators either from the factory dispatch to the utility or the required place and how it is being handled for the stringing.

So each and every information is of very important is not that the manufacturing is done in a very precise way and the usage or handling if it is done poorly then this could again see the insulator failures in the field. So care as to be taken for proper handling or managing of overhead insulators here we have few points which we will be discussing for all the three types of insulators the first being the porcelain or the ceramic insulators.

So initially during transportation in the field the porcelain insulator may cause damage from line from time to time. In case if the handling is not done properly or a rough handling of insulators done. So heavier insulators particularly like line post require careful handling so drooping creates of suspension dropping suspension or pin type while unloading from the truck should be taken care as at field are common reason where it could be damaged.

Here the utility factor somewhere around 2% damage right is estimated in the cost and case has to be taken while loading and unloading. Because a small damage or a airline crack could result in a failure so insulator that are extensively damaged could be spotted but sometimes if may also be difficult so airline crack as mentioned or internal damage or normally easily detected and this could down the system.

So careful handling of this is very important vandalism yes compared to glass insulators porcelain are not much attractive and particularly for people who have hobby of shooting the

insulators in the field. So each heat of this could produce a shell there by margin it is in the flash over. So if dedicated vandal removes sufficient porcelain from each insulators of the string then definitely the flash over occurs at the first onset of the wetting.

So compact line design is using porcelain or post insulators are normally vulnerable to line drops which result under the reports of the gun shot or same. So any single hit could cause a line post or shatters so vandalism care has to be taken for a glass or the porcelain insulators. Similarly for glass insulator handling is very important where here the failure of glass insulators originates from the surface and is usually attributed to the micro cracks which could be present during the loading unloading and also the failure which could be matching.

Normally the rate of suspension thus rate of suspension range anywhere between two 10,000 per year sometimes it could go more than 15 to 20%. So higher rates of the activities purge rate or normally reported during the construction of new lines and are handled in the field. So handling of this is very important people normally drag on the ground and this could impact the small stones or rocks or hard sand or hard soil where the small chips could develop in the toughened glass or a porcelain insulators.

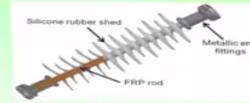
And this chip could act as the stress concentrator with moisture and thermal cycling in the insulator shell could eventually shattered. So this has to be properly taken care while the stringing is being done a proper shifting of the insulator to the exact position without damaging or dragging has to be taken. And handling of glass insulator for vandalism are very lot of reports are being seen particularly North America where they have good success toughened glass and other experience have very high rate of vandalism.

So on one hand the glass insulators are superior to porcelain and non-ceramic insulators on the other hand utilities do not favor glass insulators due to high rate of vandalism. Because there will be flash over and lock out on the permanent fault. So this is a one of the major concern pertaining to the gas insulators.

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## Handling of Composite Insulators

### 3) Non-ceramic



- These insulators can easily get damaged through handling, damage to housing during transportation - Once damage to housing the effects of moisture and voltage result in two possible failures **tracking** along the core and **brittle fracture**
- During installation cracking of the core because of cantilever or torsion loads
- Tracking of the core depends upon the extent of the exposed core, location of damage relative to line end, wetting and amount of contamination
- Brittle fracture failure occurs if damage is near the line end of the insulator due to the production of acids during corona discharge in moisture
- Brittle fracture at centre of insulator or at the structure end has rarely reported

### Vandalism

- Non-ceramic suspension and line post insulators can withstand severe gunshot without electrical or mechanical damage
- Generally it is not easy to locate the gunshot damage insulators in the field
- As brittle fracture of the core is accomplished by the line drop, insulators in the hunting areas should be inspected regularly

Coming to the handling of the composite insulation so as mentioned composite insulation silicon rubber on the outer shed and again repeating the fiber glass rod between the metal end fittings. So these non-ceramic or composite insulators can easily get damaged through handling so very important and damaged to housing during transportation. So crates which are made for transport to be carefully considered where the over lapping of silicon rubber sheds do not happen and mechanical forces do not exist on the silicon rubber.

So once damaged to the housing the effects of moisture and voltage stress could result in two possible failures which will be discussed it could be the tracking along the core or brittle fracture very serious to the non-ceramic insulators. So during installation there are reports of cracking of the core because of the cantilever or torsion loading of the insulator.

Tracking of core again depends on the extent of core which is exposed a location of the damage which is relative to line and wetting and also the amount of the local environmental pollutions or a contamination which exist at that place. So brittle fracture failure also could happen if the damage is near the line end of the insulators due to the production of nitric acid particularly during the corona discharges combination of the moisture.

So this corona discharges from the end fittings like the corona control rings and if the micro structure failures during the crimping could cause and if there is damage near the line end with the water sweeps in and the nitric acid for machine and brittle fracture issues are also

noticed in the long rod composite insulators which are used for EHP and UHP transmission. So brittle fracture at center of insulator or at the structure end are regularly reported again this could be because of the end fittings because of the corona because of the water crepe age because of the crimping at the edge.

So this could be the reason for the not many failure observed at the center of the insulator or at the structure. Vandalism again here a the non-ceramic a composite suspension and line posting insulator this could with stand a severe gunshot without electrical or mechanical damages and this are generally not easy to locate gun shot in the field because of the structure of this insulators as brittle fracture of the core is accomplished by the drop line drop.

Insulator in hunting areas I should be inspected regularly that is in case a polymer insulators are employed where people bound to shoot this insulators of regular inspecting is essential for IHP or UHP line. So we have discussed about the manufacturing of various insulators porcelain glass and composite insulation which are used for the transmission systems we have also discussed about the material handling the insulators handling the transportation that dispatch and how importance is or the care to be taken during the stringing of the insulators we will discuss about design criteria and the insulation coordination in the next class thank you