Glass Processing Technology
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Lecture - 43
Silicone Sealant for Insulated Glass

Good morning all of you. So, today I am going to take you through what are the best practices of making a double glazed unit. And especially I am going to talk about the secondary seal, which is the Silicone Sealant and it is role in while making the good quality insulating glass unit. I am Ravishankar, I come from a company called Dow Chemical International private limited and I am working as the technical service and development engineer and the leader for the Dow performance silicones. I have been in this industry for close to 15 years and supporting various projects, challenging ones as well as the regular ones throughout my career with now.

So, I will quickly take you through my agenda today.

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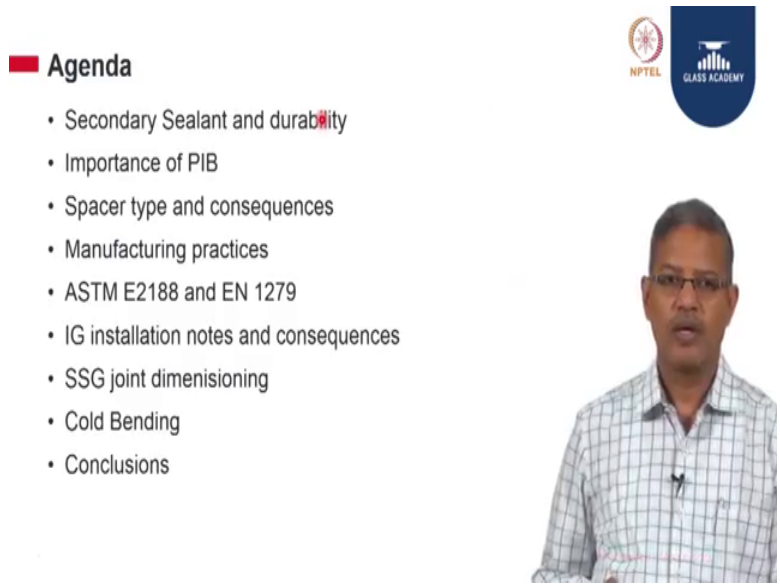

My agenda is going to cover a few essential parts for making a good DGU. We are going to talk about the secondary sealant and durability. So, a country like India or a climate like India, what we have which is tropical and I am going to talk about what is that chemistry which can work the best for the application need what we have. Not only here in many other countries as well as the developing nations the developed nations, what

they are talking about the secondary sealant and durability. And not missing on the important seal there is one more important seal which is key in giving the durability for the DGU is PIB.

So, the polyisobutylene which is also called as the primary seal is also very, very critical and it imparts a lot of, you know it plays an important role in giving the durability for the IG unit. And we are going to talk about spacer types; we are going to see what all it can cause, what is the best thing to use and some of the good manufacturing practices. So, nothing can come we can have whatever design we want to do on the paper. If you do not have a proper implementation and a standardized process while making the DGU we will essentially we will end up with a bad quality of the material. So, the manufacturing process is very, very critical including the workmanship, which is one of the key criteria for manufacturing a good quality DGU.

We are going to talk about quotes, standards and we are going to have a comparison of standards as well; to see that what suits best for us and also we will cover some of the insulation techniques what needs to be considered while designing the DGU And not, but not the least there are few points which we will cover is a joint dimensioning. The design of secondary seal is very critical for the long term performance for the DGU. And the new trends which are coming in the market their effect on DGU also I will slightly go through with my one slide, which is a coal bending technology.

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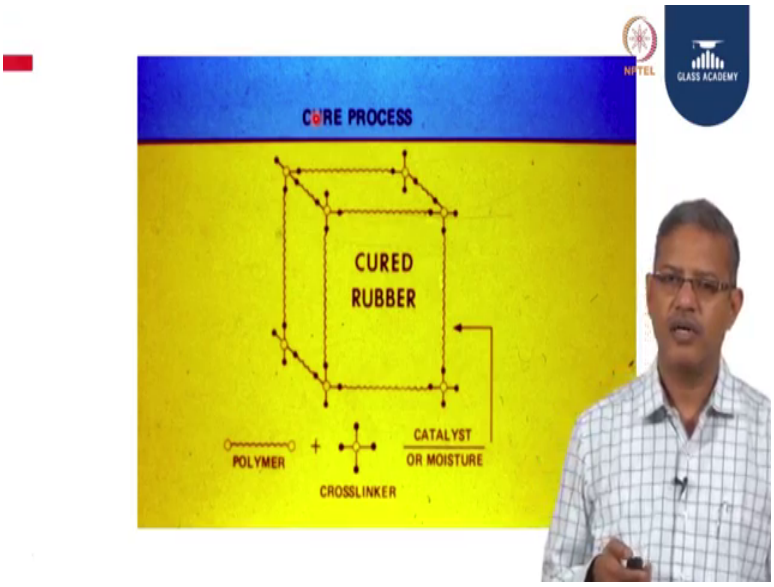

So, essentially this is an agenda, to start with you all know that silicone comes from the earth crust which is called as a quartz sand. So, quartz sand is the original raw material for manufacturing silicone and the silicone metal is the one which is first made from that quartz sand. And this is then converted into a ground silicone and as a distillation or a you know chemical plant, this is then converted into a poly dimethylsiloxane which is a silicone polymer. So, this silicone polymer becomes the backbone or the essential raw material for manufacturing sealants and many other chemicals which are made from silicone.

So, our interest today is to look at the Sealant. So, when we really see the sealant the sealant has got few ingredients added to that. The essentially the polymer which is the basic backbone which is giving all the properties, desired properties, mainly, the durability, the strength and the cross linking and also forming a rubber part. So, the polymer is very, very essential, but there are some more additives which are critical while making the sealant. They are like you need to add the cross linkers. So, you have 2 chains of you know polymer running through, but it just linear you need to bridge them to make it compact under rubber form so cross linking happens.

So, the cross linkers are important and this rate of reaction is controlled or it can be enhanced by catalyst. So, you can use an catalyst to enhance this reaction. Some amount of fillers are added to give an inherent strength. So, they give reinforcements and they improve the physical properties of the sealant. And we add adhesion promoters are added to give good bonding of silicone to different substrates.

There are some special additives added, which gives like a color or antifungal or some of the other you know special features in the product. And there is also a small amount of plasticizer added this is essential for the gun ability, but if you really look at this ingredients; you can have a product made with very good quality by, you know having a good composition you can also make a product which is very cheap. You add more filler you had more plasticizer then the naturally the polymer content goes down and the product becomes or the behaviour of the product becomes totally different. That is the reason when we go to the market you do not see that you know there is only one product sold, there are a number of products being sold at different prices.

The reason for this is selection of the type of polymer, as well as the special you know as the selection of the ingredients you can make the composition different which can work for different applications.

There is also different chemistry is involved, while the sealant is made. When I say chemistry it is in terms of cure the basic is silicone, but there are different chemistries which will happen during the cure, one is called as acetoxy cure, there is one called oxime cure and other one is called alkoxy cure. So, we generally talk about acid cure and neutral cure systems. So, I am going to take you through some of that in my presentation and see the impact of what can cause, you know what sort of you know compatibility issue with a secondary seal of the DGU.

So, this is when you make the sealant and it apply it comes in the form of a paste. So, this paste when it is applied it can flow into any shapes. It can fill in to you know narrow depths and then it can be completely it will bond and form a rubber. So, the process of curing from the paste form to rubber is called the cure process. And this is then you know this is the essential curing agent for our most of the sealants used for our application is through moisture.

So, it is a moisture cure system these are called room temperature vulcanizing rubbers. So, the moisture reacts with the you know sealant and then it cures, so that is the way it works for the one part

So, there are 2 big classification of sealant one is called as one part and second is called as 2 part. So, the one part is one which is a readymade cartridge, you get it in the market for your you know insight, or some of the weather seal applications, or some of the site applications where it is very easy to handle and apply.

The 2 part is it comes in a big drum like a 250 kg part A and a 19 kg part B, these 2 are mixed at a particular ratio and then applied. The difference between these 2 is actually the cure rate. The 2 part cures much faster because it does not require a moisture to really get into for cure, there is a catalytic reaction which happens where in this A and B react, but the by-product needs to be released. So, all the joints whatever we wake using silicone for any of the applications should have at least one side exposed to the air.

So, either if it is one part it becomes a process where the moisture can enter through cure and the by product is released. Or if it is a 2 part where there is a reaction which is which happens within itself and the by-products it is released through the exposed side. So, you cannot make a joint which is completely confined into a space and apply silicone and then pack it completely the silicone will never cure. So, it will not fully cure to it is strength and it will not give you the desired properties. So, this is an important criteria to keep in mind that; we cannot we have, we need to have a joint which is open at least one side which is exposed to the air.

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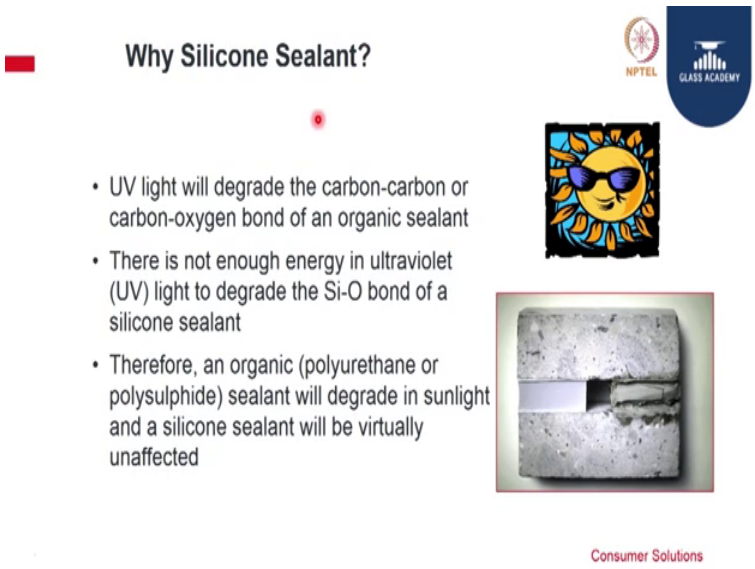

So, essentially we will look at why silicone sealant ok. So, the silicone sealant is essentially why are we looking at silicone here is essentially the when you apply silicone for any external application like a double glass, or weather seal, or a structural glazing, or a panel bonding, expansion joint, firestop, pavement all these applications it is subjected to weathering. So, there is an atmospheric condition where in this is subjected to rain, sunlight sometimes it could be an acid rain or then a lot of humidity involved. So, a sometimes it needs an fuel resistant so there are many, many properties where the product has to you know withstand against weathering.

So, the best part is the UV essentially on the building what you essentially see is there is the sunlight which is falling on the building and it is got an UV component. So, the UV light will degrade those materials which have energy lower than the. So you know UV in

the sunlight energy, so that is now very natural. So, there is an amount of energy which is falling on a particular material. And if that material does not have the strength to hold that energy or resist that it is going to degrade. So, that is what happens with carbon chemistry products. So, the products which are carbon or carbon oxygen are organic sealant.

So, the organic sealant like polysulphide or a polyurethane essentially they do not have a very good durability. I will tell you one simple example; in the automotive industry people used still polyurethane for bonding the windshield, but if you look at the windshield, the windshield has got a black ceramic paint around the perimeter to protect that sealant not to expose to the you know atmospheric conditions.

So, the UV degrades the PU so that is the reason they fretted. So, you do not do that in buildings because what you use is silicone which cannot be degraded by the UV in the sunlight, because the bond energy of silicone oxygen or a silicone is much higher than the UV in the sunlight energy.

So, therefore, you know if you really look at this picture what you see here this the left side is silicone and the right side is a polyurethane. So, when it was subjected to a simple accelerated UV testing the PU completely got degraded, when the testing was done for a hardly 2500 hours. So, this is like you know 3 or 5 years of life whereas, the silicone did not get degraded at all. So, this essentially proves that the product which has to be used for an application like, what we have in construction should have very good long term durability.

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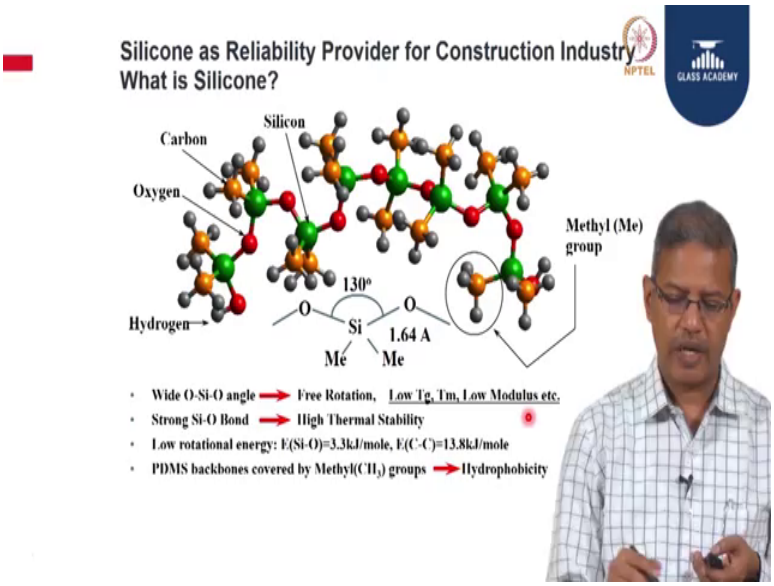

So, this is again you know explaining the structure of the material, you can see that how silicone is you know the bond angle if you really see. The silicone oxygen or the silicone by chains if you see the angle is around 130 degrees. So, this 130 degrees of angle between 2 bonds gives a excellent flexibility.

So, essentially again in construction applications if you see, we need to have some amount of rotation or a free movement which has to be you should have in the product to allow some of the thermal movements. We cannot have a system which is completely rigid holding the glass to the frame and does not allow any movement to happen. If that is so then essentially whichever is stronger that will prevail the other one will break.

So, what is important is you need to have a material which is tough, but also remain flexible and have good modulus to take certain movement. So, that is what it does with the inherent you know chemical structure of the silicone oxygen silicone. And also these are the methyl groups which are on the backbone like a Me what you see here, this imparts could hydrophobicity. So, it is such an excellent material with a beautiful chemistry wherein you get a good long term durability and also you get water resistance. So, this acts as a complete air and water tight seal on applications, wherever we use it for.

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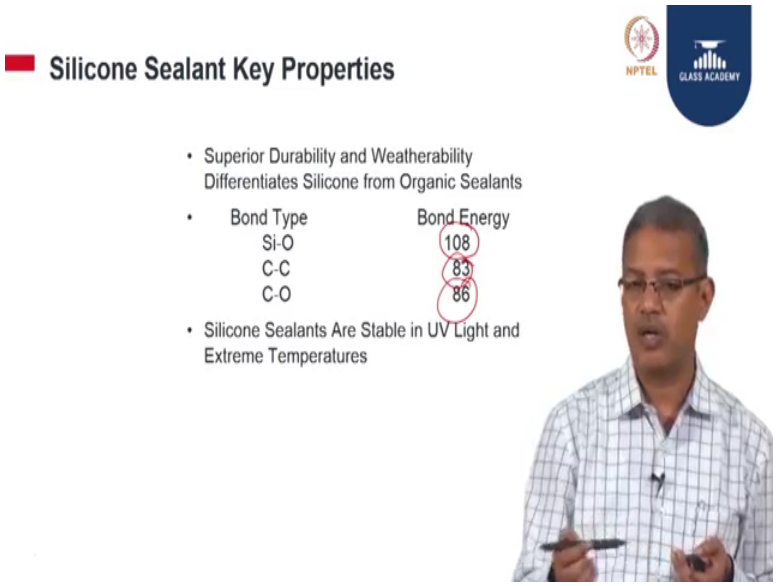

So, this let again talks about the bond energies of different materials and different chemistries. So, the first one is silicone oxygen and you can see the bond energy is 108 kilocalories ok. So, essentially if you look at so this is much higher than the UV in the sunlight energy, which is around 90 ok. So, if you look at carbon or carbon oxygen they are all much lower than the UV in the sunlight energy and that gets degraded so with time.

So, that is the reason you do not get much durability with organic sealants. I know when I started my career some people were initially using organic sealants and there was tremendous failures. I have attended few of them thinking that these are probably silicone and when we really did an analysis, we found that the product was losing out so much oil did not have the durability, it was did not have good bonding and it came out like a gasket.

So and that was a big challenge so the climate like ours we, need to be completely thinking about a long term durability and silicone has proven that and we have cases is running in India for 25 years now. The first building which was done in Mumbai was done in 1992, probably there are some more cases which I am not aware probably done much before that, but the one which I am aware of is already withstanding 25 26 years without any failures.

So, this essentially also proves that the material what is chosen also you know chosen for said application should have good you know durability and the durability comes from the chemistry. And this chemistry which is called as inorganic the silicone is much more durable than the, you know equivalent or other chemistry like carbon. With the carbon chemistries are fantastic they can be used for different applications, but not for the ones what we are talking about in construction.

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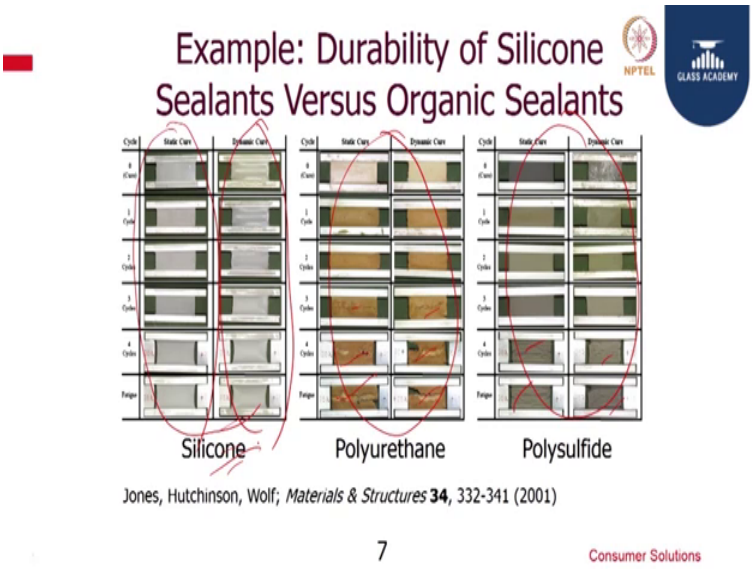

This is one more thing essentially you know I want to stress upon and show you is; the durability of sealant you know in terms of stress behaviour.

All our units if you take a double glass unit there is a there are 2 panes of glass which are bonded using silicone and it has been put on a building facade it is subjected to load. There is going to be a movement which will happen either with the full unit or sometimes within the unit because of the thickness difference. So, what you tend to see is the durability of the seal along with taking the movement is very critical. And if you see the silicone here, the silicone was subjected to you know thousands of cycles on a static as well as on the dynamic cure. So, you make the joint and then cure them and then subjected to movements. You see that there were absolutely no fatigue noticed in different cycles what you have run through.

But if you really look at your polyurethane or polysulfide you can see that there are you know failures everywhere when it is subjected to movement. So, this is essentially what I

am trying to talk about is you have to have a product which is also subjected to movement when the actual use. So, you need to have the product which is much more durable and take some movement. So, silicone is the most sustainable durable chemistry which has proven to be a better in terms of taking the weathering, as well as the you know movement capability.

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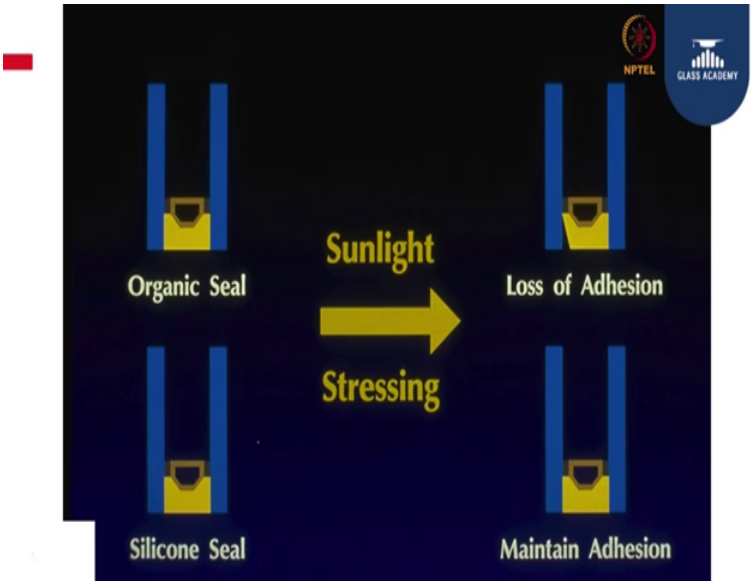

So, these are some of the typical examples of organic seal what happens with sunlight and stressing. So, when you make a double glazed unit and then you subject it to sunlight and stressing you tend to have some adhesion failure. This is essentially happened in some of the sites that where I visited and outer glass has fallen down you know few cases. And this is silicone so it does not get affected so you have the unit remain integral.

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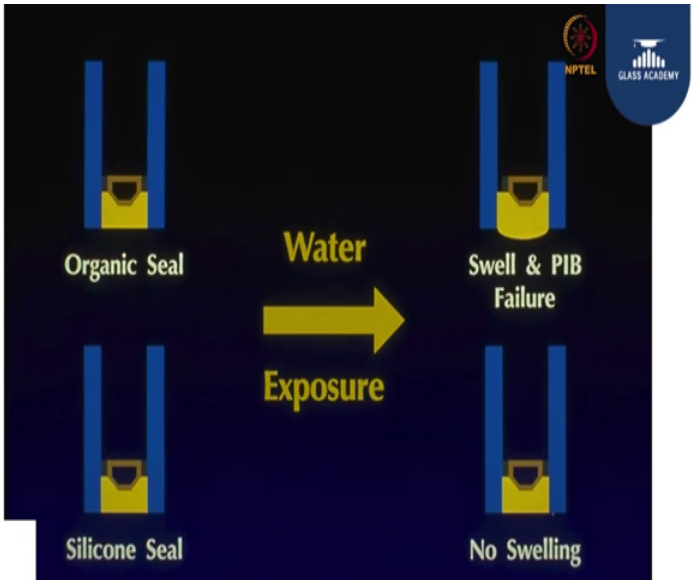

So, we are just talking about the product properties and we will come to the challenges, water are also you know we need to do well get to get a good DGU. It is not only just the product it also essentially talk about the design as well as the application. The second thing is water exposure; when you have an organic seal when you subjected to water they tend to swell ok. This swell when you swell and you try to move the units out and you try to push the you know 2 panes out. Then the primary seal which is not a load bearing member it will tend to fail. Once the PIB fails, what you get is you essentially get a failure of IG and then you get into a condensation. Whereas, silicone seal they remain exactly the same, whether you expose it to water it nothing happens to the product.

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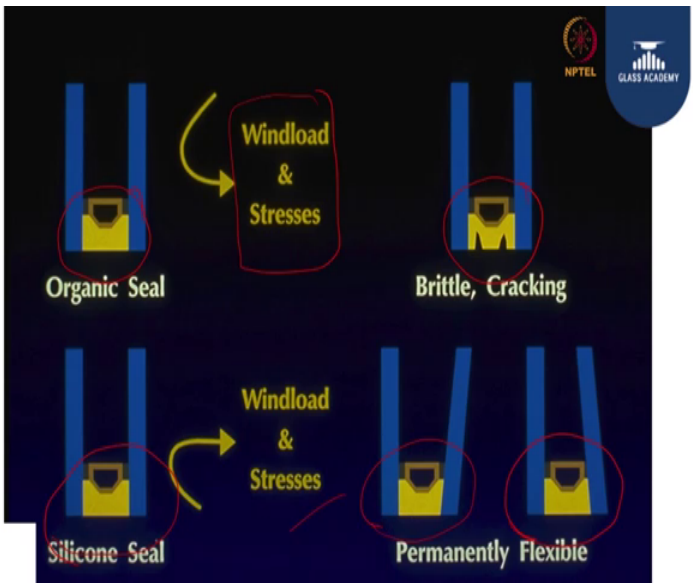

The third thing what we need to also understand is the wind load and stresses. So, all the glasses which are put on the external facades or any applications are subjected to wind load and stresses. You may have some buildings which are straight facade something which are inclined, you know something which has got a different pane thickness. So, everything is subjected to wind as well as the stresses because of the you know pressure, as well as on the dead load. So, there are many loads which are acting on the product.

So, if you take an organic seal here again this will which time it will become hardened it will become brittle and crack. So, whereas, the silicone with wind load and stressors has been proven and this is the you know important thing we need to understand is; it allows the movement to happen either in the form of 2 units moving together this way, or that way because there are some internal deflection which might happen. So, the essentially the seal has to keep them in tight ok. They should not allow the panes to really move. So, differently so it imparts any stress on the primary as well as the on the you know secondary. So, that is what is the beauty of silicone, the silicon sees proves again a better product in terms of chemistry than other chemistries.

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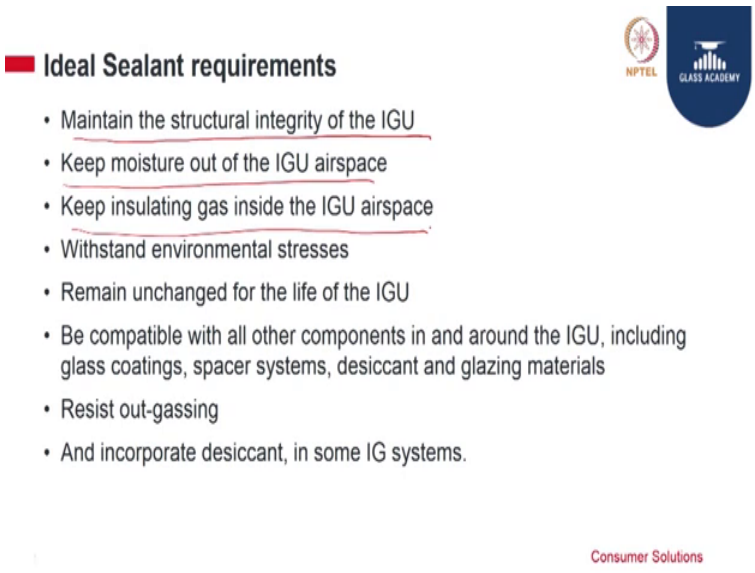

So, what is an idea of sealant requirement; what is that we need for the secondary seal of DGU. So, this is a very essential point to understand. You have to maintain the structural integrity of the IGU. So, that is what is the secondary sealant meant for; it has to hold the panes together and make them act like one and give like a structural integrity. And so, in

doing so and also if you talk about the primary seal, keep moisture out of the IGU airspace.

So, the primary seal should not allow the moisture to come in or the gas not to leak through. So, keep insulating glass inside the IGU you know airspace you have to keep that gas. So, if you have gas filled DGU that gas should not leak out.

So, when you talk about sealant here we are talking about both the seals. So, both the seals together have to work in coherence, so that you end up with a good manufactured quality DGU. And so, environmental stresses there could be temperatures which could be lower and winter, higher and summer, day and night. So, there are a lot of variations so the sealant should not be you know should not have a property which varies with this. It should have a minimal impact because of the environment and keep that stresses designed to take that stresses. So, that it the unit becomes more durable.

Remain unchanged for the life of the IGU, generally the IGU has got it is own life. So, during that life period the sealant should not give away. And what is also important to understand is; when you apply the sealant the sealant primary or secondary they are getting bonded to different materials. It gets bonded to the metal spacer, it gets bonded to the glass coating, it gets bonded to the other accessory materials ok. Like a spacer and then glazing materials. So, sometimes the weather seal comes in contact with that.

So, what is essentially we need to understand is this should be compatible. So, the material which are coming in contact with the sealants they all should be checked for it is compatibility prior to use. And resist outgassing ok, there should not be any outgassing should happen when you make the DGU. And incorporating desiccant is the standard way of doing a DGU today. Now, but there are other methods of doing it wherein we know to we do not need to fill as specific desiccant into the spacer, the spacer comes with the imbibe desiccants. So, there are spacers available with those technology as well.

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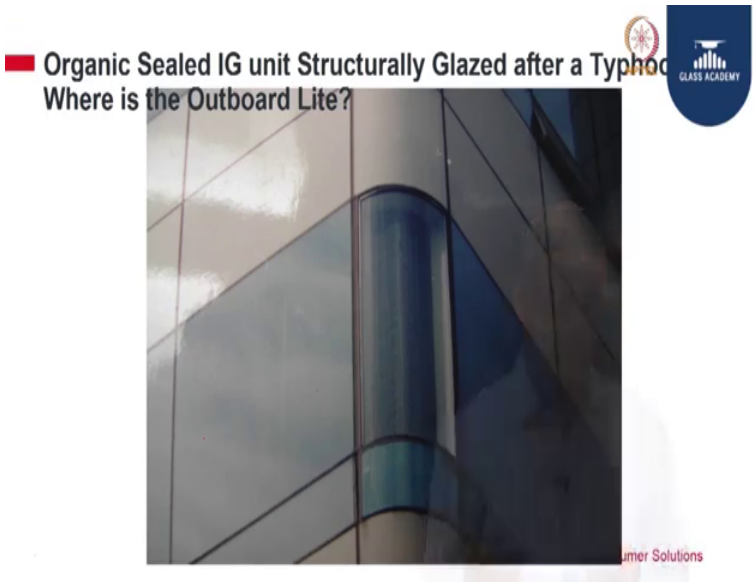

So, this is one of the project wherein there was a typhoon and you know there were corner glasses which were replaced and somebody had replaced it with a you know double glazed unit made with a organic sealant. So, after the typhoon only the inner glass and the spacer remain because inner glass was structurally bonded to the system using silicone sealant. The outer pane which was the DGU which was made with you know organic sealant the outer glass has fallen out. So, I have seen this personally in my experience, on some of the complaints. And I could really see that how this sealants behave when it is exposed to the climatic conditions like what we have. And also the loads and stresses water it is subjected to and also the water.

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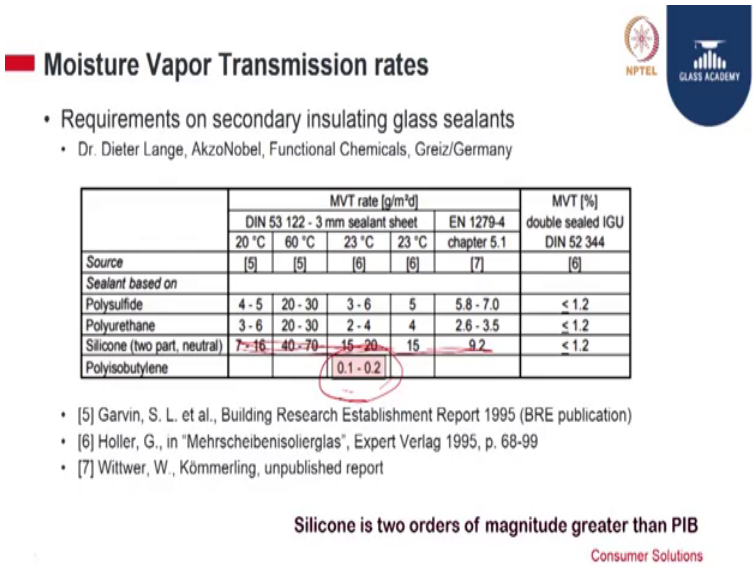

So, what is important also to understand is every product has it is own property ok. Individually they may be having different values, but what is important for us to have a when it is combined together while making the DGU. The unit or the combined system should have the best durability.

So, if you see here this is an moisture vapor transmission rate. So, you know the silicones have higher moisture vapor transition transmission rates so; that means, the moisture can pass through and then that is the way it cures if I if you remember my you know initial discussions on the curing, I said the moisture enters and it cures. So, it these are all permeable to moisture to a certain extent, but if you really see at a temperature of 20 degrees and the temperature of you know room temperatures. If you see also the high temperatures, the difference between the organic and the silicone ratios gets reduced. You know because organic sealants tend to behave differently with different temperatures. In a more larger you know extent compared to silicone.

So, but if you really see what is the best seal which has got the lowest moisture vapor permeability is the polyisobutylene ok. So, a system made with the best possible the secondary seal which is silicone and the primary seal PIB gives you the long term durable you know or DGU. So, individually you may have some values of organic sealants shall good and moisture vapor transmission rates.

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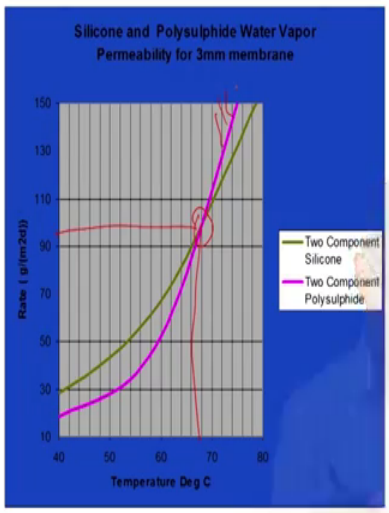

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But when it boils down to a combined unit; if you see this slide, so, though the values we saw that were like in multiples, but when you make a DGU. So, this was done when a DGU on subject a 3 millimeter membrane and it was subjected to temperatures. You can see here at this temperature the already the polysulphide has B 10 silicone and it started observing more moisture.

So, so the individually you may have a product or a chemistry which is good, but when you make it as a DGU, what happens to the long term performance when you subjected to temp. This is not un unusual, you know if you have an air temperature of 30, 35 or 40 degrees, which is very common in India and multiple locations. The surface temperature of the glass really goes up very high it could be 20, 25 30 degrees difference. So, the 65 is not very, very uncommon it is very common in India.

So, you tend to see that already the organic system has taken over the silicone because, silicone as I mentioned to you the variation the when properties because of climatic and atmospheric conditions are very, very minimal.

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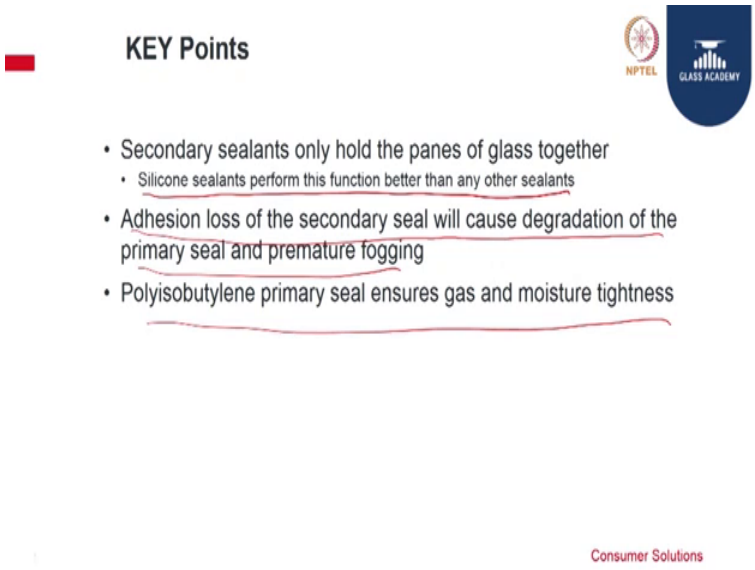

So, what is the key point? What is that we need to take away from this discussion is. Secondary sealants hold the panes of glass together. So, they are essential to structurally hold them. And silicone sealants perform this function better than any other sealants. So, we have seen n number of tests n number of experimental results, showing how silicone outperforms other materials.

Adhesion loss of the secondary seal will cost degradation of the primary seal and premature fogging. So, any other chemistry which can lead to adhesion loss if there is an adhesion loss in the secondary seal; that where the load will come on to the primary seal and it will fail and there will be premature fogging. Primary seal ensures gas and moisture tightness. The moisture as well as the gas leakage is has to be arrested by the primary seal because that has got the best moisture vapor transmission rate which is very, very low.

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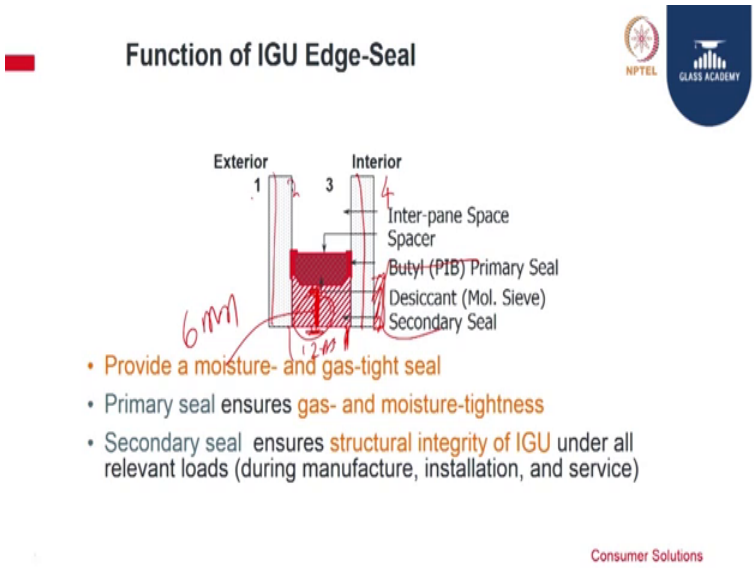

Now, we will come to the function of an IGU edge seal. So, I am going to talk about essentially the secondary seal, as well as I know how it has to be done and what other tests needs to be done while making the DGU. And I know and what are the good quality control exercise we need to do for the material as well as for the finished product.

So, these are like if you look at here the exterior glass this interior glass, the classification is the exterior side is called as 1, the inside is called as 2 and the third and this is the inside is 4th. Normally, in most of the commercial buildings or some of the high end hotel or institutional or nowadays on the even the residential building. This entire DGU gets structurally glazed where the structure of silicone will be applied here and then bonded to the aluminum frame.

So, here we if you look at these 2 are panes and this is the metallic spacer which has got a deccant filled in. And the butyl is applied to the edge of the spacer bonding the spacer to the glass and then keeps a spacer in place and this spacer provides rigidity to the DGU in terms of you know keeping the panes. And the secondary sealant here is the one which provides you the structural integrity of the IGU. Under all relevant loads whatever is a load you have and the secondary seal bite is always measured from here. Ok this is the bite and this is essentially minimum is 6 millimeters. And this is the airspace normally this is 12 and it depending upon the, depending upon the conditions in the requirement this varies to you know different air gaps.

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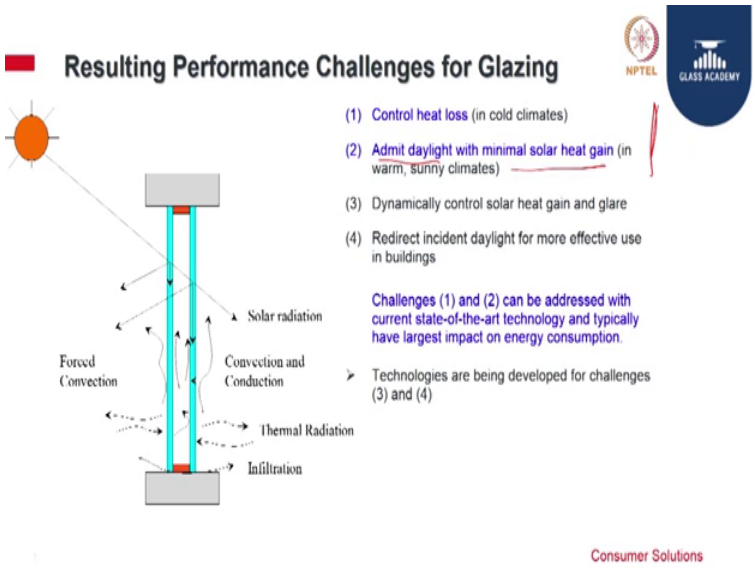

So, resulting performance challenges for glazing what do we do? We use DGU to control heat loss in cold climates these are retain the heat. So, which is exactly opposite to what we do it here and in our country like which is warm and sunny and tropical we admit daylight with minimal solar heat gain.

So, the selection of the glass definitely I am sure that the glass manufacturers would have given you enough, you know knowledge about the type of glass to be used for a climate like what we have here. So, I will not go into that detail so here you need to have a convection and conduction thermal radiation solar radiation. So, you have all these factors which happens on a DGU and 2s are coating in such a way that you get the minimal solar heat gain and also the admit the daylight.

So, there are other things which are working on dynamically control solar heat gain, glare and redirect the incident sunlight more effective rather than just making an island effect. So, there are work happening around the point 3 and 4 whereas, the 1 and 2 is almost, you know the manufacturers of glass along with the system guys, like the sealant manufacturers and then the other you know fixing manufacturers have almost addressed that 1 and 2 to a large impact large larger effect.

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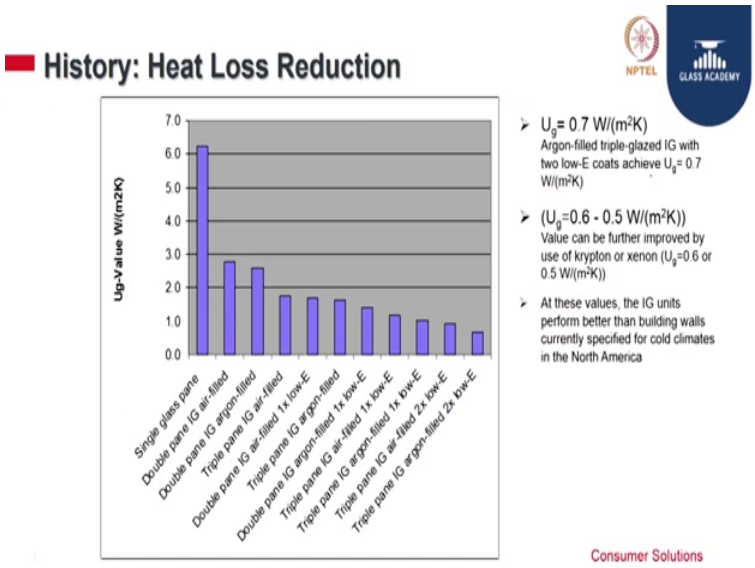

So, you know this is just to give you a brief on how the U value changes with the different composition in a DGU. So, the single glass pane will give you the highest U value it will be more conductive. So, the function of having a DGU is to reduce the thermal conductivity. So, the U value gets reduced, but you have a solar heat gain which has to be also taken care of by using a proper coating on the glass.

So, just by doing a double glass this gets will a more than you know half. So, this gets reduced by half so you get less conductivity. So, by doing different combinations of triple, low E coating, gas filled and then argon or a krypton, so you can do a combinations of that. Like you know you can look at when I say combination, you can have a low E coating with an argon or a low E coating with a krypton and then and then different types of low E coating single double and then different types of double and triple panes the U value can be reduced. So, today the U values are achieved to the best and which are essentially good for you know cold climates. And then also some (Refer Time: 29:56) for our own climates, but what is important is U and the solar heat gain both go hand in hand.

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