Experimental Stress Analysis
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Lecture – 34
Bonding of a Strain Gauge

In the earlier lectures, we have looked at in sufficient detail, the various constituents forming a strain gauge system, the knowledge of the strain gauge alloy, the carrier and the type of adhesive used is very important from the point of view of how to select a strain gauge. I have also mentioned in strain gauge analysis, when one wants to perform a experiment using a strain gauge, once selects a strain gauge rather than designing a strain gauge.

For the selection of strain gauge, we have looked at what is the kind of designation system used by 2 different manufacturers and we have also seen a variety of gauge patterns possible when you are using a metal foil for making a strain gauge, you do it by an etching operation, this gives you flexibility in designing even complex strain gauge patterns for special applications. We have looked at what are the general guidelines to select a strain gauge.

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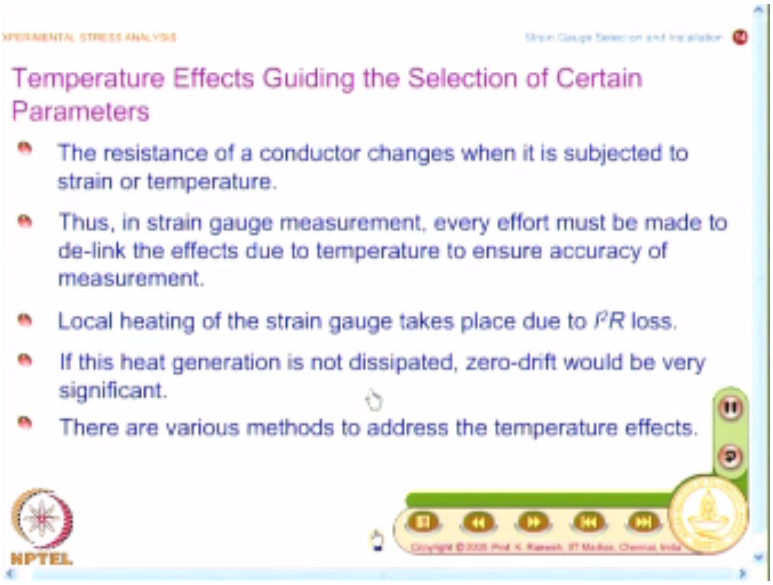

We have seen about 5 to 6 steps, we will continue in that direction and I have always been mentioning temperature effects have to be handled carefully in strain gauge technology. Though I have mentioned it several times, is no harm in mentioning it again and we will also have to look

at how the temperature effects guide the selection of certain parameters. The basic idea is the resistance of a conductor change, when it is subjected to strain or temperature.

And the question of temperature change, how does it come on a strain gauge? Local heating of the strain gauge takes place due to I square R loss, so this is a very, very important aspect and a very subtle aspect too, you have a local heating, though it is small, whatever is the heat generation that needs to be dissipated. If we do not dissipate, zero drift would be very significant in your strain gauge measurement.

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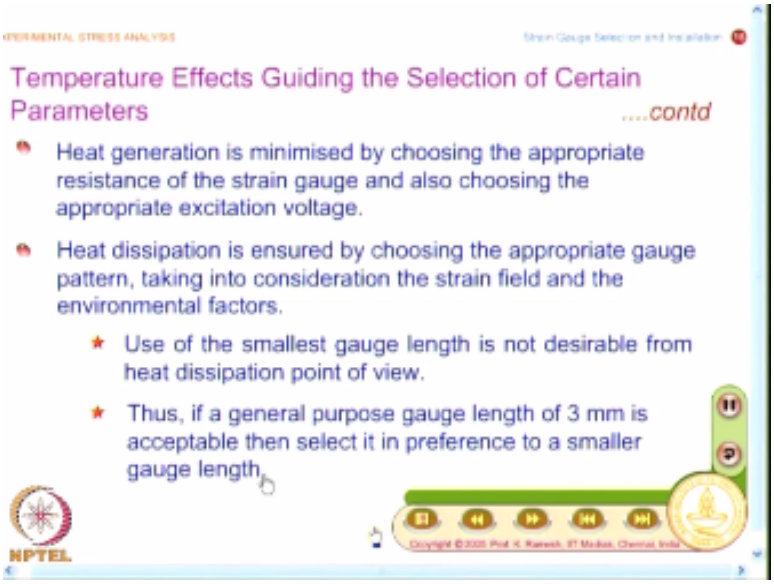

And we have looked at there are various methods to address the temperature effects and that also guides in a way how to go about in selecting a suitable strain gauge. So, the idea is what; you need to have the heat generation to be minimised. How do I minimise the generation of heat? You can choose an appropriate resistance of the strain gauge and also choose the appropriate excitation voltage.

In 2 or 3 classes before, we have looked at how to select the bridge excitation voltage, we also had a discussion on allowable power density and all those information guide, how you can modify the bridge excitation voltage, so that you minimise heat generation. So, handling the temperature effects has 2 components; minimise the heat generation and improve your heat dissipation.

You can improve the heat dissipation by choosing the appropriate gauge pattern, you know we have looked at when you are using a strain gauge rosette should you go in for stacked rosette, they are very appealing when you want to find out strain at a point of interest but from heat generation point of view, it generates more heat and also dissipation will be cumbersome in such situations.

On the other hand, if I have a larger grid pattern, it improves heat dissipation. So, use of the smallest gauge length is not desirable from heat dissipation point of view, so you may be tempted, I want to do strain measurement at a point of interest, let me go and select the smallest gauge length possible that kind of an approach is not good, when you look at heat generation and heat dissipation aspects.

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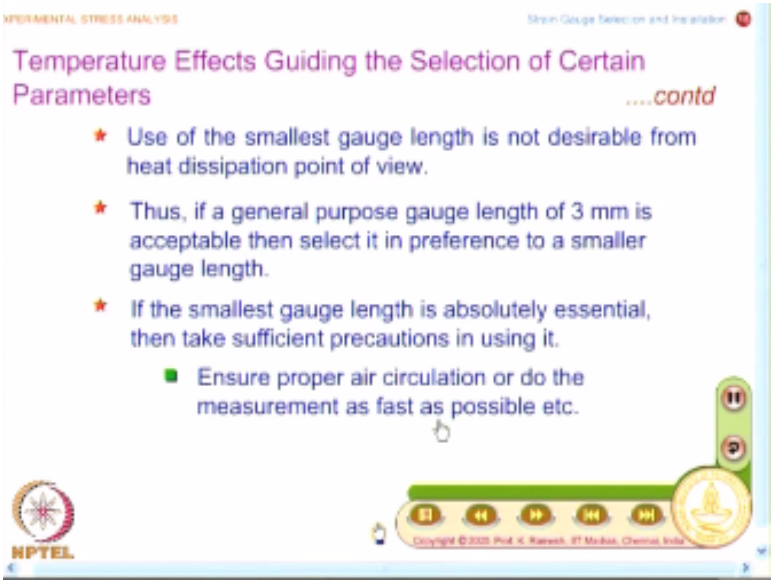

So, if a general purpose gauge length of 3 mm is acceptable, select it in preference to a smaller gauge, so this is a recommendation. So, you need to go in for selecting a longer gauge length from heat dissipation point of view there what you would normally do if you are not exposed to strain gauge technology. On the other hand, if the smallest gauge length is absolutely essential, then take sufficient precautions in using it.

You need to know the drawbacks when you use a smallest gauge length and you need to take extra precautions to avoid problems due to heat generation or dissipation. So, the idea here is ensure proper as circulation or do the measurement as fast as possible etc. Because, if the measurement is done quickly, then temperature effects would not be that significant, so the idea is do not go and jump and demand that you will use the smallest gauge length for strain measurement.

And I also said from optimising a number of channels, do not also go and demand that you will use a rosette every point in the domain, depending on the knowledge of the stress field, use a single element strain gauge, 2 element strain gauge or a 3 element strain gauge judiciously. So, these are the ways that you will minimise the entire cost of your strain gauge instrumentation.

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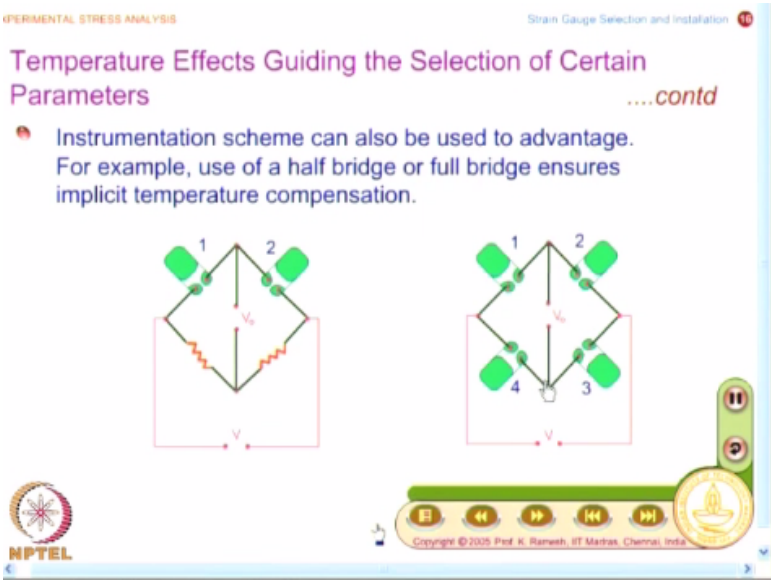

We have also seen that instrumentation scheme can also be used to advantage in handling the temperature effects. So, if you use a half bridge, whatever the temperature changes happen in arm 1, will be cancelled by temperature changes in arm 2, if both the strain gauges are exposed to similar temperature levels and a similar advantage, you also have, when I go for transducer applications where one invariably uses a full bridge configuration.

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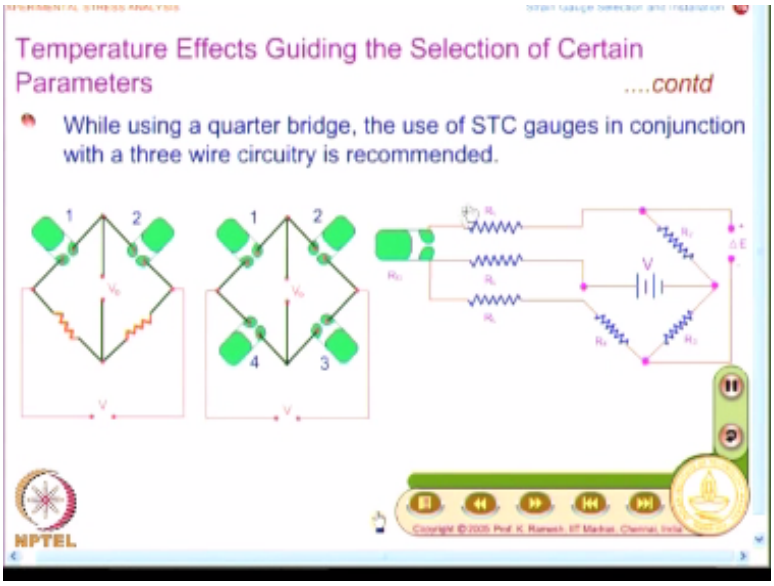

So, the advantage is; there is you maximise the signal 4 times and also has intrinsic temperature compensation but we have seen in many applications where you are interested in strain measurement, you may end up using only a quarter bridges. So, how do I do, when I have quarter bridge arrangements? We have seen how to minimise the error, when we use a quarter bridges instead of 2 wires circuitry, go for a 3 wire circuitry.

If you are able to use a half bridge, it is good, able to use a full bridge; it is well and good from transducer application point of view. From strain measurement, you will be able to do this only for certain select applications but most general arrangement what you may come across is only a quarter bridge, instead of using a 2 wire circuit, use a 3 wire circuit. We have seen the benefits for this, even while you use the 3 wire circuit, go in for a STC gauge suitable for the base material.

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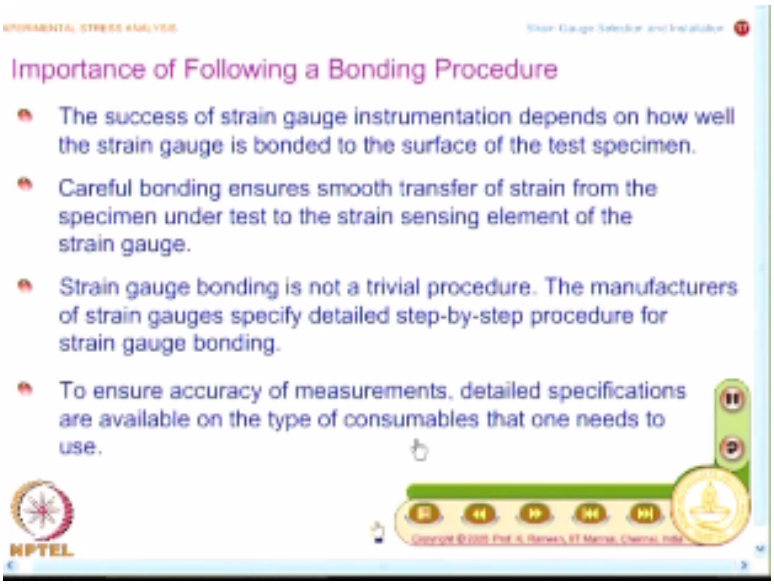

You should not mix up the STC gauges meant for aluminium, you should not paste it on steel, you should select the STC gauge meant for aluminium separately and also for steel separately and use it carefully. Now, we have all selected the strain gauge for our given application, the next important step is to bond the strain gauge to the specimen concern and this is a very, very important step.

Though, the steps require detailed preparation of the surface, bonding, alignment, soldering, etc., one needs to learn the steps carefully and also follow the steps that we discuss, if you miss out as I have mentioned in strain gauge technology, we are measuring very small quantity, every small action that you are supposed to do has an influence on the final performance of the strain gauge system.

And that is the reason why this is titled as importance of following a bonding procedure. So, the basic idea is the success of strain gauge instrumentation depends on how well the strain gauge is bonded to the surface of the test specimen. It is a very important step and what is the advantage of careful bonding? This ensures smooth transfer of a strain from the specimen and their test to the strain sensing element of the strain gauge.

And do not think that strain gauge bonding is a trivial procedure and if you look at the manufacturers of strain gauges, they specify detailed step by step procedure for strain gauge

bonding and what is the focus? You would like to maintain a certain level of confidence in the measurement of strain gauges; you want sufficient accuracy to be maintained. If you want sufficient accuracy, then all the steps are very important.

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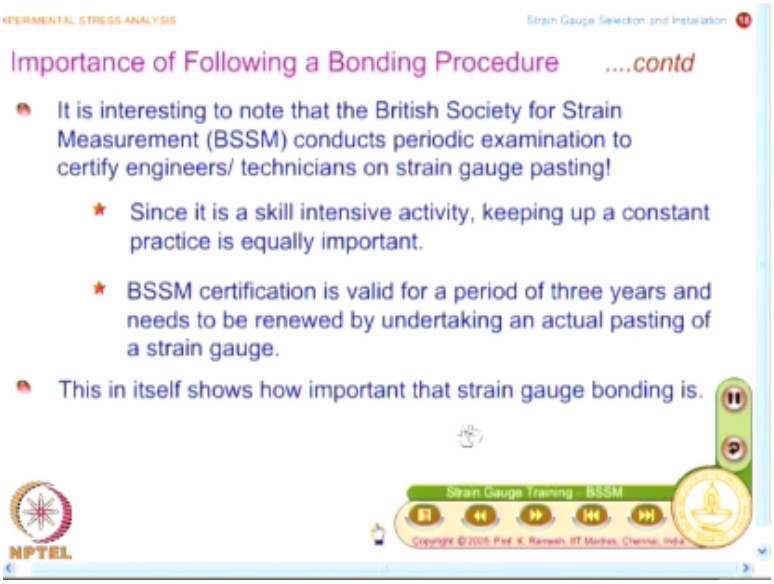

So, to ensure accuracy of measurements, detailed specifications are available on the type of consumables that one needs to use in surface preparation, bonding etc., so, it is not trivial and you have the follow the recommendation and this is very important to note that the British Society for strain measurement conducts periodic examination to certify engineers or technicians on strain gauge pasting.

See, unless the process is very important, you would not find a professional society to conduct examinations of this nature. The very fact, a professional society conducts an examination indicates how important strain gauge bonding procedure is and you should also note that it is a skill intensive activity and any activity that involves skill; you need to keep doing it. So, keeping up a constant practice is equally important.

And I have noticed that BSSM certification is valid for a period of 3 years and needs to be renewed by undertaking an actual pasting of a strain gauge, so you need to renew it every 3 years. So, the examination automatically tests your skill, have you been pasting strain gauges and

do you know nuances of it and are you able to make for simple problems, the results from strain measurement matches closely with the analytical or numerical solution, it is available.

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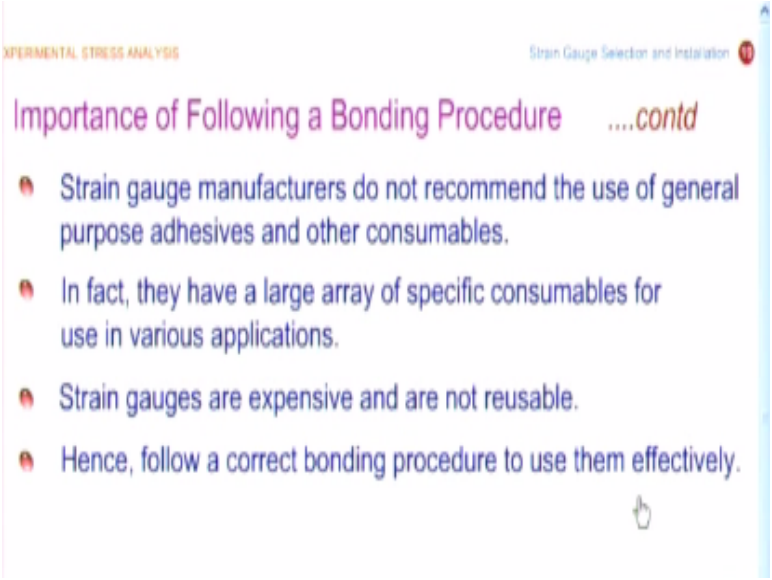

So, the very fact, a professional society conducts an examination and makes that the certificate is valid for a period of 3 years shows how important the strain gauge bonding is and if you look at the strain gauge manufacturers, they do not recommend the use of general purpose adhesives and other consumables. For strain gauge instrumentation, you should go in for specific adhesives and other consumables like a cellophane tape, we will see later.

So, you need to look at whether this has been recommended by the strain gauge manufacturer and you should also keep in mind, strain gauges are expensive and they are not reusable. So, you do a faulty bonding is not that you remove the strain gauge and restart the procedure of bonding, it is not possible, the moment you paste it, the strain gauge is lost and it is expensive. So, this emphasises the need for following a correct bonding procedure.

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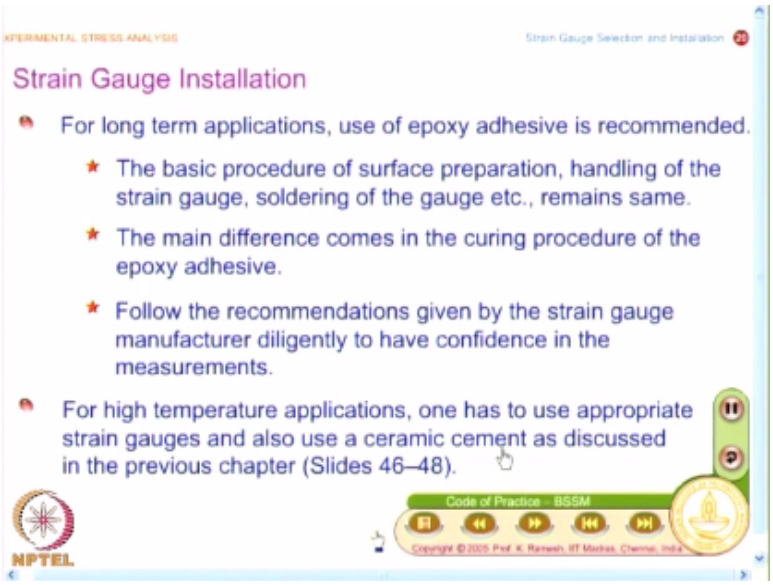

So that, you use them effectively, so what do you want to do is; we will look at how to do strain gauge installation and essentially I will be discussing how to paste a strain gauge using a quick curing adhesive such a cyano acrylate and whatever we discuss, this is also extendable to epoxy adhesive, the difference is in the epoxy adhesive. The basic procedure of surface preparation, handling of the strain gauge, soldering of the strain gauge etc. remain same.

And a general advice is; follow the recommendations given by the strain gauge manufacturer diligently to have confidence in the measurements. So, the focus is that I must have confidence in the measurement and confidence comes only when the strain gauges perfectly bonded on the surface and for perfect bonding, you need to follow a procedure and we will see even minute details, which are required in looking at various aspects of surface preparation, bonding, soldering, etc.

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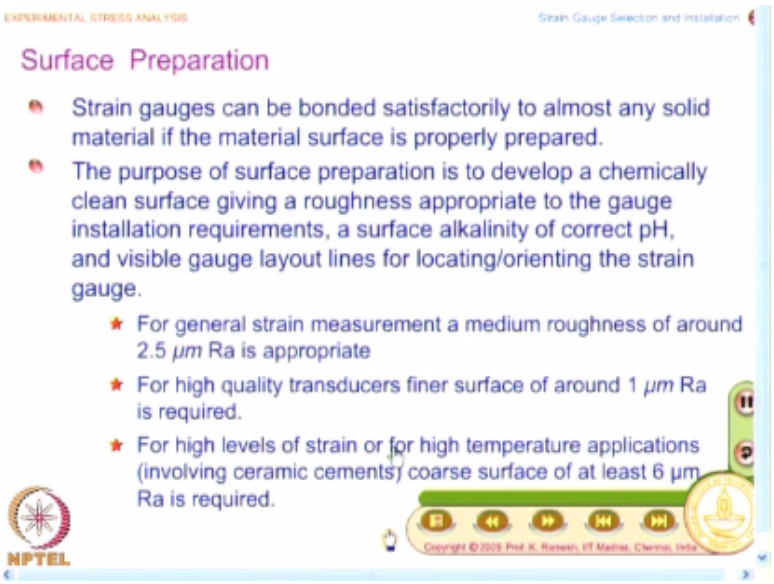

And for high temperature applications, one has used appropriate strain gauges and also use a ceramic cement as discussed earlier, you know we have discussed that separately and here, we are only going to look typically for a room temperature measurement using a cyano acrylate cement, how do I paste a strain gauge, so that gives an idea what are the basic steps involved and the first and foremost step is surface preparation.

And if you look at strain gauges can be bonded satisfactorily to almost any solid material, if the material surface is properly prepared and what is the focus of surface preparation? I have to know the the focus, then you will be able to appreciate the procedure involved. The focus is to develop a chemically clean surface giving a roughness appropriate to gauge installation requirements and the other aspect is; you also want to maintain a surface alkalinity of correct pH.

This ensures perfect bonding, so you need to maintain this. In addition, you also need visible gauge layout lines for locating or orienting the strain gauge. See, this is very, very important, when you say in an actual structure, I want to measure strain, how I have pasted the strain gauge at the point of interest matters, so I must align it appropriately, because strain gauge essentially gives you component of strain along the gauge length.

If you have a misalignment, you will measure only strain along the direction, it cannot be interpreted to your direction, then you have to do a strain transformation law. For strain

transformation law, you need to have pasted a strain rosette at the point of interest. So, strain gauge alignment is very, very crucial, it is not trivial. So, that is the reason, why you have the strain gauge carrier comes with markings on it.

And when you look at the kind of roughness, it varies. For general strain measurement, a medium roughness of around 2.5 micro meter is appropriate. On the other hand, if I go for high quality transducers, you need a fine surface of around 1 micro meter, however if you are going to measure high levels of strain or for high temperature applications, your coarse surface of at least 6 micro meter is required.

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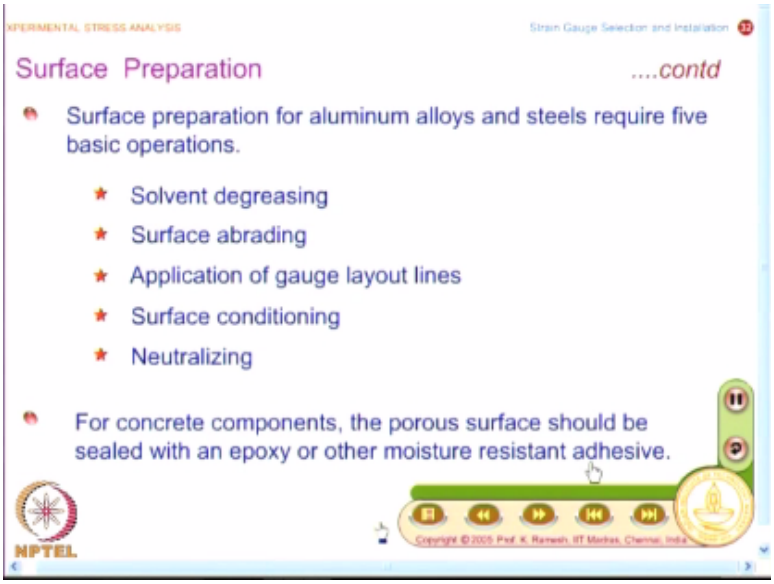

You know, before we get into the detailed steps, you need to know why we do this, we want a chemically clean surface, we want an appropriate roughness and we also maintain alkalinity of the surface for proper bonding and we also need layout lines. So, this specifies; what are the various steps that we may have to come across and if you look at for aluminium alloys and steels, the surface preparation required 5 basic operations.

So, it depends on the base material, so the steps are solvent degreasing, surface abrading, application of gauge layout lines, surface conditioning and neutralising. On the other hand, if you look at concrete components in addition, you also have to ensure that the porous surface be

sealed with an epoxy or other moisture resistant adhesive, so this is the kind of special requirement when you want to go and work on concrete.

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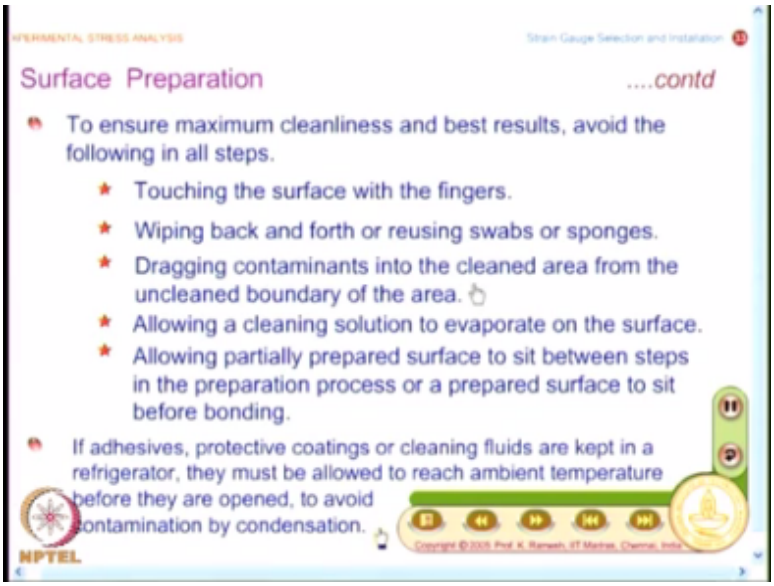

And when you go for plastics or composites, you have to try out the various steps recommended by the manufacturer and follow the recommendation after standardising the procedure. We are only going to look at how to paste a strain gauge on an aluminium surface, it is a very simple one that gives out the various steps and you get an idea, how to go about in general and there are also general recommendations.

You know, you would like to maintain cleanliness of a high order and in order to get that you need to avoid the following steps. In various steps of strain gauge bonding, you may do one or the other aspects to be focused and if you avoid these, you are assured of maximum cleanliness. So, the first aspect is; do not touch the surface with the fingers and you should not wipe back and forth or reuse the sponges.

You know, normally you would like to economise and you may have a (()) (24:34) that why not a use a same thing but you should keep in mind these are less expensive, a strain gauge is very expensive, so ultimately, you want to minimise cost by making a proper installation with one strain gauge, you do not lose strain gauges and then worry about small consumables, so liberally, use these consumables.

Other aspect is you should not drag the contaminants into the cleaned area from the uncleaned boundary of the area. So, this you will have to take care as you do each one of the steps and when you look at conditioner or neutraliser, they are all liquids and these liquids should not be allowed to evaporate on the surface. So, when they evaporate daily the residue, you would say that the recommendation would be to wipe it dry with the sponge.

You should wipe it dry rather than allow it to evaporate, if you allow it to evaporate, you will have residual thin coating formed on the surface and another important aspect is; you should not allow partially prepared surface to sit between steps in the preparation process, that means you should keep everything ready, you should know what is the first step, what is the second step, what is the third step, etc, you should not sit between the steps.

And also once the surface is prepared, you must also bond the strain gauge immediately that is what is mentioned here. You should not have the prepared surface to sit before bonding and that is also another very practical suggestion, see, when you buy an adhesives or protective coatings or cleaning fluid, they all have shelf life and in order to improve your shelf life, you normally keep it refrigerator.

And this a very subtle point, when you take these fluids from the refrigerator, you should not use it directly, you should not open the lid immediately. They must be allowed to reach ambient temperature first and only then, you should the open the lid and this is necessary to avoid contamination by condensation. See, only one good experimentalist will follow all this procedure. So, this also indicates an experimentalist have to be systematic and patient.

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It is not that you go, quickly take the adhesive and then quickly go and do the same gauge bonding, you do not do it like, you have to follow a procedure you have to be systematic. The reason is; you are measuring very small quantities and perfect bonding is a must, it is not a trivial step and this shows, what is the strain installation kit; you have a verity of fluids for cleaning, for catalyses, for adhesives.

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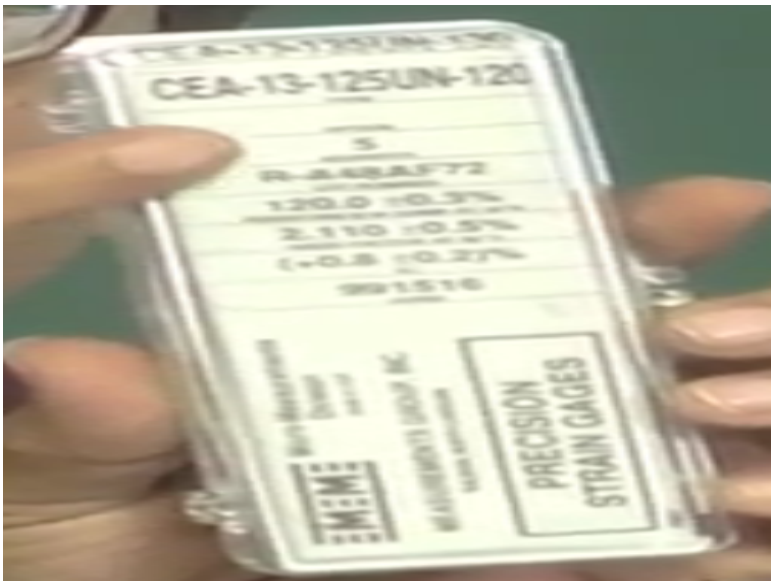

You have the special type of single strand wire to connect the strain gauge the terminal, you have soldering iron and you have the strain gauge available in a packet and I want to show you this. You know, the strain gauge box comes with all the details, you have what is the specification of

the strain gauge, designation and you have the information about the resistance, you have information about the gauge factor, you have information about the transverse sensitivity.

And you have is available in a nice box and when I open it, you know, it is also preserved like this, so all this shows how important a strain gauge is and each strain gauge is available in a package like this, you have acetate cover, so we will see how to go and open it later. So, the manner in which the strain gauge is packed shows, how important and expensive and delegate the strain gauge is.

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And we are going to take a simple cantilever beam for us to do the strain gauge bonding.

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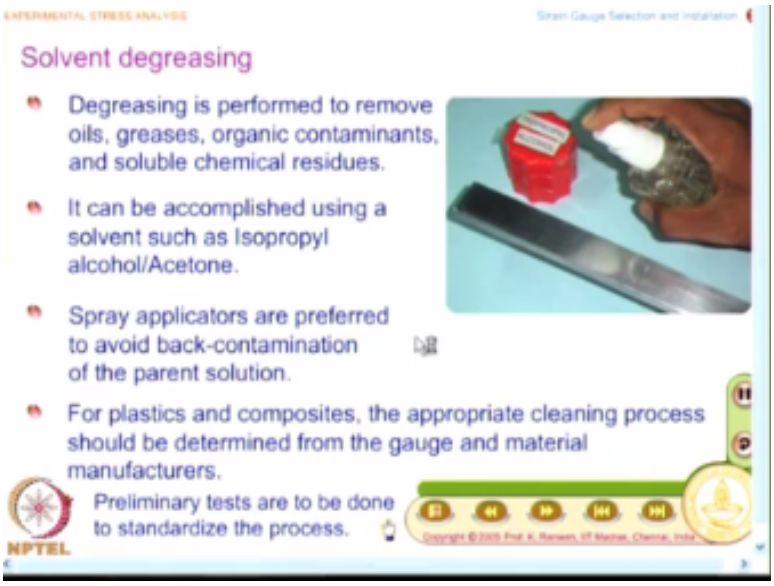

And what is the first step? The first step is solvent degreasing, so why I do this? Degreasing is performed to remove oils, greasers, organic contaminants and soluble chemical residues and here again, you have a very subtle point mention; I am going to clean the surface, the recommendation is you have the cleaning liquid in a sprayable type of container. So, if you spray the cleaning liquid, the parent liquid is not contaminated. Though it is a simple step, attention to details is very important.

So, you can do the cleaning by isopropyl alcohol or Acetone and as I mentioned earlier, spray applicators are preferred to avoid back contamination of the parent's solution and you know, composites and plastics are becoming important, you need to learn the appropriate cleaning process from the strain gauge and material manufacturers. Those are not listed in our discussion in this class but you need to learn it from the strain gauge manufacturer.

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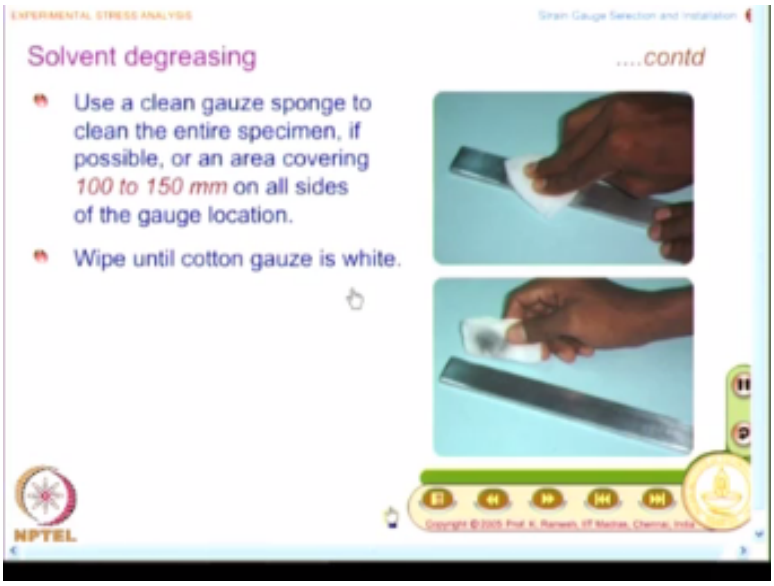

And you need to perform preliminary tests to standardise the process and I said that you should use sufficient the amount of consumables, you should not be stingy in that because your focus is to save the strain gauge, which is expensive and you know, I have this and then I clean it a gauze sponge and you will be surprised to see the surface was looking alright but when I see that gauze sponge, I see that as black.

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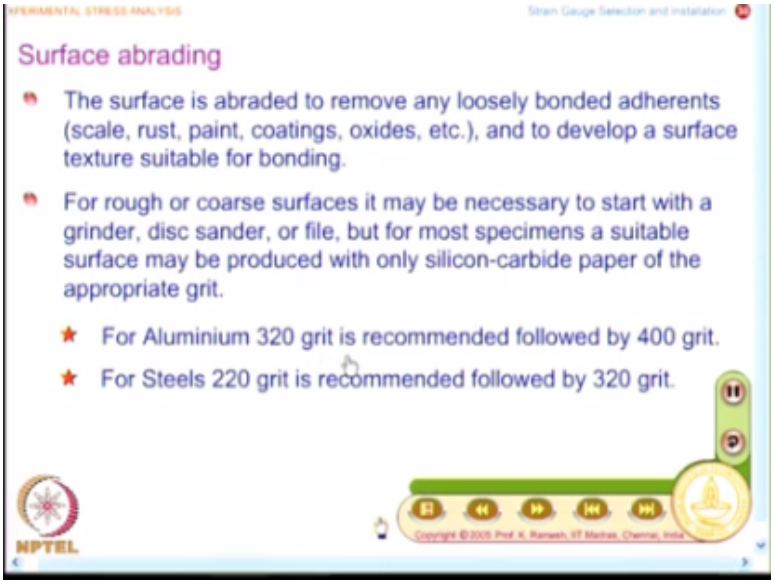

So, you need to keep using new sponges until the cotton gauze is white, so use consumables liberally, so now you have removed the grease, the next step is surface abrading and why do you do this? The surface is abraded to remove any loosely bonded adherents and to develop a surface

texture suitable for bonding. If you have a rough or a coarse surface, it may be necessary to start with a grinder, disc sander, or file.

But all that is not required for more specimens, a simple silicon carbide paper of the appropriate grit should be sufficient. See, we have looked at; I need to maintain certain level of surface roughness for effecting the strain gauge bonding and there are specific recommendations. If you go for aluminium, you how to go for at 320 grit for initial abradation, then followed by a 400 grit.

And if you look at a 400 grit, would be much finer than 320 grit that is how these are numbered, on the other hand, if you go to steels, you should start with a 220 grit followed by a 320 grit. See, it may appear very simple, you may think why one has to follow such details, that is what I said you need to maintain a certain level of surface roughness and strain gauge manufacturers have tested a variety of options.

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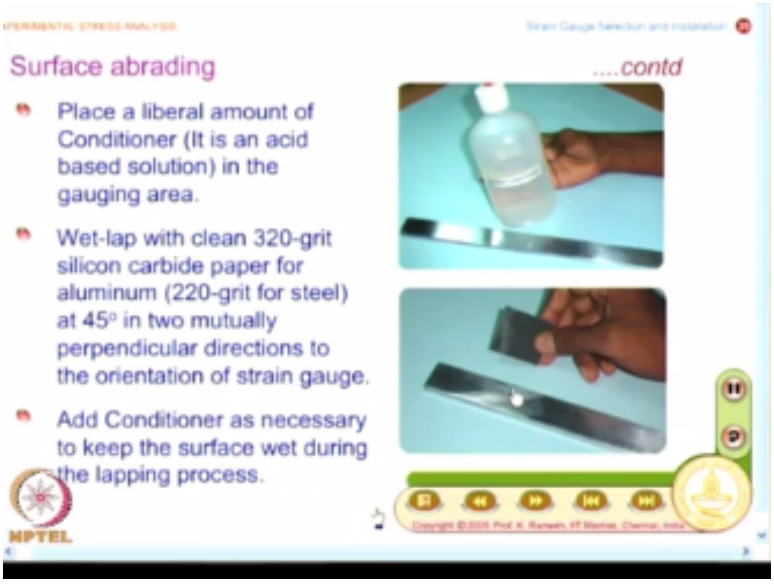

And finally, whatever the understanding that they have got they have listed it as a sequence of steps, respect those steps and recommendations and when you do this also, you need to have a wet lapping process to be done. So, you need to put a liberal amount of conditioner, which is an acid base solution in the gauging area and here, you are not testing your muscle power and go and rub the surface with full force, that is not what is anticipated.

What is anticipated is; prepare a surface which has sufficient roughness and what they say is; you have the 12 strokes at 45 degrees and another 12 strokes at – 45 degrees would do for preparing the surface and you have to maintain the conditioner as necessary to keep the surface wet during the lapping process and other important aspect is you should not allow the conditioner to evaporate.

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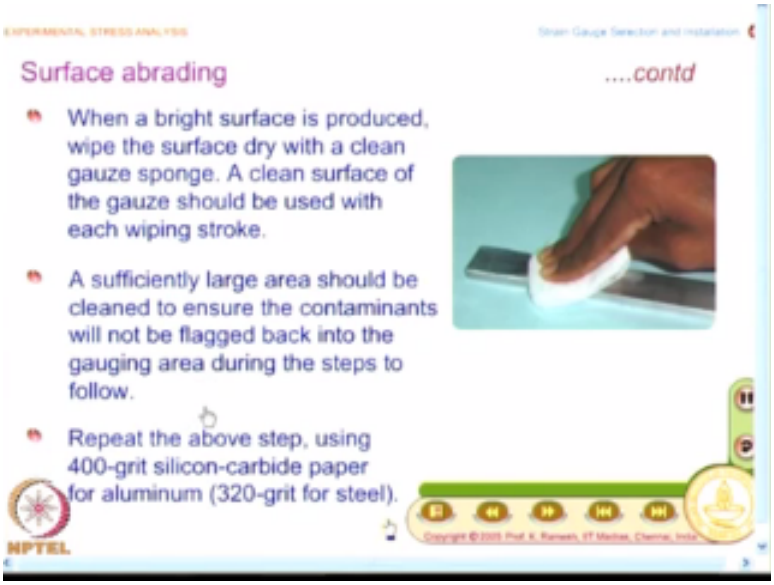

If you allow the conditioner to evaporate, then it will form a thin residue. Now, this is the recommendation, so when you get a bright surface; wipe the surface dry with a clean gauze sponge, so you need several pieces of gauze sponge before you start the installation. A sufficiently large area should be clean to ensure the contaminants will not be flagged back into the gauging area during the steps to follow. See, this is very important.

This is one of the initial cleaning process; the initial cleaning process should be on a larger surface, finally, you may want to do strain gauze only on a small localised area but in the process of cleaning, you should not bring in contaminants from outside the area and whatever you have done earlier, you have to repeat it using 400 grit silicon carbide paper for aluminium or 320 grit for steel.

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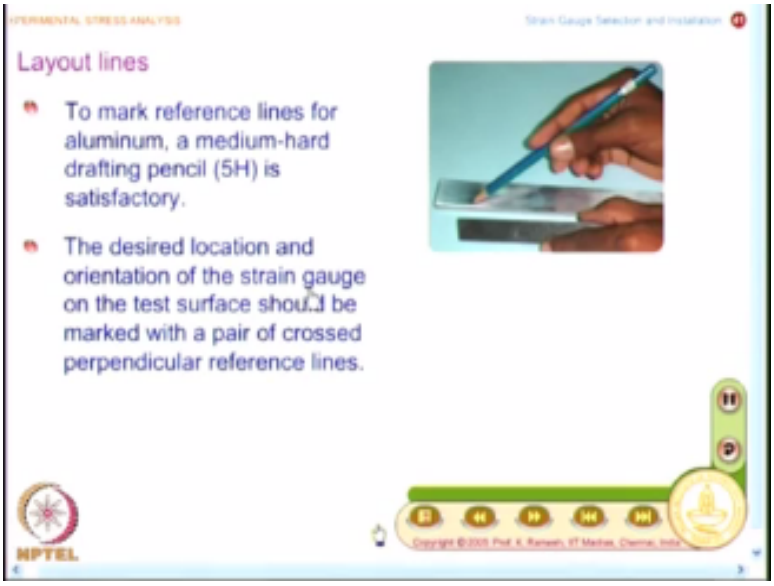

And the next important step is to put the layout lines and to mark, you can even use a drafting pencil for aluminium but for steel and other the materials, graphite pencil is not recommended, we will also see that. So, the idea of putting the layout lines is to mark the desired location and orientation of the strain gauge to be pasted. So, if you look at a strain gauge strain, gauge comes with the carrier, which has marks.

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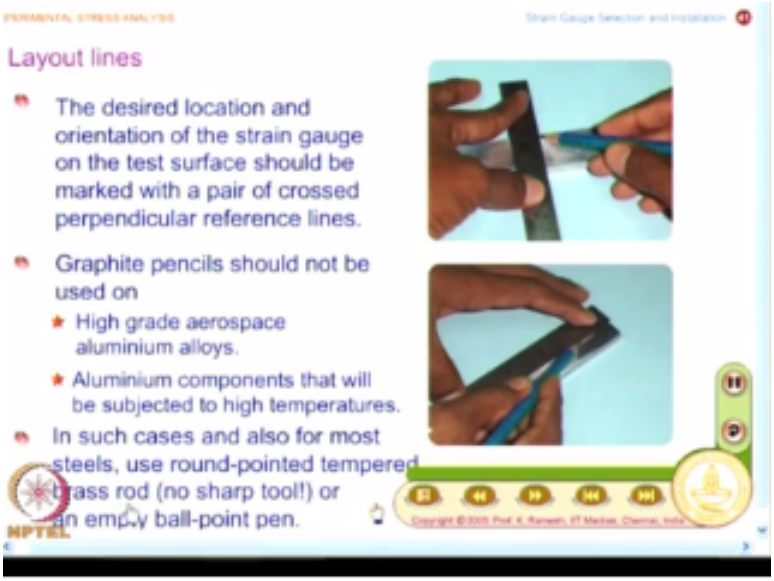

So, these marks have to be aligned at the point of interest for you to align the strain gauge, you need to have layout lines. So, you put a perpendicular line and as I mentioned earlier, you cannot use the graphite pencils on high grade aerospace aluminium alloys or aluminium on components

that will be subjected to high temperatures. Though in the class, you might have used a simple graphite pencil.

Because you worked aluminium, which works at room temperature, this is acceptable. So, if you have to use for these materials, you will need to go for a round pointed tempered brass rod that is what is recommended and this can also be used on steels. In the extreme case, you can also use an empty ballpoint pen, which is blunt. See, you may wonder why somebody gives such detailed instructions.

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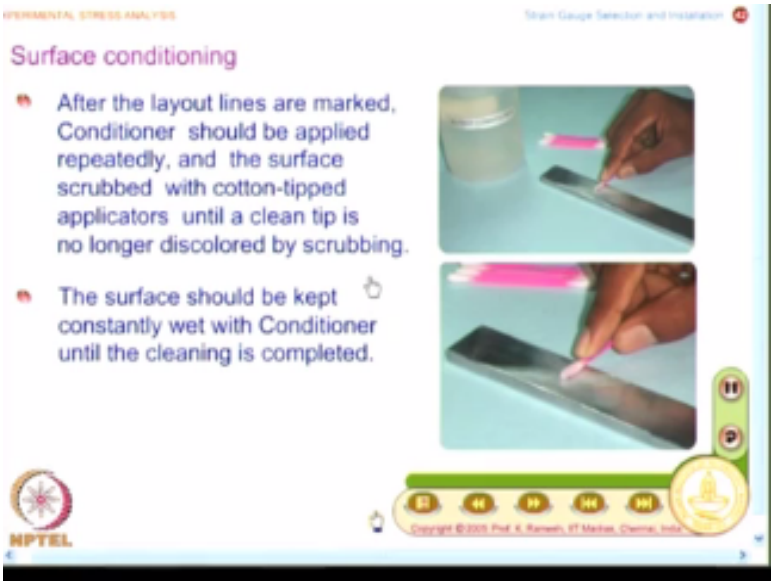

Because idea is we want to get an accuracy of 0.5 micro strains, how do I ensure that? An every step which you do has an influence on the final performance of the strain gauge system and once you put the graphite line, you know, you need to remove that carbon, so you apply conditioner and use cotton tip applicators until a clean tip is no longer discoloured by scrubbing, so this is what you do.

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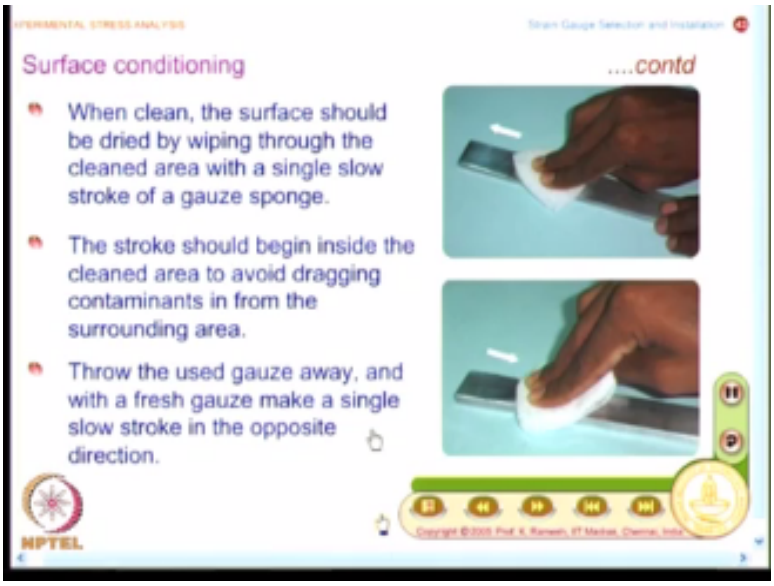

And here again, you should maintain constantly wet; the surface should be constantly wet with conditioner until the cleaning is completed because you do not want to allow the conditioner to evaporate, you keep it wet and as seen before, you need to wipe it dry, there is also a recommendation, how to wipe it. It is not that you go and then wipe it like this, you should not do back and forth.

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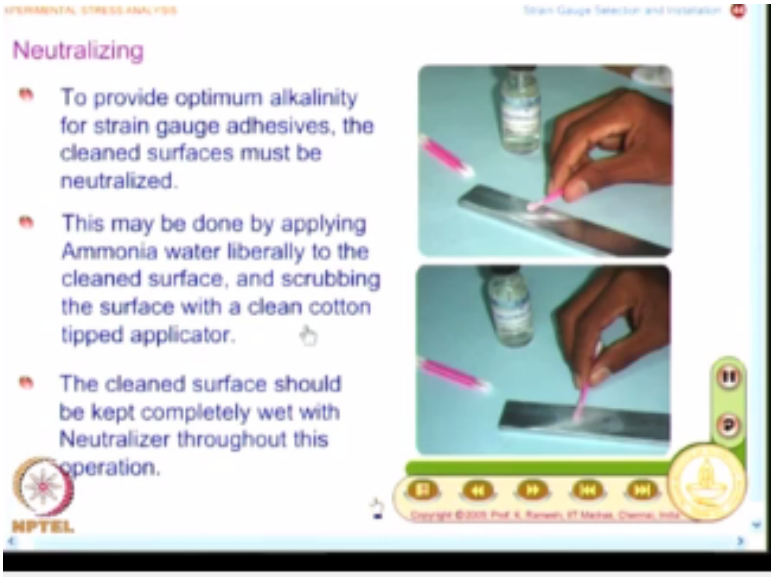

The recommendation is take one set of gauze sponge and then wipe it in one direction, take another gauze sponge and move it in the other direction. So, you need to do this also meticulously. Now, you have to do a neutralising of the surface and why do you do this? This is

done to provide an optimum alkalinity of the surface. So that the strain gauge adhesives bonds perfectly on the surface.

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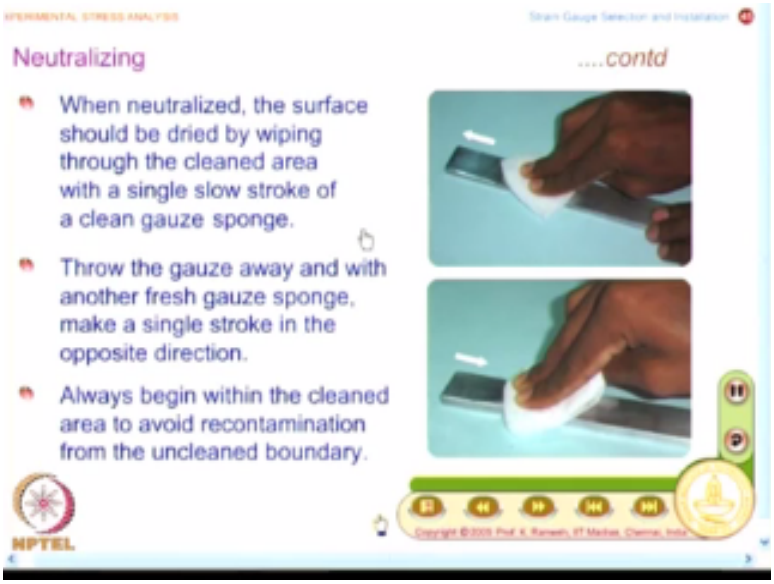

And this can be done by applying ammonia water liberally to the cleaned surface and scrubbing the surface with a clean cotton tip applicator that is what you do here and here again, you must keep the surface wet with neutraliser and as before wipe it dry with the slow stroke of clean gauze sponge, you know, though it looks very detailed set of instructions in the interest of perfect strain gauge installation, you should not get bored with this.

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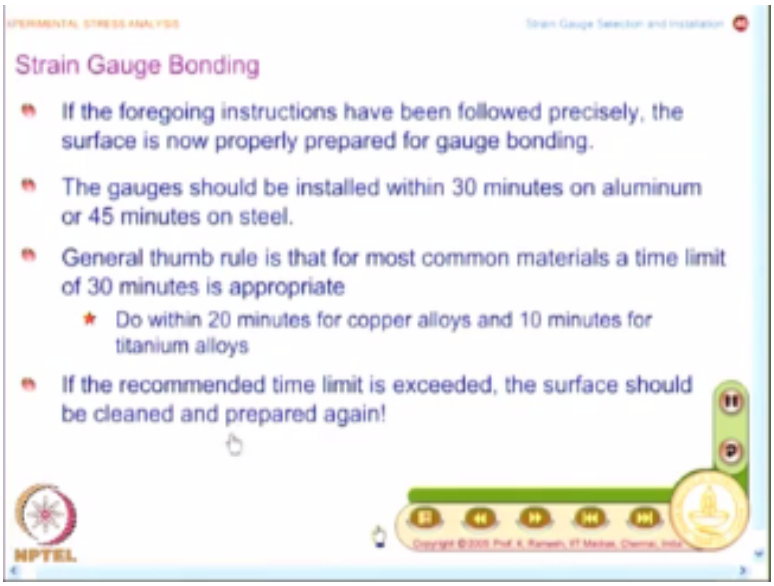

You know, once you do this 2, 3 times, you know what are the procedures involved and you will develop skill and speed and you will also have everything ready, the whole installation you could do it very fast but when you look at; when you learn, you need to know the steps systematically, there is no escape from this and what is mentioned here is; if the foregoing instructions have been followed precisely, the surface is now properly prepared for gauge bonding.

And what are the recommendations; look at this very carefully. The gauges should be installed within 30 minutes on aluminium or 45 minutes on steel and what is the general thumb rule? The general thumb rule is try to do it within half an hour but you know, you will have a general instruction as well a special rule. If you go for copper alloys, you should do it within 20 minutes, on the other hand if you go for titanium alloys, you should do it within 10 minutes.

If you do not follow this what happens; if they recommend time limit is exceeded, the surface should be cleaned and prepared again. So, if you know that this is what you how to do, this is the penalty that you will have to pay, it is better that you see this 2, 3 times and find out the what is the procedure involved, keep all the accessories ready and then do your installation, this is like cooking.

You know, when we want to make a dish, you need to keep all the constituents ready before you and add them appropriately because you have the whole thing getting heated and if you miss out, you may finally have burnt the food or the food will not be tasty, so there you develop a some kind of a skill. Similar skill is required even on strain gauge bonding; strain gauge bonding is a skill oriented activity and following the detailed step by step procedure is equally important.

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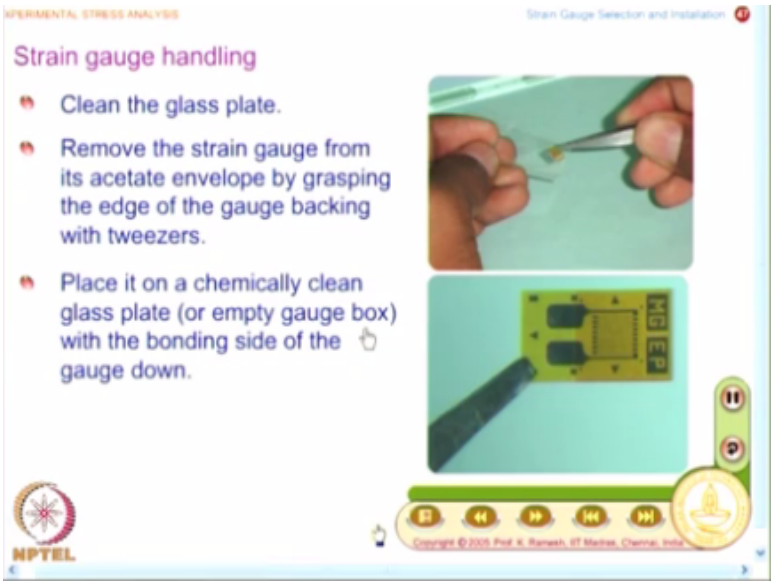

You cannot cut short steps, if you cut short steps you are not guaranteed with proper behaviour of the strain gauge system. Now, the surface is prepared, we have to take out the strain gauge and also have a via media, how to align it on the specimen. So, take a glass plate and clean it that is where you are going to keep the strain gauge and you have to remove the strain gauge from its acetate envelope by grasping the edge of the gauge backing with tweezers.

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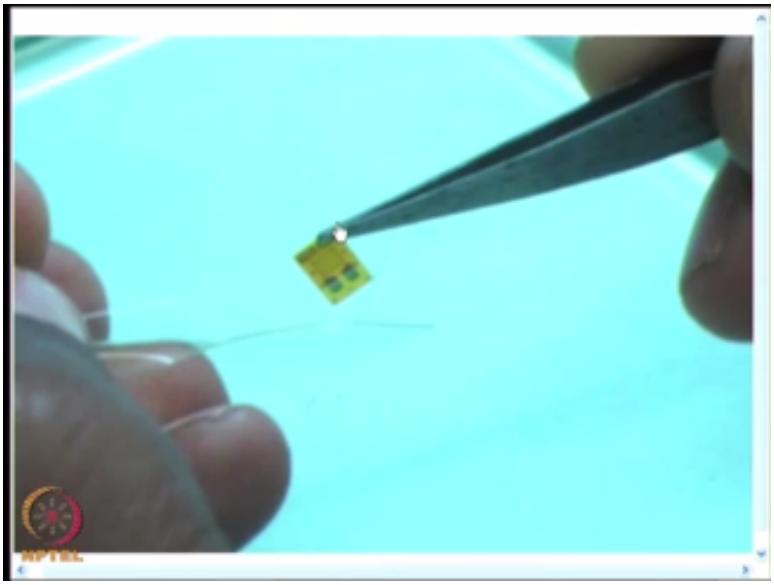

You do not handle it with hands; bare hands, you take it out with the tweezers that is what is mentioned here, we will have a closer look of it and you can see; I see the grit pattern here and this is holding only a corner of it, if you touch it in between, what will happen? The foil is so

thin, it may eventually get cut, so you need to remove with the tweezers and place it properly on your glass plate.

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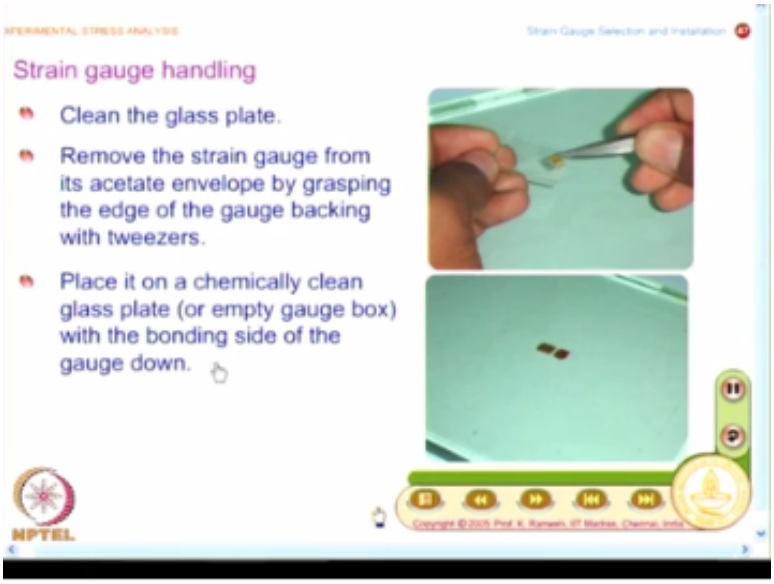

And that surface should be chemically clean that is why we have taken a glass plate or you can also use it on an empty gauge box and you also put the terminals and ensure that you keep it in such a manner that the bonding side of the gauge is down.

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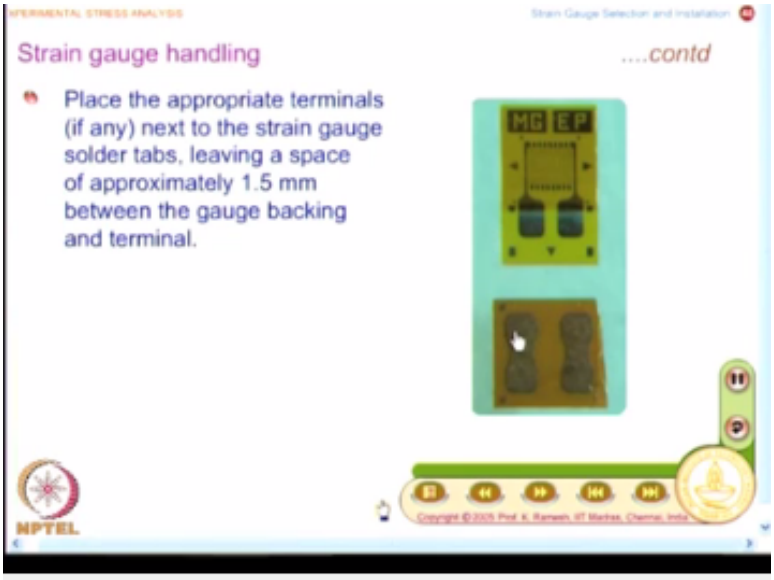

And the focus here is how to simplify your aligning process and in order to simplify your soldering, you also have additional terminals instead of directly using the lead wire up to the strain gauge, you have terminals and you will have a single strand wire connecting the strain

gauge to these terminals. Now, both of them need to be aligned properly at the point of interest; strain gauge is to be aligned very carefully.

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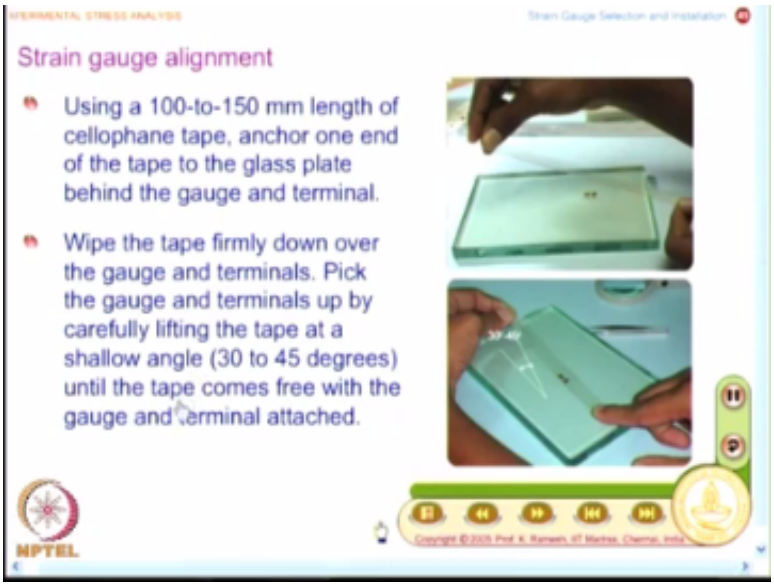

This is just for connecting the strand of wire from the tape to the terminal and in order to align the strain gauge, what you do this; you take a cellophane tape and then paste it on the complete system. So, you have a long cellophane tape taken and even the cellophane tape has to be approved by the strain gauge manufacturer because the adhesive may interfere with the adhesive on the cellophane tape.

So, you need to be very careful about that and when you place it on this and when you want to lift it, you need to lift it at a shallow angle of 30 to 40 degrees. Why do you do this? See, you are handling a cellophane tape, which is plastic and it is easy for you to stretch it and you have a metal film attached and metal film will also get stretched, even without your knowledge, you will be applying a very high level of strain.

Though it looks very trivial, why you specify the angle, why not I do it at some other angle, what is recommended here is; if you do like this, the chances of overstretching the strain gauge will not happen, so this is what you will have to do that, you need to have only 35 to 40 degrees, so pick up the gauge and terminals up by carefully lifting the tape at a shallow angle until the tape comes free with the gauge and terminal attached.

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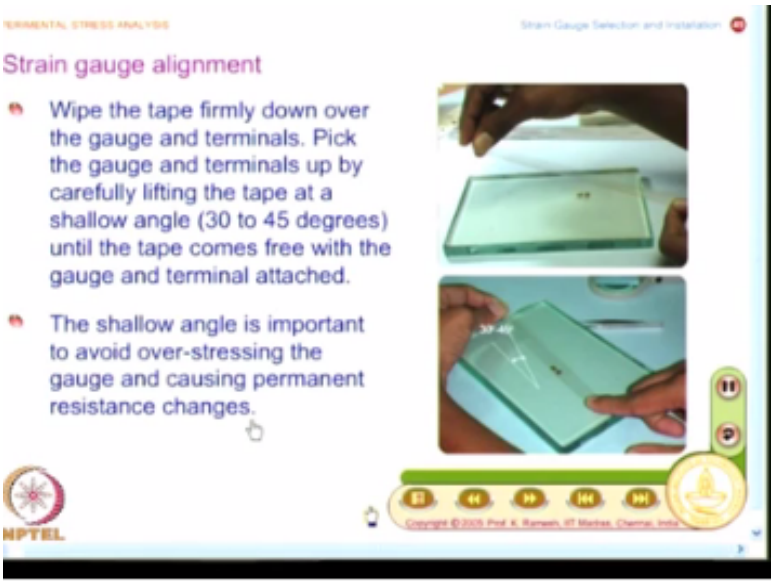

So, now you handle only the long cellophane tape with the strain gauge attached for you to align, so I can align it appropriately and you also do that practice. On the actual specimen, what you do is you put it and align it and then only go for actual bonding and this is emphasised the shallow angle is important to avoid over stressing the gauge and causing permanent resistance changes. Though this is trivial information this needs to be adhered to.

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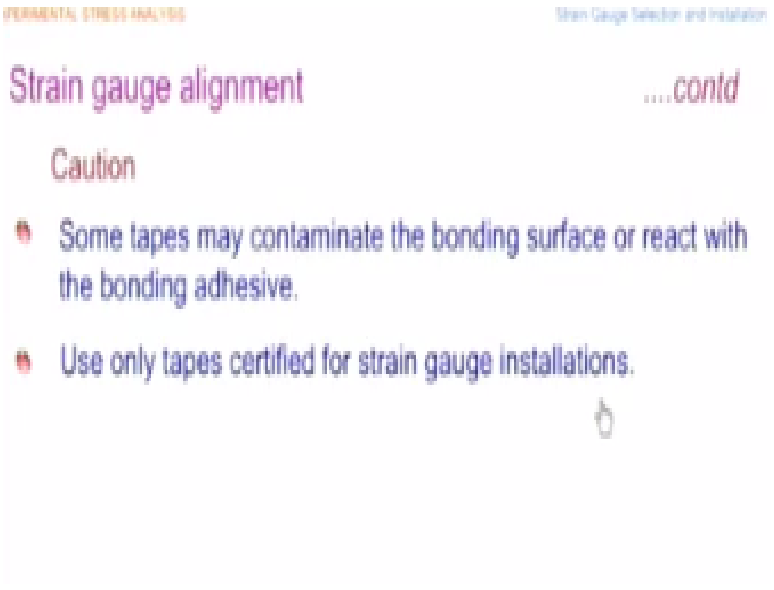

And as I mentioned earlier, the caution is also mention. Some tapes may contaminate the bonding surface or react with the bonding adhesive and you need to use only tapes certified for strain gauge installations. So, do not go with the TV advertisements, you have easy tapes, so

many tapes have come, so have to be very careful whether it is recommended by the strain gauge manufacturer that is the focus.

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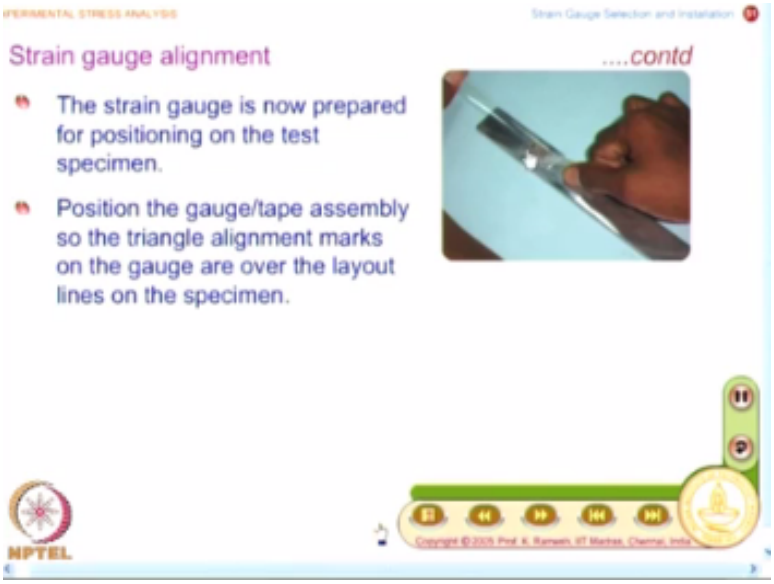

The strain gauge is now prepared for positioning on the test specimen, so you hold it like this and then position it, you position the gauge tape assembly, so the triangle alignment marks on the gauge or over the layer out lines on the specimen. So, you ensured that, you can do this back and forth until you are satisfied that the; whatever the marks on the gauge pattern matches with the layout lines.

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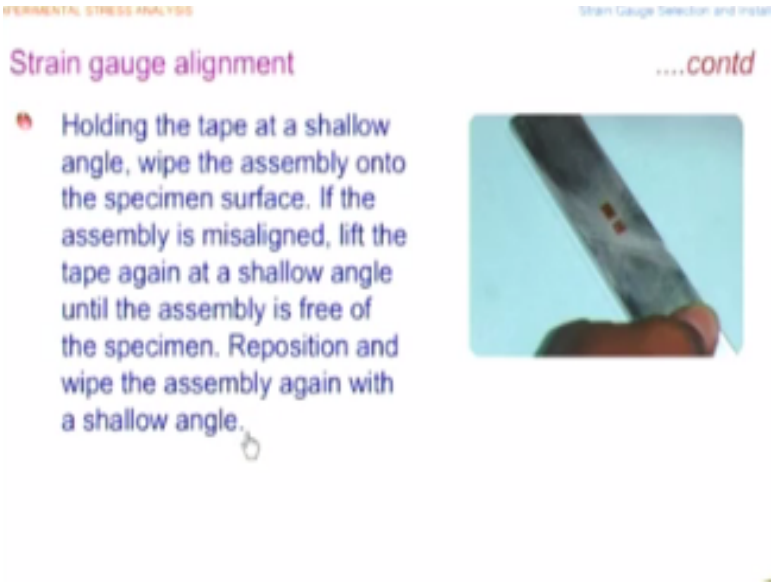

And again holding the tape at a shallow angle, wipe the assembly onto the specimen surface. If the assembly is misaligned, lift the tape again at a shallow angle until the assembly is free of the specimen, reposition and wiped the assembly again with the shallow angle. So, this is what you get finally.

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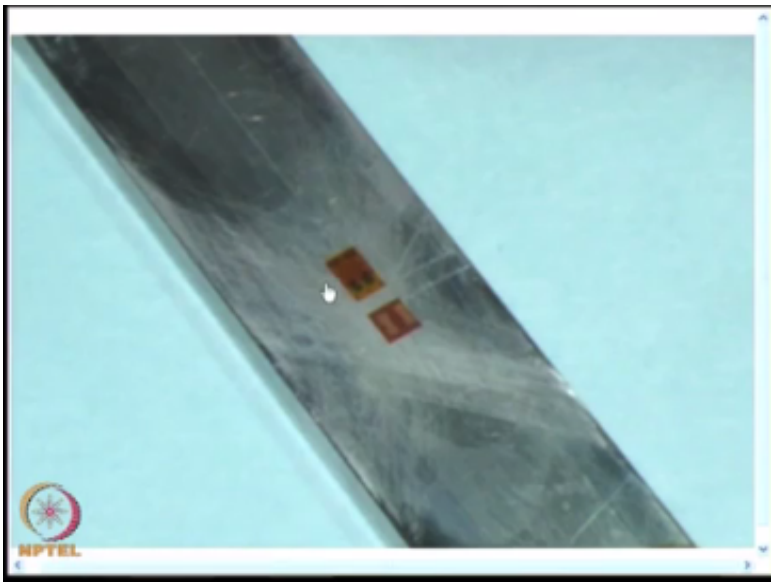

What you see here is; I could see the strain gauge and the terminals aligned on the layout line marks satisfactory, I have a line here and this is aligned with that.

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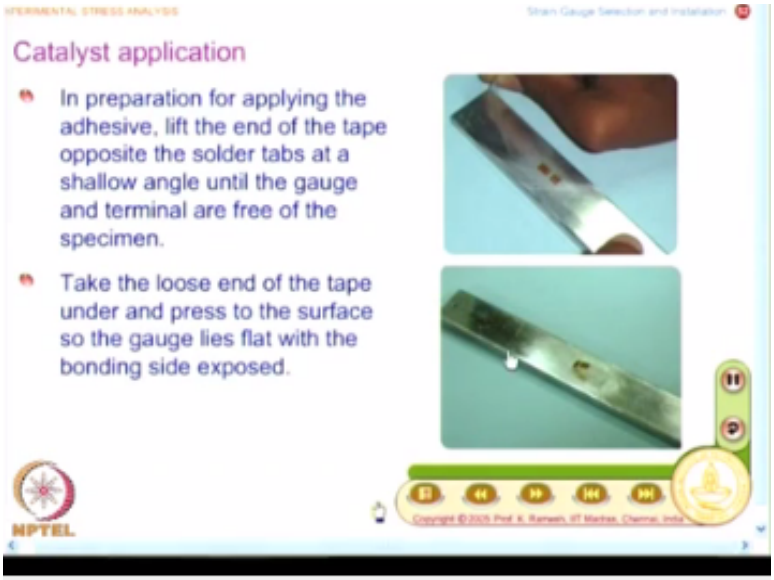

And before we apply the adhesive, we need to apply catalyst. So, you carefully remove this from the surface and that is what you see here, the tape is getting removed and you have to take it and roll it back and fold it and that is what is shown in the next slide.

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So, what you have here is; you fold it like this, so that easy for you to apply the catalyst and also when you want to put the adhesive, you will you put adhesive at the junction and then press it onto the actual surface and this is what listed here. So, you need to take the loose end of the tape and press to the surface, so the gauge lies flat with the bonding side exposed, you want to take out the tape, fold it like this; fold it like this.

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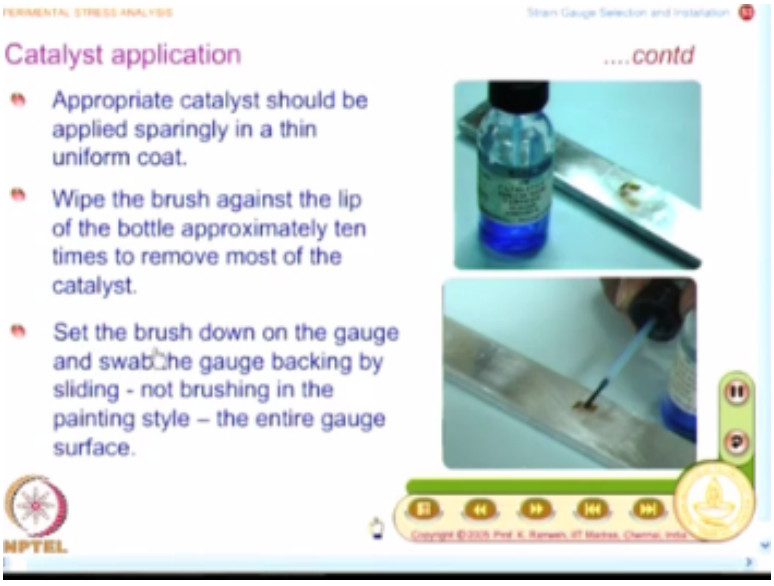

And then, you will have the surface exposed, so that is good for applying the catalyst as well as the bonding and even in catalyst application, you should not apply excessive catalyst, so the recommendation is; you need to take out that the brush, wiped the brush against the lip of the bottle, this is also given, approximately 10 times to remove most of the catalyst. You know, these are all very detailed instructions, why 10 times?

People have tried it many times and then standardised that as 10 times because you need only a very small quantity of catalyst to be applied, catalyst should be small; as small as possible, so you should not apply excessive catalyst. See, it may sometimes look ridiculous that approximately 10 times, why not 9 times, why not 8 times, you do not ask questions there because you want your strain gauge installation to be as good as possible.

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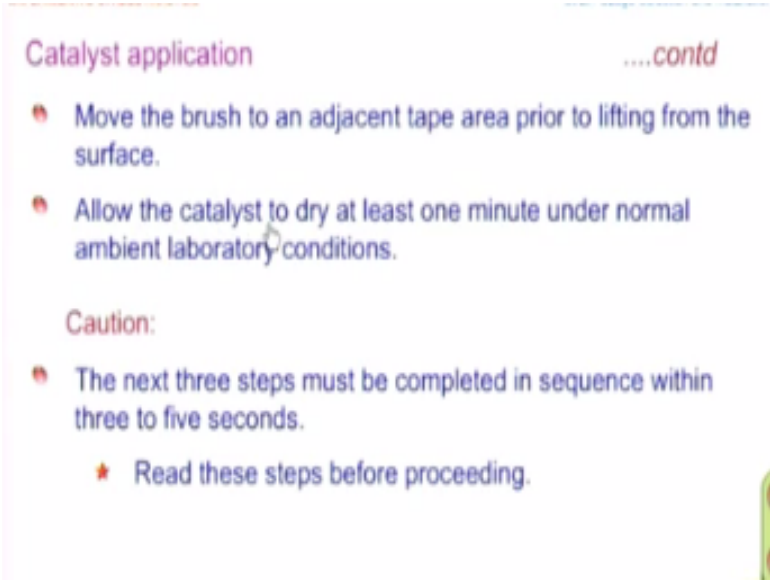

And also while putting the catalyst, you must set the brush down on the gauge and swab the gauge backing by sliding and you should not do brushing in the painting style and this is to be done on the entire gauge surface not only this, the recommendation goes a step further; move the brush to an adhesive tape area prior to lifting from the surface. See, the idea is; if you lift it earlier, a small portion may not have a catalyst.

Because you have ensured the catalyst brush will have the least amount, so that enough for applying on the surface, so ask you to go beyond that go to the tape area and then lift it and you

should allow the catalyst to dry at least 1 minute under normal ambient laboratory conditions and what is the caution here? I am going to bond the strain gauge; the next 3 steps must be completed in sequence within 3 to 5 seconds.

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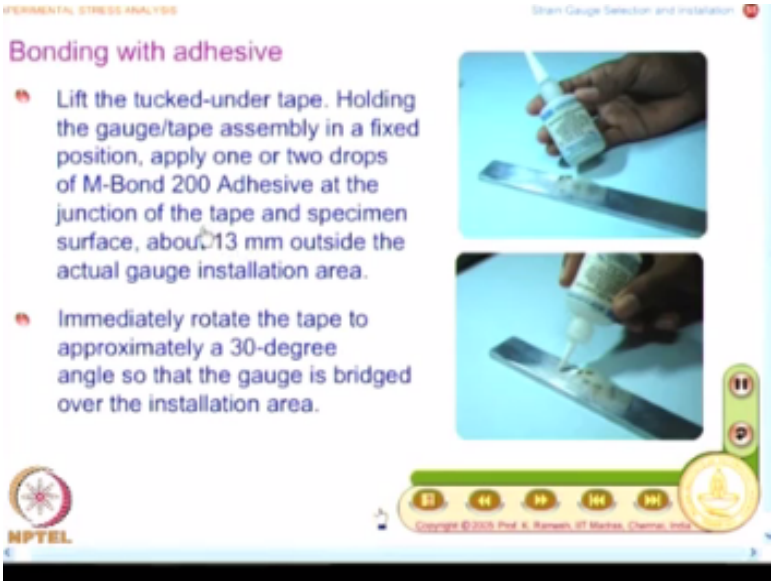

So, you need to read these steps before proceeding, so you need to have a mental picture what way you will have to go about and executed as quickly as possible. So, you have to lift the tucked under tape, holding the gauge tape assembly in a fixed position, apply 1 or 2 drops of M Bond 200 Adhesive, you also have equivalent adhesives at the junction of the tape and specimen surface.

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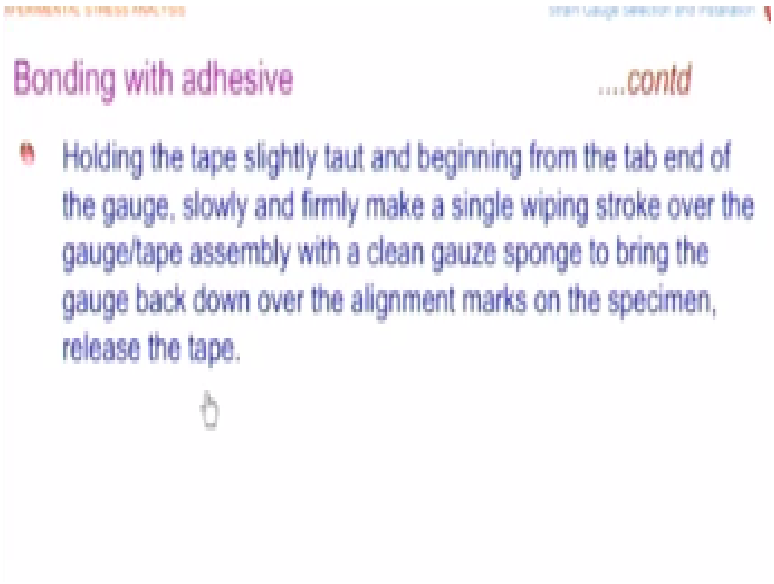

Then you need to immediately rotate the tape to approximately a 30 degree angle, so that the gauge is bridged over the installation area. This shows the sequence of steps and you will see an animation, which will give you how quickly this is done. So, what you need to do is; holding the tape slightly taut and beginning from the tab end of the gauge slowly and firmly make a single wiping stroke over the gauge tape assembly with the clean gauze sponge to bring the gauge back down over the alignment marks on the specimen and release the tape.

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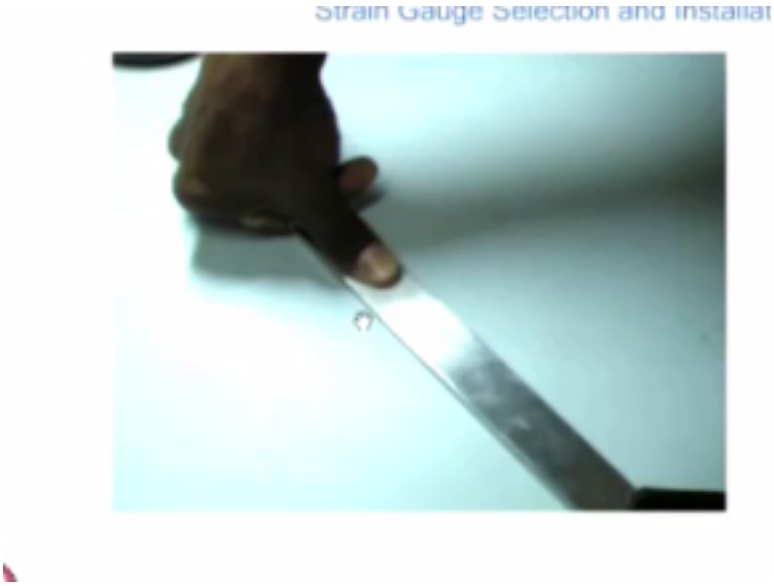

I will show the animation, this idea will become very clear and this is what you see here, so you need to press it with the thumb at the end of the process, so you had the cotton gauze sponge, which is used to wipe out. Why do you use a cotton gauze sponge? So that you are able to apply a uniform pressure; the pressure will be uniform when you do it with a cotton gauze sponge and finally press it with your thumb pressure.

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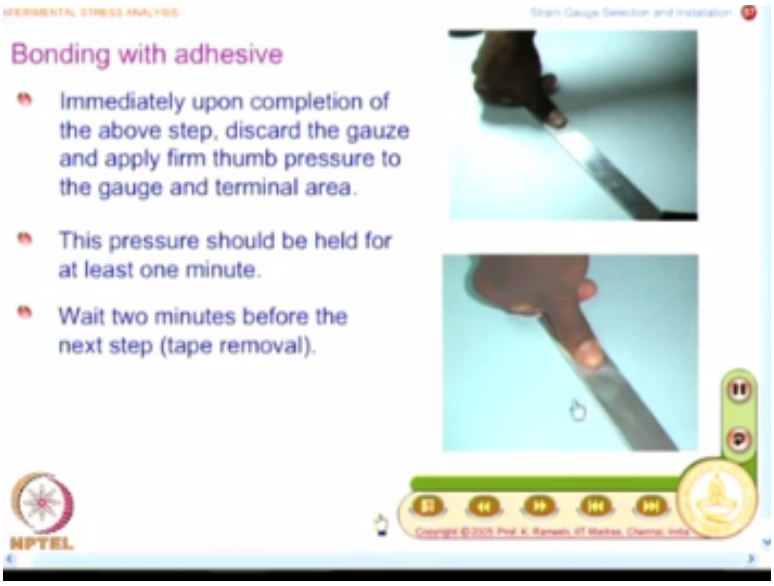

And this you need to hold it for about a minute and the bonding is complete. So, immediately upon completion of the above step, discard the gauze and apply firm thumb pressure to the gauge and terminal area, so this is how the strain gauge is bonded and you need to wait 2 minutes before the next step that will take it up later but what I will do is; I will repeat the animation for you to appreciate the sequence involved.

So, you see you are holding one end of the cellophane tape, then wipe it with the gauze sponge, take out the gauze sponge and press it with your thumb that is what you have seen, all that was discussed as text, when you see that as text, it is confusing but when you see the animation, you get to know what is the procedure involved. So, in this class what we looked at was in detail, we started looking at how to bond a strain gauge.

We have looked at the first step of surface preparation, conditioning and utilising and finally bonding the strain gauge. Now, we will have to take up how to connect the lead wire, how to do soldering, how to apply a protective coating only then the strain gauge bonding is complete, only then it is ready for making the strain measurement, this we will take it up in the next class.