Experimental Stress Analysis

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Lecture No. # 37

Bonding of a Strain Gauge

In the earlier lectures, we have to look at in sufficient detail, the various constituents forming a strain gauge system. The knowledge of the strain gauge alloy, career, and the type of adhesive fused is very important, from the point of view of how to select the strain gauge. I have also mention in strain gauge analysis, when one wants to perform an experimental using strain gauge, one selects the strain gauge rather than designing a strain gauge. For the selection of strain gauge, we have to look at what is the kind of designation system used by two different manufacturers.

And we have also seen variety of gauge patterns possible, when we 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 look at what are the general guidelines to select a strain gauge. We are seen about 5 to 6 steps, we will continue in the direction and I always been mentioning temperature effects have to be handled carefully in strain gauge technology.

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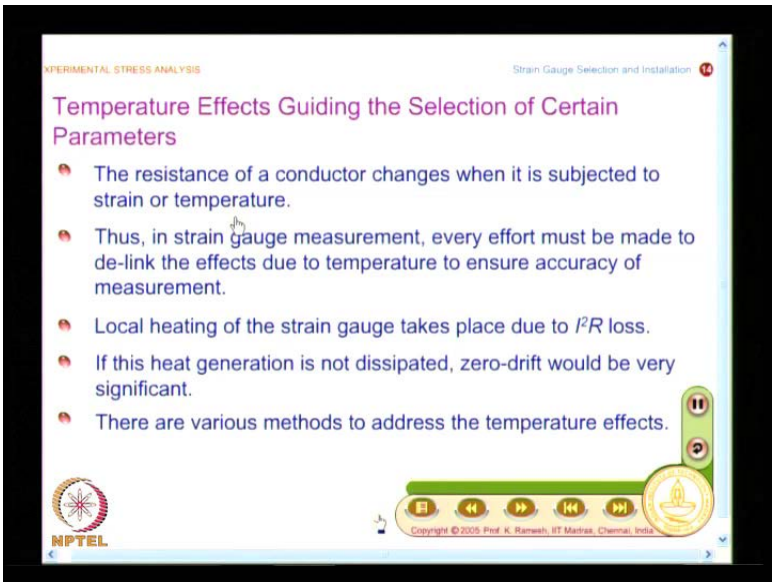

Though I have mentioned with several times it is no harm, a, in mentioning at again. And we will also have to look at how the temperature effects, guide the selection of certain parameters. The basic idea is the resistance of a conductor change, when it is subjected to strain or temperature. And the question of temperature changes, how does it come on a strain gauge.

Local heating of the strain gauge takes place due to I square R loss; this is a very, very important aspect and a very certain aspect too. You have a local heating, though it is small whatever, the heat generation, that needs to be dissipated; if you do not dissipated, zero drift would very significant in your strain gauge measurement, and we are looked at, there are various methods to address the temperature effects.

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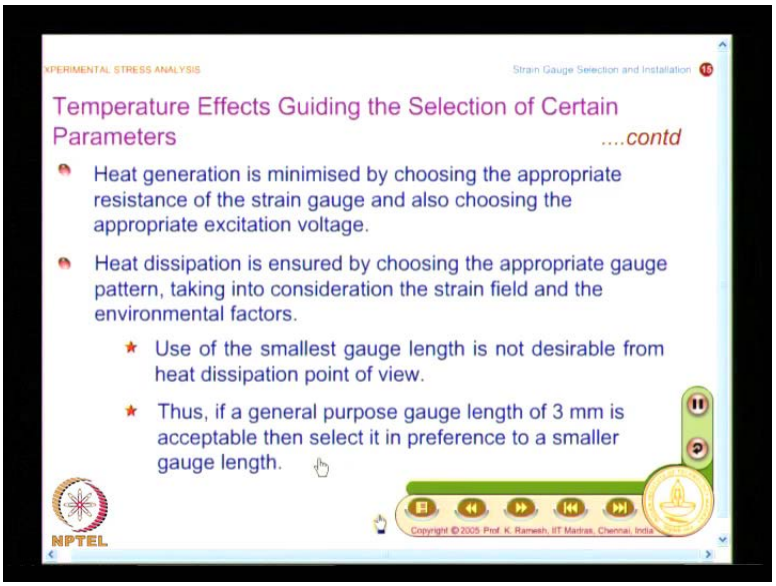

And that also guides in a way how to go about in selecting a suitable strain gauge. So, the idea is what you need to have heat generation to be minimized; how do I minimize the generation of heat? You can choose an appropriate resistance of the strain gauge and also choose the appropriate excitation voltage. When 2 or 3 classes before, we have look at how to select the bridge excitation voltage, we also had discussion on allowable power density, and all those information guide, how you can modify the bridge excitation voltage, so that, you minimize heat generation.

So, handling the temperature effects has to two components - minimize heat generation and improve your heat dissipation. You can improve the heat dissipation by choosing the appropriate gauge pattern. You know, you have to look at, when you are using a strain gauge, rosette should, you, going in for stack rosette, they will or very appearing, 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 grit 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 the 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. So, if a general purpose

gauge length of 3 millimeter is acceptable, then select it in preference to a smaller gauge length; so, this is the recommendation.

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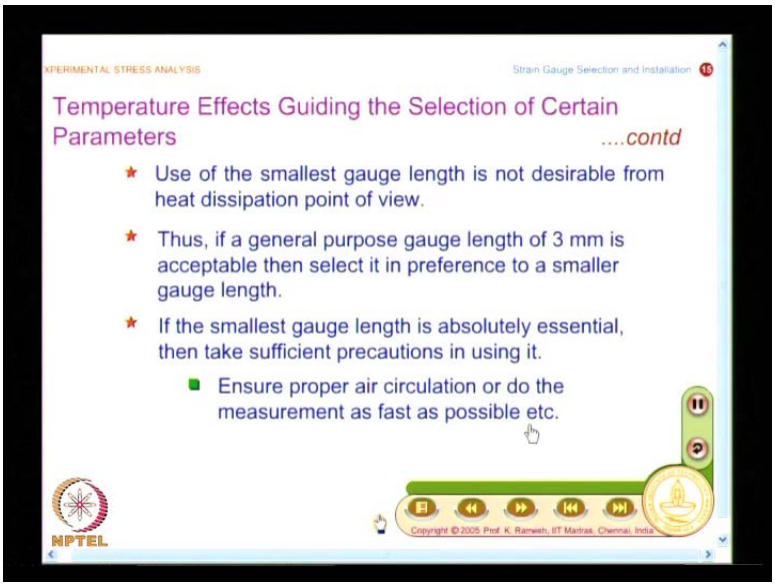

So, you need to go in, for selecting a longer gauge length from heat dissipation point of view, then what you would normally do, if you are not in expose to strain gauge technology. On the other hand, if the smallest gauge length is absolutely essential, then take sufficient precautions in using it; 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 air circulation or do the measurement as fast as possible etcetera, because if the measurement is done quickly, then temperature effect should not be that significant. So, the idea is do not go and jump, and demand that you will use a smallest gauge length for strain measurement, and I also said from optimizing your number of channels, do not also go and demand, that you will use as rosette at every point in the domain. Depending on the knowledge of the stress field, use a single element strain gauge, two element strain gauge or a three element strain gauge, judiciously.

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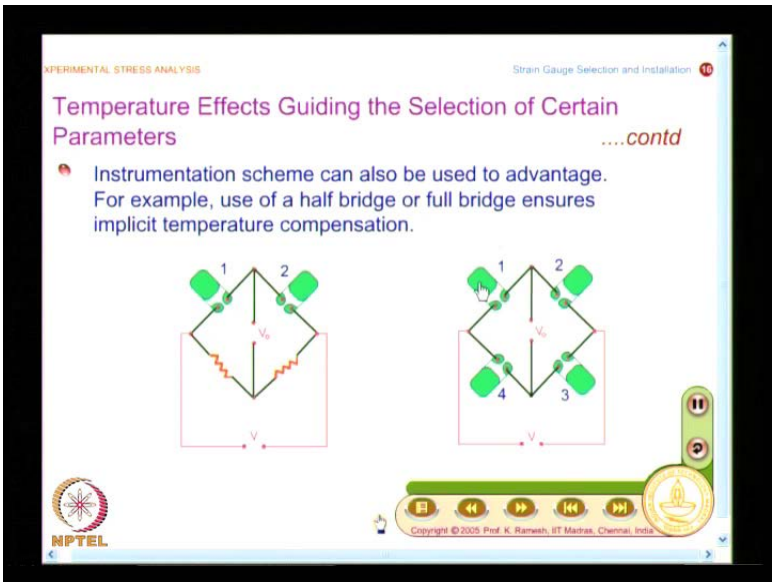

So, these are the ways that you minimize the entire cost of your strain gauge instrumentation. We have also seen, that instrumentation scheme can also be used to advantage in handling the temperature effects. So, if we use a half bridge, whatever the temperature changes happen in arm one will be canceled by temperature changes in arm two, 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. So, the advantage there is, you maximize the signal four 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 bridge.

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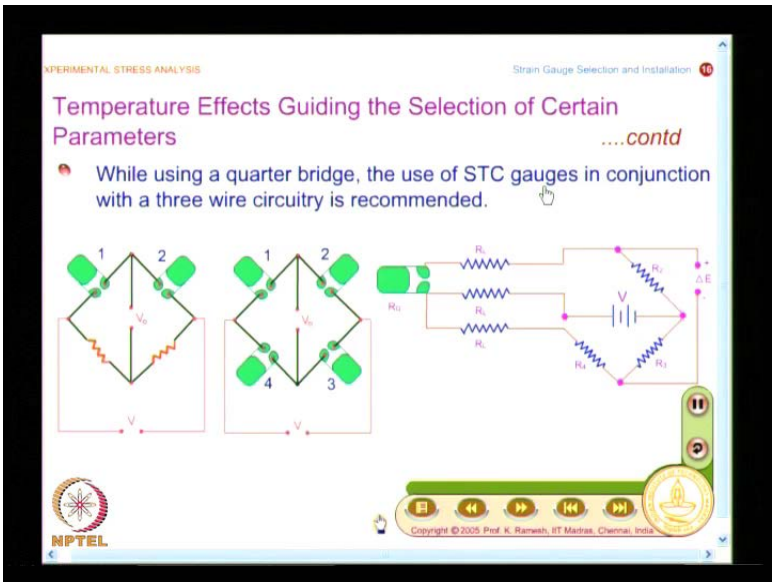

So, how do I do, when I have a quarter bridge arrangements, we have seen, how to minimize the error, then you use a quarter bridge, instead of a two wire circuitry go for a three wire circuitry. If you are able to use a half bridge, it is good; able to use a full bridge, it is well and good from transducer application point of view. From strain measurements, you will 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 two wire circuit, use a three wire circuit, we have seen the benefit for this; even, while you use a three wire circuit, go in for a STC gauge suitable for the base material; you should not mix up the STC gauges meant for aluminum, you should not paste it on steel; you should select the STC gauge meant for aluminum separately, and also for steel separately and use it carefully.

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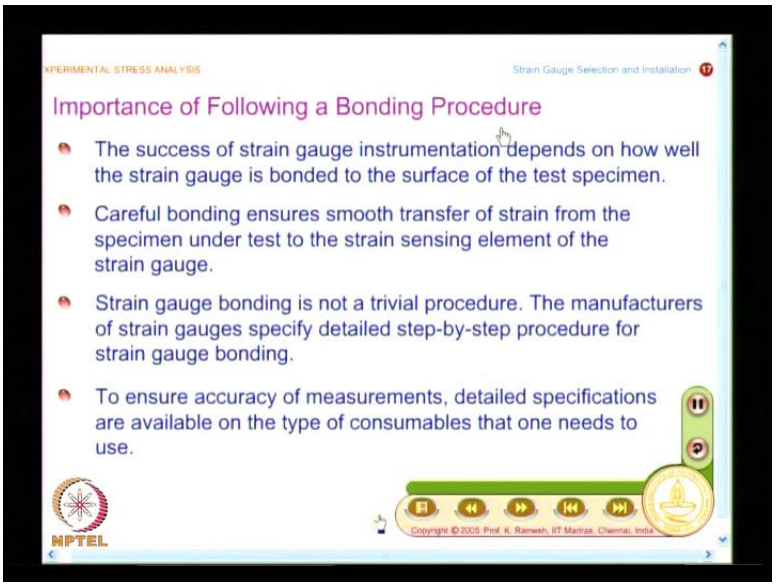

Now, we have all selected the strain gauge for our given application. The next important step is to bond the strain gauge to the specimen concern and this is the very, very important step, though the steps requires detailed preparation of the surface bonding, alignment, soldering etcetera, one needs to learn the steps carefully and also follow the steps that we discuss; if you mix out, as a I have mention 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. So, very important step and what is the advantage of careful bonding, this ensures smooth transfer of strain from the specimen under test, to the strain sensing element of the strain gauge and do not think the strain gauge bonding is a trivial procedure.

And if we 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 maintain, if you want sufficient accuracy, then all these steps are very important. So, to ensure accuracy of measurements, detailed specifications are available

on the type of consumables, that one needs to use in surface preparation, bonding etcetera.

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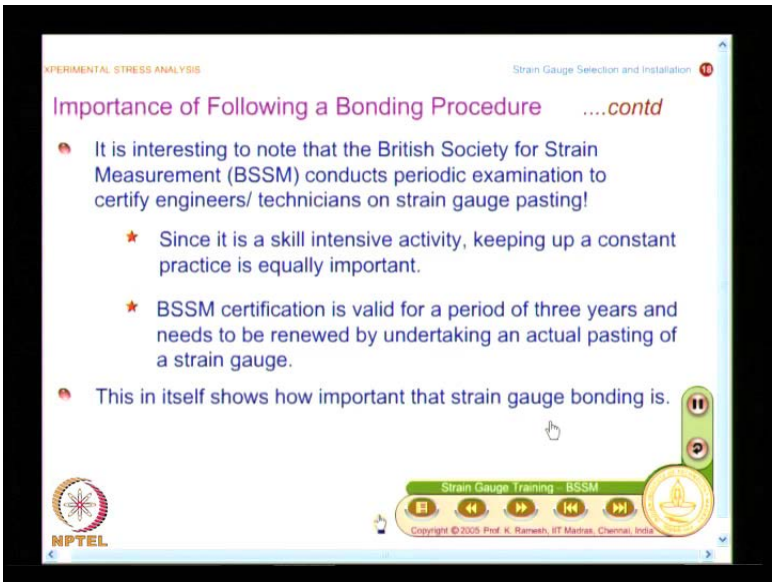

So, it is not trivial and you have to follow the recommendation. And this is very important to note that the British society for strain measurement conducts periodic examination to certify engineers or technicians on strain gauge pasting; see, unless the process is very important, you would not find a professional society to conduct examination of this nature; a verified 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 notice that BSSM certification is valid for period 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 paste in strain gauges, and doing, you know the 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. So, the very fact, a professional society conducts on examination, and makes that the certificate is valid for a period of 3 years, shows how important the strain gauge bonding is.

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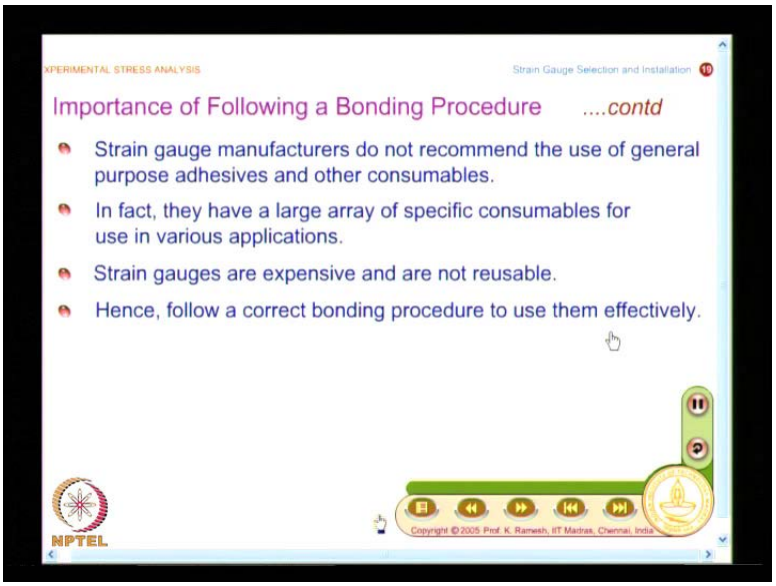

And if we look at the strain gauge manufacturers, they do not recommend the use of general purpose adhesives and other consumables. For strain gauge instrumentation, you should go in for specific adhesives and other consumables, like a cellophane tape, you will see later. So, you need to look at whether this has been recommended by the strain gauge manufacture.

And you should also keep in mind, strain gauges are expensive and they are not reusable. So, you do a faulty bonding, it 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 emphasize the need for following a correct bonding procedure, so that, you use them effectively.

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So, what we are going 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 as cyano acrylate, and whatever we discuss, this is also extendable to epoxy adhesive; the difference is in the curing procedure of the epoxy adhesive. The basic procedure of surface preparation handling of the strain gauge, soldering of the strain gauge, etcetera remain same.

And an general advice is follow the recommendations given by the strain gauge manufacturer, diligently to have confidence in the measurements focus, is that, I must have confidence in the measurement and confidence comes only, when the strain gauge is 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 etcetera.

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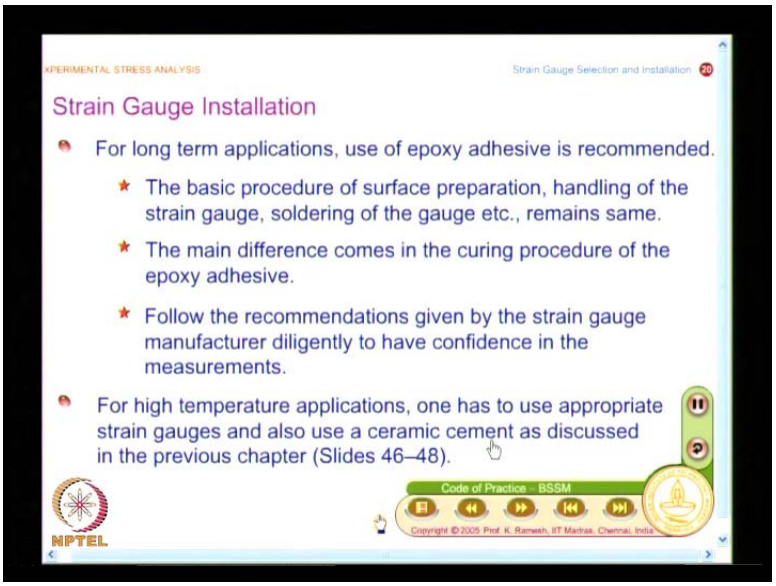

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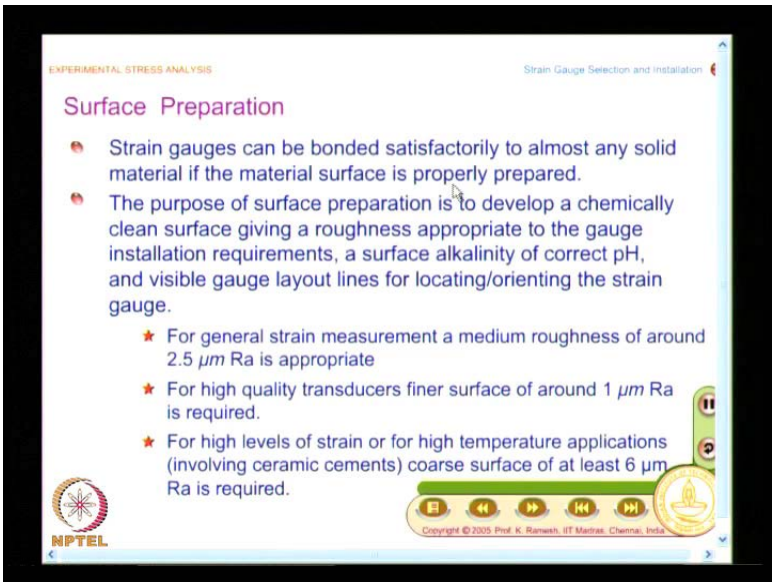

And for high temperature applications, one has to use appropriate strain gauges, and also use a ceramic cement, as discussed earlier, you know, we know, we have discussed that separately, and here, we have only going to look at typically for a room temperature measurement, using a cyano acrylate cement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

And if we 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 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 the gauge installation requirements. And the other aspect is, you also want to maintain a surface alkalinity for 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. So, this is very, very important, when you say an actual structure, I want a 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 that direction, it cannot be interpreted to your direction, then you have do a strain transformation law; for strain transformation law, you need to have pasted strain rosette at the point of interest. So, strain gauge alignment is very, very crucial, it is not trivial, that is the reason why you have the strain gauge career 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 micrometer is appropriate.

On the other hand, if I go for high quality transducers, you need a fine surface around 1 micrometer, however if you are going to measure high levels of strain or for high temperature applications, your coarse surface of at least 6 micrometer is required; no before, we get in to 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.

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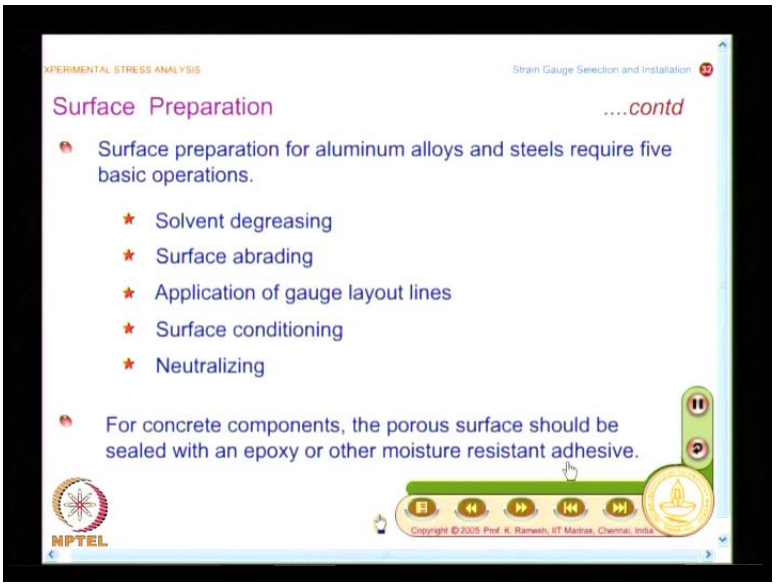

And if you look at for aluminum alloys and steel, the surface preparation require five basic operations; so, it depends on the base material. So, the steps are solvent degreasing, surface abrading, application of gauge layout lines, surface conditioning and neutralizing. On the other hand, if we look 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 a kind of special requirement, when you want to go and work on concrete, 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 standardizing the procedure; we are only going to look at how to paste a strain gauge on an aluminum surface.

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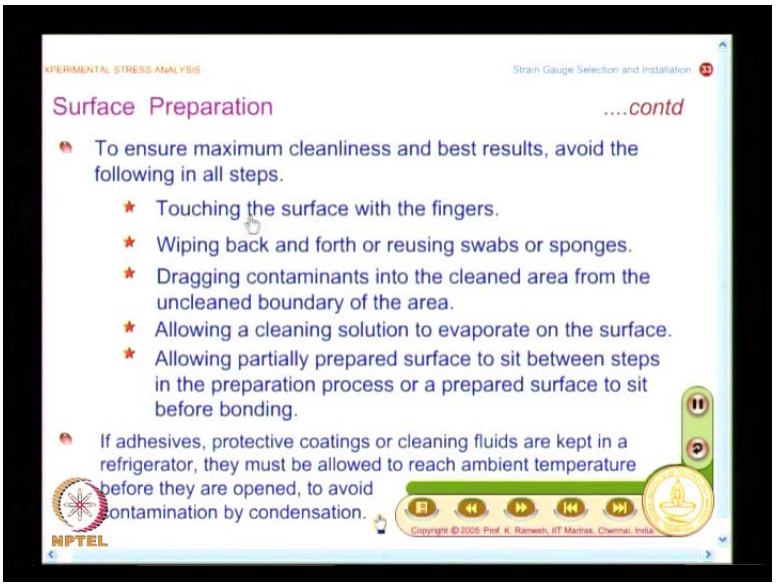

The very simple one that gives out the various steps and you get an idea, how to go about in general, when and they are also general recommendations, you know, you would like to maintain cleanliness of a high order and in order to get that, you need to avoid the following steps, in various steps of strain gauge bonding, you may do one or the other aspects to be focused, and if you avoid these, your 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 economize, and you may have (( )), why not I use the same think, but you should keep in mind, these are less expensive, a strain gauge is very expansive. So, ultimately, you want to minimize cost by making a proper installation with one strain gauge, you do not, do strain gauges and then worry about small consumables.

So, limberly use this 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 neutralizer, they are all liquids and these liquids should not be allowed to evaporate on the surface; so, when they evaporate, they leave a residue; you would see the recommendations would be to wipe it, dry with a sponge.

You should wipe it dry rather than, allow it evaporates; if you allow it evaporates, 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 etcetera; you should not sit between the steps.

And also once the surface is prepared, you must also bond on 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 given, see when you buy an adhesive or protective coatings or cleaning fluid, they all have shelf life and in order to improve your shelf life, you normally keep it a refrigerator.

And is a very certain 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 open the lid, and this is necessary to avoid contamination by condensation.

See only good experimentalist will follow all these procedures. So, this also indicates an experimentalist have to be systematic and patient, it is not that you go quickly take adhesive, and then quickly go, and do the strain gauge bonding, you do not doing like that, you have to follow a procedure, we have to be systematic, the reason is you are measuring a very small quantities and perfect bonding is a must, it is not a trivial step.

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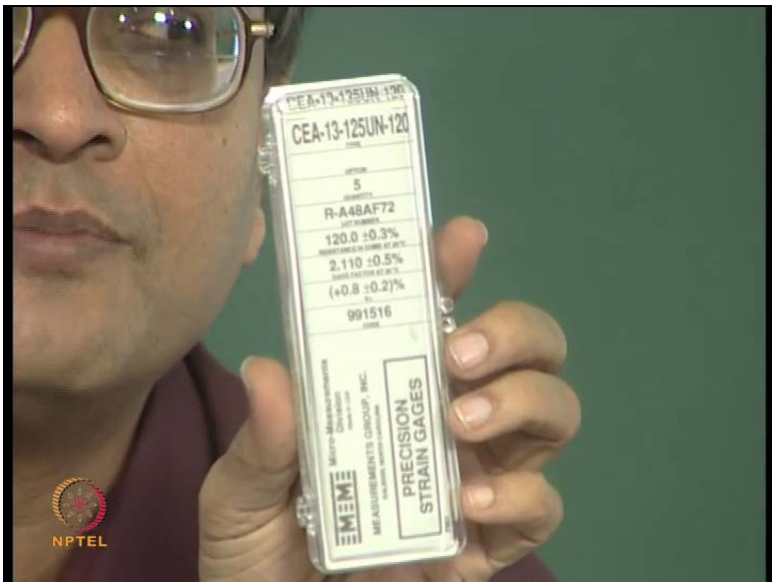

And this shows what is a strain installation kit, you have variety of fluids for cleaning, for catalysis, for the adhesive, you have special type of single stand wire to connect the strain gauge terminal, you have a soldering (( )), and you have a strain gauge available in a packet, and I want to show 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 about the transverse sensitivity, and you have this available in an nice box, and when I open it, you know, it is also preserved like this.

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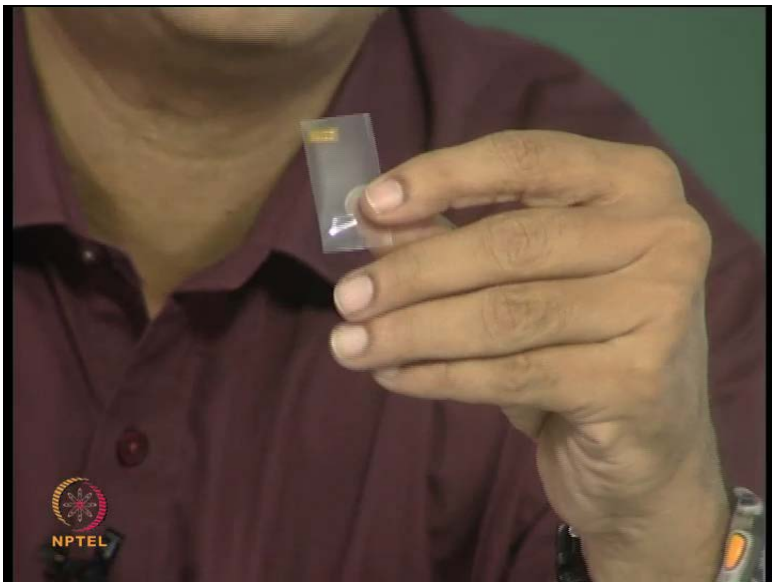

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So, all these shows, how important as a strain gauge is and each strain gauge is available in a packet like this, you have a acetate cover; so, we will see how to go and open it later. So, the manner in which a strain gauge is packed, shows how important and expensive and delicate the strain gauge is, and we are going to take a simple cantilever beam for us, to do the strain gauge bonding.

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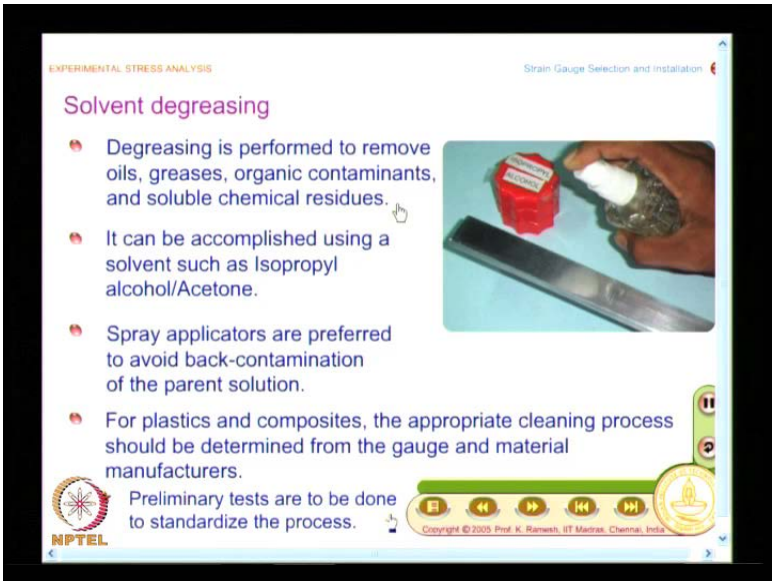

And what is the first step, the first step is solvent degreasing; so, why I do, this degreasing is performed to remove oils, greases, organic contaminants, and soluble

chemical residues, and here again you have a very (( )) point mention, and I am going to clean the surface, the recommendation is, you have the cleaning liquid in a spray able type of container; so, if you spray the cleaning liquid, the parent liquid is not containment, though it is a simple step, attention to detail 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 solution, and you know composite 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 and you need to perform preliminary tests to standardize the process.

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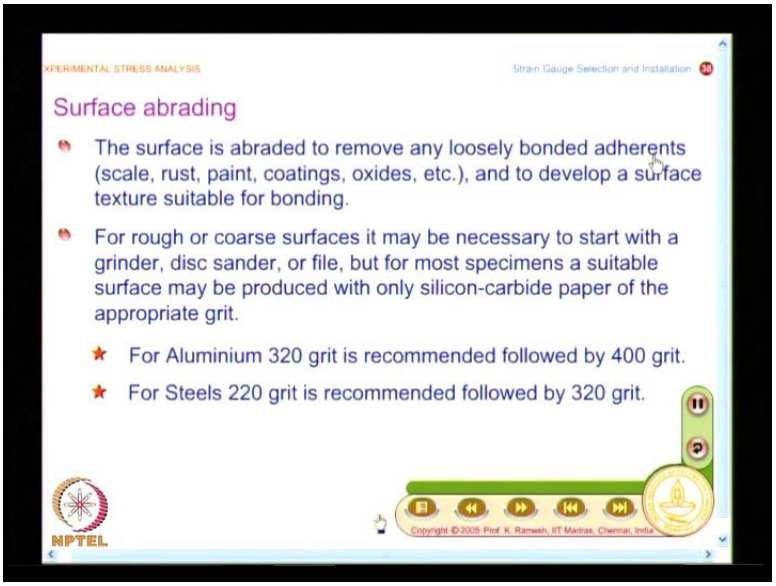

And I said that, you should use sufficient amount consumables, you should not be stingy in that, because your focus is to save the strain gauge, which is expensive, I know, I have this, and then, I clean it with a gauze sponge, and you will be surprise to see the surface was looking alright, but when I see the gauze point, I see that as black; so, you need to keep using new sponges, until the cotton gauze is white.

So, use consumables liberally; 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 we have a rough or coarse surfaces, it may be necessary to start with a grinder, disc sander or file,

but all that is not required for most specimens, a simple silicon carbide paper of appropriate grit should be sufficient.

See we have already looked at I need to maintain certain level surface roughness for effective, in the strain gauge bonding, and they are specific recommendations, if you go for an aluminum, you have to go for a 320 grit for initial abrasion, then followed by a 400 grit. And if you look at a 400 grit will be much finer than 320 grit that is, how these are number.

On the other hand, if you go to steels, you should start with 220 grit followed by 320 grit, see it may appear very simple, you may think, why one has to follows such details, that is what I said, you need to maintain a certain level of surface roughness and strain gauge manufacturers have tested variety of options, and finally, whatever the understanding that they have got, they have listed it as a sequence of steps, respect those steps and recommendations.

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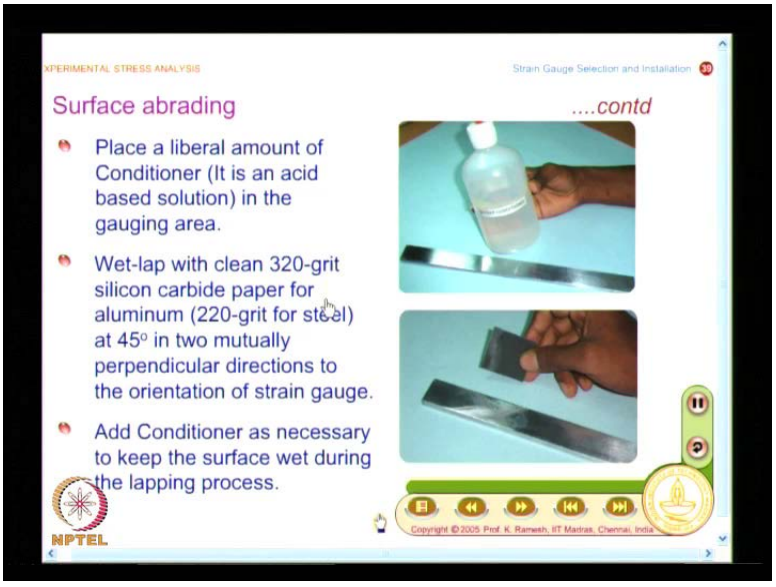

And when you do this also, you need to have a wet lapping process to be done; so, you need to put a liberal amount of conditioner, which is an acid based solution in the gauging area, and here you are not testing your muscle power and go and rub the surface with full force, that is not what is anticipated.

What is anticipated is, prepare a surface which has sufficient roughness, and what they say is, you have 12 strokes at 45 degrees, and another 12 strokes at minus 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, if you allow the conditioner to evaporate, then it will form thin residue.

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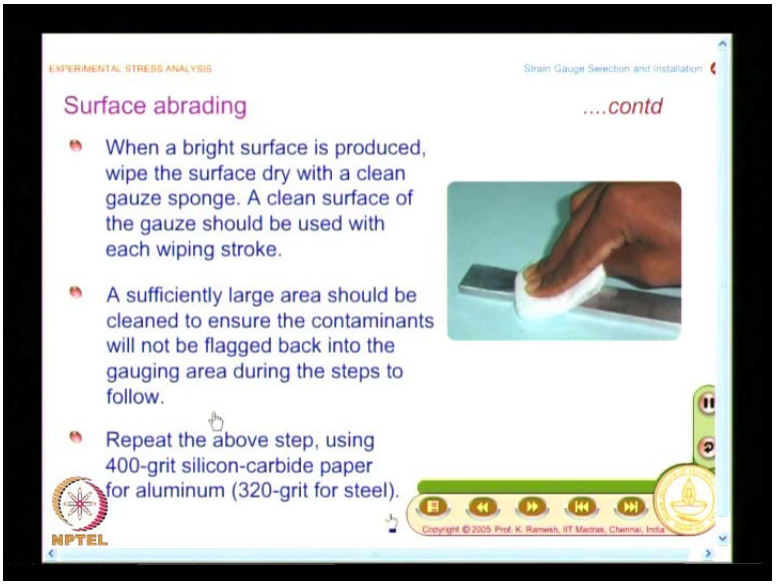

This is the recommendation; so, when you get a bright surface, wipe the surface dry with a clean gauze sponge; so, you need several pieces of gauze sponge, before you start the installation. a sufficiently large area should be cleaned to ensure the contaminants will not be flagged back into the gauging 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 gauge only as small localized 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 grits silicon carbide paper for aluminum or 320 grit for steel.

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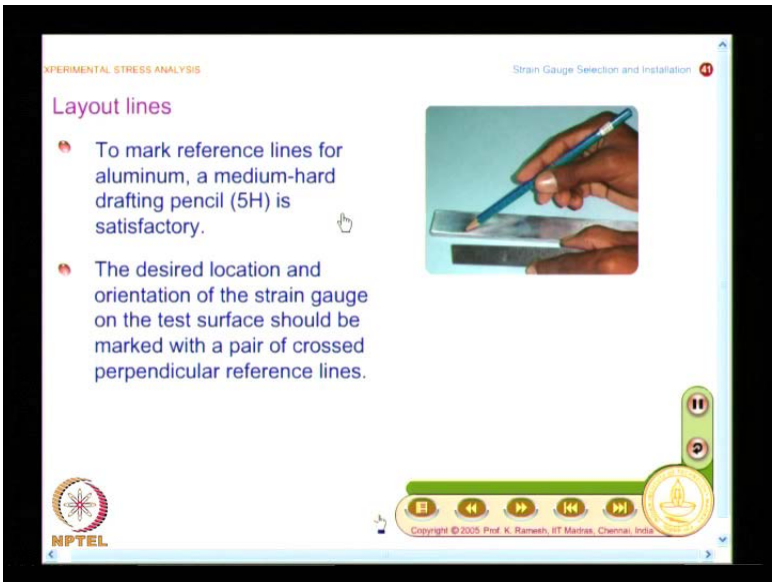

And the next important step is to put the layout lines; and to mark, you can even use a drafting pencil for aluminum, but for steel and other materials, drafting pencil is not recommended, we will also see that; if the idea of putting the layout line is to mark the desired location and orientation of strain gauge to be pasted; if we look at a strain gauge, strain gauge comes with a career which has marks; so, these marks have to be aligned at the point of interest, for you align the strain gauge, you need to have layout lines.

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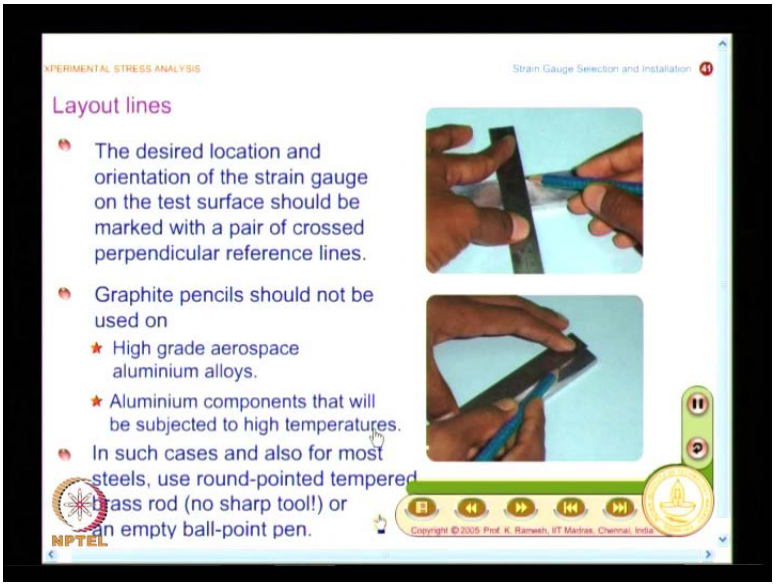

So, you put perpendicular lines and as I mentioned earlier, you cannot use the graphite pencils on high grade aerospace aluminum alloys or an aluminum components that will be subjected to high temperatures; though, in the class, you might have used simple graphite pencil, because you worked on aluminum which works at room temperature; this is acceptable.

So, if you have to use for these materials, you 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 ball point pen which is blunt, see you may wonder, why somebody gives such detailed instruction, because idea is we want to get an accuracy of 0.5 micro strain, how do I ensure that, and every step which you do has an influence on the final performance of the strain gauge system.

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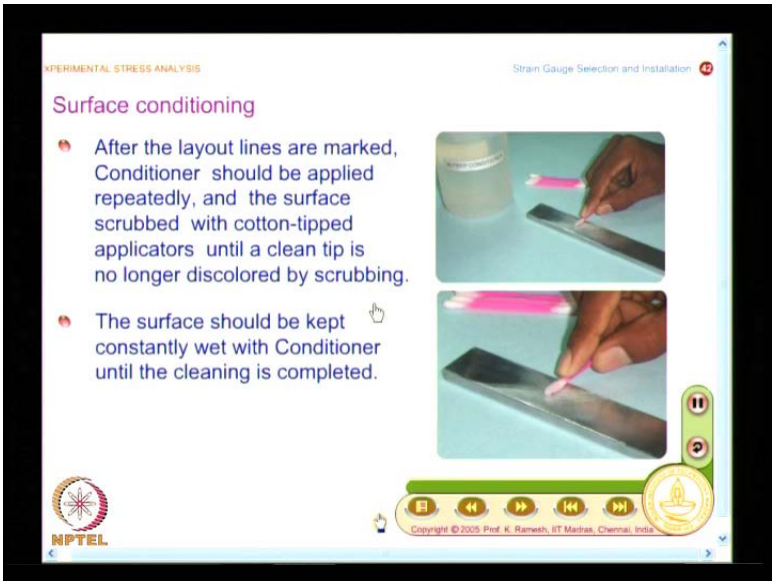

And once you put the graphite line, you know, you need to remove that carbon, so you apply conditioner, and use cotton tipped applicators, until a clean tip is no longer discolored by scrubbing; so, this is what you do. And here again, you should maintain constantly wet, the surface should be constantly wet with conditioner, until the cleaning is completed, because you do not want to allow the conditioner to evaporate, you keep it wet.

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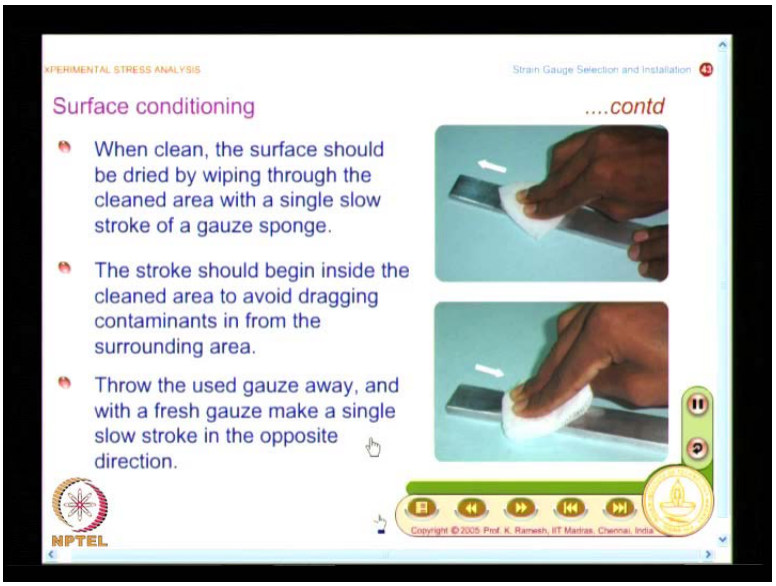

And as seen before, you need to wipe wet dry, there is also recommendations, how to wipe, it is not that, you go and then wipe, it like this, you should not go back and forth, the recommendation is take one set of gauze sponge, and then wipe it in one direction, take another gauze sponge and move it in the other direction; so, you need to do this also meticulously.

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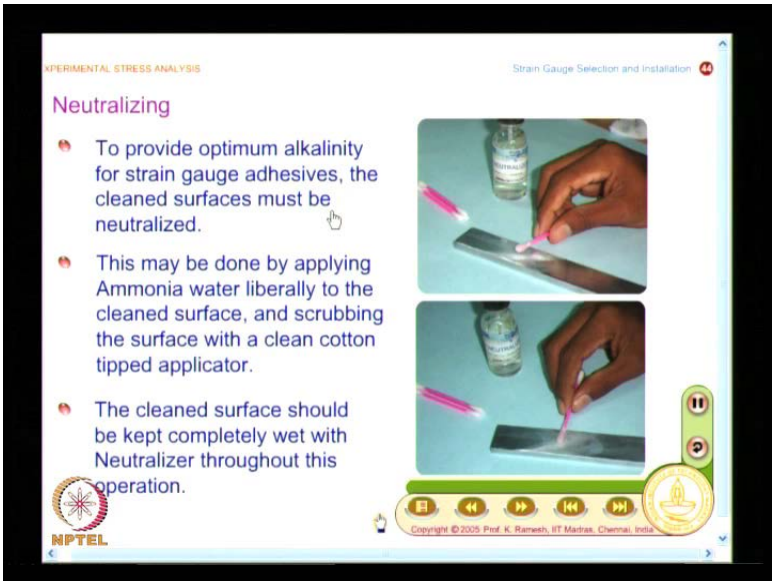

Now, you have to do a neutralizing of the surface, and why do you do this, this is done to provide an optimum alkalinity of the surface; so that, the strain gauge adhesive bonds

perfectly on the surface, and this can be done by applying ammonia, water, liberally to the cleaned surface, and scrubbing the surface with a clean cotton tipped applicator, that is what you do here, and here, again you must keep the surface wet with neutralizer.

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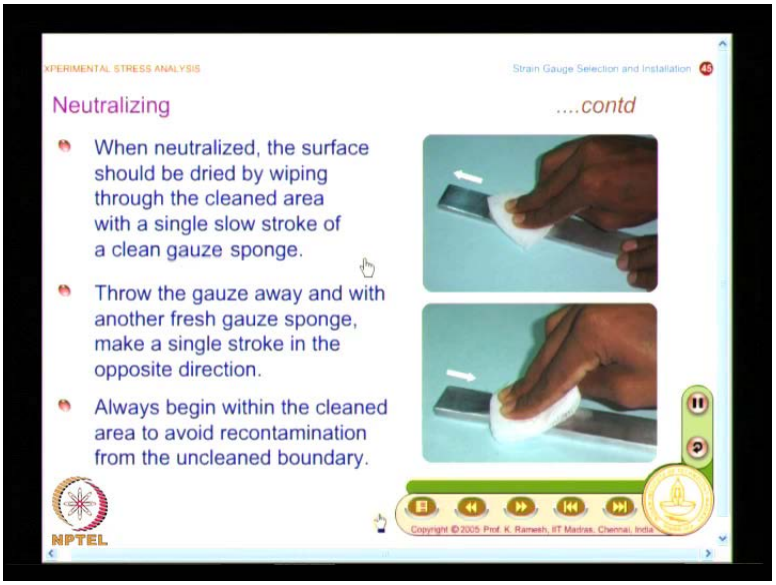

And as before wipe it, dry with a slow stroke of clean gauze sponge, you know, though it looks very detailed set of instructions, in the interest of perfect strain gauge installation, you should not get both with this; you know, once you do this two, three times you will know what are the procedures involved, and you will develop skill, and speed, and you will also have everything ready, the whole installation you could doing it very fast.

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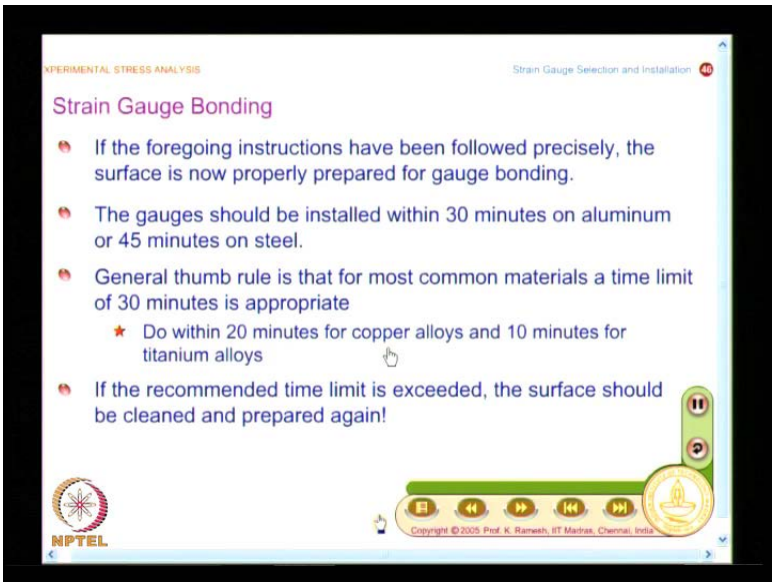

But when you look at, when you learn, you need to know the steps systematically, there is no escape from this. And what is mentioned here is, if the foregoing instructions have been followed precisely, the surface is now properly prepared for gauge bonding, and what is the recommendation, look at this very carefully, the gauges should be installed within 30 minutes on aluminum or 45 minutes on steel. And what is the general thumb rule, a general thumb rule is try to do it within half an hour, but you know, you will have a general instruction, as well as special rules.

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 the recommended time limit is exceeded, the surface should be cleaned and prepared again; so, if you know that, this is what you have to do this penalty, that you will have to pay.

It is better, that you see this two, three times, and find out what is the procedure involve, keep all the accessories ready, and then, do your installation, this is like cooking, you know, when you want make 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 burn the food or the food will not be tasty; so, there you develop some kind of a skill, similar skill is required, even on strain gauge bonding.

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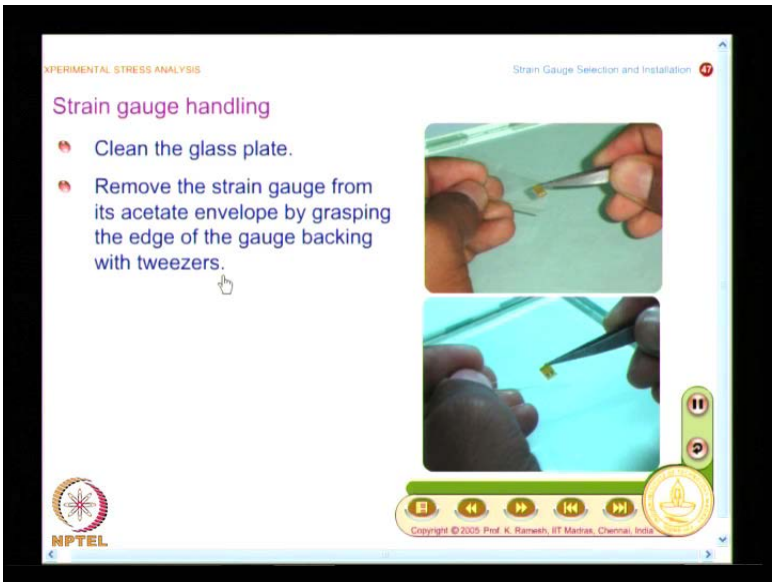

Strain gauge bonding is a skill oriented activity, and following the detailed step by step procedure is equally important, you cannot cut short steps, if you cut short steps, you are not guaranteed with proper behavior of the strain gauge system. Now, the surface is prepared, we have to take out the 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 go 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, you do not handle it with hand, where hands, you taking out with tweezers, that is what is mentioned here, we will have a closer look of it.

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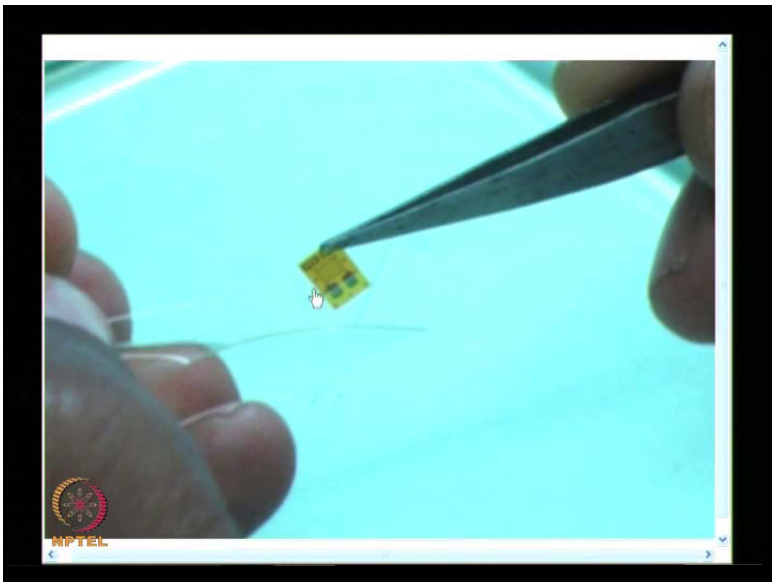

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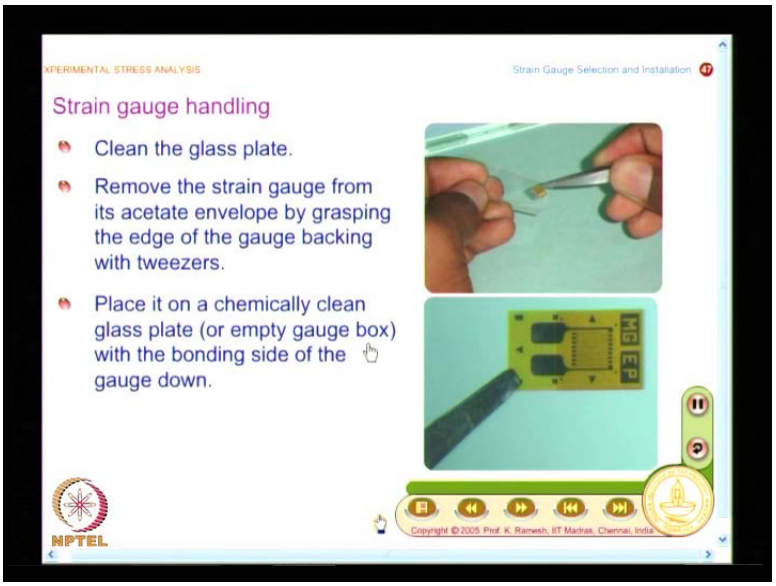

And you can see, I see the grit pattern here, and this is holding only a corner of it. If you should touch it in between what will happen, the foil is so thin it may eventually get cut, so you need to remove it with tweezers, and place it properly on your glass plate, and that surface should be chemically clean, that is why we have taken a glass plate or you can also use it on a 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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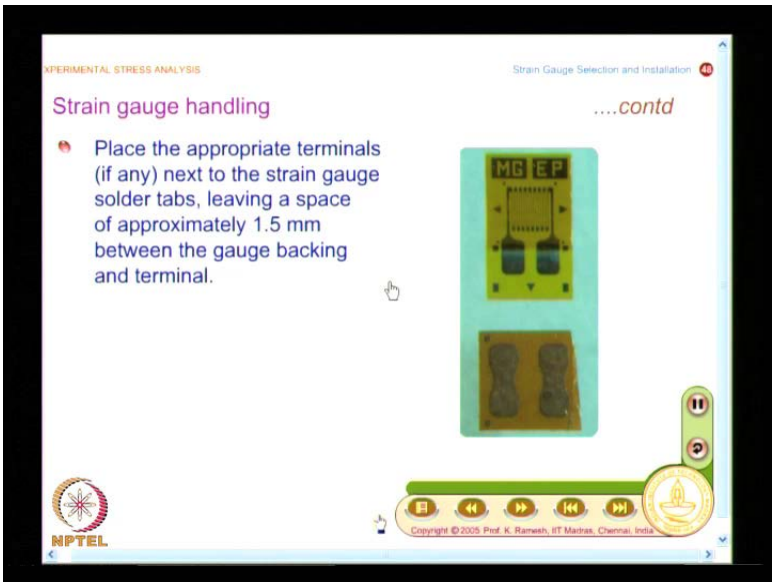

And the focus here is how to simplify your aligning process, and in order to simplify your soldering, you also have additional terminals, instead of directly using the lead wire up to the strain gauge, you have terminals, and you will have a single stand wire connecting the strain gauge to these terminals; now, both of them need to be aligned properly at the point interest, strain gauge needs to be aligned very carefully; this is just for connecting the stand of wire from the tap to the terminal, and in order to align the strain gauge, and in order to align the strain gauge, what do you do this, you take a cellophane tape and then paste it on the complete system.

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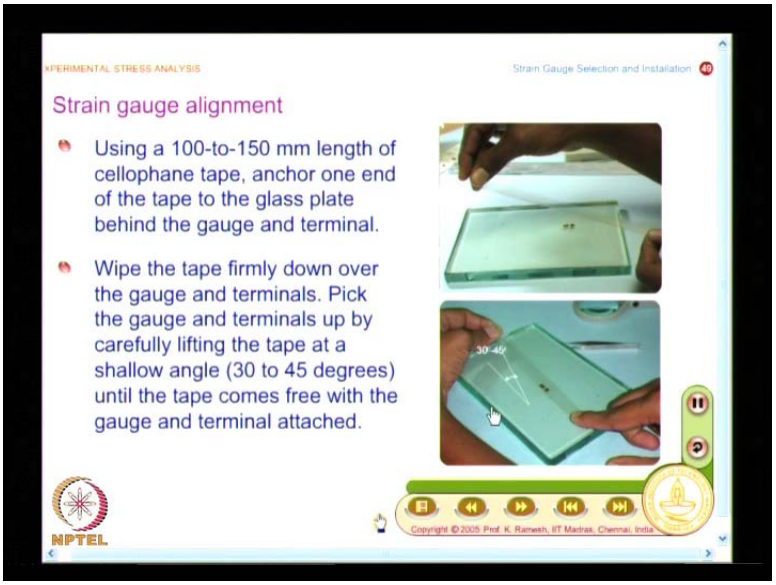

So, you have a long cellophane tape taken, and even this cellophane tape has to be approved by the strain gauge manufacturer, because adhesive may interfere with the adhesive on the cellophane tape; so, you need to be very careful about that. And when you place it on this, and when you want to lift it, you need to lift it at a shallow angle of 30 to 45 degrees.

Why did you do this, see your 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 also will get stretched, even without your knowledge, you will applying a very high level of strain, though it looks very trivial, why use specify the angle, why not I do it at some other angle, what is recommended here is, if you do like this, the chance of over stretching the strain gauge will not happen.

So, this is what you will have to do, that you need to have only 30 to 45 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; so, now, you handle only the long cellophane tape with the strain gauge attached, for you to align it, so I can align it appropriately.

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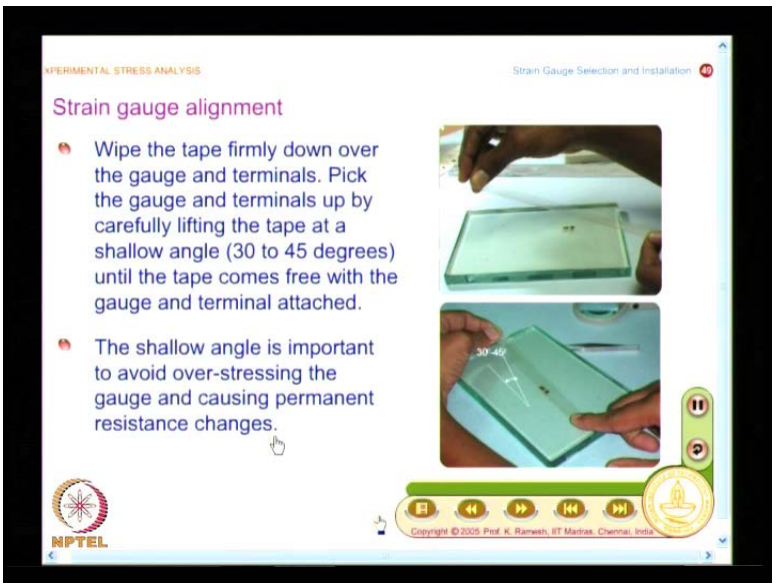

And you also do the practice on the actual specimen, what you do is, you put it, and align it, and then only go for actual bonding. And this is emphasize, the shallow angle is

important to avoid over stressing the gauge, and causing permanent resistance changes; though, this is the trivial information, this need to be adhere to.

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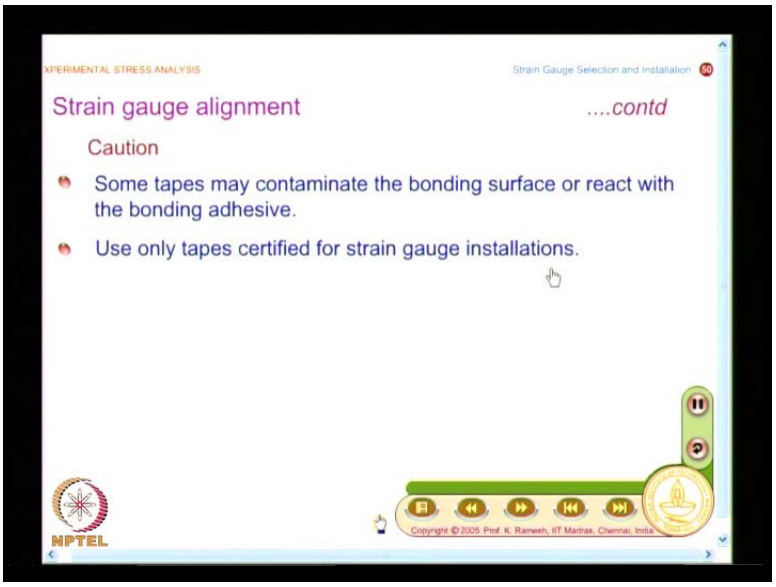

And as I mentioned earlier, the caution is also mention; some tapes may contaminate the bonding surface or react with the bonding adhesive, and you need to use only tapes certified for strain gauge installations; so, do not go with TV advertisements, you have easy tape, so may tapes come, so you have to be very careful, whether it is recommended by the strain gauge manufacturer that is the focus.

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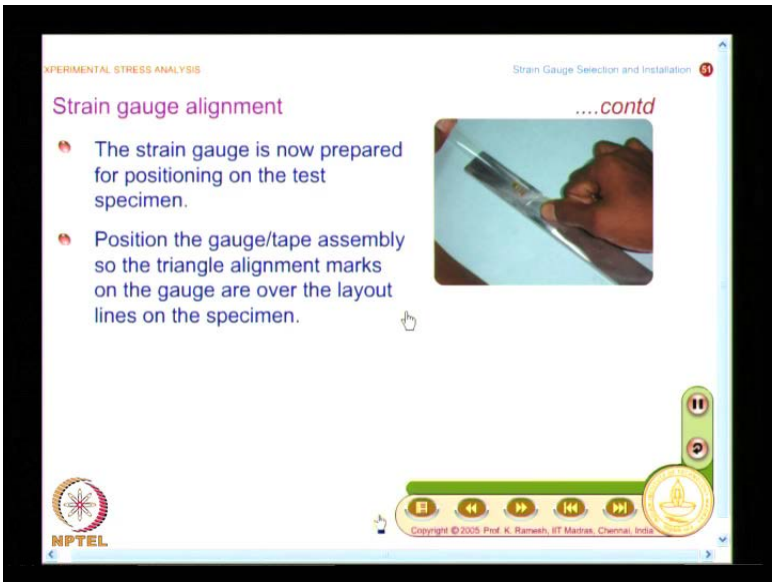

The strain gauge is now prepared for positioning on the test specimen; so, you hold it like this and then position it; you position the gauge tape assembly, so the triangle alignment marks on the gauge are over the layout lines on the specimen. So, ensure that, you can do this back and forth, until your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

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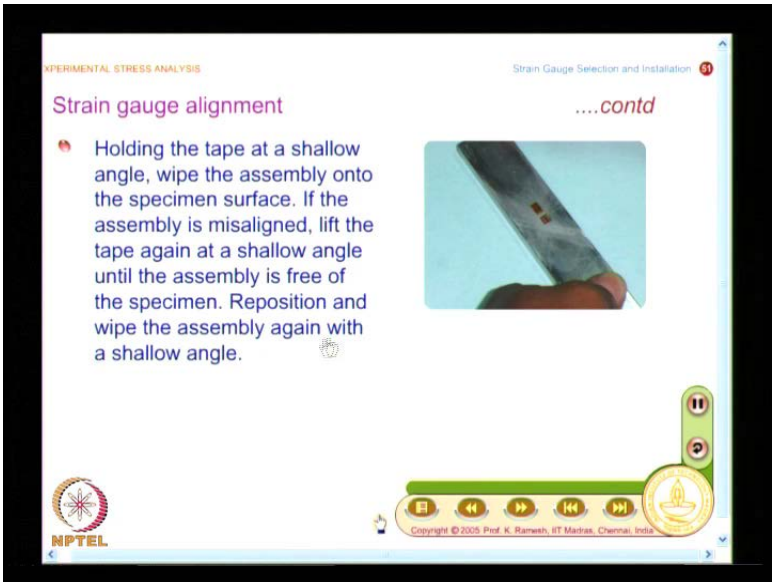

And again holding the tape at a shallow angle, wipe the assembly onto the specimen surface. If the assembly is misaligned, lift the tape again at a shallow angle, until the assembly is free of the specimen reposition, and wipe the assembly again with a shallow angle, so this is what you get finally.

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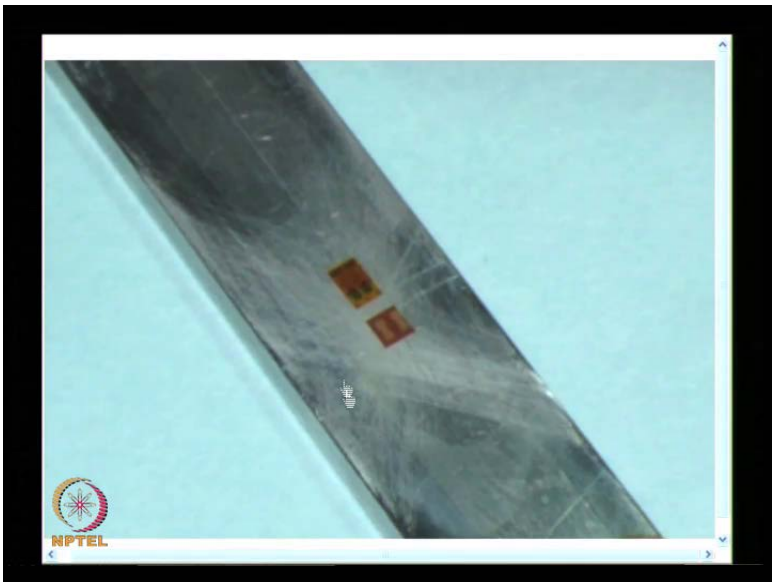

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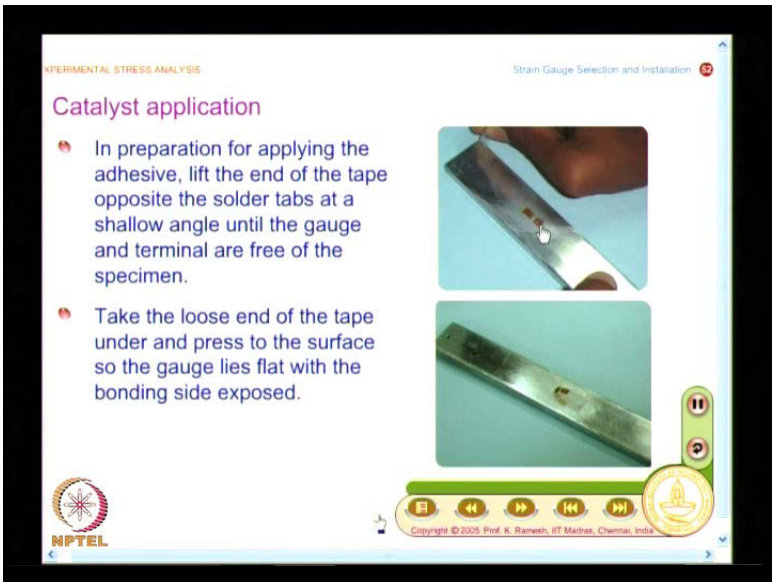

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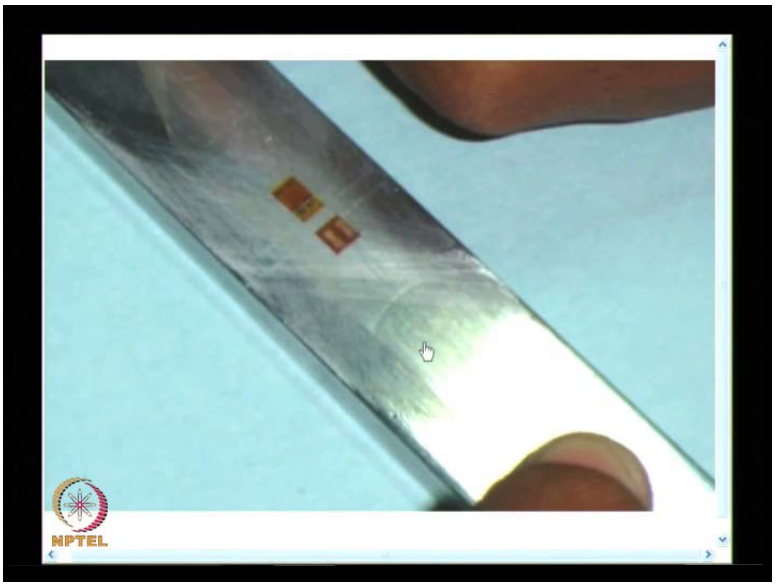

What you see here is I could see the strain gauge and the terminals aligned on the layout line marks satisfactory. I have a line here, and this is the aligned with that, and before we apply the adhesive, we need to apply catalyst; so, you carefully remove this from the surface, and that is what you see here, the tape is getting the move, 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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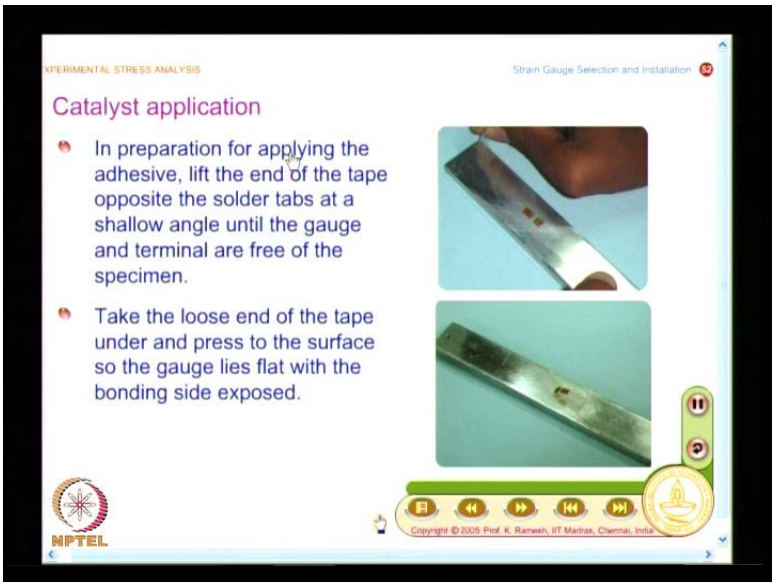

So, what you have here is you fold it like this, so that, it is easy for you to apply the catalyst, and also when you want to put the adhesive, you will put the adhesive at the junction, and then press it on to the actual surface, and this is what listed here. So, you need to take loose end of the tape,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

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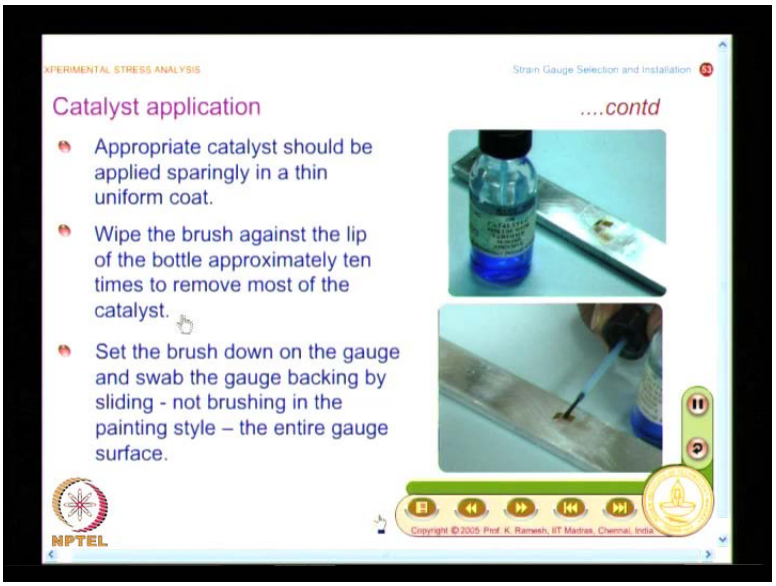

And even in catalyst application, you should not apply excessive catalyst, so the recommendation is you need to take out that brush, wipe the brush, against the lip of the bottle, this is also given approximately 10 times to remove most of the catalyst; you know, these are all very detailed instruction, why 10 times, people have tried it many times, and then standardized 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 a excessive catalyst see, it may sometimes look ridicules, that approximately 10 times, why not 9 times, why not 8 times, you do not ask question there, because you want your strain gauge installation to the as good as possible, and also while putting the catalyst, you must set the brush down on the gauge, and swap 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.

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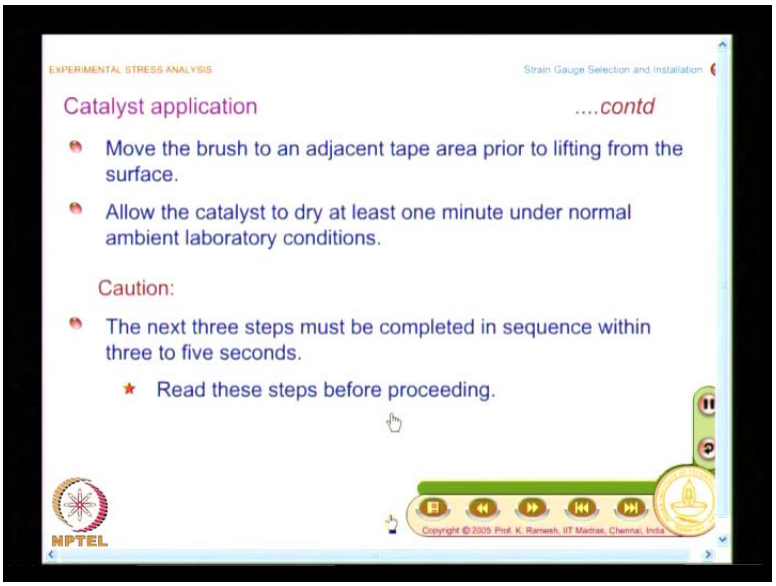

Not only this, the recommendation goes a step further; move the brush to an adjacent tape area prior to lifting from the surface; see the idea is, if you lift it earlier, a small portion may not have a catalyst, because you have ensured that catalyst brush will have the least amount; so, that enough 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 one minute under normal ambient laboratory conditions, and what is the caution here, I am going to bond the strain gauge, the next three steps must be completed in sequence within 3 to 5 seconds; so, you need to read these steps before proceeding.

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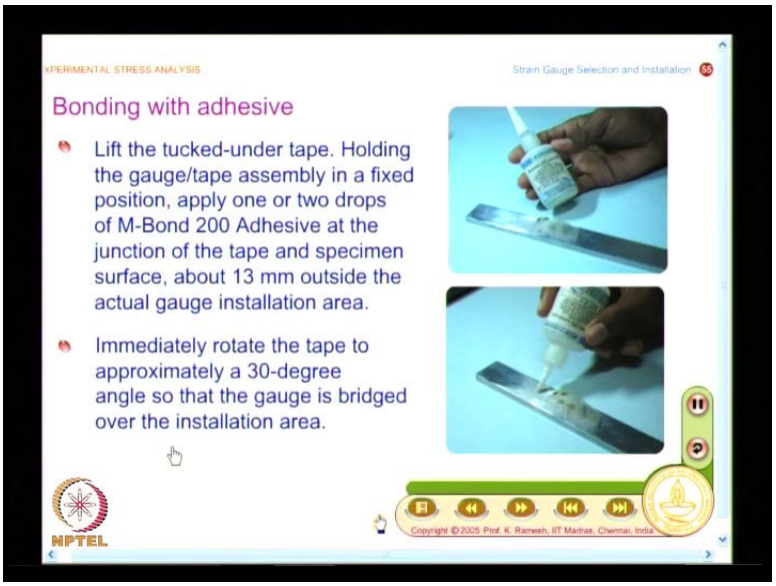

So, you need to have a mental picture what way you will have to go about, and executive it as quickly as possible. So, you have to lift the tucked under tape, holding the gauge tape assembly in a fixed position, apply 1 or 2 drops of M-Bond 200 adhesive, you also have equivalent adhesive at the junction of the tape and specimen surface, 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.

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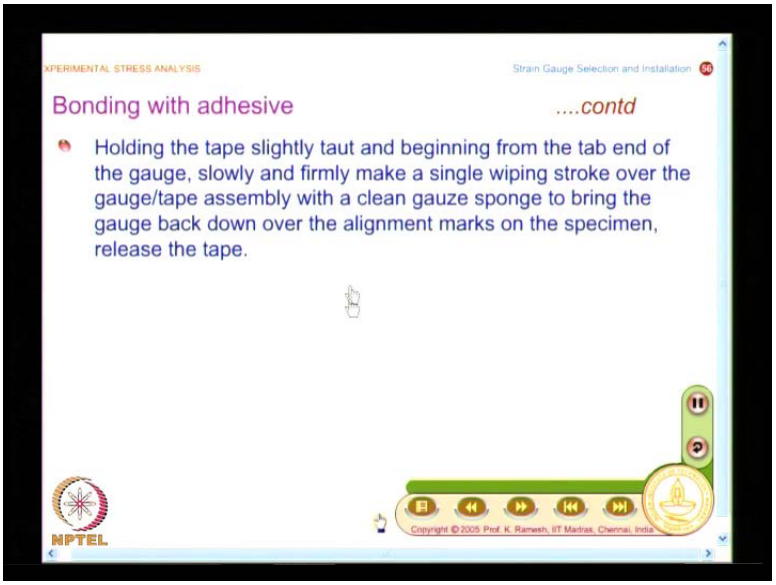

So, what you need to do is holding the tape slightly taut, and beginning from the tab end of the gauge slowly, and firmly make a single wiping stroke over the gauge tape, assembly with a clean gauze sponge to bring the gauge back down over the alignment marks on the specimen and release the tape; I will show the animation, this idea will become very clear.

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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 did you use the cotton gauze sponge, so that, you are able to applying 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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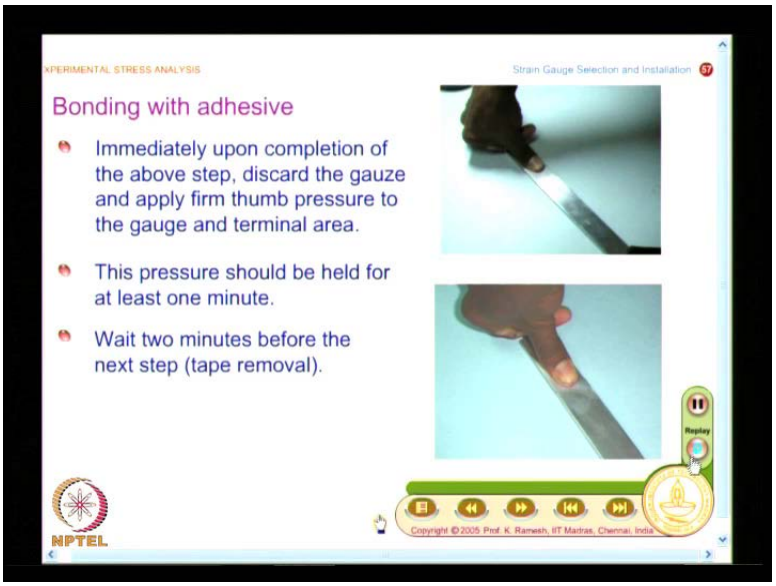

And this you need to hold it for about a minute and the bonding is complete. So, immediately upon completion of the above step, discard the gauze, and apply firm thumb pressure to the gauge and terminal area. So, this is how strain gauge is bonded, and you have needed to wait 2 minutes, before the next step that we will take it up later.

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But what I will do this, I will repeat the animation for you to appreciate the sequence involved; so, you see, your holding one end of the cellophane tape, then wipe it with 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 know what is the procedure involved.

So, in the class what we look at was in detail; we have started looking at how to bond a strain gauge, we have looked at the first step of surface preparation conditioning and neutralizing 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 applying a protective coating, only then the strain gauge bonding is complete, only then it is ready for making the strain measurement. This will take in the next class.