

Experimental Stress Analysis
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Lecture No. # 36
Strain Gauge Selection

We have looked at in the last class what is the basic aspect of a strain gauge. We have looked at strain sensitivity of a conductor, then strain sensitivity of a strain gauge. Then we also looked at what are the ways that you can make the measurement. The importance of 2 wire and 3 wire circuits, then we also looked at from the performance of the strain gauge what aspects need to be looked at in the process of such discussions we have also said that you need to understand why you have to select a particular alloy, particular carrier, particular adhesive etcetera. Now, we will move on to discuss formally how do we go and select a strain gauge and then make an installation.

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And when you go for strain gauge selection and installation, you have various patterns available and for a plate with the hole you have a strip gauge that is pasted here. And this shows what are the accessories that you require for strain gauge bonding and this gives

an illustration how do you use a cyanoacrylate cement? What kind of procedure that you need to adopt to effect a bonding? So, you have to move and then put your thumb pressure and thumb pressure itself is sufficient to effect polymerization in the cyanoacrylate cement and you are in a position to get a installation which is done reasonably fast.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Introduction

- A stress analyst has to select appropriate choice of strain gauges to suit the application.
- A single strain gauge can provide only the component of strain along the gauge length.
- For measurement, each strain gauge requires a channel of the measuring instrument.
- In transducer applications one designs a spring element such that four strain gauges could be mounted at appropriate locations having both positive and negative strains of equal magnitudes and are connected to four arms of a Wheatstone bridge for maximising the signal but occupying only one channel.

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So, as a stress analyst you have to select appropriate strain gauges to suit the application and I have always been mentioning that a single strain gauge can provide only the component of strain along the gauge length. And for measurement each strain gauge requires a channel. See, from a large installation point of view, you may need to find out strain at several points on the object and you may have a instrumentation system which has an upper limit on how many channels that you can employ. This is a very important issue when you are handling complex problems.

So, you have to effectively utilize the channels available in your measurement system. At the same time from design point of view, you should be able to acquire as much information as possible from the structure. And I have always seen there is confusion in the minds of the students, the distinction between what is a strain gauge and what is a strain gauge channel. See, if I have to measure strain at a point completely I need three strain gauges. For each one of the strain gauge you need to have a separate Wheatstone bridge to measure the signal. So, a rosette will have depending on the number of gauges

in the rosette whether it is a t rosette or a delta or rectangular rosette, it will have 2 or 3 channels as the case may be. So, you have to make distinction between what is the strain measurement and what is the number of channels that you require, that we will have to see back and forth. So, that you have a clear picture of the distinction between the two.

See, in the case of transducer applications one designs a spring element such that 4 strain gauges could be mounted at appropriate locations. Why we do this? In transducer application you want to maximize the signal and you design your own spring. So, when you design your own spring you ensure that you quadruple the signal. So, that is what you do by identifying zones where you have tension compression and invariably they may be of equal magnitudes.

So, when you connect them in a full bridge it gives you two advantages. One advantage is it has a self temperature compensation due to thermal effects, the other advantage is you multiply the signal 4 times. So, you have to make a distinction between transducer application and general strain measurement. So, in transducer applications you have a situation where you maximize the signal by connecting 4 strain gauges, but it occupies only 1 channel of your measurement system. So, what decides the channel is how many Wheatstone bridges that you are going to use for measurement. So, do not make a mistake if you have a delta or rectangular rosette, connect all of them in one Wheatstone bridge you do not have any interpretation to such type of connection.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Introductioncontd

- In general stress analysis, as one is interested in measuring strain at a point of interest, each strain gauge element would invariably demand a fresh channel.
- As the number of channels available for measurement are limited one has to judiciously select a combination of single element strain gauge, two element strain gauge or a three element strain gauge for a given application.
- It is to be noted that a T-rosette requires two channels and a delta or rectangular rosette requires three channels for measurements.

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So, the distinction is in general stress analysis one is interested in measuring strain at a point of interest. That is a focus, maximizing the signal is secondary because you may not be in a position to connect four strain gauges. If you want to maximize the signal you may have to think in terms of increasing your bridge voltage or increasing the resistance of the strain gauge you have may have to take any of those type of measures and as I mentioned earlier in a given instrumentation system, you may have an upper limit on number of channels.

So, before you make a plan for strain gauge instrumentation you need to select judiciously a combination of single element strain gauge, 2 element strain gauge or a 3 element strain gauge for a given application. See, the idea what is mentioned here is I want to find out strain at a point, why not I go and paste at every point which I want to make measurement a rosette. That means, you are demanding 3 channels per point, which may not be required. You may have a knowledge that in a particular zone of a component you may have only uniaxial stress, a single element strain gauge is good enough and you may also have in certain locations the principle stress directions are known. Once, the principle stress directions are known it is enough I use a T rosette because I can align it along one of the principle stress directions and I do not need three strain gauges. Only in situations where you do not know what is the state of strain or you know in advance that it is a biaxial state of stress then I need to put a strain gauge rosette for me to measure three components of strain. And, this is what is emphasized again you need to know T rosette requires 2 channels and a rectangular or delta rosette requires 3 channels for measurements. So, you should know a distinction between what is that you want to measure and how many channels that you use it looks very simple, but when you ask in the examinations people make mistakes. So, have a clarity in this aspect.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Introduction

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- It is desirable that before strain gauge measurement, one is able to identify regions of the test part where principal strain directions are known so that a single grid element or a T-rosette could be used instead of a three element strain gauge rosette.
- Usually one performs a brittle coating test on the object to get an idea of the principal stress directions at various locations in the model.
- In many aerospace applications, use of a photoelastic coating test has provided key information in identifying the critical zone for strain gauge measurements.

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So, the recommendation is it is desirable that before strain gauge measurement one is able to identify regions of the test part where principal strain directions are known. So, that a single grid element or a T rosette could be used instead of a three element strain gauge rosette. You know this is the reason why we discussed the method of brittle coatings before strain gauges. Primarily brittle coating gives you contours of is statics. So, you can know in advance that these are all the principle strain directions on the component. That knowledge could be well utilized in reducing the number of channels per point. You know that makes a difference. So, that you are able to utilize your instrumentation system effectively. And another aspect is you know strain gauge is a point by point technique and if you take a look at any one of the optical techniques like photo elastic coatings that gives you whole field information.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Introduction

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- Usually one performs a brittle coating test on the object to get an idea of the principal stress directions at various locations in the model.
- In many aerospace applications, use of a photoelastic coating test has provided key information in identifying the critical zone for strain gauge measurements.
- In some instances photoelastic coating test has also revealed the choice of appropriate gauge length for strain measurement.

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So, when you get the whole field information the advantage is you have a knowledge of the critical zone where you need to make further study using strain gauge measurements. Other aspect is when you are looking at the fringe patterns, the fringe patterns also give an indication of the gradient. If the fringes are very dense then you have a very sharp variation of strain values. So, you can also make some assessment on the choice of appropriate gauge length for strain measurement. See, this is the general thumb rule when you are actually looking at a complex problem. Combination of a whole field technique and a point by point technique makes your analysis faster, at the same time reasonably accurate because in a complex problem first identification is which are all critical zones. A whole field technique can give that very easily and in those locations you paste strain gauges and refine your measurement.

So, the recommendation is try to use a whole field technique in conjunction with the point by point technique. A point by point technique alone will not be very effective and we have seen some examples. Some examples, where a mere application of strain gauge technique was not sufficient because you pasted it slightly away from the critical zone. So, it under estimates the maximum strain. So, your design can be way off.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Introduction

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- Once the type of gauge is selected (single, T or three element rosette), careful and rational selection of gauge characteristics are very important.
- Some of the aspects that need to be kept in mind are
 - Optimizing the gauge performance for specified environmental and operating conditions.
 - Obtaining accurate and reliable strain measurements.
 - Contributing to the ease of installation.
 - Minimizing the total cost.

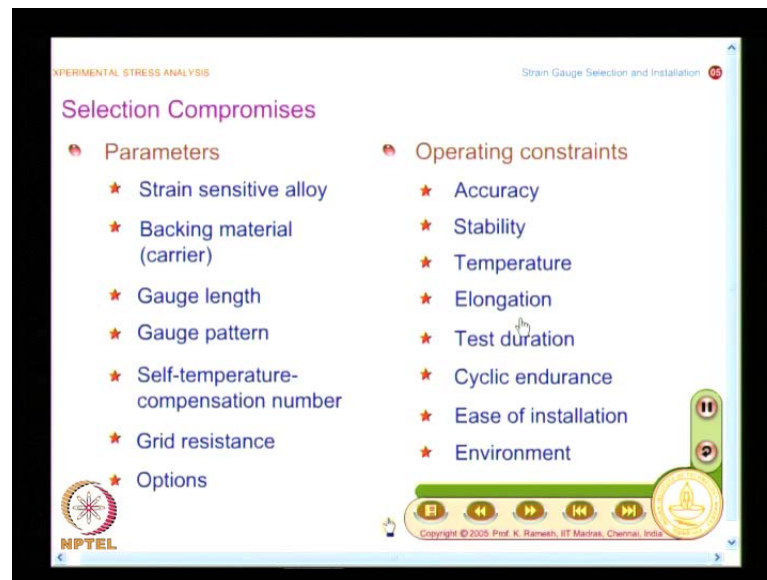
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So, the recommendation is combine the use of whole field technique and a point by point technique.

So, once you decide I need to have in these locations a single strain gauge a T rosette or a three element rosette, you have to make a careful and rational selection of gauge characteristics for the given application. And what are the aspects that you need to keep in mind, you need to optimize the gauge performance for specified environmental and operating conditions. And obviously, you want to have accurate and reliable strain measurements that is the basic focus and in certain applications ease of installation also dictates the selection, this is also an aspect which needs to be weighed in rational selection of strain gauge characteristics. And finally, you would like to have minimizing the total cost. You do not want to increase the cost of installation that is what I said you do not want to put strain gauge rosette at every point or you do not go and say I will select strain gauges with pre attached lead wires which will reduce my effort, but it will also increase the cost.

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So, you need to make these kind of decisions for you to effectively utilize the strain gauge instrumentation and; obviously, in any one of this selection approaches you will have selection compromises.

So, you will have a set of parameters and set of goals that you need to have. And when I look at a strain gauge what all I need to worry about? I need to worry about what is the strain sensitive alloy that I need to select. We have seen in a application where stability was important we found going from an advanced to karma has improved the performance and we in the same application we also saw the selection of backing material from polyimide to epoxy phenol resin has definitely improved the performance. And depending on the strain gradients that you are going to encounter you need to decide the gauge length and gauge pattern is also equally important, we have looked at from heat dissipation point of view, we have looked at charts which give you recommendation for a given power density what kind of gauge patterns that you can select. And we have also said for small temperature variation it is desirable that you go for a self temperature compensation and depending on the specimen material on which I am going to do the test I need to select this number. And again the heat dissipation brings in what is the grid resistance that I should select, if I have a higher resistance I minimize $i^2 r$ laws thereby minimizing the heat generation this may be necessary when I go and work on composites or poor conductors of heat as specimen material. And finally, I will also have to select options. See, we said in one of our earlier applications we use the karma alloy

for improving the stability and one of the basic difficulty in karma alloy is it is difficult to solder the lead wire. So, there you can go for the option of pre attached lead wires from the manufacturer and let us look at what are the operating constraints.

So, we have to focus on accuracy, the measurement should be stable for long durations of time and at what temperature I need to make the strain gauge measurement and what is the level of strain I am looking at, that is dictated by the elongation and the test duration, am I doing a dynamic test or am I doing a test on in situ measurements which requires monitoring over months and years. And particularly in transducer applications I need to ensure cyclic endurance and you should not ignore the difficulties in installation, that is why you have ease of installation is also one of the operating constraints. And finally, what is environment am I working at room temperature or am I working at aggressive environment like exposure to sea water. And obviously

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Selection Compromises

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- Parameter choices which tend to satisfy one of the constraints or requirements may work against satisfying others.
- Gauges shorter than about 3 mm are generally characterized by
 - ★ Lower maximum elongation
 - ★ Reduced fatigue life
 - ★ Less stable behavior
 - ★ Greater installation difficulty
- In view of the above, for general purpose applications use gauges with gauge lengths 3 mm or more.

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when you have a selection parameter choices which tend to satisfy one of the constraints or requirements may work against satisfying others. This is there in any selection. So, when you have to make a selection you have to strike a compromise that is why even the discussion is mentioned as selection compromises. So, you compromise it scientifically. See, I have always been saying the general purpose strain gauges have a gauge length of 3 millimetres. Suppose, I go and try to use a strain gauge shorter than 3 millimetre what is the kind of problem that I may have to encounter? It may have lower maximum

elongation, it will have a reduced fatigue life and it will have a less stable behaviour and finally, it will have greater installation difficulty. See, before you take up the discussion on strain gauges you would have heard that strain gauge is a point by point technique and you would have imagine I can find out what happens at a point precisely. What we saw was from the way we have to make a strain gauge. I do not have a material which has very high resistance wherein I can put a speck of material and measure what happens at a point of interest I need to essentially make a grid. So, it is not point by point technique it is only measuring over a small finite area in bring in certain approximations. So, from that point of view you may want to simply go for the shortest gauge length possible.

So, what is the recommendation here is when you go for smaller gauge length than required then you need to face these kind of difficulties. So, the thumb rule is for general purpose applications, use gauges with gauge lengths 3 millimetre or more. This is the thumb rule and if it works be happy with it, do not go and emphasize that you need to go for smaller gauge lengths. And you know if I have to select a strain gauge of suitable characteristics and also to order these gauges, strain gauge manufacturers use a strain gauge designation system.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Strain Gauge Designation System

- In order to facilitate selection of strain gauges of specific characteristics to suit a specific application and to order these gauges, strain gauge manufacturers use a strain gauge designation system.
- Designation system is manufacturer dependent and gives information about the backing material, strain gauge alloy, gauge length, pattern of the gauge, gauge resistance etc.
- In the following slides, the designation systems used by Vishay Micro-measurements and HBM are presented.
- In principle, there could be slight modifications in the designation system from time to time and use the current catalogue of the manufacturers to place an order.

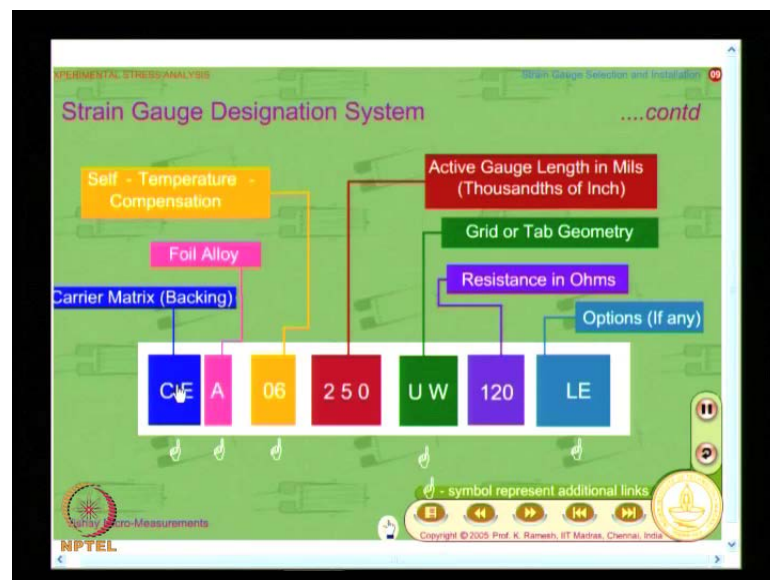
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So, it does two jobs one is to facilitate selection of strain gauges of specific characteristics and also to order these gauges and obviously, the designation system is manufacturer dependent and gives information about the backing material, strain gauge

alloy, gauge length, pattern of the gauge, gauge resistance etcetera. See, we have looked at various aspects of the strain gauge alloy backing and also the adhesive to facilitate our current discussion on selection for a given application. So, what way we will go and look at is what way a strain gauge is designated and provide a general guidelines on how to go about in selecting this parameters. We may not take a specific problem to select a strain gauge, but we will provide you general guidelines on how to go about and for these discussions I have the designation system from Vishay micro measurements and HBM and you can also look at other manufacturers. You have manufacturer from Japan and you should also keep in mind these are discussions to give you a idea of what way you can go about and there could be a slight modifications in the designation system from time to time and use the current catalogue of the manufacturers to place an order.

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So, here we are looking at what aspects are important. That also gives you an idea how do you go about in deciding what strain gauge you want and you have a very elaborate strain gauge designation system. So, I have one, two, three, four, five, six, seven items are mentioned in the designation system used by Vishay micro measurements. So, the first symbol or set of symbols tells you what is the career matrix, then the second one tells you about foil alloy, the third one gives you the self temperature compensation number and the fourth one gives you active gauge length in mills. See, though you have s i units this is the kind of system that they use in the Usa. So, you have a u s a manufacturer, gives you only in terms of mills and then you have grid or tab geometry.

So, this becomes important when you look at a particular installation you need to have the tabs at a particular orientation, then you have resistance in ohms.

So, when you look at the designation you will know whether you are talking 120 ohms or 350 ohms and finally

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The slide is titled "EXPERIMENTAL STRESS ANALYSIS" and "Strain Gauge Selection and Installation". The main heading is "Carrier Matrix (Backing)". It lists three options:

- E:** Open Faced cast polyimide backing. Low elastic modulus and very flexible – can easily follow the contour of the specimen.
- W:** Fully encapsulated; glass fiber reinforced epoxy-phenolic resin.
High-endurance lead wires. Useful for fatigue loading conditions.
- CE:** Thin, flexible gauges with a cast polyimide backing and encapsulation featuring large, rugged, copper-coated solder tabs.

The slide also features an NPTEL logo, a "Back to main" button, and navigation icons. Copyright © 2015 Prof. K. Ramesh, IIT Madras, Chennai, India.

you will have options. And we will see some of these parameters and when I go to carrier matrix or backing you know I have a list, I have a list of symbols, the idea is to give a flavour that when I have symbol e, symbol w, symbol CE what happens. So, when I have E it is simply open faced cast polyimide backing and when I say w it is fully encapsulated, you use a glass fibre reinforced epoxy phenol resin and CE denotes thin flexible gauges with a cast polyimide backing and encapsulation.

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EXPERIMENTAL STRESS ANALYSIS Strain Gauge Selection and Installation

Foil Alloy

- A: Constantan Alloy in self-temperature-compensated form.
- P: Annealed Constantan.
- D: Isoelastic Alloy
- K: Modified Karma Alloy

This is the last slide for this link. To go to next/other chapters navigate through the main menu button.

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So, this is the polyimide with encapsulation, w is glass fibre reinforce epoxy phenolic resin and if you to go to foil alloy you know you will have symbols for advance constantan because I am going to show you some strain gauges from Vishay micro measurements, should be able to find out what these strain gauges are in reality. And A denotes advance it is a constantan alloy in self temperature compensated form, P is annealed constantan, D is Isoelastic alloy and K is modified karma alloy. So, by looking at this we will also know what is the foil alloy and ((C)). And you have already noted you know what is the self temperature compensation number for various specimen materials?

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EXPERIMENTAL STRESS ANALYSIS Strain Gauge Selection and Installation

Grid or Tab Geometry

- In these set of slides, a sample of possible grid types are given.
- The purpose is to show the variety possible.
- The patterns listed are no way exhaustive and the user is advised to look at the current catalogue of the manufacturer.
- Note the gauge designation indicated against each gauge.

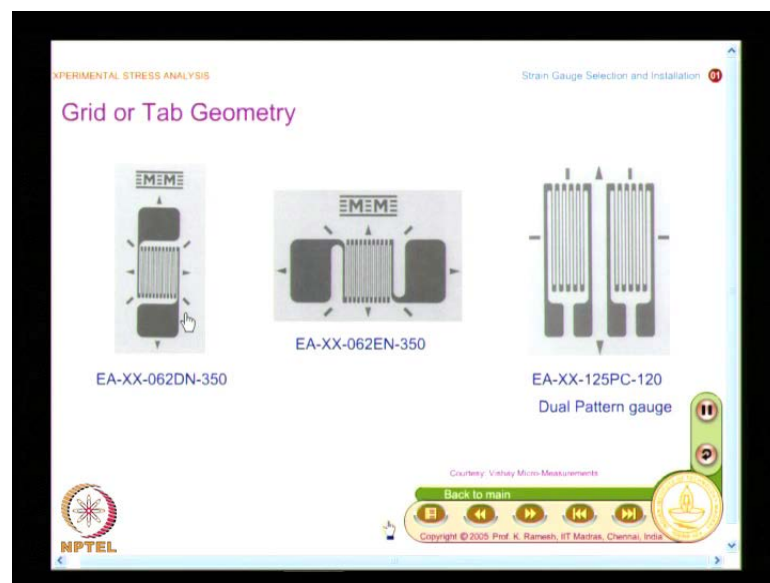
Courtesy: Vishay Micro Measurements

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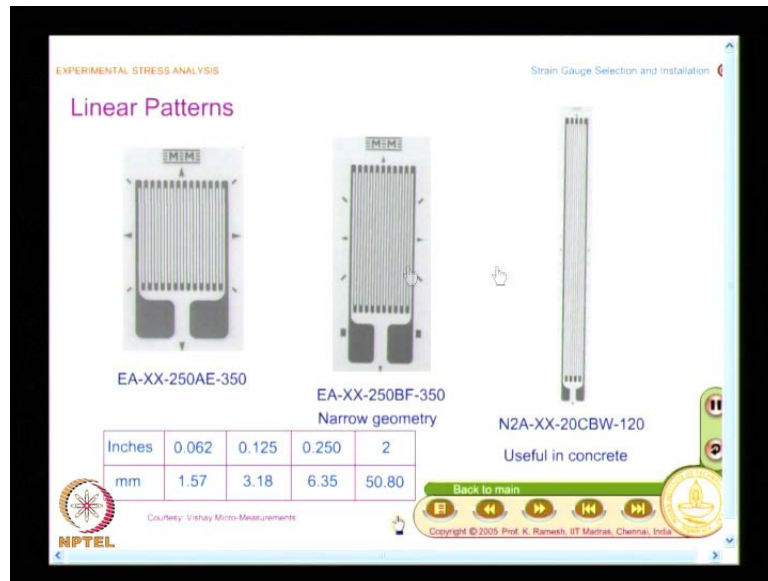
So, now, we focus our attention on what are the grid and tab geometry available. So, what I try to provide in these set of slides is only a sample of possible grid types because you need to know what is the variety possible, a strain gauge is not just a single set of loops, the patterns listed are no way exhaustive and as an user you have to look at the current catalogue of the manufacturer and the idea what I want to show is when you look at these grid patterns also note the gauge designation system indicated against each gauge. So, you have a number assigned to it you will be able to quickly find out what kind of a strain gauge am I looking at.

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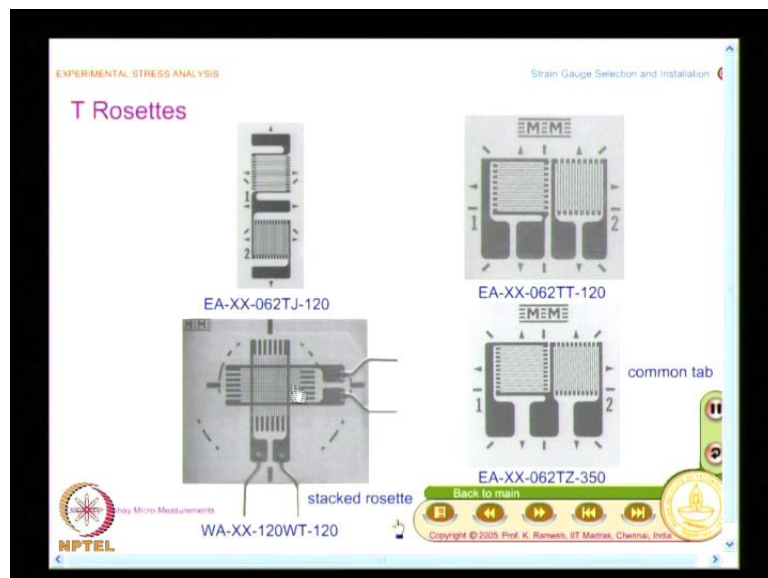
And obviously, the simple strain gauge what you have is a simple loop like this and what is shown here is you have the tabs on either end and for this the particular manufacturer gives this as d n. So, e denotes the carrier backing, a denotes advance alloy and XX denotes depending on the specimen material I will have to select my self temperature compensation number that is why this is not listed. So, the same kind of pattern will be available for a set of base specimen material and e n is the kind of gauge where I have this is horizontal. And you know in the case of maximizing the strain reading in one of the classes I said you can also paste two strain gauges adjacent to each other, instead of you make the alignment you have that available as a pre aligned gauge. So, that has a specific designation by the manufacturer and in all these cases you also have the last digit indicating the resistance. I have 350 ohms, I have 120 ohms here and there are no special options.

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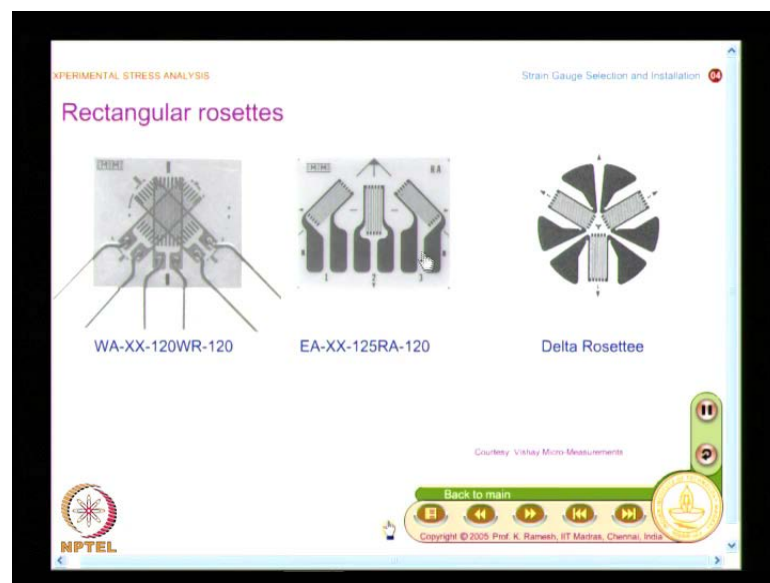
And the idea here is to show a variety, you know I can have a very wide grid pattern. Why do you have the wide grid pattern? For heat dissipation. If the heat dissipation is an issue then go for a wide grid otherwise go for a narrow grid and this is the other extreme you have a very long strain gauge. You have to know that such strain gauges are really available and this is about 50.80 millimetre. These are very long and useful in concrete. And in all these cases you have separate symbols for indicating the pattern.

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And I said that you have T rosettes where two strain gauges are available and if you note very carefully the elements are mutually perpendicular. So, I will measure strain at two perpendicular direction. And I have also mention you also have stacked rosettes available because you should see that stacked rosette then only you will find out if I want to get the strain at this point stacked rosette is very good from that point of view because the approximations involved are less and in this you have variety of patterns available.

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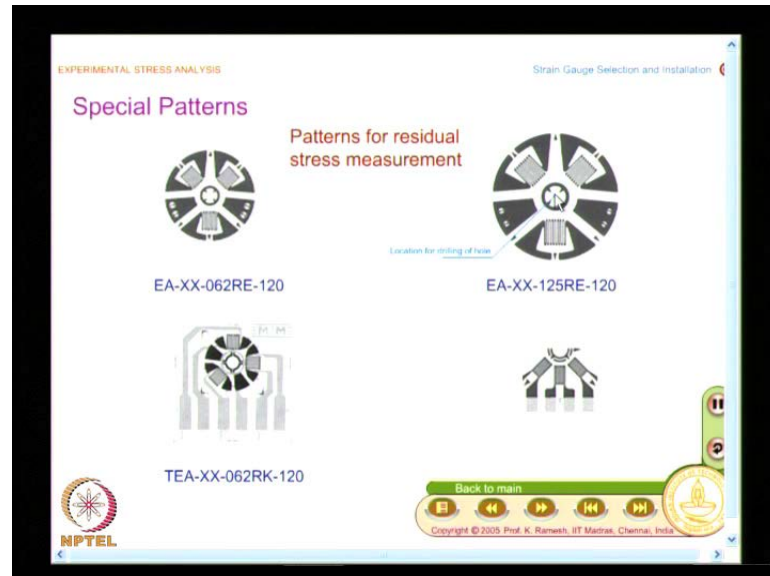


See one of the simple examinations I will have is, I will give you a few patterns and you should be able to distinguish what class of strain gauge it is, that familiarity you need to develop that is why these patterns are shown and you have this as stacked rectangular rosette and the moment you have this as w then you can imagine that it is a encapsulated epoxy phenol and a denotes it is a self temperature compensated advance alloy and you have the same rectangular rosette in the conventional form here. This rectangular rosette is expected to measure strain at this point where this 3 strain gauges meet. On the other hand this is good from analytical thinking point of view, but there is a practical difficulty, it is going to generate lot of heat and particularly in bending applications this is not recommended.

And you also have another variation that this is a delta rosette which is better than a rectangular rosette when you want to find out what happens at the point of interest because that is enclosed by all the 3 strain gauges. So, this again selection of delta or

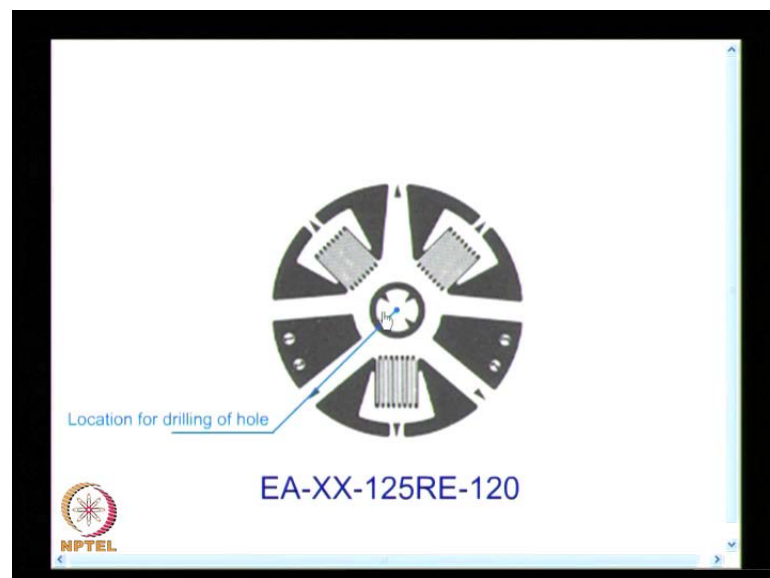
rectangular dictated by your strain field, you need to select appropriately also the installation considerations can also decide one way or the other.

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Then you have very special patterns, you have special patterns for residual stress measurement. See, if you look at it casually it will look like a delta rosette.

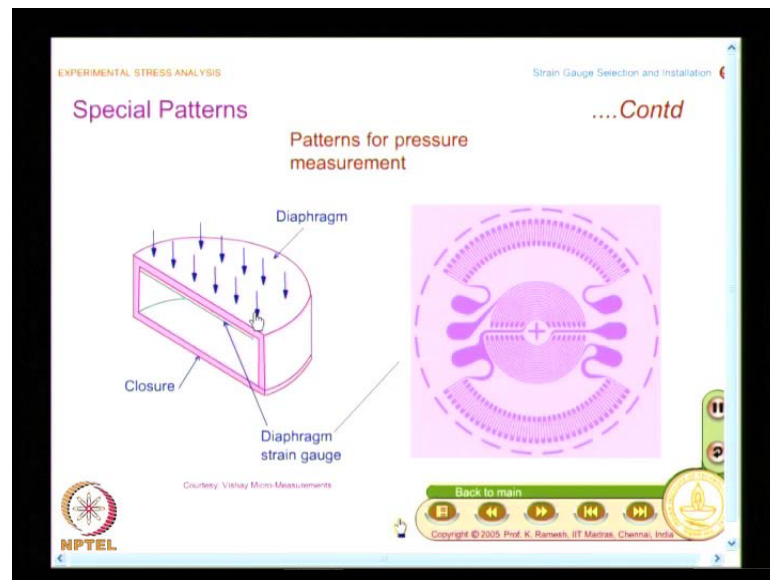
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I will magnify this you make a sketch of one such strain gauge. It will look like a delta rosette, but it is not a delta rosette you have a provision to drill a hole at the centre and you have very sophisticated drilling gadgets that comes along with this. So, the idea here

is when you drill the hole the stresses get relieved and those relieved stresses are sensed by these strain gauges and you have expressions available from the manufacturer how to interpret and find out the residual stress. See, residual stress is a very difficult problem to handle with and this is a semi destructive type of approach, you need to remove material. It is not like X-ray diffraction, where you do not do any destructive analysis, but where you can find out residual stress only up to very small depths. Here you can go to two to three millimetre depth and it will look very similar to your delta rosette, but because I have provision to drill a hole here, you must distinguish that this is the strain gauge meant for residual stress measurement and what you have in the slide is the different ways the tabs are provided to facilitate ease of installation.

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So, ease of installation dictates this. Then you have another interesting pattern, you have a special pattern for pressure measurement. I have a thin diaphragm and I have a strain gauge which is shaped in this manner because I use a metal foil and then I do an etching process I can put any complicated pattern for me to do the etching and you have one set of patterns which are radial like this. What is the component of strain that this will sense? It will sense the radial strain because it measures only strain along the gauge length. You have another set of patterns which are circular. So, this will measure the tangential strain, circumferential strain or tangential strain.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Crack Detection (CD) Gauges

Courtesy: Vishay Micro Measurements

- Convenient, economical method of indicating the presence of a crack, or indicating when a crack has progressed to a predetermined location on a test part or structure.
- By employing several CD gauges, it is also possible to monitor the rate of crack growth.
- Available with various strand lengths
 - ★ From 10 mm [CD-XX-10-A] for applications where space is limited, to 50 mm [CD-XX-50-A] for use where the direction of crack propagation, or the point of crack initiation, is uncertain.

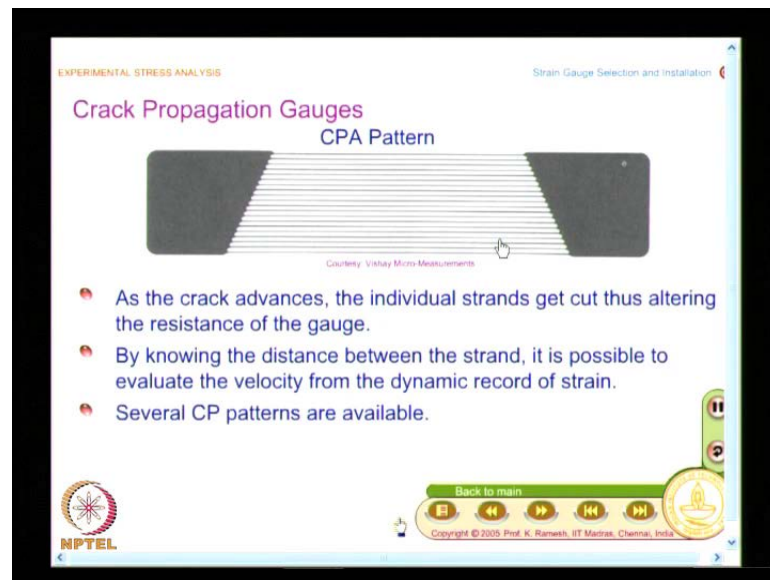
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So, you have a special pattern meant for measuring pressure and you also have because you have an etching process, you also have special gauges these are not essentially meant for strain measurement because fracture mechanics is becoming very important, you also have what are known as crack detection or CD gauges. The principle of operation is simple suppose I have a crack and this crack crosses the strain gauge it will cut the element because when the crack passes through the connectivity of this conductor is lost. So, that is detected to know, yes the crack has crossed a particular point of interest. So, this is the very interesting application of metal foil gauges. So, they are convenient and provide an economical method of indicating the presence of a crack. And we also have another variation of this which is meant for measuring the velocity of crack propagation.

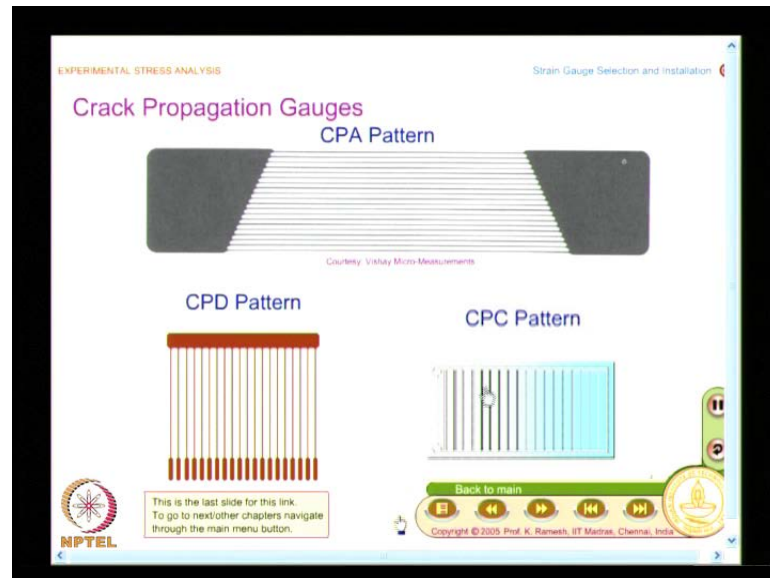
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So, what you have here in one foil I have several strands shown here. So, what will happen as the crack advances the individual strands get cut thus altering the resistance of the gauge. So, use the same principle you are not measuring strain, but you are measuring crack propagation. Very interesting, because I know the distance between the springs so, I can also find out the velocity since I know the distance between the strands, it is possible to evaluate the velocity from the dynamic record of strain. See, we have to look at fracture mechanics this is becoming very important from design point of view. And once you look at strain gauge development we will also look at if time permits towards the end of the course how to measure stress intensity factor from strain gauge measurement.

This is going to make your utility of strain gauge for a variety of practical problems of current interest. And you also have several such patterns available, I have shown one such pattern here and you have another two set of patterns.

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Which are like this. This is designated as CPD and then you have another pattern called CPC pattern. In this case the grids are aligned like this and this is also used for finding out the crack propagation and eventually its velocity. And finally, we look at what are all the options available. We have looked at carrier matrix, we have looked at foil alloy, you have already seen what is self temperature compensation then you have the gauge length, grid pattern we have seen. The idea is to show a variety of strain gauges possible, then you have resistance in ohms and what are the options.

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The slide is titled "Standard Options" and is part of a presentation on "EXPERIMENTAL STRESS ANALYSIS" under the sub-heading "Strain Gauge Selection and Installation". It contains a table with three columns: Option, Description, and Series availability. The table lists five options: W (Integral terminals and encapsulation), E (Encapsulation with exposed tabs), SE (Solder dots and encapsulation), L (Preattached leads), and LE (Preattached leads and encapsulation). The NPTEL logo is visible in the bottom left corner, and navigation controls are in the bottom right.

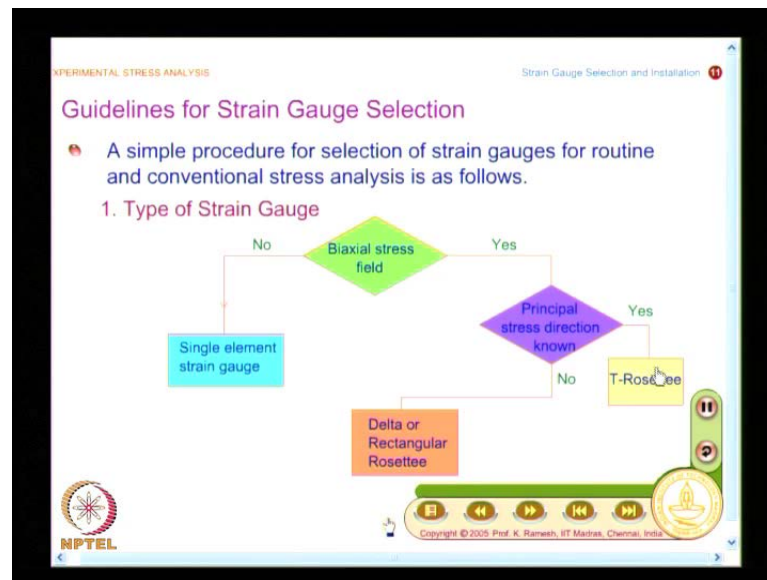
Option	Description	Series availability
W	Integral terminals and encapsulation	EA, EP, WA, ED, WD, EK, WK
E	Encapsulation with exposed tabs	EA, ED, EK, EP
SE	Solder dots and encapsulation	EA, ED, EK, EP
L	Preattached leads	EA, ED, EK, EP
LE	Preattached leads and encapsulation	EA, ED, EK, EP

So, when we look at the options you know I have w which is integral terminals and encapsulation and when I have L it is like pre attached lead wires and if I put LE it is pre attached leads and encapsulation. So, the idea is to emphasize for special applications look for suitable options to minimize your effort in installing the strain gauge. So, that is what we have looked at and now what we will do is we will go and see the designation system adopted by HBM and I have try to use a same colour code for similar parameters. Obviously, the order is different here, he has first code as standard or configurable and the second one is number of measuring grades and the relative positions to each other, then he classify this as strain gauge series, then you have a gauge pattern, you also have a gauge pattern.

I wanted to make a note of this you need to know that I have one, two, three, four, five, six, seven, eight parameters are necessary. And the common ones are you have a gauge pattern, he may have a different designation, but gauge pattern is forming part of the designation system. The designation system also gives you s t c number and mind you the classification of s t c number by this manufacturer is different. So, it is manufacturer dependent. Then by looking at the designation you can also look at the gauge length and he gives you an s i units this gauge length is given in millimetres and in both the designation systems you have a resistance in ohms. So, by looking at the designation you will know what is the gauge length? What is the resistance? What is the specimen material it is meant for directly?

The other ones are manufacturer dependent very closely because you need to select the grid pattern and then you will have to look at what kind of backing and alloys, these are different. And, now we will look at a generic recommendation

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on how to select a strain gauge for a given application. What is the first step? The first step is what is the type of strain gauge that I need at a point of interest. I have to ask the question am I working on a biaxial stress field? If the answer is no it tells me it is enough I use a single element strain gauge, on the other hand if the answer is Yes then I need to ask the other question do I know the principle stress direction. If I know the principle stress direction from a brittle coating test, I can use the t rosette, 2 strain gauges are sufficient and you are going to occupy 2 channels. After looking at transducer application where you connect 4 strain gauges to 1 Wheatstone bridge, do not go and connect 2 strain gauges of the rosette in 1 Wheatstone bridge, it does not make any interpretation possible

You need to measure strain at 2 perpendicular directions from a measurement point of view and suppose I have a situation where the principle stress directions are not known and I am in a biaxial stress field I need to have a delta or rectangular rosette. So, you would first decide whether you want a single element T rosette or a delta or rectangular rosette.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Guidelines for Strain Gauge Selection

....contd

2. Type of Strain Measurement
 - ★ Static, dynamic, in-situ measurement for long duration.
 - ★ Select the gauge series appropriately.
3. Characteristics of the anticipated strain field
 - ★ Decide the range of gauge length acceptable.
 - ★ Select the gauge resistance based on the accuracy required and the strength of the signal.
4. Heat dissipation characteristics of the test material
 - ★ Decide the self temperature compensated number.
 - ★ Select a higher gauge resistance if available.

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And what is the second step? What is the type of strain measurement? Am I going to make a static strain measurement or dynamic strain measurement or in situ measurement for long duration? So, this helps me to select what? What is the strain gauge series appropriately because you have different types of series for static dynamic and in situ. When I go for dynamic I can go for is elastic alloy, when I go for in situ measurements you may go for a karma alloy. So, you need to decide the type of strain measurement. And, what are the characteristics of the anticipated strain field is a third step. So, if I know the strain field I can decide the range of gauge length acceptable because if I am going to have a very sharp changes in strain levels, I need to go for a smaller gauge length and this also gives me an indication what is the gauge resistance that I need to have based on the accuracy required and the strength of the signal.

So, this is where I said when I am talking about strength of the signal when you are designing a loading grid for you to test your component, you select the load in such a manner at the point of interest you should be able to get at least 100 micro strain because we have seen many of the installation aspects like if you do not connect the lead wires as a 3 wire circuit, if you do only a two wire circuit a small temperature change itself can give you an error of 156 micro strain.

So, many of the installation and other associated aspects of strain gauge measurement can make so much variation on the measurement, it is desirable that you have a situation

where if possible load it to an extent that I get 100 micro strain at least. Suppose, I do not have that luxury then what I have to look at is I must find ways to increase the signal strength by modifying the gauge resistance and you have to look at heat dissipation characteristic of the test material. So, this decides the self temperature compensation number and here again if necessary select a higher gauge resistance.

So, what we have looked at is first decide the number of strain gauges you need to do then decide whether you want to do for static, dynamic or in situ measurements, then look at the characteristics of the anticipated strain field, look at what gauge length is appropriate. This gives to some indication on the gauge resistance possible then address the issue of heat dissipation which helps you to determine the self temperature compensated number.

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EXPERIMENTAL STRESS ANALYSIS

Strain Gauge Selection and Installation

Guidelines for Strain Gauge Selection

....contd

5. Requirement of Installation
 - ★ Decide the grid geometry.
6. Options
 - ★ Select from the various options to simplify the installation of strain gauge and minimise the cost of installation.

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And you will also have to look at requirement of installation. See, this you may ignore, many times you say I am not going and installing only my technician is going to install, let him face the music of difficulties in installation. If you leave it, you do not have a confidence on the strain measurement. You will also have to look at difficulties in installation as an issue and decide the grid geometry. So, finally, you select the set of options that would help you to simplify the installation of strain gauge and minimize the cost of installation and this is what I said if you are using a karma alloy it is better to go for a pre attached lead wires rather than you struggle in trying to solder it.

So, in this class what we looked at was what are the nuances in the selection of a strain gauge for a particular application and we have also looked at a typical strain designation system by two manufacturers. So, that gives you an idea by looking at the designation of a strain gauge. You look at the gauge alloy, you look at the backing, you also get an identification of what is the grid pattern, what is the self temperature compensated number, what is the resistance and also options if any. And finally, we looked at a sort of a general guideline how do you go about in a step by step fashion to decide on a particular strain gauge for a given application. Thank you. .