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Theory and Practice of Non Destructive Testing

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Acoustic Emission Testing - 1

Hello everybody today I am going to start a new topic as part of this lecture series on NDT and this will be on acoustic emission testing.

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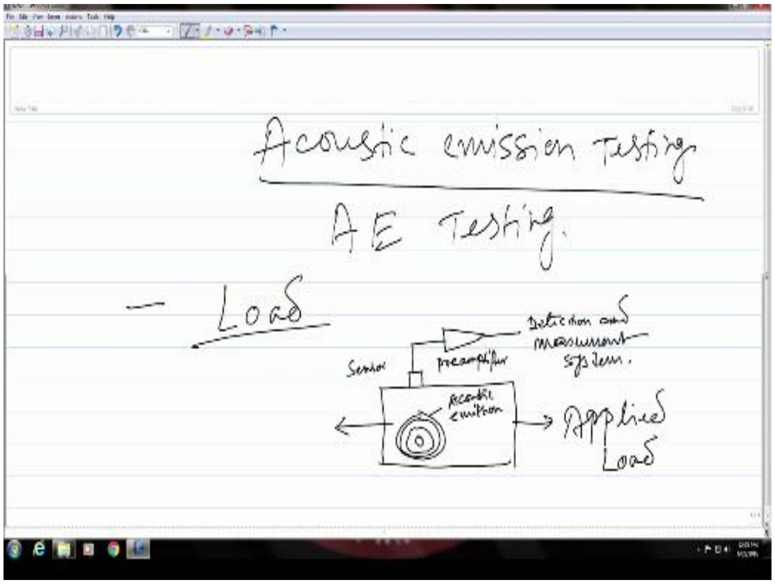

Which is also known as AE testing in short okay. So like what you always do first we will learn about the basic principle of this technique and then we will see how it is done. In the last topic if you remember it was on ultrasonic testing and what we saw in that case is that you have a piezoelectric ultrasonic transducer through which you are sending ultrasonic waves into a sample and whenever these sound waves reflect back from a surface or from discontinuities we collect this echo and then we display them okay.

And that is how we get to know about the presence of defects in a given sample okay. So utilizing sound waves and their reflection we do the entity in that case. In this particular technique also the acoustic emission testing as the name suggests particularly the term acoustic it also indicates that it has to do something with sound waves okay. But in this case it is bit different from what we do in order sonic testing in the sense in ultrasonic testing you have a two-way traffic you first send the sound waves into the sample and then you collect the echoes back okay.

So when you send sound waves inside the sample as we would have discussed the sound waves propagate by creating oscillatory movement in the atoms or in the molecules okay. So it propagates by some kind of elastic waves through the sample okay. Now for any reason if you have this kind of waves generated inside the sample itself okay then when they come out from the part and if you could receive them by a sensor then also that could be used to do non-destructive testing okay.

But in order to create these elastic waves inside the sample without exciting it there has to be some movement which can provide this oscillatory movement to the atoms okay, and for that to happen the sample has to be loaded then only you could have some dynamic events inside the sample which will in turn create some kind of elastic stress waves which will propagate through the sample and come out okay.

So if you have a dynamic or moving defect when the sample is loaded then in this case also some kind of sound wave or some elastic wave can be generated inside the sample and they will come out of the sample okay. So if you have a sensor you could receive this elastic waves which are known as acoustic emission waves okay. So the source of acoustic emission wave is the redistribution of a stress field inside the sample due to a movement of some kind of defect for example it could be a crack which can initiate and then propagate.

So due to that crack propagation there will be some movement on an atomic scale and due to that this elastic waves will be generated and if you have a sensor to receive them you would be able to know that you know there is a source of acoustic emission inside the sample, and hence there could be some defect which is active okay. But in order to generate those elastic waves okay, the first requirement is that the component or the part which is being examined must be loaded.

Because in order to clear that stress wave you need to apply some load then only there will be you know some change like crack initiation or propagation which can generate these elastic waves okay. So that is the first requirement that the part or the system which is being examined must be loaded okay. So let us say you have a component and you load it in a particular fashion, then in some part of the sample this stress waves will be generated so that will be the source of the emissions.

And then this waves will propagate from this source okay. So this is the source of acoustic emission or stress waves generated due to this applied load for whatever reasons which we are going to talk about little later. Now if you have sensor over here which can sense these waves coming out from the sample then you would be able to collect them, so first thing that you need to do in order to collect and then utilize them is to amplify them because generally the intensity of this kind of emission will be very low.

So you use a preamplifier and then send this signal to the detection and the measurement system which will generate an electrical signal out of this elastic waves and give you something to see on that display okay. And then that can be interpreted and then you would be able to know if there are any defects which are active inside the component okay right. So this is how this technique works.

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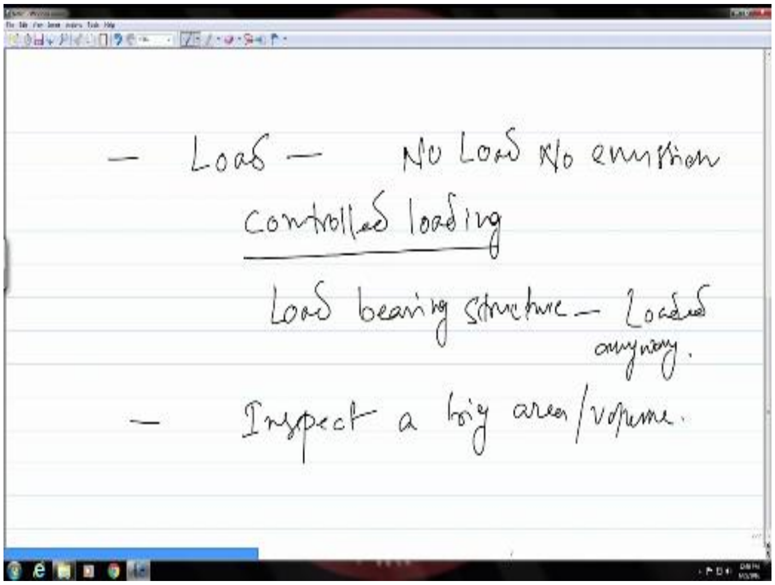

So the first requirement is that it has to be loaded if there is no load, then there is no emission so this is the first characteristic feature of acoustic emission if the defects or the damage that you have inside a component if it is not active okay, then you are not going to get any emission out of it okay. So that is the first and the foremost difference between acoustic emission testing and any other NDT method in which case we have seen that we detect the existing defect okay, whatever it may be which may or may not be active.

For example, if you have a crack that crack may not have to be propagating in order to be detected by other entity methods okay. But in this case if you want to detect that crack it has to be active when it has to propagate okay. So that is the prime difference between acoustic emission testing and any other entity technique and for the defect and the cracks to be active the part has to be loaded okay.

So that is the, that is how this particular characteristic come into picture that if there is no load there is no emission okay. So when you do acoustic emission testing then the part has to be loaded by controlled loading. So this can be before service or during the service of that particular component and if it is a load bearing structure, then you know it is anyway loaded okay. So all you have to do you have to place the sensors at appropriate locations and then try and see if you get any acoustic emission signal coming out from different regions okay.

So this kind of system will be loaded anyway, so then in these cases there is no need to load it externally okay. And the other important aspect of this particular technique is you would be able to inspect a big structure in a single inspection, so you do not really have to do local examinations in this case like you do for many other entity techniques.

So even if you have a very big structure or very big area to be inspected that can be done in a single examination itself by placing a number of sensors at different locations where you think there could be a potential source of damage which could lead to a caustic emission events okay. So this is another characteristic feature of this particular technique that you do not need to do inspection in small local areas rather you can inspect the whole structure in one go itself and that is how these offers some advantage in terms of time and cost okay.

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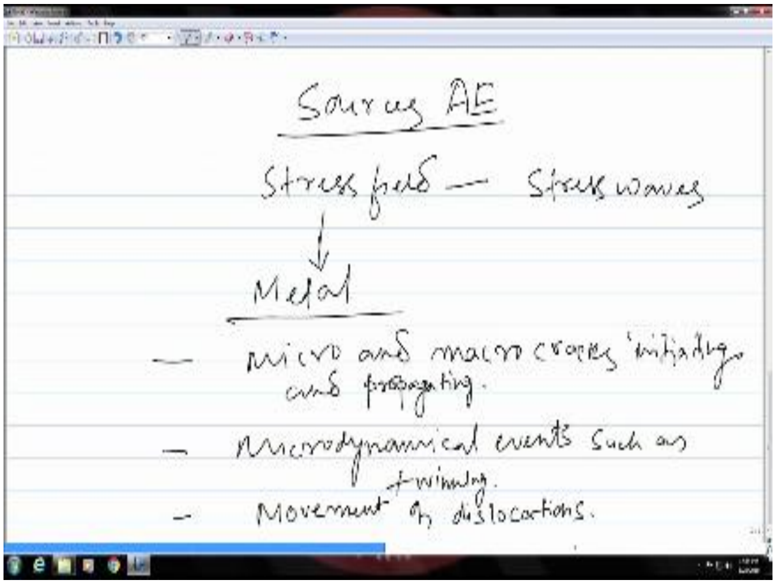

So if you see the sources of acoustic emission as I said you need a stress field which will generate these stress waves which will propagate through the sample and will be received by the sensor okay. So when you load a material or a system then various things can happen depending on what kind of material or what kind of a system it is which can act as sources of acoustic emissions okay, by providing you some active defect okay inside the component.

For example, if you have a metal so in metallic systems when it is loaded different phenomena can take place for example, you could have micro and macro cracks initiating and propagating, so initiation and propagation of cracks when a metallic system is loaded I can generate lot of acoustic emissions lot of this stress waves and this will serve as a source okay. Then you could have some micro dynamical events like twinning when you talk about metals, metals deform mainly by two mechanisms.

One is known as slip and the other one is known as twinning okay. Whenever a metal is loaded I could either have a sleeve happening or twinning happening depending on the conditions and that is how they plastically deform and the process of slip happens due to a lattice defect which is known as dislocation so when you load a metallic system this dislocations will move and due to that movement it creates what is called a slip which is movement of atomic planes over one another as if they are sleeping over each other when the dislocations move, okay. So movement of these lattice defects known as dislocations can also generate acoustic emission inside metals.

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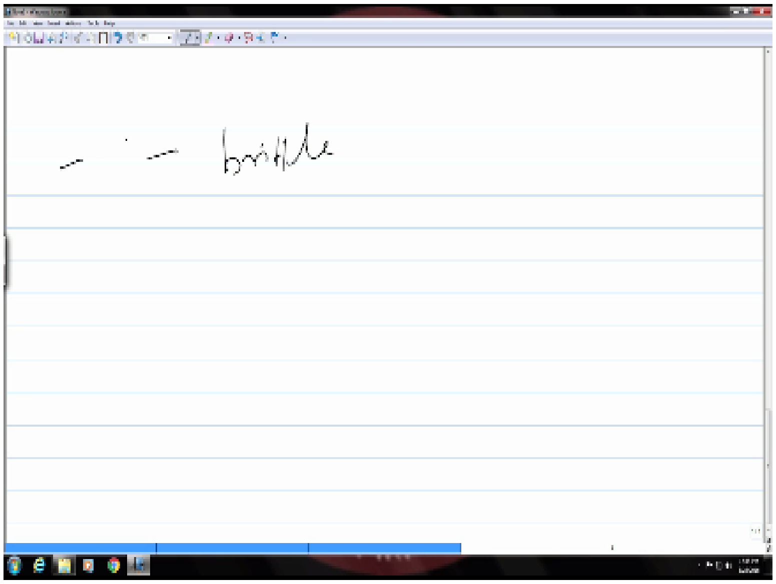

Then if there are brittle inclusions or some kind of impurity which is leading to formation of this kind of you know brittle foreign elements or foreign inclusions inside a metal then fracture of this kind of brittle inclusions when you apply the load can also generate acoustic emission.

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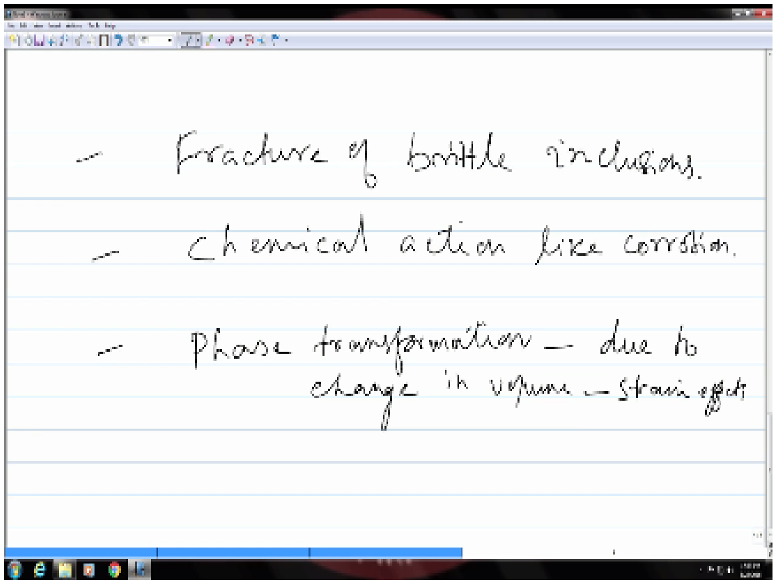

Then other events like a chemical action such as corrosion which is common in metals can also lead to or these elastic stress waves or acoustic emissions, okay. Then many of the metallic system goes through what is known as phase transformation wherein it changes from one phase to another phase at a particular temperature for a given system, okay. So the parent phase and the phase which is forming they are different and their volume also could be different so due to this change in the volume it can lead to stresses inside the material and due to that stress again this kind of acoustic emission can be generated, okay.

So phase transformation can also be a source of acoustic emissions in metals so this happens as I told due to a change in the volume which leads to small strain effects okay, and then this in turn will generate the elastic waves or the acoustic emissions.

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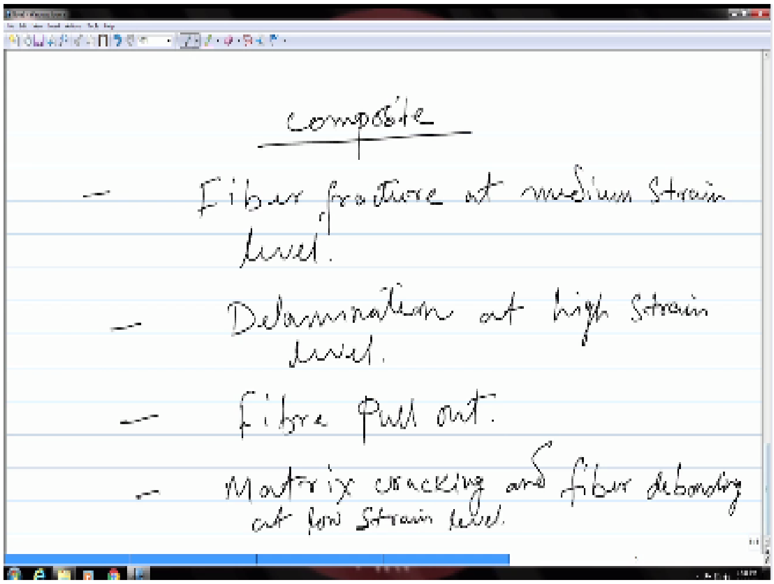

Then if you take a material like a composite then in that case acoustic emissions can generate due to fracture of the reinforcing fibers at medium strain level delamination this is again a type of damage in composite materials which can happen at high strain levels, then another common phenomena in composite material when it is loaded is fiber pull out these fibers will simply pull out from the matrix a living behind some voids so that kind of event can also generate these stress waves and we lead to acoustic emission.

Then the matrix also can crack so matrix cracking and fiber debonding from the matrix this can happen at low strain level in the other previous two cases it was at medium strain at high strain and at lower strain you could have this kind of phenomena happening inside a composite material the matrix can crack or the fiber can separate or the fiber can debond at lowest end levels, okay. So these are the different sources in case of composite materials.

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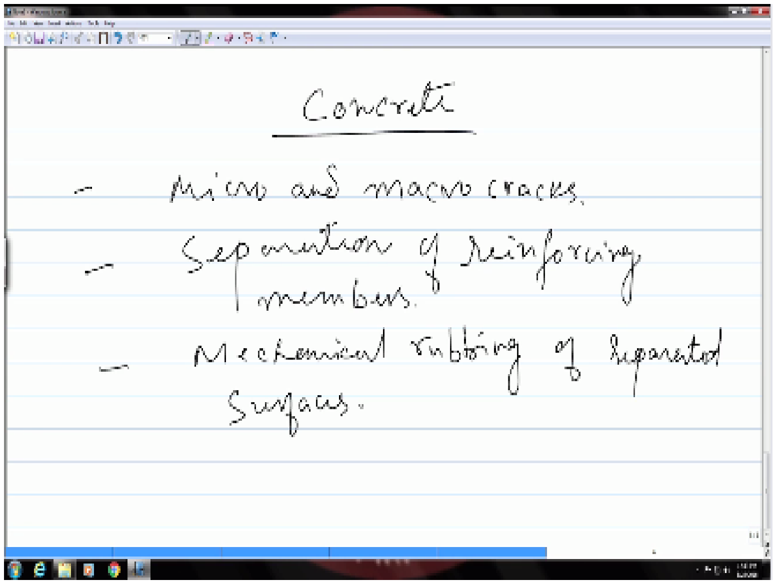

Then if you have a system like a concrete there also you have those reinforcing bars which reinforce the concrete, okay. So those reinforcing steel bars we all have seen so they are bonded to the rest of the material the rest of the concrete material so then there also I mean it is loaded different kind of phenomena can happen which can lead to generation of this stress waves or acoustic emissions.

For example, there also it can crack so you can have micro and macro cracks then the reinforcing bars can separate and when there is some separation there could be also mechanical rubbing between the separated paths which can also lead to generation of this acoustic emissions.

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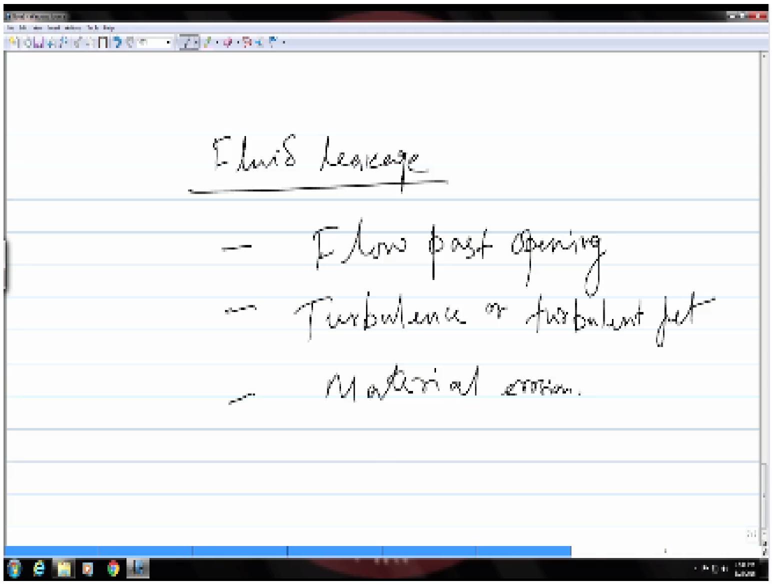

Then in a component like a tanker which carries a huge volume of liquid or gas okay, there could be some fluid leakage in cases of big tanks feet store or carry fluids and due to that you could have this flow past the leakage or the opening and this can generate a lot of elastic stress waves that means this can also serve as a source for acoustic emissions. Then turbulence or the turbulent jet due to the presence of liquid head or some fluid pressure if there is any turbulence in this liquid or there is any turbulent jet that will also create a lot of stress which can lead to acoustic emissions.

And in this kind of component material erosion is a common phenomena so there again it will generate lot of stress leading to emissions, okay. So these are different kind of sources depending on what kind of component or what kind of system you have okay. So we have understood something about these acoustic emissions now what their sources are how they generate testing a component okay, and what is the difference between these acoustic emission testing and any other entity technique that also we have understood, okay. So now before we conclude today let us see the typical features of this kind of waves.

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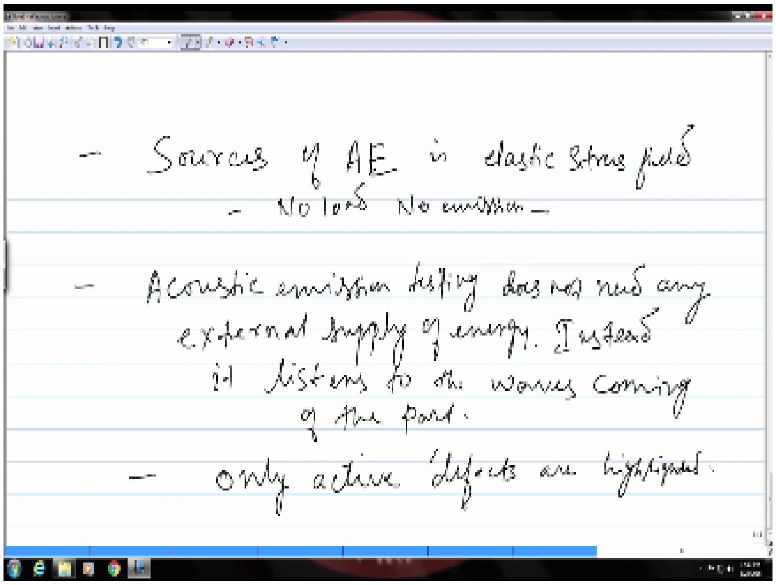

I have talked about a bit in the beginning but let us list them down, so this is what we have learned so far sources of acoustic emission is the elastic stress field or the elastic stress waves it happens when the component is loaded. So let me reiterate this again, no load, no mission this is the typical characteristic of acoustic emission, then acoustic emission testing does not need any external source it does not need any external supply of energy all you do you listen to the waves which come out from the sample.

So instead it listens to the waves coming out of the part and this also we have talked about only active features are highlighted unlike the other energy methods which detects existing defects which may or may not be active, so in this case this acoustic emission testing it detects the movement of defects, okay so that is why only active defects are highlighted in this case.

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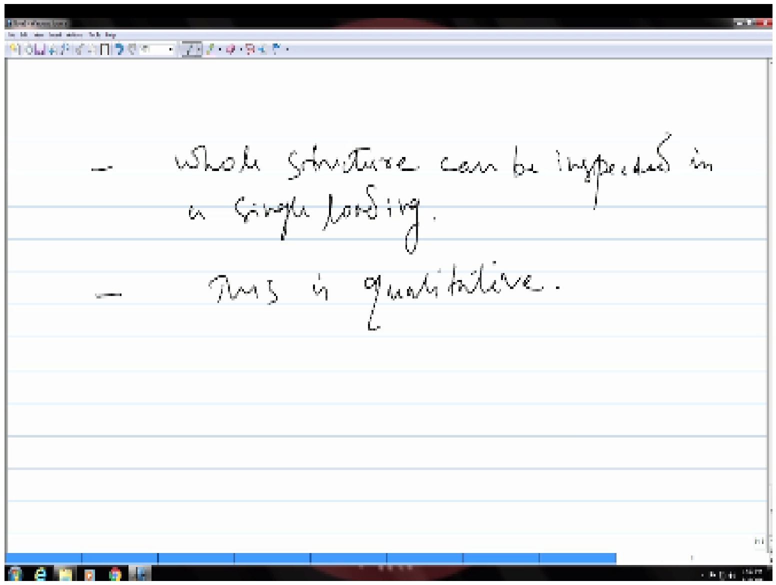

The entire structure can be inspected in a single examination as I would have said before also and that is how this can save a time and cost and this is primarily qualitative this does not really provide you any idea about the size of the defect or the location as such so this is primarily a qualitative method, okay. So these are the typical characteristics of acoustic emission so in this class today we have learned about the basic principle of this particular technique and we also saw the sources of acoustic emission. In the next class we are going to continue on this and then we will see how the test is done what are the test parameters and the other aspects okay, so for today I will stop here I will see you next time. Thank you.

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