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Theory and Practice of Non Destructive Testing

Dr. Ranjit Bauri
Dept. of Metallurgical & Materials Engineering
IIT Madras, Chennai 600 036

Radiography – 10

So in the last class we have learnt about digital radiography and now that we have covered digital radiography also we have almost covered all the aspects of radiographic testing now. And the one important aspect which I am going to talk about today right now is that whenever you do radiographic testing which involves these radiations the radiation safety is very, very important okay.

So this is one thing that one should always keep in mind while working with radiations like what you have in case of radiographic testing okay. So this radiation safety that is what will be the topic for our discussion today and if you talk about safety with regard to radiation there are two things.

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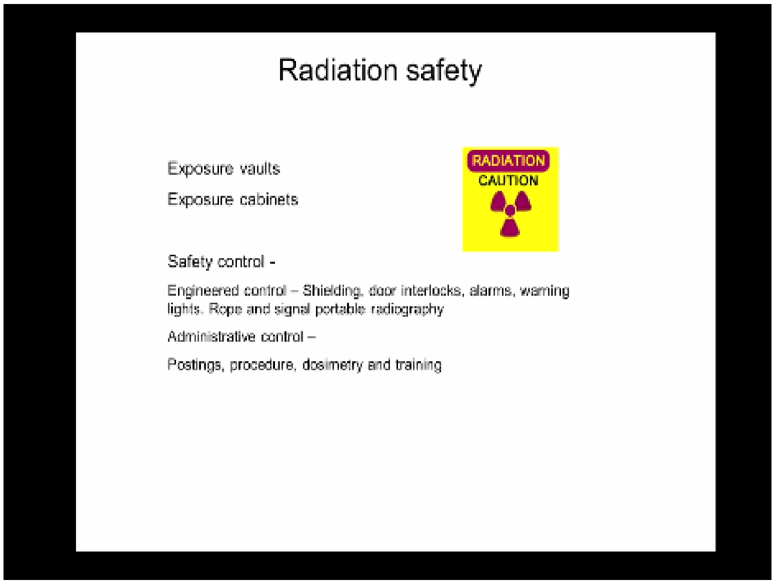

One is called the engineering safety controls and the other one is called administrative control okay. So this all is to ensure that the personal and the examiners who are working with the radiation for doing radiographic testing they are not exposed to harmful radiations okay, and at the same time people around this radiation zone are also not exposed to this radiations okay. So all these things are done in order to protect people from the harmful radiations okay.

So if you talk about this engineering control for the safety you have this under this engineered control shielding door interlocks, alarms, warning, lights, rope and signal around the portable radiography which is done on the site. So you might have seen this kind of signals this kind of science in and around areas where there is radiation okay. So this must be there around the lab where this x-ray radiation or x-ray radiography is done, because then people would know that around that zone there is a chance of exposure to radiation.

So this is the first thing that you should do in order to let everybody know that around that particular zone there is x-ray machine and there are radiations around it okay. So that is just to indicate the area where you have the radiations, but you cannot let the radiations go out even if you indicate that around these areas there are x-rays and some things like that you cannot let the radiation go out just like that okay.

So that means when you do this excel radiation exposures for capturing these radiographic images you need to do it under a shielded condition okay. And for that you need to have the exposure bolts or exposure cabinets okay. So you need to keep the x-ray machine first of all inside a room which is well protected against radiation, so you should have thick walls thick concrete walls so that is the first thing.

In many of the cases where the radiations or the x-ray intensity is higher you also may have to use lead sheets on along the walls of that particular exposure room. So that nothing comes out from the exposure room and around that area there is very low level of radiation which is not really harmful and as far as possible these radiation going out of the room should be kept close to zero okay.

So that is about the exposure room then when you have the machine in the machine also you should not keep the sample openly, so that machine also should have an exposure chamber which is again still lead okay. And lead is one material if you remember I told about this before also that lead a material which is very useful shielding against x-rays, because it can easily capture and absorb x-rays okay.

So the exposure chamber that you have in the machine it has to be made out of lead sheets or similar kind of materials which can easily absorb x-rays. So that from the machine itself you start the shielding process okay, and whatever comes out from this shielding chamber from this exposure chamber that you control through the walls of the exposure room okay. So outside the exposure room as I said you should ensure that the radiation level is really very, very low close to zero.

And when you do the exposure it is also advisable that you let others know that the radiation is on so you should have some kind of alarms or indicating lights you might have seen this in an x-ray lab that can be right outside the door there is some red color light and whenever the x-ray machine is on that light should also be on okay.

So that is how people would know that right now the x-ray exposure is being done and it is better not to go around that area okay. So that is about alarms and warning which comes under this engineered control with regard to safety against x-ray radiation, and if you are doing it on the side where you have open exposed areas then around that exposure area, since now you do not have four walls an enclosed room you should use ropes around it you know first of all to prevent people going around that area.

And you also should provide enough signals and indications signs things like that around that area so that people know that, that area is being exposed to x-ray radiation and they should not go around that area. Then you have administrative control this is with regard to protecting the people who are working with radiation, so you should have postings and procedure and should train the people who are dealing with x-ray radiation.

And you should also do time to time dosimetry, dosimetry means you should examine the people who are working with radiation and examine the radiation level inside their body okay in some intervals time to time. So that you know that they are not really exposed and nothing harmful is happening due to the fact that they are working with x-ray radiation okay.

So dosimetry is again important with regard to protecting people who are working with radiation and it also has to involve training so that people who are going to work on this kind of systems and who will be dealing with radiation this would also be trained and they should be made aware that what could be the effects of radiations if they are exposed to it directly without any protection okay.

So these are the different things which must be done with regard to safety against radiation whenever you are working with x-ray radiation or any other form of high intensity radiation okay so I said that lead is a material which is very useful for radiation shielding okay if you have a thin sheet of lead metal you can use that to make a sealing chamber around the exposure area or around the x-ray tube that you have in the machine okay but in order to ensure that the most of the radiation is absorbed by the extra plate you need to provide a particular thickness okay.

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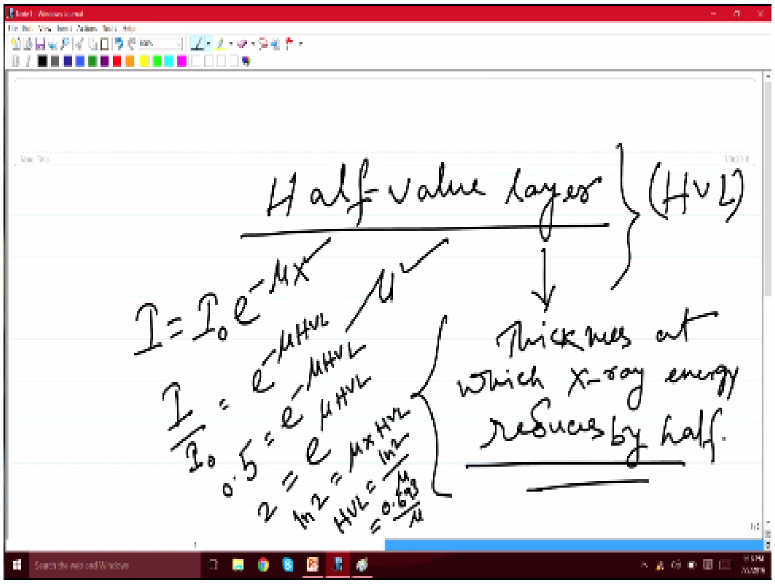

So in order to know that what should be that thickness which will completely absorb the x-ray intensity you need to know about a parameter which is called half value layer so the shielding is nothing but absorbing so it has to do with the absorption coefficient μ and this half value layer as the name suggests this is a thickness at which the x-ray intensity decreases by half and that is why the name okay half value layer and this is a parameter which is much easy to remember because this is just a depth or a thickness instead of remembering this μ and that is why with regard to ceiling this is the parameter which is used for designing this shielding chamber and shielding vault sand things like that okay.

So if you go back to this you can easily find out how the half value layer is related to the absorption coefficient μ so we can go back to this equation that we started with okay so in this case what we are saying that this is the thickness X at which the intensity would decrease by half okay so this X is the half value layer in this case which will call us HVL so for HVL the reduction in intensity is 50% so this I by I_0 is 0.5 when this X is equal to HVL okay or you can write in this form also okay which will give you HVL equals ln2/ μ and this gives you HVL equals 0.693 it is the value of ln2/ μ.

So this is the parameter which can be used for designing shielding vaults and shielding chambers so this will give you the thickness which is needed that to completely seal x-ray radiation.

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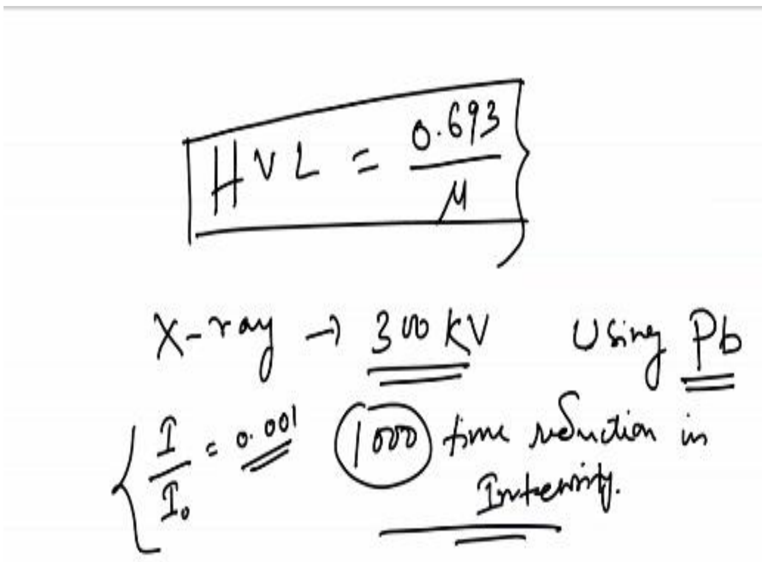

Let us take an example and then see how late or any other material can be designed to make shielding chamber based upon this half value layer for lead μ is known and from this relationship you can find out HVL for any given material okay so let us say I have extra energy of 300 kv and I want to seal this x-ray of this kind of intensities by using lead sheets so here I need to decide what should be the thickness of lead sheet which can reduce the intensity let us say by thousand time okay.

So that means what we are saying is this will be reduced by thousand times okay so I by I_0 will be 0.01 so this is like almost absorbing and shielding the x-ray radiation so we need to find out for a reduction of this extent what should be the thickness of the late seat.

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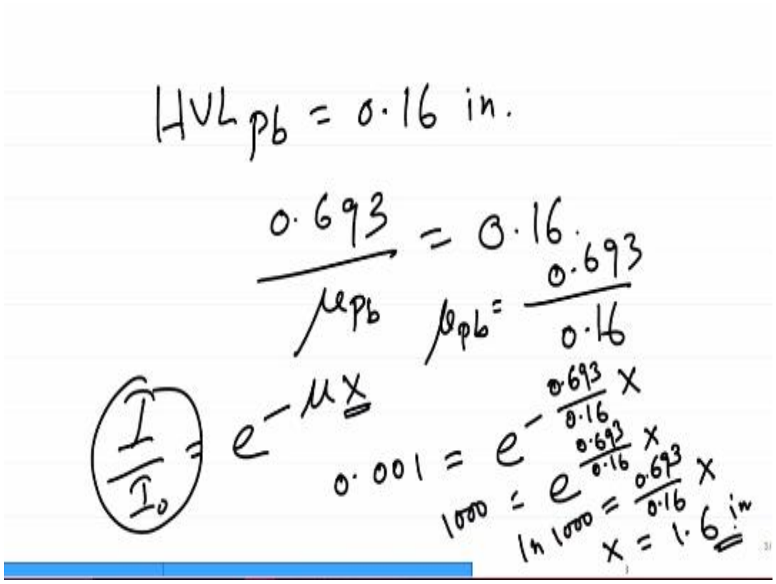

And all I know is the HVL for lead because as I said for this kind of designing with regard to shielding this is the parameter which is used for lead it is 0.16 inches okay so that means I know that 0.693 / μ of lead is 0. 16 okay so I can from here I can easily get the μ and then I can use this in this equation again so we are looking for this thickness X which will make this 0.001 and μ is this which simply got from the HVL and from here we can easily derive X and if you calculate X from this you will get a value of about 1.6 inches okay.

So you can see with just only 1.6 inches of lead you can reduce the x-ray intensities by thousand times okay so that is why as I said before also lead is one material which is very useful against x-ray or which is useful for shielding against x rays.

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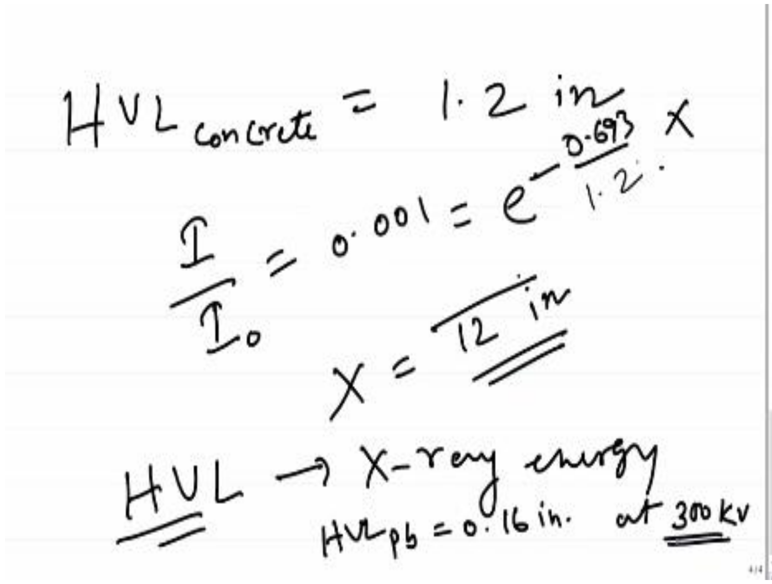

And other material which is used for shielding is concrete because you can build thick concrete walls or even the exposure chamber also in the x-ray machine can be built of concrete walls so for concrete the HVL is 1.2 inches and if you do the similar calculation like what he did just now then you will see that the thickness for which this reduces by thousand times this X will be around 12 inches okay.

So for lead you need only 1.6 inch but for the same shielding if you want to use concrete then the thickness of the concrete wall should be at least12 inches which will reduce the x-ray intensity by thousand times okay, so this is how based upon this HVL the thickness can be calculated for a given material for shielding purpose and at this point I should also tell you that HVL would depend on the x-ray energy.

Because μ is dependent on x-ray energy so for the value that we had derived previously that is the HVL that he had for lead that was 0.16 this is for this x-ray energy 300k because this is calculated based upon μ at 300 k v and with this we come to the end of radiographic testing this method we started the couple of weeks back and now that today we have finished it will be good to take a moment to summarize and then see what we have learnt on this particular technique.

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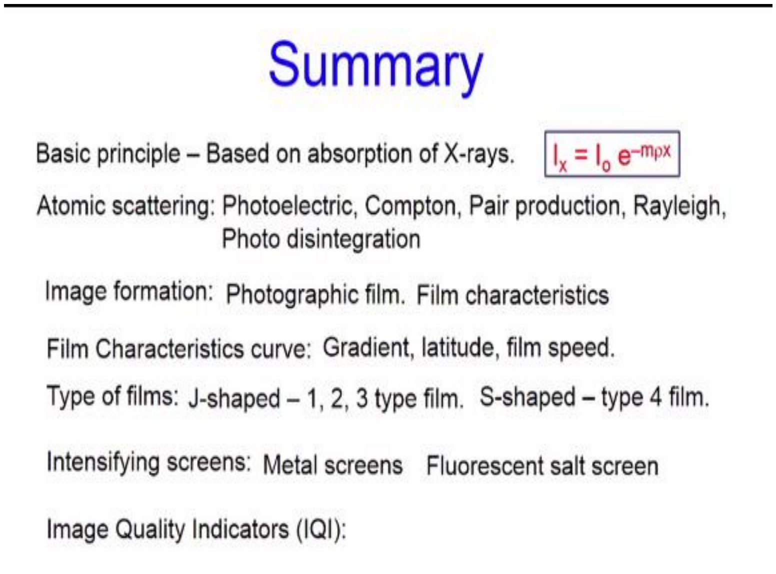

So first we saw the basic principle of this particular technique and then we learn that it is based upon absorption of x-rays which can be defined by that particular equation and then we also saw that the absorption happens due to atomic scattering events and we also learn about different types of atomic scattering like photoelectric content pair production Rayleigh scattering and photo disintegration okay.

And we have also talked about the relative contributions of each of these scattering events to radiographic method and after that we learn about the formation of the image in which we talked about first about the photographic film and then so how it is made what is the constituent of the film and after that we discussed about the characteristics of the film and we also learnt about what is called as a film characteristic curve from which we could derive this film parameters like gradient latitude and film speed.

And from the characteristic curve we also learned that there are two types of curves or two types of films, one is J shaped in which you have one two and type of film and the other one is S shaped in which you have type for film and then we talked about intensifying screens which are used for enhancing the quality of the image and also to filter out the scattered radiation and in that we saw that there are two types of intensifying screens, metal screens and fluorescent salt screens.

After that we talked about the image quality and image quality indicators with regard to the image quality we have seen that the quality of the image depends both on the film as well as on the x-ray source so there are some parameters from the film which will control or affect the quality of the image and there is some parameter from the x-ray source which will also affect the quality of the image and with regard to the x-ray source we learned about the concept called an sharpness which primarily comes due to the finite size of the focal spot of the x-ray source.

And in image quality indicators we learned about two types of indicators, one is a hole type and the other one was wire type.

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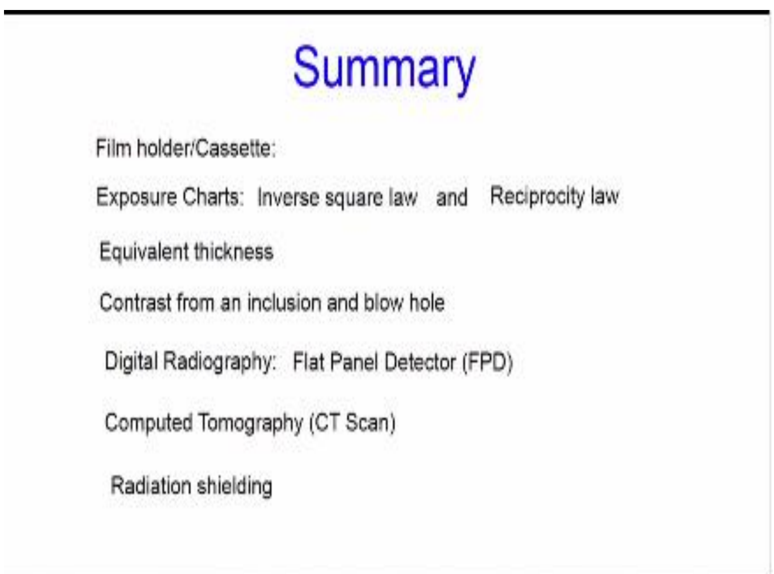

And after that we talked about the film holder or the cassette which is used for loading the film into the x-ray machine and then we talked about the exposure charts which are used to decide the exposure time and we saw that the exposure charts are derived based upon these two laws the inverse square law and the reciprocity law and then we talked about the equivalent thickness also because most of the time this kind of exposure charts are derived for a particular material like steel and if you want to use that chart for other materials then you have to convert the thickness into an equivalent thickness of that particular material using which the exposure chart was derived.

Then we talked about the contrast from an inclusion and blow hole as an example to show you as to how the contrast can be decided based upon the parameters which are used to capture the image, and then we talked about this particular technique digital radiography and in this we learnt that it is primarily based upon this kind of detectors which are known as flat panel detectors which can convert x-ray intensity into an electrical signal which is finally converted into a digital signal to form the digital image.

And we also learned about this technique called computed tomography or commonly known as CT scan which is again based upon digital radiography so we talked about that also and finally we talked about radiation shielding because that is also important whenever you are dealing with the radiation and things like that shielding and protection is also important, so we talked about radiation shielding as well in which we discussed different ways by which you can do radiation shielding and what are the methods and procedures applied for shielding against radiation, okay.

So this will bring us to the end of this particular chapter also and by now we have covered all the NDT methods all the commonly used entity methods we started with dye penetrant testing and then we have come all the way to this radiographic technique, okay. So we have seen the basic principle behind each of these techniques and then we have seen how each of these methods are done okay, so you have a wide range of energy techniques to choose from when you are doing NDT, okay.

So the question here is how do you go about selecting a particular NDT method when you are doing NDT okay, so this question that an NDT inspector has to face at some point or the other so is there any guideline which can help us in choosing a particular NDT method okay. So let us see if you have that kind of guideline which you can use and decide a method for doing NDT on a given component.

So the first thing that you should know when you are trying to select a particular NDT method for a given part that you have, there are two aspects of it one is with regard to the defect itself and the other is with regard to the capability of the NDT method that you have in mind okay, or you have available with you. You remember we had talked about the broad classifications of NDT where I said that this can be broadly classified into surface entity method and bulk NDT method.

So this was primarily based upon the location of the defense okay, so if the defects are located on the surface then you have to go for a surface NDT method similarly if you think that defects are located below the surface into the bulk of the material. Then you have to go for a bulk annuity method okay that is the first thing that you should know you should have some idea before and as to whether the defects are going to be limited on the surface or they will be below the surface within the bulk okay.

So based off of that information you could select NDT method either a surface entity method or a bulk NDT method or a method which can do both okay so that is the first thing that you should know you should have some idea as to what you are looking for whether you are looking to inspect the surface or you are looking to inspect the bulk okay and then you see with regard to that surface method or bulk method what are the techniques that you have at your disposal that you can use okay.

And whatever technique you have then you see their capabilities whether they will be able to do that what you are looking for let us say you know that your defects are going to be located on the surface primarily so you look for surface NDT methods and you have two or three of them so then you see for each of them what is their capability in terms of the sensitivity to detection so if you remember we have talked about this for some of the NDT methods as to how the sensitivity is for a particular entity technique okay.

So that you see you see the capability of the technique that you have in mind or you have at your disposal and selectively so as I said there are two components of it when you are when you when you talk about selecting a particular entity method one component is about the location of the defect and the second one is about the capability of the method that you want to use so all this can be combined into a table like this which will guide you okay so this table will give you an idea as to how to go about selecting a particular entity method.

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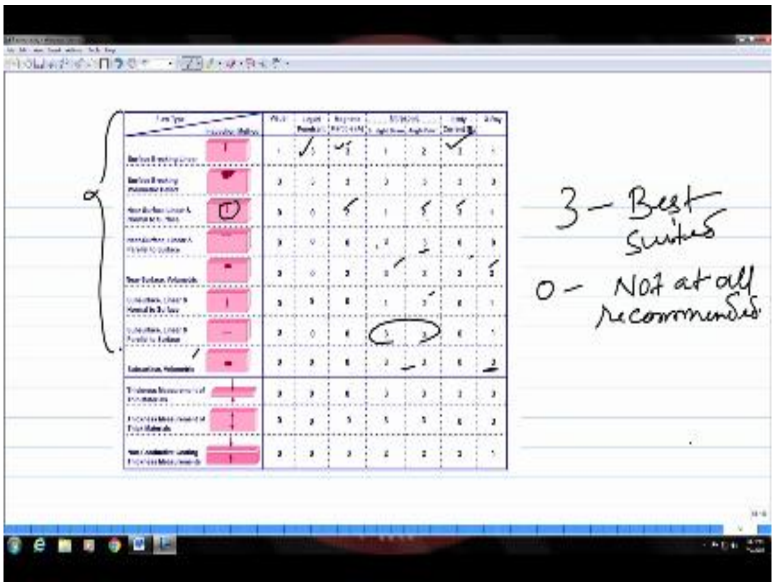

So as I mentioned before you have to first see what is the type of defect you have whether it is a surface defect or whether it is a volume or bulk defect you also should see what is the nature of the defect apart from the location that means whether it is a linear defector any volumetric defect and things like that so both are important in terms of their detect ability and here on these columns you could see all the NDT methods are mentioned and on these rows you can see some numbers are there okay.

So these numbers indicate the suitability of a particular method for a given type of defect okay for example if it is 3 it means it is the best possible method that you have so 3means it is best suited and if it is 0 then that means that for that particular kind of defect this particular technique cannot be used okay so three means best suited and zero means not at all recommended and then you have something in between like one and two also you have one means it is not so good and two means it is kind of okay to use.

Okay so let us have a look what kind of defects you have and some examples as to which particular entity method will be best suited for that so if you have a surface breaking linear defect let us say you have a crack at the surface which is linear okay so for that kind of surface defect you could see that visual method is not so good because that crack may not be big enough to appear to the naked eye or even with the help of some kind of visual optical aids and the surface energy methods that we discussed like liquid penetrate testing magnetic particle testing and eddy current testing okay.

So these are the three surface methods that we have discussed and you could see since it is a surface flaw all these three methods are good for inspecting this kind of surface defects okay so that is why a number three is given for all these three methods if it is a surface breaking follow metric defect that means it is located at the surface but it is not linear it is volumetric then you could see all the methods can be used whatever we have discussed all of the methods can be used for those kind of bulk defect which is right at the surface okay.

So for that kind of defect we do not really have any confusion as to which entity method to select any of the methods which is available at your disposal you can use that including the visual optical and then you have defects like near surface linear but normal to the surface like this kind of defect okay so here again it is a surface defect but it is near surface or subsurface so you remember I said that magnetic particle testing is one of the methods which is good for this kind of subsurface defect so number two is given for that so it is good and the base for this kind of defect is eddy current okay.

Ultrasonic is not really good for this because this is very close to the surface and you might have that dead zone effect what angle beam can be used for that it is given a grade of 2 okay and other methods are not really good for this kind of surface defects on the other hand if you have a near surface linear and parallel to the surface that kind of defect if you have then the best possible method would be this ultrasonic testing provided you have selected the frequency properly and you have taken care about the near surface dead zone effects.

Then near-surface volumetric defects if you have then the best possible would be any of this ultra Sonics eddy current or x-ray radiography okay on the other hand if you have subsurface linear and normal to surface then ultrasonic is a good method to use others cannot be used if you have a similar defect but parallel to the surface there again ultrasonic method is the best one and for volumetric kind of defects which are below the surface then you could see that none of the surface NDT methods can be used only the volumetric methods like ultrasonic and x-ray radiography can be used okay.

So the selection of these techniques this is depending on the type of defects and this is how based on this particular table that you have you can get some guidelines as to how to go about selecting a particular entity method for a given type of defect okay so this will be again as I said will be based on the type of defect and the capability of a particular technique for the detection of that type of defect okay so now we have covered all the commonly used NDT methods and just now we saw as to how to go about selecting a particular method okay.

So this means that we are approaching the closer of this particular course but this course will not be complete without acknowledging the help and support that I have received from various people for creating this particular content.

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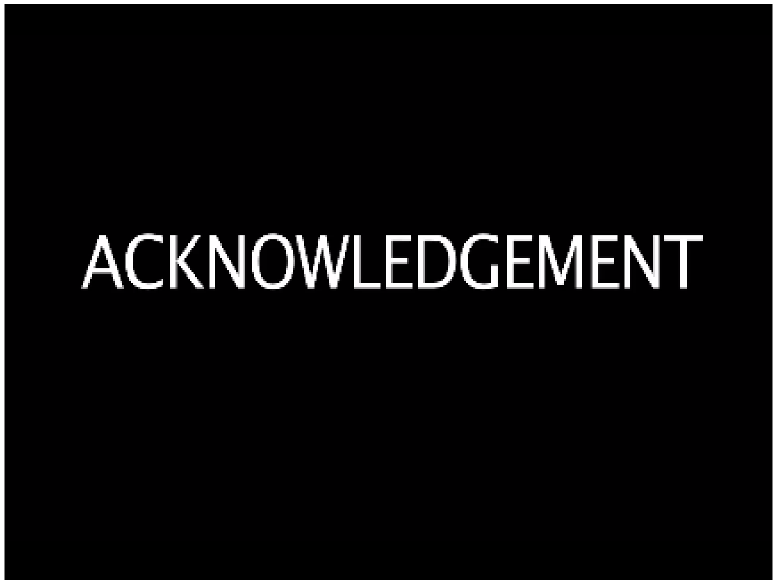

First of all I would like to put on record my appreciation for this NPTEL program which has provided a wonderful platform for sharing knowledge and in that regard I would like to thank the NPTEL coordinators professor Prathap Haridas and professor Andrew for spearheading the NPTEL program at IIT Madras and I must thank the director IIT Madras and administration of IIT Madras for providing all the infrastructural facilities for creating this video content.

The entire Imperial team is working relentlessly behind the screen for creating all these video content that we have under this NPTEL program and it goes without saying that creation of this particular course would not have been possible without their help and support I have received a tremendous amount of support from the entire team and I am so very grateful to all of them I would like to thank as well the NPTEL camera crew team who were particularly instrumental in creating the videos.

And at this point in time I want to specially thank here one person Mr. Ravichandran who was there with me from beginning to end for creating this video content okay and last but not the least I would like to thank all of you who have connected through this forum in any manner without your participation it can ever be complete and with that note it is time for me to say goodbye I hope this content will help you in your respective carriers if you have any queries with regard to this particular course please do get back to us and I do look forward to receiving your feedback as well and with that it is time for me to sign off thank you one and all goodbye and take care you.

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