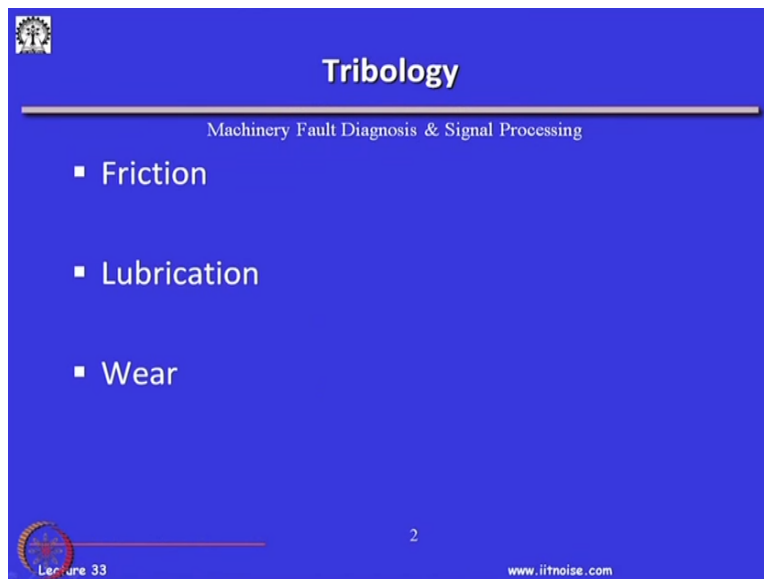


Machinery fault diagnosis and signal processing
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Module No # 07
Lecture No # 33
Oil Analysis

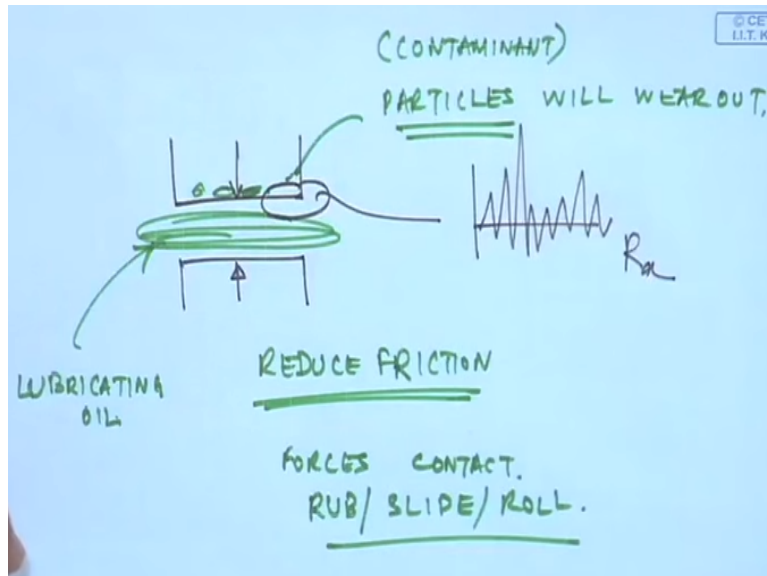
This lecture is a oil analysis in fact this is a continuation of earlier class on contaminant analysis as you know wear and debris analysis almost constitute 20% of CBM or condition based maintenance technique which are adopted throughout the world. So right now we will be talking about all analysis.

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So as you know just t recap you know the tribology is study of friction, lubrication and wear.

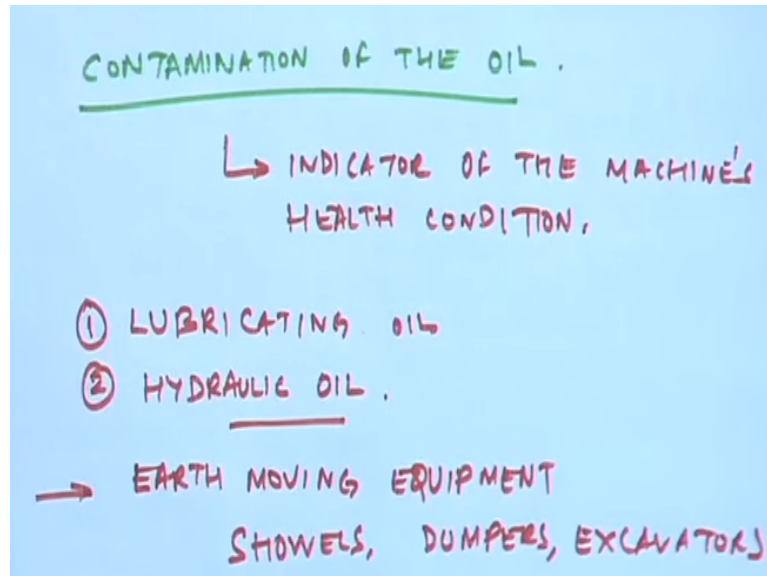
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And it is two of this machine components when they interacted with slide or rub and this surfaces are actually variable rough see the surface roughness they are very rough and they have a certain line average so what happens to reduce this kind of friction we need to give a layer of lubricating oil. Now because of forces which are responsible for contact the surfaces could rub against each other they may slide they may roll okay.

And this is how the two surfaces meet so to reduce friction we need to give lubricating oil now wherein the course of the time operation of the machine what happens these particles they will wear out particles will wear out and the last this last class seen wear the particles are g contaminants because they are going to contaminant the oil which is there so this particles will wear out and get deposited in the lubricating oil.

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Now because of this contamination of the oil this becomes an indicator of the machine's health condition. Now you will see in every machine being an internal engine be it a pump, blowers etc. We need to have lubricating oil between the components particularly bearing locations particularly at the wherever the surfaces are contacting each other they are sliding over the one other we need to give oil.

Upper format there is another scenario one is this lubricating oil another components which become is hydraulic oil. There are many operations particularly equipment earth moving equipment when you talk about big shovels, dumpers, excavators etc., they actually use hydraulic oil for activating the loading unloading mechanisms and so on. So what happens to consider or to understand the health of machines we may periodically look into the condition of the lubricating oil.

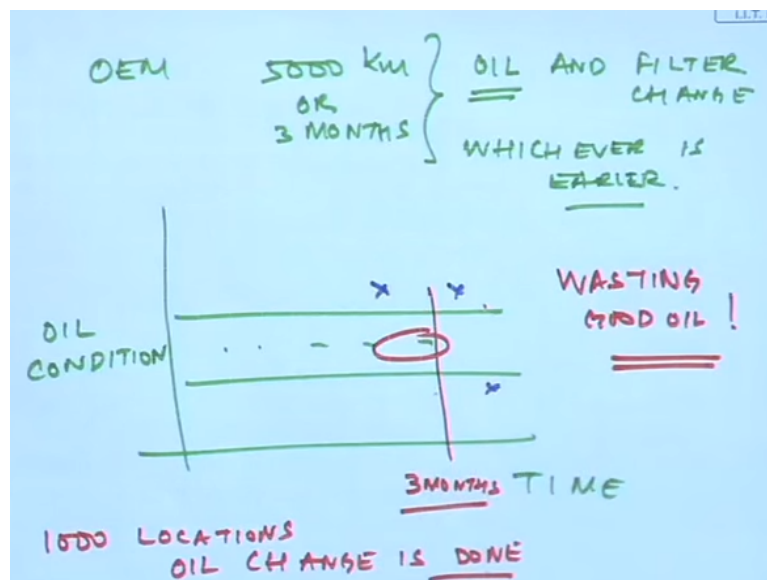
So what happens initially this oils have some properties made the physical properties in terms of their intensity viscosity and temperature stability of the viscosity index how the viscosity varies with temperature these are some of the physical properties on top of it their chemical properties their composition and comes of their bond which are there we give some stabilizing elements to the oils to be stable so that the bonds do not break up and then they lose their properties.

But in due course of time because of the fact that because of machines rubbing against each other wear particles will bound to get deposited they are no place to go but they are in lubricating oil. So in

process what happens the physical and chemical properties have their lubricating oil due change with time. So if you have some mechanism as to we collect this oil do a test in a laboratory wherein we measure the physical properties or chemical properties and see how much have changed or gone for worse from the initial condition of virgin oil or the new oil or the brand new oil we will get a clue as to there is something perhaps wrong with the machine.

So this is what is the most important and then why we do oil analysis and to find out the machines and conditions.

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So with time what happens the oil condition all condition could be remaining like we have some physical properties and some chemical properties and we have may be they will change may be and or it could be either way also. So between tolerable band you know this is tolerable band by this two are the tolerable band. So if the properties deviate beyond this tolerable band upper limit and lower limit.

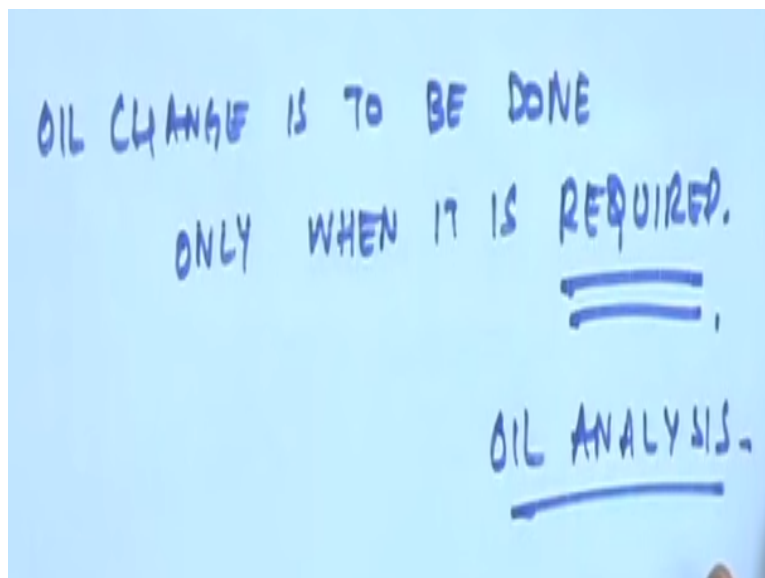
We know time to change the oil I will just give an example is to for example when we have periodic maintenance actually in a regular interval change oil in the machine okay. Now this is good for an individual for a very good example like I always give is you know when you have an automobile, two wheeler or four wheeler you go as per the OEM manufacturer they say every 5000 kilometer you go for oil and filter change.

Or sometimes or three months whichever is earlier if you go and see the car manual or service manual or the two wheeler service manual. This what is normally says now it may so happen that your oil condition was much within the tolerable band such that talked about okay somewhere here and we are unnecessary changing the oil because your three months as come here in time or you say it is time to change my oil.

But usually oil is still in a good condition there was no necessity to change the oil but because we are following religious the OEM manufacturer recommendation we are changing good. Now imagine if in a plant where we have maybe thousands of such locations where oil change is done. And it so happen that the condition of oil was within the tolerable bands. But then because we are changing the oil all may be good we are wasting good oil.

So wasting good oil if I do what is known as the periodic maintenance and there have been in people have a shown statistics and done surveys and found out that by not changing the oil periodically that has been mentioned by the OEM but changing it only when it is required because the properties have gone beyond the band in somewhere we are here etc., then only we change the oil.

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OIL CHANGE IS TO BE DONE
ONLY WHEN IT IS REQUIRED.
OIL ANALYSIS.

So all changes to be done when it required oil change is to be done only when it is required now who tells us that it is time for the oil to change and this is where our oil analysis come to the

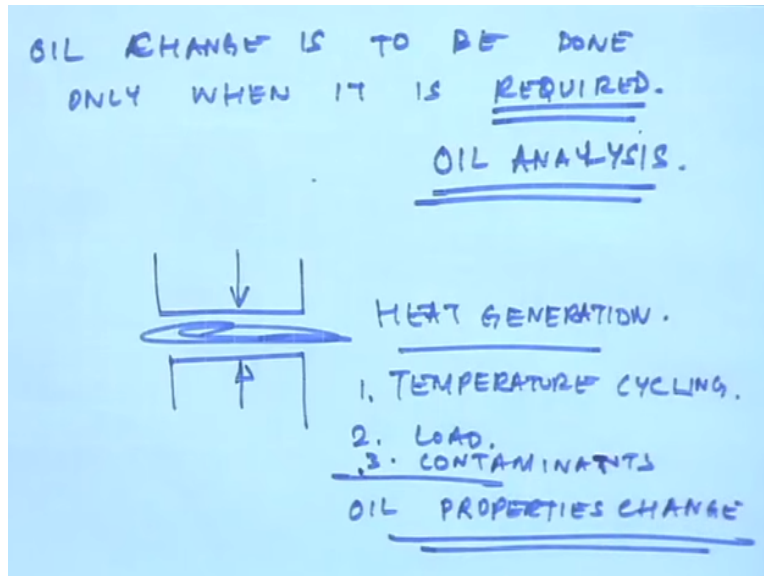
help. And going back to the earlier example there are have been lot of cost saving when we do a oil change as per the recommendation or as per the findings of the oil analysis okay.

Otherwise we did not change the oil there have been lot of considerable lot s saving in finance when you do an all change when it is required okay. Particularly in many plants many of this automation plants where we use lot of hydraulic oils if you talk about an automatic currency note printing shop we have an currency note printing plant very close to Kharaghpur and where they use lot of hydraulic oils for operating of the machines wherein the currency sheets are printed you know the way they are measured counted then the way they are packed in bundles these are all hydraulic operations.

We have done surveys wherein we found out that it is cheaper and much economic if you change the oil only when it is required. In this case the hydraulic oil and not regularly religiously every three months four months change the oil okay. So in a plant in the long run actually oil analysis serves you two purposes one is its tells you that what is the present condition of the oil and next is you know whether it is time to change the oil or not change the oil okay.

So we just going back to the oral travelagical analysis for condition machine monitoring we have what is know as the contaminant analysis okay which we discussed yesterday that is the spectroscopy where the particle size are less than two microns then we have the wear debris analysis and ferrography wherein the particles go from.

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As I was telling oil analysis is to be done only when it is required now question is who decides or what is required actually when it is required at this is actually done by oil analysis. Now I will just give you examples we have a currency note you know rupee note which is printed we have a currency note printing plant very close to Kharaghpur therein after the printing press the sheets of paper because you know counting is very important when you doing a currency note printing the counting and the process of packing and bundling etc.

Are all done through activators and there is lot of hydraulic oil flow from plants in the circuits different actuation when the mechanisms or counting mechanisms. And it was reported that earlier when very religious where doing a this hydraulic oil change in a periodic they were in incurring lot of cost rather then they did the hydraulic analysis and only change when I was the oil analysis is recommended or indicated that the oil quality is decorated.

Now it is time to change the hydraulic oil they followed this practice and then there as been considerable savings in the plants because of implementing oil analysis in the hydraulic oil requirement. In same of course we can do the engine lubricating oils particularly in the in such a plant actually mostly it is hydraulic oil but the DG set the generator sets which they required for a back of power are actually where the lubricating oil are actually analyzed.

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Tribological Analysis for Machine Condition Monitoring

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- **Contaminant Analysis**
 - Spectroscopy
 - Wear Debris Analysis (Ferrography)
 - Contaminant Particle Count
- **Oil Analysis**



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One is contaminant analysis which I talked about in last class and where the contaminants can actually be categorized into three categories the spectroscopy is the contaminant size less than 2 microns wherein in actually in spectroscopy is to recap actually in spectroscopy because the particles are such a small size we cannot see the through unless we are very high magnification like an scanning electron microscope.

Or otherwise you know the spectroscopy is used actually to find out the chemicals consequent of the wear particles terms of chemical elements. It could be how much percentage of RN is there how much aluminum is there how much of copper zinc etc., are there. Next comes actually this wear debris analysis wherein this samples are the size from maybe 10 microns to as high as 50 microns.

When the particles size is become large they are the contaminant particle count actually becomes the good indicator about the wearing mechanism. And this particle count is actually given in how much parts in million milliliter of oil okay. But in this class we are focusing on oil analysis right in the beginning I told you because this oil has got contaminant it is going to end because it has been subjected to lot of temperatures you know temperature fluctuation could happen because of lot of oil.

Because once when two members are matting against each other there will be lot of heat generation and you know if you shut of a machine there will be lot of temperature cycling. So

because of load, temperature cycling okay etc. the oil are going to lose its properties change in an of course the contaminant himself properties change okay. So we need to do the oil analysis I will briefly recap you know regarding the contaminant analysis.

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Typical Oil Additives

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Oil Additive	Purpose	Remarks
Anti-oxidation	Slow down the formation of oil oxidation which produces lacquers	Inactive compounds are formed instead, but the additives are used up in the process
Anti-wear	Improve the metal surfaces so that wear is reduced	An adsorbed film is produced on the metal surface
Corrosion Inhibitor	Counteract the development of acids	High alkalinity is given to the oil, but this greatly reduces the effectiveness
Demulsifier	To separate the water from oil	This is used up in proportion to the water present
Extreme Pressure Agent	Improve the surface of metal under pressure	A chemical reaction is caused by the additive
Viscosity Index Improver	Reduce the change in viscosity with temperature	Long chain polymers which open up with temperature

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Because this contaminant oil analysis actually together side by side and that being with just give a over view why this oil properties change you know in a typical oil and then the virgin oil we give lot of additive agents to the oil for example so in this table if you see the first column is the oil additive the second column is the purpose why this oil additive have has been given to the oil and certain remarks.

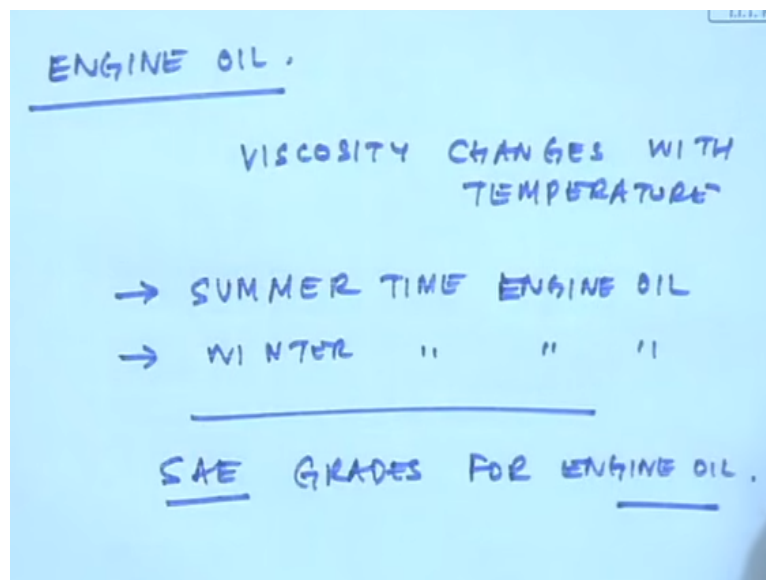
So to have an anti-oxidation slow down the formation in oil oxidation which produces lacquers actually the oils abstract they will become gummy type of things okay. And they could unnecessary increase the friction etc., certain antivirus additive are there so there they wear is reduced and actually a thin film is produced and obviously in tools and oil we need to give corrosion inhibitor we basically is an alkani we mix so that it count a development of a acids okay.

And thus how alkalinity is given to the oil demulsifier to separate the water from oil usually in the plants the lot of problem come because these oil get ingested with water okay. And then water forms a layer and sometimes you must have seen they were in engine oil once the water is mixed lot of problems okay ideally it has lot of determent effect on to the properties extreme

pressure agent improve the surface of metal under pressure in chemical reaction is caused by this additive.

Viscosity index improver reduce the change in viscosity with the temperature and actually the long chain polymers which open up with temperature. Basically viscosity index has I was telling you the oil are submitted to lot of temperature cycling and you know viscosity is a function of temperature okay. But then this viscosity index improver give an viscosity index this is actually the function of how the viscosity changes its temperature.

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We would not like a oil to drastically change the viscosity with temperature but you know you must have noticed in just as an example in engine oil particularly not in our countries but in the countries in northern or southern hemisphere close to the poles actually the lot of temperature variations this viscosity changes with temperature. So they have a summer time engine oil and a winter time engine oil okay.

Because of course if go to the SAE grades you know for the engine oil you can see how the temperature variation of the viscosity is given okay.

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Spectroscopy Methods

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- Emission Spectrometer
- Absorption Spectrometer
- Scanning Electron Microscopy (SEM)
- X-Ray Diffraction Technique
- X-Ray Fluorescence Technique

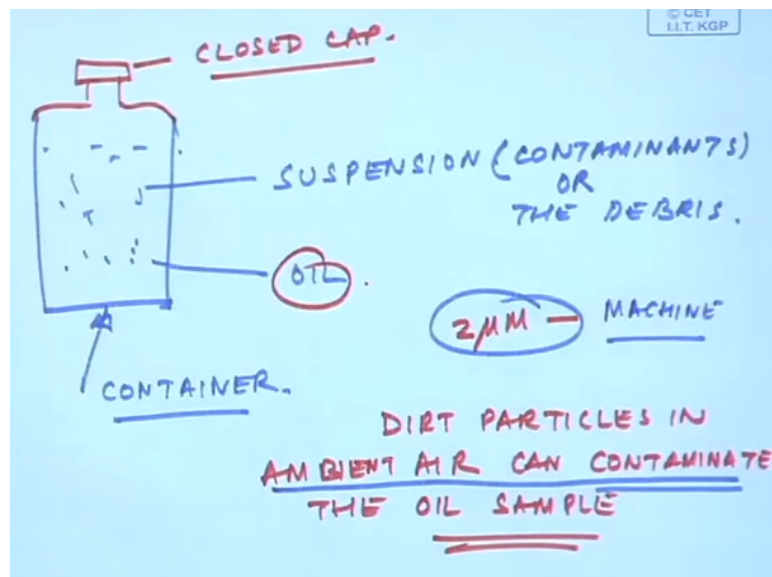


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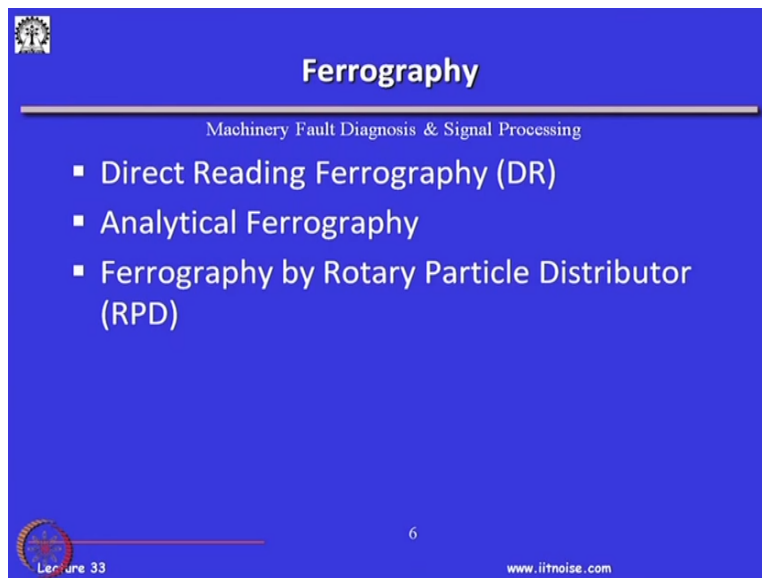
So just to recap you know when you do this spectroscopic methods actually how are the contaminants we cannot collect contaminant of 2 microns size just by picking them up. So actually they are as an suspension in the oil and this is our container so this suspension is nothing but the contaminants or the debris but in this we are focusing on as I was telling you on this oil whose properties have the changed okay.

And so you can take this same container okay if you have this oil which has been collected from a machine actually they are close okay cap okay there is reason why I mentioned this close cap because when I am talking about size of 2 microns or less even the dirt particles in air in the

ambient air can contaminant the oil sample. So it is not very easy that you open the engine and then get a dips taken or get a container and full of oil no there is procedure detail procedure of how this oil is to be collected.

So that our ambient air does not contaminant does not contaminant the sample other you know we will no whether in this particles which are there in the oil is it because of the machine or because of the environment okay. To avoid such false negative test we have to do this okay.

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Ferrography

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- Direct Reading Ferrography (DR)
- Analytical Ferrography
- Ferrography by Rotary Particle Distributor (RPD)

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Of course you know ferrograph are in different of formats you know direct reading or the analytical ferrograph from the ferrogram etc.

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Ferrographic Wear Particles

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- Normal Rubbing Wear
 - Flat platelets (5-10 μm in size)
- Cutting Wear
 - (Thin to Thick curled strips)
- Spherical Particles
 - (Spheres 15 to 20 μm in size)
- Severe Sliding Wear
 - (Long and Flat, larger than 30 μm)
- Bearing Wear Particles
 - (Laminar particles, edges split, holes present)
- Gear Wear Particles
 - (Rough & Irregular surface)



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And the ferrographic particles are there in the oil they have different sizes for examples in normal rubbing wear the debris look like flat platelets of the size 5 to 10 microns size. Cutting wears are actually thin to thick curled strips spherical particles of small sizes 15 to 20 microns size. If there is a severe sliding wear the particles will be long and flat and larger than 30 microns either or bearing with bearing particles there will be laminar particles edges plates and holes.

In gear particles gear wear particles are easily rough and irregular surface just to give you brief idea regarding all the particles look like.

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Wear Debris Composition

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- Quality and Composition of wear metals allows to set alarm levels
- Knowledge of metallurgical composition is helpful in localizing source of wear metal production



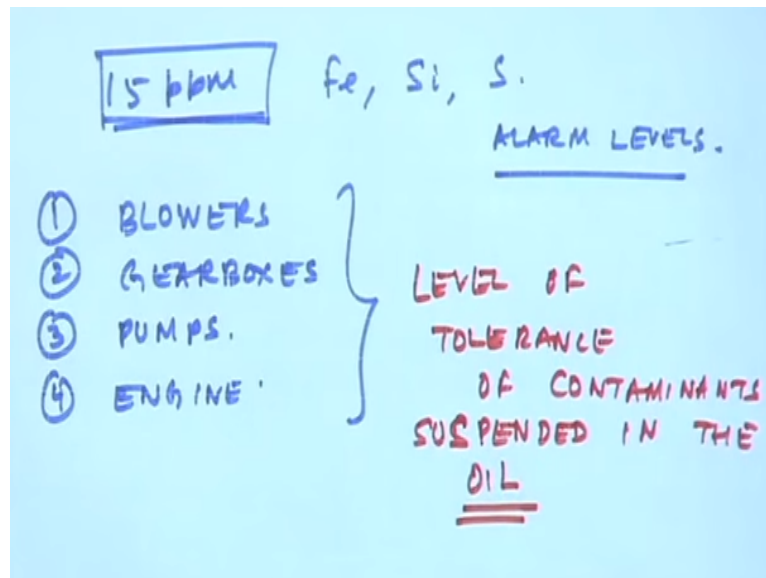
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But the wear debris composition the quality and composition of wear metals are allows us to set alarm levels you know this maybe comes from experience how you know you parent material as so much of iron and so much of coppers zinc etc., you can recent you standard usually this standards are given in the national standards.

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About may be if you have may be usually it is more than 15 PPM in a particular 10 ML or whatever parts per million are available of iron and or silicon or sulphur etc., in order to be measure the alarm level of course these are this is very relatively speaking okay this levels but then you can set up you standard for you know for all the blowers in you plant all the gear boxes in the plant all the pumps in the plant okay all the engines in the plant you can set up the standard for what is the level of tolerance of contaminants suspended in the oil okay.

Yourself can consider okay and of course come back to this wear debris composition another very important aspect is this knowledge of metallurgical composition is helpful in localizing source of wear metal power friction. Because once I am getting this contaminants are where metal in the suspended oil I need to be I need to know where from this material came so the parent metallurgical composition of this elements is very important.

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Strategies of Wear Contaminant Analysis

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- Catch faults early
 - Low cost, planned & manageable remedy
- Identify precise source of fault
 - Use different technologies & analytical methods
- Identify the forcing function
 - Identify abnormal wearing conditions



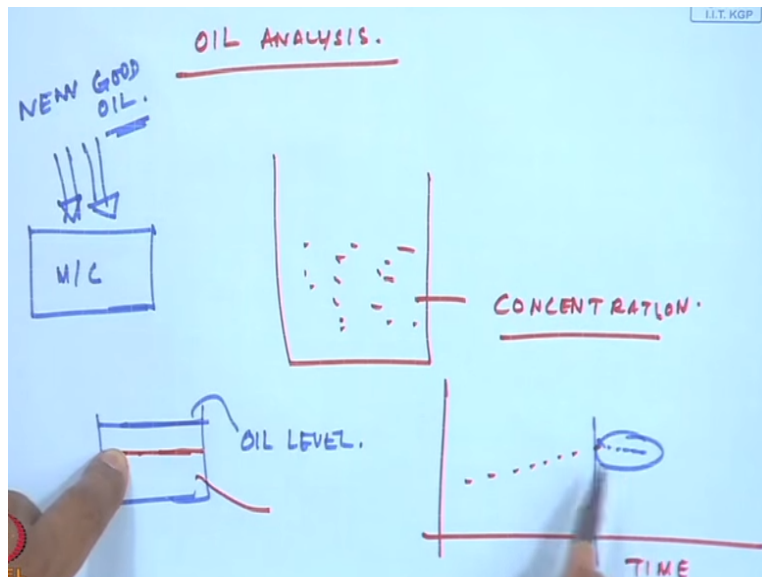
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And this all these some strategies which we follow for the wear contaminant analysis one is we have to catch the faults early okay. Because low cost and plan and manageable remedy okay they have to be planned and we need know the solution.

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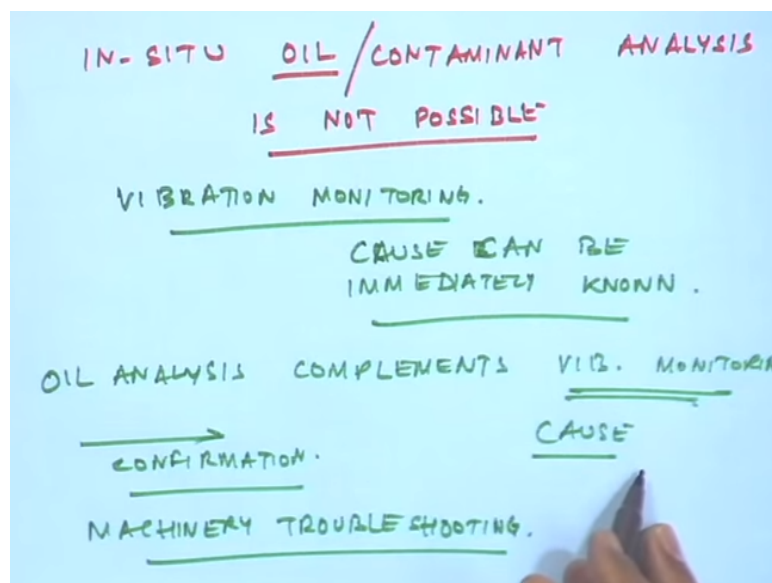


Because many times what happens when you are I will just give an example of oil we have collected all okay which has a particular concentration okay and you have train of the concentration with time okay we are doing this. But suddenly what happens in the machine in the mean time we have added new good quality good oil or virgin oil say for add this concentration is go to go plus we have to give be careful that during my training plot there is a when I collect the next sample after this time that if the oil or machine has been upgraded.

Because you know we do not care from an operational point of view if they say if the machine as to be filled with so much of oil level from an operation point of view we have to ensure that the oil is filled in that time okay. But it as show up in a collected the oil was actually was at this level okay. So you will get a richer concentration okay of the contaminants and then now if you next dilute it good oil this concentration is going to reduce so we have to be careful about this kind of planning.

So we should know what is the procedure to catch this defects so called in the oil of course a identify precise source or fault this require difference technology and analytical method like as was telling you like these spectroscopy methods are the ferrograms etc they are very cost intensive operations.

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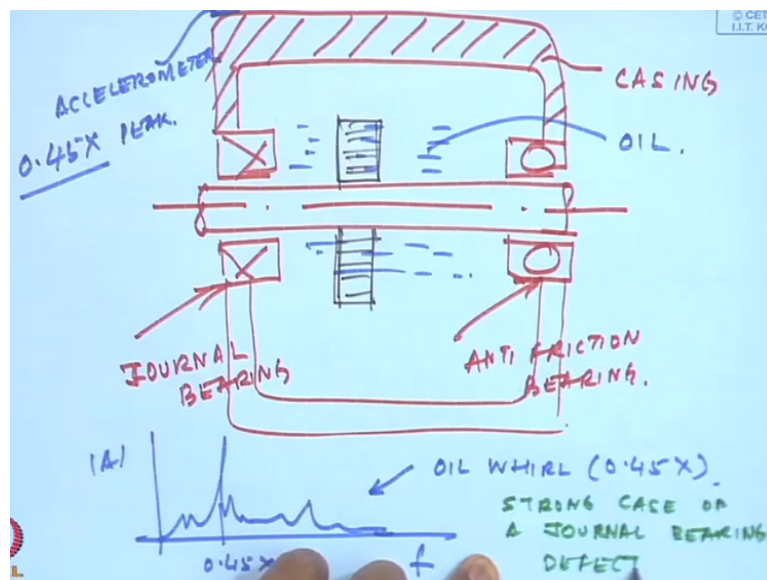


So in- SITU oil or contaminant analysis is not possible because of many reasons they are bulky they require a clean environment to do this operations they are very costly and so on. So we infact I suppose to just if you compare I suppose to be vibration monitoring one is the reason why vibration monitoring is very popular I would say is couple of things is one is in-SITU measurements are possible and they are very cheap and because of the signal processing techniques right away by having a signal analyzer we can right away tell the cause can be immediately known okay.

So a and in fact that is the reason why this vibration monitoring is popular but the oil analysis actually complements the other vibration monitoring because if you have got some clue or some cause known from vibration monitoring you can confirmation can be done by an oil analysis or an wear debris analysis. In fact in many plants when they do a machinery trouble shooting they adopt both the techniques.

They do an – SITU vibration monitoring analysis and then they collect all the sample send it to a lab do the analysis and labs will also suppose for example I will tell that the vibration monitoring says that you are in another example.

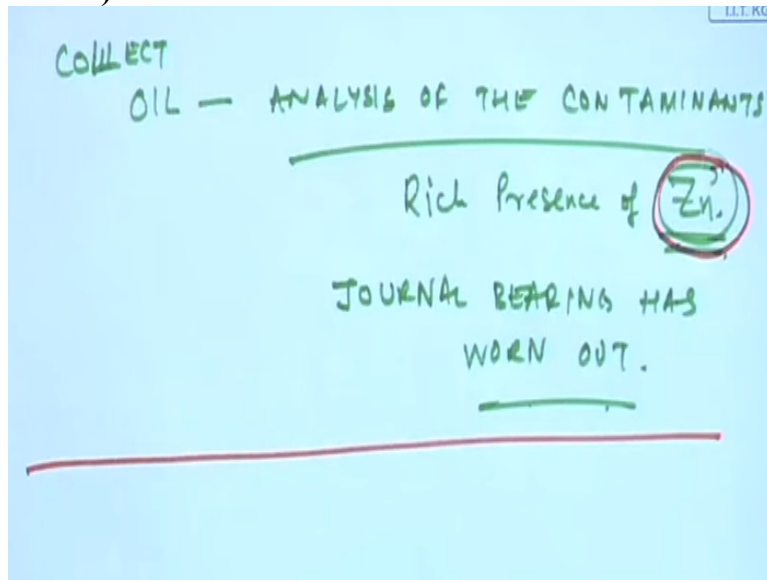
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Say for example I have a shaft which is supported in case journal bearings in case it is antifriction bearings this is an antifriction bearings and actually there is casing and so on. And this is filled with some oil this could be carrying couple of this rotor this as an example okay. Now it so happen that dye having vibration monitoring if I put transducer here and it says that I am getting a .45X peak okay.

Other than I am getting an predominant 4, 5X peak in this spectrum okay and this correspond to 45X frequencies I am getting some amplitude okay. This is the vibration signature looking at this knowing that this bearing we may think that this is an oil will which is occurring because of .45X usually it is .45 or 42 but then we are getting around .45X. So we may lead to a conclusion that there is a strong case of a journal bearing defect.

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And how this is complemented to oil analysis is now if you collect the oil from the same machine and say there it has and then do a analysis of the contaminants collect oil and do the analysis of the contaminants. You will see that there is rich presence of zinc this means that the journal bearings as zinc as worn out.

So oil analysis is also now confirming earlier observation that there is a defect in the journal bearings because I have a got a .5, 45X peak. And now a because of this oil analysis am seeing rich amount of zinc and which means that there is a defect in the journal and this is how its help us okay.

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Wear Particle Analysis Tactics

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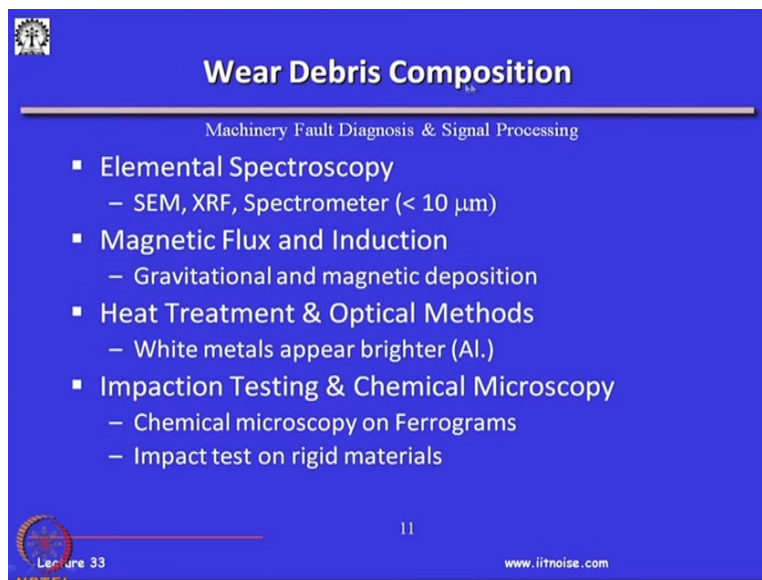
- Improving the quality, Trendability & Density of the Data
 - Errors in sampling process/analysis
- False Positives
 - Environmental contaminants during sampling
- False Negatives
 - Sampling from “Dead Zones”
- Normalizing Data
 - Dilution because of new oil addition
- Reducing Data Noise
 - Poorly filtered oil

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So the wear particles analysis technique is improving the quality and design of the density of the data particularly we have to be very careful about the errors in the sampling processes analysis like the example as to be two examples one is your about collecting the samples in an environment where the environment itself as its lots of suspended you have dirt particles.

Particularly in the case of the coal mine where there is lot of coal dust so and this dirt's could be size of more than 5 microns. We should not be collecting samples during environmental contaminants during sampling. Sampling from dead zone like dead zones where also sediments get deposited normalizing the data because dilution because of new oil addition. Reduce data noise poorly filtered of so these are the techniques which we have to take care of.

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The slide is titled "Wear Debris Composition" and is part of a presentation on "Machinery Fault Diagnosis & Signal Processing". It lists four main methods for wear debris analysis:

- Elemental Spectroscopy
 - SEM, XRF, Spectrometer ($< 10 \mu\text{m}$)
- Magnetic Flux and Induction
 - Gravitational and magnetic deposition
- Heat Treatment & Optical Methods
 - White metals appear brighter (Al.)
- Impaction Testing & Chemical Microscopy
 - Chemical microscopy on Ferrograms
 - Impact test on rigid materials

The slide also includes a small logo in the top left corner, a footer with "Lecture 33" and "NPTEL" in the bottom left, the page number "11" in the bottom center, and the website "www.iitnoise.com" in the bottom right.

And we do about the wear debris composition I will be not dealing much on them.

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Fluid Analysis

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- Spectral Oil Analysis
 - Atomic Absorption, Atomic Emission
 - Chemical elemental analysis (metallurgy, additives, chemical contamination)
- Particle Analysis
 - Wear Debris Analysis, Ferrography
 - Physical particle analysis (extent, mechanism, location)
- Particle Counting
 - Laser Light, Filter blockage
 - Particle size determination (contamination)



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And rather I will go to the fluid analysis

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Forms of Metal Wear Present

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- Metal Only → Mechanical Wear
- Metal Oxide → Oxidative Corrosion
- Dissolved or Metallic Components → Chemical Corrosion



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So the forms of metal wear present metal only means mechanical wear metal oxide oxidation corrosion. Dissolved or metallic components could be because of chemical corrosion.

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Effective Oil Analysis Programme

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- Establish objectives and an oil analysis schedule
- Handle the oil sample correctly
- Proper communication with the analysis lab
- Understand the different oil analysis tests
- Put the right oil in the right machine
- Extend oil drain intervals when needed
- Identify the quantity of Contaminants
- Identify the origin of Contaminants
- Provide feedback to the laboratory
- Evaluate the cost effectiveness



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So an effective oil analysis program needs to have these features in the mind we obviously cannot start an oil analysis schedule after the machine as a gone bad. So we have to establish the objective in oil analysis schedule regular manner. Handle the oil sample correctly because these samples from say for example in a plant I have 1000 different locations wherein have to sample the oil samples.

So every collectant point as to be named numbered date when it was collected this as to be done okay. And then proper communication with the analysis lab because you are somewhere the plant is somewhere and you lab is may be you know 1000 of kilometers away from your plant. So we need to communicate with analysis lab as to where from this all have been collected how their it is been collected.

What are the different analysis time analysis test which is to be done and of course put the right oil in the right machine you know extent drain intervals when needed identify the quantity of contaminants verify the origin of contaminants provide if we coming back to laboratory value of cost effectiveness. Because this same oil is server both the purpose of course of doing the oil analysis the next purpose of doing also the contaminant analysis.

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Lubricating Oil Analysis

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- Viscosity
- Contamination
- Fuel Dilution
- Solids Content
- Fuel Soot
- Oxidation
- Nitration


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Now what are the lubricating oil analysis properties basically the lubricating oil is analyzed for this parameter one is the viscosity the contaminants the fuel dilution solids content the fuel soot oxidation nitration. So there are actually many standards which are available so we need to specify either to the lab by telling them the standard numbers or tell them the procedure with the filter should be international standard.

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Spectroscopy Tests

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- Atomic Emission Spectroscopy (NTSL-01)
- Rotrude Filter Spectroscopy (NTSL-02)
- Fourier-Transform Infra-Red (FTIR) Spectroscopy (NTSL-08)

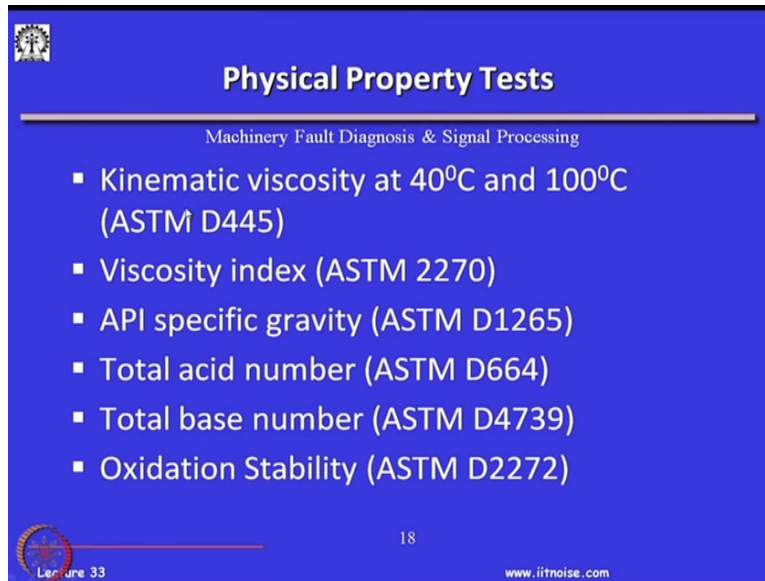

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So in this few slides am going to tell you about some of the standard which are internationally followed for doing such test and when you in your plant give the oil sample to another test agency or an analysis laboratory we need to specify the standards. For example if we need to do

the atomic emission spectroscopy these are the NTSL 01, NTSL 02, FTIR spectroscopy to specify this standards.

So for the purpose of giving this standards means you need to be aware of this standard of course this standards level from the sources and then you can study them.

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The slide is titled "Physical Property Tests" and is part of a presentation on "Machinery Fault Diagnosis & Signal Processing". It lists six ASTM standards for oil analysis:

- Kinematic viscosity at 40°C and 100°C (ASTM D445)
- Viscosity index (ASTM 2270)
- API specific gravity (ASTM D1265)
- Total acid number (ASTM D664)
- Total base number (ASTM D4739)
- Oxidation Stability (ASTM D2272)

The slide also includes a small logo in the top left corner, a circular logo in the bottom left corner, and the text "Lecture 33" and "www.iitnoise.com" in the bottom left corner, and the number "18" in the bottom right corner.

Particularly when we did the physical property test the kinematic viscosity at 40 Celsius and 100 degree Celsius to be calculated and measured as per this ASTM standard. So the purpose of letting you know in this classes not to discuss about how this standards and what their standard is just to make you aware that such standards do exist. So all you have to do is collect the all sample to a particular lab and specify a standard by which they need to do this test.

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Contamination Tests

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- Gross water content by crackle test (NTSL 22)
- Moisture by Karl Fischer method (ASTM D1744)
- Total Chlorine content of lubricating oils (EPA SW-846)
- Manual particle count (SAE ARP 598)
- Laser particle count (NEPA/T2.9.16)
- Pore blockage particle count (NTSL-21)

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Similarly very important is this contaminant test is the oil the gross water content by crackle test. Crackle test is actually once to heat that oil sample we hear lot of crackling noise and that is why the name crackle test came we have moisture absorption by KARL FISCHER method. Chlorine content of lubricating oil okay and these are some of the test you may be aware of in you chemical chemistry lab and in your chemical analysis lab.

And then of course there are certain standards as to count as per the SAE standard NEPA standard basically through a laser light you will see a laser light being incident on this suspended all particle and once this laser light gets reflected the intensity of the reflection you see the clue as to the measure of the amount of contaminant in that all and this is how either you have a particle count or by having filters have different diameter you can also do the pore blockage particle counts.

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Wear Debris and Contaminant Analysis

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- Direct read ferrography (NTSL-13)
- Millipore patch test (NTSL-25)
- Analytical ferrography (NTSL-09)
- Ferrographic image of wear and/or contaminant particulate (NTSL-09)



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And then there are few more wear debris and then contaminant analysis by directly read ferrography, Millipore patch test these are all in NTSL standard which is available.

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Oil Analysis Sampling Frequencies (Facts to Consider)

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- Safety Risk
- Criticality of Equipment
- Environmental Conditions
- Operating Conditions



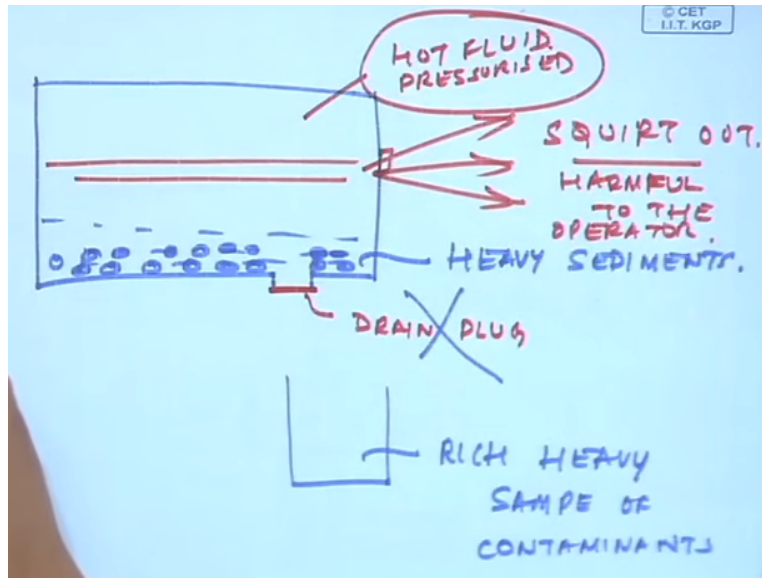
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Now a very important fact which been need to consider is how do I collect the oil okay. It is just not that I open the drain plug and collect the oil infact let me tell you the drain plug in an engine is not the place to collect oil.

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But for convenience many do that I know suppose this is something am not going to discuss about the internals but okay and this is the drain plug and imagine if this machine was not operating and then the oil was not in motion what would happen all the heavy sediments would come to the bottom of the tank heavy sediments okay. Now if I collect the oil just by opening the drain plug and then I will get a very rich sample okay of contaminants and that is not the right way to collect oil it is definitely not correct method okay.

And obviously when this disc is very important if I tap a hole because the oil could be under high pressure and high temperature so then squirt out and create harmful to the operator or the technician. So the safety risk has to be considered because there will be hot fluid pressurized okay so one has to be very careful that pretty simple that you know I just you should in fact never open a machine anything you know when because there is lot of dynamics occurring in the shaft rotating at very high speed lot of fluid under pressure they can damage.

And criticality of the equipment for example like I said how frequently we need to consider this oil samples. Is it every for example if you talk of an aircraft engine due you mean to say after you know every two years we have to just open the oil collect the oil samples you know depending on the criticality of the oil we need to increase the frequency of the oil sampling. Environmental conditions whether it is a dirty environment whether it is a very clean environment.

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Sampling Objectives

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- Produce a sample that is representative of the material the system is producing and the contamination that has entered the system.
- Ensure a proper timing for sampling.
- Prevent contamination of the sample during sampling.



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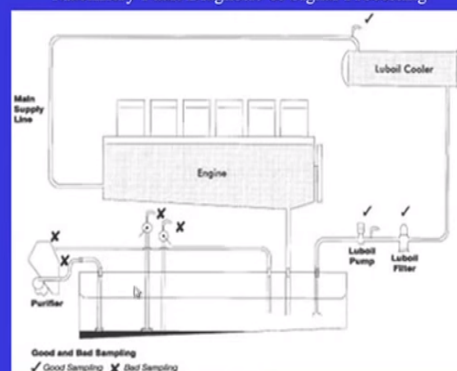
These also factors go into the consideration of oil sampling so the sampling of objective is they are produce a sample that is representative of material the system is producing and the contaminant that as entered the system. Ensure a proper timing for sampling prevent contamination of the sampling by now you will get and idea like I told you about the coal mine whether a lot of hydraulic operating shovels draglengs excavators in such an environment is very very careful as to how to collect the oil samples.

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Good and Bad Sampling

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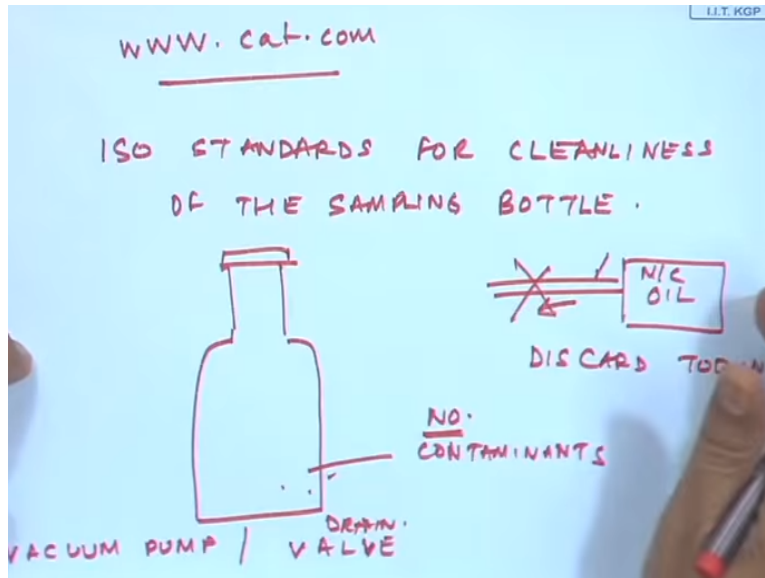


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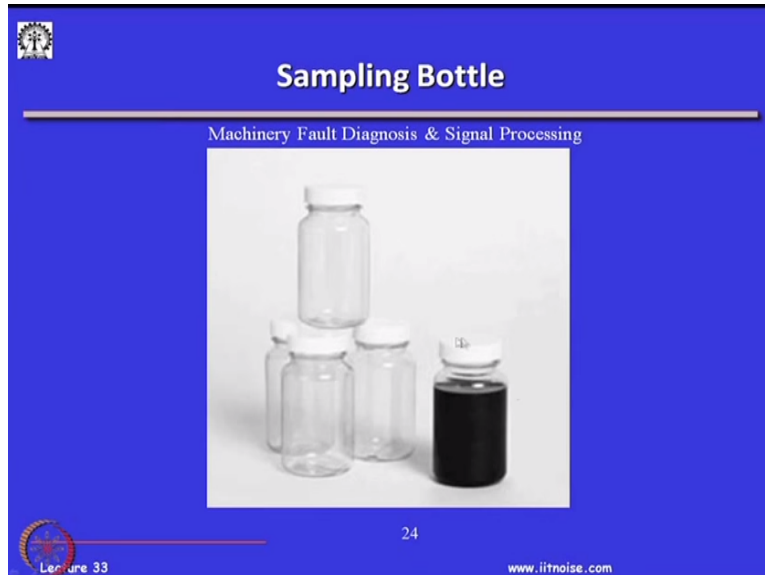
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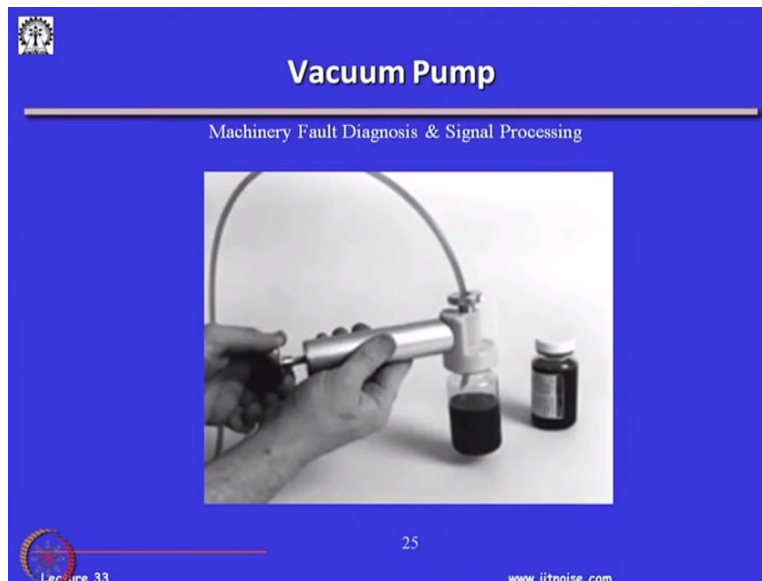
This is a figure from an caterpillar website okay some of this figure which are actually from the we can go some of the website actually this figures are from that site okay. So these are some of the engine another is lube oil and this are the filters so some good locations to collect the oil okay and this are different definitely not the cross ones the bad points okay.

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Actually the sampling bottles are look something like this and the bottles themselves have to be a very clean and then they are ISO standards for cleanliness of the sampling bottle. Because the bottle themselves if you are talking about bottle the bottle itself should not have contaminants it should be no contaminants but no difficult to define there are as of standards as to say what is what?

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And how you collect it actually through a vacuum pump or a valve drain valve etc.. this all they are collected. So this ISO 3722 cleanliness of sampling method tells that it is clean.

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The slide is titled "ISO 3722 Cleanliness of Sampling Methods" and is part of a presentation on "Machinery Fault Diagnosis & Signal Processing". It lists three levels of cleanliness:

- Clean (less than 100 particles greater than 10 microns/ml)
- Super Clean (less than 10 particles greater than 10 microns/ml)
- Ultra Clean (glass bottles washed and dried in clean environments)

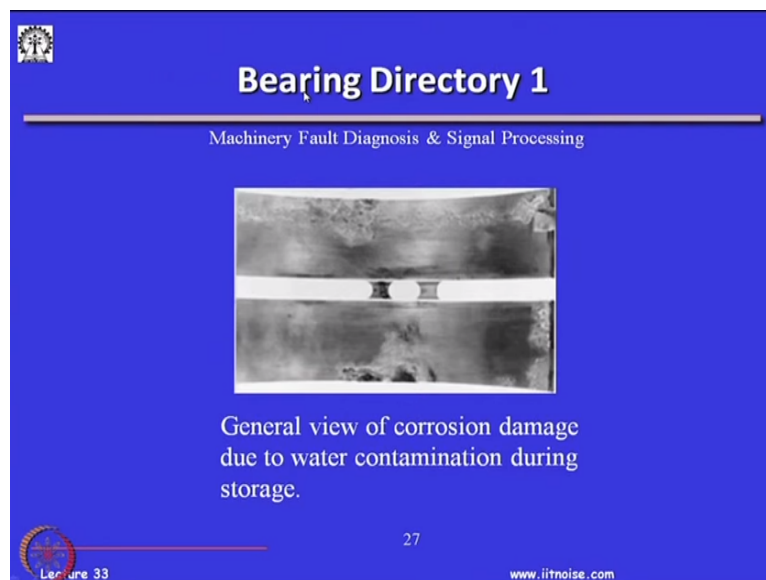
The slide number is 26, and the website www.iitnoise.com is mentioned at the bottom.

When they are there are less than 100 particles greater than 10 microns per milliliter okay. Super clean less than 10 particles greater than 10 microns per milliliter ultra clean glass bottles washed and dried in clean environments are such I have cleanliness of sampling method is very important because I cannot have an dirty bottles where in the contaminated.

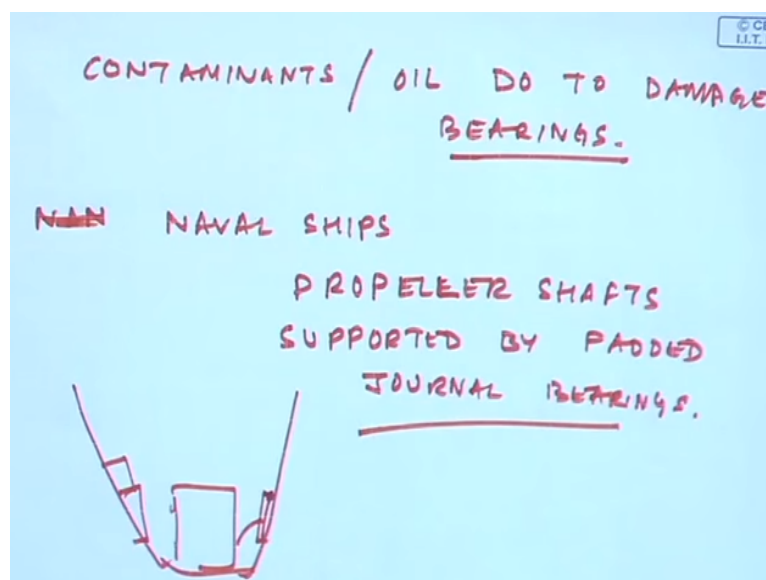
In fact some time when this tubing's are required in this vacuum pump this tubing's once you have collected in one place the machine you have collected oil when you go to next machine we should discard the tubing and you should put a fresh tubing the contaminants from the earlier machine are going to get deposited in the walls of the tubing and it is going to contaminate this second reading.

So contamination has to be avoided at any cost and that is why the cleanliness is essential to be maintained through this ISO 3722 standards.

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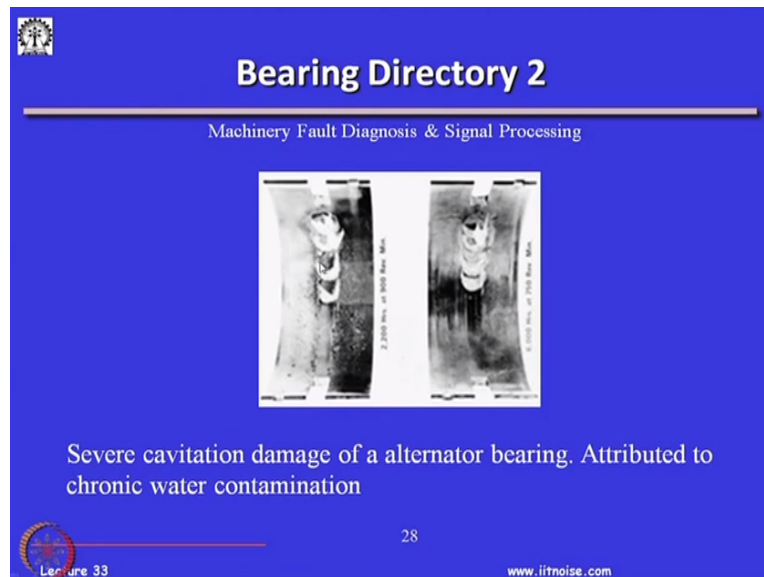
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Now before I conclude this class I will be telling some of the effects contaminants or the oil do to damage bearings and these are available in the hand books particularly the travel handbooks okay. This is just a figure as to the journal view of corrosion damage due to water contamination during storage particularly when you go the ships in naval ships.

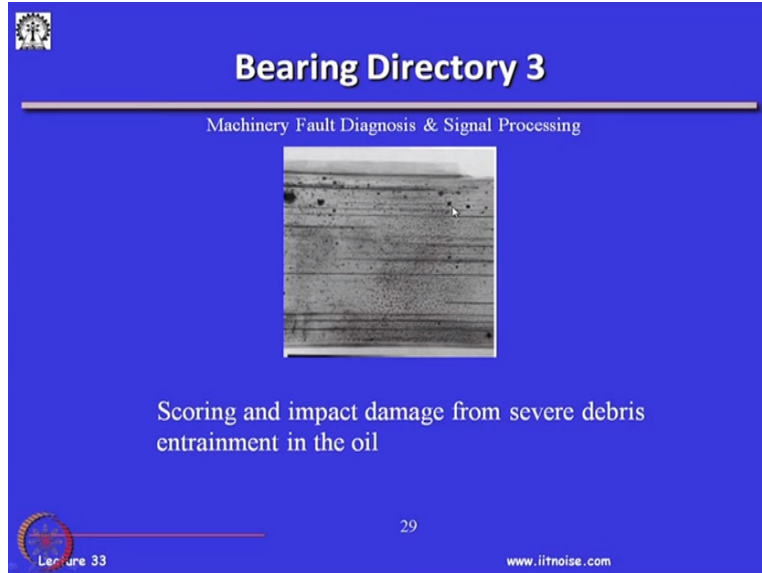
The propeller shafts are supported by padded journal bearings and if you go to the hall of the ship where in this is the ship and actually when they go to the high seas this store this bearing pads you know on the shall and whenever the extra pads are required in the system mode and during the storage for long time you know because of mass entertainment lot of water contamination during storage and we can see it goes neglected this corrosion marks they are in the vane.

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Sever cavitation damage of an alternative bearings attributed to chronic water contamination cavitation damage in an alternative bearing okay.

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Scoring and impact damage from severe debris entrainment in the oil there was an wear particle it was there in the oil. It score and then damage it is just like this you know bad patches on the road okay and if this undetected then uncared for this are going become bigger and bigger and eventually there will be a huge failure of the bearing okay.

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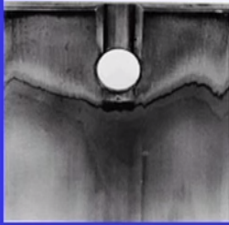


Next is you know lot of acid face of the copper lead bearing lead is very susceptible to acid attack as talking about as it is which are there and they lead to corrosion that is why we need to give this oil are lot of anticorrosion additives basically in alcoholic treatment.

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 **Bearing Directory 4**

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Acid attack of bearing materials . The bearing material has been completely dissolved showing the overlay, nickel interlayer, underlay and steel backing.

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Acid attack of the bearing material the bearing material has been completely dissolved showing the overlay, nickel interlayer, underlay and steel backing okay acid attack is very dangerous.

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 **Bearing Directory 5**

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Long term overload and resultant axial fatigue damage of a small end bush

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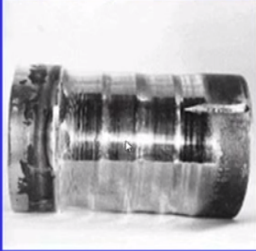
Lecture 33

Actually this is because of fatigue loading fatigue damage this smaller bush.

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 **Bearing Directory 6**

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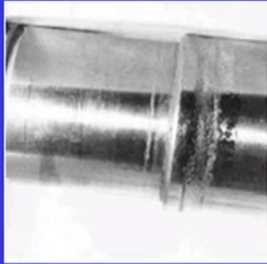
Severe overloaded ball bearing pin showing plastic deformation, fatigue and scoring.

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And Of course you can see the overload ball showing plastic deformation fatigue and scoring.
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 **Bearing Directory 7**

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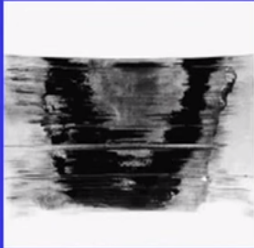
Fatigue damage to a roller bearing pin

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Fatigue damage did a roller pin
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 **Bearing Directory 8**

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Severe axial shaft misalignment overloading one edge of the bearing

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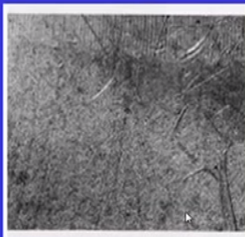
Lecture 33

Several axial shaft is misalignment overloading one edge of the bearing here overloading at the one edge of the bearing okay.

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 **Bearing Directory 9**

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Electrical discharge damage to an alternator bearing, estimated at the 50mV level.

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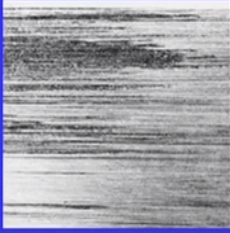
Lecture 33

Electrical discharge damage to an alternative bearing estimated at the 50MV per level okay lot of discharge occurs which are discussing in last class particularly when this sparks occurs okay.

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 **Bearing Directory 10**

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Scoring and pitting from electrical discharge on an operating high-speed alternator

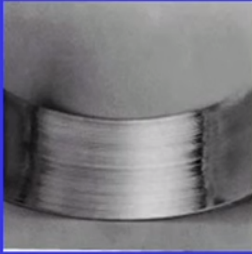
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So in conclusion one of course the scoring and pitting from electrical discharge on an operating high speed alternator.

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 **Bearing Directory 11**

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Generalised bearing wear due to insufficient oil film thickness. Probably the result of oil dilution with a distillate fuel.

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Generalized bearing due to insufficient oil film thickness probably the result of oil dilution with a distillate fuel. So in conclusion in this class we discussed about how oil and analysis is important and how oil analysis are contaminated oil analysis can complement to whatever we done through vibration monitoring. And in particular what are the techniques of oil sampling or what are the precautions we need to take regarding all sampling.

And how important the cleanliness of the sampling bottle is what is the importance of the cleanliness sampling bottle. And what happens if the bearing is oil contaminants and how they can damage the bearings. So in a nutshell of an oil and contaminant analysis actually form 20% of cases of the CBM throughout the world and they actually help supplement the vibration monitoring techniques okay thank you