Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 04

Lecture No. # 3.1

Case studies (continued)

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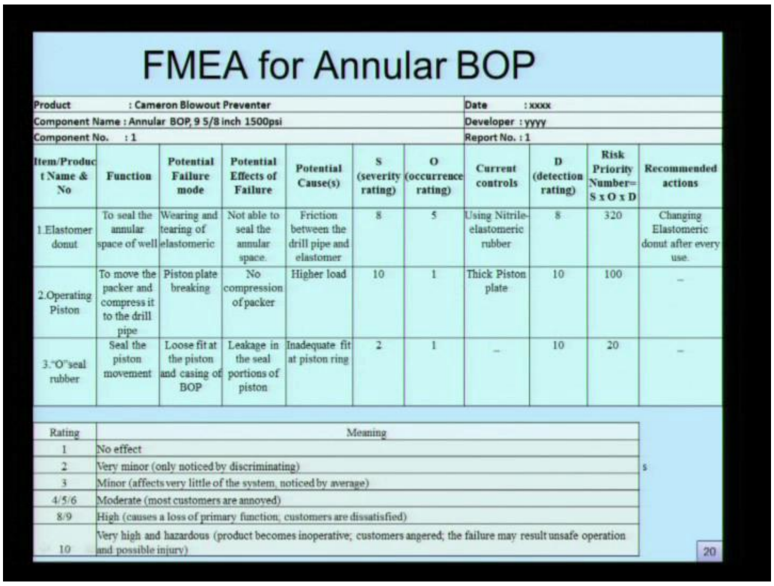

FMEA for Annular BOP

Product : Cameron Blowout Preventer		Date : xxxx
Component Name : Annular BOP, 9 5/8 inch 1500psi		Developer : yyyy
Component No. : 1		Report No. : 1

Item/Product Name & No	Function	Potential Failure mode	Potential Effects of Failure	Potential Cause(s)	S (severity rating)	O (occurrence rating)	Current controls	D (detection rating)	Risk Priority Number= S x O x D	Recommended actions
1.Elastomer donut	To seal the annular space of well	Wearing and tearing of elastomeric	Not able to seal the annular space.	Friction between the drill pipe and elastomer	8	5	Using Nitrile-elastomeric rubber	8	320	Changing Elastomeric donut after every use.
2.Operating Piston	To move the packer and compress it to the drill pipe	Piston plate breaking	No compression of packer	Higher load	10	1	Thick Piston plate	10	100	–
3."O"seal rubber	Seal the piston movement	Loose fit at the piston and casing of BOP	Leakage in the seal portions of piston	Inadequate fit at piston ring	2	1	–	10	20	–

Rating	Meaning
1	No effect
2	Very minor (only noticed by discriminating)
3	Minor (affects very little of the system, noticed by average)
4/5/6	Moderate (most customers are annoyed)
8/9	High (causes a loss of primary function; customers are dissatisfied)
10	Very high and hazardous (product becomes inoperative; customers angered; the failure may result unsafe operation and possible injury)

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Now, we shall discuss the design FMEA for the annular BOP. This is basically the failure mode and effect analysis on different components of the blow out preventer. We have discussed the different components of blow out preventer in the previous slide. Let us pick up few components by name Elastomer donut, operating piston and O-seal rubber. These are some of the components which are very vital for effective functioning of the blow out preventer. So, this is the standard FMEA design sheet, which contains the first column as the item and product name, in the second column we discuss about the functional aspects of the specific item, in the third column we discuss potential failure mode of those components and the effects of that failure. In the next column, we discuss the potential causes for such failure, depending upon the potential causes we look into the severity of cause, occurrence and detection rating.

Severity is basically the effect of the consequence of the cause. How frequently this cause can occur? If at all this cause or the failure is occurring or they detectible, so that is what we see in the column detection. We can parallel also look into what are the existing control measures available to control a failure of that component. We try to find out what is called RPN; that is risk priority number which is the product of severity, occurrence and detection. Based on this, we can prioritize the risking depending upon the component numbering. You can look here, the severity occurrence and detection actually are rating.

(Refer Slide Time: 00:10) So, what we are trying to do here is the qualitative effects of failure, the qualitative potential failure modes are converted quantitatively by giving a rating to them. When we look at the rating, these rating anywhere vary from 1 to 10. If I say one, no effect will be there on that particular number. If I say ten, it has got a very high and hazardous. For example, if the Elastomeric donut has a severity of eight, it means that it has a potential to cause a loss of a primary function. Here on the top, we write down the product name; here we write down the date of evaluation; we write down the component name; we write down the component number; we write down the developers name and address, and we classify the report number. So, this is the standard design FMEA sheet, which is being demonstrated for you for an example of applied to angular BOP.

Now, let us look at once specific component of Elastomer donut. The main function of the Elastomer donut is to see the annular space of the well. The potential failure mode of the Elastomer donut is the wearing and tearing of the elastomeric rubber. The potential effect of this failure is, is unable to seal the annular space. The potential causes could be friction between the drill pipe and the Elastomer. The severity rating is considered as eight; the frequency of occurrence rating of this is considered as five.

So, it is a moderate occurrence and if you look at the current controls available, you can use Nitrile-elastomeric rubber which is having less severity and occurrence rating compared to other rubbers. So, you can use a material replacement of the existing elastomeric donut by Nitrile-elastomeric rubber. However, if at all the Elastomer donut fails, the detection rating is very high; you will be able to note down the detection very easily. So, product of this will give me the risk priority number and the recommended action could be change the elastomeric donut after every use. So, once you have done the drilling and after the first cycle of drilling operation is complete, the elastomeric donut should be changed at every use. Similarly, one can do for the operating piston, one can do for O-seal rubber, and you can develop, what we call as on design FMEA sheet.

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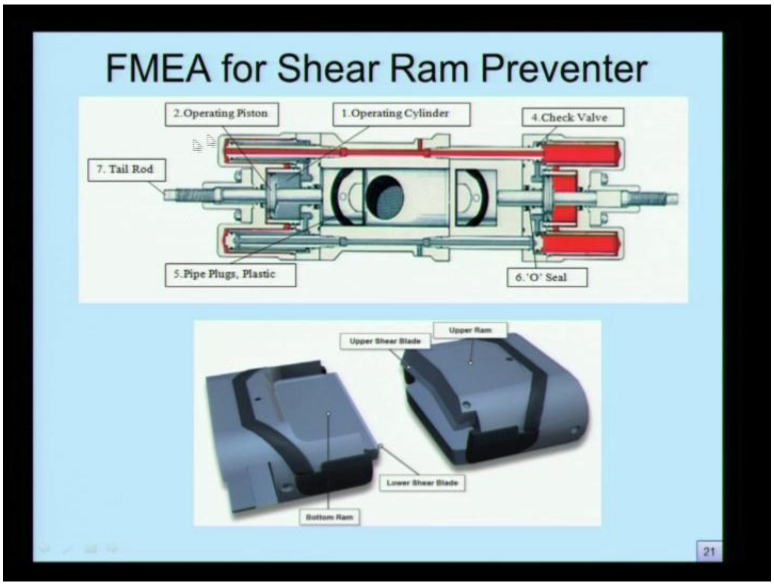

Let us look one more example of on FMEA for as a shear ram preventer. This is another important component in a blow out preventer. This is the view of a shear ram preventer; it contains an operating cylinder; it contains an operating piston, which moves forth and back which will control with the cylinder. This is sealed by an O-seal ring which we have here and this operates as the check valve which will control the exit and entry of the liquid inside the container. And, you can also note down some minor components as pipes, plugs and plastic components here and this is what we call as a tail rod.

If you look at the shear ram blade, basically this is what we call as lower blade, this is what we call as an bottom ram; this is an upper ram; this is an upper shear blade. So, these two blades shear one over the other to cut and close the drilling stack, this is what we call a shear ram. And once it cuts and seals the drilling stack, it prevents the flow hydro carbon from sub sea level to my top side; that is why it is called shear ram preventer. Now, let us do on FMEA analysis for a shear ram preventer, we have grossly understood different operating components of this mechanical device.

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FMEA for blind shear ram

Product : Hydril Blowout Preventer							Date : xxxx			
Component Name : Blind Shear Ram BOP 13-5/8" 3000psi							Developer : yyyy			
Component No. : 1							Report No. : 2			
Item/Product Name & No	Function	Potential Failure mode	Potential Effects of Failure	Potential Cause(s)	S (severity rating)	O (occurrence rating)	Current controls	D (detection rating)	Risk Priority Number = S x O x D	Recommended actions
1.Operating Piston	To Seal the annular space of well and shear the drill pipe	Wearing and tearing of sharp edges and elastomer	Not able to seal the annular space.	Friction between the drill pipe and elastomer	8	3	Using Nitrile-elastomeric rubber	8	192	Changing and replacing with new piston.
2.Operating Cylinder	To move the packer and compress it to the drill pipe	Piston plate breaking	No compression of piston	Higher load	10	1	Thick plate	10	100	_
3.Locking Screw	Seal the piston movement	Loose fit at the piston and casing of BOP	Leakage in the seal portions of piston	Inadequate fit at piston ring	2	1	_	10	20	_

Let us list these components here, component number one - operating piston; two - operating cylinder; three - locking screw and so on and so forth. The product name is hydril blowout preventer; the component name is blind shear ram BOP 13-5 by 8 inches operating at 3000 psi pressure. The date and developers name are entered here; this is component number one, and report number two. So, the essential function of an operating piston is to seal the annular space of the well and shear the drill pipe. The potential failure mode is wearing and tearing of the sharp edges and Elastomer; the effects of the failure will be unable to seal the annular space, the causes could be develops friction between the drill pipe and the Elastomer.

The severity rating of this component can be taken as 8 on a 10 point scale; the occurrence is 3; it is a low occurrence phenomenon, because generally the operating piston does not fail so frequently. You can use a Nitrile-elastomeric rubber to reduce even the occurrence rate further. If at all it fails, you will be able to visibly notice the failure for detection rating is very high in this case and I get the product of S O D as what I have as risk priority number.

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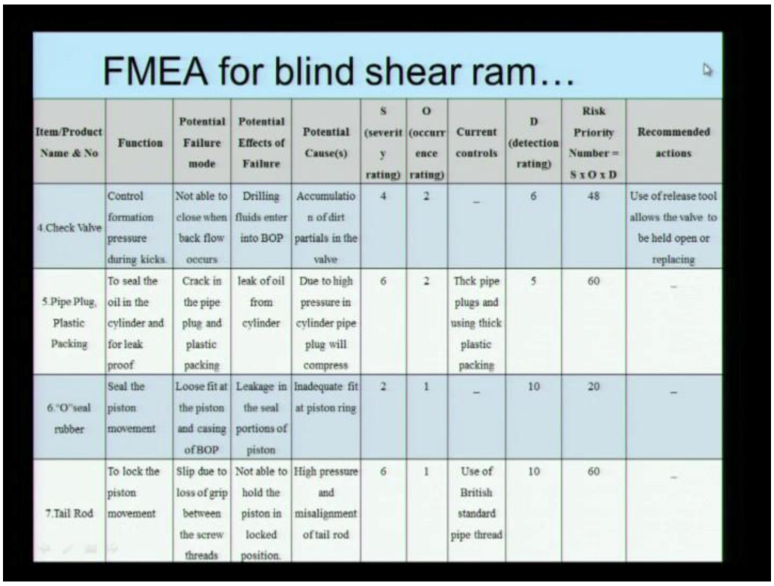

FMEA for blind shear ram…

Item/Product Name & No	Function	Potential Failure mode	Potential Effects of Failure	Potential Cause(s)	S (severity rating)	O (occurrence rating)	Current controls	D (detection rating)	Risk Priority Number = S x O x D	Recommended actions
4.Check Valve	Control formation pressure during kicks.	Not able to close when back flow occurs	Drilling fluids enter into BOP	Accumulation of dirt partials in the valve	4	2	_	6	48	Use of release tool allows the valve to be held open or replacing
5.Pipe Plug, Plastic Packing	To seal the oil in the cylinder and for leak proof	Crack in the pipe plug and plastic packing	leak of oil from cylinder	Due to high pressure in cylinder pipe plug will compress	6	2	Thck pipe plugs and using thick plastic packing	5	60	_
6."O"seal rubber	Seal the piston movement	Loose fit at the piston and casing of BOP	Leakage in the seal portions of piston	Inadequate fit at piston ring	2	1	_	10	20	_
7.Tail Rod	To lock the piston movement	Slip due to loss of grip between the screw threads	Not able to hold the piston in locked position.	High pressure and misalignment of tail rod	6	1	Use of British standard pipe thread	10	60	_

I keep on obtaining there is the risk priority number for different components like operating piston, operating cylinder, locking screw, check valve, pipe, plug and plastic packing, O-seal rubber and tail rod. There is standard software available to do on FMEA analysis. In the next lecture, I will discuss about the different kinds of software available for doing risk analysis on oil and gas industries.

So, in this particular example the FMEA has been done using PHA pro, for example, you can look at the fourth component also as a check valve, the essential function of check valve is the control formation pressure during the kicks. It is unable to close when the back flow occurs; that is what we called as a potential failure mode of the check valve. The effects of the failure will be, the drilling fluid enters into the BOP, which is not supposed to enter. The potential cost could be accumulation of dirt particles inside the valve. The severity of course, is four occurrence rating is very rare, but detection rating is slightly higher. So, I will be able to get the risk priority number as 48. The recommended action for this specific component is use of a release tool, allows the valve to be held open or replace the valve, whenever it is to be required to be replaced. So, design FMEA can be conducted for different component level analysis for a BOP as shown in the current example.

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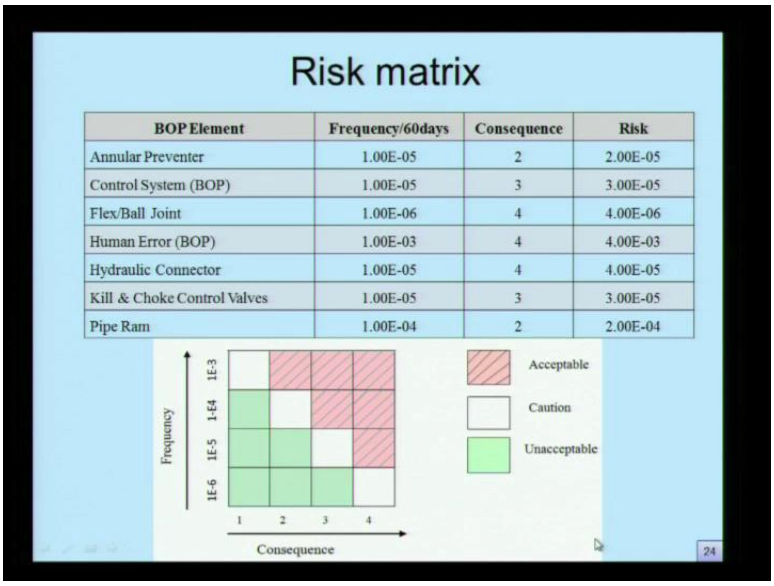

Risk matrix

BOP Element	Frequency/60days	Consequence	Risk
Annular Preventer	1.00E-05	2	2.00E-05
Control System (BOP)	1.00E-05	3	3.00E-05
Flex/Ball Joint	1.00E-06	4	4.00E-06
Human Error (BOP)	1.00E-03	4	4.00E-03
Hydraulic Connector	1.00E-05	4	4.00E-05
Kill & Choke Control Valves	1.00E-05	3	3.00E-05
Pipe Ram	1.00E-04	2	2.00E-04

Once this is done, we will be able to estimate what we call as a risk matrix. The risk matrix gives all the BOP elements on one column; the frequency with respect to one month in next column; the consequence of that failure in the third column. And of course, I estimate of risk based upon the value of frequency on the consequence in the fourth column. If you look at the BOP elements, what we discussed in the current analysis annular preventer, control systems, ball joints, human error, hydraulic connector, kill and choke control valves, and pipe rams. To the frequency of these kinds of failure could be based on this scale, and the consequence could be again arrived on a five point scale ultimately risk can be estimated as a product of consequence and risk.

I, can also plot the risk matrix as x-axis showing the consequence and y axis showing me the frequency, and whatever regions you see here (( )) are consider to be an acceptable region; whatever the white region, you see here are the region with caution, and whatever the green regions you see here in this matrix are unacceptable region. On the other hand, a consequence of very low frequency is also not acceptable. So, based on the risk matrix estimated for different elements of BOP, I can estimate and plot what we call as a risk matrix.

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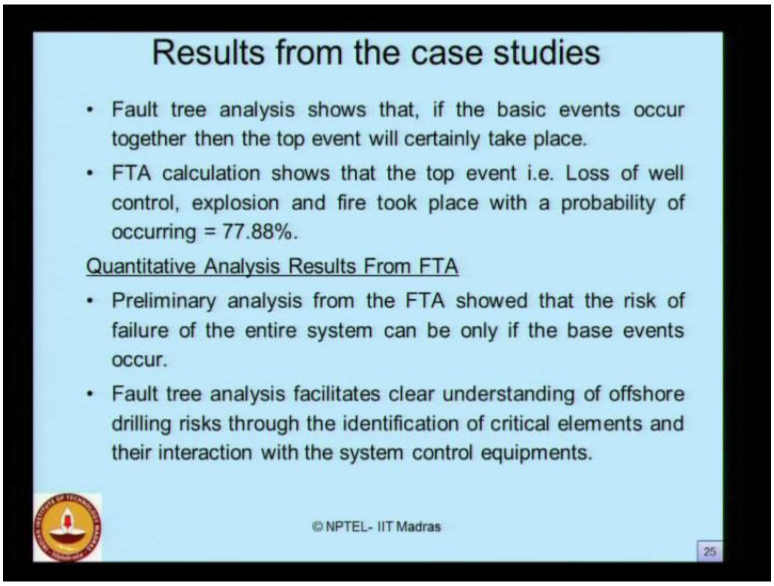

Let us now look into the results from the case studies what we have done so far. The first example, what we discussed is on the fault tree analysis of a given problem. Fault tree analysis shows that, if the basic events occur together then the top event will certainly take place. The fault tree analysis calculation shows that the top event; that is in the given example the loss of well control, explosion and fire took place with a probability of occurrence of about 78 percentages.

We also did, what is called quantitative risk analysis results which will arrive from the fault tree analysis. The preliminary analysis from the fault tree analysis showed that the risk of failure of the entire system can be only if the base events occur. Fault tree analysis, facilitates clear understanding of offshore drilling risks through the identification of critical elements and their interaction with the system control equipments.

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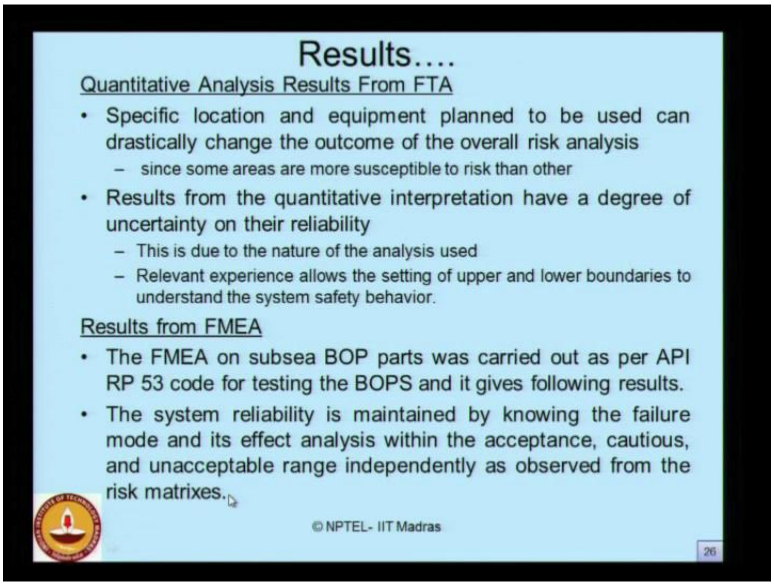

Specific location and equipment planned to be used, can drastically change the outcome of the overall risk analysis. Ladies and gentlemen, this is a very important result what we achieved from the QRA results of FTA. The overall risk analysis results can always change or can show a different consequence depending upon where the equipment is being planned and to be used in a specific location. Because some areas where the equipment is being used or planned to be used or more susceptible to risk than the other areas. Results from the quantitative interpretation have a degree of uncertainty on their reliability. Any QRA study which gives you the probability of occurrence of any specific event always is associated with the degree of uncertainty, which we call as the reliability.

Mainly this is due to the nature of the analysis what you perform; it also depends on how experienced you are in doing such analysis. Relevant experienced person, if they do the analysis, they allow setting of upper and lower boundaries to understand the system safety behavior. If you look at the failure mode effect analysis, what we conducted for annular BOP and the shear rams BOP.

The results from FMEA you can also be concluded as we see here. The design FMEA conducted on subsea, blow out preventer parts is carried out in accordance to international regulation called AP RP 53 code. API RP 53 code, is essentially the code used for testing the blow out preventers and the following results are arrived based on the FMEA conducted. The system reliability is maintained by knowing the failure mode and its effect analysis within the acceptance, cautious, and unacceptable region independently as observed from the risk matrixes. It is a very important conclusion, we arrived that the failure mode and its effect analysis is known to me on different regions, as acceptable region, region with the caution, and unacceptable region. Based on the observations what we conducted and what we formulate as, what we call as a risk matrix.

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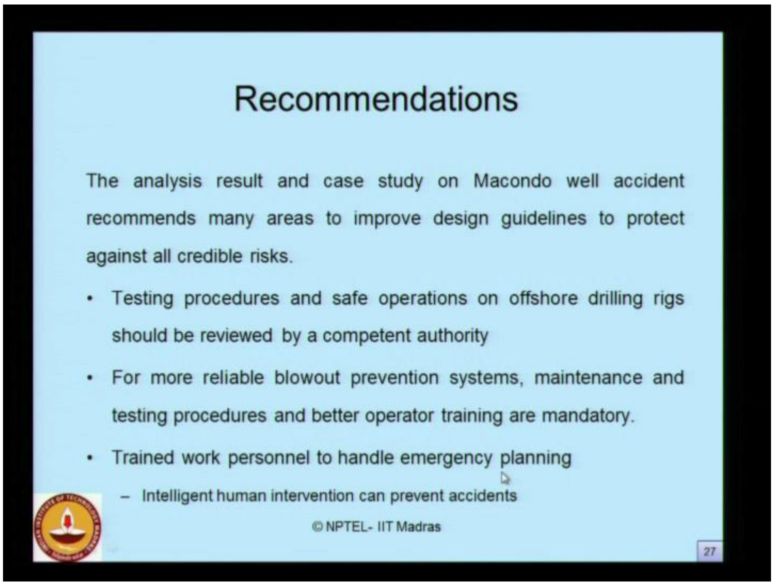

So, based on the analysis what we conducted, one can summarize the recommendations, what we can give for the case studies analyzed in this presentation. The analysis result and case study on Macondo well accident recommends many areas to improve the design guidelines which can be used to protect against all credible risk. The testing procedures and safe operations on offshore drilling rigs should be reviewed thoroughly by a competent authority, before it is put to use. For more reliable blowout prevention systems, maintenance and testing procedures and better operator training are mandatory. Trained work personnel are required to handle emergency planning. It means that intelligent human intervention can prevent accidents in offshore and gas industry. This is where people generally focus on HSE studies, because HSE studies do lot of capacity building for improving the personnel skills of the trained work labor, in the people working on board in oil and gas industry.

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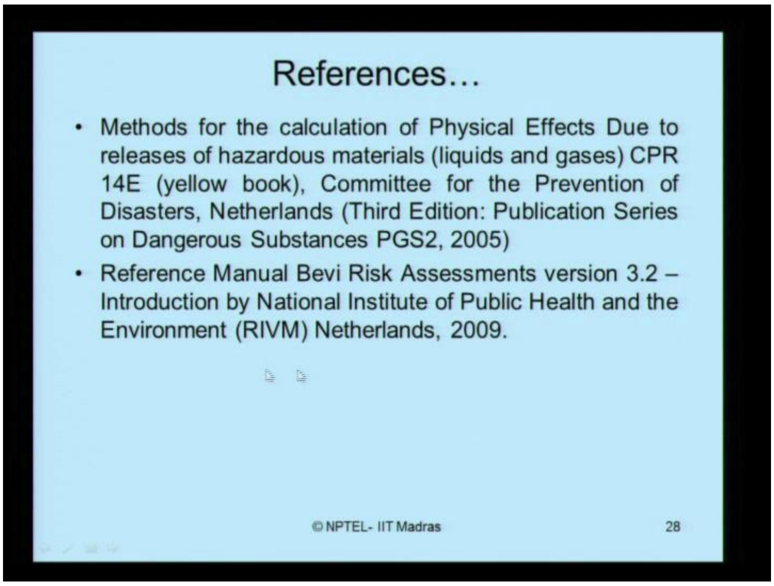

The study has many references. Methods for calculating physical effects due to release of hazardous materials, what we call as an CPR - yellow book, committee for prevention of disasters, Netherlands. Reference Manual Bevi Risk Assessments version 3.2- introduction by National Institute of Public Health and Environment, Netherland, 2009.

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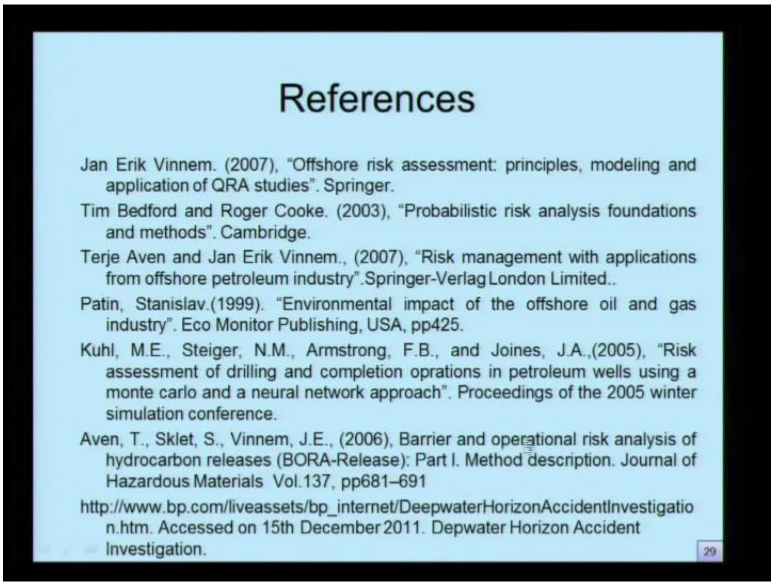

Then the book suggested by Jan Erik Vinnem, Offshore risk assessments principles, modeling and application of QRA studies. Tim Bedford and Roger Cooke, Probabilistic risk analysis foundations and methods, Cambridge publication. Terje Aven and Jan Erik

Vinnem, Risk management applications offshore industries, Springer. Patin, Stanislav, Environmental impact on offshore and gas industry, Eco monitor publishing US. Kuhl atell, Risk assessment of drilling and completion operations proceedings of winter simulation conference. Aven atell, Barrier and operational risk analysis of hydrocarbon releases, Journal of hazardous materials and so on and so forth.

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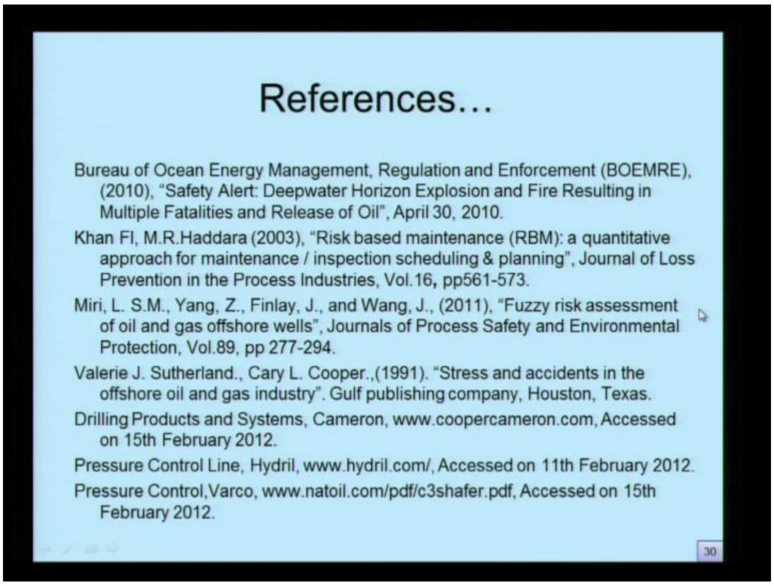

Ladies and gentlemen, these references are very interesting and very important for you to further given interesting reading on the topic, what we discussed during the course of the lecture. You must try to acquire the original copies of this publication and try to read them and understand them thoroughly for better knowledge level growth in the topic. Thank you.