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Health, Safety & Environmental Management in Offshore and Petroleum engineering (HSE)

Module 2: Accident modeling, Risk assessment & Management

Lecture 6: Accident modeling II (continued..)

Friends welcome to the 6th lecture on module 2 we are talking about accident modeling risk assessment and management under the brace of HSE course in NPETL IIT Madras this lecture is of course a continuation of the 5th lecture I request the viewers the first look at the 5th lecture and understand before we look at the 6th lecture because this is a continuation part if the last lecture. In the last lecture we have been discussing.

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Failure cases and consequences of LPG filling station			
Sl. No.	Failure Case	Failure Mode	Consequence
1	Full bore / failure of LPG outlet line of Bullets	Random	Dispersion, Jet fire, UVCE
2	80% CSA failure of LPG outlet line of Bullets	Random	Dispersion, Jet fire, UVCE
3	LPG pump discharge line full bore failure	Random	Dispersion, Jet fire, UVCE
4	Road tanker failure	Random	Dispersion, fire ball, BLEVE
5	LPG pump mechanical seal failure	Mech. seal	Dispersion, Jet fire, UVCE
6	LPG Pump Outlet Line Gasket failure	Gasket	Dispersion, Jet fire, UVCE
7	Road Tanker unloading arm failure	Random	Dispersion, Jet fire, UVCE

The different failure cases and consequences of a case study of LPG filling station located at two different places geographically different failure cases where identify full mode failure of the

LPG outlet line of bullets 20% gross section area failure LPG bump discharge line full bore failure road tanker failure LPG bump mechanical seal failure LPG bump outlet line gasket failure and road tanker unloading on failure these where the different failure cases for which the consequences could be deposition jet fire cloud exposition BLEVE and fire ball etc..

So we have been discussing partly the disposition in let fire in the last lecture yesterday you please understand that the failure more of all these failure cases are more less random except some of them may be totally dedicated to the mechanical systems which can also be corrected using a detail FMEA analysis.

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Sl. No.	Failure Case	Failure Mode	Consequence
8.	LPG unloading vapor compressor outlet line Full bore failure	Random	Dispersion, jet fire, UVCE
9.	Catastrophic Failure of a Single Bullet (Capacity: 180 MT)	Random	Dispersion, Fireball, BLEVE
10.	Domino Effects Of Bullets	Random	Dispersion , Fireball , BLEVE

Sub sequently we also said LPG unloading vapor compression out let line full bore failure catastrophic failure of the single bullet and domino effects of bullets sequential gasket getting effect can also be a random mode failure which can result in fire wall BLEVE and dispersion.

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The slide is titled "Types of damages" in a large, light-colored serif font. Below the title, there is a list of items, each preceded by a green circular bullet point. The items are: "Effect of thermal radiation", "Effect of over pressure", "Consequences", and "Vapor cloud explosion (VCE)". Under "Consequences", there is a sub-list with four items: "Dispersion", "Jet fire", "Bleve", and "Fire ball". In the bottom left corner of the slide, there is a small circular logo for NPTEL (National Programme on Technology Enhanced Learning) and the text "© NPTEL IN Madras". In the bottom right corner, there is a small number "4".

There are different damages we saw effect if thermal radiation effect of over pressure and the consequences derived from this damages could be dispersion jet fire, Bleve, fire ball and VCE in the last lecture we discussed about the consequences of disposition and jet fire on both the plants located ABC and xxx locations respectively

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Fireball

Catastrophic failure of single bullet (ABC plant)						Catastrophic failure of single bullet (XXX plant)					
Sl. No.	Thermal Load KW/m ²	Distance (m)				Sl. No.	Thermal Load KW/m ²	Distance (m)			
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec			Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	748	728	732	734	01.	4	730	738	736	746
02.	12.5	371	382	364	386	02.	12.5	364	369	387	376
03.	37.5	NR	NR	NR	NR	03.	37.5	NR	NR	NR	NR

Catastrophic failure of three bullets (ABC plant)						Catastrophic failure of three bullets (XXX plant)					
Sl. No.	Thermal Load KW/m ²	Distance (m)				Sl. No.	Thermal Load KW/m ²	Distance (m)			
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec			Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	1404	1372	1381	1388	01.	4	1379	1397	1390	1419
02.	12.5	730	716	717	721	02.	12.5	715	726	722	739
03.	37.5	112	87	82	92	03.	37.5	79	103	96	129

Now we will continue to discuss with this now what will be the consequences of the fire ball on both the plants let us say the left hand side shows the consequences of fire ball on the ABC plant and the right hand side table show the consequences on the XXX plant the catastrophic failure of single bullet catastrophic failure of three bullets and similarly at ABC and xxx I mean discussed here and we all understood that for a given thermal rotation the intensity load varying from 4 to 37.5 kw/m² for an average period for an year the distances in terms of fire ball is evaluated for different cases for different locations for different kinds of failure may be a single failure may be three gasket failure of three bullets sub sequently.

Now we can understand that the same distances kept on increasing for the whole period of the year when you talk about the thermal load variations from 4 to 37.5 and when the gasket effect of three bullets are happening obviously the hazard distances are the same distances for your fill rising from the fire ball or kept on increasing where as in this case it is not so and the same thing also seen in both the locations ABC as well as to plus plant.

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Fireball of road tanker failure (ABC plant)						Fireball of road tanker failure (XXX plant)					
Sl. No.	Thermal Load KW/m ²	Distance (m)				Sl. No.	Thermal Load KW/m ²	Distance (m)			
		Jan - Mar	Apr - Jun	Jul - Sep	Oct - Dec			Mar - May	Jun - Aug	Sep - Nov	Dec - Feb
01.	4	378	373	374	375	01.	4	374	377	378	381
02.	12.5	187	184	185	186	02.	12.5	188	187	186	189
03.	37.5	NR	NR	NR	NR	03.	37.5	NR	NR	NR	NR

Similarly fireball can arise also from a road tanker failure on both the locations ABC and xxx we can see that the hazard distances or LFL distances arrive for the fireball failure is also shown for three thermal load intensities varying from 4, 12.5 and 37.5 KW/m²

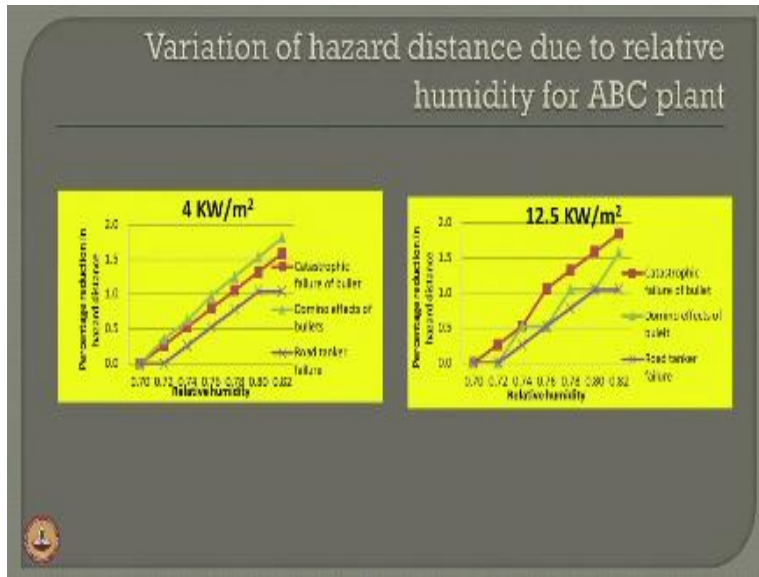
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Sl. No.	Failure Case	Hazard distance for intensity load 12.5 KW/m ² (ABC plant) in metre	Hazard distance for intensity load 12.5 KW/m ² (XXX plant) in metre
1	Road tanker failure	197	109
2	Catastrophic Failure of a Single Bullet (Capacity: 150 MT)	371	376
3	Domino Effects Of Bullets	730	730

Now based on this we attempted to determine the fireball hazard distances for different kinds of full failures for a road tank failure, catastrophic failure of a single bullet of a capacity 150 metric tank and domino effects of bullets we get hazard distances for intensity of 12.5 which is kept common for both the cases in terms of meters where I see the domino effect generally has the more hazard distance compared to that of a road tanker failure.

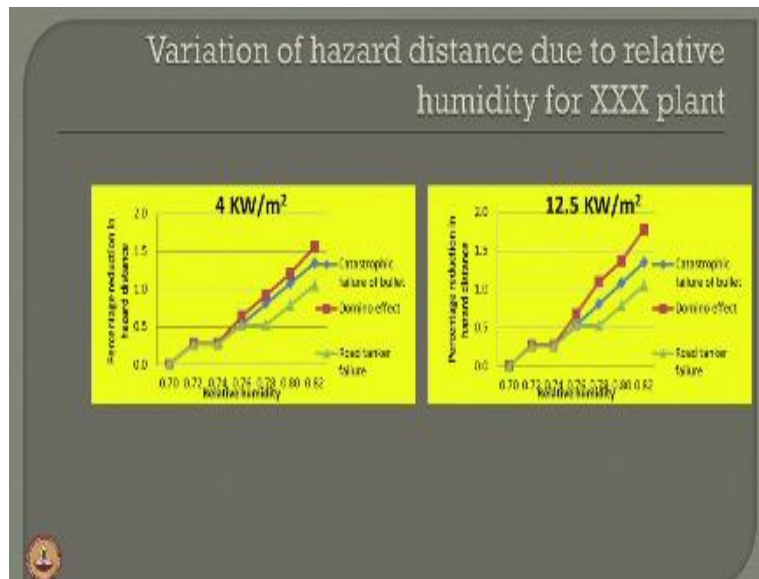
This highly local that has a domino is nothing but the cascading effect of C is a failure of bullets which has more hazard distance in both the locations. However you will also see the fireball hazard distance computation is not significantly influenced by the location of the plant because you know the stability class for different plants at A, B, C and XXX are not same even the weather conditions the wind velocity where vary even then the fireball hazard dances is not inflamed by the location of the plant in the geographic manner.

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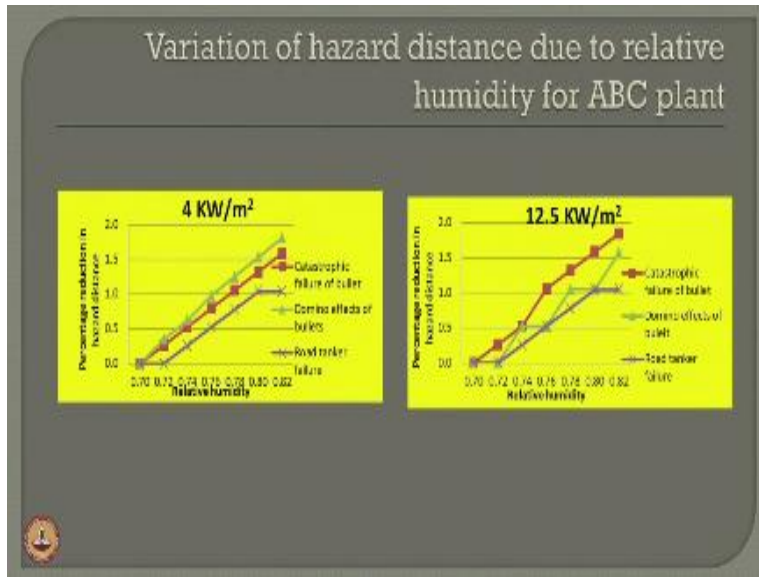
Then we attended to study the various hazard dance due to relative humidity for the A, B, C plant again for the preliminary intensity of 4 and 12.5.

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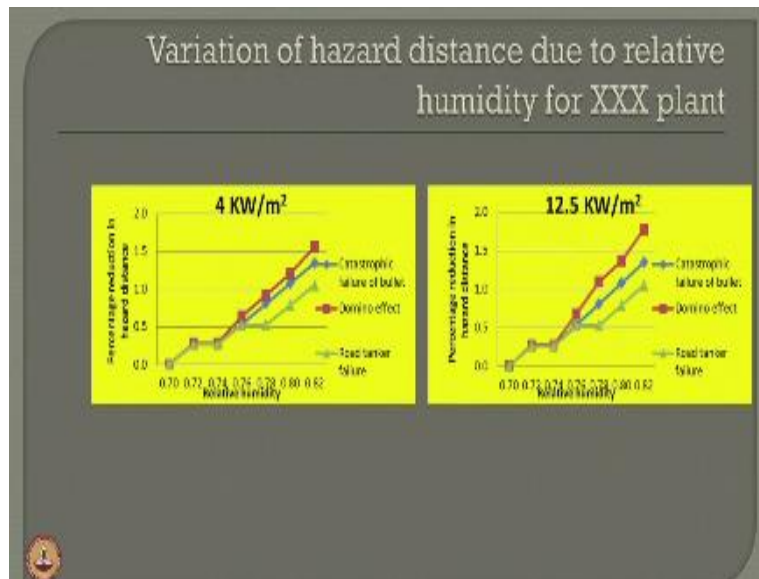
We studied these for both XXX plant and A, B, C plant respectively.

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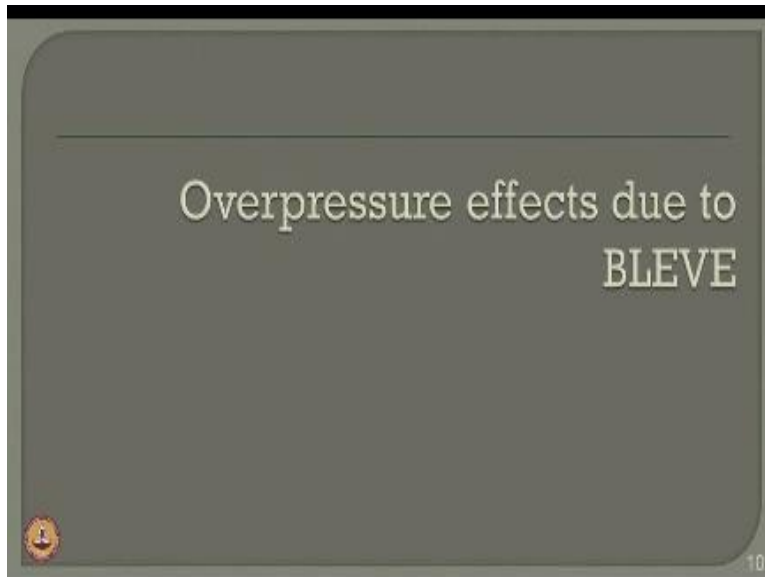
You see that for a different kinds of failure catastrophic failure of the bullet domino effects of the bullet and road tanker failure you will see this more or less increasing that is the percentage hazard reduction in the hazard distance is in the higher side as respect to the relative humidity kept in increasing and this I almost seen for both radiation intensities for 4 and 12.5 respectively.

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Of course a similar trend is also absorbed in the other location in XXX plant.

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The second focus was subsequently in today's lecture is, what is a consequence of over pressure effect due to BLEVE arising in both the plants.

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Hazard distance due to BLEVE

Catastrophic failure of bullet (ABC plant)						Catastrophic failure of bullet (XXX plant)					
Sl. No.	Shock load in bar	Distance (m)				Sl. No.	Shock load in bar	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb			Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	0.03	601	601	601	601	01.	0.03	601	601	601	601
02.	0.1	240	240	240	240	02.	0.1	240	240	240	240
03.	0.3	179	179	179	179	03.	0.3	179	179	179	179

Catastrophic failure of bullet (ABC plant)						Catastrophic failure of bullet (XXX plant)					
Sl. No.	Shock load in bar	Distance (m)				Sl. No.	Shock load in bar	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb			Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	0.03	270	270	270	270	01.	0.03	270	270	270	270
02.	0.1	108	108	108	108	02.	0.1	108	108	108	108
03.	0.3	58	58	58	58	03.	0.3	58	58	58	58

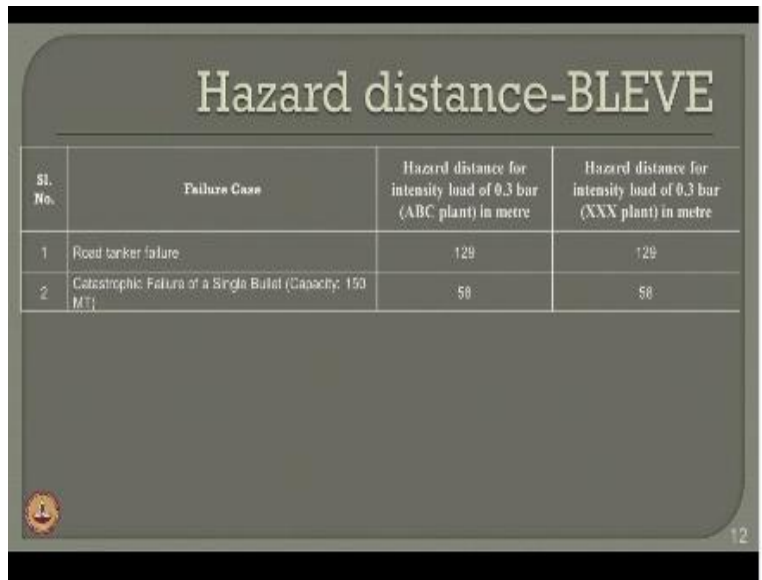
Sp the left hand side table shows the effect of catastrophic failure of the bullet on A, B, C plant and cascade effect of series of bullets on the plant A, B, C whereas the right hand table shows the same effect subsequently on the XXX plant, of course the study is been done for a shock load in terms of bar because shock loads determine what will be the consequence of BLEVE arising because we have already seen explosion is always carried by the shock wave front.

So shock low has been considered for a different intensity in terms of bar and the hazard distances has been worked out as BLEVE consequence arising from the catastrophic failure of the bullet and failure of the bullet separately, this series of bullets is bullets actually is a cascading effect, we will see that the effect of hazard distance due to BLEVE arising is note because this is highly local as far as the single failure bullet is concerned whereas the cascade effect you see that it is not affected much.

Because the distances is getting reduce compared to that of the failure case of bullet in case of in A, B, C a similar trend is also seen in case of XXX plant, you will also notice that the hazard distance arising from BLEVE is not significantly influenced by the location of the plant that be A, B, C having a different weather condition being XXX which has different weather condition

the hazard distance does not vary significantly due to arising from BLEVE in this kind of accident.

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Sl. No.	Failure Case	Hazard distance for intensity load of 0.3 bar (ABC plant) in metre	Hazard distance for intensity load of 0.3 bar (XXX plant) in metre
1	Road tanker failure	129	129
2	Catastrophic Failure of a Single Bullet (Capacity: 150 MT)	50	50

One cannot estimate hazard distance for a different failure case like a road tank failure and catastrophic failure of single bullet you will see that for a single bullet the hazard distance is highly local compared to the road tank failure because BLEVE is an explosion release model which tries to spread over a large area which affords a public population in a larger way.

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Risk Assessments

<h3>INDIVIDUAL RISK</h3> <ul style="list-style-type: none">• Ratio of number of fatalities and number of people at risk• Risk contour $IR_{x,y,z} = F_{x,y,z} \int_0^{y_0} [P_{y_0} P_{y_0}] dy$	<h3>SOCIETAL RISK</h3> <ul style="list-style-type: none">• Number of people suffered from the accidental consequences• FN curve $N_{x,y,z} = \int_0^{y_0} n_{x,y,z} P_{y_0} dy$
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Now based on these studies one is interested to know now the risk assessment, now we want to assess the risk arising from these failure cases and this corresponding consequence. Now the risk assessment can have two parts one is the individual risk, one can be a societal risk. Individual risk we all know is a ratio of number of fatalities and number of people at risk which can be expressed in terms of risk contour. Whereas societal risk is expressed as the number of people suffered from the accidental consequences it is generally expressed in terms of FN curve.

That equations given to you on either side will give you the plot or the equation to calculate the individual risk and the societal risk in the FN curve directly from this equation.

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Failure frequency

Sl. No.	Failure Case	Failure frequency
1	Full bore / failure of LPG outlet line of Bullets	15E-8/Average year
2	20% CSA failure of LPG outlet line of Bullets	3.3E-7/Average year
3	LPG pump discharge line full bore failure	3E-5/Average year
4	Road tanker failure	1E-6/Average year
5	LPG pump mechanical seal failure	5E-6/Average year
6	LPG Pump Outlet Line Gasket failure	5E-6/Average year
7	Road Tanker unloading arm failure	3E-8/hour



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Where is being plotted now, based on the study conducted we arrive at the failure frequency for different failure cases which are envisaged in this specific problem. Let us start looking at each case separately, let us full bore failure of an LPG outlet line of the bullets. Now the failure frequency is about 15×10^{-8} per an average year. Whereas the failure frequency keeps on increasing for different case of failure except that of road tank failure which is very rare. So the full bore failure has got 15×10^{-8} whereas 20% CSA failure, LPG pumps, road tank failure, road tank unloading arm failure which is having a very large frequency.

LPG mechanical seat failure extra. Now looking at this failure cases one can easily observe that a common frequent failure is the discharge pump, so it is important to know that one should pay more attention to this kind of failure discharge pump failure in the LPG stations as we saw from this specific study.

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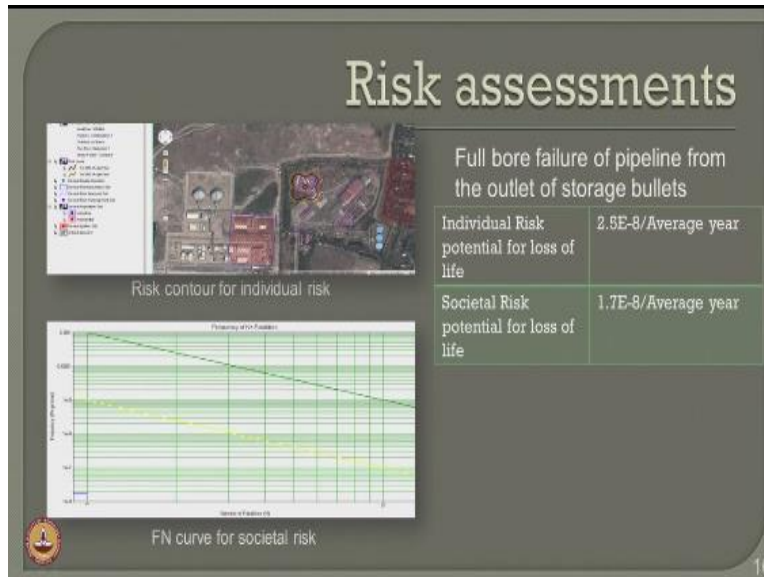
Sl. No.	Failure Case	Failure frequency
1	LPG unloading vapor compressor outlet line Full bore failure	2.9E-6/Average year
2	Catastrophic Failure of a Single Bullet (Capacity: 150 MT)	2E-6/Average year
3	Domino Effects Of Bullets,	2E-10/Average year



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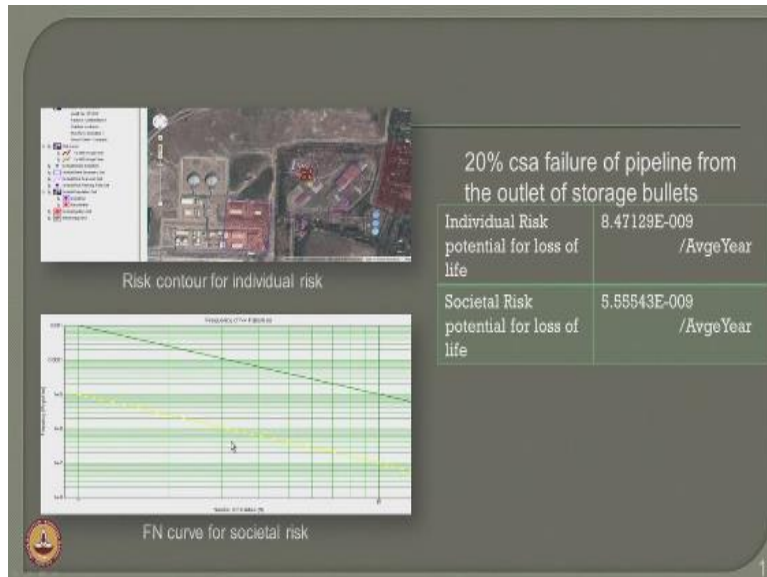
Looking at the LPG unloading vapour compressor outlet, now this is having a very high frequency compared to the earlier case and the maximum frequency what you see in the study of occurrence is domino effects on bullets you generally the cascading effect failure of series a bullets does not frequently happen in LPG stations.

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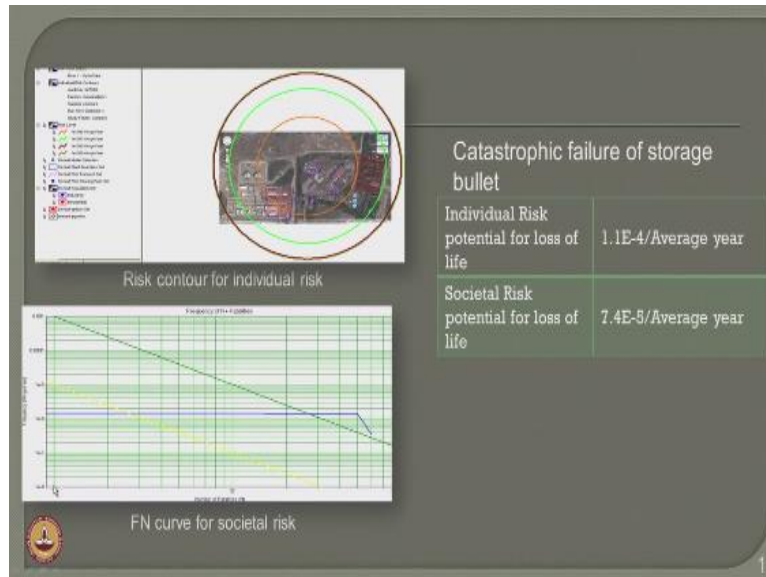
Now as we understand we are now trying to plot the risk contour for individual risk and FN curve for the societal risk. let us take case by case, now first case discussed here is a full bore failure of a pipeline from an outlet of a storage bullet at ABC plant. In the individual risk is arrived as about 2.5×10^{-8} average year whereas societal risk is about 1.7×10^{-8} average year as you see from this. ladies and gentle men is very interesting and important to know that these plots of risk contour and societal risk plots of FN curve or automatically arrived as an outcome for the software analyzed and used in the study.

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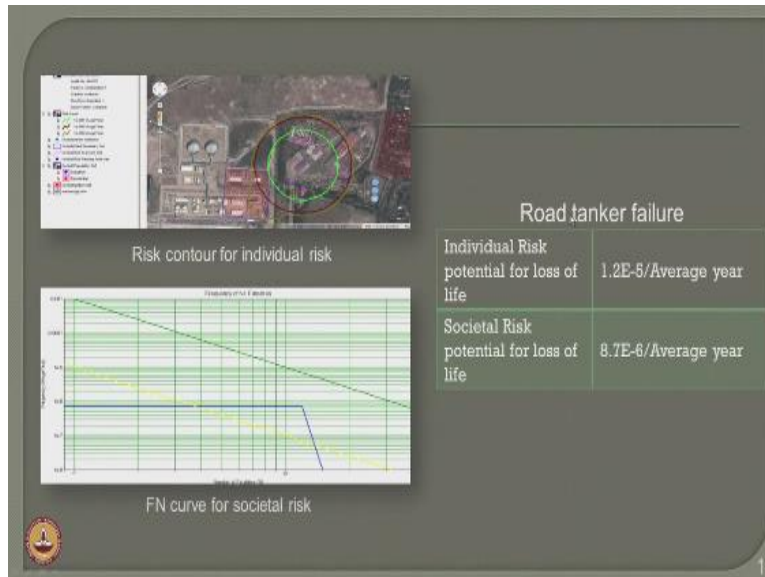
Similarly for a 20% CSA failure with the pipeline from the outlets of the storage bullet individual risk has been seen as about 8.4710^{-9} whereas societal risk is about 5.5610^{-9} where the plots are shown very clearly here for an individual risk and for the societal risk separately.

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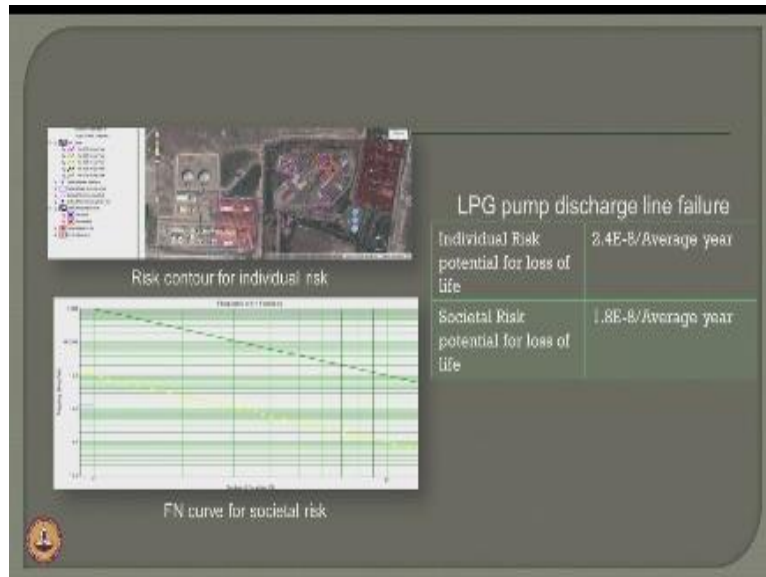
Of course when we look at the catastrophic failure of the storage bullet, now the frequency is higher it has 1.110^{-4} now we are contours mean developed and it is been shown that how the safe hazard distance can be extended circum financially from the epicenter of the failure of a catastrophic failure of the storage bullet. Similarly when we look at the societal risk FN curves you will see there are three plots available one is the yellow one should obviously be between the blue and the green one indicating that it is safe. Whereas in this case you will see it is even mush safer for certain number of fatalities when the frequency is lower.

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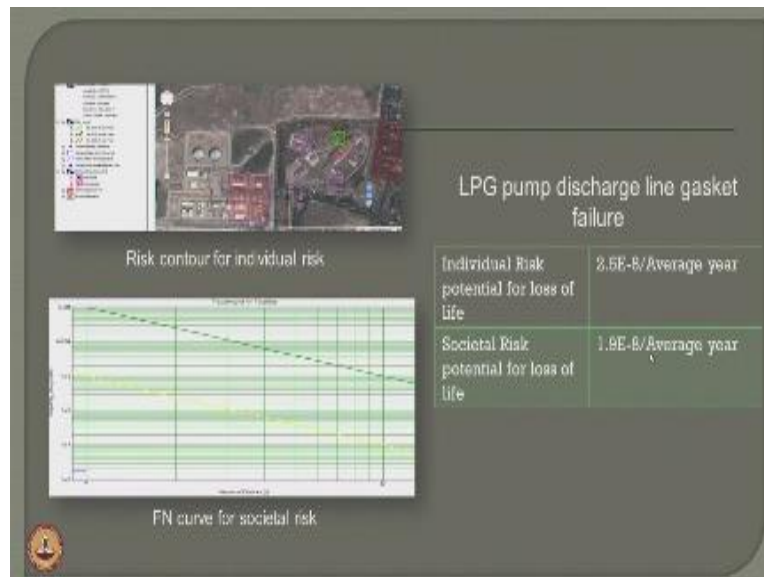
Talking at the road tanker failure this also one of the local failure road the frequency arrived is about $1.2E^{-5}$ for the individual risk where as for societal risk in this as I as $8.7 \cdot 10^{-6}$ for the plot shows very well that it is between the band of acceptable limits on the societal risk and this curves very clearly show from the periphery of the center of the road tank failure the hazard distances which we discuss in the last slides have in plotted graphically from the software directly.

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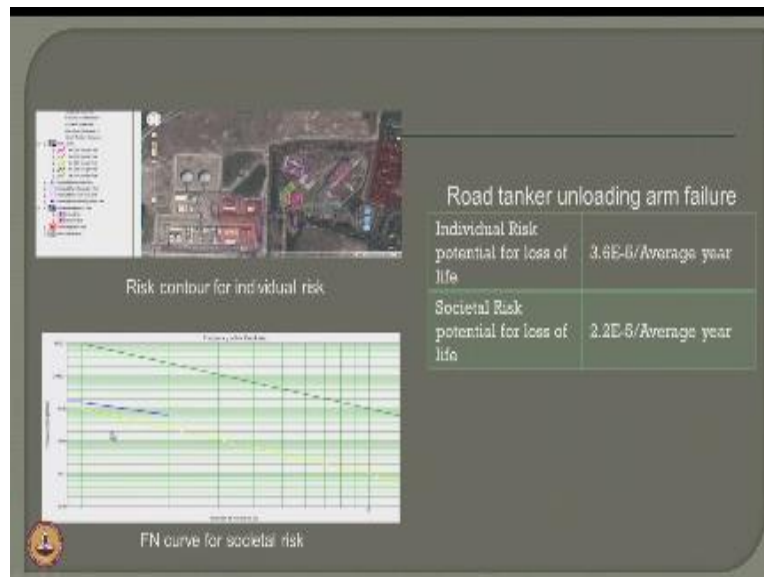
Looking at the LPG pump discharge line failure for ABC plant the individual risk is shown as 2.4×10^{-8} where as the societal risk is about 1.8×10^{-8} is slightly larger compared that or be individual risk in LPG pump discharge line failure.

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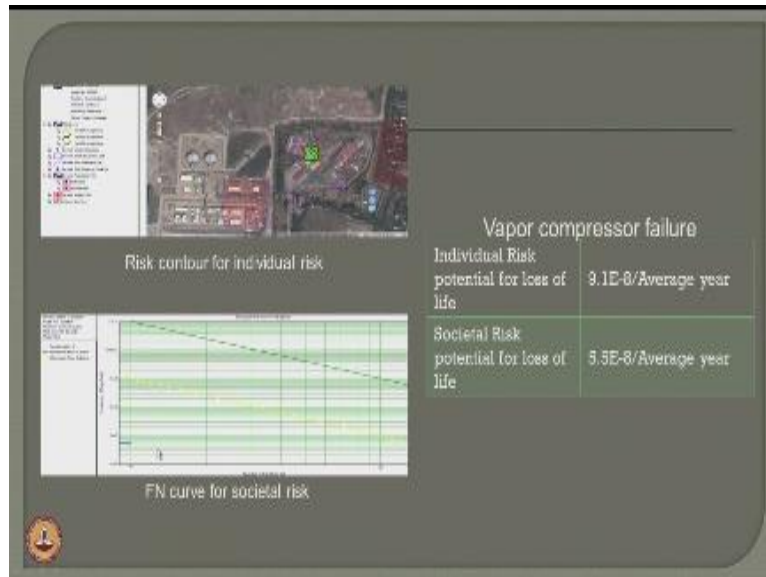
The LPG pump discharge line gasket failure shows an individual risk of about 2.5×10^{-8} it is only seen only in this area and where is the place where the LPG pump discharge is being located in the plant and societal risk is very much within the band down acceptable limits which is 1.9×10^{-8} for average here.

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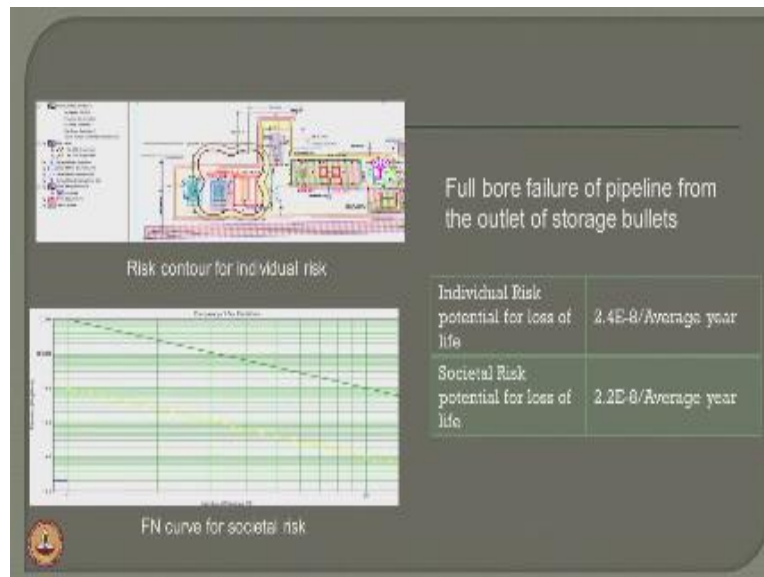
As I told you the road tanker unloading on failure for tanker unloading on is a specific geography glucosion the given plant this is about 3.6×10^{-5} average here there is a societal risk is slightly higher compared to this which is 2.2×10^{-5} it is beyond the boundary of acceptable limits of the risk can flow.

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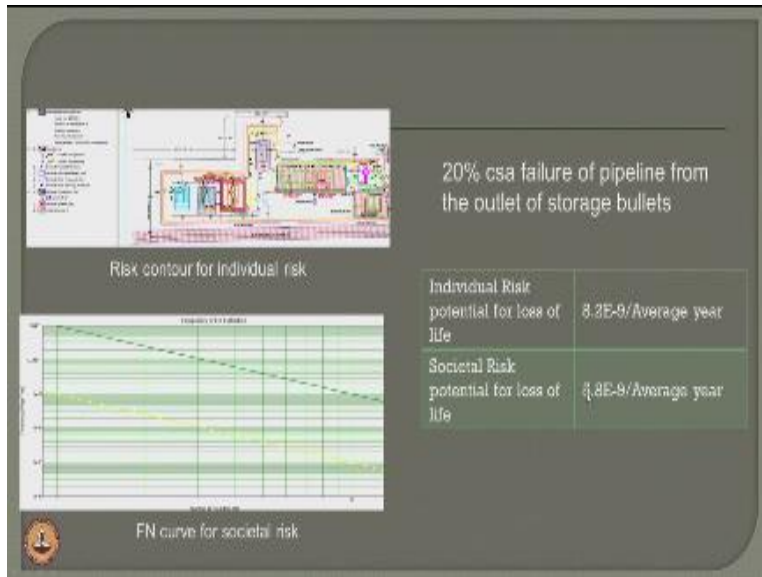
Vapor compression failure which is gain local in a specific point where the fatal has been discharged the frequencies found to be 9.1×10^{-8} compared to the certain risk which is around 5.5×10^{-8} and you can see that the societal risk is again it is in the bands on the acceptable values.

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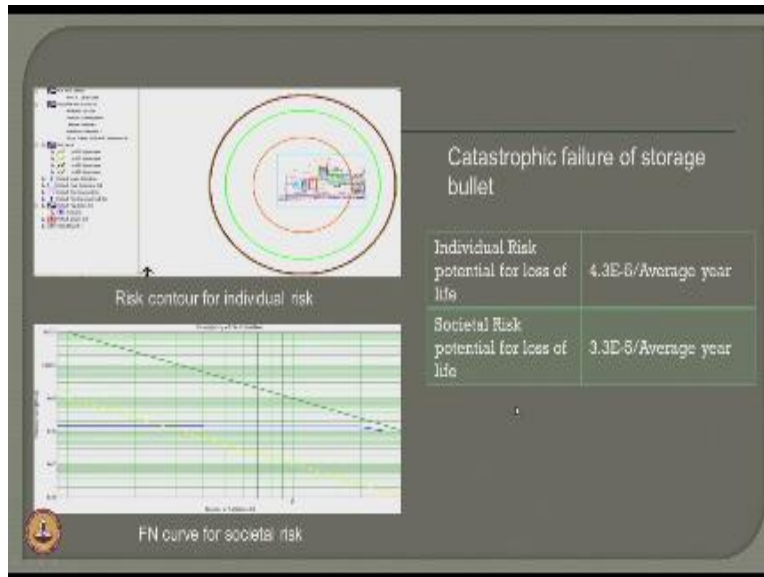
Talk about the full bore failure of the pipeline from the outlet of storage bullets individual risk is focused to get about 2.4×10^{-8} there are societal risk is about 2.2×10^{-8} which is again the acceptable limits of the.

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Oil gas industry when we talk about 20% cost in a failure with the pipeline for the entire layout of the plant individual risk feels to be very high frequency of 8.2×10^{-9} but a societal risk is in the lower frequency how about 5.8×10^{-9} however both of them are within acceptable limits has per the --

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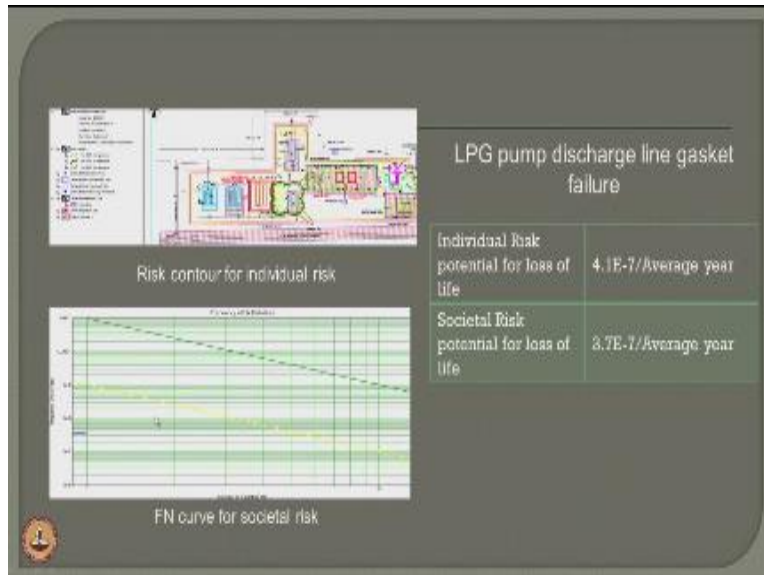
Oh yes 80 standards similarly look at the catastrophic failure in the storage bullet the contrast spherically show that what it is average of about 4.3×10^{-6} – way average here the hazard distance are computed just on the verify or the center of the catastrophic failure gather storage bullet is being parked.

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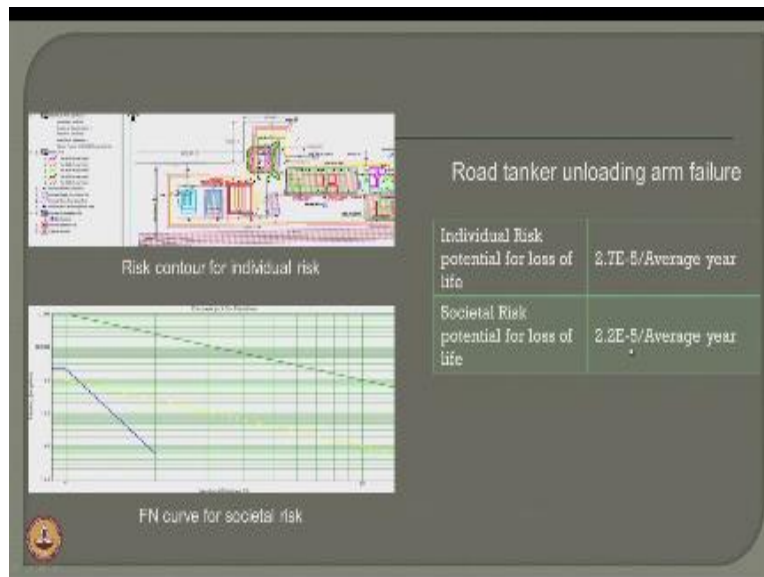
When you talk about road tank failure of XXX model it shows 9.1×10^{-6} and 8.5×10^{-6} respectively for individual and societal risk for the plant.

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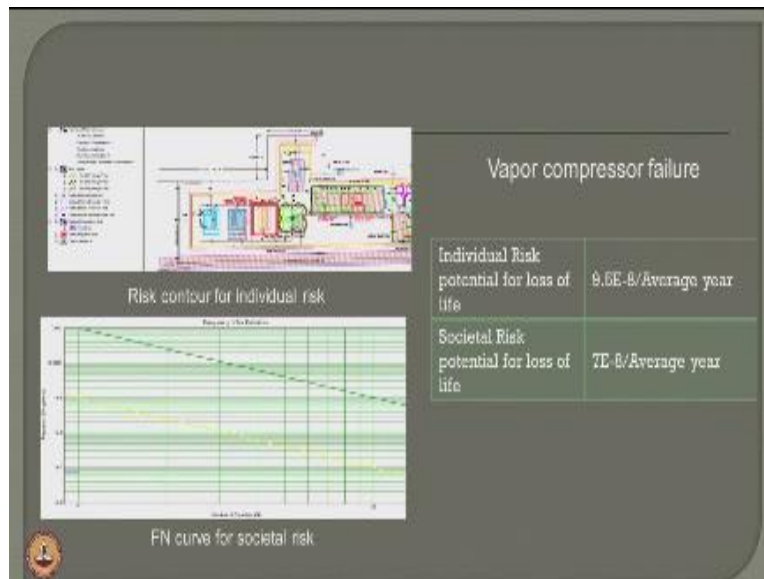
If you talk about LPG pump discharge line failure for xxx plant then again the AP center is shown in different contacts which gives me a value of 5.4×10^{-7} compared that of 4.9×10^{-7} across societal risk we talk about the gasket failure in LPG pump discharge line the frequency that shown in the table and they are much within the acceptable limits of oil stand gas industry standards.

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The road tanker unloading arm failure is a different location compared that ABC plant as got where individual risk of 2.7×10^{-5} which is slide to higher compared the ABC plant where a societal risk is again within the acceptable plants which is around 2.2×10^{-5} .

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The vapor compression failure xxx plan is our high frequency of 9 point fit and 4-8 located on a specific plant were the ferry bullets are parked.

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Sl. No.	Failure Case	ABC plant		XXX plant	
		Individual risk (per average year)	Societal risk (per average year)	Individual risk (per average year)	Societal risk (per average year)
1.	Full bore failure of LPG outlet line of Bulbuls	3.3E-006	1.7E-006	2.4E-006	2.2E-006
2.	20% CSA failure of LPG outlet line of Bulbuls	8.3E-006	3.6E-006	9.2E-009	6.6E-009
3.	Catastrophic failure of storage bulks	1.1E-004	7.4E-006	4.4E-006	3.3E-005
4.	Road tanker failure	1.3E-006	3.7E-006	6.1E-006	6.5E-008
5.	LPG pump discharge line full bore failure	1.7E-006	1.3E-006	5.4E-007	4.9E-007
6.	LPG Pump Outlet Line Gasket failure	2.5E-006	1.9E-006	4.1E-007	3.7E-007
6.	Road Tanker unloading arm failure	3.6E-005	3.3E-005	2.7E-005	3.2E-005
7.	Vapor compression line failure	9.1E-008	5.5E-008	6.9E-008	7E-008

Now let us compare the risk obtain our different failure cases for different plants ABC and XXX as I told you one cannot directly compare the risk constitutively obtain for different plants because the stability class the weather condition the relative humanity etc for or not saying for the two geographical locations of the plants. However for a compared study let us see both of the values simultaneously on the screen for full board failure of an LPG out left line which come from out of the bullets.

You will see that ABC plan shows an individual risk about 2 point fit and 4 – 8 that is societal risk is much higher compare to that of this on the contrary if we look at the triple explains the values are almost comparable and we can drivel inference from here saying that what about the geographic location maybe stability class relative humanity the full more failure is not influence by this conditions in terms of in duel risk as well as for settle risk.

The other comparison we can make is in both the cases the societal risk frequency is much higher compare that of in duel risk in both the locations, similarly for 20% per sections here failure capacity to be failure of the storage bullets road tanker failure LPG pump discharge line failure LPG gas get failure road tank and unknowable non failure and vapor compression line

failure one can prepare and compare the frequencies of individual risk and societal risk as we have spend as an out come from the study from the software.

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Now we take the plan this acceptable risk level in terms of ALARP triangle now ALARP triangle in this example as been used by the Government is given by a HSE UK because based upon existing hazard is industries in UK ALARP triangle is in suggested by HSE UK which is being use for comparison in this present study. Or the values of 10^{-6} and 10^{-4} clearly show the border line of unacceptable and ALARP region. However the values of frequency or below 10^{-6} let us say in most of the cases they are broadly acceptable for oil gas industries.

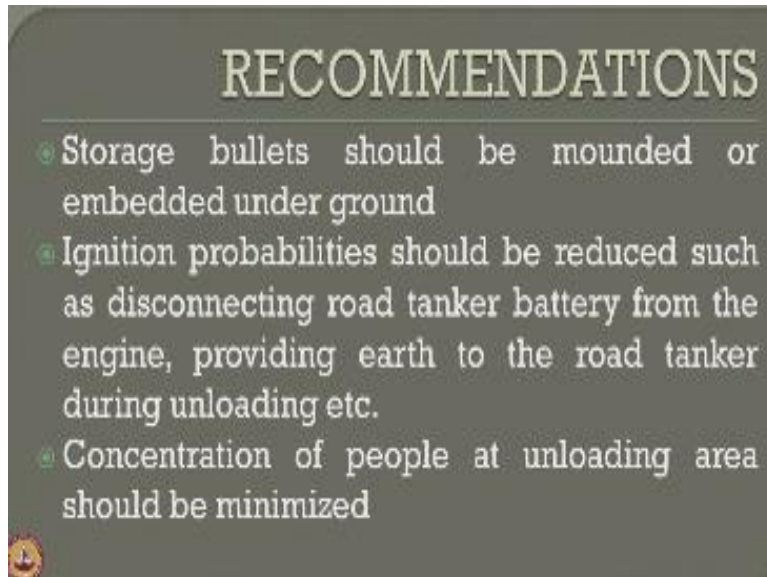
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		Risk			
Sl. No.	Failure Case	ABC plant		XXX plant	
		Individual risk (per average year)	Societal risk (per average year)	Individual risk (per average year)	Societal risk (per average year)
1	Pull back failure of LPG outlet line of Bullets	2.8E-006	1.7E-006	2.4E-006	2.2E-006
2	50% CSA failure of LPG outlet line of Bullets	2.8E-006	5.6E-006	3.2E-006	6.8E-006
3	Capacity failure of storage bullets	1.2E-004	1.4E-003	4.4E-006	3.3E-005
4	Road tanker failure	1.3E-005	6.7E-006	9.1E-006	6.9E-006
5	LPG pump discharge line fail bore failure	2.4E-006	1.8E-006	5.4E-007	4.9E-007
6	LPG Pump Outlet Line Corrosion failure	2.5E-006	1.9E-006	4.1E-007	3.7E-007
7	Road Tanker unloading arm failure	3.6E-005	2.3E-005	2.7E-005	2.2E-005
8	Water streamer line failure	9.1E-008	5.5E-008	9.5E-006	7E-006

So now super imposing the values based upon ALARP acceptance level of HSE UK we see very clearly that the value shown in red and yellow are unacceptable and in ALARP regions respectively however this is border case therefore we put them in red so we clearly understand for an ABC location of the plant the capacity failure for storage a bullets in unacceptable failure however the same failure for a different geographic location becomes an ALARP region.

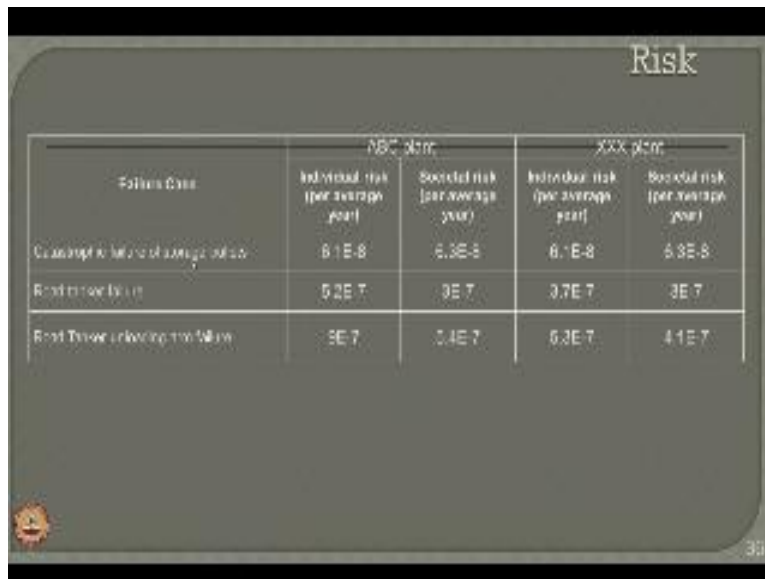
So friends please understand the failure cases and the consequences and the frequency which arrive and ALARP distances are influence by the location and geographic layout of the plant obviously however it is interesting for all of to understand that since this industries have been built maintain properly by OS id standards. You will see most of the cases the frequency of failure are within acceptable limits try ALARP conditions of HSE UK. Accept for a campest to be failure of the storage bullets so based on this study.

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A few recommendations were made to both this plants with a list now the storage bullets should be either mounded or embedded underground, ignition probabilities should be reduce such as disconnecting road tanker battery from the engine providing proper earth in to the road tanker during unloading etc. they should also recommend and we have recommended concentration of people at unloading area to minimize the concentration, so the recommendation implemented.

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Risk

Failure Case	NBC plant		XXX plant	
	Individual risk (per average year)	Societal risk (per average year)	Individual risk (per average year)	Societal risk (per average year)
Case study in terms of average values	$6.1E-8$	$6.3E-6$	$6.1E-8$	$6.3E-6$
Road traffic failure	$5.2E-7$	$3E-7$	$3.7E-7$	$3E-7$
Road Traffic involving the failure	$3E-7$	$1.4E-7$	$5.3E-7$	$4.1E-7$

33

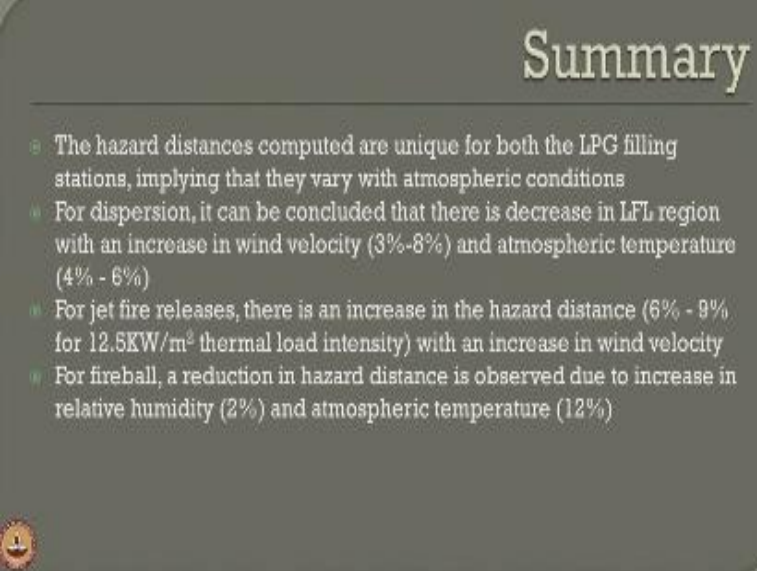
The studies again reconducted an ABC plant an access plant only on those regions where the study was showing alarm and un acceptable for example look at this table.

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Risk					
Sl. No.	Failure Class	400 plant		300 plant	
		Individual risk (per average year)	S societal risk (per average year)	Individual risk (per average year)	S societal risk (per average year)
1	Def. Valve failure of LPG outlet line of Bulb	8.0E-008	1.1E-018	8.4E-008	8.8E-008
2	Def. Valve failure of LPG inlet line of Bulb	8.8E-001	2.8E-019	8.2E-001	5.8E-009
3	Catastrophic failure of storage bulks	1.1E-001	3.8E-001	4.4E-001	3.1E-001
4	Roof failure bulks	1.2E-001	5.1E-001	9.1E-001	8.8E-001
5	LPG gas pipe along low level line bulks	8.4E-008	1.8E-018	9.4E-001	4.9E-007
6	LPG Tank Outlet line Gasometer	8.8E-001	1.8E-001	4.1E-007	5.7E-007
7	Roof failure of loading area bulks	3.6E-001	2.8E-016	9.7E-001	8.8E-001
8	Valve failure of the Bulb	8.1E-008	8.3E-005	9.6E-001	7E-001

Only in this three locations that is catastrophic failure of storage bullets or tanker failure and o tanker un harm failure has indicated an acceptable and unacceptable regions are failure so they have been revised again after recommend is implemented and now they see all of them are coming within acceptable levels so recommendations are implemented and the plant safety has been accenting in terms of its risk to the society as well as individual working in the plant.

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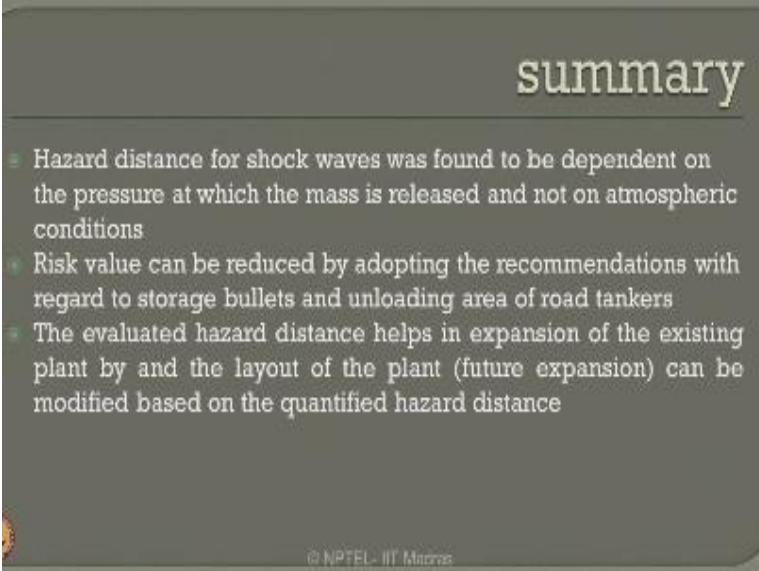
Summary

- The hazard distances computed are unique for both the LPG filling stations, implying that they vary with atmospheric conditions
- For dispersion, it can be concluded that there is decrease in LFL region with an increase in wind velocity (3%-8%) and atmospheric temperature (4% - 6%)
- For jet fire releases, there is an increase in the hazard distance (6% - 9% for 12.5KW/m² thermal load intensity) with an increase in wind velocity
- For fireball, a reduction in hazard distance is observed due to increase in relative humidity (2%) and atmospheric temperature (12%)

Let us look at the summary of the both the lecture quickly the hazard distances computed are unique for the both the LPG stations implying that the vary with atmospheric conditions for dispersion one can conclude that there is a decrease in LFL region with an increase in wind velocity and this variation is about (3-8%) and decrease LFL region with increase in atmospheric temperature which varies above (4-6%)

For jet fire releases there is increase in hazard distance about 10% for a 12.5Kw /m² thermal load intensity with an increase in wind velocity ,we will also see the fire ball a reduction in hazard distance is observed with increase in relative humidity ,and this reduction is 2% quantified and for atmosphere temperature variation as high as 12%.

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summary

- Hazard distance for shock waves was found to be dependent on the pressure at which the mass is released and not on atmospheric conditions
- Risk value can be reduced by adopting the recommendations with regard to storage bullets and unloading area of road tankers
- The evaluated hazard distance helps in expansion of the existing plant by and the layout of the plant (future expansion) can be modified based on the quantified hazard distance

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Hazard distances verified for shock waves was found to be dependent on the pressure at which the mass is released and off course they are not dependent on atmospheric conditions at all ,risk value therefore can be reduced by adopting the recommendation with regards to storage bullets and unloading area of road tankers ,the evaluated hazard distance helps in the expansions of the existing plant and the layout of the plant for future expansion therefore modified based on the quantified hazard distances.

(Refer Slide Time: 22:24)

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So ladies and gentlemen the study presented is very interesting and it gives a very well risk picture of two locations LPG stations and off course the study supported by different references which showing now on the screen.

(Refer Slide Time: 22:35)

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And I request that you please go through the lectures one second simultaneously together so that you understand the serious of failures addressed in both the cases of LPG plants located at ABC and XXX you will then understand with easily how interesting infernsis of risk contour social and individual can derived from studies which can easily done using a software in the next lecture I will try to show you an hands of experience on the software so that you can also use the software readily in input data available to you in input industry thank you very much.

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