NPTEL

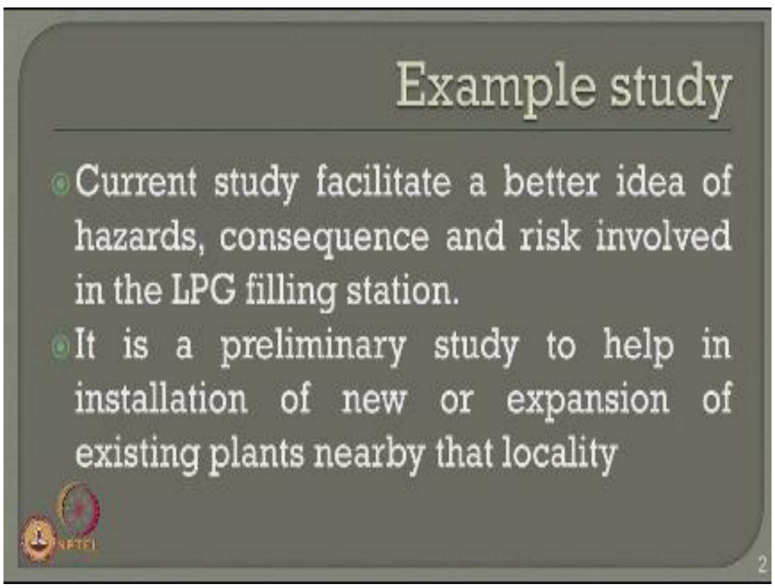
NPTEL ONLINE CERTIFICATION COURSE

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

Module 2:
Accident modeling, Risk assessment & Management
Lecture 5: Accident modeling I

Dear friends normal tool in which is the course and NPTEL IIT Madras we are discussing accident modeling risk assessment and management in this lecture which is the fifth lecture in module two we are going to talk about a case example on accident modeling which is the part of the case study did at IIT Madras.

(Refer Slide Time: 00:38)

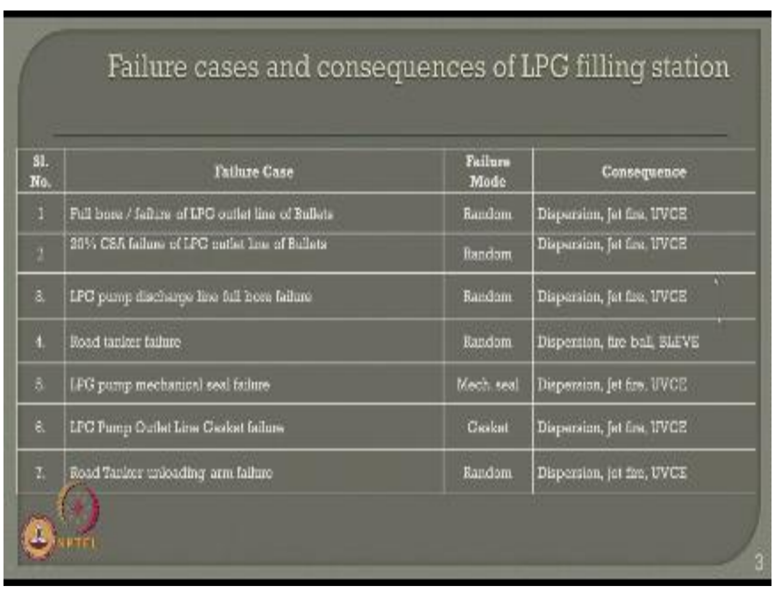


We now pick up an example study and need to understand how the accident modeling convenient is an support of the software I will also show you the steps involved in making a numerical model for gas dispersion release studies as them up till case studies in location given as masked in the study the current study which i show you will facilitate a better idea of hazards consequence of risk assessments involved when an LPG liquid petroleum gas filling station to filling stations are identified the location of these filling stations are masked for strategic reasons.

The study will explain completely how the consequence analysis risk assessment and hazard identification has been carried out in these two filling stations located at different geographic locations in the world it is of course opinion study which will help you to understand the risk assessments involved in the LPG plant the outcome of the study should help installation of new or the expansion of existing plants nearby that locality as we are understand when we compete risk assessment or Hazard identification of consequence analysis the outcome should be understandable to the general public.

So i miss give the societal risk plots and remedial risk plots the economic perception of risk involving an assessment of these kinds of studies are very important in economical perceptive of any oil and gas industry so the outcome of these two case studies which I will show you in consecutive lectures the way people understand how the societal risk individual risk an economic perception of risk assessment and management can be perceived easily using a software.

(Refer Slide Time: 02:35)



Sl. No.	Failure Case	Failure Mode	Consequence
1	Full bore / failure of LPG outlet line of Bullets	Random	Dispersion, Jet fire, UVCE
2	20% 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

As we all know for doing any risk assessment or consequence modeling first step the most difficult step is identifying the failure cases and the corresponding consequences of a given study so the table which is shown in the slide here is the list of possible failure cases and the corresponding consequences of an LPG filling station this table has been prepared after detail site inspection to the side and in consultation with a hazop team and with the plant managers involved in safety and risk assessment of these two plants if you look at the table here seven cases are listed as failure cases.

Which are commonly accepted in the open domain literature forces similar analysis I would urge the participants to refer to the literature review or the papers refer in NPTEL left side of HSE course let us quickly lift up the list of the failure cases fill the rupture or failure of LPG outlet lines of the bullets with a failure where of such bullet failure is usually considered as random failure let us see what will be the consequences if this village rupture or freeway failure happens on the outlet lines.

It can be result on this pressure it can cause Jet fire it can cause vapor cloud explosion I hope all of us understand the important definitions and classifications of these kinds of consequences as applied to gas release models please refer to the previous slides and the lectures given an idea about the definition of these as well as consequences of this as say as they are as applied to any process industry in particular oil and gas industries.

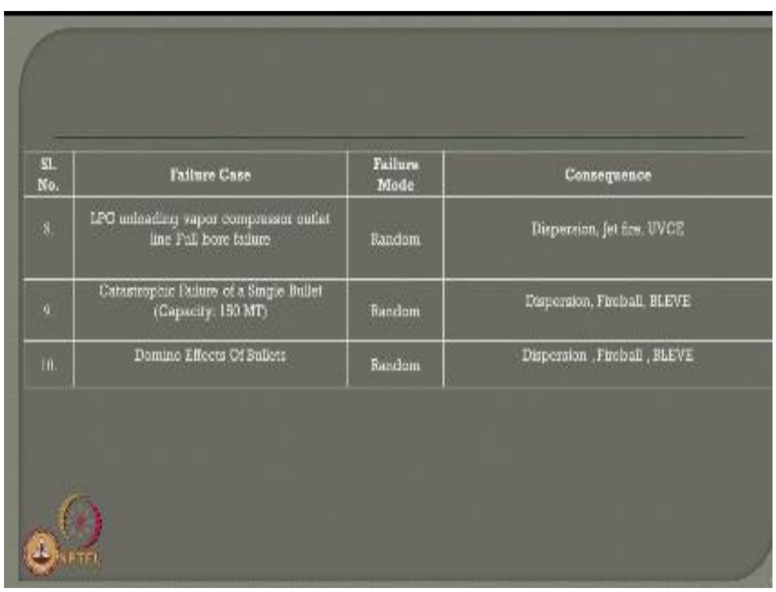
The second failure case which is generally attempted to be done for risk management an assessment in oil gas eight to the stations essentially Is certain percentage of the cross-sectional area field for example rather big diameter pipe but hold on enter pipe may not fail so one cannot leave not assume a freeway rupture but you can always assume we have partial rupture of the pipeline it is a general property of any given pipeline because of it is in effect there can be leaks in the pipeline this leaks will result a local stress concentrations.

Which can expand and start giving rupture in a partial cross section mediate so here example here consider it 20% of the cross section area if it fails what will be the failure mode the failure mode on such cases is unpredictable therefore they are random in nature and it maybe result an again dispersion jet fire and vapor flow explosion you can also say the other failure cases as LPG pump discharge line their failure road tanker failure LPG pump mechanical seal can also fill the LPG pump outline gasket can fail and of course the road tanker unloading on in the case of the station.

Can also fit they say except for one specific case remaining all failure modes are essentially random in nature but for any specific material failure as in the case of a gasket failure so if you have any mechanical component is failure mode is completely attested or attached to the mechanical fault for this specific release alone one can also be an FMEA as we are understand what is the use of FMEA for working components in mechanical aspects pass industry is so one can be in a FMEA and improve the design so that the seal does not fade however if there is a mechanical pump.

Seal failure which happens on LPG pumps then in that case though the failure mode is mechanical however the consequences in all the cases are almost sent.

(Refer Slide Time: 06:34)



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: 150 MT)	Random	Dispersion, Fireball, BLEVE
10.	Domino Effects Of Bullets	Random	Dispersion , Fireball , BLEVE

Further consequences can be LPG unloading vapor compressor outlet catastrophic failure of a single bullet and domain effects of the bullets which is a cascading effect of series or bullets as well understand generally in LPG filling stations you always have series of bullets packed with the required distances and the dykes constructed around these bullets for operational and safety reasons so all the failure modes essentially in LPG stations have been certified and understood and inspected as random failure modes.

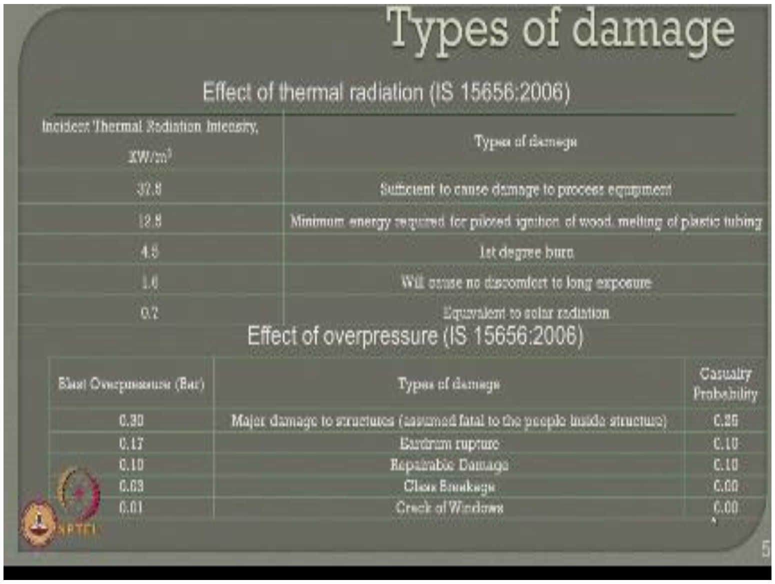
You cannot paid this failure at all in advance and the consequence is essentially can usually be dispersion jet fire or unloading vapor explosion sometimes it can be even a fireball and maybe so we are know the individual definitions of all of these so let us quickly see after listing the causes of failure and then the corresponding consequences of this failure.

(Refer Slide Time: 07:35)

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: 150 MT)	Random	Dispersion, Fireball, BLEVE
10.	Domino Effects Of Bullets	Random	Dispersion , Fireball , BLEVE

Let us go to the next step of risk assessment of the specific station.

(Refer Slide Time: 07:39)

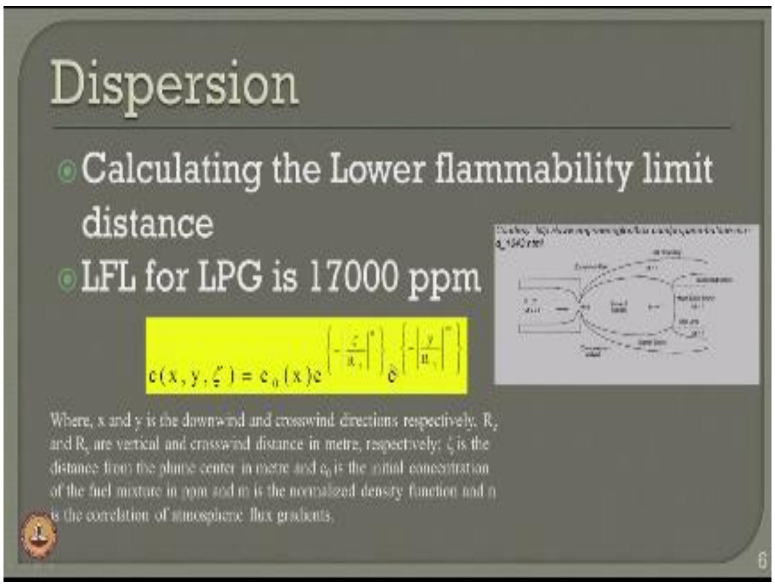


As per the literature one is interested to also identify varieties are types of damage that can be caused in LPG station the moment is type of a damage as per IS 15 656 Indian standard code of practice 2006 there are common types of damage ascertain and recommended for analysis for repair chemical industries one is the effect of thermal radiation in the plant other is effect of over pressure on the plant when we talk about thermal radiation obviously the type of damage will be classified dependent on whether the radiation intensity as we all know radiation has got a major classification of 4.5 12.5 and 37.5 kilo watt per square meter.

However one can also try to find out the effect of as play as thermal radiation intensity varying from point 7 to 1.6 as well it will be the types of damage costs by these kinds of radiation intensities as suggested by Indian code of practice if you have a very high value of variation intensity it can result a type of damages to the complete process equipment whereas then I got a very low thermal radiation intensity it can cause equivalent persuade radiation effect on a given plant similarly the second type of damage identified as a major damage in petrochemical industry is effect of work pressure.

We all not pressure the generally measured in bar so varying from point 3 to 0.01 on the other hand contradictory as well as 0.01 to as I guess point three point lead causing major dimension to the structure whereas point 01 can result in tracking of windows glass breakage etc. Now most importantly what will be the casualty problem will take if this kind of a lower pressure damages on foreseen in the given system so periods send her from practically close to 0 to get of as I as 25%.

(Refer Slide Time: 09:44)



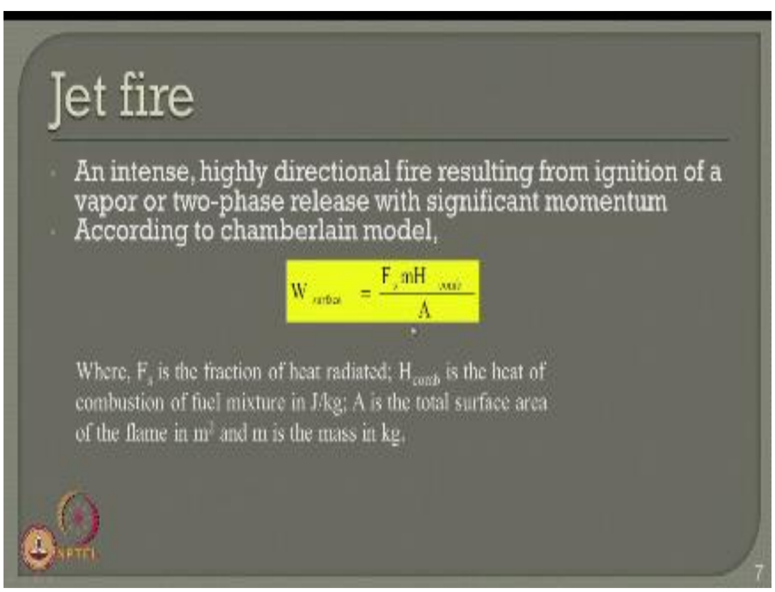
Let us now let discuss about the consequence modeling of the dispersion releases in an LPG plant the fore most part of study will focus on the dispersion release model so when you talk about dispersion release models the first factor is computation of layered flammability limit distance it is the distance within which or divide which the flammability limit will be having a serious consequence on the dispersion release modes so the equations suggested the weather is given here in this case.

The layer flammability limit for LPG is taken as 17,000 parts per million now once you have a value of them very much later than one the expansion fan and the compression waves can result in if no ability level which results in a slip line or reflective chop whereas this is the possibility there the N number goes greater than one where are these the reason where the n number is much better than one if the N number is slightly higher than 1 then we result in a boundary of a different nature.

So we have capture this particular dispersion release we are want the equation suggested by weather which is a function of XY and Z of there X and Y or the download and cross for directions respectively and r0 not why are we are nor Y in this equation of the vertical and the cosmic distances in meters respectively the hazop course is a distance from the plain center in meters and see not his initial concentration of the field mixture in parts per million because the value also available the left in parts familiar whereas the case of the exponential N and N.

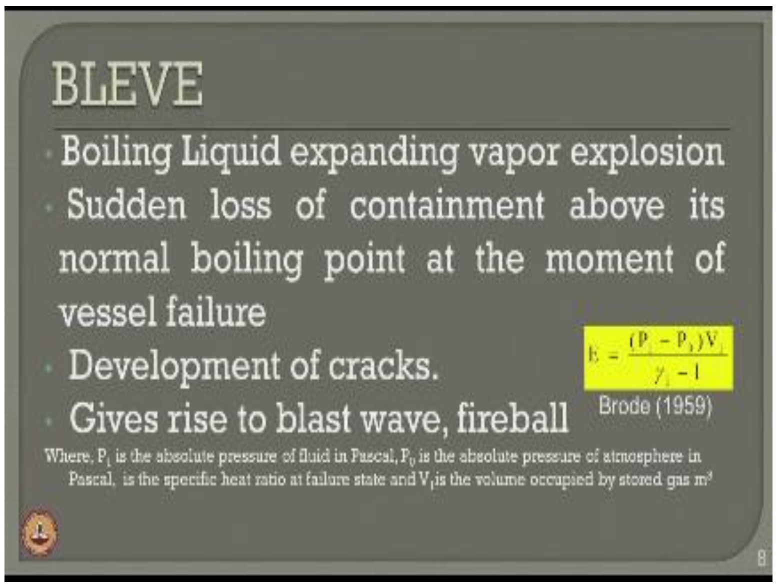
M is the normal density function and N is a correlation of atmospheric flux gradients used in this equation.

(Refer Slide Time: 11:52)



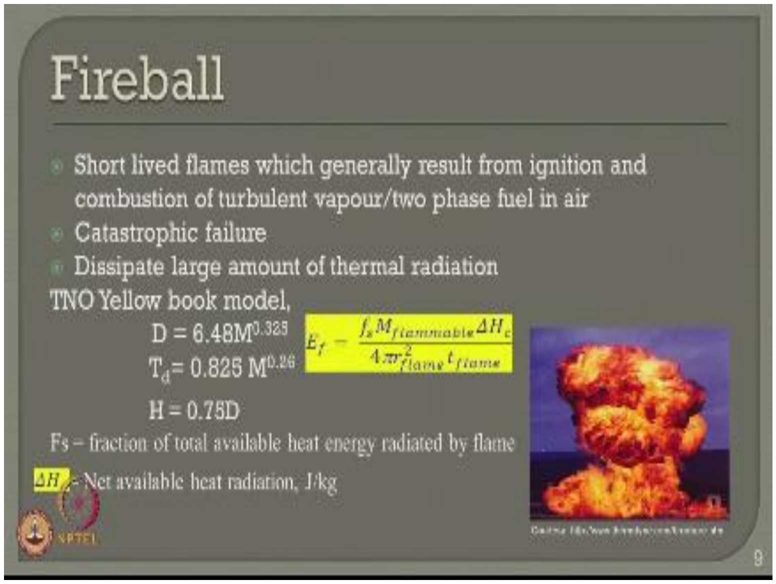
The second consequence would be interestingly focused on jet fire weather there is another outlet as we see this we saw in the last table jet fire is nothing but intense highly directional fire resulting the deviation of a vapor or at a tool phase release with significant momentum according to chamberlain model as suggested below the value can be obtained for Jet fire which is a function of FS which is the fraction of heat radiated H combination is a heat of combustion of fuel mixture induced per kg and ray is a total surface area of the flowing in square meters and M is a mass in kg.

(Refer Slide Time: 12:37)



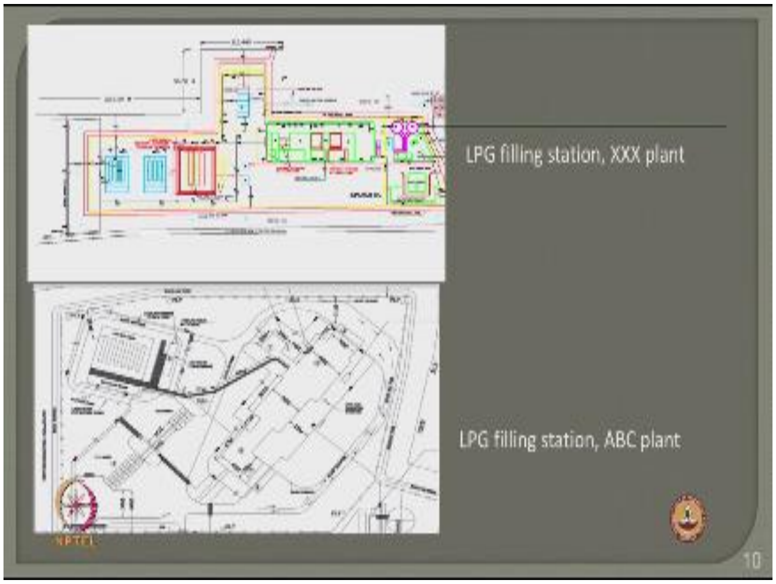
The third consequence as you saw on the table is BLEVE boiling liquid vapor explosion the equation given by bra 17 59 is shown in the right hand side the boiling liquid expanding vapor expression is nothing but a sudden loss of containment away its normal boiling point at the moment of vessel failure it results in development of cracks the energy released is given by the value as you see in the equation with this gives rise to a blast 3 in the fireball in this equation P_1 and p_0 or the absolute pressure fluid in Pascal and absolute pressure of atmosphere in Pascal. V1 is the value occupied by the state gas in kg meter i mean to the specific heat ratio at the failure state.

(Refer Slide Time: 13:21)



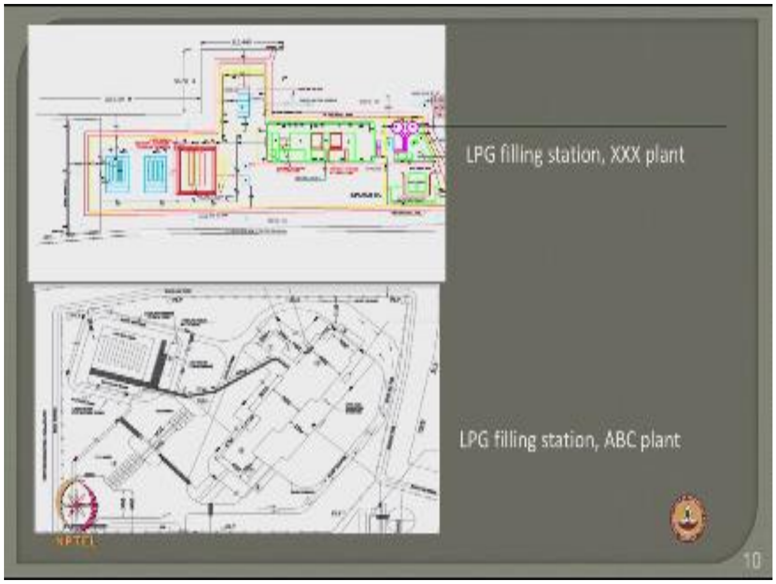
The other consequence in the table of an LPG gas release there is the fireball fire ball acting that short-lived flames this generally result from equation and combustion of turbulent vapor two phase fuel in air it results in a catastrophic failure it dissipates large amount of thermal radiation according to TNO yellow book model the energy released using a fire mod is given by this equation where Fs in the other equation is the fraction of total available heat energy variant by the flame and ΔHC is in it available heat radiation induced per kg in this equation D can be 6.4 again to a power of point 325 whereas DT which is used is $.825M^{26}$ and of course the distance H is given as point 75 D.

(Refer Slide Time: 14:17)



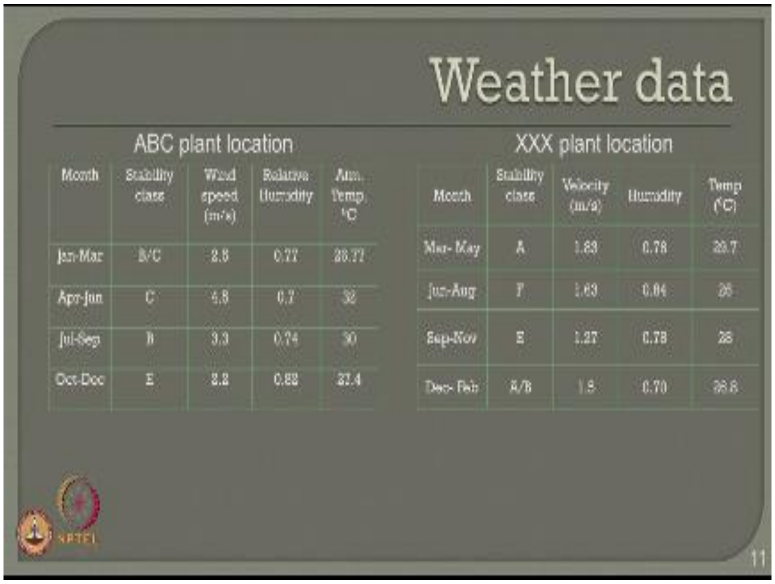
Let us come into the case to the examples which we will discuss in this lecture of partly and then continue in the next lecture they talking about the consequence model and axonal release modeling for two LPG stations located at two different locations but geography conditions and the locations are different so they are masked as XXX plant and ABC plant respectively.

(Refer Slide Time: 14:41)



So the picture that shows you is a layer of the success plant and this is the layout of the LPG filling station at ABC plant.

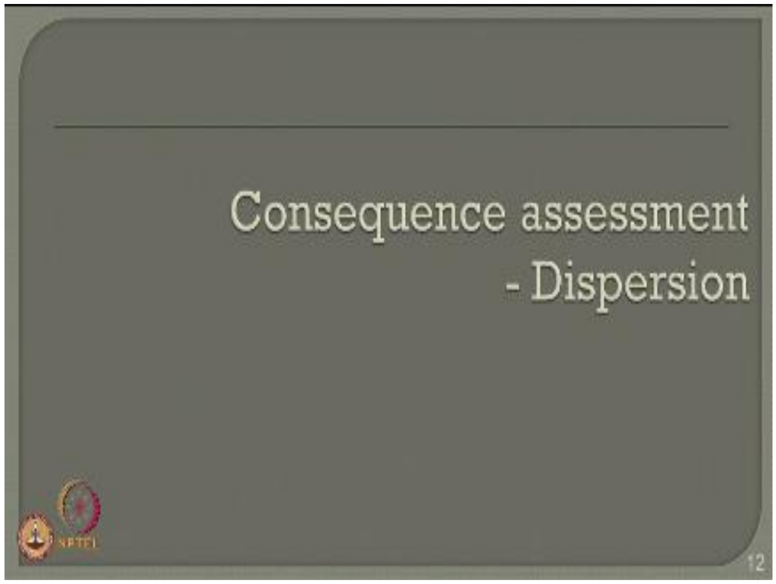
(Refer Slide Time: 14:50)



Whether data place a very important role in accident modeling we look at the weather data of ABC plant right from January till December the stability class asked if I the international standards varies from DC and E depending on stability class that are select the wind speed in meter per second as shown here relative humidity and atmospheric temperature in degree Celsius the same where top parallel is also given for the XXX plant location varying from February till March of the following year after the stability classifies here it varies from A and F which are not present in the ABC plant.

On the other hand the wind velocity the humidity and the temperature variation and of course stability class are different for XXX plant compared with of ABC plant so two different plants are two different geographic locations or consider for the study just to compare the effect of these data on the final outcome of the study.

(Refer Slide Time: 15:58)



Here is no do consequence assessment let us start with doing dispersion release modeling.

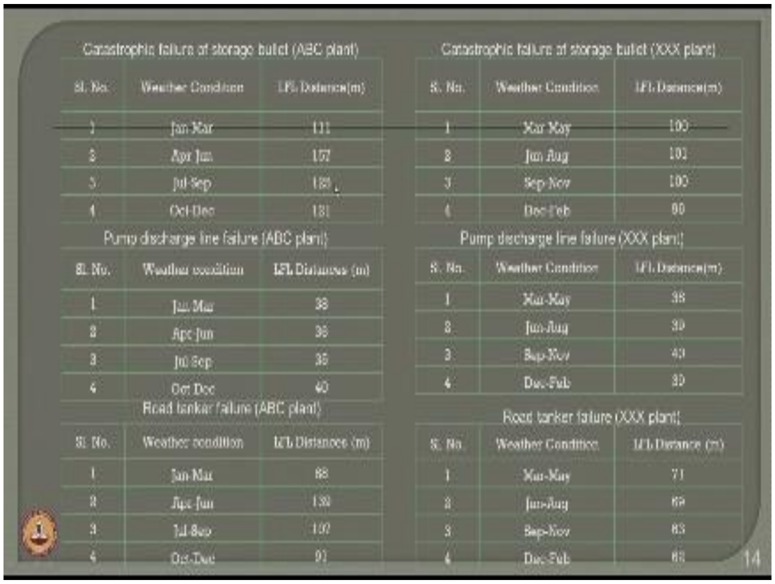
(Refer Slide Time: 16:03)

So it is interesting to know what would be the hazard distance for the layer Florida limit of the LPG as we said these are some of the failure of cases that we identified in the initial table fill they rupture about that line coming from the storage bullet and 20% cross section area failure at the out that line from this storage bullet the left hand side figures are the tables give you for ABC plant and the right hands attributed values are showing for XXX plant for different weather conditions the LFL distances has been worked out from the software model directly for lower limit of LPG gas.

So you can very well see here for different, different locations though the geographic location of where the plants are different that so the way the locations are different however the LFL distances in terms of meters is not varying much for the entire year so therefore the influence of Hazard distance terms of LFL on the dispersion release is marginal comparative the weather conditions or the geographic locations of the plants if you talk about 20% cost section area failure you out that line for the weather conditions selected in the problem.

For two different locations again the influence of the failure from the weather conditions and LFL Hazard distances you again marginal because is more or less same for the entire area for both the plant locations.

(Refer Slide Time: 17:40)



Catastrophic failure of storage bullet (ABC plant)

Sl. No.	Weather Condition	LFL Distance(m)
1	Jan-Mar	111
2	Apr-Jun	157
3	Jul-Sep	181
4	Oct-Dec	131

Catastrophic failure of storage bullet (XXX plant)

S. No.	Weather Condition	LFL Distance(m)
1	Mar-May	100
2	Jun-Aug	101
3	Sep-Nov	100
4	Dec-Feb	90

Pump discharge line failure (ABC plant)

Sl. No.	Weather condition	LFL Distances (m)
1	Jan-Mar	38
2	Apr-Jun	36
3	Jul-Sep	35
4	Oct-Dec	40

Pump discharge line failure (XXX plant)

S. No.	Weather Condition	LFL Distance(m)
1	Mar-May	38
2	Jun-Aug	39
3	Sep-Nov	40
4	Dec-Feb	39

Road tanker failure (ABC plant)

Sl. No.	Weather condition	LFL Distances (m)
1	Jan-Mar	88
2	Apr-Jun	139
3	Jul-Sep	107
4	Oct-Dec	91

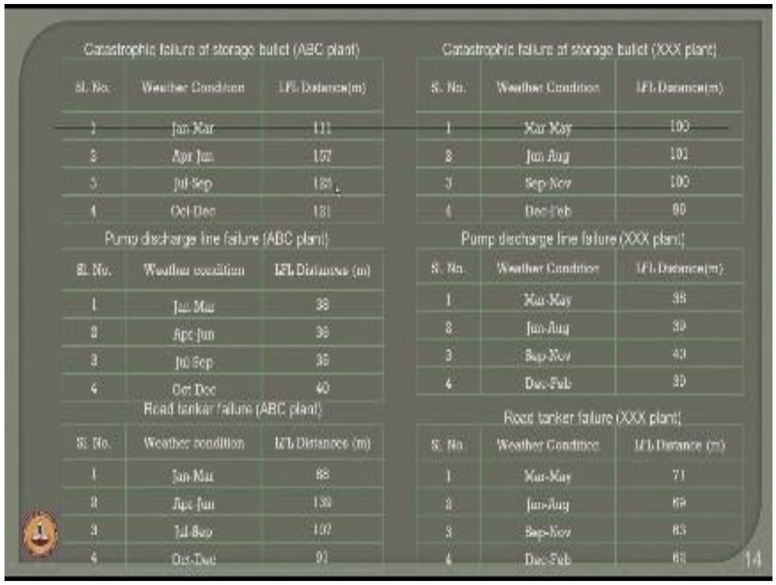
Road tanker failure (XXX plant)

S. No.	Weather Condition	LFL Distance (m)
1	Mar-May	71
2	Jun-Aug	69
3	Sep-Nov	63
4	Dec-Feb	63

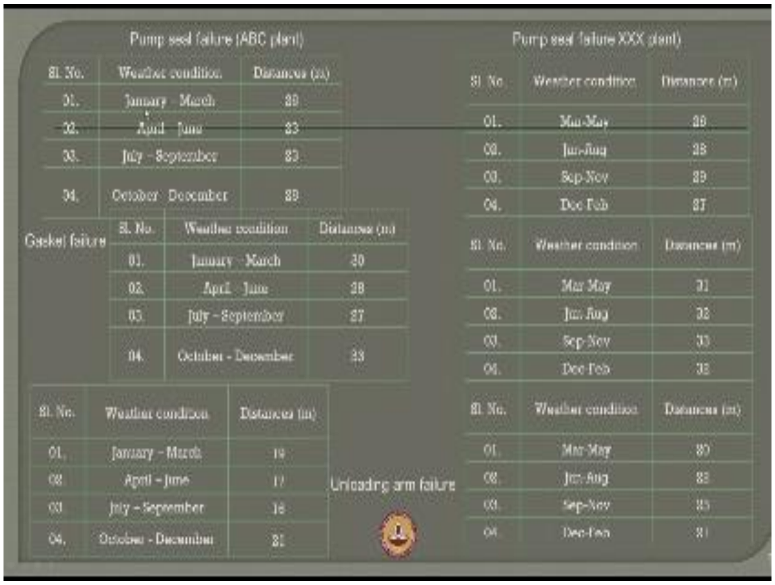
14

Let us lift up the other failure cases nominated in the table earlier we saw catastrophic failure the story bullet pump discharge line failure road tank a failure for the entire area now here the influence of the weather conditions in terms of different types of failure is significant however when the compartment of the different locations accept of our certain period the variation is not significant.

(Refer Slide Time: 18:14)



(Refer Slide Time: 18:14)



Similarly for it as a failure as pumps seal failure gasket failure and unloading on failure my left hand side shows a data for the ABC plant and the right hand shake shows the data for the XX plant for the entire area for the full year period taken for the study however if you look at the influence of different types of failure that arise from the other conditions for the single plant they are significantly different however when they compared them for a specific type of failure for three of the year they related is a different the variation is not very significant.

(Refer Slide Time: 18:53)

Dispersion distances

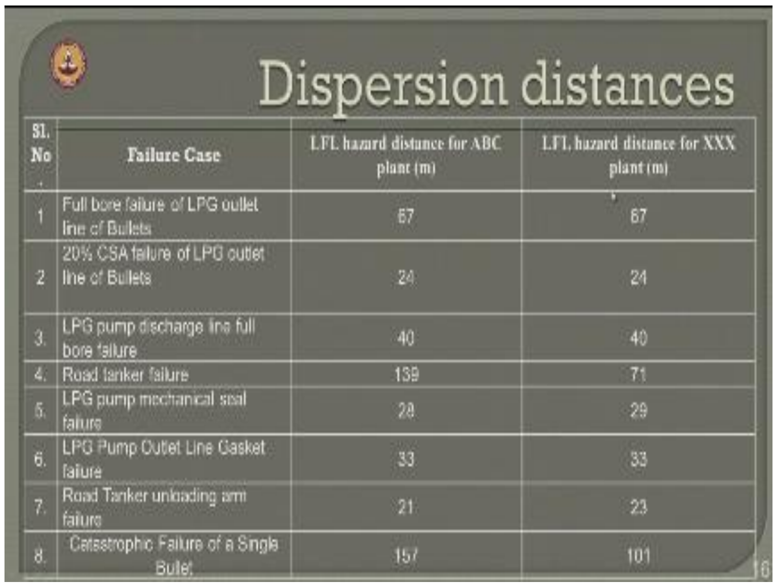
Sl. No.	Failure Case	LFL hazard distance for ABC plant (m)	LFL hazard distance for XXX plant (m)
1	Full bore failure of LPG outlet line of Bullets	67	67
2	20% CSA failure of LPG outlet line of Bullets	24	24
3.	LPG pump discharge line full bore failure	40	40
4.	Road tanker failure	139	71
5.	LPG pump mechanical seal failure	28	29
6.	LPG Pump Outlet Line Gasket failure	33	33
7.	Road Tanker unloading arm failure	21	23
8.	Catastrophic Failure of a Single Bullet	157	101

Based on the dispersion believes LFL distance hazard distances one time to find out what is the dispersion safe distance for a two plants located what we call as layer delimit hazard distance for both the plants ABC and XXX in meters for different types of failure cases identified in the problem we will see that the hazard distance for a specific plan varies significantly it is as play as 20 meter to as high as about 160meters whereas in XXX plant location It is as low as 25 meters or 10 millimeters.

And as high as only 100 meters on the other hand the location of the plant which is influenced by the weather data the stability class and wind velocity and humidity plays a very important role in deriving the safe hazard distance for dispersion release models for a specific plan therefore friends it is very important that the never play two plants located a different geographic locations with different stability class one cannot actually compare the distances in terms of dispersion between the plants located the different geographic locations all other hand FMEA to study.

If I made a study on a specific plan at XXX location you cannot extrapolate the results to a YYY plant is located geographically at a different place because the local stability class the wind velocity humidity temperature influence significantly that dispersion distances that arise from any dispersion release models that is very important therefore the comparison.

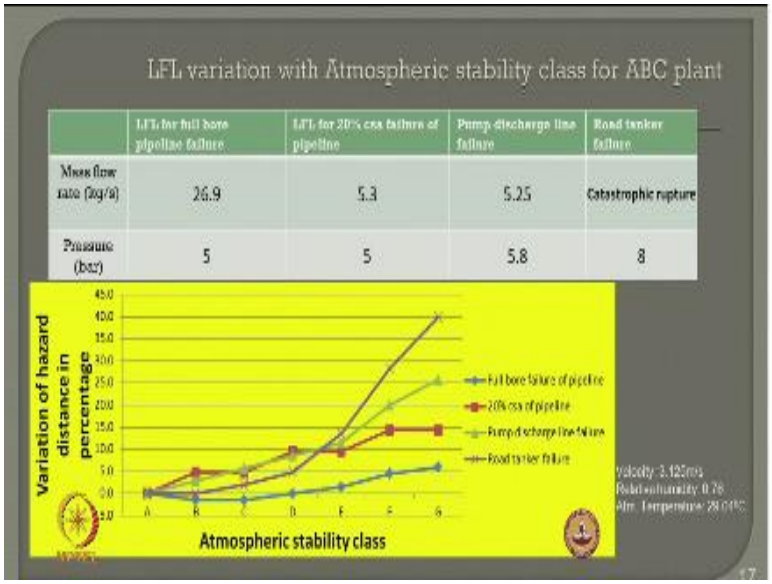
(Refer Slide Time: 20:38)


Dispersion distances

Sl. No.	Failure Case	LFL hazard distance for ABC plant (m)	LFL hazard distance for XXX plant (m)
1	Full bore failure of LPG outlet line of Bullets	67	67
2	20% CSA failure of LPG outlet line of Bullets	24	24
3.	LPG pump discharge line full bore failure	40	40
4.	Road tanker failure	139	71
5.	LPG pump mechanical seal failure	28	29
6.	LPG Pump Outlet Line Gasket failure	33	33
7.	Road Tanker unloading arm failure	21	23
8.	Catastrophic Failure of a Single Bullet	157	101

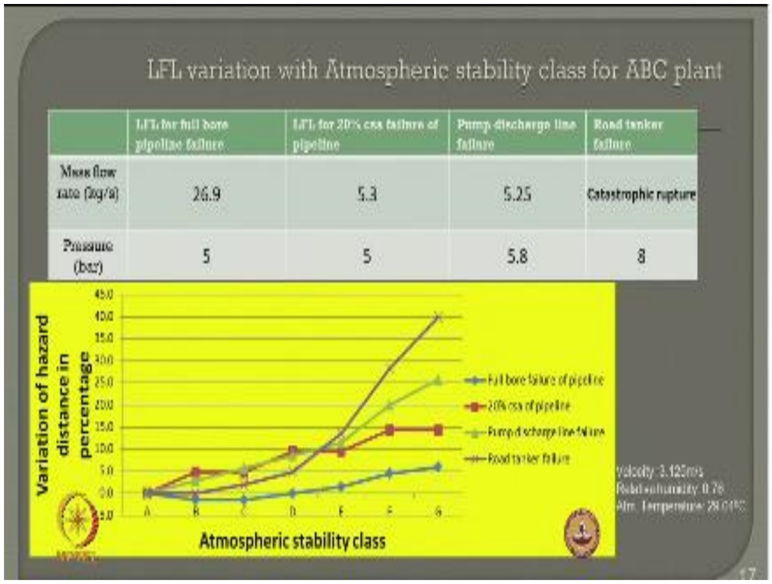
Are extrapolation of these distances done for a one study cannot be interpolated for the next study is very important so if you really want me to do the hazard distance is still late for a specific plant it is always local to the plant it cannot be highly generalized.

(Refer Slide Time: 20:56)



Let us time to see what could be the LFL variation lower formality limit variation the atmospheric stability class for an ABC plant as I told you we will not know compare ABC and x axis for different failures but we have time to see what are the factors that influence the LFL safe distances early within this part CC plant location so if you look at the --

(Refer Slide Time: 21:23)

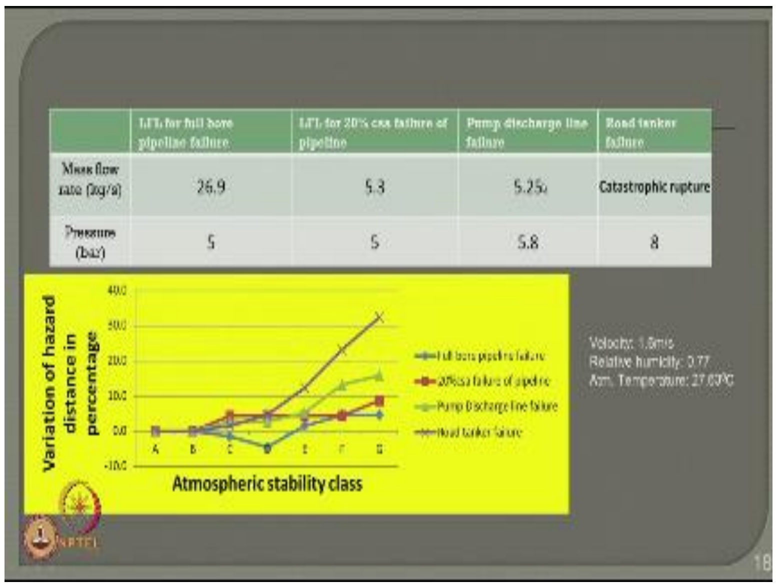


Stability class influence on the LFL variation for a ABC plant location which is also plotted as the atmospheric stability class varies from a range of A to G they stability class of A to G very clearly specifies the disability the humidity the temperature in, in the present study the velocity is taken as 3.125 meter per second rear divinity of point seven six and the atmosphere temperature at the study is conducted is about 29.04C so different legend show different types of failure which are taken as catastrophic or very highly hazard failures for the specific location full be a rupture.

20% cross section area of pipeline and discharged and failure and road tanker failure so in all the cases obviously the failure variation distances in hazop percentage keeps on increasing and the stability class changes from A to G other however in certain ranges we will see they are more or less same so underneath and the stability class influence on the LFL variation for a specific location is and cannot be generalized for all the plants are such in different locations and it possibly important role that the variation of hazard distance is significantly influenced by the bar pressure and of course the mass flow rate which is indicated here.

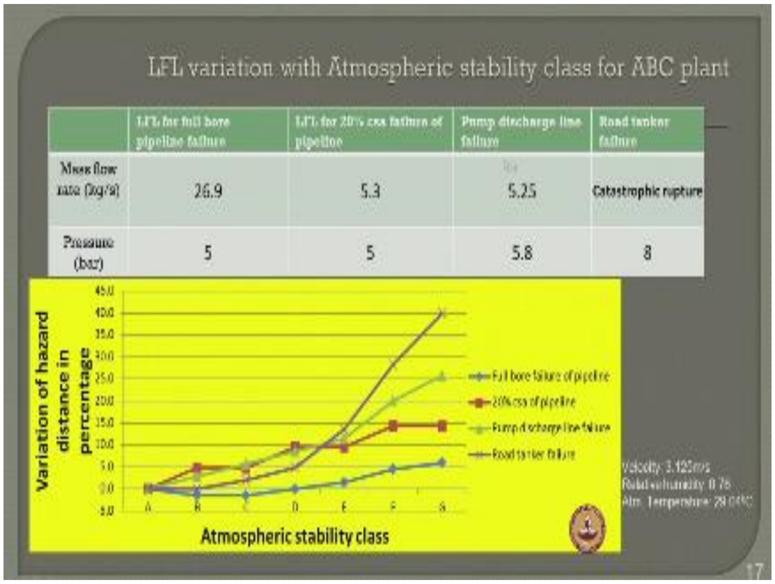
And as we all when the mass flow rate is not in the range of a specific chosen type of failure you cannot compare these modes of failure types or types of failure also for a given stability class but one thing you can learn very clearly where is that the influence and stability class on the variation of hazard distance is significant for certain stability classes it is marginal for certain stability classes.

(Refer Slide Time: 23:20)



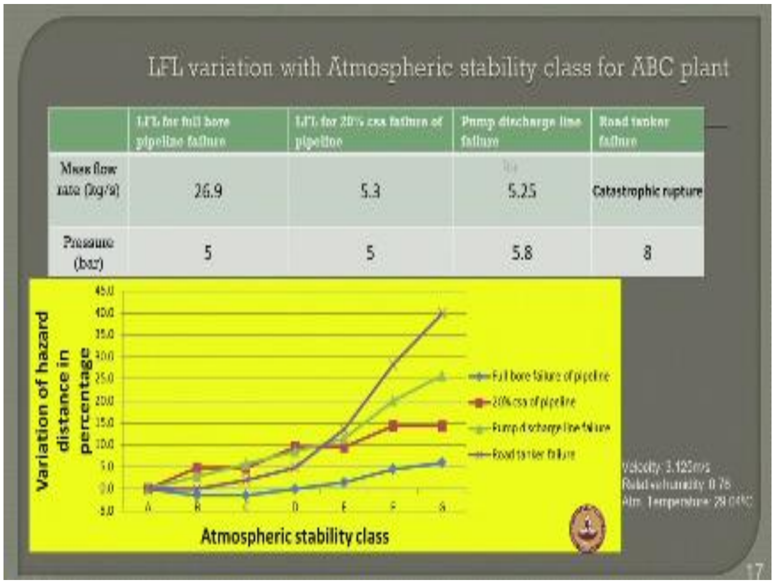
Now the same variation for another plant which is now compile locally in this case deliberately relative humidity and temperature are different from the tub the ABC plant and here also we get the similar significant derive saying that the stability class influences the LFL variation distance for a certain class of stability but certain class does not influence significantly on the other hand the mass flow rate which is considered as free both LFL and pump discharge failure is comparable with that of.

(Refer Slide Time: 23:59)



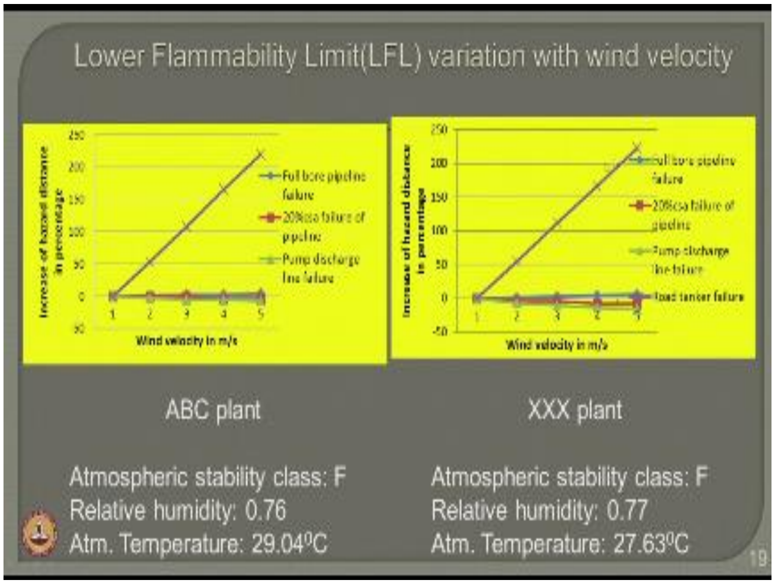
The ABC plant because these values and the pressure are almost.

(Refer Slide Time: 24:03)



Considered to be similar to the way of the plants so for a same mass flow rate for the same pressure variation they are only identifying where the influence on Agnes stability class on the LFL variation and they are understood that depending upon of the ratification of the plant the septal stability class influences the variation hazard distance significantly certain class does not influence the variation of hazard distance in the LFL variation.

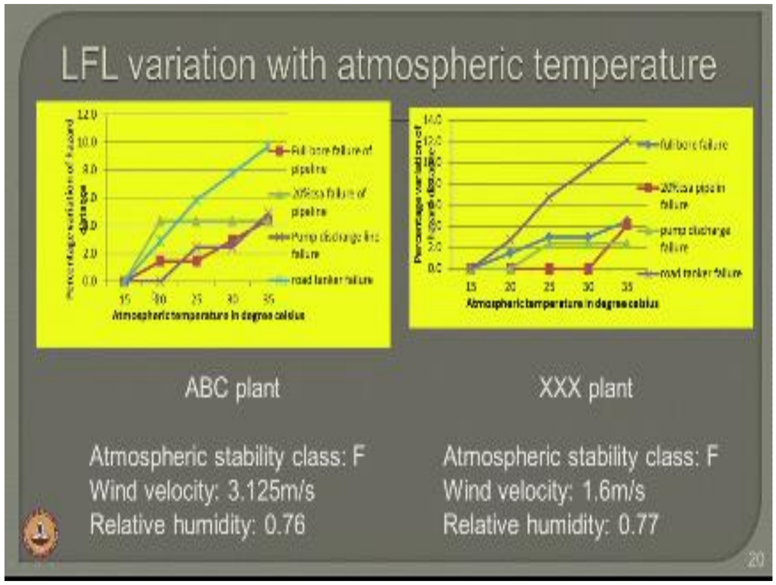
(Refer Slide Time: 24:32)



So let us talk about the second parameter which is a very nasty influence on the LFL variation now in this case the utmost stability class in both the studies are considered to be yes because F seems to be an influence factor for the LFL distance in terms of dispersion of these models for a same humidity temperature almost a divinity of point 76 and 77 but I use the same atmosphere temperature over 29and 27 we have studied the influence of wind velocity on the lower flammability limits variation and we will see that we except for one specific kind of failure which is the road tanker failure.

The influence of other types of failure on the LFL based on wind velocity is not significant so if the beam velocity is changed and furnace facility class of F which is highly influential on the dispersion release models on LFL distances if the road tanker failure is happened to be there which is a catastrophic failure its influence on hazard distance is very high.

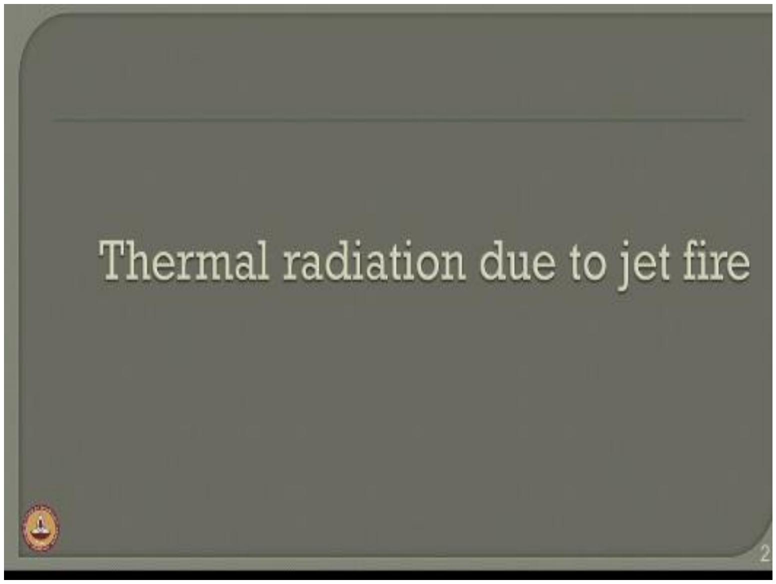
(Refer Slide Time: 25:47)



The next factor consider is the atmosphere temperature in this case again study the class F is maintained wind velocity of 3.1 pay phone in 1.6 were local specification for the given plants and of course rated entities almost same however the atmospheric temperature variation taken from 15 degree Celsius to the tough as I us 30 40 Celsius shows that they also influence even vacantly depending upon the type of failure what you consider however at lower temperatures the variation is not significant that for a higher temperature when it comes to road tank failure except on the temperature significant.

We will also see in case of a 20-% cross section failure area in both the cases the LFL distance more or less becomes constant after specific temperature it means the influence of atmosphere temperature for a given stability class for a given velocity in the failure is seems to be twenty percent for section a video of the pipeline it is not influence beyond may be approximately about 20 degree Celsius.

(Refer Slide Time: 26:53)



The next the lean of study will be on thermal radiation effect which is caused due to jet for.

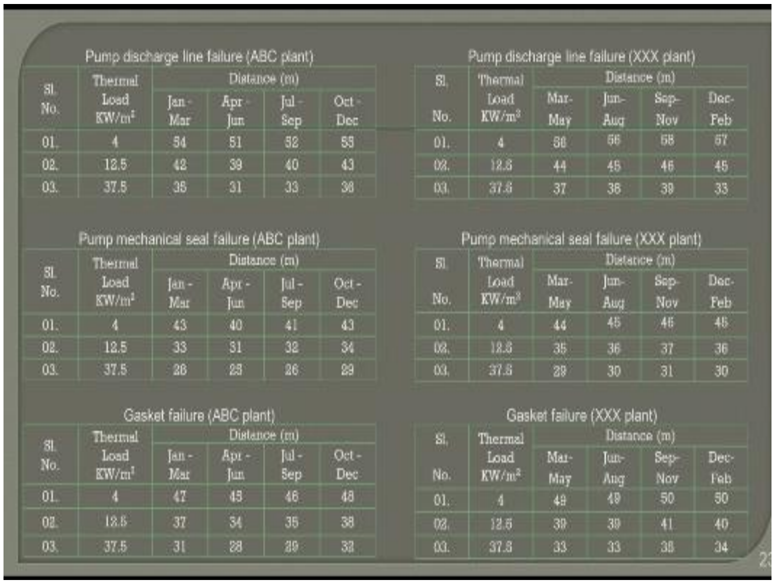
(Refer Slide Time: 27:02)

Now we try to conclude that hazard distances which are caused the affair for two different plant locations ABC an xx plant they have also studied this for different types of failure as identified in the earlier table for your rupture and twenty percent cross section area failure dr. Klein's vary for different thermal intensity however this is shown the table are varying only from three major thermal intensity ratios those are considered as per the international standards so for 12.5 and13 points a kilo watts per meter are the thermal of considered for analysis and explain the radiation in terms of distances you seem fair throughout the entire here for all the types of failure.

We will also see that the hazard distance cost due to jet fire is highly influenced by the thermal note for the film director compared to the top 20%cross-section failure because here hazard distance is as high as about 90meters whereas in this case it is only updated 40 meters so the influence of hazard distance caused due to jet fire that are the other type of failure also important even for the same thermal load intensity variation as per this is this factor is applicable in other cases also in a different location so there is a relative location changes that.

Influence what we have drawn for the hazop variation in the hazard distance for failure rupture is significant compared to that of the twenty percent or a partial rupture be given pipeline.

(Refer Slide Time: 28:42)



Pump discharge line failure (ABC plant)

Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Jan - Mar	Apr - Jun	Jul - Sep	Oct - Dec
01.	4	54	51	52	55
02.	12.5	42	39	40	43
03.	37.5	35	31	33	36

Pump discharge line failure (XXX plant)

Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	58	56	58	57
02.	12.5	44	45	46	45
03.	37.5	37	36	39	33

Pump mechanical seal failure (ABC plant)

Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Jan - Mar	Apr - Jun	Jul - Sep	Oct - Dec
01.	4	43	40	41	43
02.	12.5	33	31	32	34
03.	37.5	26	25	26	29

Pump mechanical seal failure (XXX plant)

Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	44	45	46	45
02.	12.5	35	36	37	36
03.	37.5	29	30	31	30

Gasket failure (ABC plant)

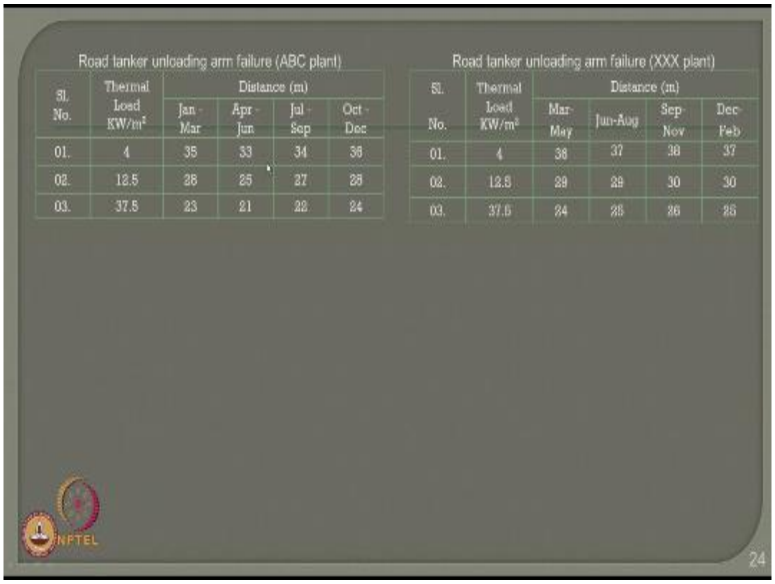
Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Jan - Mar	Apr - Jun	Jul - Sep	Oct - Dec
01.	4	47	45	46	48
02.	12.5	37	34	35	38
03.	37.5	31	28	29	32

Gasket failure (XXX plant)

Sl. No.	Thermal Load KW/m^2	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	49	49	50	50
02.	12.5	39	39	41	40
03.	37.5	33	33	35	34

This is a study you note carried for other types of failure like come discharge from mechanical seal and gasket failure and the results are tabulated.

(Refer Slide Time: 28:54)



Road tanker unloading arm failure (ABC plant)

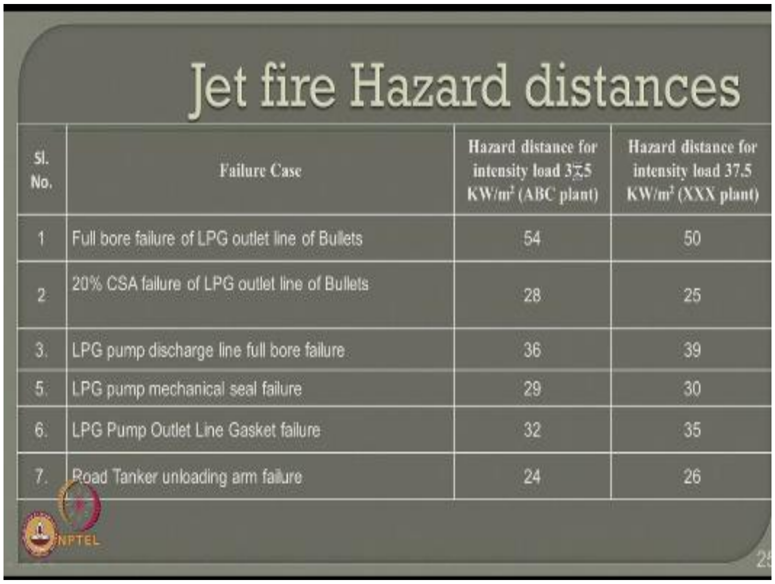
Sl. No.	Thermal Load KW/m²	Distance (m)			
		Jan - Mar	Apr - Jun	Jul - Sep	Oct - Dec
01.	4	35	33	34	36
02.	12.5	28	25	27	28
03.	37.5	23	21	22	24

Road tanker unloading arm failure (XXX plant)

Sl. No.	Thermal Load KW/m²	Distance (m)			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
01.	4	38	37	38	37
02.	12.5	29	29	30	30
03.	37.5	24	25	26	25

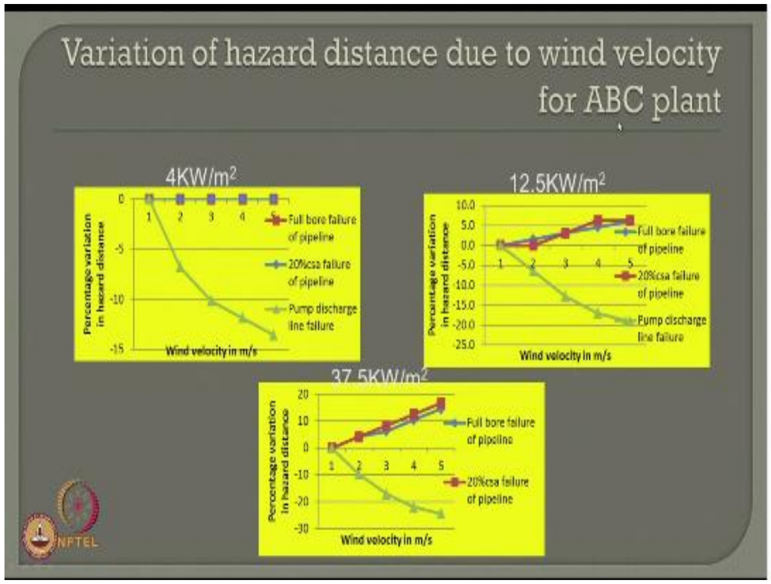
In the slide as shown to you we also study the rectangular unloading on failure and you see that the radiation for different terminate intensity this marginal compared to the top rather freely of cases.

(Refer Slide Time: 29:09)



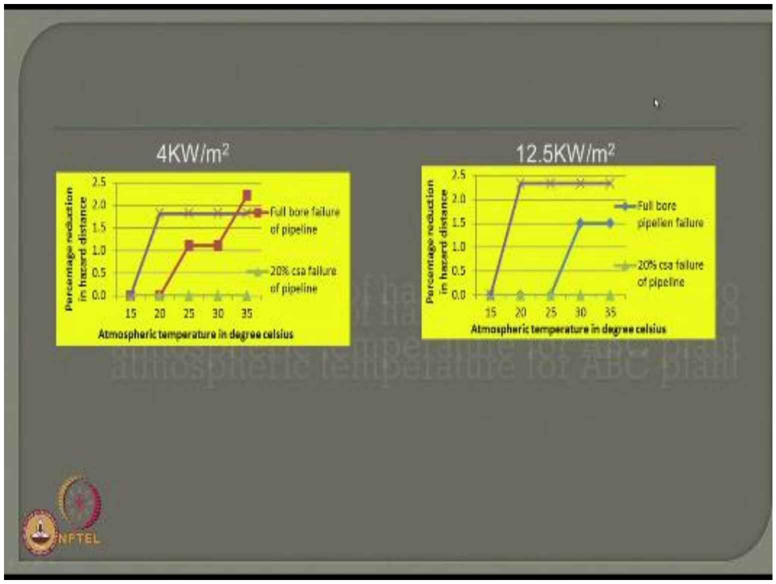
Have to indistinct this they like to complete a hazard distances that arise from the jet failure for different failure cases now that distances thought the maximum thermal air intensity of 13.5 is tabulated here for different plant locations we will see that for a filthy rupture the hazard distance is about 54 or 50 meter respectively but for a road tank on failure there are fifty percent of this approximately so Allah distance is influenced significantly that the type of failure we will do we have time to compare for a specific thermal load intensity concentration.

(Refer Slide Time: 29:50)



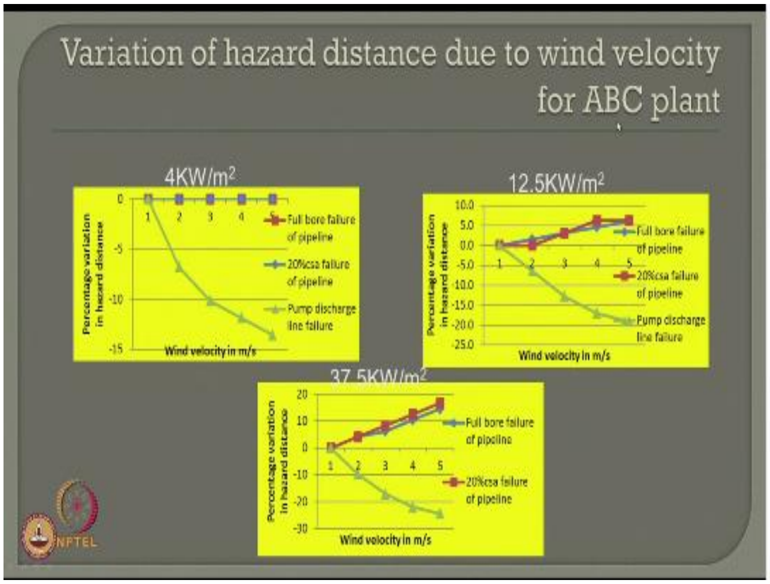
Now you have to also find out the influence on wind velocity on the hazard distance costs by jet fire for different thermal intensity they except for a specific type of discharge failure to respond discharge failure the variation for other types of failure is not significant in all the three cases of thermal load intensity for an ABC plant now has looked at this particular consequence.

(Refer Slide Time: 30:17)



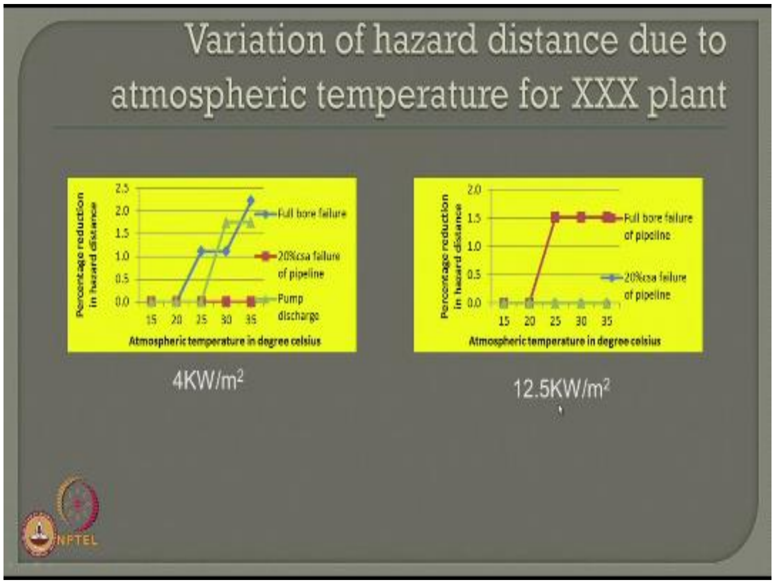
In terms of x axis span it also shows a similar study saying that the pump discharge line failure is significantly influenced by the wind velocity variation for different thermal intensity for that success plant also as compared to the tap ABC plant.

(Refer Slide Time: 30:35)



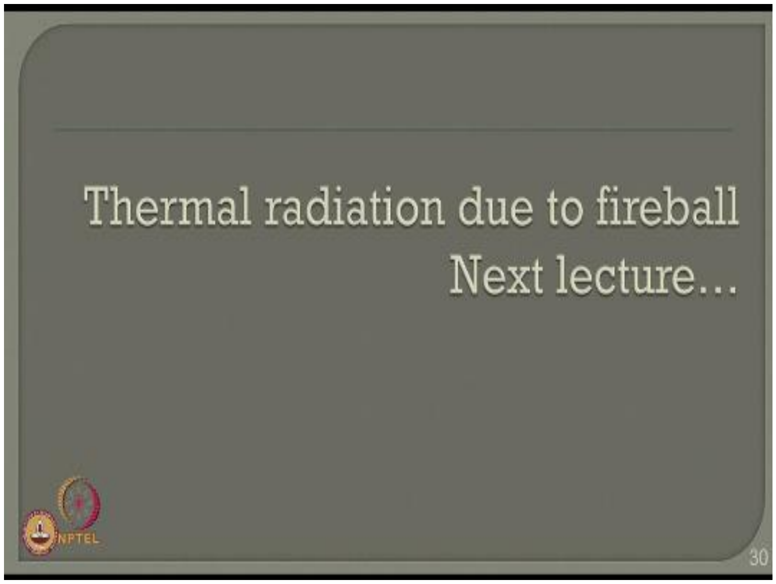
The next can be the variations hazard distance we will atmosphere temperature for a specific wave intensity of flow and 12.5 at an ABC plant it can be very clearly seen thereafter specific temperature of maybe 20identifying the hazard distance practically remains constant but in case of a free day observe the pipeline the guard distance increases further for increase in temperature.

(Refer Slide Time: 31:01)



If you look at the variation at hazard distance in x-axis plan on atmosphere temperature they similarly so seen in the case of a face a plant of course for afraid they rupture the internment intensity of wave value plays another layer which increases the hazard distance after specific temperature which is not seen at higher thermal intensity variations.

(Refer Slide Time: 31:27)



Let us now talk about the thermal radiation effect which is caused due to fire mode which we discussed in the next lecture in this lecture we attempted to show you how the gas release dispersion model can be study for an LPG plant located in two division different geographical location in the we also see what are the factors which influence the hazard distances that caused that this derive from different types of failure is very interesting that how such studies can be mathematically are numerically modern using a software after I complete this presentation I also show you walk through the software which have used for the study which really useful the business any questions please post to NPTEL website thank you very much bye.

Online Video Editing /Post Production

K.R. Mahendra Babu

Soju Francis

S. Pradeepa

S. Subash

Camera

Selvam

Robert Joseph

Karthikeyan

Ramkumar

Ramganesh

Sathiarai

Studio Assistants

Krishnakumar

Linuselvan

Saranraj

Animations

Anushree Santhosh

Pradeep Valan .S. L

NPTEL Web & Faculty Assistance Team

Allen Jacob Dinesh

Bharathi Balaji

Deepa Venkatraman

Dianis Bertin

Gayathri

Gurumoorthi

Jason Prasad

Jayanthi

Kamala Ramakrishanan

Lakshmi Priya

Malarvizhi

Manikandasivam

Mohana Sundari

Muthu Kumaran

Naveen Kumar

Palani

Salomi

Senthil

Sridharan

Suriyakumari

Administrative Assistant

Janakiraman .K.S

Video Producers

K.R. Ravindranath

Kannan Krishnamurty

IIT Madras Production

Funded by

Department of Higher Education

Ministry of Human Resource Development

Government of India

www.nptel.ac.in