

NPTEL

NPTEL ONLINE CERTIFICATION COURSE

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

Module 2:

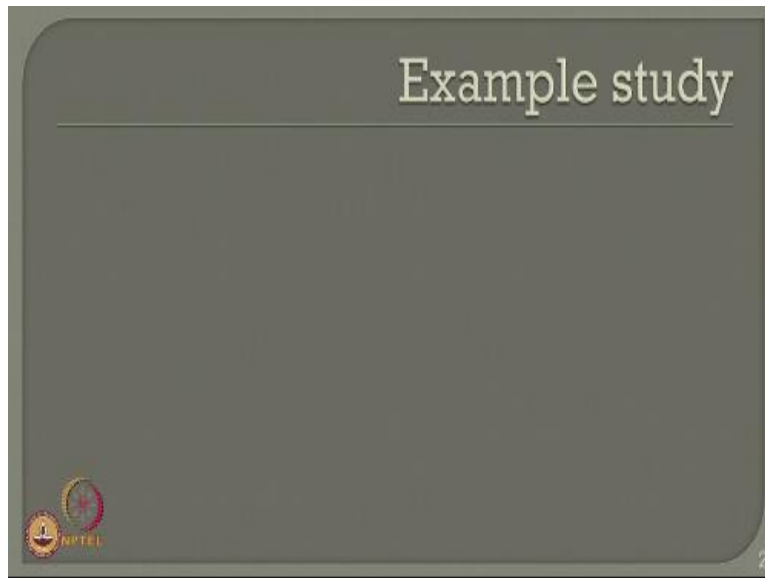
**Accident modeling, Risk assessment &
Management**

Lecture 7:

Software application in Risk assessment

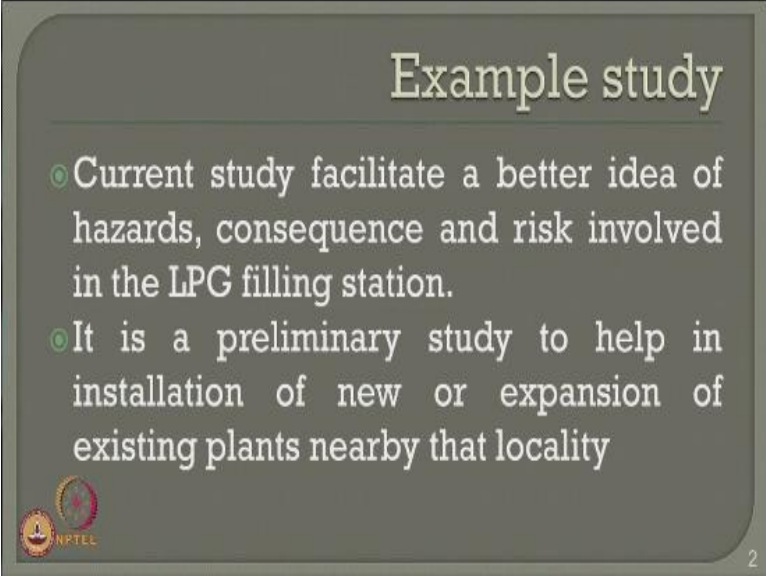
Friends welcome to the 7th lecture on module 2 where we are going to focus on an important software application in risk assessment in offshore and petroleum industries this is a very interesting lecture where you will get a walk through exercise on how to use a software application for quantification risk assessment in a given problem this is under the asepases of module 2 accident modeling risk assessment an management under HSE course organized at NPETL ITT Madras.

(Refer Slide Time: 00:48)



We will solve the same example what we discussed in the previous lectures which is showed you the results but now I will explain you in this presentation how to model that numerically using a software where you will get the same results as we showed in the last lectures.

(Refer Slide Time: 01:06)

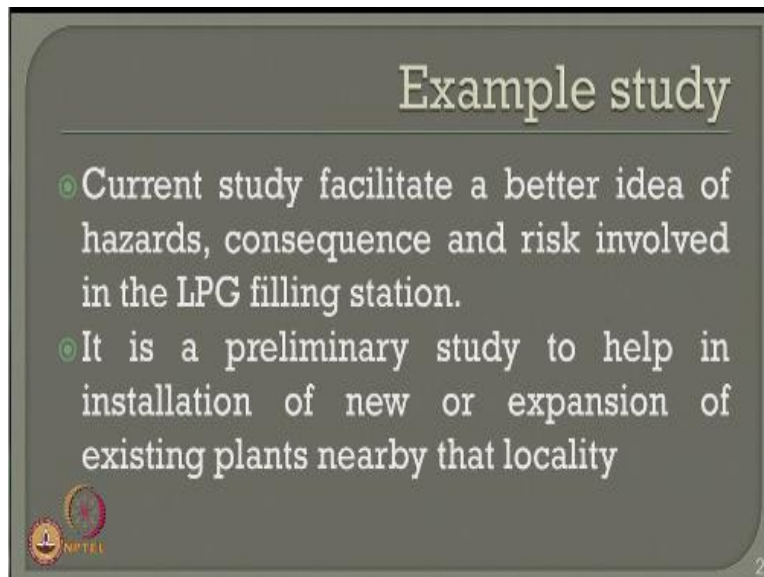


The slide is titled "Example study" in a large, light-colored serif font. Below the title, there are two bullet points, each starting with a small green circle. The first bullet point reads: "Current study facilitate a better idea of hazards, consequence and risk involved in the LPG filling station." The second bullet point reads: "It is a preliminary study to help in installation of new or expansion of existing plants nearby that locality". In the bottom left corner of the slide, there is a small circular logo with the text "NPTEL" below it. In the bottom right corner, there is a small number "2".

- Current study facilitate a better idea of hazards, consequence and risk involved in the LPG filling station.
- It is a preliminary study to help in installation of new or expansion of existing plants nearby that locality

We allow looking at a current study which facilitates a better idea of hazards consequence a risk involved in the specific process industry I have taken LPG filling station as an example case study for this specific lecture. This is of course a preliminary study which will help you to understand the instillation complexities of an existing plant or expanding a new on in case of the plants considering a assists located near by the existing locality of the plant.

(Refer Slide Time: 01:37)



The slide is titled "Example study" and contains two bullet points. In the bottom left corner, there is a logo for "HOTEL" featuring a globe and a building. A small number "2" is visible in the bottom right corner of the slide.

Example study

- Current study facilitate a better idea of hazards, consequence and risk involved in the LPG filling station.
- It is a preliminary study to help in installation of new or expansion of existing plants nearby that locality

Just to recollect what are the different failure case and consequences of an LPG filling station because as we understand now identifying the consequences and HAZID identifying hazards in a given satiation for a process industry is a most difficult task which requires lot of experience and exposes to lot of case studies now let us look at a LPG filling station which we already solved in the last lecture but still we are now looking at the failure cases the failure different failure modes and the corresponding consequences that arise from this failure cases so the failure cases can be fill bore.

Failure of an LPG outlet line which comes from the bullet it can also be 20% cross section area failure of an LPG outer line which is coming from the bullet LPG pump discharge line will have a full bore rupture road tanker failure can be one of the failure cases LPG pump mechanical seal failure can be one example where we can also do an FMEA an FMECA to reduce the probability of this kind of failure LPG pump outlet line gasket failure again an FMEA, FMECA can be again done for identifying the probability of failure of this gasket road tanker unloading arm failure most of these failure cases will result in a common consequences slide disposition, jet fire, vapor cloud exposition, fire ball and BLEVE.

(Refer Slide Time: 03:09)

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




4

We can also look at the unloading vapor compression outlet full bore lecture of the line we can also look at the catastrophic failure of the bullet itself single bullet in our design is consider as 150 MT capacity we can also look at the gasket effect of failure of different bullets in series which we call as domino effects of bullets most of this failure modes as you see in this slide.

(Refer Slide Time: 03:30)

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



3

And the previous slide or random however mechanical seal failure and a gasket can be easily identified using an FMEA or FMECA so the probability of this kind of failure can be reduced so friends we have already discussed this kind of failure cases different failure modes and consequences we discuss this consequences in detail and obtain the results for different consequences for two different plants geographically located in different places depending upon the weather condition stability class, wind velocity, humidity, temp evasion etc. I showed you the results in the last lectures now we will handle the same problem using a software.

(Refer Slide Time: 04:14)


Types of damage

Effect of thermal radiation (IS 15656:2006)

Incident Thermal Radiation Intensity, kW/m^2	Type of damage
37.5	Sufficient to cause damage to process equipment
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing
4.5	1st degree burn
1.0	Will cause no discomfort to long exposure
0.2	Equivalent to solar radiation

Effect of overpressure (IS 15656:2006)

Blast Overpressure (Bar)	Type of damage	Casualty Probability
0.30	Major damage to structures (assumed fatal to the people inside structure)	0.25
0.17	Eardrum rupture	0.10
0.10	Repairable Damage	0.10
0.05	Glass Breakage	0.00
0.01	Crack of Windows	0.00



Before we consider how to model this particular scenario in a software, let us again quickly look at the types of damages which I am looking at, one can also look at the effect of thermal variation as one of the important serious damage in this kind of plants which essentially arise from three cases of radiation intensity which is advised by oil, safety, industrial directed that is 4.5 kilo watt per square meter 12.5 and 37.5 kilo watt per square meter.

So 4.5 can result in the first degree burn whereas 37.5 can result in a sufficient damage to an entire process equipment given in the industry, similarly talk of over pressure effect of over pressure on the plants and equipments and even human body we also see the blast over pressure variation in bar varies from 0.01 which will result in a crack of windows whereas very high value of 0.3 can cause a major damaged to the structural members which can result in fatal to the people inside the structure.

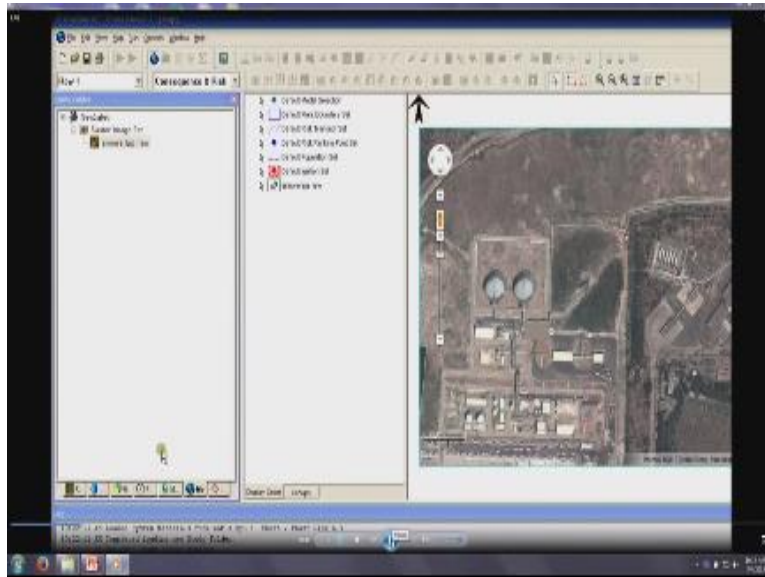
However the casualty of these kinds of events are closer to 0 and above 0.25 this has been absolutely taken from the experiences and the case study is taken for different plants of similar location in the nearby industries. Now once we have identified the causes the types of damages the consequences now I have a enough data to model this in a software and try to find out the

results. Now friends you must understand the essential outcome of QRA in this kind of study or two, one the societal risk which is given in FM curve the individual risk which is given as an elapse triangle or an hazard distance or an hazard envelope. Now let us see whether we are able to get these two outputs for using a software directly.

(Refer Slide Time: 06:07)



(Refer Slide Time: 06:10)



Now let us look at this example where we are talking about a new problem being done in the software which is PHAST RISK 6.0, I want actually plan this specific location off the plant so I select the object or the coordinates as an raster image from a system, I pick up a specific map available in the system, I select the coordinates by which I want to locate it and I also give the east and north coordinate displacements of the system which is entered manually in the system.

The moment they say have a geographic location I have to identify the storage space the storage space is LPG and I given horizontal storage unit as one in number I will also locate the storage center in terms of local coordinates as given from the epi-centre of this problem, I gave a geographic space, once I click this I will able to get the required space the raster image of a plant as you see in the screen now.

So this has been obtained directly from the chosen coordinates from the geometry of a specific plant, once this is done I right now select the material which will involve in the combustion process, I am looking for a mixture material because LPG is a new mixture which is not available in the standard data base, if you can always edit the data base and create your own user friendly data base for the software, so now in this case I am handling this as a new mixture I am

looking for LPG I am giving the bases molar I add the two components of LPG as butane of 0.45 mole amount and the other component is propane of 0.55 mol amount. Then I say flammable toxic and interaction parameters I can always calculate interaction parameter directly.

Now you will see here automatically the interaction parameters like the flammable toxic chemical the molecular weight the reactivity with atmosphere the critical temperature at which this can burn the critical pressure the normal boiling point and melting point are automatically obtained by using this button calculate which is available in the software database. Once this is done I say okay, go back to my weather class default weathers are available in the system as you see here I can say the default weather as it is or I can give a stability class varying from ABCDEF which are now enter.

I pick up a specific class, I can enter the wind velocity speed then say here the wind velocity can be entered manually or can also select a specific stability class as we discussed in the last lecture. So I say stable class here, I calculate the atmosphere parameters substitute our data then I do this for next class stability class D and 1.5 wind velocity. Then I save this as a specific file create a study I insert now different sources of fire like fire ball vessel rupture blavy, jet fire which are supposed to be the consequences which identify in the previous slide in this lecture.

Now for each study for each case I must identify the source for example, let us say where is the vessel located so I picked up a specific geometric coordinate in the given raster image and indicated that once I select that it tells me I want associate this whether specific consequence is it a vessel location is it a fire ball, it is a jet fire clouding, it is an explosion or what are may be the location of the plant. So I must select a specific study case in the job geographic geometry directly from the plant and associate that it is specific kind of consequence.

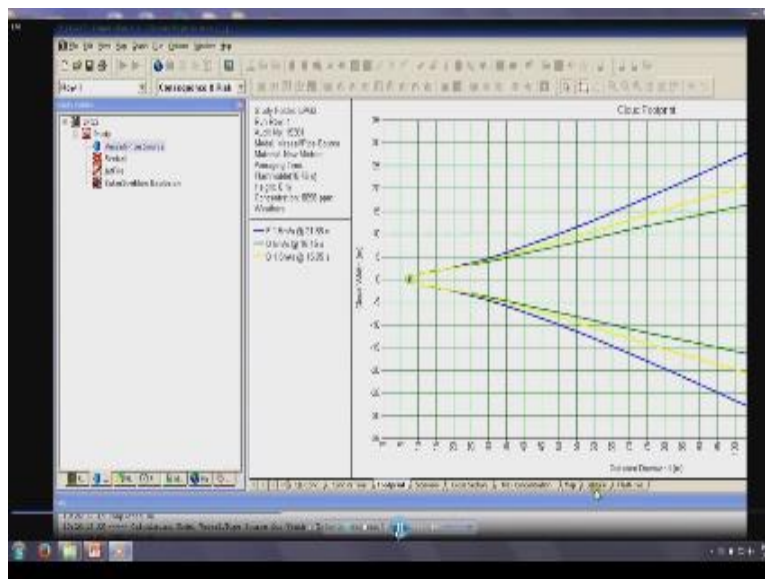
So now I associate this point with the cell rupture, I also show that the explosion can be close designated to this location then I select the mixture again which is the new mixture, which is available in the database picked up the new mixture say okay, enter the mass in terms of participation. Please understand we looking for a vessel which is above 150 matrix tone, so it is 150, 000 kg I have entered then I given the process conditions as statured a liquid and looking at

the cage pressure which is available in my problem, I calculate the risk in terms of even frequency as $1.3E^{-5}$ of course even frequency our specific result rupture depends upon the hazards survey conducted in similar plants elsewhere in a proper location.

So enter the even frequency then look at the scenario the scenario can be what you see here can be a leak, can be a line rupture, can be a catastrophic rupture extra. Now you have different consequences we can select directly, now in this case for example, we have said it is a leak, it is an outdoor release. So takes the whole diameter it is 15 mm for this given problem then look at the vessel tank head and it is 4 meter height look at the location look at the geometry the band data and other parameters which are required was been direction which is horizontal the explosion efficiency of the given mixture and discharge parameter once above this then do the same thing for different consequences then run the case once you run you save it in the specific locations and call that while as LPG 2.

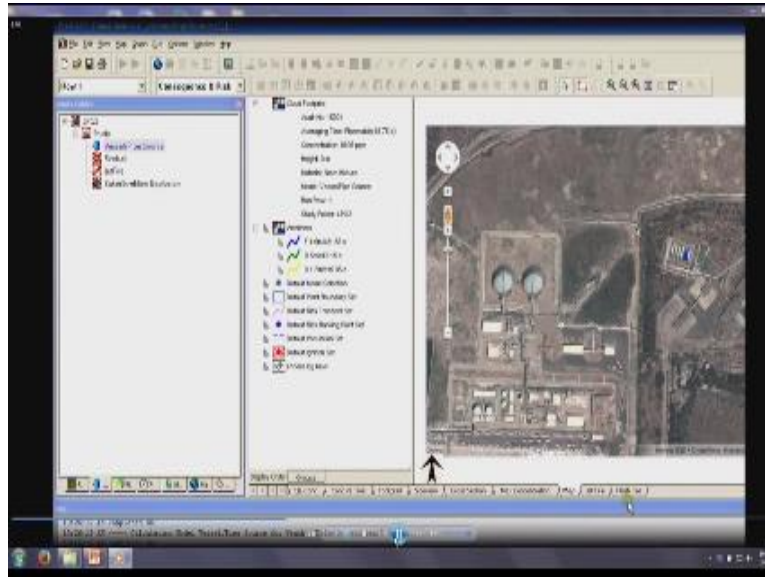
As shown in this example so now it calculates the model vessel 5 sources etc. For a given d class of all find 5 meter/ per second velocity then now select the default weather conditions for calculating risk assessment for this given problem.

(Refer Slide Time: 12:53)



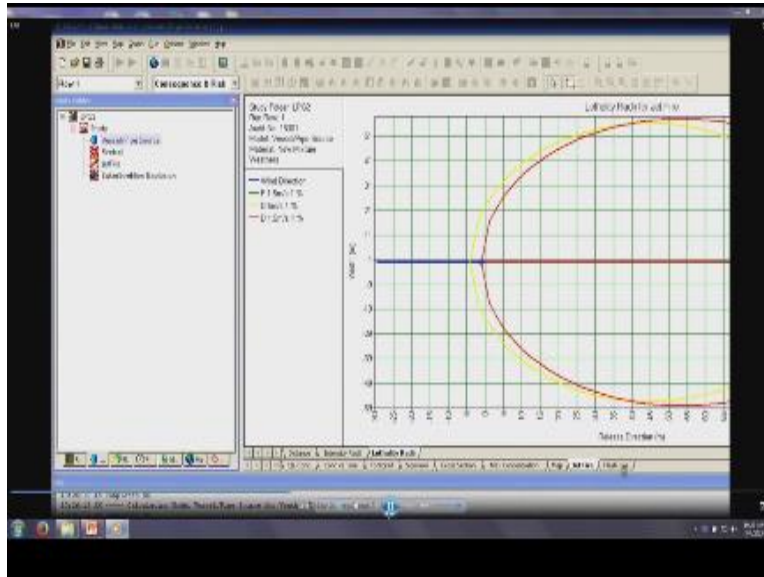
Similarly now the moment you do that you will have to no fix up the central in concentration the distance of the given concentration the fluid enters of the PPM.

(Refer Slide Time: 13:02)



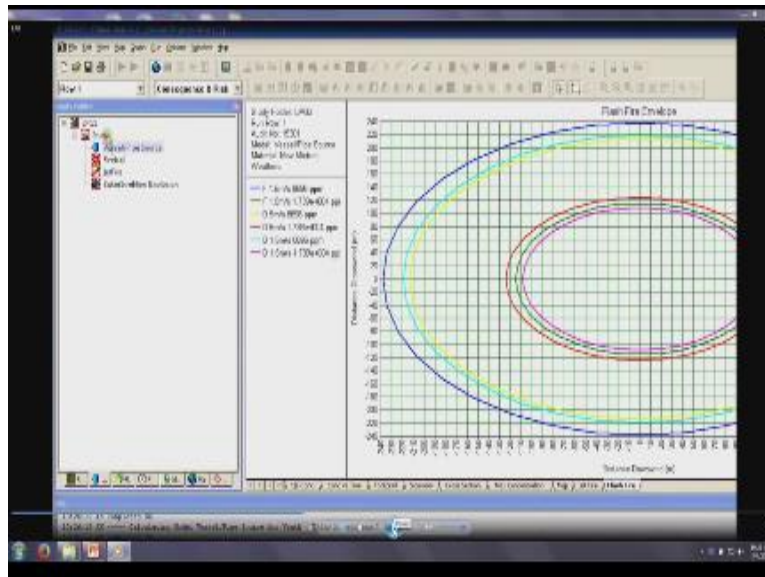
So now you are looking for mapping you select the source in the given field look for the mapping and then show this area where the.

(Refer Slide Time: 13:09)



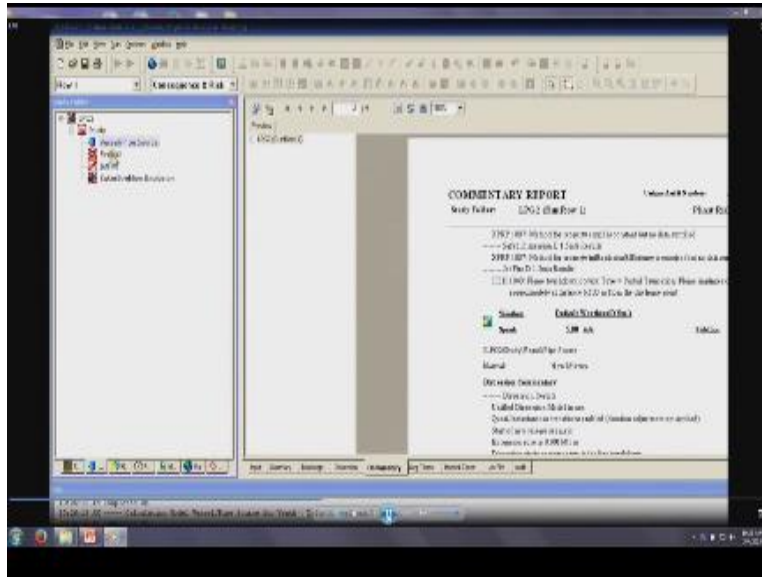
Jet fire will operate so jet fire will have a different radiation density varying from 4 to 37.5 also give the intersecting radii of the jet fire in terms of meters.

(Refer Slide Time: 13:20)



The radiation distance can also give the flash fire envelope for example the flash fire envelope of blue color shows this stability class of F that one part m/ s with 86 96 parts if million participation in a given system whereas the K1 shows their velocity of 1.1 meter per second by the stability class is D for stability class D the humidity and temperature of weather conditions are different than the tough to be class F so once you fix a base it gives me a flash fire envelope from the epicenter after given problem once this is done you select the source.

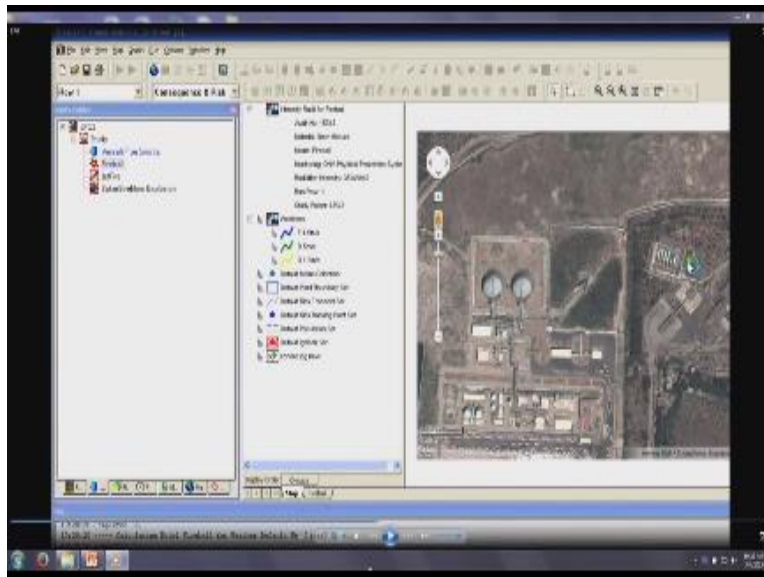
(Refer Slide Time: 14:02)



Save the file create a data which can be also with whatever you have given the data is also available in the text form for your understanding we can also add commentary to this report this report can be printed and submitted for a approval one this is done in four pages in this case then you move on to the next consequence by just fire ball similarly fire ball I want to estimate risk I want to select the mixture again it is anew mixture select the new mixture given the combination separate both pressure.

At least the fire ball can happen enter the even frequency depending up on the experience in case study done intimate the fire ball shape intimate the related mass participation which is 150 tons vapor fraction in terms of this participation identify the geometry for the given problem go to the source.

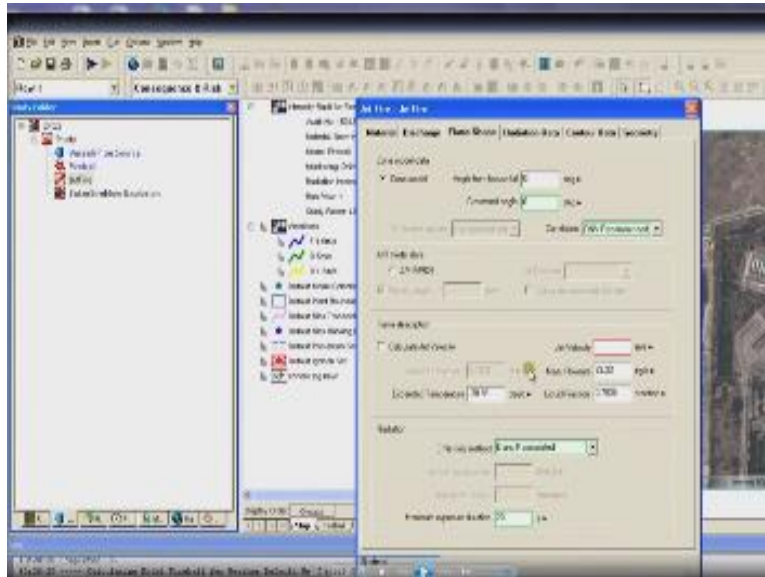
(Refer Slide Time: 15:07)



Take of the geometry from the picture and enter that associated the fire ball run the case save it get there is as for all the other classes of D F and so on now you will see here a counter is plotted for weather conditions for example the blue one is for the weather condition of F 1.2 meter per second the blue one which you can see closer to blue here is again 5.5ms and yellow is further inside and so on for different kinds of this kind of weather conditions be able to get this plot essentially is the fire ball envelope.

Which will get from a given source one you obtain this go for the next consequence with jet fire select the mixture LPG is a new mixture so select the new mixture given the elevation at which is going to happen.

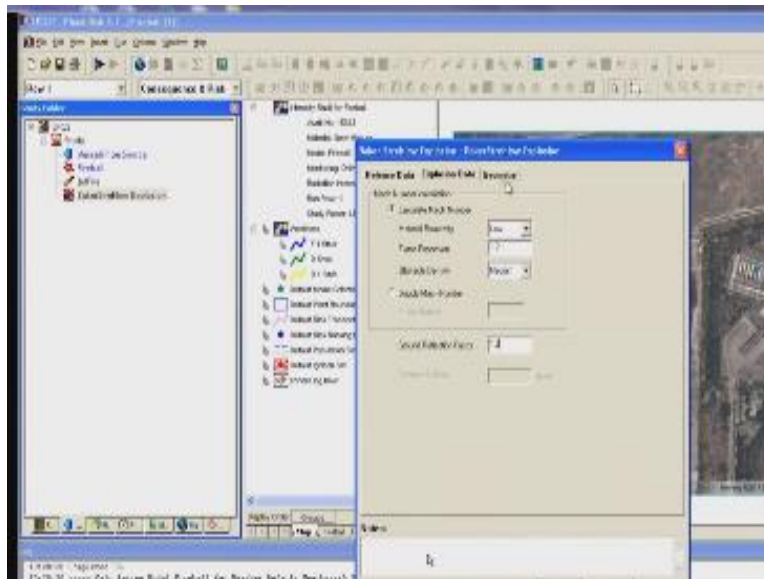
(Refer Slide Time: 16:00)



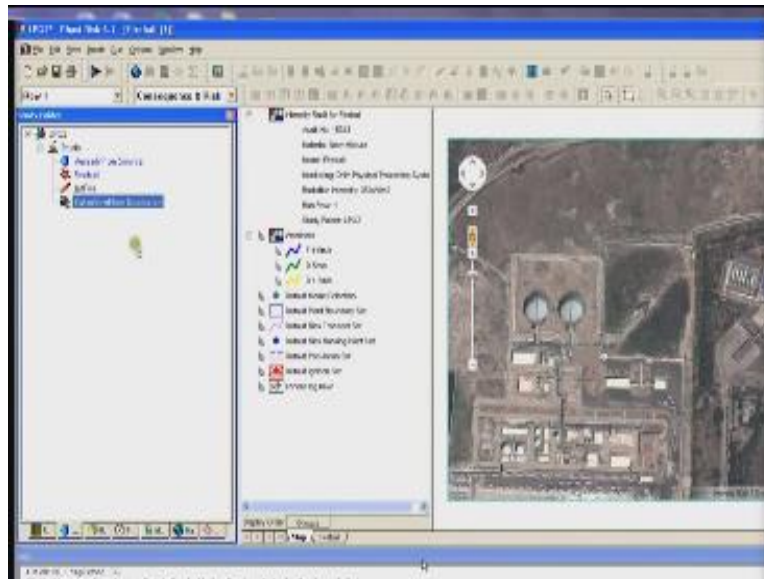
Enter the elevation enter the storage pressure and the temperature depending upon the stability class enter the whole diameter 50mm calculate now it gives me the angle from the horizontal over to enter let us say 0 the wind velocity is approaching horizontal to the particular structure then you enter the z velocity or to calculate this velocity directly enter the radiation data look at the geometry and so on.

Pick up the next explosion go for the new mixture again repeat\eat the same procedure and keep on calculating enter the favorable mass present in clouds participating in this particular problem enter the distance of interest which you want to actually mapped the counter, what is the step size you want to do give the explosion data I can give a mat number or you can calculate the mat number for medium or in this case you do it for low give a flame expansion given the optical density give a ground reflection factor the mat number is automatically calculated say okay.

(Refer Slide Time: 17:09)

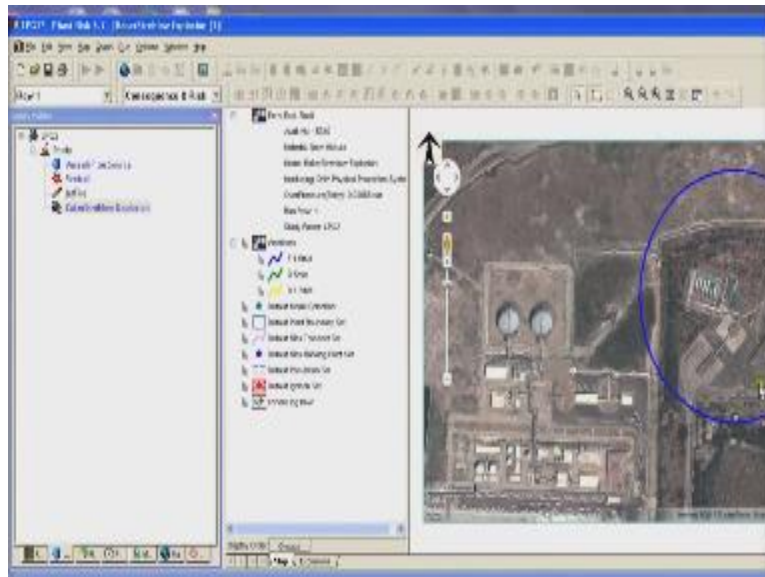


(Refer Slide Time: 17:14)



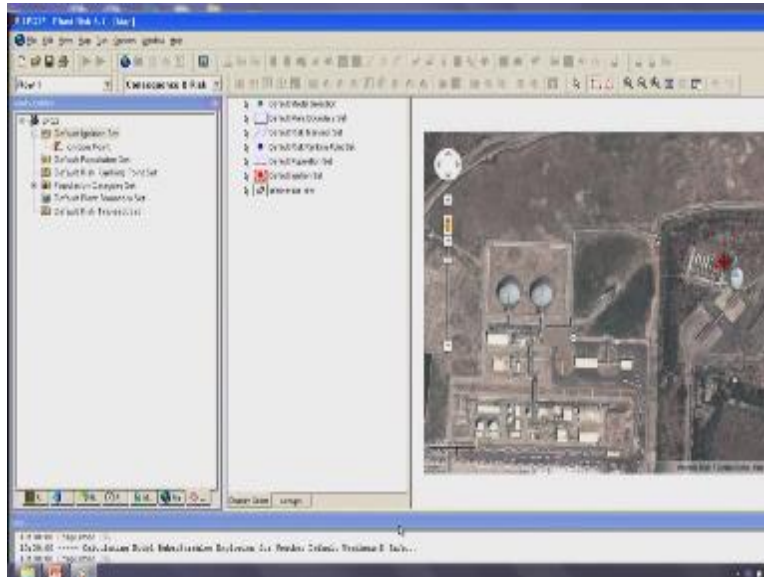
For this specific case run the results enter the favorable distance get the answers and run it for all default weather conditions.

(Refer Slide Time: 17:31)



Once this is completed now you will get a new envelope where you will be able to show for different weather conditions what is the explosion coverage of this specific risk, now look for consequence and risk for the given problem calculate risk values for all the stability classes default ignitions set please insert the value ignition point where you want to ignite go to the geometry take the you note the ignition point select the ignition point give the ignition probability and operating probability select the geometry go to the geometry and insert the point in the geometry.

(Refer Slide Time: 18:11)



Go for the electric line where the source is now applied draw an electric line select the operating probability of this kind of failure and say okay. Now enter the default of the population set insert the population set give a population point where two people or three people maybe at the plant of the working time enter the population at that particular location maybe 2 or 3 in this case we are doing for 2.

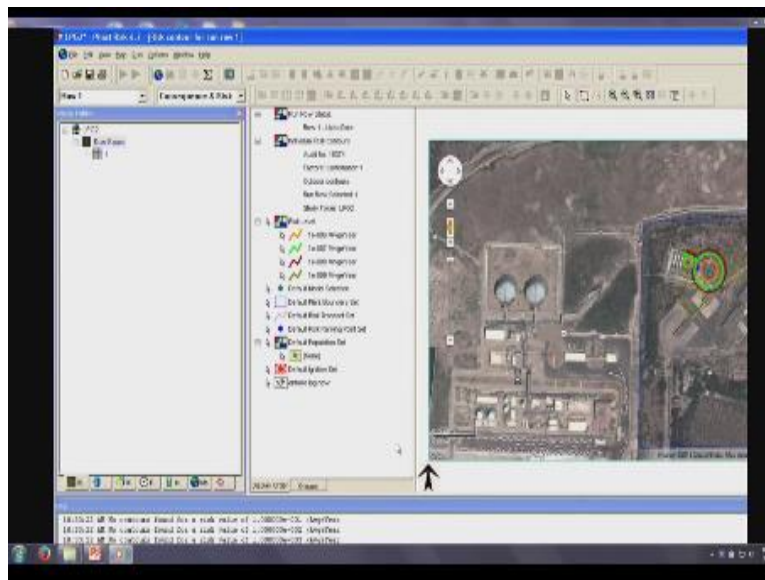
Looking for the societal risk in this case then again enter the default population now enter a population rectangle where the population concentration in different area can be different from that of the vessel enter the rectangle once enter the rectangle the values automatically calculated it can always change the value depending on intensity or density of population in this case we are entering a value as 50, say okay.

Can also create L number of such rectangles are different locations to know on the societal risk applied from this problem create another rectangle near by the plant near by the vessel in this case have a population density different for this case, so we can change this intensity to 50 say okay. And keep on entering the default population set once you finish this default risk ranking points set.

This to be established select this point said go for a 2b analysis also have a risk lounging point select the plain boundary for the given problem where you want analyze so select their boundary the entire problem we see the boundary have been selected in the screen now once it is selected it will become blue the colour changes now the boundary selected now the boundary for risk analysis are lot out to the system.

Now we can also group the boundary separately as you see here ,you do this calculation for all weather condition run all the rows, do for default weather conditions run for all the cases do the consequences do the calculation of risk analysis for all the cases for default boundary chosen for the problem. Once you choose the parameters say OK run rose now run the problem get the results you will see on the screen now the jet fire explosion where pro loaded all are being completed now you can show the graphs.

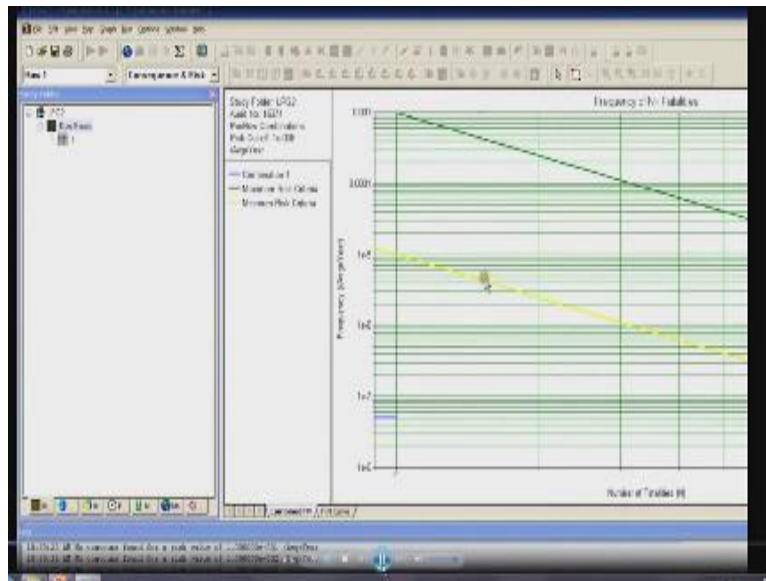
(Refer Slide Time 20:45)



The risk count is now plotted you can see now the risk count is available for different risk example the green one what you see here shows the risk level of 110^{-7} per an average year so for a given population for a chosen source for a given weather stability class for a given

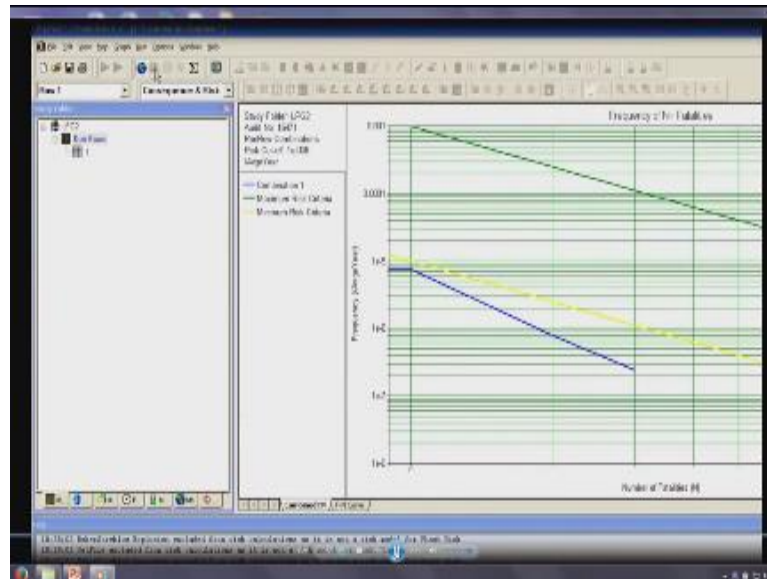
geographical location in wind direction the risk analysis been done an individual contours been plotted epicenter for this particular location once this is done you can also do the societal risk in a fine curve which I show you now you can also change the population rectangle ,go to the run rose again

(Refer Slide Time 21:28)



Do the analysis back again now you will see the FN curve where N stands for fertility F stands for frequency in this case the green one shows the maximum risk criteria for the given problem, the yellow one shows the minimum risk criteria for the given problem as per ALAR, whereas A problem is located much below the minimum risk it means the consequence are arising from the specific location in the specific plant is below the risk available in the gas industry. Now if I change the population set move it closer to the source of the value which I will show you know I go for a different population set change the value move the rectangle closer in a GPRS system.

(Refer Slide Time 23:17)



Now you see here in the specific case for the maximum and minimum risk for a new combination the risk analysis moved from 10^{-7} to as close to as 10^{-5} but still this value as below are is much safer a minimum risk however when keep on moving the epicenter value of the risk rectangle or the population rectangle towards the epicenter of the problem you will see that the risk is getting enhanced so the software gives the very fine wonderful experience and on work on calculating the suitable risk and individual risk contours as you saw in this example.

Individual contours are plotted for different risk level for different boundary class for different stability class and different velocity ratios I hope you understood this problem clearly so friends we have used different types of damages.

(Refer Slide Time 24:18)


Types of damage

Effect of thermal radiation (IS 15656:2006)

Incident Thermal Radiation Intensity, kW/m^2	Types of damage
37.5	Sufficient to cause damage to process equipment
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing
4.5	1st degree burn
1.6	Will cause no discomfort to long exposure
0.7	Equivalent to solar radiation

Effect of overpressure (IS 15656:2006)

Blast Overpressure (Bar)	Types of damage	Casualty Probability
0.30	Major damage to structures (assumed fatal to the people inside structure)	0.25
0.17	Earthm ruptures	0.10
0.10	Repairable Damage	0.10
0.03	Glass breakage	0.00
0.01	Crack of Windows	0.00




5

Deferent consequences.

(Refer Slide Time 24:19)


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



We have used different failure cases.

(Refer Slide Time 24:23)

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	30% 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



Analyse them for different problems and gave the results for societal as well as individual risk contours thank you very much.

(Refer Slide Time 24:31)



Online Video Editing /Post Production

K.R. Mahendra Babu

Soju Francis

S. Pradeepa

S. Subash

Camera

Selvam

Robert Joseph

Karthikeyan

Ramkumar

Ramganesha

Sathiarai

Studio Assistants

Krishnakumar

Linuselman

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 Krishnamurthy

IIT Madras Production

Funded by

Department of Higher Education

Ministry of Human Resource Development

Government of India

www.nptel.ac.in

Copyrights Reserved