Chemical Process Safety
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Lecture – 50 Jaipur Terminal Fire, India
October 29, 2009

Now, welcome to this module related to the fire and we are going to discuss a case study of Jaipur terminal fire took place at IOCL terminal facility at Jaipur on 29th October, 2009 and after the flex (())(0:45) this is one of the most dangerous most devastating and most capped catastrophic accident related to the fire. So let us have a background of this particular facility by the description of the facility.

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At the time of accident the age of the plant was around 12 years and this Plant was housed in about hundred and twenty acres of the land. Now, this the plot housed the facilities for the marketing terminal of IOCL and they were having 11 storage tanks of kerosene, motor spirit and high speed diesel. Apart from this they were having the truck loading facilities to delivery for the delivery of these is product into truck and the product pumping facilities to the neighbouring installation of Hindustan Petroleum Corporation Limited and Bharat Petroleum Corporation Limited through pipeline.

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Now, apart from this the plant accommodated the facilities for pipeline division which operated the cross country pipeline that is Koyali Sanganer product pipeline feeding to this particular terminal and the marketing terminal occupied around hundred and 5 acres of the pipeline division facilities which was located in 15 acres in the North East corner of the particular facility.

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So, this was the Koyali Sanganer product pipeline here this is the Sanganer, so this is the oil pipeline network of IOCL so they are having some existing product pipeline, some crude pipeline they are well connected with various Refineries of Indian Oil Corporation, apart

from this they are having certain LPG pipeline. So this is a Piping network of Indian Oil Corporation.

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Now, the location of the Sanganer was as a plot was far away from then the residential localities of Jaipur city and at a time there was no neighbouring industries or factory located within few kilometres from the plot boundary of time of installation of that particular terminal. Subsequently a large number of industrial establishments they were developed by the state government all around the terminal area. So, you may say that they may be the other the outcome of that particular accident.

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Now, there are certain salient features of this Jaipur terminal. It was the first automated oil terminal in the country and this terminal was fed by the Koyali Sanganer product pipeline and receive product from product they were having two three different type of product like a motor spirit, that is petrol, high speed diesel and kerosene from the Koyali refinery. The terminal also used to receive and distribute the lube oils in drum through trucks, so they were having a the storage facilities for lube oils.

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Now that terminal delivered the petroleum product through the tank trucks to retail outlets and also supplied lube oils to the local market of Rajasthan. And now this particular terminal was also supplied the petroleum product to the neighbouring terminals of other oil companies like HPCL and BPCL.

Now BPCL Sanganer terminal is dependent entirely on receipt of the product from this IOCL terminal. So because these Oil Companies they are having some sort of arrangement internal arrangement so that they can borrow the product from 1 terminal and the share the equivalent amount of the product from their own terminal to the other oil company.

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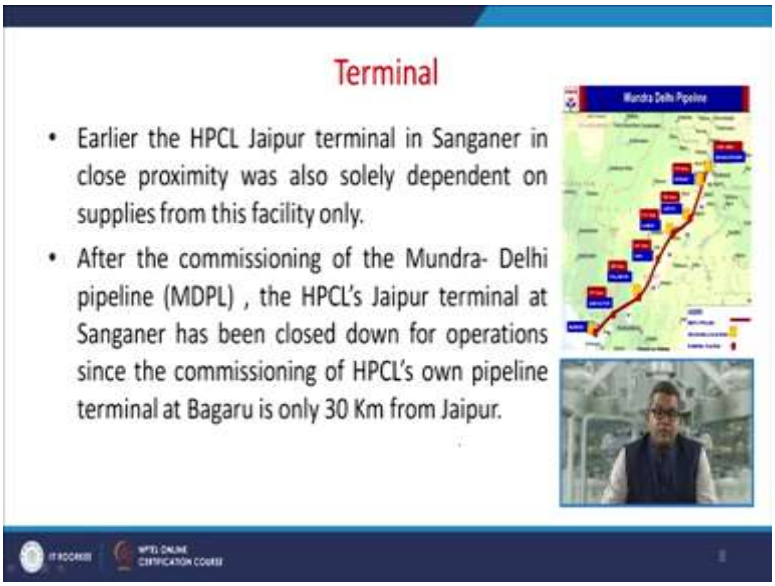

Now earlier HPCL Jaipur terminal in Sanganer which was in the close proximity, was also solely depend on the supplies from this facility only so but after the commissioning of Mundra Delhi pipeline MDPL, the HPCL's Jaipur terminal at Sanganer has been closed down for operation since the commissioning of HPCL's own pipeline terminal at Bagaru, this is only 30 kilometres from Jaipur. So you can see in this the Mundra - Delhi pipelines you can see that they are having its own terminal.

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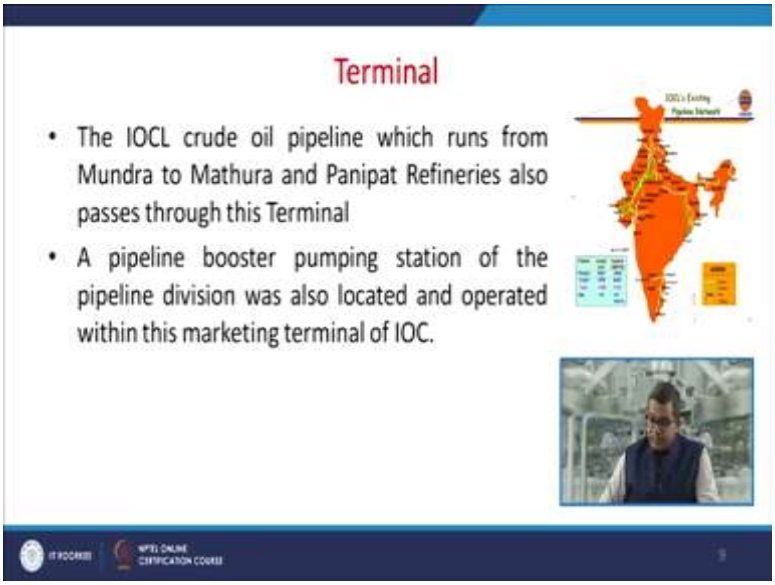

Now the IOCL crude oil pipeline which runs from Mundra to Mathura and Panipat Refinery because in the Northern belt, Mathura and Panipat Refinery these are these two refineries are

owned by IOCL, so they are also pass through this, that particular pipeline was also pass through this particular terminal. So a pipeline booster pumping station of the pipeline division was also located and operated within the marketing terminal of Indian Oil Corporation.

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So they were having a very good storage facility so the storage facility is originally consists of 9 tanks for petroleum products and subsequently two more thanks were added for Motor spirit tank followed by one more tank that was not commissioning commissioned at the time of accident under pipeline division for the receiving the pipeline interface. So there are certain interface because sometimes these pipelines are attributed for more than one product so there is some interface which is usually send back to the refineries.

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Now, this is the three dimensional plot plan they were having the this is the tank yards this was the entrance administrative block, account section etc. there having the pipeline so in all they were having all the tank facilities over here and there this is the tank lorry depot.

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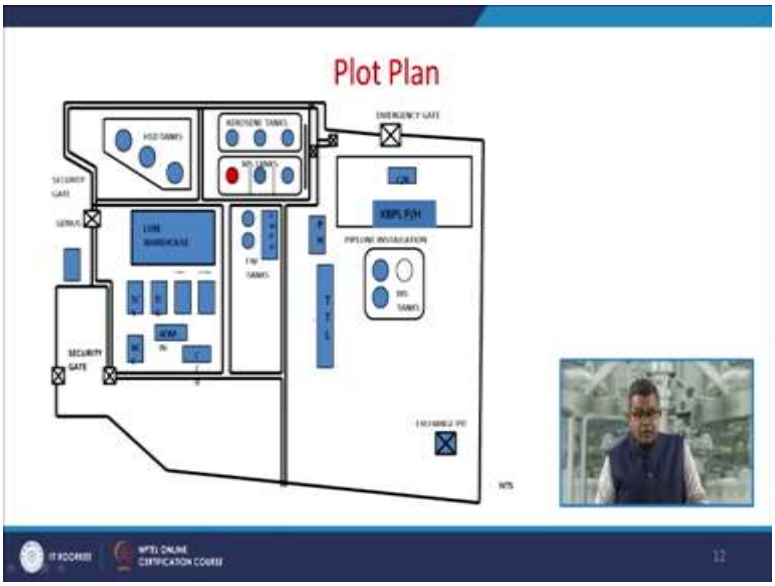

Now this is a you can say the more clear form here they were having the high speed diesel tank facility there are the kerosene tank, the motor spirit tank which was involved in this one which was involved in that particular accident. They were having the lube warehousing apart from this the security gate and adjacent to the security gate they are having one inverter factor

that is called the genus factory and this was the pipeline installation and this is that a tank card loading facilities etc. this was there in the exchange pic.

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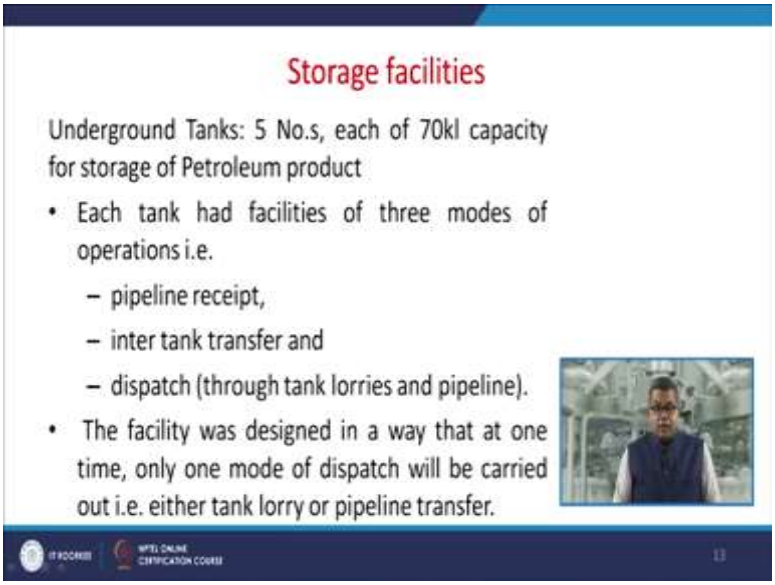

So while we are having the continued discussion about the storage facility is underground tanks they were having the five in number and each of having was the capacity of 70 kilo litre for the storage of the petroleum product. So each tank had facilities on three modes and that is important and that was the main crust of the accident. One mode was the pipeline receipt so when the material is coming to the through the pipeline second is attributed to the inter tank transfer and third one is the dispatch.

So you can say these two facilities the pipeline receipt and dispatch they were inlet and outlet and this one is for the inter tank, so when you are having two tanks inline so you may connect all those these two tanks apart from this one is inlet another one is the outlet. Now, this facility was designed in a way that at one time only, only one mode of dispatch will be carried out that is either tank lorry or a pipeline transfer so this is again a very important aspect of this the designing.

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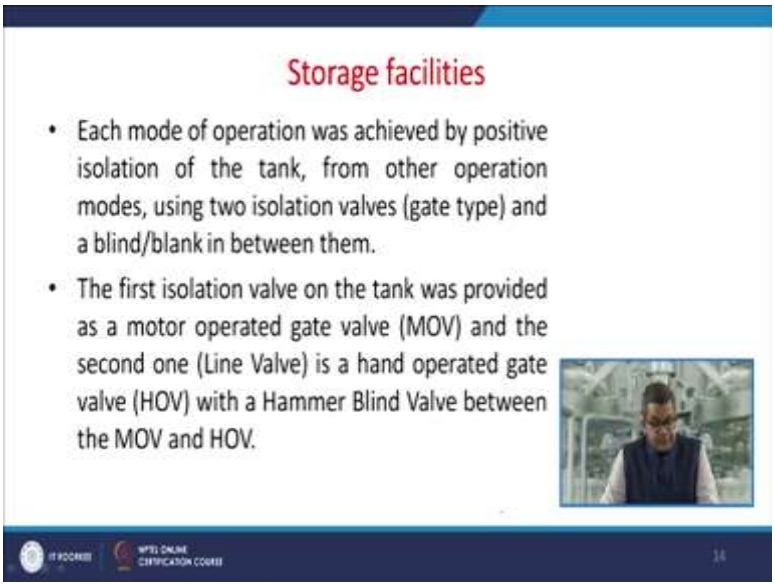

Now each mode of operation was achieved by a positive isolation of a tank so the proper safety installation or a proper safety devices they were there. So isolation of the tank from the other operation modes using two isolation valve and they are attributed to the gate valve and they were having a blind or a blank in between them.

So the first isolation valve on the tank was provided as the motor operated get gate valve and the subsequent slides this is referred as a MOV and the second one is the line valve which is the hand operated gate valve and referred as HOV. Now this they are having a hammer blind valve between the motor operated valve and hand operated valve.

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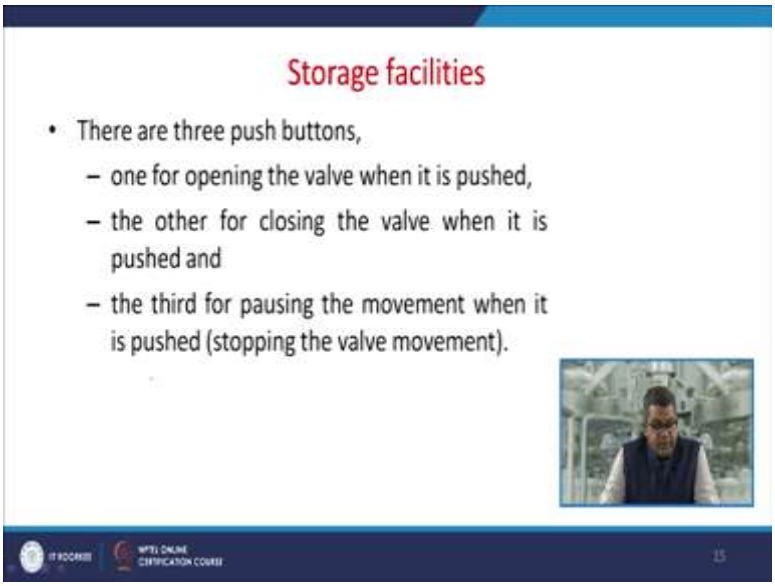

Now they were having three push buttons one for operating the valve when it is pushed the other for closing the valve when it is pushed and third for pausing the movement when its pushed for stopping the valve movement.

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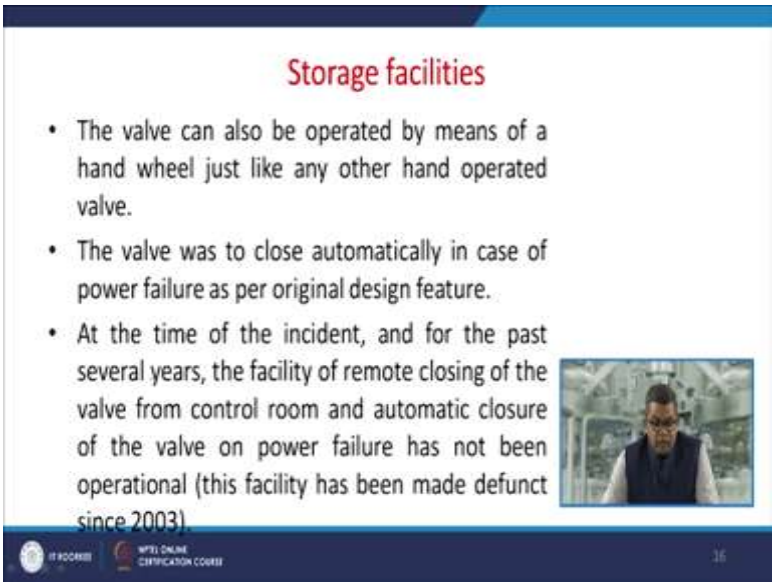

Now, these valve can also be operated by means of a hand wheel just like any other hand operated valve. So the valve was to close automatically in case of power failure as per the original design features some sometimes it may be violated. So at the time of the incident and for the past several years the facility of a remote closing of the valve from control room and automatic closer of the valve on power failure has not been operational. So this facility has been made defunct since 2003 one of the main reason why this accident took place.

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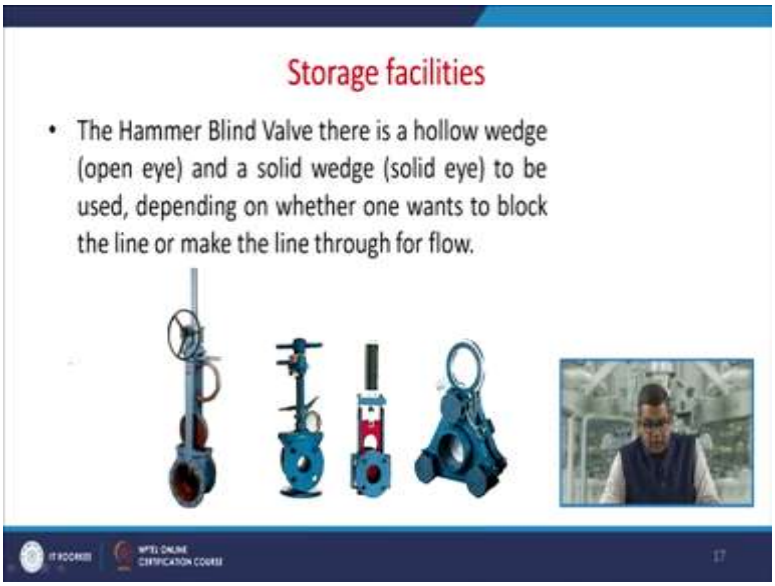

Now, let us have a look about the hammer blind valve. The hammer blind valve there is a hollow wedge open eye and a solid wedge that is a solid eye to be used and depending on whether one wants to block the line or make the line through a flow like this, this is the opening and this is the complete closer, so whenever it operates it moves like this direction so the opening my take place. And if it is like this then no flow can pass through this particular valve. So some, there are 4 different type of HOVs, so this is the crown wheel through which you can control the flow either closed or open.

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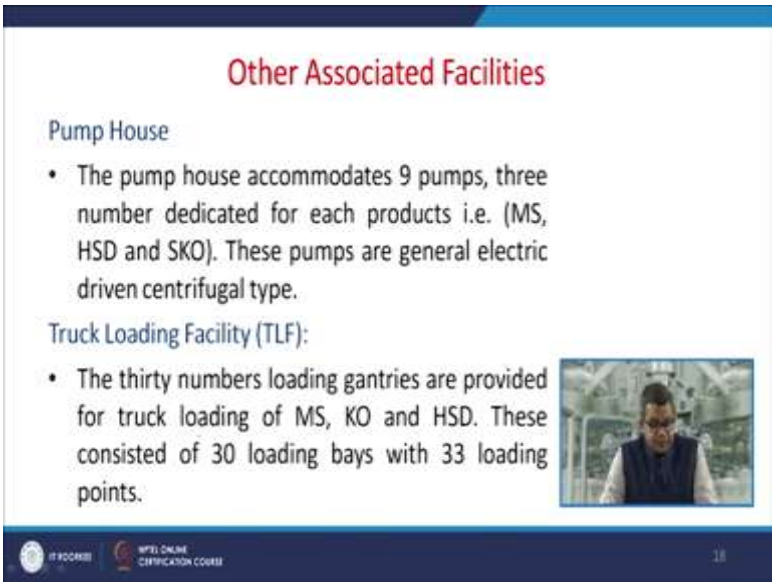

There are several other associated facilities in that particular plant like the pump house the pump house accommodates nine pumps three numbers they are dedicated for each products, motor spirit that is petrol, high speed diesel and kerosene. And the pumps and these pumps are generally electric driven centrifugal pumps the plant was having the truck loading facilities referred as DLF. There are 30 numbers of loading gantries are provided for truck loading of motor spirit kerosene and high speed and this consists of 30 loading bays with the 33 loading.

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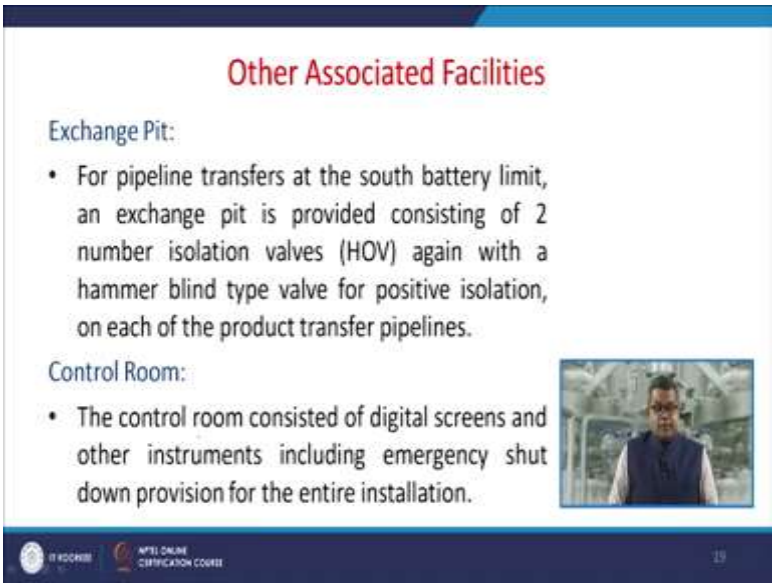

They were having one exchange Pitt Fury calling the plot plan at the corner of the plot they were having the exchange pit. So for pipeline transfer at the South battery limit and exchange pit is provided consisting of two number of isolation valve one is HOV. Again with the hammer blind type of valve for the positive isolation on each of the product transfer pipeline, they were having a control room the control room mainly consisted of a digital screen and other instruments including emergency shutdown procedure for the entire installation.

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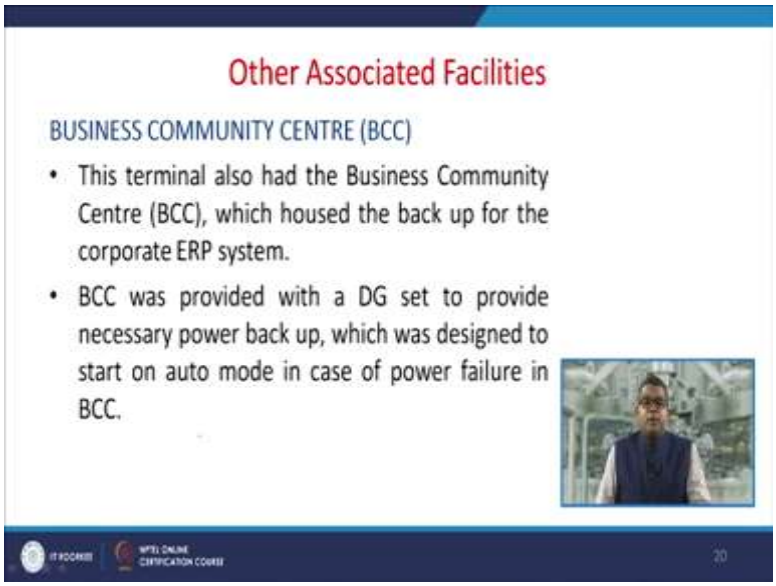

They were having a business Community Centre this terminal also had the business Community Centre which housed to the backup for the corporate ERP system and this business Community Centre was provided with a DG set to provide the necessary power backup which was designed to start on auto mode in case of any power failure in the centre.

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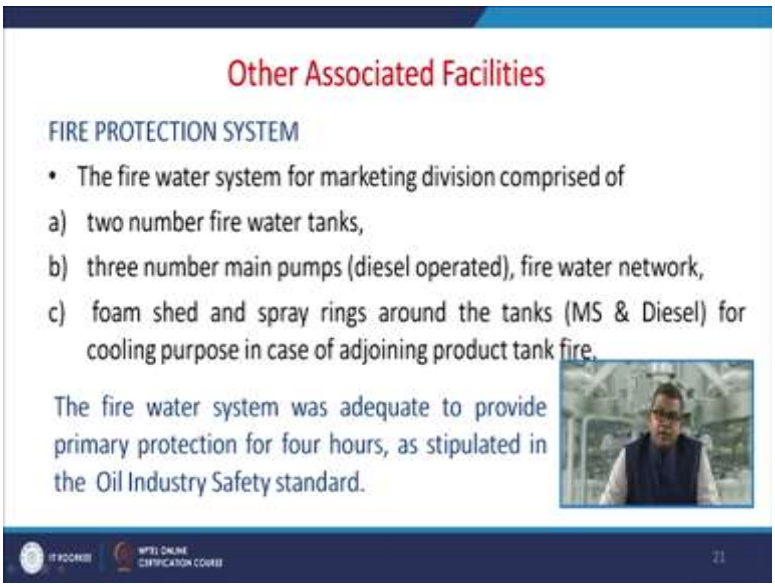

There was a good power protection system now this unfortunately this fire protection system was not competent enough to come to cater the need of entire plant. So this fire water system for marketing division is composed of two number of fire water tank and as a basic protocol three number of main pumps diesel operated for fire water network and foam shed and spray

rings around the tanks for both motor spirit and diesel for cooling purpose in case of adjoining product tank fire.

Now you can imagine that all these activities they were actuated at a time of accident but they failed so you can imagine that scenario and you can imagine that how much quantum of enthalpy generated at the time of an that particular accident. Now, the fire water system was adequate to provide the primary protection for 4 hours as stipulated in oil industry safety standard so they were very much within those standards.

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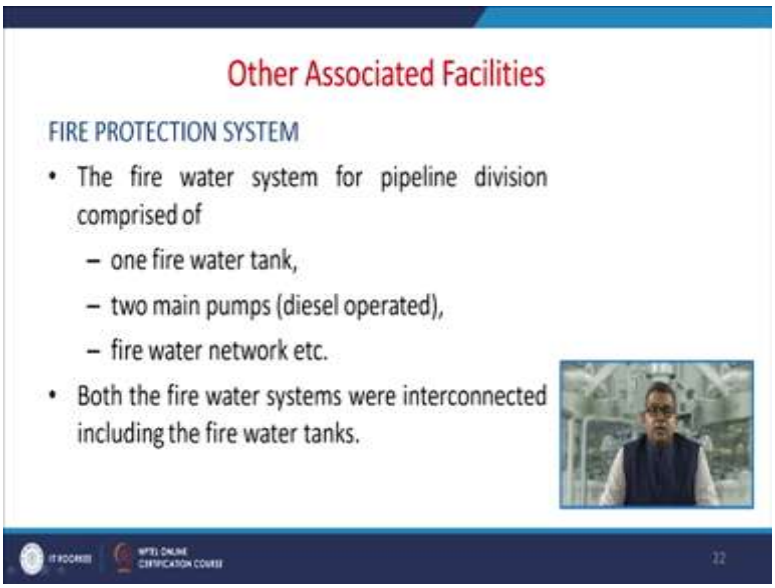

The fire water system for pipeline division that was comprised of one fire water tank, two main pumps usually they were diesel operated firewater network. Now, both the water fire water system were interconnected including the fire water tanks.

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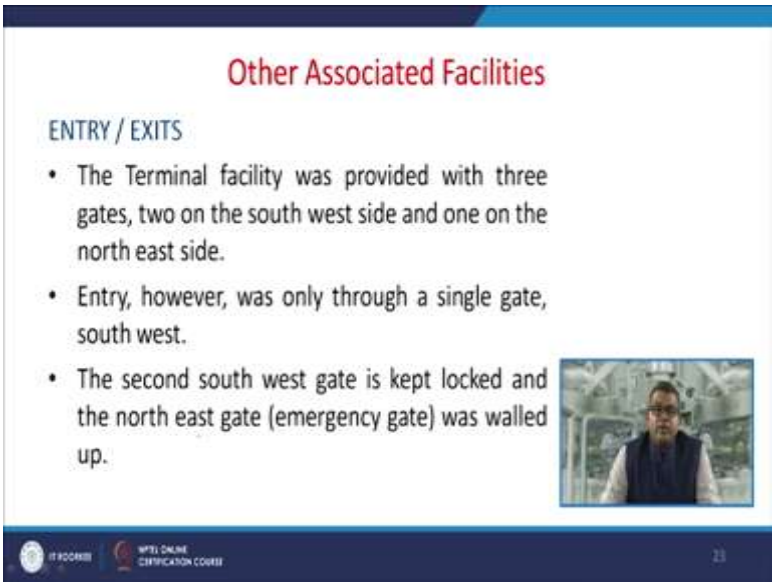

They were having some entry and exit protocols the terminal facility was provided with three gates two on the south west side of the plot and one at the north east side so. So, why I am telling you all these sides because the time of accident the meteorological conditions also play very vital role. So entry was only through a single gate that was in the southwest and the second south west gate is kept locked and the northeast gate was used in terms of emergency protocol.

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Apart from other things they were having the effluent treatment facilities so oily waste water from the pump house area and tankage area is routed via a closed system to a RCC sump in

the effluent treatment plant. Now, it is usually then pump with a effluent feed pumps to the inlet of tilted plate interceptors where in the free of oil droplets they are intercepted and form a floating layer of oil, which is skimmed through a rotatable skim pipes.

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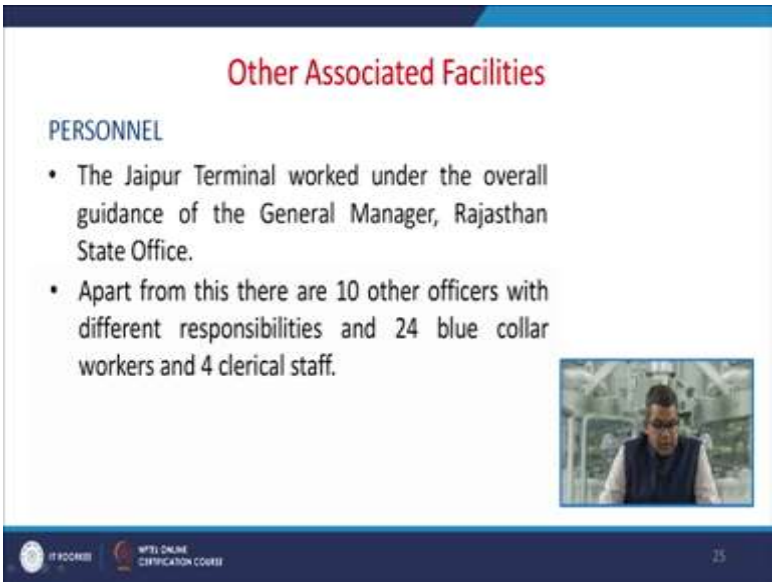

As far as the personnel are concerned, the Jaipur Terminal worked under the overall guidance of the general manager, Rajasthan state office they are having the IOCL Regional Centre at Jaipur apart from this there are 10 other officers with the different responsibilities and 24 Blue Collar workers and 4 clerical staff.

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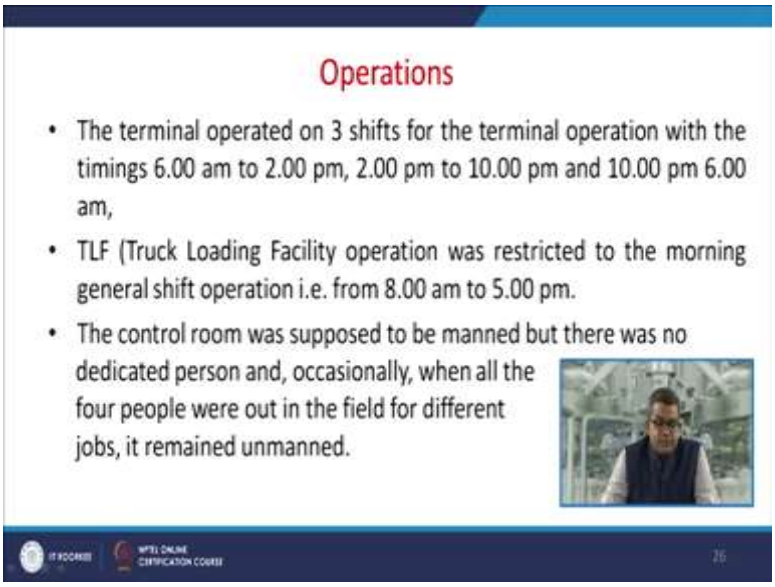

Now, let us have a discussion about the operation so this terminal operate usually operated in 3 shifts so for the Terminal operation with the timing of 6:00 a.m. to 2 p.m. and 2:00 p.m. to 10:00 p.m. and 10:00 p.m. to 6:00 a.m. in the morning. The TLF that is the truck loading facility operation was restricted to the morning general shift operation that is from 8 a.m. to 5:00 a.m. 5:00 p.m. The control room that was supposed to be manned but there was no dedicated person for it and occasionally when all the four people were out in the field for different job it remained unmanned, this is again a problematic issue.

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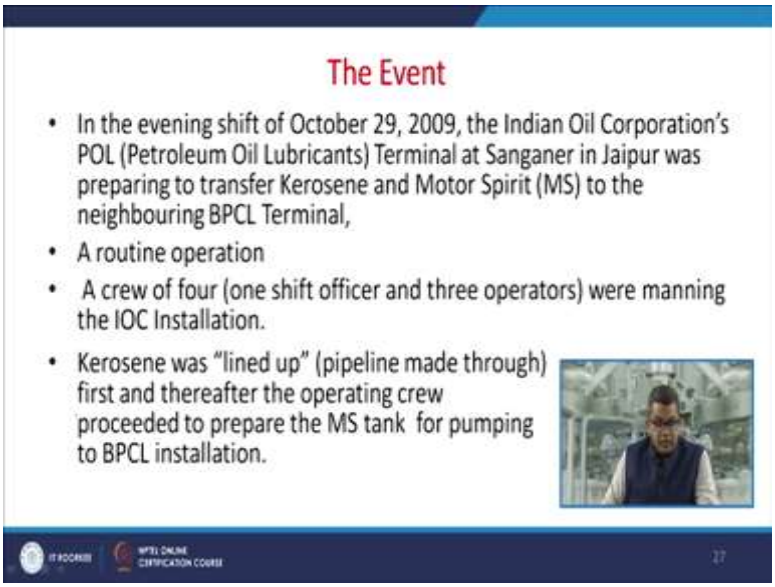

In the evening shift of October 29, 2009 the IOCL petroleum oil lubricants terminal at Sanganer in Jaipur was preparing to transfer kerosene and motor spirit to the neighbouring BPCL terminal that was obviously a routine operation so a crew of 4, one shift officer and three operators they were manning the IOCL installation and kerosene was the lined up first that is through pipeline. And thereafter the operating crew proceeded to prepare the motor spirit tank for pumping to BPCL installation.

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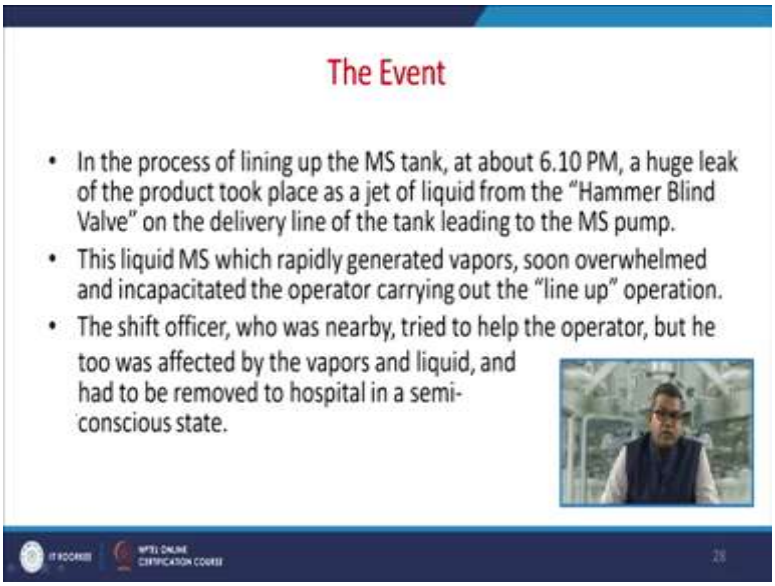

So in the process of lining up MS tank at around 6:10 p.m. a huge leak of the product took place as a jet of liquid from the hammer blind valve on the delivery line of the tank leading to the MS pump that is motor spirit pump. Now this liquid petrol which rapidly generated a vapours and soon overwhelmed and incapacitated the operators carrying out the line of operation.

So they were practically helpless at the moment because the quantum and velocity the pressure was so high, the shift operator or shift officer who was nearby try to help the operator but he two was affected by the vapours, liquid and had to be removed to hospital in semi conscious state so you can imagine the scenario.

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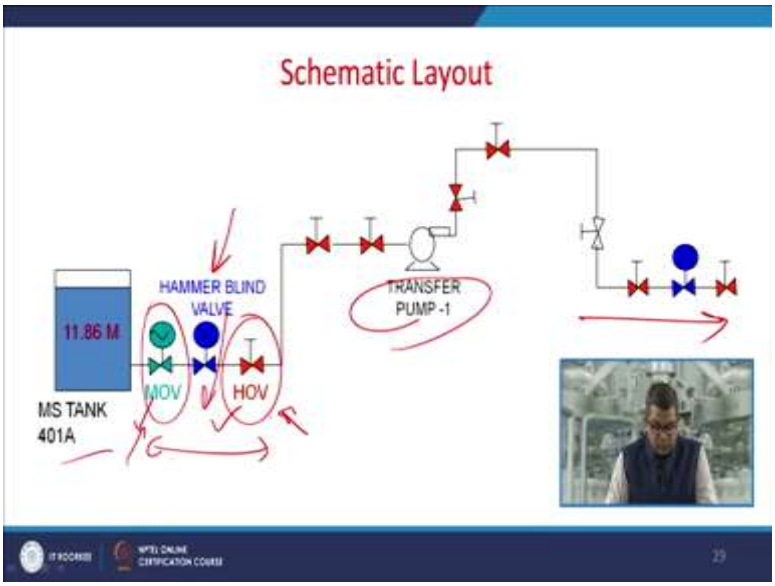

So, this is the schematic layout, this was an Motor Spirit tank and that was the MOV and this is the HOV and this one is the hammer blind valve so and this was the transfer pump and this is again the same scenario, so the problem took place in synchronising all these three steps.

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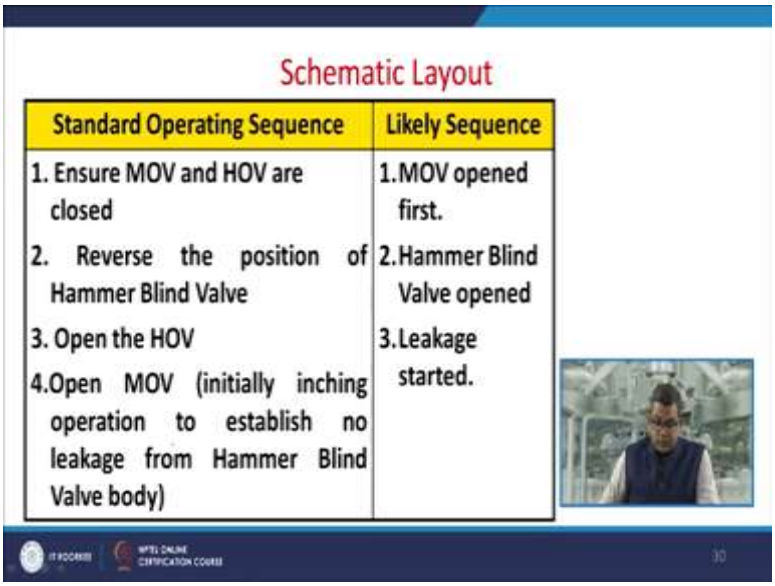

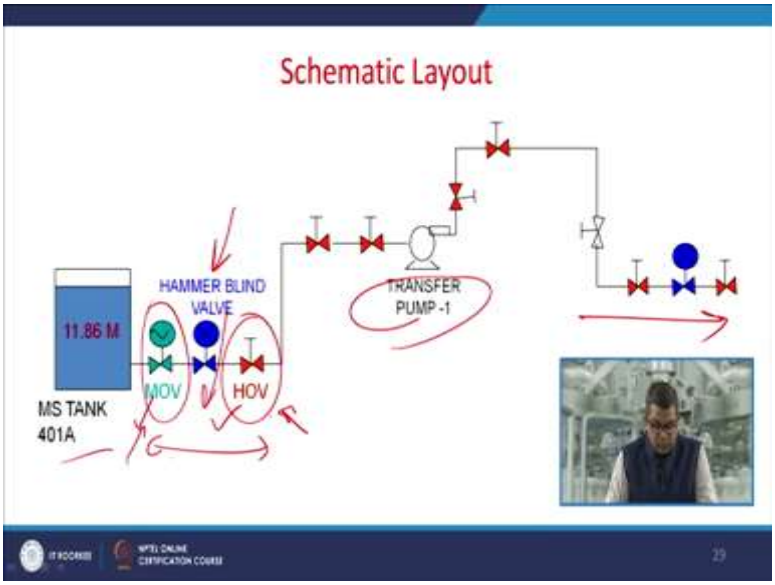

So, now the standard operating sequence was to ensure that a MOV and HOV this and this both are closed then reverse the position of hammer blind valve so that you can have a desired scenario then open the HOV this one, then open the MOV initially inching operation to establish the leakage from Hammer blind valve body now the likely sequence says the MOV opened first. However, desired was the HOV but initially MOV opened first and then hammer blind valve this was opened that is in the second step and then because of lack of the synchronisation the leakage started.

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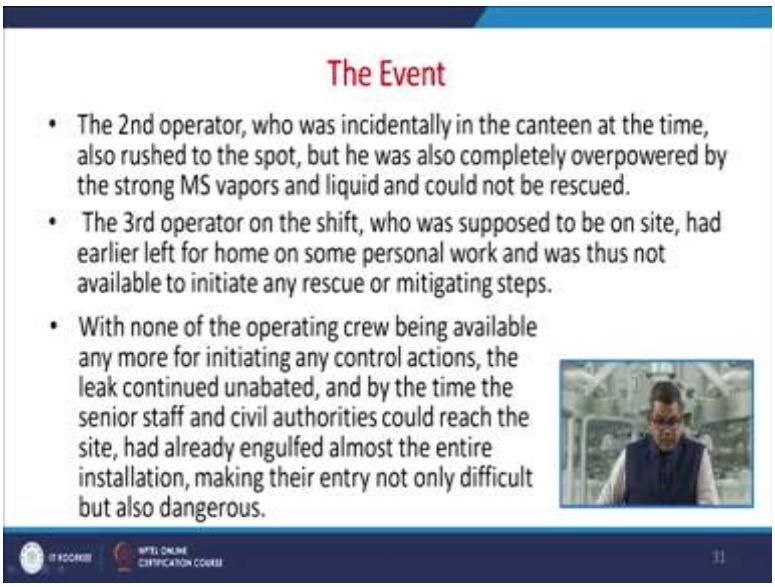

So the second operator who was incidentally in the canteen at the time also rushed to the spot but he was also completely overpowered by the strong petrol vapors and liquid and could not be rescued. So the third operator on the shift who was supposed to be on site had earlier left

for home for some personal work and was thus not available to initiate any rescue or mitigation step.

So, these two are again the contributing events that particular accident. With none of the operating crew available any more for initiating any control action the leak continued unabated and by the time the senior staff and civil authorities could reach the site had already gulped almost the entire installation making their entry not only difficult but also dangerous. So you can say that this was the initiation and this is the total propagation.

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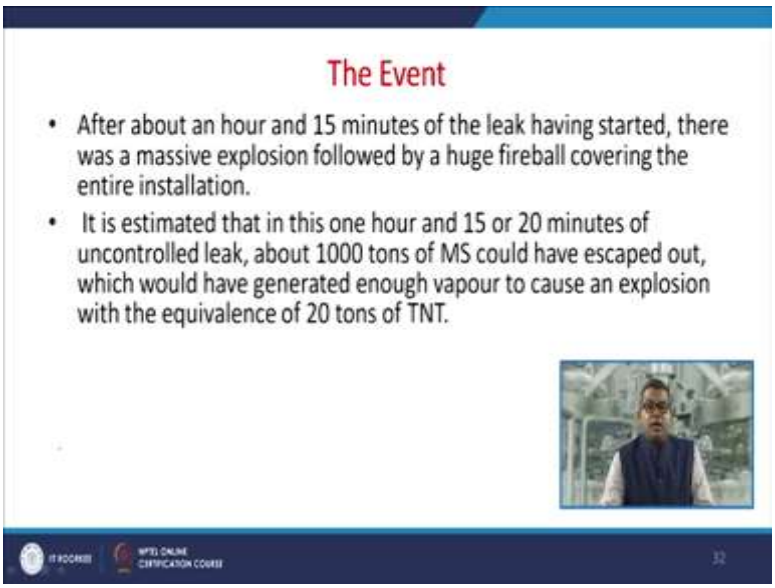

So, after about an hour and 15 minutes the leak having started there was a massive explosion followed by huge fireball covering the entire installation. So it is estimated that in this one hour and 15 to 20 minutes of uncontrolled leak about thousand ton of motor spirit could have escaped out, which would have generated enough vapour to cause an explosion with equivalence of almost 20 tons of a TNT.

Now, remember when this huge firewall occurred, then there is may be a generation of huge quantum of heat and that may initiate by any modes of heat transfer, that may initiate the vapour formation and pressure build up in the adjoining tanks so the explosion in other adjoining tanks may took place.

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Now, this was the source of motor spirit leak, now you can visualise there are hand operated valve motor operated valve and this one is the blind, blank, now this is the mean scenario so it was not been inserted properly while the transfer took place.

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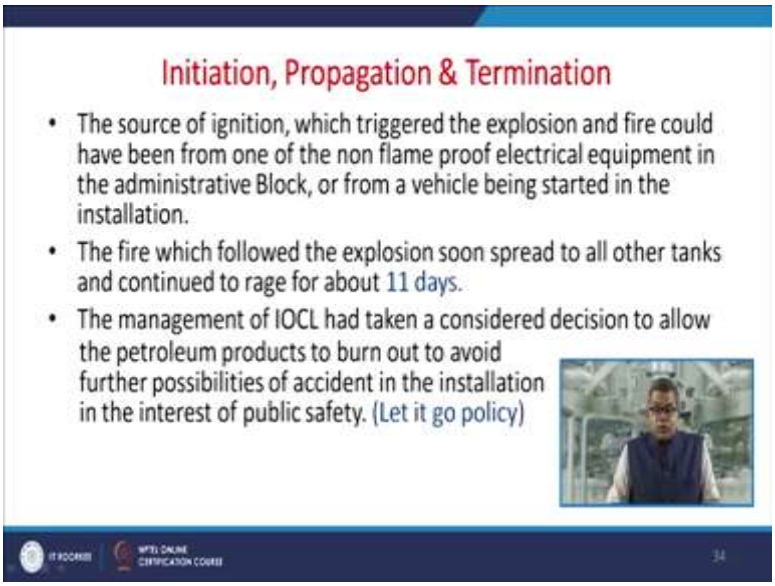

So, let us have a look about that all three steps of this particular incident initiation, propagation and termination. So the source of ignition which triggered the explosion and fire would have been found from one of the non flameproof electrical equipment in the administrative block or from a vehicle being started in the installation. Now remember when

vapour escapes from any kind of facility in terms of a vapour cloud and if it is exposed to the atmosphere it may form the uncontrolled vapour cloud.

Then it is very difficult to prevent all the presence of all kind of source of ignition and moreover they were, these vapours are under the grip of atmospheric air so sufficient supply of oxygen is also there, so you cannot avoid the scenario of generation of either fireball or fire. So, the fire which followed the explosion soon spread to all other tanks and continue to rage for about 11 days so that was the a propagation step.

The management of IOCL they had taken a consider decision to allow the petroleum product to burn out to avoid for the possibilities of accident in the installation in the interest of the public safety. So you can say that it is let it go policy because practically the quantum of heat was so high at the moment that they were practically helpless to extinguish the fire by the usual methods available as on date.

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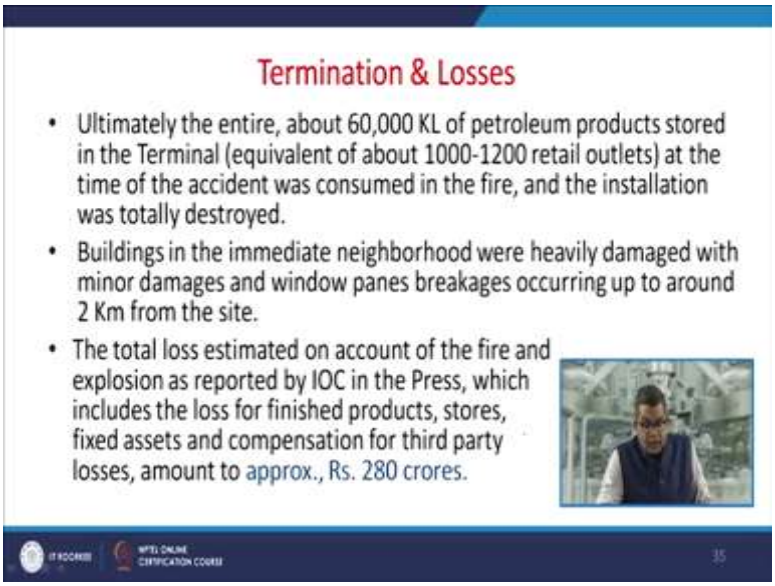

So, ultimately while we consider the termination and discuss about the losses so ultimately the entire about 60,000 kilo litre of Petroleum products stored in the terminal that is equivalent to about 1000 to 1200 retail outlets at the time of accident was consumed in the fire and installation was totally destroyed. Now building in the immediate neighbourhood were heavily damaged with a minor damage and window panes breakage occurring up to around the two kilometres from the site.

Now the reason was when the tanks they were exploded the noise or the vibration was so high that all the window panes damage some cracks etc. They were they took place at the site. So the total loss estimated on account of the fire and explosion as reported by Indian Oil Corporation in the press which includes the loss of the finished product, stores, fixed assets and the compensation for the third party losses amounted to be 280 crores.

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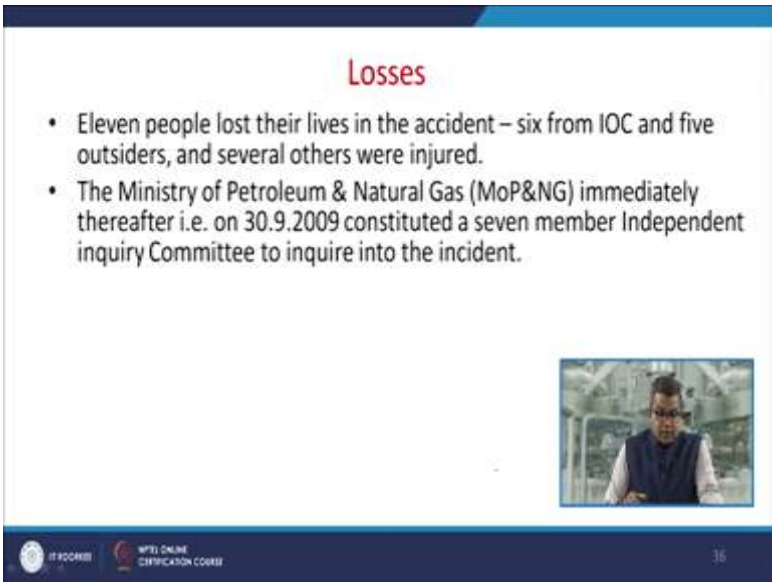

11 people lost their lives in the accident and 6 from IOC and 5 from outsider and several others were injured. The Ministry of Petroleum and Natural Gas they immediately thereafter that is on 13th September 2009 constituted the seven member in independent enquiry committee to enquire into the incident. So in inertial you can say that if the operators they didn't follow the protocol that means the lack of training and lack of a technical competency.

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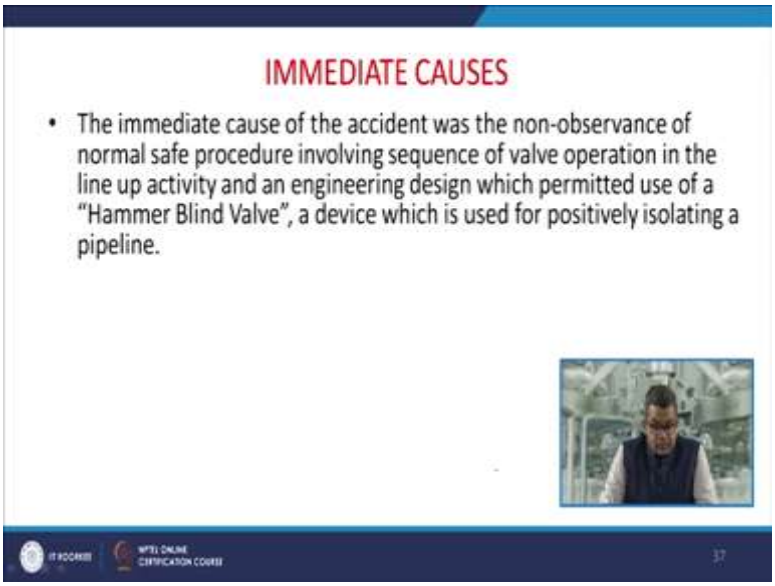

So, let us have a discuss about the immediate cause the immediate cause of the accident was the non observance of normal safety protocols involving the sequence of valve operation in the line of activity and engineering design which permitted use of Hammer Blind Valve a device which is used for the positively isolation of pipeline so they have not follow the standard operating protocol.

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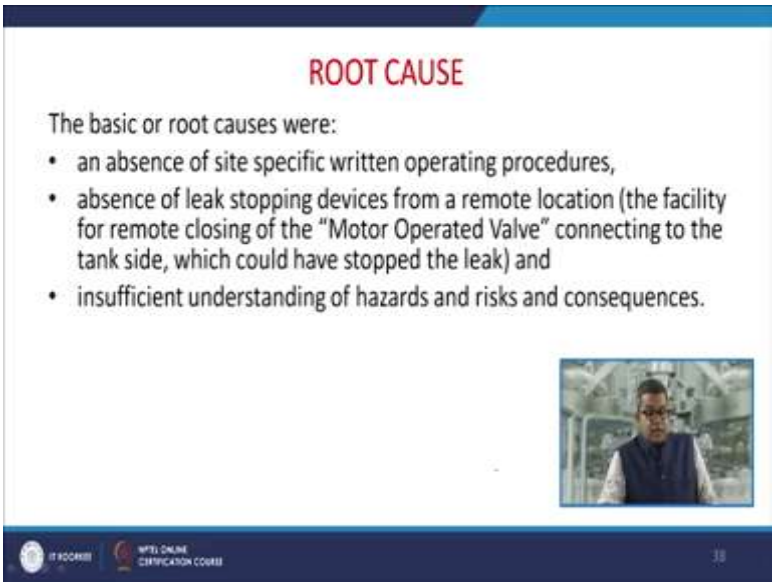

The root causes, the basic root causes were the absence of site is specific written operating process protocol or a procedure the absence of leak stopping devices from a remote location this facility of a remote closing the motor operated valve connecting to the tank side which

could have stopped the leak, although some of the safety protocols they were defunct at the time of accident. Now insufficient understanding of hazard and risk consequences.

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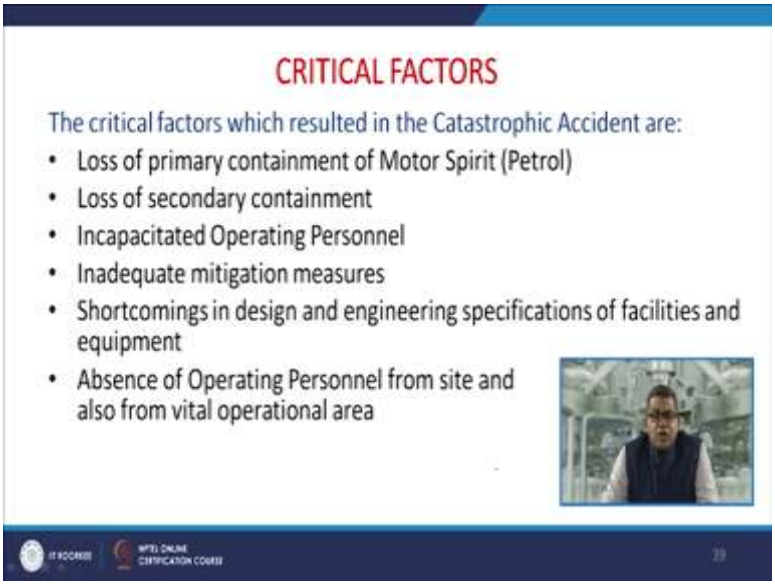

There were some critical factors involved in that particular plant that critical factors which resulted the catastrophic accident are the laws of primary containment of motor spirit that is petrol so but practical they were not in the position for the containment of motor spirit so that is why it escaped from the storage facility, the loss of secondary containment so the incapacitated the operating person because at the time of accident one was away to his home and remaining persons they were not in a position to control the things, they were not having a proper mitigation measures at the time of accident.

So inadequate mitigation measures there was so many shortcomings in design and engineering specification of facilities and equipments because when the person is not in a position to operate this HOV or MOV with the blind then definitely they may be certain shortcomings in design and Engineering specification there was absence of operating personal from site and also from the vital operation area which they were not supposed to do so.

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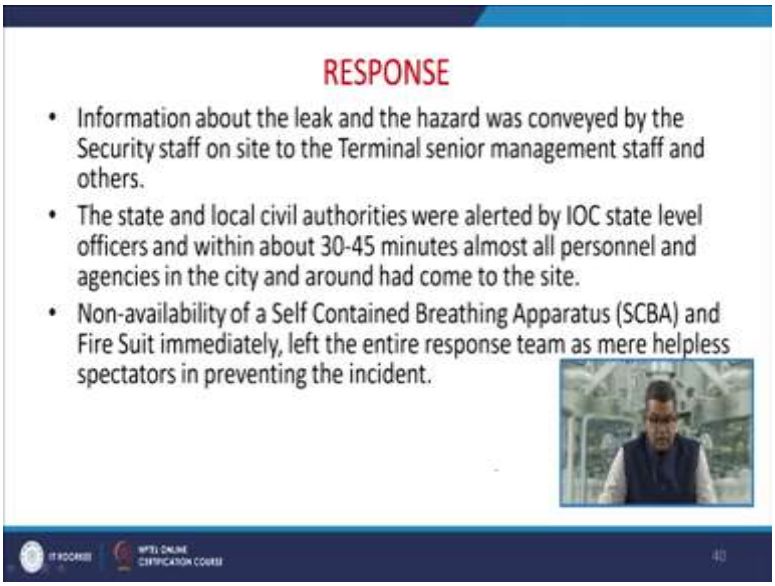

Then the question arises about the responses so information about the leak and hazard was conveyed by the security staff on site to the terminal senior manager staff and others the state and local civil authorities they were alerted by IOC state level officers and within about 30 45 minutes almost all persons and agencies in the city and around that come to the site. There was a serious non availability of a self-contained breathing apparatus and fire suite immediately, and when it was not available they left the entire response team as a mere helpless spectators in preventing the incident.

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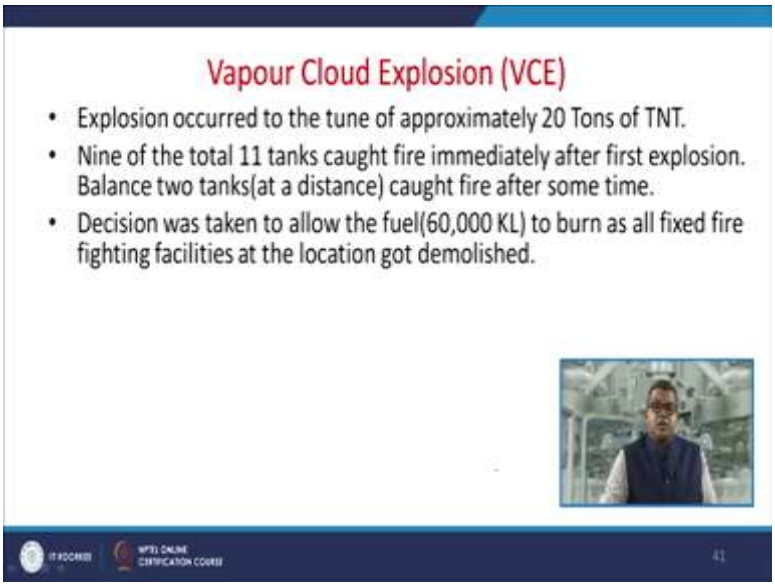

So because this accident was attributed to the vapour cloud explosion so explosion occur. The to the tune of approximately 20 tons of TMT, 9 of the total 11 tanks got fire immediately after first explosion balance two tanks maybe at a distance got fire after sometime so because of regular heat transfer modes for which they caught the fire. So decision was taken to allow the fuel that is 60,000 kilo litre to burn as all fixed fire fighting facilities is at the location got demolished and they were not in a position to handle the scenario where the external fire fighting devices.

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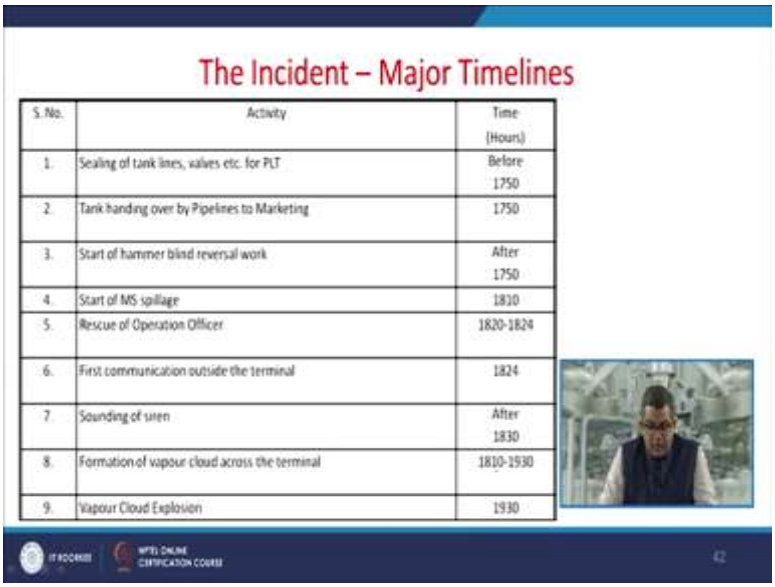

Now this is the major timeline for the accident. Now the sealing of tank lines, valve, etc. to before 5:50 p.m., the tank handing over by pipelines to marketing 5:50 p.m., start of hammer blind reversal work after 5:50, start of motor spirit spillage at around 6:10 p.m., rescue of operation officers officer between 6:20 to 6:24 and the first communication outside the terminal gate which was supplied to 6:24 and sounding of siren after 6:30 and the formation of vapour cloud across the terminal, it took place around between 6:10 p.m. to 7:30 p.m. and vapour cloud explosion took place at 7:30 p.m.

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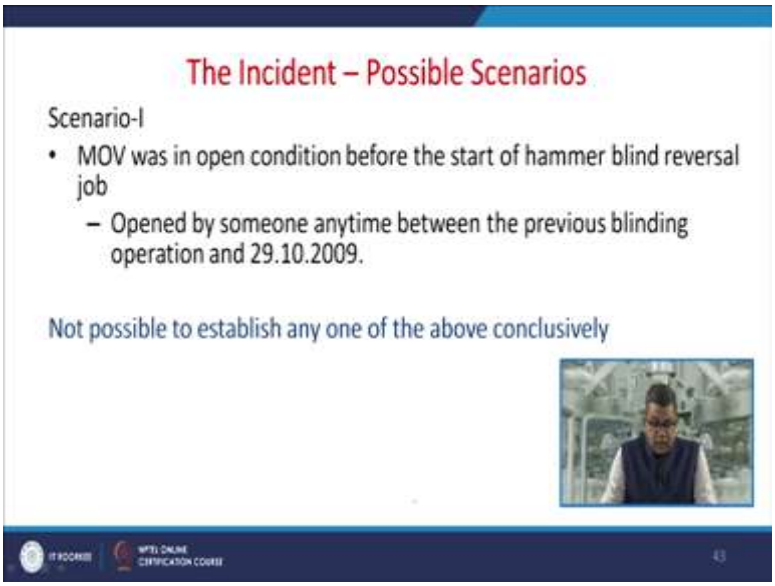

Now we can discuss the possible scenarios for this particular accident. The scenario one the, the motor operated valve was in open condition before the start of hammer blind reversal job so this maybe that attributed to the this opened by someone anytime between the previous blinding operations and on 29th October, 2009. Because it is not at all possible to establish any one of the above conclusively the reason is that whenever they started the job then definitely they might have look into this aspect.

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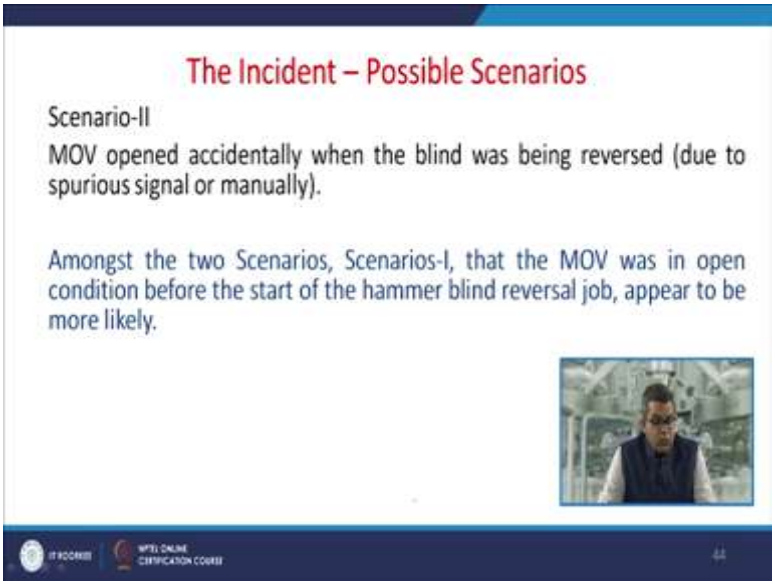

Then the scenario to the motor operated valve opened accidentally when the blind was being reversed due to the spurious signal or manually. So among the two scenarios, scenario one

that the MOV was open condition before the start of hammer blind reversal job appear to be more likely.

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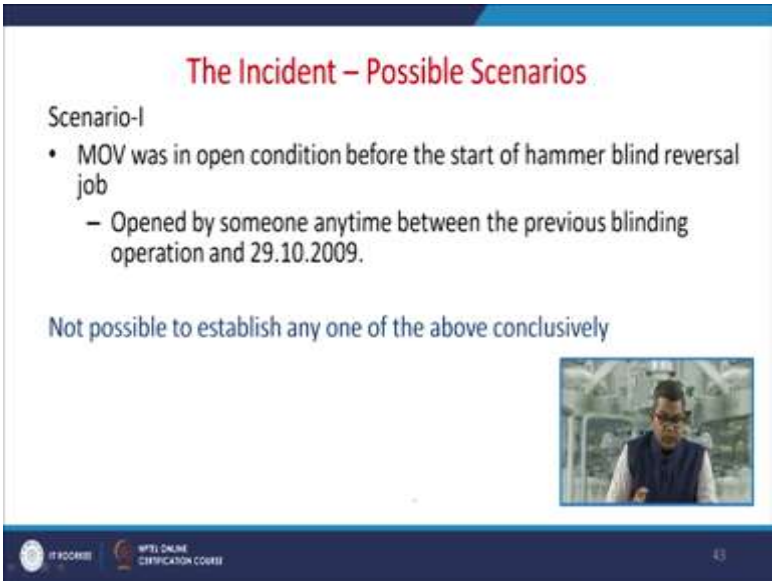

So when they discussed about these two scenario they found that this scenario is most appropriate one.

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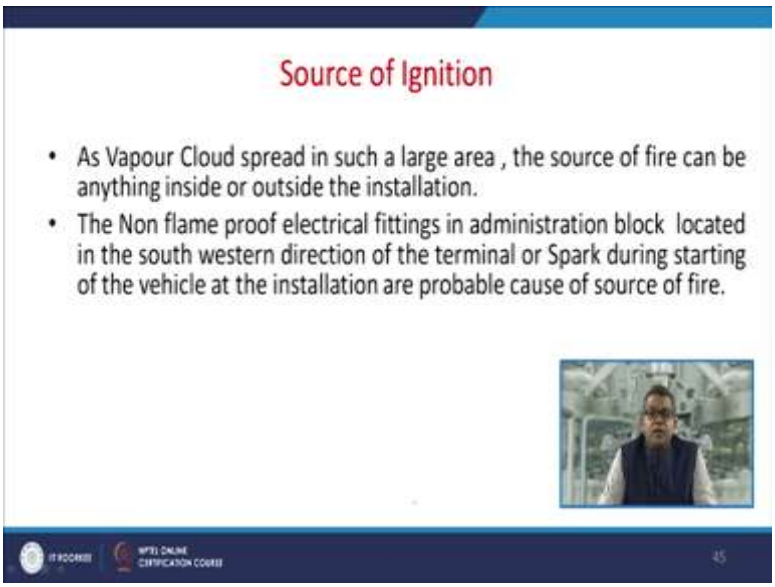

Then they discussed about to the source of ignition so as vapour cloud spread in such a large area the source of fire can be anything inside or outside the installation so the non flameproof electrical fittings in administration block located in the south western direction of the

terminal or spark during the starting of the vehicle at installation they are the probable cause of the source of fire.

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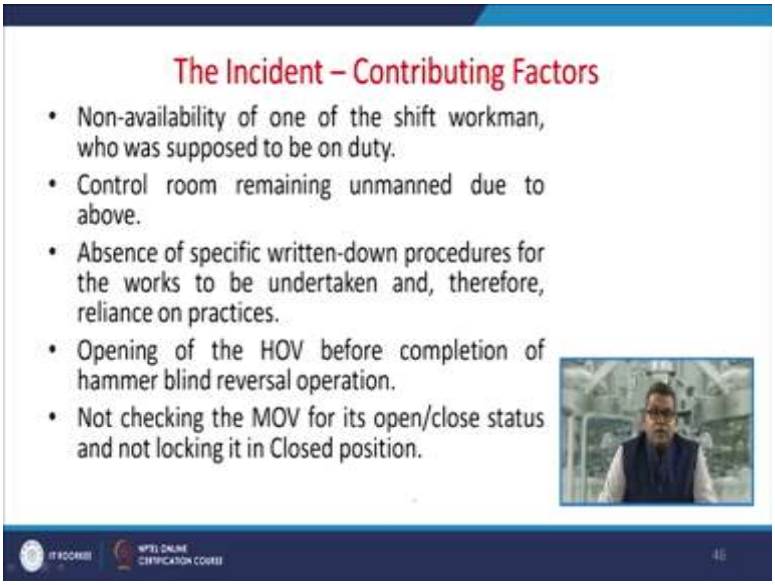

Now there are certain contributing factor to this incident that is one is a non availability of a one of the shift work man who was supposed to be on duty so when the investigation team carried out the investigation they found out these are the contributing factors. Second may be the control room remaining unmanned due to the above things.

The third one is the absence of a specific written time procedure for the works to be undertaken and therefore at the reliance on practice. Fourth may be the opening of hand operated valve before the completion of a hammer blind reversal operation. Another one is that not checking the motor operated valve for its open close status and not lock locking the closed position.

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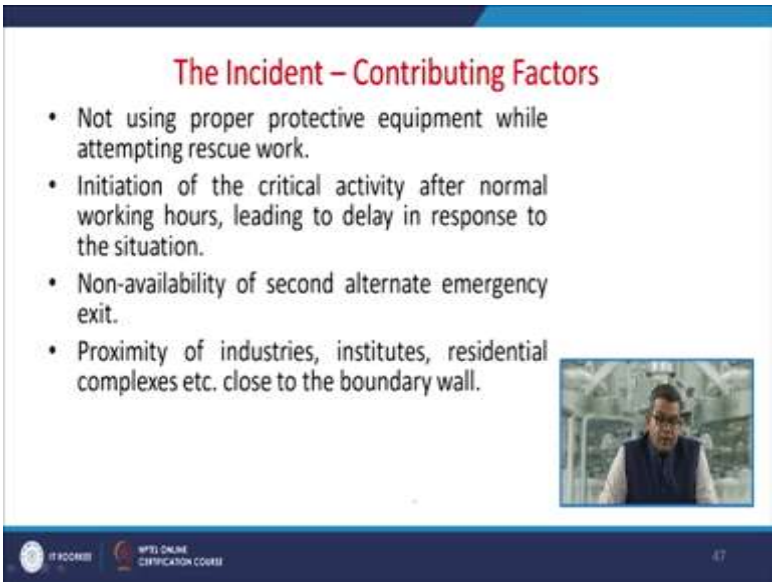

One may be that not using the proper protective equipment while attempting rescue work. The initiation of the critical activity after the normal working out leading to delay in response to the situation. Sometime, another contributing factor may be non availability of the second alternate emergency exit and the last one is that the proximity of industries institutes residential complexes etc closed to the boundary valve.

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So, based on all the facts and incidents the Ministry of Petroleum and Natural Gas, Government of India they constituted and independent seven member committee headed by Shree MB Lal, ex-chairman Hindustan Petroleum Corporation to enquire to the incident. So

the committee submitted their report on 29th January, 2009 and made the following observation. This Jaipur accident was first of its kind in India and the third one reported globally. So you can assess that how much the gravity of that particular incident

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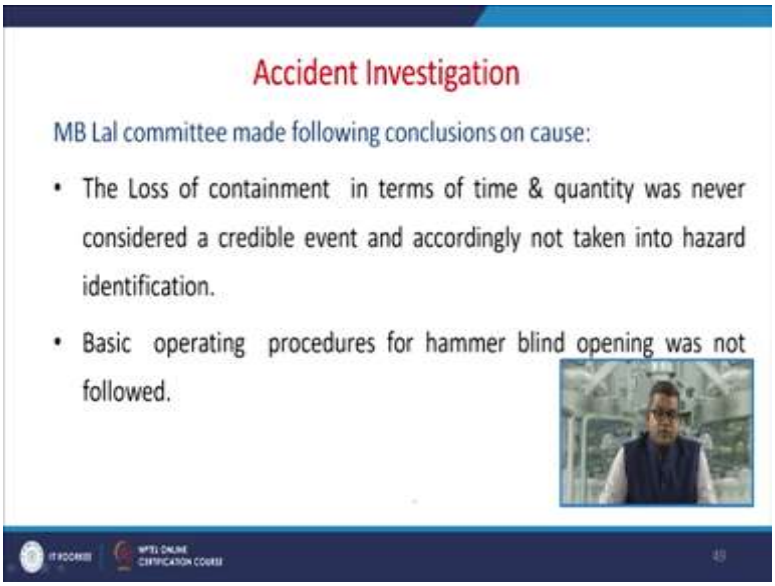

So that this committee made the different conclusion on cause the loss of containment in terms of time and quantity was never considered a credible event and accordingly not taken to the hazard identification so that might be the part of the Hazard identification for the future study. Now basic operation operating procedure for hammer blind opening was not followed.

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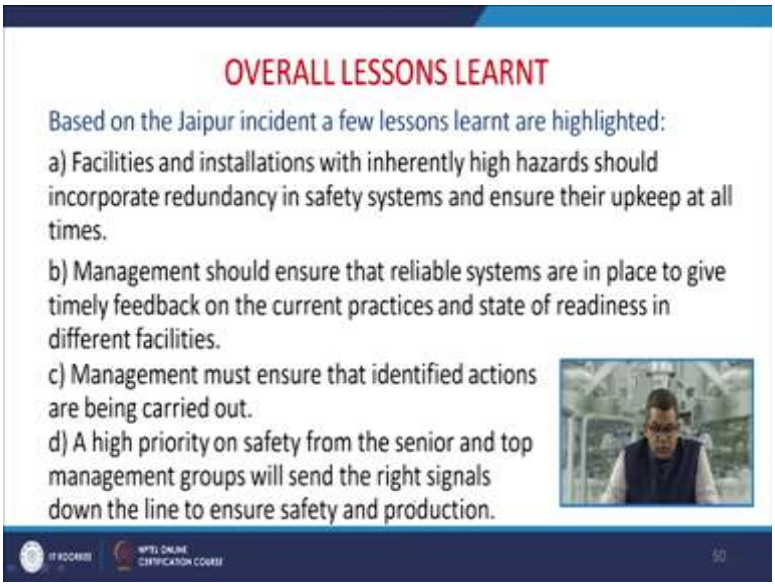

So the overall lessons one must learn that the facilities and installations with inherently high hazards should incorporate redundancy in the safety system and ensure their upkeep at all times. The management should ensure that reliable system are in place to give timely feedback on the current practices and the state of readiness in the different facilities. The management must ensure that identical actions are being carried out. High priority safety from the senior and top management groups will send the right signal down the line to ensure safety and production.

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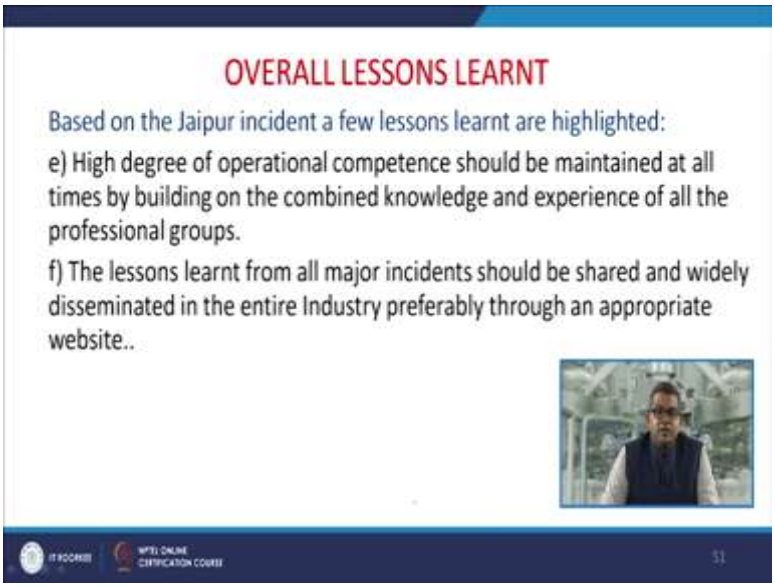

High degree of operational competency should be maintained at all times by building on combined knowledge and experience of all the professional groups. The lesson from all major incidents should be shared that may be the part of the safety review and widely disseminated in the entire industry preferably through an appropriate website.

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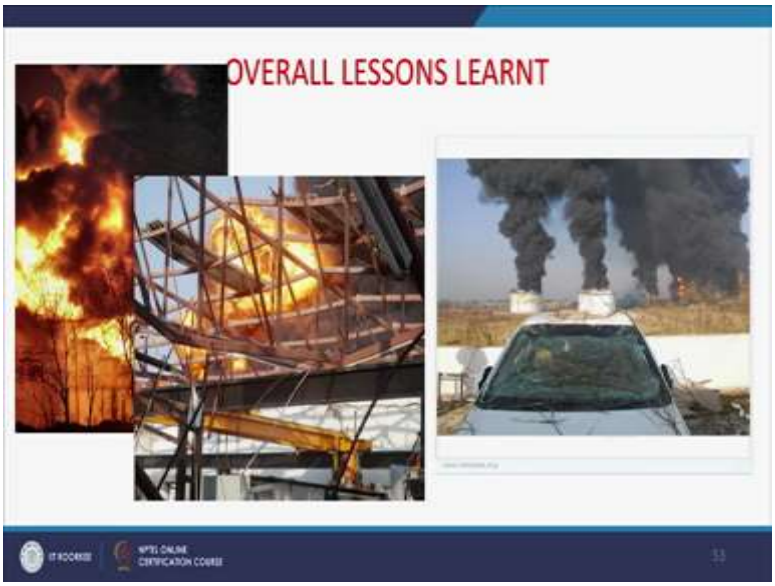

Now you can have a look of the gravity of this particular accident through these photographs. Now these tanks they were burning and the car in the nearby location it is burnt out. Now you can see that this is the storage tank facility how much pressure being built up so that it the entire tank which is so strengthen installation is collapsed.

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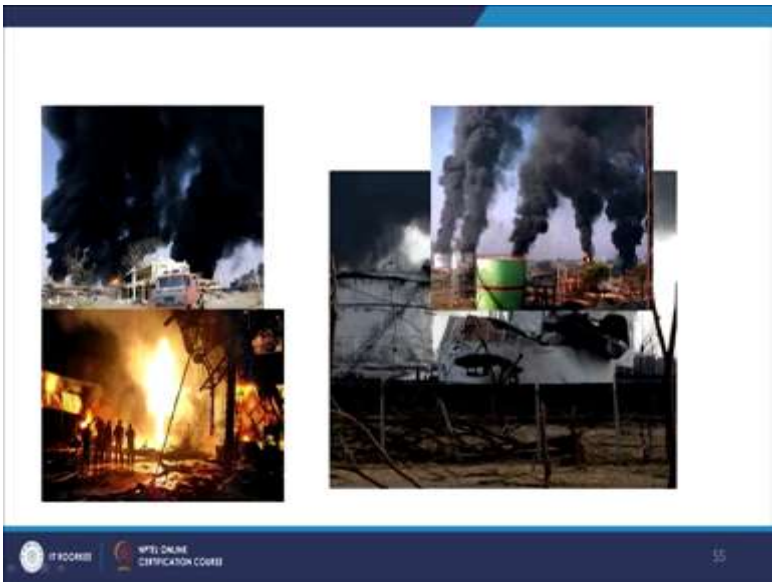

Now you can see like this, this is the firewall,

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Now, this is the highway nearby that installation so you can see the gravity of this particular accident.

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The people were running around now unfortunately we should not install like this.

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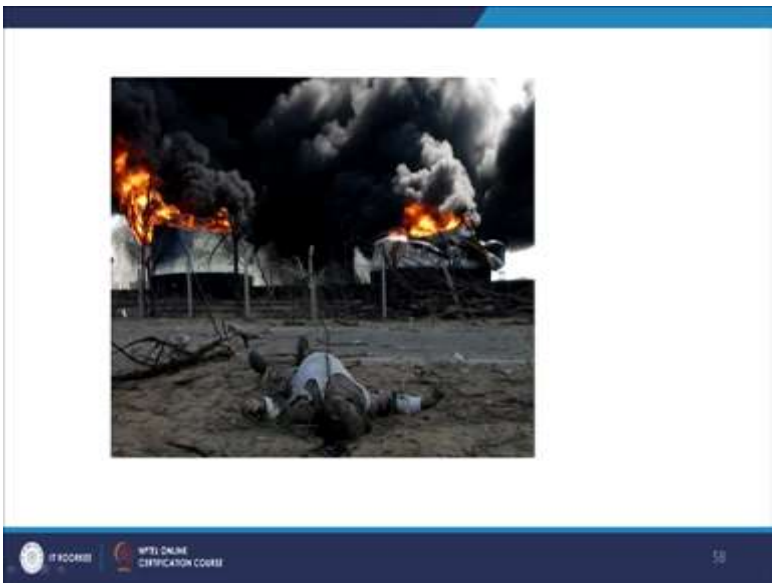

So, these are the couple of the photographs which looks they are so which depicts that how much the gravity of that particular accident.

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Now, you can see that after the accident this was the scenario of the all tanks those who were there at the time.

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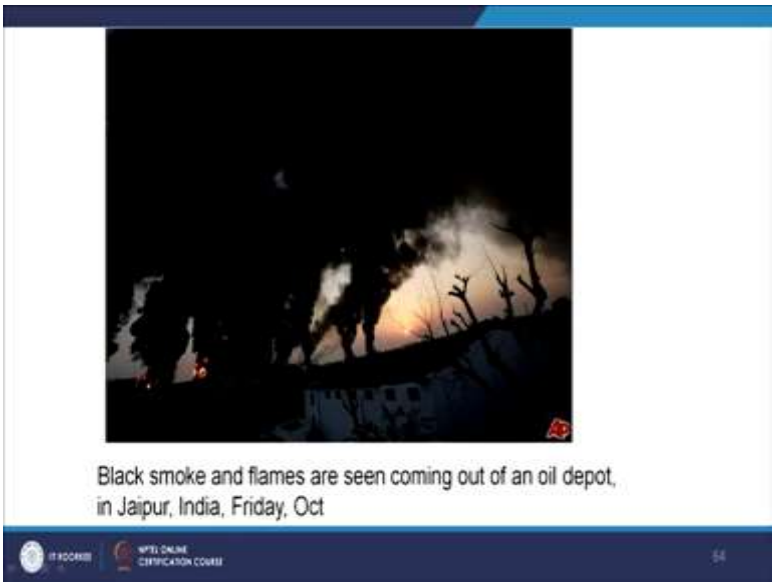

So, you can see the black smokes and flame they are seen out of an oil depot of the Jaipur. So, by this particular case study we have studied that this is the main you can say the latest of in the fire and explosion accident and again by not observing the standard operating protocol this this kind of a major accident they may take place in any kind of establishment. Thank you very much!