Chemical Process Safety
Professor Shishir Sinha
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Module 11
Lecture 54
Bhopal Gas Tragedy
(December 03, 1984)

Welcome to another module of case study, in this module we are going to discuss one of the most worst industrial disaster of its time, that is Bhopal Gas Tragedy, this gas tragedy and accidental investigation or case study is pertaining to the information or knowledge related to the toxic release. Now this, the severity of this particular gas tragedy you can imagine in terms of that changes all the parameter, it changes the all the guidelines and other protocols listed in chemical engineering aspect. So let us have a look about this particular gas tragedy.

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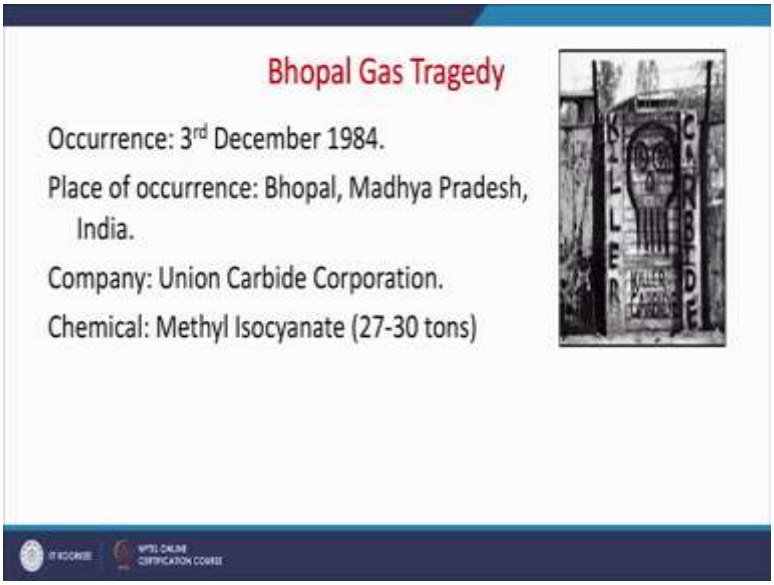

So this gas tragedy occurred on 3rd December 1984 in Bhopal, Madhya Pradesh and the company which was involved in this particular gas tragedy was Union Carbide Corporation and the chemical which was responsible for the death of almost one lakh twenty thousand and the people the involvement of one lakh twenty thousand people is responsible the methyl isocyanate and it was released in the quantum of 27 to 30 tons.

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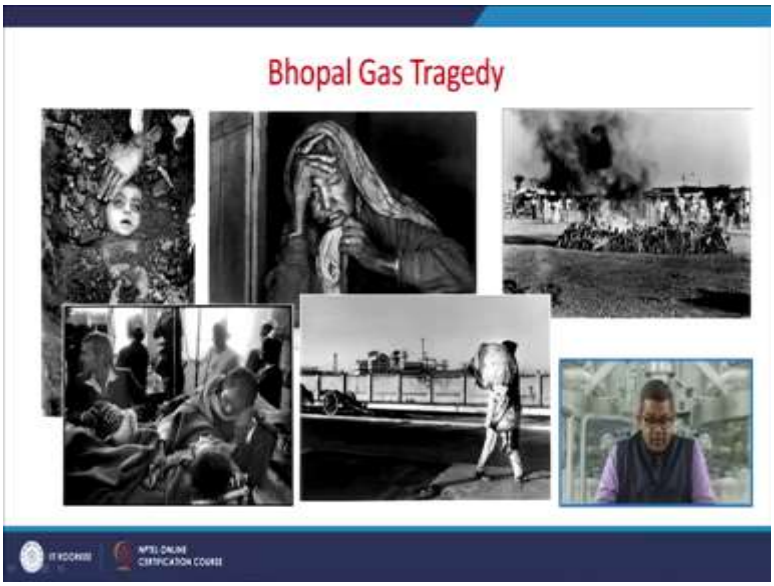

Now the gravity of this particular gas tragedy you can imagine through these photographs and these photographs are quite disturbing but it tells you that how worst this particular accident was.

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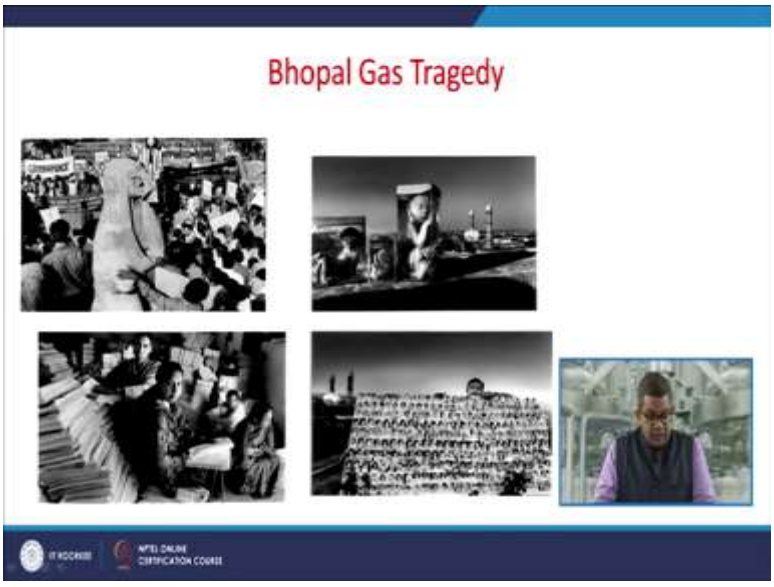

Now these are the some of the photographs and which was published in different newspapers, different magazines of across globe.

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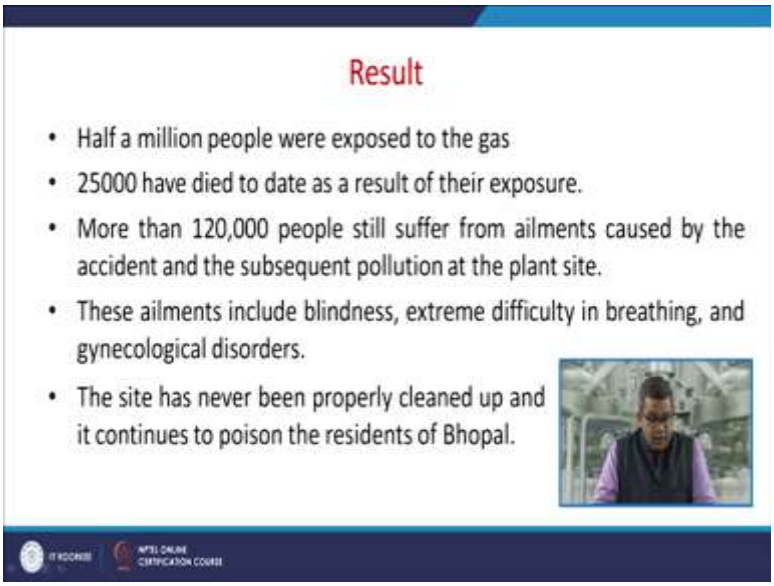

So, the result of this particular release was that half a million people they were exposed to the methyl isocyanate gas and 25,000 have died to date as a result of their exposure and these are some listed number more than one lakh twenty thousand people they are still suffering from different type of ailment caused by the accident and subsequent pollution at the plant site. Now these element includes blindness, extreme difficulty in breathing, gynecological disorder, carcinoma etc. Now this site in Bhopal has never been properly cleaned up and it was sometimes it is said that it continues to poison the resident of Bhopal.

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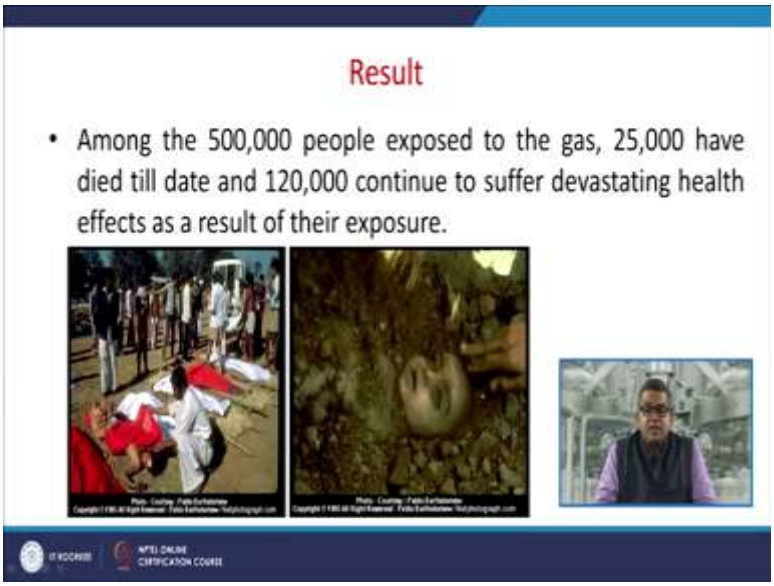

Now the purpose of this particular slide is that you can imagine that how severe that accident was and why we are saying that this is one of the most worst accident in the history. So, at the time of exposure almost 5 lakh people they were exposed and still people are suffering and you can see that the different images of the accident.

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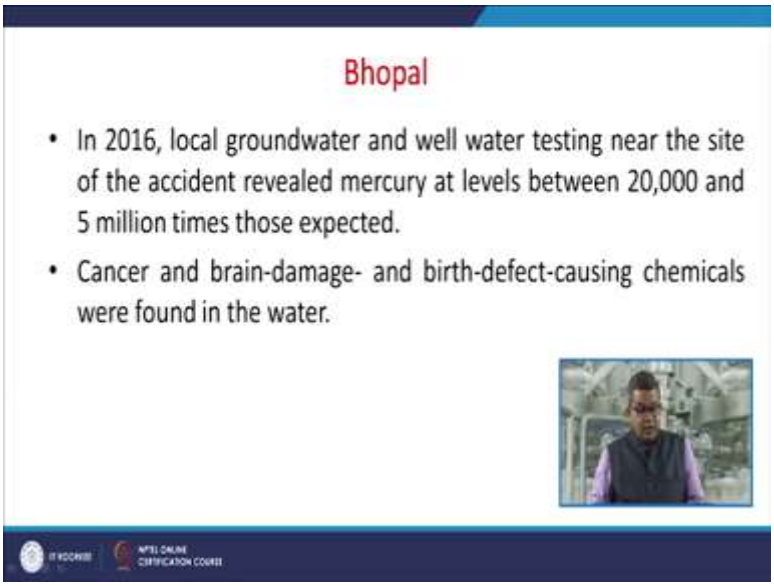

So in 2016 the local groundwater and the well water testing near the site of the accident they revealed that mercury level between 20,000 and 5 million times of those expected cancer and brain damage and birth defect, they are causing chemicals they were found in the water.

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So let us have a look about this accident, so at the start we would like to have a brief knowledge about the company and its management. So the Union Carbide they began its operation in India way back in 1904, in 1983 they were having 14 plants operating in the country and at the time of

accident the Union Carbide India Limited was owned by 50.9% by the American parent company that is Union Carbide Corporation and 49.1% by Indian investors. The Union Carbide India Limited they began operation in Bhopal in 1969 and initially this plant was formulated the carbamate pesticides from the concentrate they used to import from United States West Virginia plant. In 1975, they were licensed to manufacture its own carbaryl with the trade name of seven.

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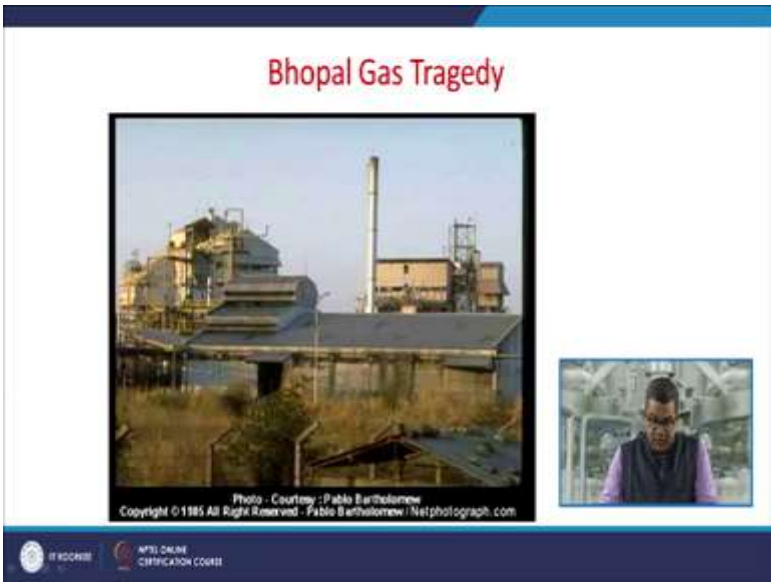

Now, this is the photograph of Union Carbide Bhopal facility.

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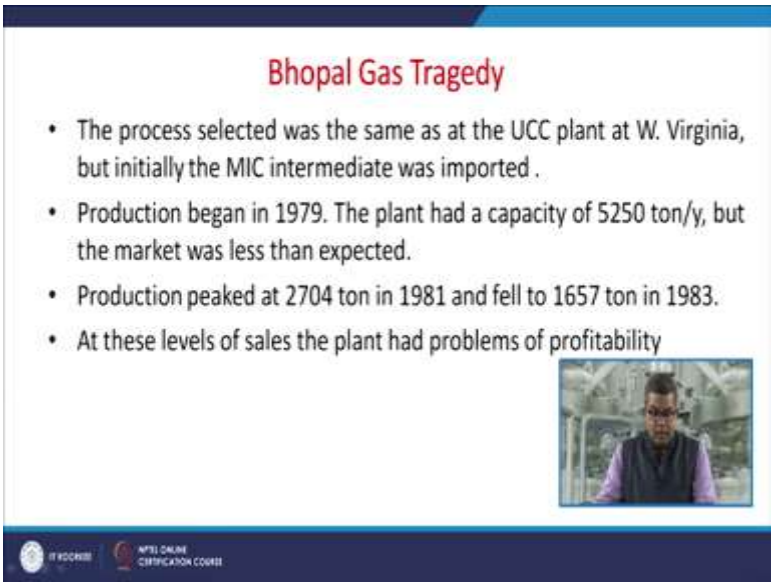

Now, the process which they selected was the same as the Union Carbide plant that West Virginia but initially the MIC methyl isocyanate intermediate, they tend to import from United States. They began the production in 1979 and initially the plant had the capacity of 5250 tons per year, but the market was less than expected. Now this while the analyzing the root cause of accident we can remember that the market scenario was not up to the mark for the Union Carbide and this is one of the reason why they have cutted down several other safety measures because the plant was running under loss.

So the production peaked at 2704 tons in 1981 and fell down to 1657 tons in 1983, so at these level the sale of the plant had the problem of profitability and that is why they were forced to cut the several safety measures and other trained workers.

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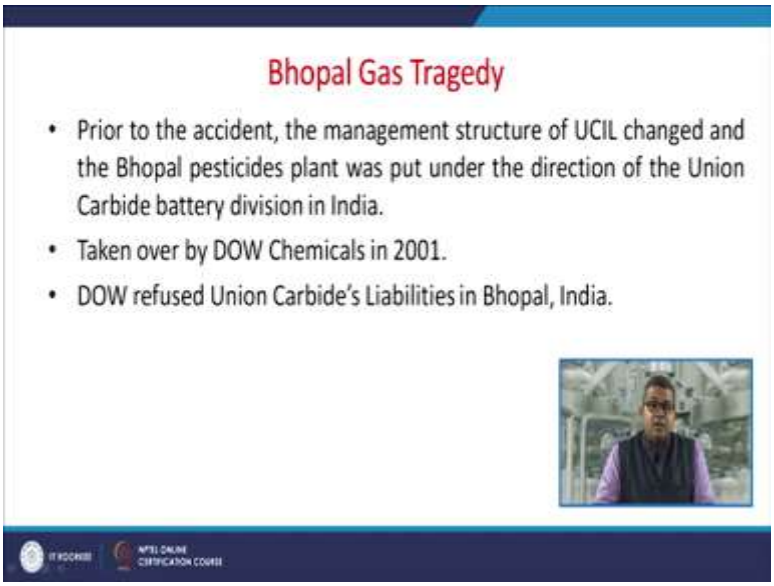

So the prior to the accident, the management structure of UCL changed and the Bhopal pesticide plants was put under the direction of Union Carbide battery division in India and the entire Union Carbide operation globally was taken over by DOW chemicals in 2001, but DOW Chemical they refused to take any kind of Union Carbide's liability in Bhopal.

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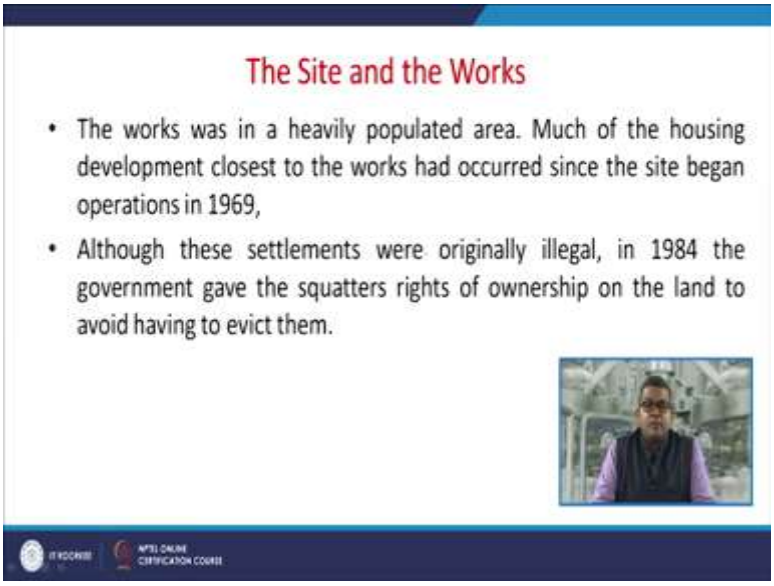

So let us have the site and work, the work was works was in heavily populated area and much of the housing development close this to the work at occurred since the site began operation in

1969. So that attributed of the human value because the people they used to have a tendency to settle down near the workplace so that the commutation time and charges may cut down, that was the reason why the illegal settlements they were coming up the site at the vicinity of the Union Carbide plant. So in 1984, the government gave the squatters right of ownership and the land of to avoid any kind of eviction problem for those originally illegal settlements.

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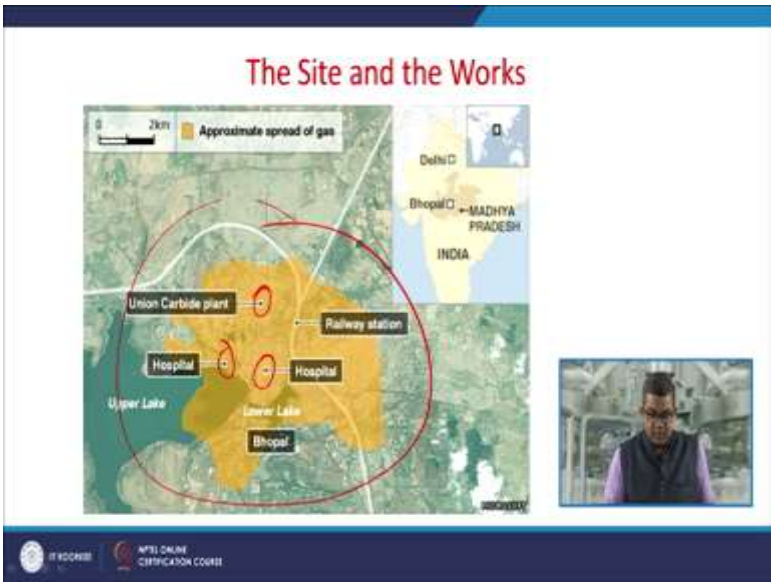

So this is the site in Bhopal and this is the site of that particular Union Carbide, this is the Upper Lake and this was a Union Carbide plant and these two are the nearby hospital and this is the railway line.

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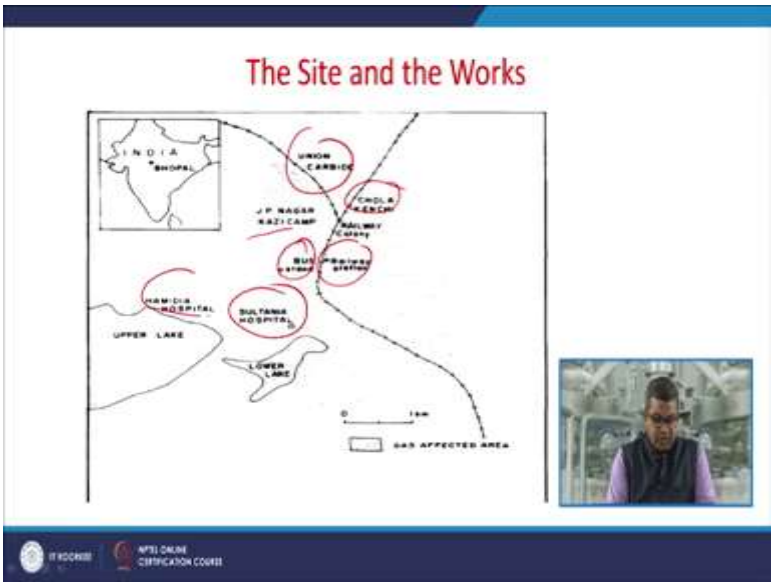

Now you can have a more, the more specific look of this site, this was a Union Carbide plant just into the JP Nagar and Akagi camp and Chula Kimchi and bus-stand, railway line they were two hospitals Hamidia Hospital and Sultania Hospital.

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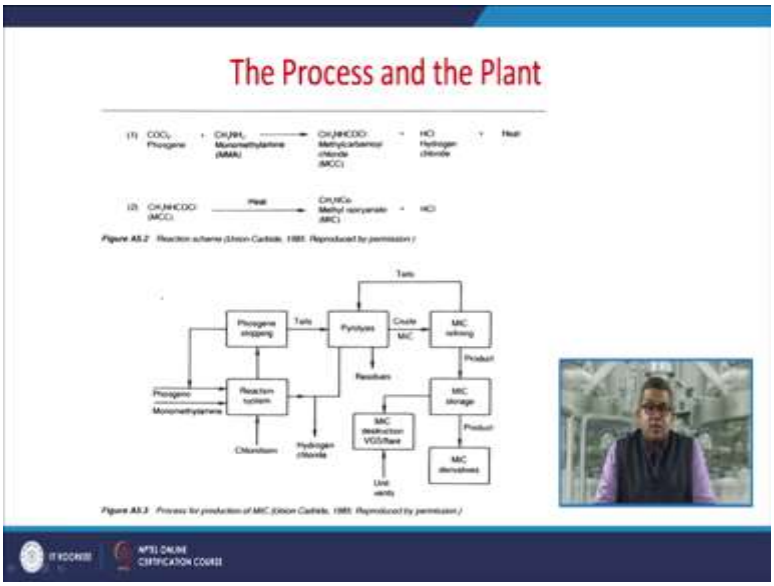

Now this is the process because this is the prima facie this is important aspect to for any accident investigation to have a look of the process and the plant scenario. So the Union Carbide they used to produce phosgene on sites of phosgene they used to react with the mono methyl amine MMA to give the methyl carbamyl chloride MCC with hydrogen chloride and little bit amount of heat being liberated. So this is purely an exothermic reaction. Now this methyl carbamyl chloride is destructive distillation, this is subjected to the production of methyl isocyanate and HCL.

Now this is the flow diagram of the entire production facility the phosgene in mono methyl amine, this was a reaction system where this was the chloroform quenching was given and then this entire content is subject was subjected to the pyrolysis and through pyrolysis the product MIC is subjected to the refining it is subjected to the MIC storage and different derivative streams and whatever left behind like tales et cetera they are sent back to the pyrolyzer, et cetera and hydrogen chloride and et cetera they are just as a reaction byproduct.

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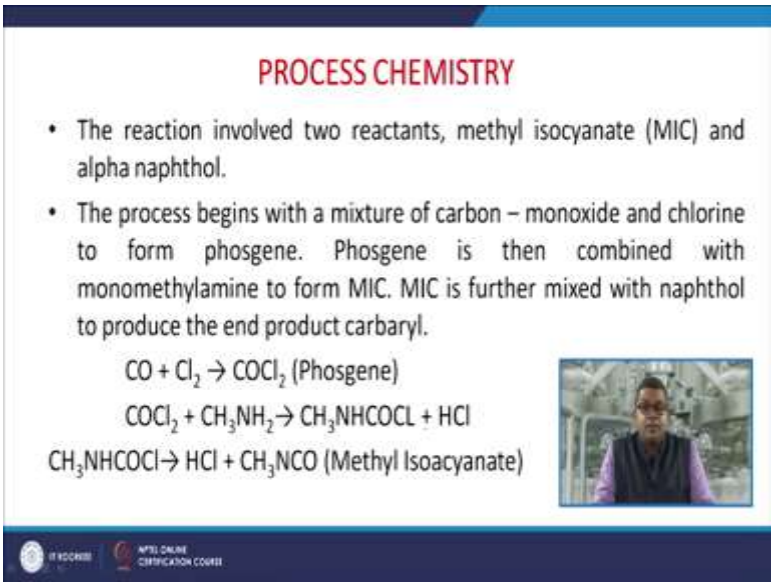

So basically the reaction involved two reactants methyl isocyanate and alpha naphthol the process begins with the mixture of carbon monoxide and chlorine to produce phosgene and phosgene is then combined with mono methyl amine like in this particular slide to form MIC. Now MIC is further mixed with naphthol to produce the end product carbonyl. So this was the entire stream and the chemical reactions are given in this particular these lines.

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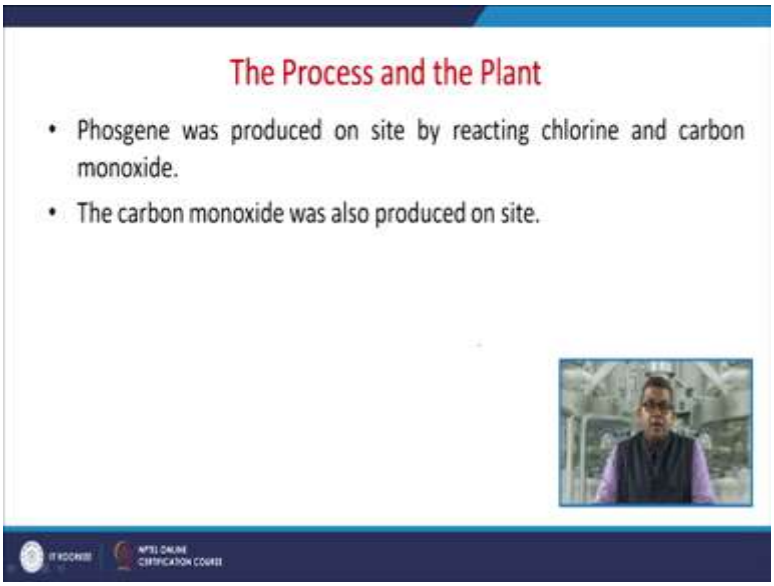

So phosgene was produced on site by reacting chlorine and carbon mono oxide and this carbon monoxide was also produced on site. So that is why when the initially whatever gas was leaked the prima facie formation provided by Union Carbide to the local authority that it is chlorine. So the treatment of chlorine and is entirely different with methyl isocyanate. So we will discuss this particular aspect in due course of time.

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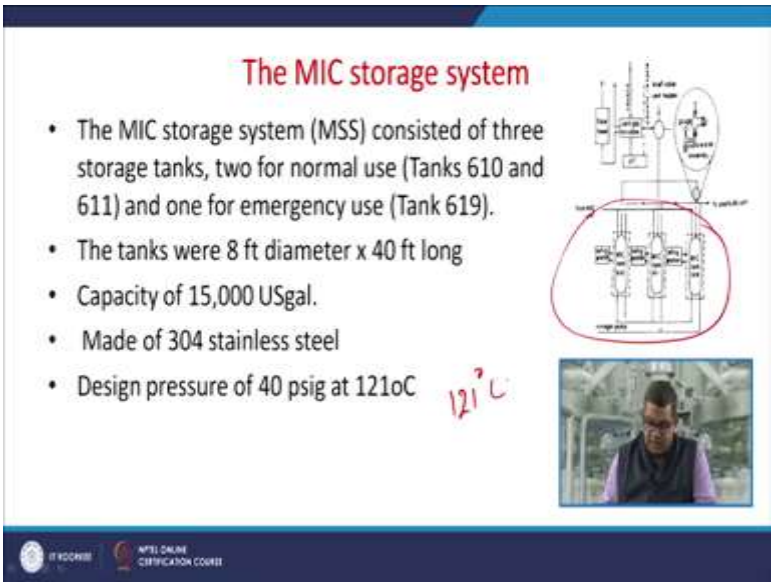

Now let us have a look of the main problematic area the MIC storage system, the MIC storage system consisted of three storage tanks two for normal use that is tank number 610 and 611 and one for the emergency use and that was named as a tank number 619 so you can see the entire storage battery over here, these tanks were 8 feet in diameter and a 40 feet long and the capacity of each tank was15,000 US gallon and they are made of SS 304 and the design pressure of each tank was 40 PSIG at 121 degree Celsius of the temperature.

Now, these are the critical parameters because when the accident took place the temperature was on the higher side as well as the pressure was on so and the higher side and every tank or this entire storage battery was fitted with the different types different safety measures like they were having the vent gas scrubber, they were having the flaring tower and they were having the relief valve vent header and these were the probable these were the cause of the release. So in a nutshell when we will discuss all these things, let us have a primarily look of the root cause somehow the pressure inside any tank was built up and MIC was escape through the relief of valve vent header, which was the primarily meant for the taking care of pressure release.

Now this is subjected to the vent gas scrubbers so sometimes if any kind of they will leak of MIC then it can be scrubbed out with the help of a caustic solution and whatever off gases they are, that could be the flared off. So the entire assembly or entire plant they were having very good safety norms. Now, there are two issues one is that since they know they were very much aware

about the gravity of this MIC, why the proper information was not passed in on and second issue is that why these safety devices was not actuated at the time of accident. So we will discuss this these things in due course in this particular module.

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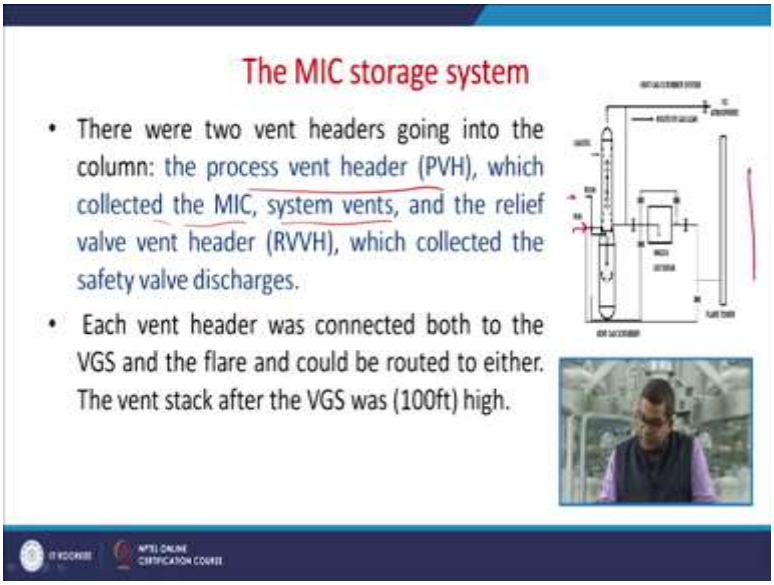

Now let us have the autopsy of these safety devices, so there were two vent headers going into the column, one was the pressure vent header PVH this one and which collected the MIC system vent and the relief valve vent header this one, this is the safety device which collected the safety valve discharge. So they were having the safety valve, so whatever discharge was there, they used to collect through relief valve vent header and whatever the system vents are there or MIC this is collected to the process vent header. So each vent header was connected both to the VGS and the flare and could be routed either and though the vent is take after the VGS was a 100 feet in height.

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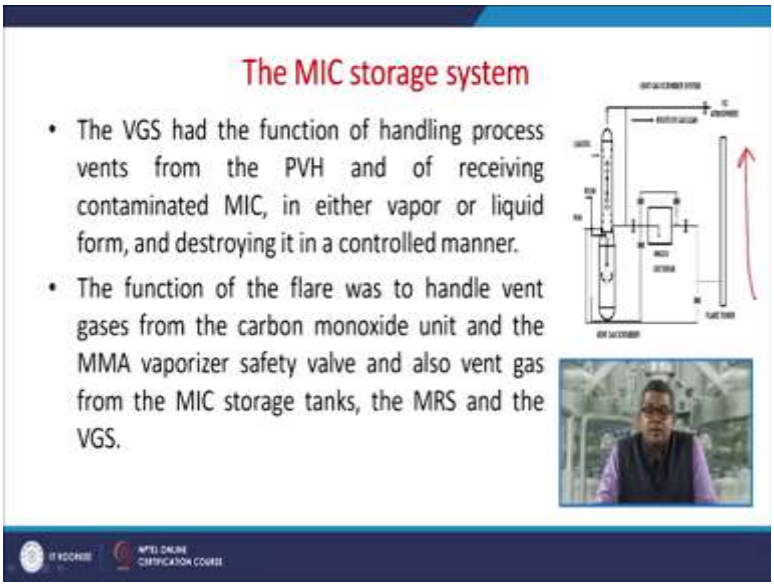

So VGS, the vent gas scrubber had a function of handling the process vents from PVH and of the receiving contaminated MIC in either vapor or a liquid form and destroying it in a controlled manner. So the function of the flare was to handle vent gas from the carbon monoxide unit and MMA vaporizer safety valve and also vent gas from MIC storage tank and MIC refining still and the vent gas scrubber. So all the things whatever the dangerous thing they were ultimately subjected to this flaring tower to have a destructive flaring off.

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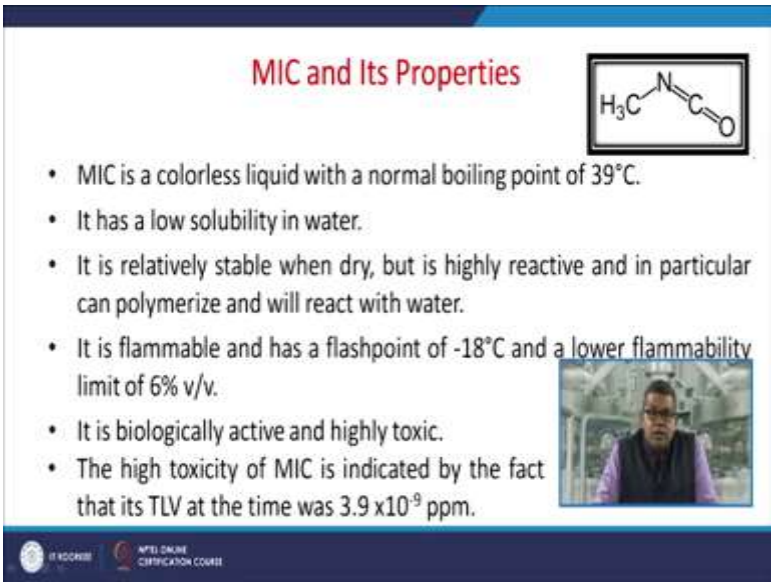

Now let us have a look of methyl isocyanate and its property, so we are discussing the abridged MSDS of methyl isocyanate. So methyl isocyanate is a colorless liquid with a normal boiling point of 39 degrees Celsius, it has a very low solubility in water, it is relatively stable when dry but is highly reactive and in particular it can polymerize and will react with water, now it is flammable and has a flash point of minus 18 degree Celsius and a lower flammability limit of 6 percent volume by volume. Now, it is biologically active and it is extremely toxic in nature, the toxicity of MIC is indicated by the fact that its TLV is very low at the time of accident, it is very low.

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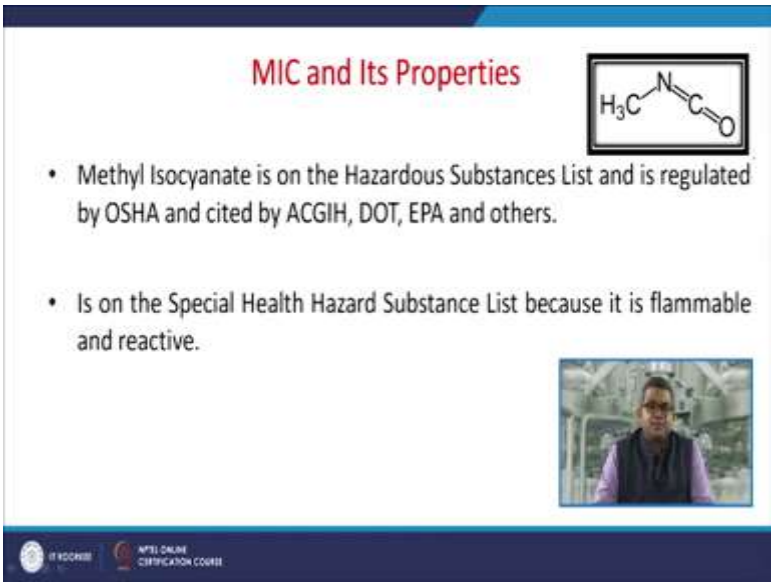

The this MIC is on the hazardous substance list and as regulated by OSHA that is Occupational Safety and Health Administration, United States and cited by ACGIH, Department of Transportation, Affluent Protection Agency and others so is on the special hazard substance list because it is flammable and extremely reactive.

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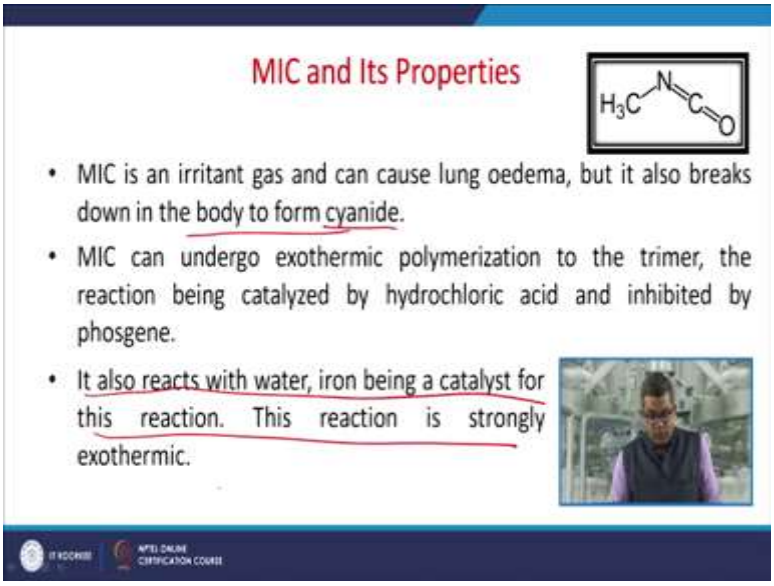

Now, this MIC is an irritant gas and can cause the lung edema but it also break down in the body to form the cyanide, so the root of this breakage is again important and because it was the root

cause of so many fatalities. Now this MIC can undergo the exothermic polymerization to the trimer and the reaction being catalyzed by the hydrochloric acid and inhibited by the phosgene. So it also reacts with water and iron being a catalyst for this reaction and this reaction is strongly exothermic. Now this reaction took place in the storage facility of MIC and that was the root cause of that particular accident.

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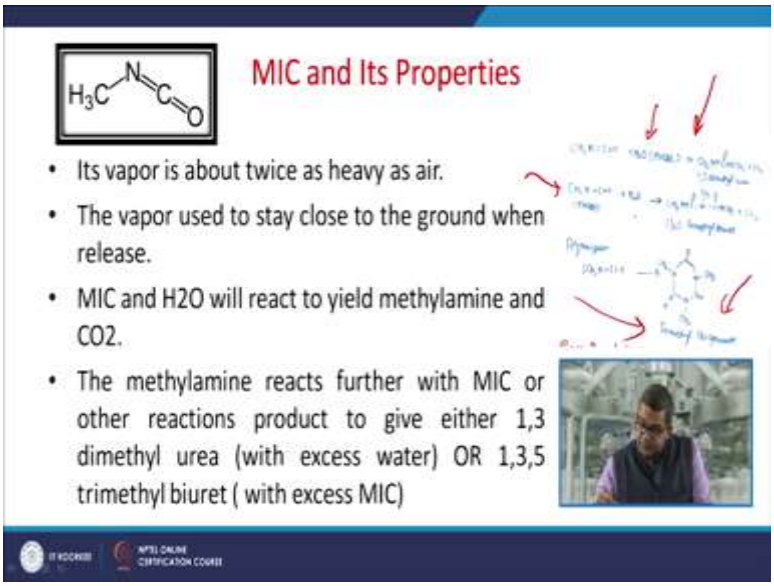

Now its vapor is the twice as heavy as the air, the vapor used to stay close to the ground when it release the MIC and water they react to yield the methylamine and CO2. Now we have presented two reaction streams, one is in when the water is in excess to it produces 1, 3 dimethyl urea this one and when MIC is in excess then it produces 1,3,5 trimethyl biuret. So upon polymerization it gives the tri methyl isocyanate, which was the cause of that the formation of this particular component was the cause of this worst tragedy.

So the methylamine they usually react further with MIC and other reactant they produce to give this 1, 3 dimethyl urea. So we have presented these two reaction stream for the better look that what was the root cause and if water is in excess, then we can have this one and if this MIC is in excess then we can have this one.

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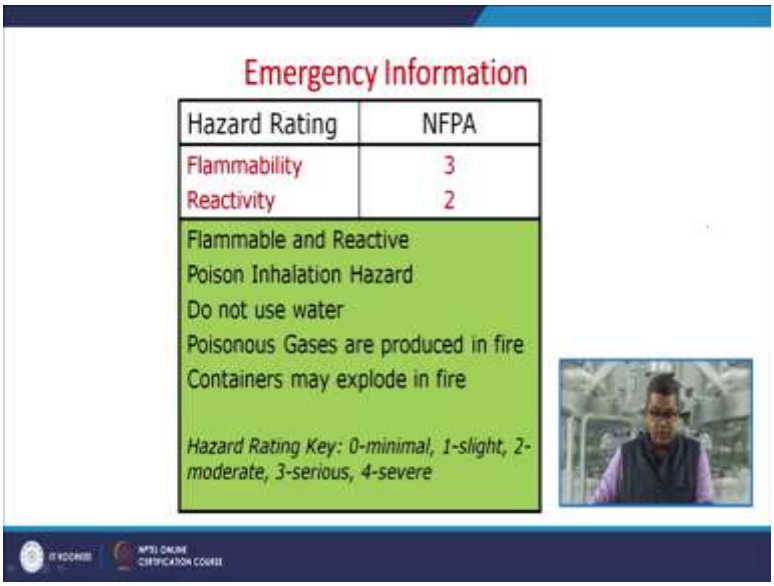

Now this is the emergency information and the hazard rating, it is extremely flammable. So the flammability rating is given by 3 and the reactivity in is on the again on the higher side and it was given as 2. So it is flammable and reactive the poison inhalation hazard and it is an advisory while using MIC that do not use water because we have seen in this particular slide that it may react with water to form the isocyanate, this poisonous gases they are produced in fire containers may explode in fire.

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Now at the time of accident the various other chemicals they were dumped by Union Carbide in Bhopal facility and these chemicals they are listed over here methylene chloride, methanol and some of them are being used for various kind of reaction remember they used to produce phosgene from carbon dioxide and chlorine and this phosgene is being used to produce MIC and other products. So they maybe they might be using variety of the chemicals in the factory like different solvents, different catalysts like trimethyl amine they were using as a catalyst some sort of ingredients they were having the various products like carbaryl, LD carb etc.

Now in this particular slide we have enlisted that the nature of original pollution maybe in air sometimes some chemicals they intend to pollute the air, water and soil etc. Similarly mercury, they were having one metric ton of mercury, which is extremely dangerous substance. So it may contaminate the water and soil so they were having a large inventory of the chemicals in the plant and we have enlisted the amount that was dumped in by Union Carbide in Bhopal facility, so that was in again on the excess side.

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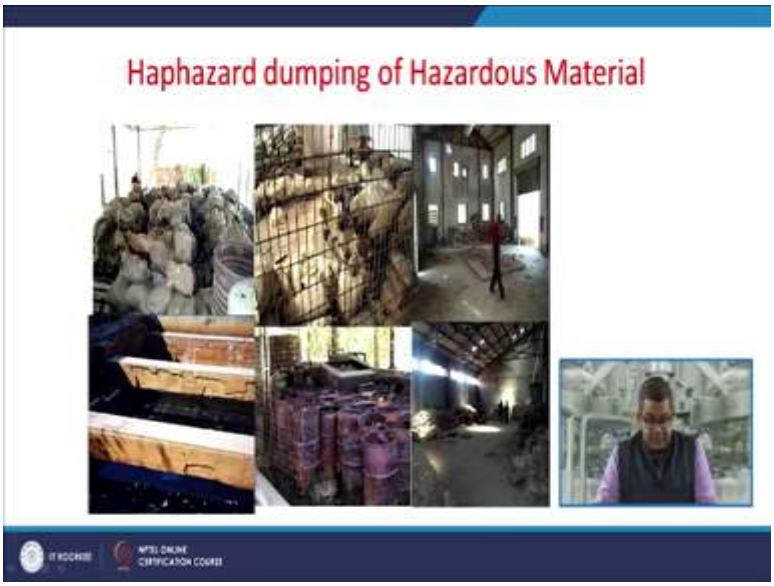

So you can have a look up these haphazard dumping of hazardous materials like this so they were not following the proper protocol of storage of for these chemicals.

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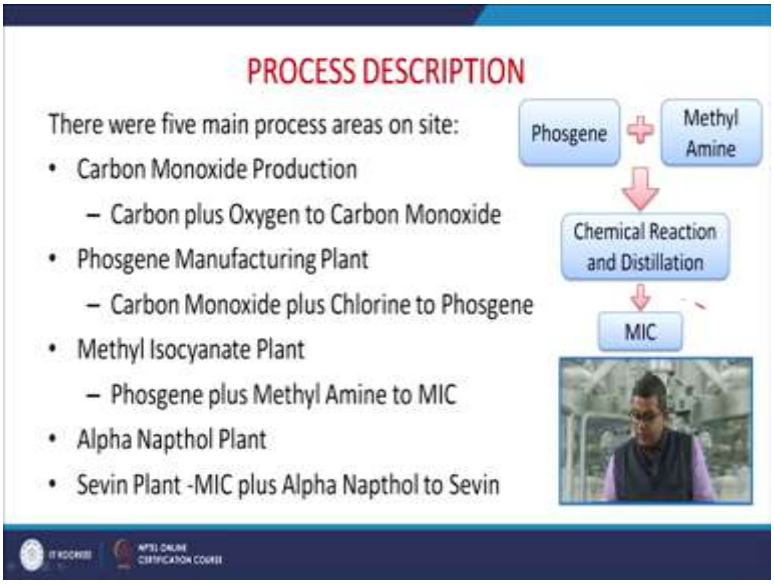

Now, let us have a look about the process description, so there were five main process arena, carbon mono oxide production with the help of carbon plus oxygen to give the carbon monoxide, the second was the phosgene manufacturing unit this the carbon mono oxide plus chlorine to produce the phosgene then they were having the MIC plant that is phosgene plus methylamine to

produce the MIC then they were having the alpha naphthol plant to produce a Sevin that is MIC plus alpha naphthol. So this one is the more elaborative that is phosgene plus methylamine and the chemical reaction distillation to give the MIC.

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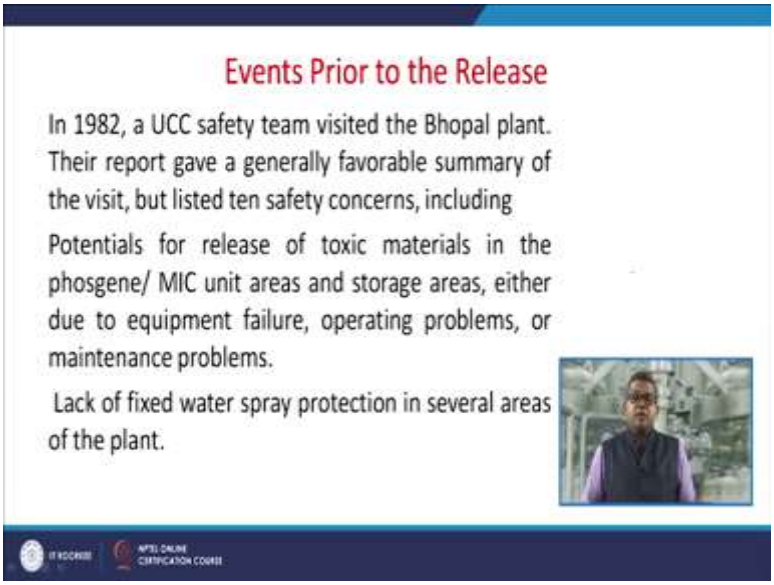

Now there are several events attributed to the prior to the release, so in 1982 Union Carbide Corporation team from United States and especially they were having to some safety persons they visited the Bhopal facility so their report usually gave a favorable summary of the visit but listed ten safety concerns including the potential for release of toxic material in the phosgene or MIC unit area or storage area either due to the equipment failure or operating problem or some sort of maintenance problem, they enlisted the lack of fixed water spray protection in several areas of the plant.

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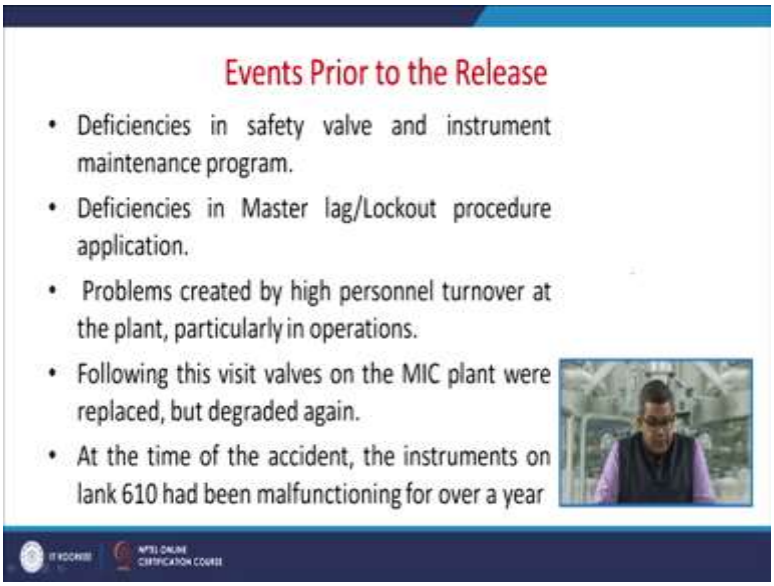

They notice several deficiencies in safety valves and instruments maintaining program, they reported the deficiencies in master lag lockout procedure or application, there were several problems they were created by the high personal turn over at the plant particularly in operation. We have already discussed this personal turnover because of the reason plant was running in loss. Now following this particular visit the valves on the MIC plant they were replaced but they were degraded again. So they never noticed by why these MIC valves they were degraded again and again.

So if they have noticed and if they have analyzed this particular aspect the problem can be rectified much earlier than this worst accident. So at the time of accident the instruments on tank number 610 had been malfunctioning for over a year and that was an outcome of a safety review.

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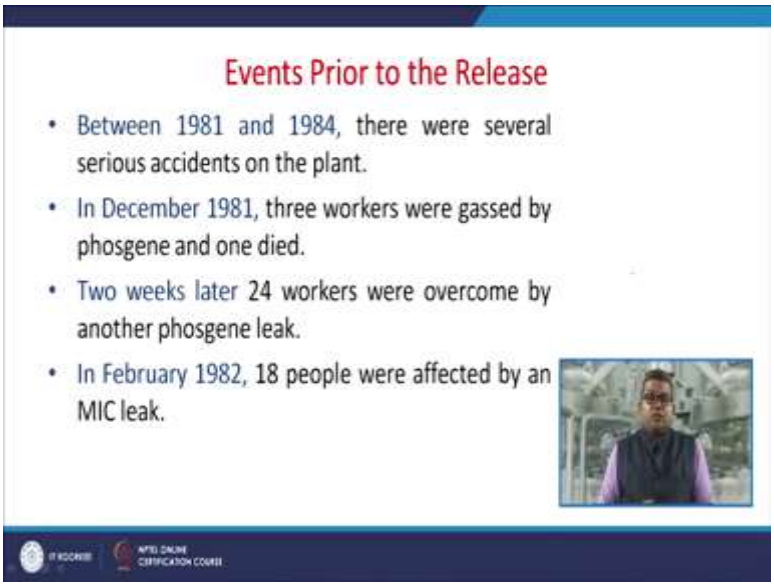

So between 1981 and 84, there were several serious accidents on the plant in December 1981 three workers were gassed by the phosgene and one died, but they never investigated the root cause of this one, a two weeks later 24 workers say they were overcome by the another phosgene leak in February 1982, 18 people they were affected by an MIC leak.

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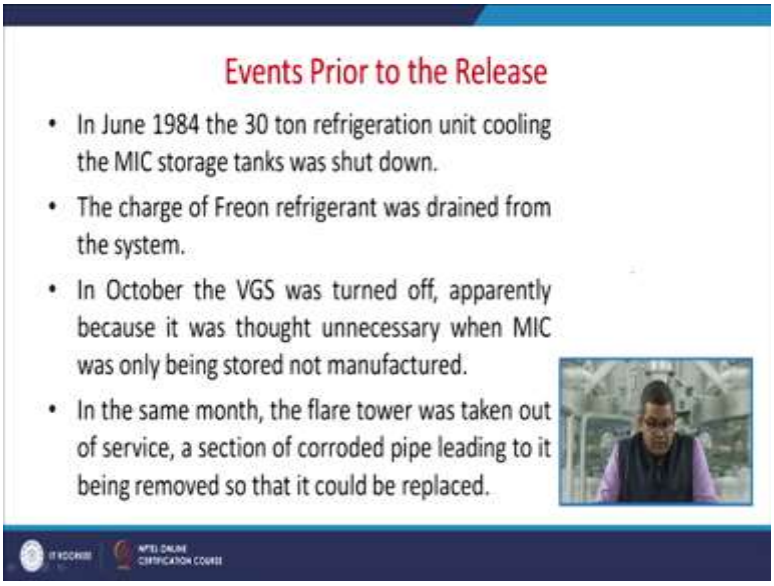

In June 1984, about 10, about 30 ton refrigeration unit cooling the MIC storage tank was shut down and the charge of the Freon refrigerant was drained from the system. The again the reason

was that they were not producing MIC in the continuous fashion, only the they were intended to store that MIC. So that is why they turned on off this refrigeration plant. So on October the vent gas scrubber was is turned off apparently because it was thought and necessary when MIC was only being stored not manufactured. So in the same month, the flare tower was taken out of service section of corroded pipe leading to being it was removed so that it could be replaced. So the timely replacement and timely repairing of the corroded pipe was not taking place in the time of accident.

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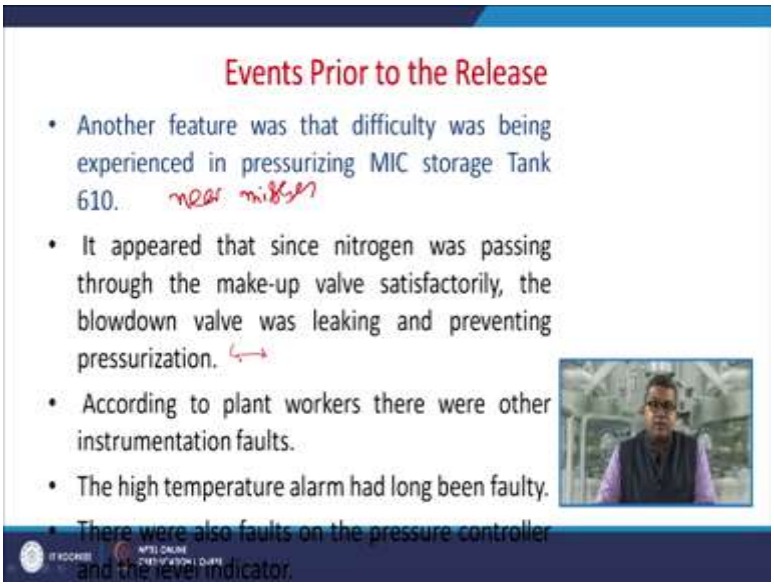

Now another feature was that there was a difficulty being experienced in pressurizing MIC storage tank so you can say that if they notice this type of thing in a priory, then it is a case of near misses. So it appeared that since nitrogen was passing through the makeup valve satisfactory the blow down valve was leaking and the preventing pressurization. So they noticed and they try to analyze but they failed because of lack of technical competency or a lack of knowledge. So according to the plant workers there were other instrumentation failures like high temperature alarm had long been faulty, there were also faults on the pressure controller and other level indicators.

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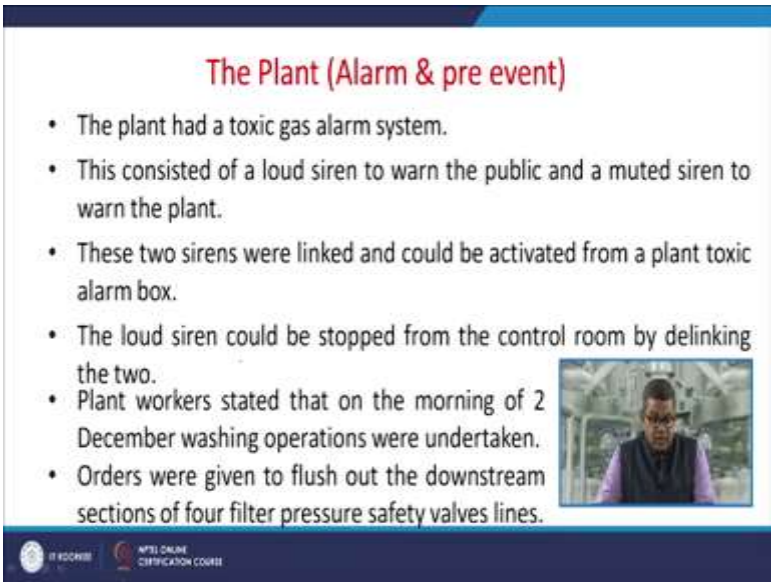

Now, this particular plant was because of the gravity of and the sensitivity of that particular component they were having a very good system of alarming, they were having very good system of safety but the question was at the time of accident none of them was working properly. So the plant had a toxic gas alarm system this consisted of a loud siren to warn the public and a muted siren to warn the public so that sometimes they used to operate the muted siren. Now if they use this loud siren, then it, there may be unnecessary there may be a panicky situation for the outside public. So that is why they were having the two different types of sirens within the plant periphery.

Now these two sirens they were linked and could be activated from plant toxic alarm box now the loud siren could be stopped from the control room by delinking the two so the plant worker they stated that on the morning of 2nd December washing operation was carried out and the plant officials they are given the orders to flush out the downstream section of four filter pressure safety valve lines.

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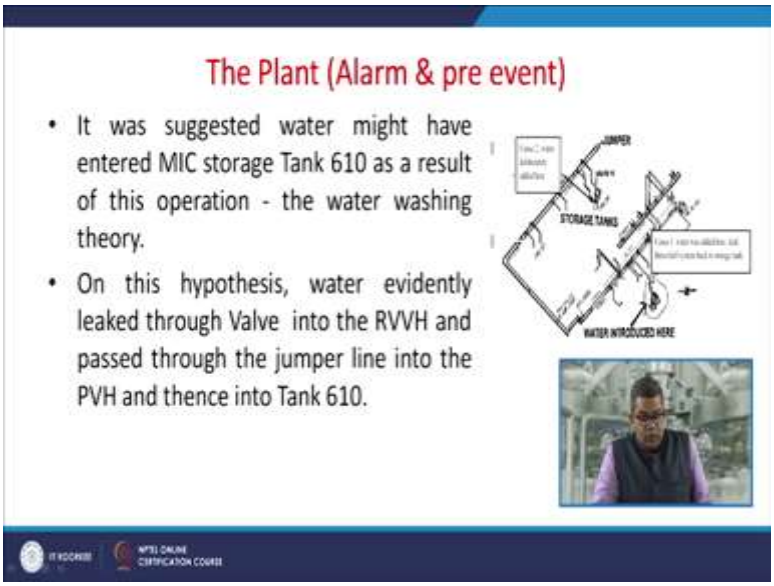

Now, it was suggested that water might have entered into the MIC storage tanks 610. Now this was the storage tank battery. Now they have anticipated that there were two causes, one cause was that the water was deliberately added to this point of time for another cause that to water was added there and leak through the relieve system back to the storage tank. So if this possibility persists then again there was a lack of training because the primary it is required that blind or a blank should be inserted to prevent the entry of water to the storage arena.

So on this particular hypothesis, the water evidently there leaked through the wall into the relief vent valve header and passed to the jumper line into the process vent header and then into the tank number 610.

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Now these are the jumper lines, now this is the actual figure of the jumper line.

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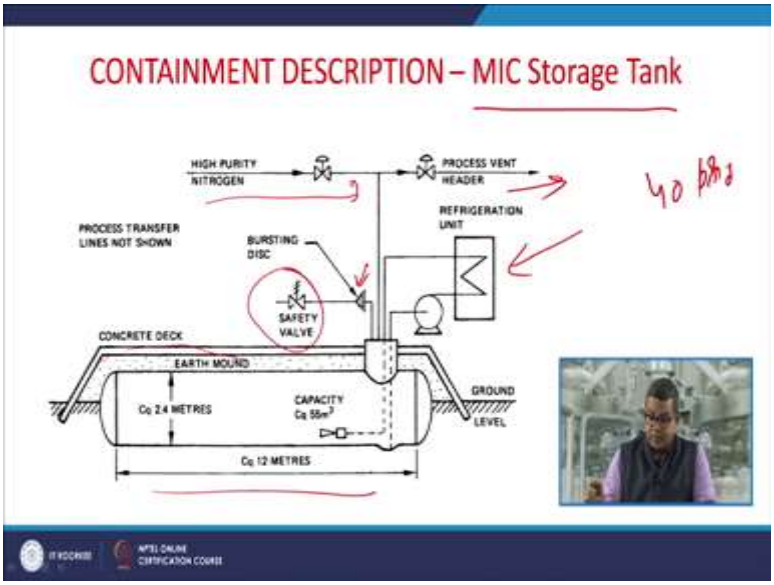

So when it was entered into the storage tank, so let us have a containment description that is the MIC storage tank. Now this MIC storage tank was having the diameter of 2.5 meter the length of 12 meter, it is duly supported by the safety valve with the busting disc, this is equipped with the refrigeration unit. It is having the ground level concrete deck and we have already discussed that

the design pressure was 40 PSIG and it is having the high purity nitrogen blanketing system and there was a process vent had a line.

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Now this is picture of the tank as on today, now it is just unearthed and so that it can be inspected clearly.

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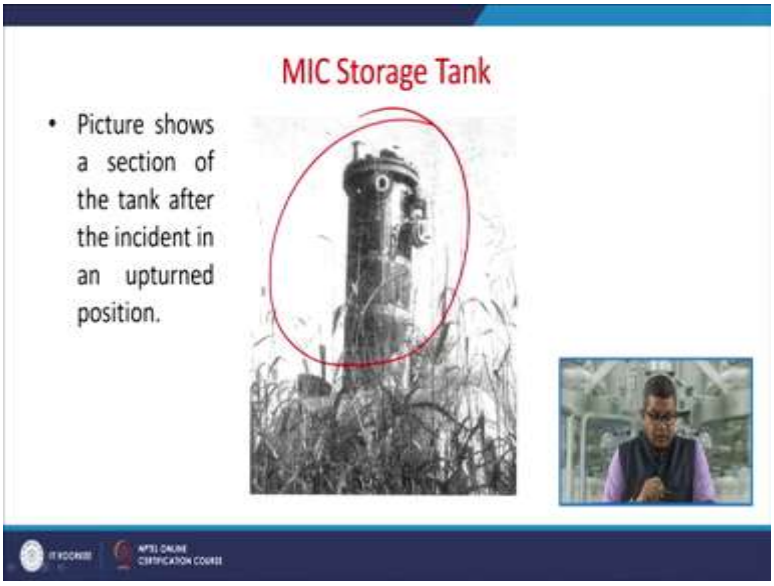

Now this is the picture of a section of the tank after the incident upturned position.

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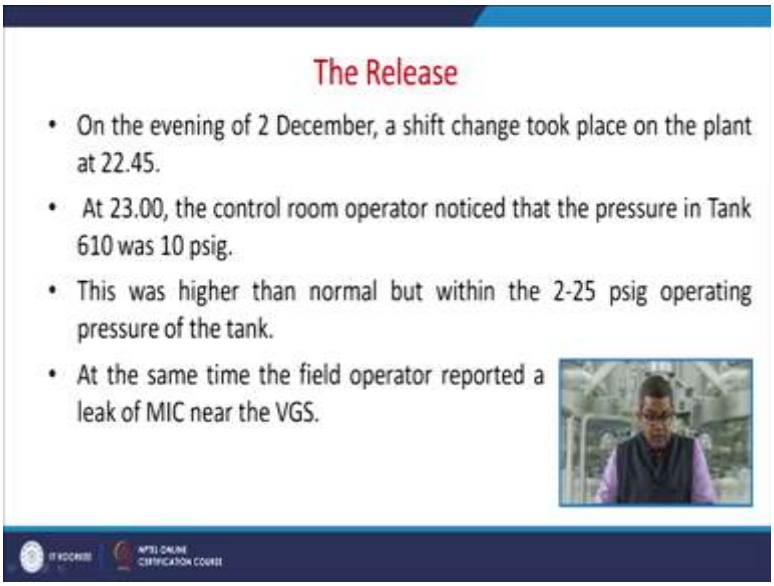

Now, let us talk about the release, so on the evening of 2nd December a shift change took place on the plant at around quarter to 11:00 p.m. At 11 pm the control room operator he notices the pressure in the tank 610 was 10 PSIG. So it was bit higher than the normal one, but it is within the safe range of 2 to 25 PSIG. Remember the design pressure of the storage tank was 40 PSIG. So at the same time the field operator he reported a leak of MIC near the vent gas scrubber.

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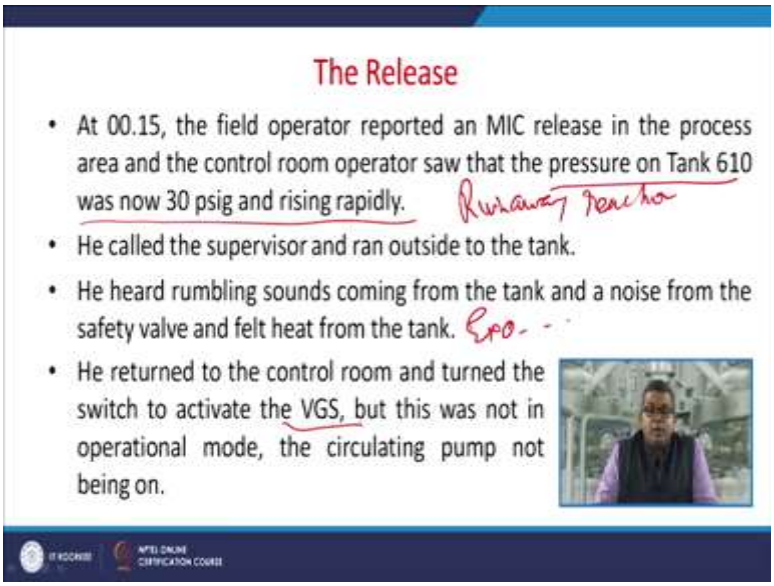

So at 12:15 am and the field operator reported in MIC release in the process area and the control room operator saw that the pressure on the tank 610 was now 30 PSIG and rising rapidly, that means the chance of runaway reaction, that is the runaway reaction. So he called the supervisor and ran outside to the tank and he heard the rumbling sound which was coming out from the tank and a noise from the safety valve and felt heat from the reaction, that means the exothermicity was on the higher side. So he returned to the control room and turn to the switch to activate the vent gas scrubber, but at this time it was not in operational mode because we have enlisted the event prior to the accident that this vent gas scrubber was turned off because they thought that MIC is being stored not continuously produce. So he tried to open the circulating pump, which is again not in the operational mode.

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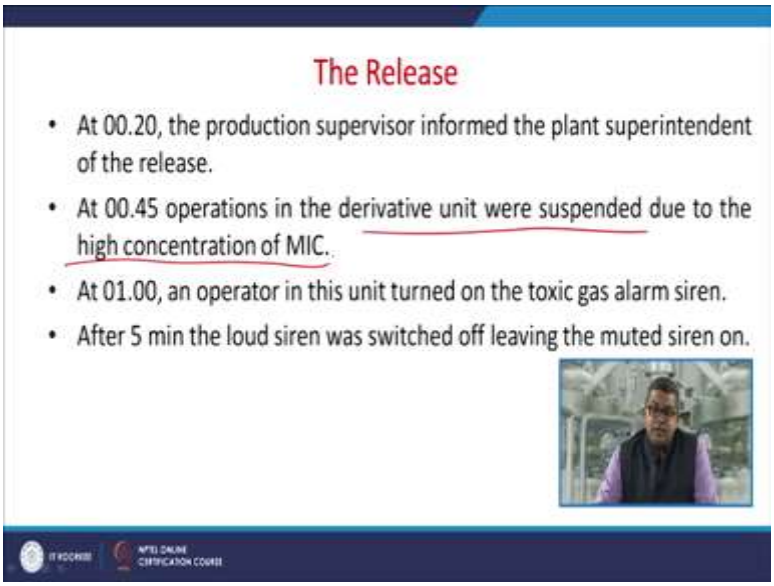

So at 12:20 a.m. in the morning the production supervisor informed the plant superintendent about the release and a quarter to 1:00 am operation in the derivative unit was suspended due to the high concentration of MIC. Now the high concentration of MIC is attributed to the fact that MIC was continuously being released and the temperature was on the higher side because of the exothermicity of the runaway reaction and the pressure was again built up. So this attributed to the high concentration of MIC to the derivative unit.

So at 1 am an operator on this unit turned on the toxic gas alarm siren and after 5 minutes the loud siren was switched off leaving the muted siren on, that means they declared the emergency within the plant.

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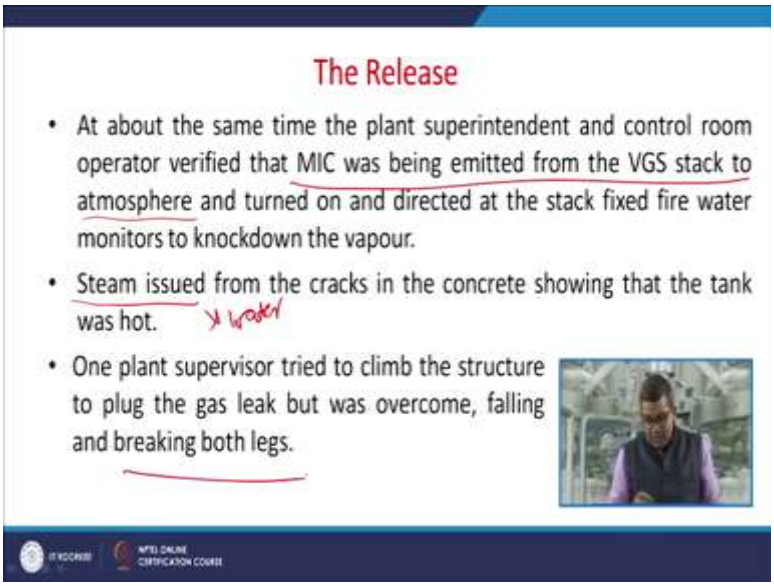

So at about the same time the plant superintendent in the control room operator verified that MIC was being emitted from the vent gas scrubber to stack to the atmosphere and turned on and directed at the stake fixed fire water monitoring system to the knockdown the vapor. Now steam is you continuously issued from the crack in the concrete showing that the tank was hot. Now the reason of the steam that the water was inside the tank and a runaway reaction they that was leading towards the exothermicity of the reaction and that was the cause of the steam generation within the tank 610.

So one plant supervisor he tried to climb the structure to plug the gas leak, but was overcome and falling and breaking both the legs. So that was the only injury took place within the plant premises.

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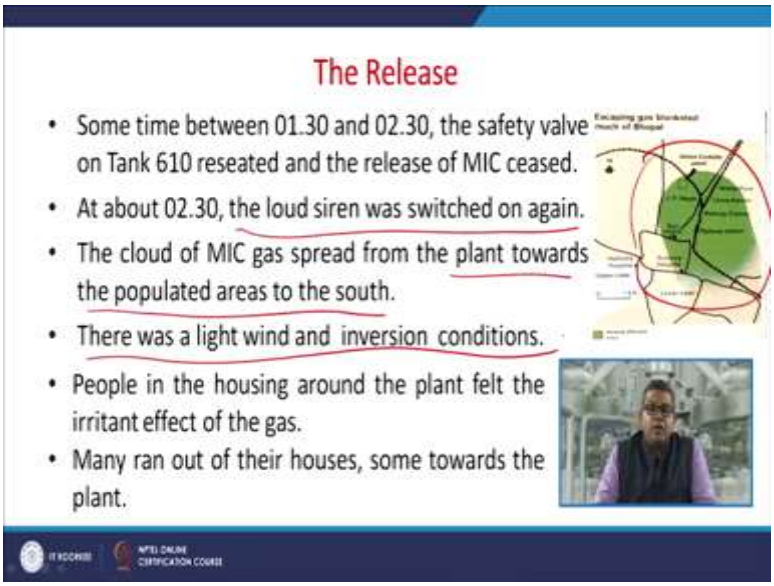

So sometime between 1:30 to 2:30 am the safety valve on tank 610 was reseated and a release of MIC ceased, this is attributed to the pressure lowering within the tank number 610. So at about 2:30, the loud siren was switched on again to sensitize the people around the plant premises. So the cloud of MIC gas spread from the plant towards the populated area to the south. So whenever you are performing any kind of accident investigation this type of meteorological information plays a very vital role while analyzing this investigation. So there was a light wind and inversion conditions because it was the month of December.

So people in the housing around the plant they felt the irritant effect of the gas so many ran out of their houses and some towards the plant to inquire (with) what is wrong with this plant.

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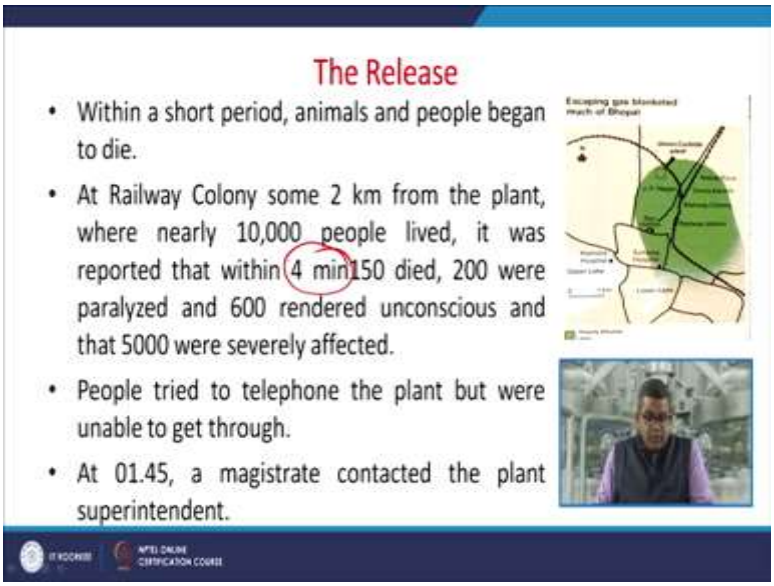

So within a short period of time animals and a people they begin to die and Railway Colony some 2 kilometers from the plant where the nearly 10,000 people lived, it was reported that within four minutes 150 died, 200 was paralyzed and 600 render the unconsciousness and 5,000 they were severely affected. So people tried to telephone the plant but because the time you can see that it was 4 minutes, so they try to contact the plant official but were unable to get through.

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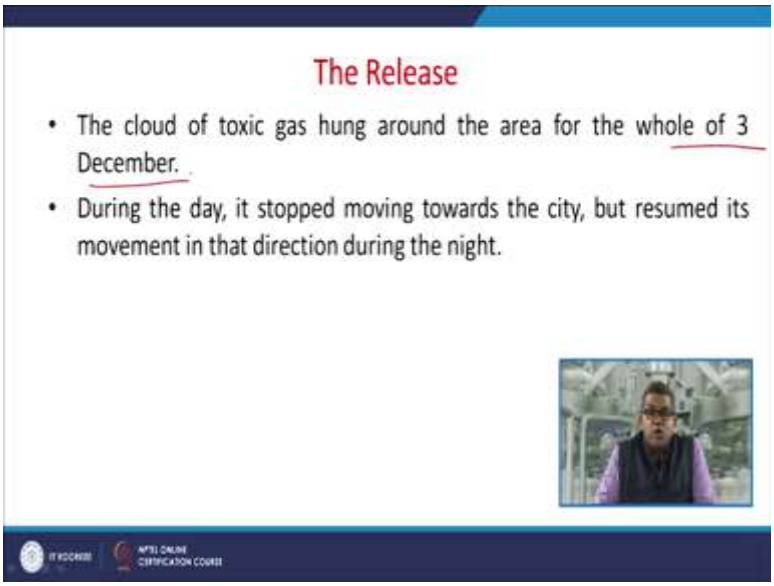

So at quarter to one, magistrate contacted the plant superintendent and still the cloud of that particular toxic gas hung around the area for three for entire 3rd December 1984. So during the day it is stopped moving towards the city but resumed its movement in the direction during the night. Now at that particular time, it was the duty of the plant official to provide the adequate knowledge to the local authorities because it is one of… and practically they knew that this is the MIC and they knew that how worst this particular chemical is.

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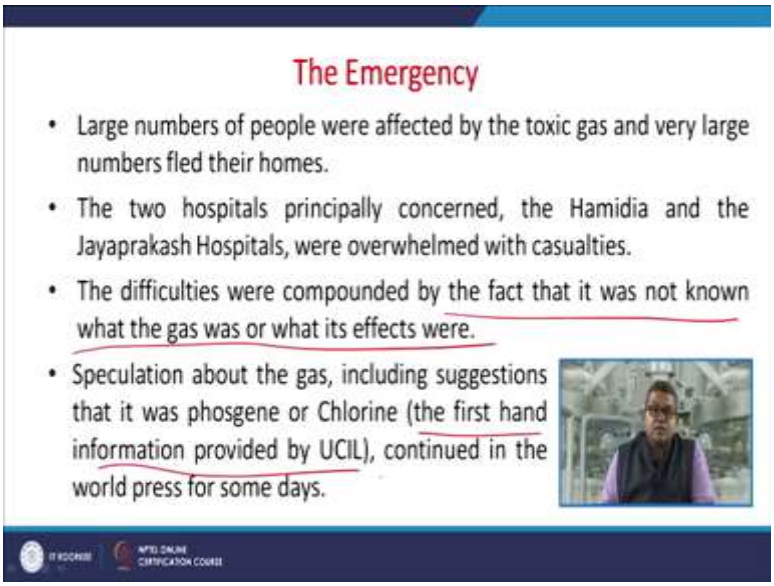

Then there was a scenario of emergency and a large number of people they were affected by the toxic gas and a very large number fled their homes and two hospitals Hamidia and Jayaprakash they were flooded with the people and the casualties and difficulties were compounded by the fact that it was unknown what the gas was and what its effect were, that means the company provided a very low information for this particular aspect. So speculation about the gas including the suggestion that it was phosgene or a chlorine that is was the first hand information provided by the Union Carbide India limited. So if it is a chlorine then the remedial measures are entirely different with methyl isocyanate. So this is a purely a speculation at the time of the release.

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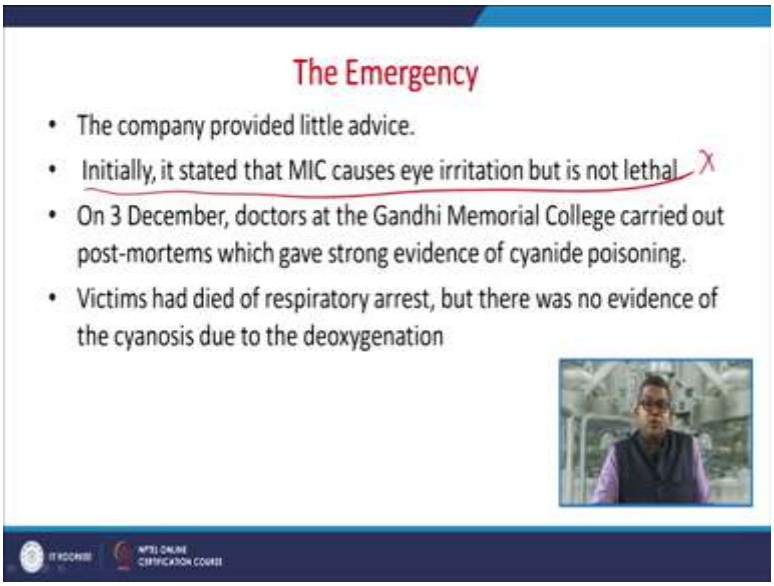

So that is why it is the company was charged that they provided very little advice in this context and if you recall that we have discussion about the MSDS. So in MSDS, usually it gives the information about any kind of spill or leak and what kind of the first aid treatment you require. So initially the company provided another information that MIC causes eye irritation and it is not lethal. However this is practically not true because MSDS gives a proper information. So on 3rd of December doctors at Gandhi Memorial College they carried out first autopsy, which gave the strong evidence of cyanide poisoning, then the cross investigation carried out so victims had died of the respiratory arrest and there was no evidence of the cyanosis due to the de-oxygenation.

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Now you can see that some of the photographs the people have experienced at the time of release.

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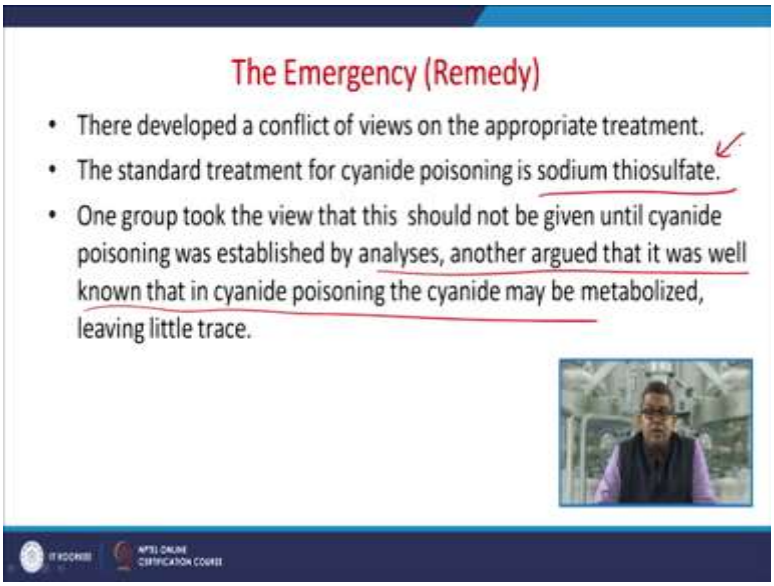

So the time half a million people were they were exposed and again, these are the some disturbing photographs. So now when there was a question of remedy, so they developed a conflict of views on appropriate treatment. The standard treatment for cyanide poisoning is sodium thiosulfate that is hypo solution. So one group took the view that this should be given until the cyanide poisoning was established by the analysis and other suggest that it was well known that the in cyanide poisoning the cyanide may be metabolized leaving a little trace. So people were fighting in with respect to the thoughts that what they need to give for the victims because the side sodium thiosulfate on its own having service several disadvantages.

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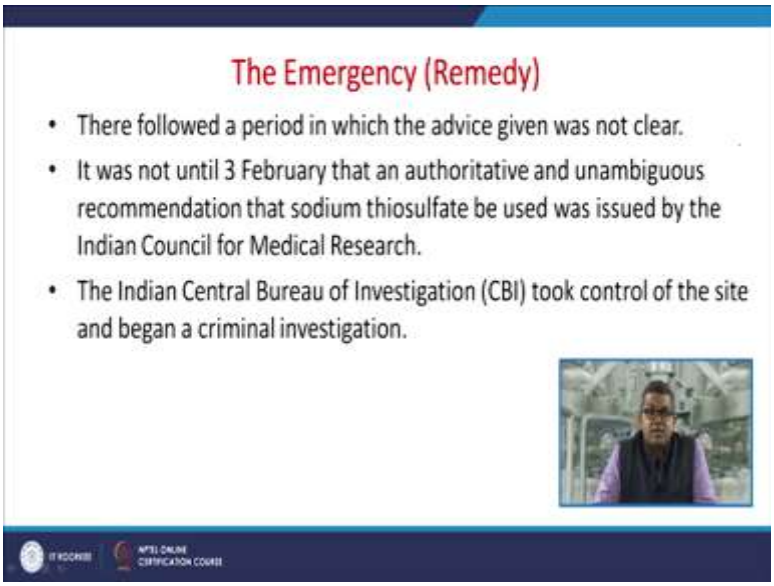

So there followed a period in which the advice given was not clear, it was not until 3rd of February that an authoritative and unambiguous recommendation that the sodium thiosulfate be used was issued by Indian Council of for medical research. Then at the time of incident the CBI, the Central Bureau of Investigation they took control the site and begin a criminal investigation.

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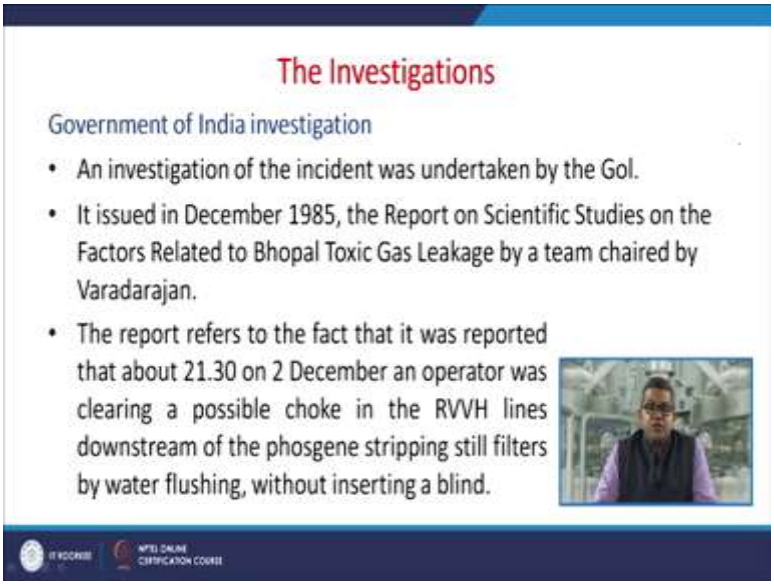

Now, the investigation was started in two fold one was the government of India they carried out the investigation another was carried out by the Union Carbide India limited. So let us have a

look about the government of India investigation the government of India undertaken the investigation aspect and formed an investigation team led by Professor Varadarajan and he was the chairman of council for scientific and Industrial Research at the time of accident.

So there the report refers the fact that it was reported that at around 9:30 pm on 2nd December an operator was clearing the possible choke in relief involvement header lines downstream of the phosgene stripping still filter by water flushing without inserting a blind that was the root cause why this accident into place.

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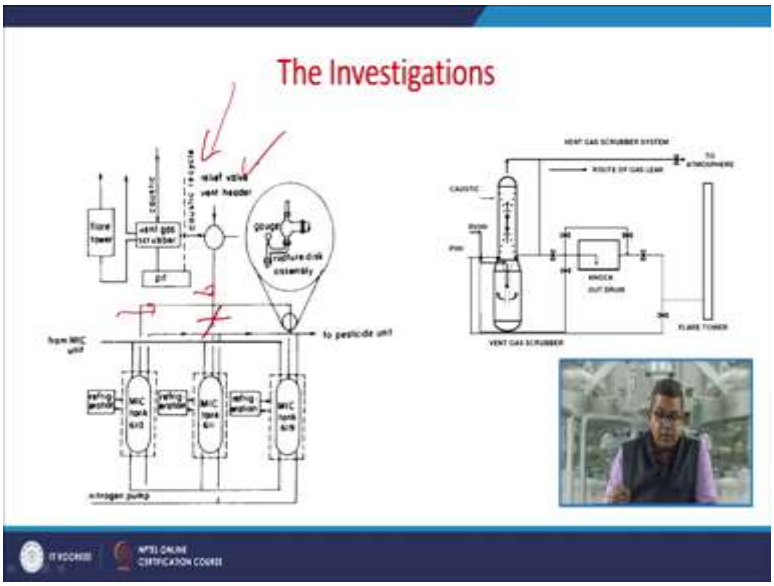

So this was the thing like this was the vent gas scrubber cost with the caustic and this was the relief valve head the vent header. So he was trying to clear the any kind of possible choke and in these lines, but he forget he probably he forget to insert a blind within this system.

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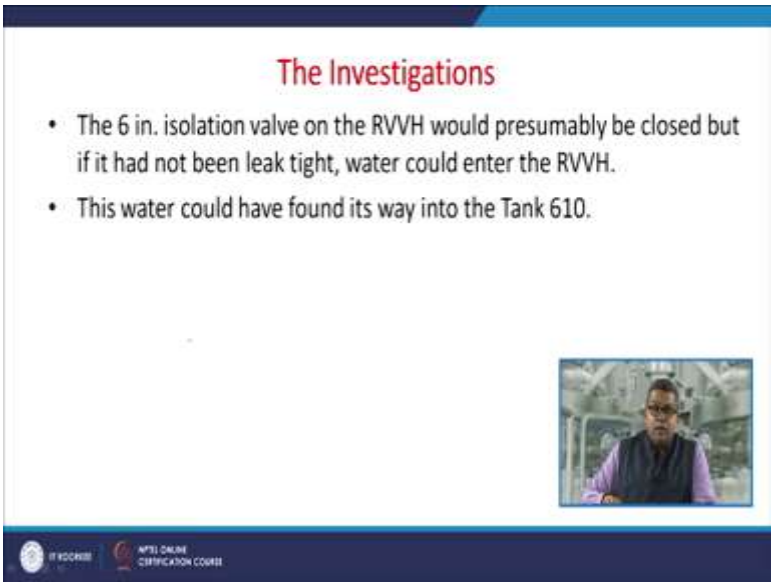

So a six-inch isolation valve on relief valve vent header would presumably be closed but if it had not been leaked tight water could enter the RVVH. So it was mandatory at the time that either the blind or a blank should be inserted because if this isolation valve is not tight enough then water may enter into the tank 610, so water, so by this way, the water could have found its way into the tank number 610.

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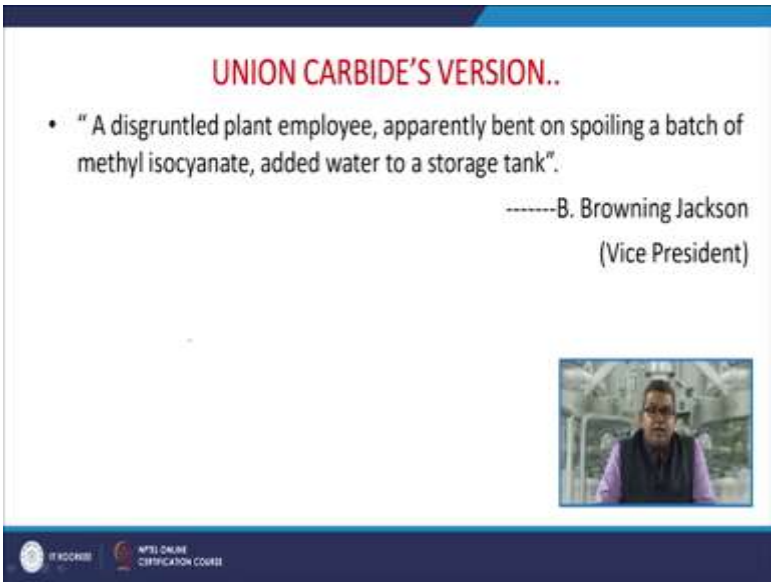

One you can say one a debatable version was given by the Vice President of Union Carbide Browning Jackson that a disgruntled plant employee apparently bent on the spoiling a batch of methyl isocyanate added water to a storage tank, so this may led to the another theory that is called the sabotage of that particular aspect. So in case if it is it was established then definitely the Union Carbide might not be in any in a position to pay any kind of compensation towards this particular accident.

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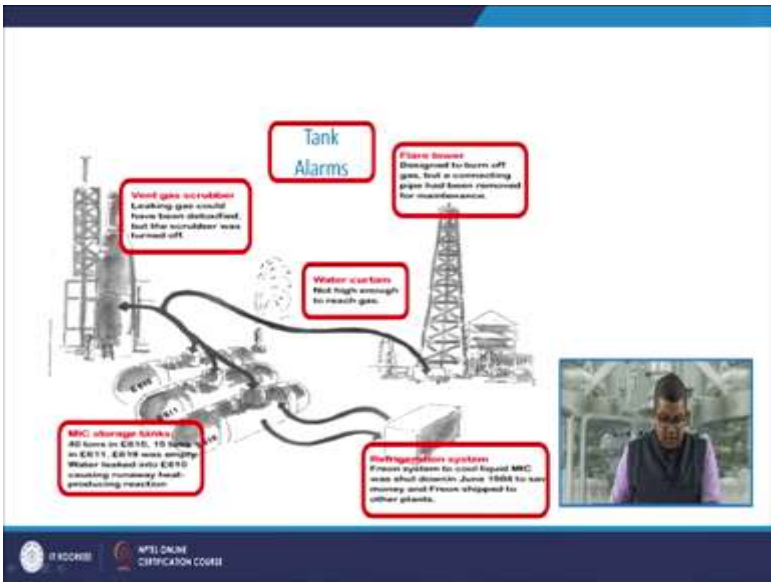

Now this is a more clear picture of the tank facility, these were the storage tanks 40 tons of in 610, 15 tons in 611 and they were in 619 was empty and water leaked into the tank number 610 causing the runaway heat-producing reaction. Now this reaction was catalyzed by the iron and the nickel particles inside the present inside the corroded 610 tank. Now this particular storage battery was supported by the refrigeration system and a free on refrigeration system was used. This is the flaring tower and this was the vent gas scrubber.

So you can see the different pipelines like this one, the refrigeration system they are all interconnected and the water curtain was given not tight enough to reach the gas and this one is the vent gas scrubber, it is duly connected with the flaring tower for the destructive decontamination of various of gases being collected from various parts of the plant. So in this particular module we have discussed about the Bhopal gas tragedy, the introductory part of the Bhopal gas tragedy then we had a discussion about the process and we discussed about the release aspect of methyl isocyanate and we have started the discussion about the various investigatory aspect of this particular gas release.

In the next module we will discuss the investigatory part of this book the release of MIC from the Bhopal gas group Union Carbide Bhopal facility in detail, thank you very much.