Chemical Process Safety
Professor Shishir Sinha
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture-55
Bhopal Gas Tragedy - Investigation

Welcome to the case study related to the Bhopal gas strategy investigation part. And this is the 2nd part of this Bhopal gas tragedy because we have divided this particular module into 2 steps because it is one of the most worst industrial disasters of its time. So, in the last module we had discussion about the plant site, the process involved, what kind of scenario there was, the scene related to the release of most dangerous methyl isocyanate. So, in this particular module we will conclude about the investigation that was carried out by 2 agencies, one was attributed to the Union Carbide investigation team and 2nd was the Government of India.

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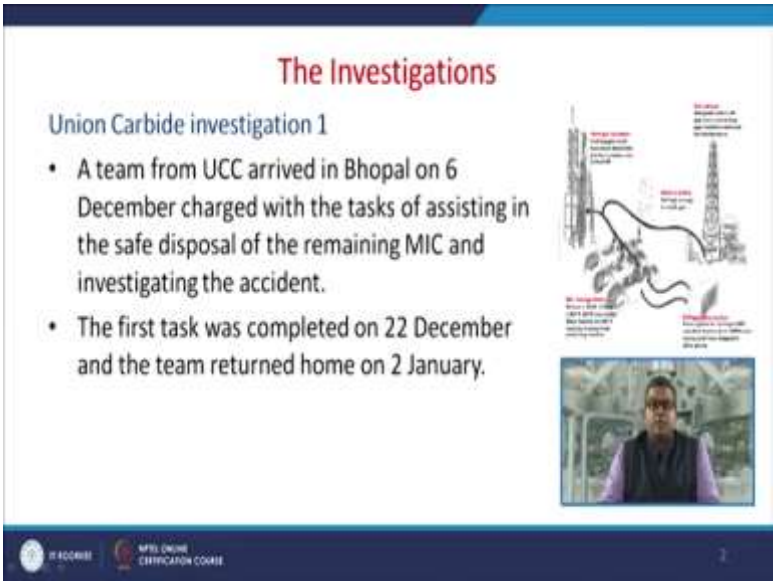
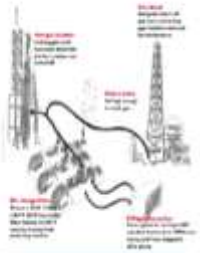


The Investigations

Union Carbide investigation 1

- The investigation was severely constrained by the CBI control of the site and by the criminal investigation.
- The team were allowed only limited access to plant records and personnel.
- They were permitted to talk to certain persons, but not to interview staff directly involved in the incident.



The Investigations

Union Carbide investigation 1

- They were allowed to take samples from Tank 610, but not to open and inspect the tank and its piping or to take samples from elsewhere on the plant.
- On their return home, the investigators carried out a programme of some 500 experiments to establish what had occurred.
- The most abundant component in the residues was MIC trimer. (Other: DMI,DMU, TMU, TMB)

The Investigations

Union Carbide investigation 1

- There were also iron, chromium and nickel in approximately their proportions in 304 stainless steel and some 5 % chloride.
- Trimerization had obviously occurred, but it was unclear what other reactions had taken place.
- The investigators carried out experiments in which the principal materials believed to have been in the tank, namely MIC, chloroform, water and iron, heated at 200°C

So, let us start with the remaining part of Union Carbide investigation. So, the team from Union Carbide Corporation, they arrived on 6th of December, 3 days after the incident and they were charged in terms of 2 aspects. One is to assist the save disposal of the remaining MIC in the plant and 2nd was to investigate the accident and what went wrong. So the 1st task that was related to the safe disposal of remaining MIC was completed by 22nd of December and the team returned home on 2nd of January to carry out a series of experimentation to find out that what went wrong.

Now, this investigation team, they were having the controlled access of the plant because CBI, they took the charge of the entire plant. Now, the team was allowed to the limited access of the plant record and personnel, so that it cannot alter any record that is the securing evidence aspect. And they were permitted to talk to certain persons, but they were not allowed to interview staff directly involved in that particular incident.

So, they were allowed to take the samples from the tank number 610, that was the main culprit tank, but they were not allowed to open it and inspect the tank and its piping to take the samples from elsewhere on the plant. So, on their return to West Virginia, the investigators, they carried out a series of programs of some 500 experiments established that what had occurred. So, the most abundant component in the residues was MIC trimer, other than DMI, DMU, trimethyl uric and trimethyl biuric, et cetera…. There was also the contamination of iron, chromium, nickel and approximately the proportion, whatever the proportion they are having in SS 304 steel and some 5 percent fluoride.

So trimeriazation, that obviously occurred but it was unclear that what other reactions might have taken place in that particular arena. So the investigators can read out the experiments in which the principal material believed to have been in the tank, namely methyl isocyanate, chloroform, water, iron and they heated up to 200 degrees Celsius.

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The Investigations

Union Carbide investigation 1

- Development of a reaction scheme which accounted for the production, starting from these materials.
- From plant records, Tank 610 contained prior to the incident 41 ton (90,400 lb; 11,290 USgal) of liquid.
- The team estimated that Tank 610 had originally contained 1000-2000 lb(120-240 USgal) water and 1500-3000 lb chloroform.

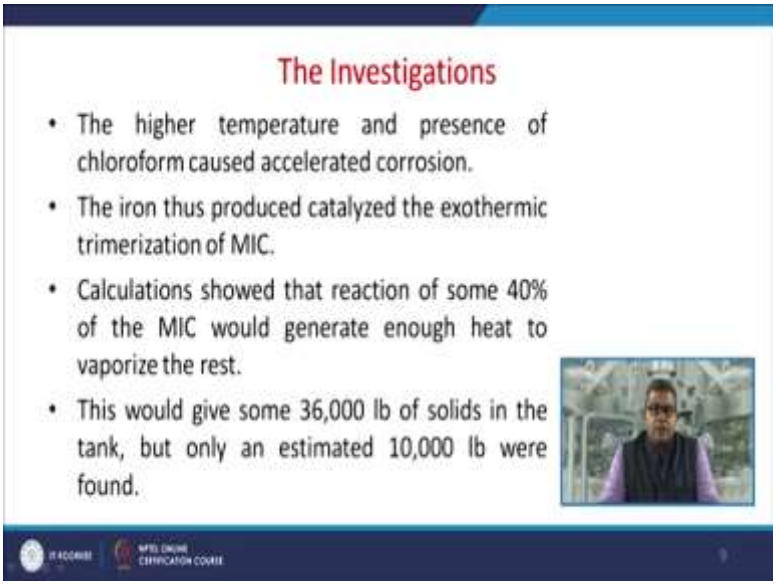
The source of the water was uncertain

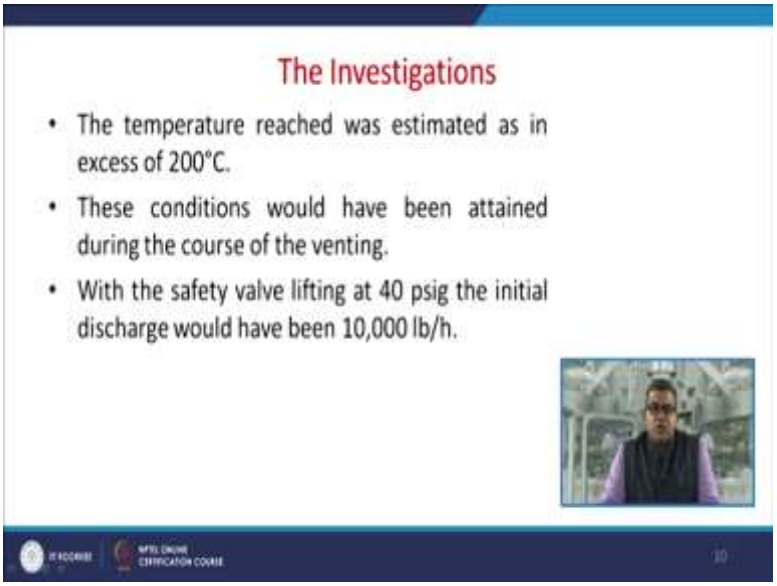
The Investigations

- The chloroform could be accounted for by the fact that the MRS had been operated at a temperature higher than normal and in preparation for shutdown MIC with a high chloroform content has been sent to Tank 610 rather than Tank 619.
- The iron could have come from corrosion, given high chloroform and water contents and high temperature.

The Investigations

- The scenario which the investigators invoked can be explained as follows.
- The contents of Tank 610 were initially at 15-20°C.
- Some 1000-2000 lb water entered the tank in a manner unknown.
- The exothermic reaction between MIC and water led to an increase in temperature and also in pressure due to evolution of carbon dioxide.





So, the development of reaction scheme which accounted for the production of starting from these materials. So, the plant record, the Tank number 610 contained prior to the incident contained 40 ton of liquid. Now the team estimated that tank 610 had originally contained 1000-2000 pounds of water and 1500 to 3000 pounds of chloroform. But still the source of water was uncertain. So, the chloroform could be accounted for by the fact that MRS, MIC refining steel was operated at a temperature higher than its normal one. So the preparation during the preparation for shutdown MIC, a higher chloroform content has been sent to tank number 610 rather than 619.

So, this was the committed mistake at that point of time. So, the iron could have come from the corrosion, given high chloroform and water content at a high temperature. So the scenario which the investigators invoked can be explained in the sequential manner, which is as

follows, the tank 610, initially it was maintained at 15 to 20 degrees Celsius, that was much desired and does not have any kind of adverse effect. Some 1000 to 2000 pounds of water entered the tank in a manner which is unknown. The exothermic reaction between MIC, which we had earlier discussed in the previous module, that started between MIC and water, this led to the increase in temperature and also pressure due to evolution of carbon dioxide.

So, whatever carbon dioxide that was involved in the time, was responsible for the pressure built up within this pressure vessel. So, the higher temperature and pressure of chloroform cost the accelerated corrosion. And the iron, usually thus produced from the tank, catalysed exothermic trimeriazation of MIC. So, they have carried out a series of calculations, this showed that the reaction of some 40 percent of MIC would generate enough heat to vaporise the rest one. So, this gives rise to some 36,000 pound of solid in the tank but only estimated 10,000 pounds, they were found in that particular tank.

So, the temperature reached was estimated as in the excess of 200 degrees Celsius as opposed to the desired one. Now, these conditions would have been attained during the course of the venting. So, with the safety valve lifting, because it was designed to lift at 40 psig, the initial discharge would have been 10,000 pound per hour.

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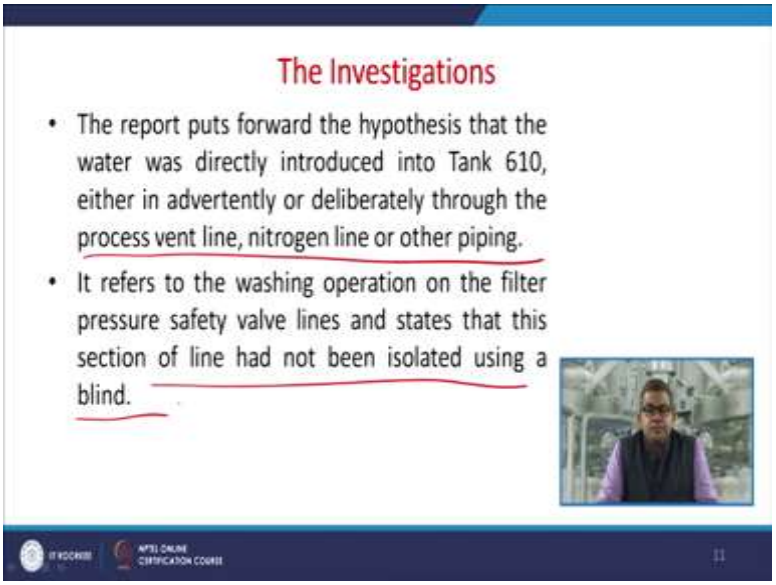

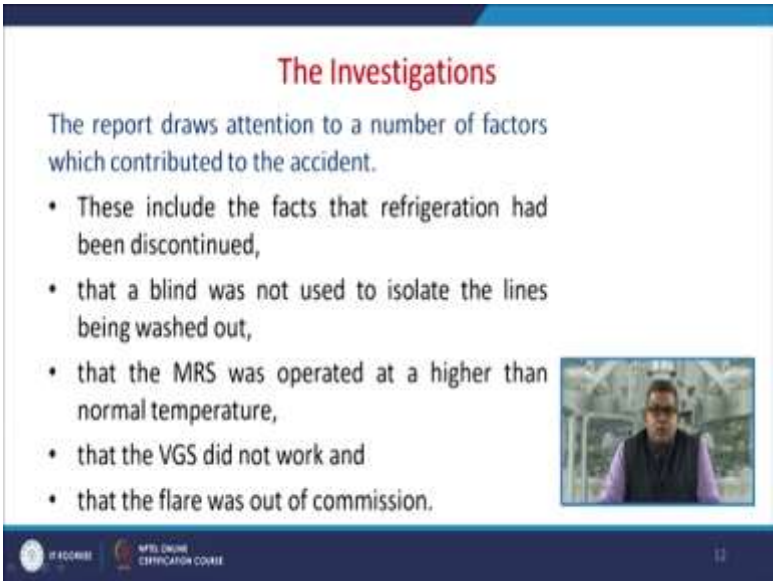

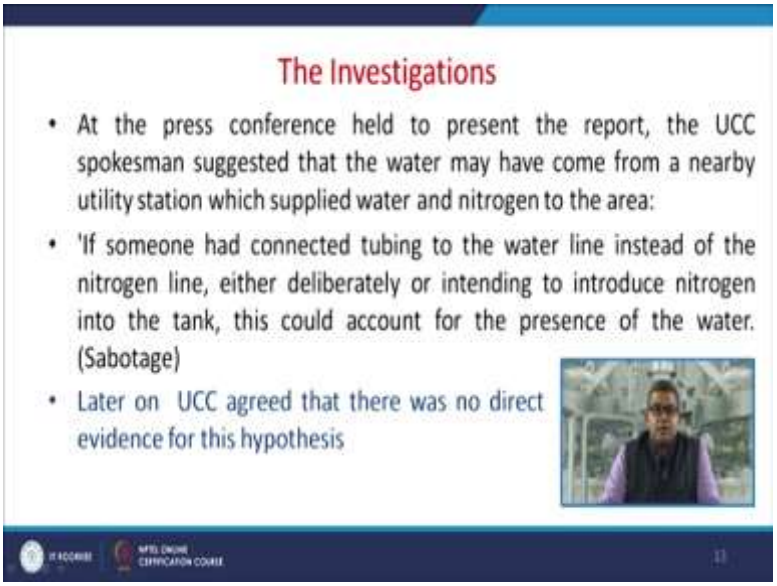

So these reports put forward the hypothesis that the water was directly introduced into the tank 610, either deliberately or by mistake through the process vent line, nitrogen line or other piping. So it refers that washing operation on the filter pressure safety valve lines and states that this section of line had not been inserted a blind or not been isolated. So, that was one of the reasons why this water was introduced into the tank number 610. So, report draws attention to a number of factors which contributes to accident.

This includes the fact that refrigeration had been discontinued. Previously we had a discussion that the refrigeration unit was turned off, just because they thought that MIC is being stored rather than produced continuously. That a blind was not used to isolate the lines being washed out, it is primarily, it was required as per the MSDS and as per the safety norms of that particular plant. MIC refining steel was operated at a higher temperature than the

normal temperature. So, if they would have been noticed this particular aspect, then they could have made the corrective measures, so that the temperature of the MRS would have been corrected down.

They had shut down the VGS vent gas scrubber, just because of the reason that MIC is not being produced continuously it is being stored. The flare was out of commission, obviously the region that we have already discussed. So, just to cut short the measures of economy, they have reduced the number of safety operations and those attempts led to this dangerous or devastating accident. So, the Union Carbide officials, they had carried out a press conference and they suggested that the water may come from the nearby utility station which supplied water and nitrogen in that particular area.

So, if someone had connected tubing of water line instead of nitrogen line, either deliberately or intending to introduce nitrogen into the tank, so this could account for the presence of the water, that will lead to the sabotage. Later on Union Carbide officials they agreed that there was no direct evidence for this particular hypothesis. But they agreed that water was introduced in that particular tank number 610. So, apart from this, the high moisture content, and there was aerosol in the discharge when evaporation gave rise to the heavy gas, which rapidly sank to the ground. So, this was the reason the weather egged on the process.

And weak wind which frequently changed direction, which in turn helped the gas to cover more area and shorter period of time about 1 hour. And the weak vertical turbulence also caused the slow dilution of the gas, thus allowed the poisonous gas to spread over considerable distance. So the precise numbers of the death and injuries at the Bhopal gas tragedy are still uncertain. The scale of the accident was such that it led to much confusion. The people have continued to die of the effects over a period of years. The Indian government estimate of the death toll about 2 years after the event was 1754 that the compensation was paid off. By 1989, this had risen to 3150 and by 1994 approximately 4000.

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THE WEATHER EGGED ON THE PROCESS...

- The high moisture content (aerosol) in the discharge when evaporating, gave rise to a heavy gas which rapidly sank to the ground.
- A weak wind which frequently changed direction, which in turn helped the gas to cover more area in a shorter period of time (about one hour).
- The weak wind and the weak vertical turbulence caused a slow dilution of gas and thus allowed the poisonous gas to spread over considerable distances.

The Investigations

- The precise numbers of the dead and injured at Bhopal are uncertain.
- The scale of the accident was such that it led to much confusion.
- People have continued to die of the effects over a period of years.
- The official Indian Government estimate of the death toll about 2 years after the event was 1754.
- By 1989, this had risen to 3150 and by 1994 to 4000.

The Investigations

- Some 130,000 were treated in Bhopal hospitals, mainly for lung and eye injuries, and some 40,000 in 22 other districts. Some 12,000 of the 170,000 were in a critical condition and 484 died.
- The disaster led to various sets of court proceedings.
- The GoI instituted criminal proceedings against UCC.

The other figures given are 30,000 permanently or totally disabled 20,000 temporarily cases and 50,000 with the minor injury. So, one report says that in 1985, states that the number of people treated in states hospitals had been given an approximately 1,70,000. Some 1,30,000 were treated in Bhopal, various hospitals of Bhopal mainly for lung and eye injuries. Some 40,000 in 22 other district and around 12,000 of 1,70,000 were in the critical condition. And out of this 484 died. So, the disaster led to various sets of court proceedings and government of India instituted criminal proceedings against Union Carbide Corporation.

And they became the party to the proceedings in United States courts. In 1987, Union Carbide Corporation made a final settlement with government of India of about 470 million US dollars. Now the victim did try to challenge this in the federal courts of United States but the US Supreme Court ruled that they lacked legal standing to do so.

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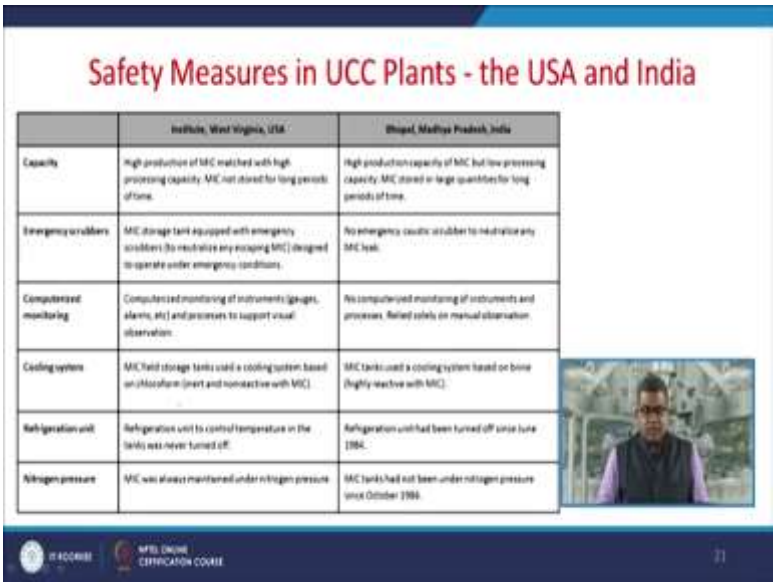

Capacity	High production of MIC matched with high processing capacity. MIC not stored for long periods of time.	High production capacity of MIC but low processing capacity. MIC stored in large quantities for long periods of time.
Emergency scrubbers	MIC storage tank equipped with emergency scrubbers (to neutralize any escaping MIC) designed to operate under emergency conditions.	No emergency caustic scrubber to neutralize any MIC leak.
Computerized monitoring	Computerized monitoring of instruments (gauges, alarms, etc) and processes to support visual observation.	No computerized monitoring of instruments and processes. Relied solely on manual observation.
Cooling system	MIC held storage tanks used a cooling system based on chloroform (inert and nonreactive with MIC).	MIC tanks used a cooling system based on brine (highly reactive with MIC).
Refrigeration unit	Refrigeration unit to control temperature in the tanks was never turned off.	Refrigeration unit had been turned off since June 1984.
Nitrogen pressure	MIC was always maintained under nitrogen pressure.	MIC tanks had not been under nitrogen pressure since October 1980.

Now let us have a discussion about the various safety measures in Union Carbide Corporation plants in the USA and in India. The Union Carbide plant in West Virginia was better equipped compared to the plant in Bhopal. There were a number of critical differences in levels of design and operations of the Bhopal and the institute plans. Now these are some of the enlisted comparisons between the institute West Virginia plant USA and the Bhopal, Madhya Pradesh.

The capacity, they were having the higher production of MIC matched with higher processing capacity and MIC not stored for long period of time. Whereas in Bhopal they were having high production capacity of MIC but low processing capacity, further processing that is in

terms of a derivative plant. And MIC stored in the large quantity for a long period of time, so that is the difference between the West Virginia plant and Bhopal plant.

Then emergency scrubbers, MIC stored tank, they kept with emergency scrubbers to neutralise any escape of MIC designed to operate at the emergency condition. However in Bhopal plant, at the time of accident, no emergency caustic scrubber to neutralise the MIC leak was present. About the computerised monitoring, the computerised monitoring of all the instruments like gauges, alarms, et cetera. and the process to support the visual observation was in place in West Virginia plant.

Whereas, in Bhopal there was not at all a computerised monitoring of instruments and process, relied solely on the manual observations. As far as cooling system is concerned, MIC field storage tanks, the used cooling system based on chloroform in West Virginia plant. Whereas in Bhopal plant the MIC tanks used cooling system based on brime. They are highly reactive with MIC. The refrigeration unit was also there in both the plants, in West Virginia plant the refrigeration unit to control temperature in the tank was never turned off, whereas in Bhopal plant, the refrigeration unit had been turned off since June 1984.

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The nitrogen pressure, the MIC was always maintained under the nitrogen pressure, whereas in Bhopal plant the MIC tanks had not been under the nitrogen pressure since October 1984. So, they have put all these cut short measures to save certain amount of money. In West Virginia plant, they were having an elaborated 4 stage emergency plan to deal with any kind

of toxic releases, fire, et cetera including a general public alert link to the community police, River and the rail traffic and local radio station.

Whereas in Bhopal plant, no system to inform the public authorities or the people living adjacent to the plant and there was no emergency plan shared with the communities living adjacent to the plant. So, if you remember the accident chronology, then there was a communication gap between the plant officials and local authorities. About the maintenance plan, the maintenance program to determine and evaluate the replacement frequency for valves and instrumentation and alarm system, whereas in Bhopal there was no evidence of any effective instrumentation maintenance program and safety valve testing program, largely it was ineffective.

As far as the lab analysis is concerned, lab analysis of MIC was conducted to test quality and a cheque for contamination prior to the storage processing or distribution in West Virginia plant. But in Bhopal, there was no lab analysis being carried out for the quality check and that was uncertain, the MIC stored for longer period without testing of any kind of contaminants. The training, the extensive employee training program was in place in West Virginia plant, whereas in Bhopal, the operators put in charge without sufficient training.

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Twenty years later, the floura covers the Tank 610 which has been removed from the earthen mound

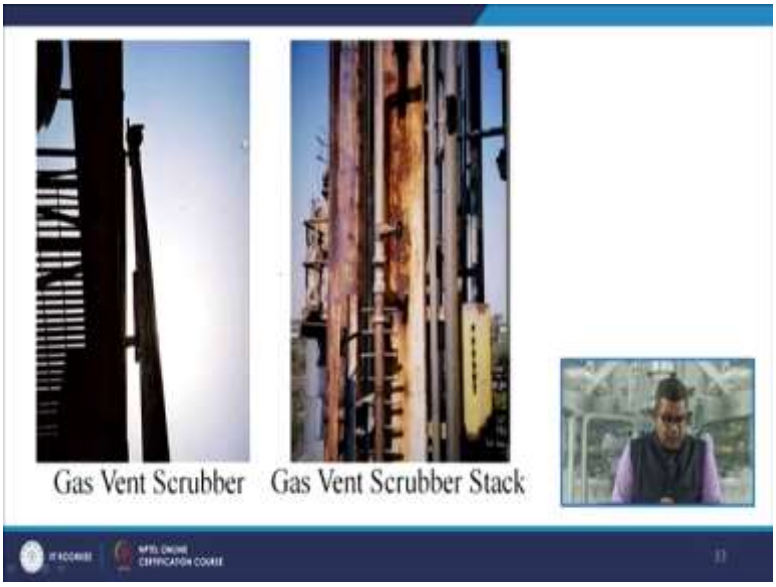
Photograph near the filter area. Some of the critical components are identified in the photograph

Photograph of Tank 611 entry piping. Rupture disk is in center, spring relief valve is behind flora that has grown in over the years.

Photograph of the scrubber system.

Photograph of the disabled flare tower.

Corroded tank with unknown contents lying below.



Now, you can have a look at the photographs taken shortly after the accident. This is a pipe rack is shown in this arena and the partially buried storage tank, there were 3 in total for MIC located in the mid of the photograph, if you are able to locate them. Now this is the photograph of 20 years later, the Flora covers the tank 610 which has been removed from the earthen mound and this is a photograph near the filter area. Some of the critical components are identified in this particular photograph.

This is the valve to process vent meant header and this one is for the filter area. Now this is the actual photograph of the spring relief valve and this one is the ruptured disc. So, this is a photograph of tanks 611 entry piping, ruptured disc is on the centre here somewhere here. Spring relief valve is behind the Flora that has grown over the years. Now this is the

photograph of the scrubber system that is the scrubber which we were talking about. This is the flaring system, which was disabled at the time of accident.

These are the corroded tanks with unknown contents lying below. So, this is again a very crucial information for the accidental investigation. These are some of the photographs of jumper lines, et cetera you can see. Now, this is a remote photograph of gas vent scrubber and this is the gas vent scrubber stack. Then the people analyses about the possible reasons of this accident.

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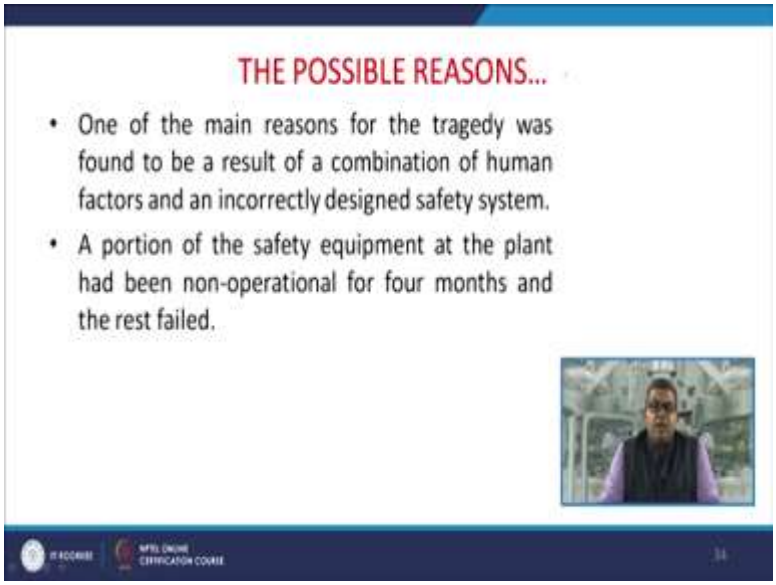

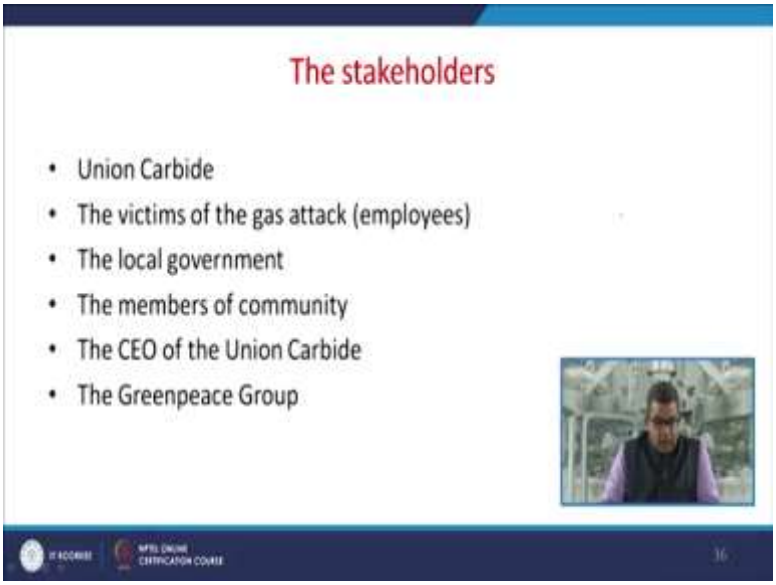

So one of the main reasons for the tragedy was found to be the result of the combination of human factor and incorrectly designed safety system and not follow up of all those safety norms been laid down for MIC storage. So, a portion of the safety equipment at the plant had been on operational for 4 months and rest failed. So, there was a serious lapse on the part of the government. The officials responsible probably had not mandated any safety standards at that time. So, Union Carbide, they failed to implement of its own safety rules, which was at the time of accident they used to follow in West Virginia plant.

So, the Bhopal plant experienced 6 accidents between 1981 to 1984, at least 3 of which involved MIC or phosgene, so they have sensitised or they have sensed that there are some problems going on either with the MIC or phosgene. Now there were several stakeholders of this particular plant and accident, the Union Carbide, the victims of the gas attack, those employees plus persons, local government, the member of community, the CEO of Union Carbide, the Greenpeace group.

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Before the Disaster

- The Union Carbide: cut off costs, increase profits
- The victims of the gas attack: safe working conditions, equal pay
- The local government: ensure the safety of employees, prevent environmental damage
- The members of community: ensure the environment is clean
- The CEO of Union Carbide: to increase profits as much as possible
- The Greenpeace Group: to ensure the plant is not polluting the environment

After the Disaster

- Union Carbide: to pay as little compensation as possible and escape all responsibility
- The victims of the gas attack: require fair compensation
- The local government: to ensure the victims get fair compensation and assign responsibilities for cleaning up the pollution caused by the plant
- The members of the community: help clean up the pollution
- The CEO of Union Carbide: escaping responsibility
- The Greenpeace Group: to make sure UCC cleans up the pollution

Legal Action Against Union Carbide

- December 1984: Legal proceedings were started against UCC, the United States and Indian governments, local Bhopal authorities.
- March 1985: Government of India passed the Bhopal Gas Leak Act in March 1985, making the GOI to act as the legal representative for victims of the disaster that helped in leading to the beginning of legal proceedings.
- **1985:** The US government called for inquiry into the Bhopal disaster, by Henry Waxman, a Californian Democrat.

Now, before the disaster, we have synchronised the accident chronology, the Union Carbide, they were compelled to cut off the costs and increase profits. The victims of the gas attack the safe working conditions and they were demanding for equal pay. The local government, they ensure the safety of employees and prevent the environmental damage. The members of the committee, they ensure that the environment is clean for the livelihood. The CEO of Union Carbide was intended to increase the profit as much as possible and the Greenpeace group that ensure the plant is not polluting the environment.

So, the responsibility of the stakeholders are just like this. Now, after the disaster, we are just comparing the involvement of all stakeholders. So, after the disaster, the Union Carbide was intended to pay as little compensation as possible and escape all its responsibility. The victims of the gas attack, they require the fair compensation. The local government, they ensured that the victims get the fair compensation and assign responsibility for cleaning up the pollution caused by the plant.

The member of the community, they were intended to help clean up the pollution, the CEO of Union Carbide, they were escaping their responsibility and still they are escaping their responsibility. And the Greenpeace group, they make sure that Union Carbide Corporation cleans up the pollution. There were several legal actions against the Union Carbide. In December 1984, the legal proceedings were started against Union Carbide Corporation, the United States and the Indian government, local Bhopal authorities. So, in March 1985, the government of India passed the Bhopal Gas Leak Act in March 1985 in Parliament, making the government of India to act as the legal representative for the victims of the disaster that helped in leading to the beginning of legal proceedings.

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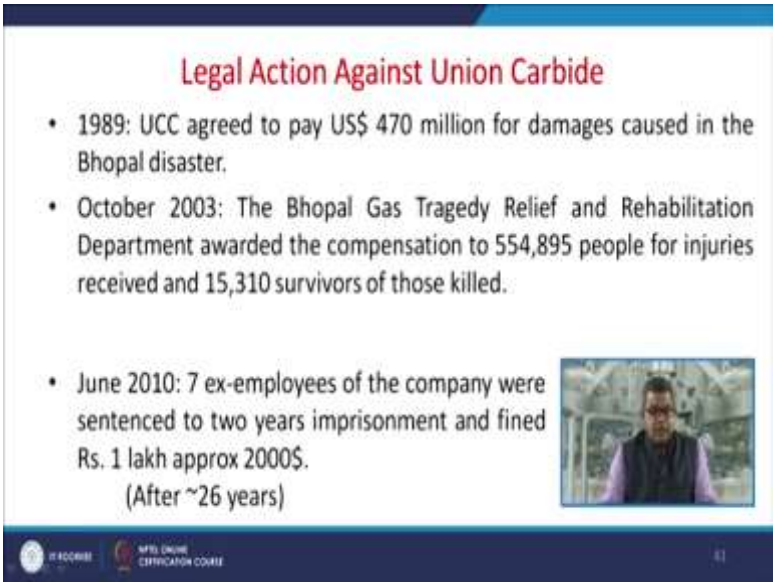

In 1985 the United States government called for an enquiry into the Bhopal gas disaster by Henry Waxman, a Californian Democrat. In March 1986, the Union Carbide Corporation offered a settlement figure, providing a fund for Bhopal victims of between 500 to 600 million dollars over a period for 20 years. In May 1986, the US Federal government transferred the litigation to Indian courts from United States. In 1988, 355 million US dollars was claimed by the gamut of India from the Union Carbide Corporation.

In November 1988, the Supreme Court told both sides to come to an agreement and start with a clean slate. And in 1989, Union Carbide Corporation, they agreed to pay 470 million US dollars for damages caused in the Bhopal disaster. So, October 2003, the Bhopal Gas Tragedy Relief and Rehabilitation Department awarded a compensation to 554,895 people for injuries received and 15,310 survivors of those killed in the Bhopal gas leak. In June 2010, 7 ex-

employees of the company were sentenced to 2 years imprisonment and fined rupees 1 lakh Approximately, comes out to be 2000 US dollars, that is after 26 years of leak.

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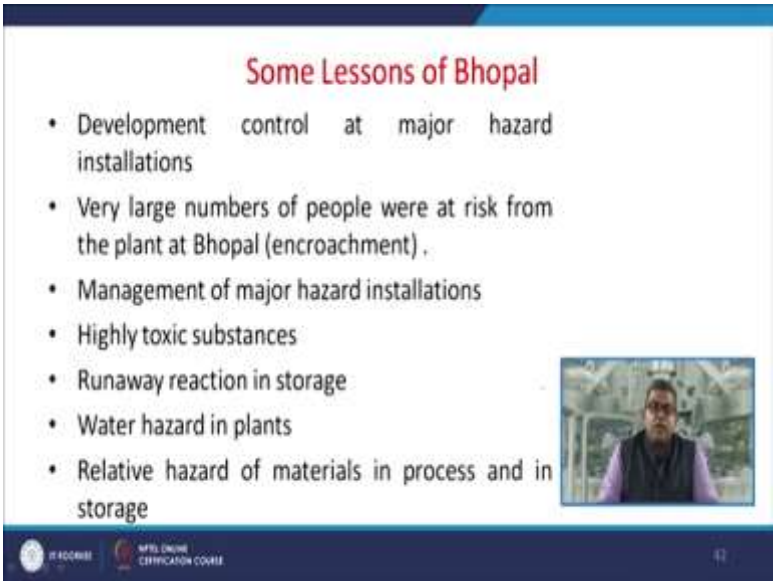

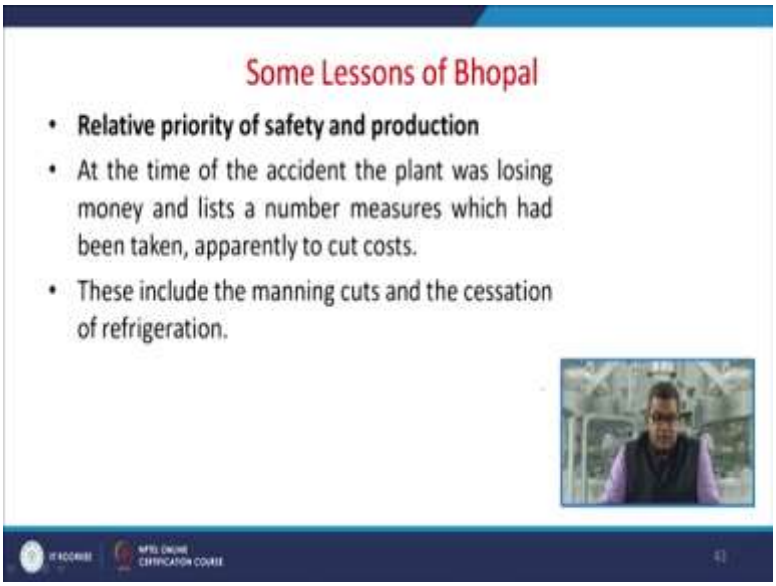

Now, we have to learn some lessons from Bhopal that the development control at the major hazard installations, we have to look into this and a very large number of people were at risk from the plant at Bhopal, may be attributed to the encroachment or other settlement problems. There was a major problem attributed to the management of major hazard installations. There was a highly toxic substance at stake. There was a possibility and it is very rarely but there was a possibility of runaway reaction in the storage because usually we observe that runaway reactions in the reactors but this is somewhat unprecedented run away reaction took place in the storage arena.

Nobody were taught about the water hazard in the plant and that was attributed to the Bhopal gas tragedy. Relative hazard of the material and process and storage, so no one ever thought about this kind of approach, so these are the some lessons which we may learn from the Bhopal gas tragedy. Apart from this, there are several other things which we need to address, like relative priority of safety and production, because you can observe that the Union Carbide, they gave the priority to production rather than safety and ultimately happened that they have to wind up their own business from India.

So, time of accident, the plant was losing the money and the lists a number of measures which had been taken, apparently to cut the costs. We have already discussed those measures which were involved for the cutting of those costs. Some of them like the manning cuts and the cessation of refrigeration, et cetera. The outcome of this particular Bhopal gas tragedy is that there must be certain limitations on the inventory in the plant. The proper set pressure of the relief devices must be put forward.

They have disabled the protective system, so some mechanism should be there so that once the protective system is disabled, then the production lineup should be modified accordingly. The maintenance of the plant and equipment and instrumentation was on the poor ground. So, there may be a possibility or there may be some approaches or there should be some approach adopted for the proper maintenance of these plant equipments. Standard operating practices should be implemented for the isolation procedure while the maintenance has been carried out or housekeeping being carried out.

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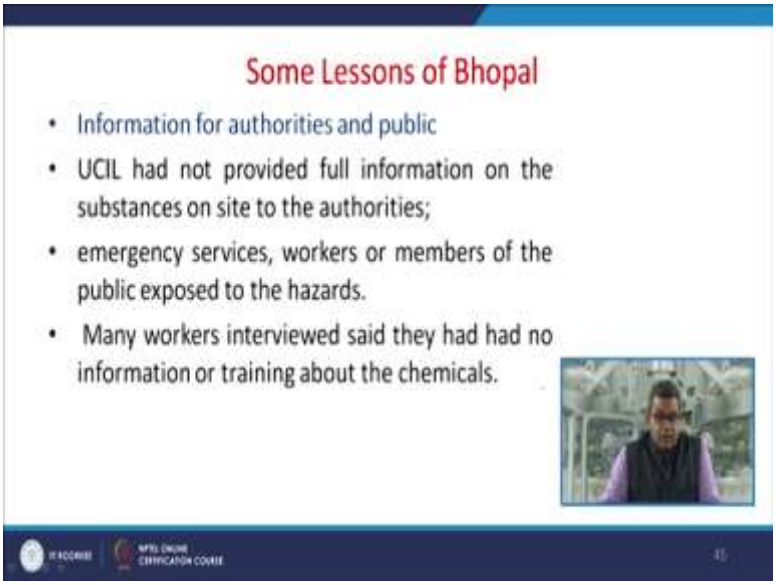

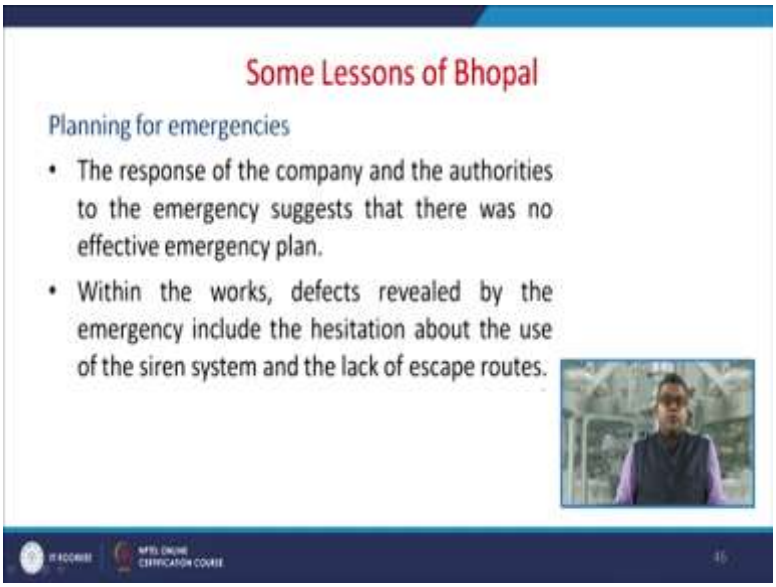

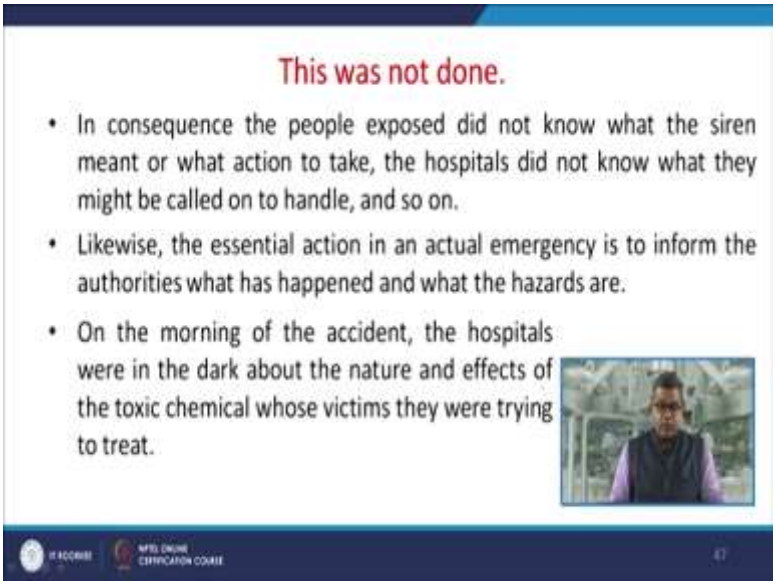

And there must be certain control of plant and process modifications so that all the standard operating practices could be followed. Apart from this, as we discussed that there was some communication gap between the authorities and the public, so UCIL, they had not provided full information on the substances on the site to the authorities. The emergency services, workers are members of the public, they exposed to the hazard. Many workers interviewed and said that they had no information training about the various chemicals those who were being stored, those who were involved in the process area.

So, the training and experience, when these 2 aspects were in questions, so Union Carbide was lacking behind. Then they were not having the adequate planning for the emergencies. So the response of the company and the authorities to the emergency suggests that there was no effective emergency plan. So, within the plant work defects revealed by the emergency includes the hesitation about the use of the siren system and the lack of escape routes. So, this again because if you see the sequential order, sometimes they opened the loud siren and then muted and, then they turned on the muted siren and so on. So, they were in a bit of confusion.

So, this was not at all done, in consequence the people exposed did not know what the siren mean for what action to take. The hospitals did not know what they might be called on to handle and so on. So, likewise the essential action on the actual emergency is to inform the authorities what has happened and what the hazards are. So, on the morning of the accident, the hospitals were in practically dark about the nature and effect of the toxic chemicals whose victims they were trying to treat. So, practically there was no information available at the time of accident.

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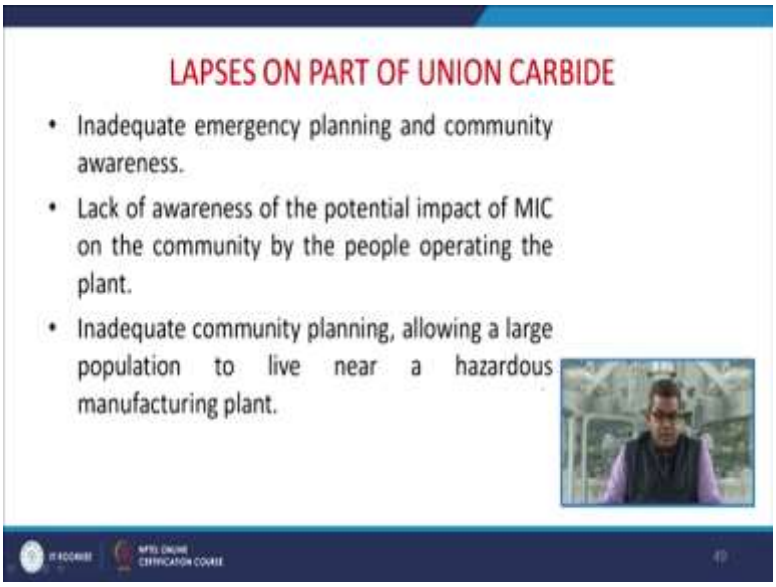

So, the lapses on the part of Union Carbide, they were having the improper design of chimneys without consideration of the weather conditions in all seasons. So, you see that major quantity was release through flaring tower. Now, they were having the improper design and maintenance of safety equipment. They were not following the safety norms and regulations as they were supposed to follow by the Union Carbide Corporation plant in the United States. So, the decision to neglect the flair system in need of repair that was again a crucial issue and it was a lapse on the part of Union Carbide.

They were not fit with the adequate emergency planning and community awareness. They were having the lack of awareness of the potential impact of MIC on the community by the people operating the plant. And there was inadequate community planning allowing a large

population to live near hazardous manufacturing plant. So, that was again a major issue and just a year or less than a year ahead, the State government gave the legal rights for those illegal quarters.

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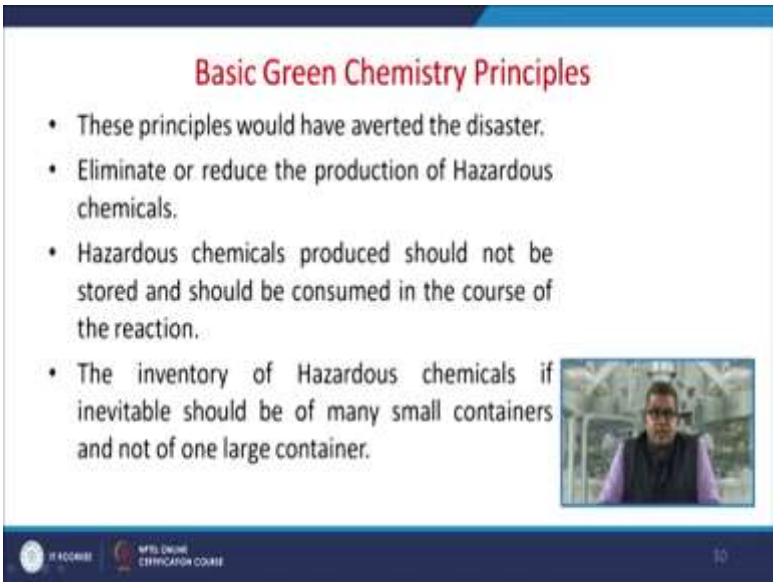

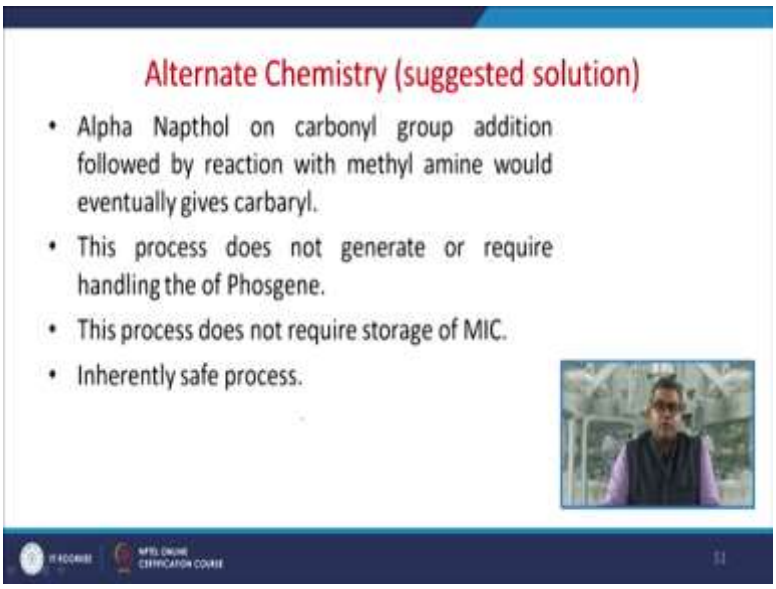

Now let us have something related to the basic green chemistry principles. So, these principles would have averted the disaster if they had been followed. Now, one thing is that to eliminate or reduce the production of hazardous chemical, that is the 1st protocol. Hazardous chemicals produced should not be stored or should be consumed in the course of the reaction, just to avoid this type of thing. The inventory size must be as low as possible. So, the inventory of hazardous chemical is inevitable, should be in a small containers and not on one large containers.

So that reduces the chance of any kind of hazardous scenario. There are certain other suggested solutions that alpha napthol on carbonyl group edition followed by the reaction with methyl amine would eventually give carbaryl. So, this process does not generate or require handling the phosgene. So, the process does not require any kind of MIC. So, this practically process is inherently safe. So, the Union Carbide could have adopted this particular process rather than utilising the phosgene, et cetera.

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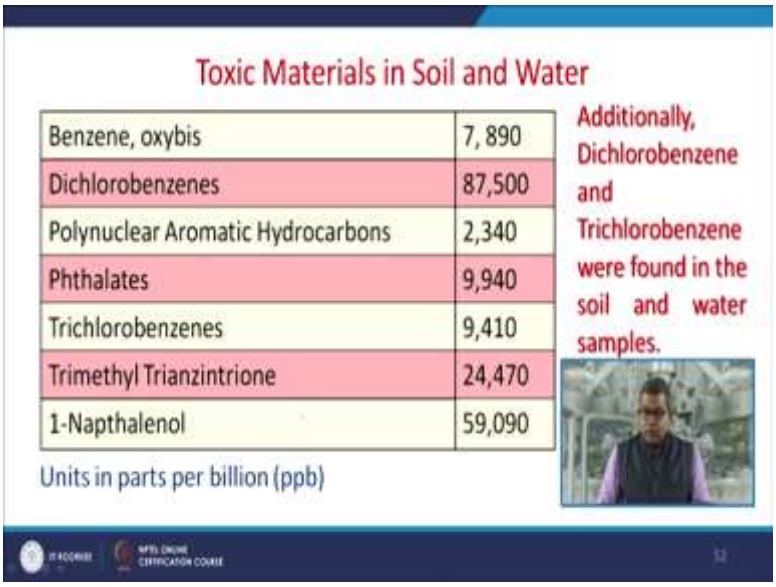

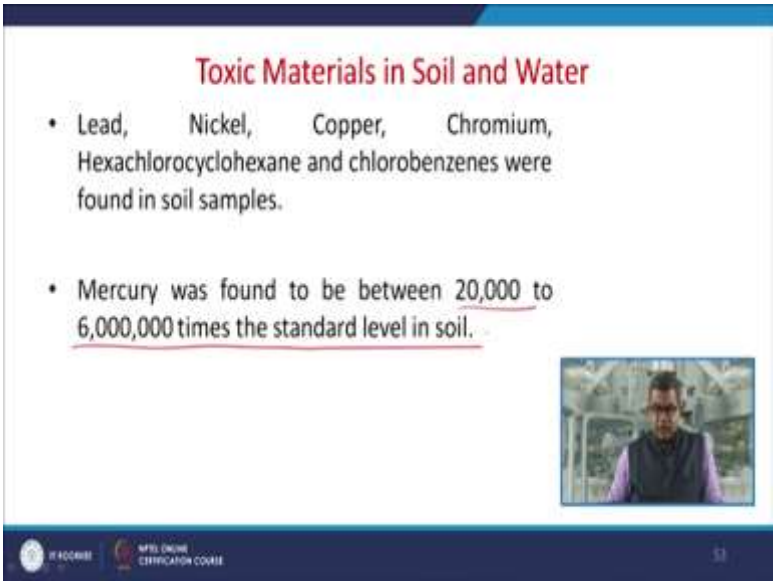

Ethical Issues before the Disaster

- Workers were forced to use English manuals, even though only a few understands the languange
- 70% of the plant's employees were fined for refusing to deviate from the proper safety regulation (replacing leaked pipes)

Repressive Style Management

Ethical Issues before the Disaster

- As of 2008: UCC had not released information about the possible composition of the cloud gas
- Several internal studies which exhibited severe contamination were not made public

Withholding of Information

ENVIRONMENT Change

- 1950: population 70,000
- 1956: Becomes State Capital
- 1984: population 695,000

So, these are some toxic materials in the soil and water, benzene, dichlorobenzene, Polly Nuclear aromatic benzene, et cetera. So, additionally this dichlorobenzene and trichlorobenzene were found in the soil and water samples and they were analysed in the vicinity of Union Carbide plant and within and outside the plant. So, lead, nickel, copper, chromium, hexachlorocyclohexane, chloro benzene, they were found in soil samples. So, Mercury was found to be between 20,000 to 60 lakh times the standard level in soil.

So, that is extremely dangerous scenario and may lead to the carcinoma. There are certain ethical issues before the disaster. Workers were forced to use the English manual, even though only a few understand the language, that was a major problem, they were not practically trained or they did not have the knowledge about the various safety issues. And 70 percent of the plants employees were fined for refusing to deviate from the proper safety regulations, replacing the leaked pipes, et cetera. So, this was again one of the ethical issues.

As of 2008, Union Carbide Corporation had not released information about the possible composition of the cloud gas. So, they withhold that particular type of information. Now, several internal studies which exhibit severe contamination, they were not made public. So, this is again the ethical issue. One of the another reason is that environmental change. In 1950 the population of Bhopal was around 70,000, 1956 it became the state capital, in 1984 the population was around 695,000.

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Lessons Learnt

- Industry and government need to bring proper financial support to local communities so they can provide medical and other necessary services to reduce morbidity, mortality and material loss in the case of industrial accidents.
- Existing public health infrastructure needs to be taken into account when hazardous industries choose sites for manufacturing plants.

Lessons Learnt

- Legislation and regulation needs to evolve in active consultation with all stakeholders laying emphasis on emerging requirements, and increasing standards with appropriate emphasis on actual functioning of safety mechanisms and inculcation of an active safety culture.
- Multinationals, by virtue of their global purpose, organization, and resources, should be treated as single, monolithic agents, rather than as a network of discrete, non- interdependent unit

Alternatives Before the Disaster

Alternative #1

- Try to increase the product sales
  - Keep all production

Alternative #2

- Cease production and dispose all MIC chemical gas
  - Safe for the local residents
  - The cost of disposing the gas is large

So, the national government and international agencies should focus on widely applicable techniques for the corporate responsibility and accident prevention as much in the developing world context as an advanced industrial nations. And this was lacking behind in the Union Carbide Corporation because they did not follow the same safety norms, those who were applicable in West Virginia plant. So, the local government clearly cannot allow the industrial facilities to be situated within urban areas, regardless of the evaluation of land use over time.

Now, industry and government need to bring the proper financial support to local communities so that they can provide at medical and other necessary services to reduce morbidity and mortality and material laws in case of any industrial accidents. Existing public health infrastructure needs to be taken into account when hazardous industries choose sites for manufacturing plants. Now, the legislation and regulation, they need to evolve in active consultation with all stakeholders laying emphasis on emergency requirements and increasing standards with appropriate emphasis on actual functioning of safety mechanism and inclusion of an active safety culture.

So, multinationals, by virtue of their global purpose, organisation and resources, should be treated as a single monolithic agents, rather than as a network of discrete or non-interdependent unit. Now, there were certain alternatives before the disaster. The 1st alternative was try to increase the product sales. So, they will keep all the productions, et cetera. And 2nd was cease production and dispose of MIC chemical gas, that is safe for the local residents, the cost of disposing the gas is very large quantity.

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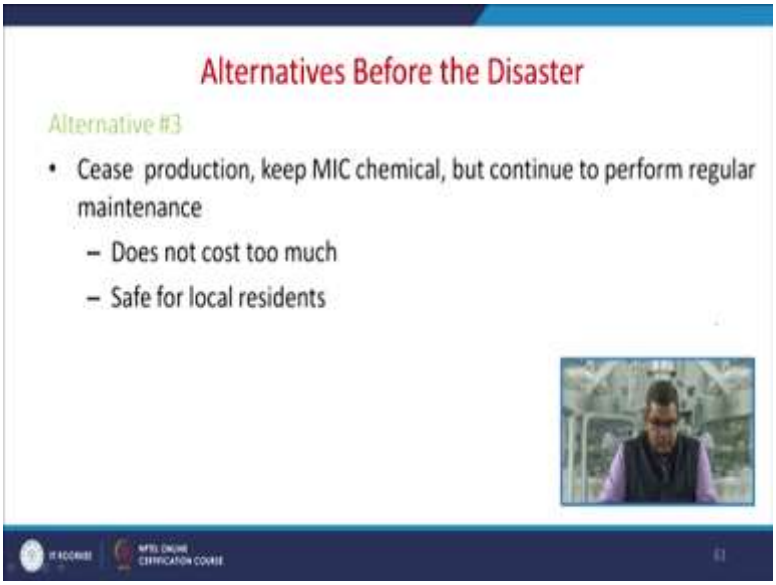

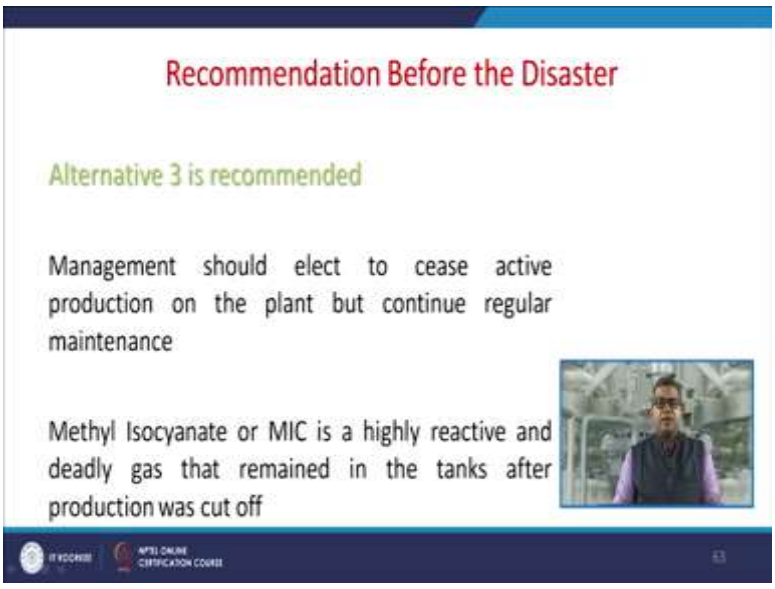

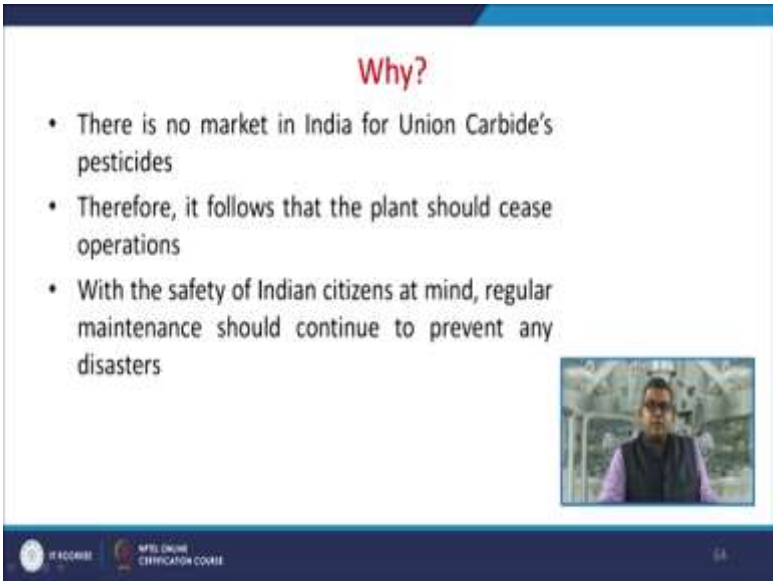

The 3rd and the last alternative was to cease production, keep the MIC chemical but continue to perform the regular maintenance. Now usually this does not cost too much and it is relatively safer for the local residents. But they did not follow this one. Another things, which is alternative after the disaster, that is compensate to the victims. So, the increasing the compensation to help people survive, that was one of the prime motto. And providing at least 20 years worth of medical expenses. Although the DNA sequencing or gene structure is concerned, this timeframe is very small.

Another alternative is that properly clean up the site and provide safe drinking water for the nearby people, so that the new generation will not be poisoned. So, the recommendation before the disaster, obviously the alternative 3 is recommended. And the management should elect to cease the active production on the plant but continue regular maintenance. And MIC or methyl isocyanate is a highly reactive and deadly gas that remained in the tanks after production was cut off.

So, the reason was why there was no market in India for the Union Carbide's pesticides and therefore they follow that the plan should seize the operations. And with the safety of Indian citizens at mind, regular maintenance should continue to prevent any kind of disaster. Now, there are several recommendations following the disaster.

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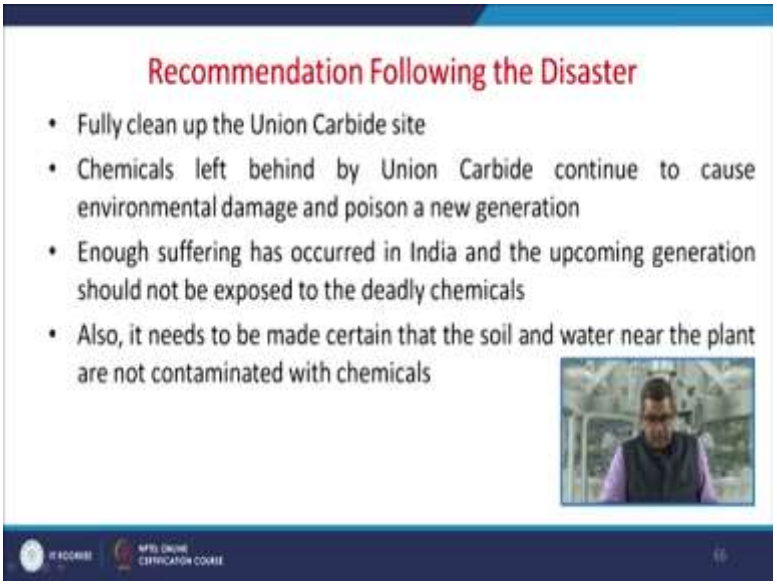

The victim needs to be better compensated although the era is gone. Now they have endured much suffering and deserve better treatment than they have received to date. Provide compensation for at least 20 years worth of medical expenses as oppose to the 5 years originally offered and that was the part and parcel of the settlement. The key component of new compensation settlement, the consultation with the victims. And the victims should have a say in compensation levels, as they were the ones who have suffered.

Another is that the Fully cleanup the Union Carbide site which is not at all being done as on date. The chemicals left behind by the Union Carbide continue to cause environmental damage and poison the new generation. There are enough sufferings had occurred in India and the upcoming generation, they should not be oppose to the deadly chemicals that is one of the desired level. So, it needs to be made certain that the soil and water near the plant, they are not contaminated with the chemicals. So, we can avoid, once we follows these things, we can avoid such type of things, thank you very much.