Chemical Process Safety
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Lecture 57 - Process Safety Management

Welcome to the new module of Process Safety Management. Now, this process safety management is a very important aspect of chemical process safety because in different models we have studied about the various aspect of chemical process safety: identification, training, toxicological studies. So, this particular aspect refers to the integration of all kind of various activities being associated with the chemical process safety. So, in this particular module we are going to study with the basic principle of process safety management.

And occupational safety, health administration of United States, they are a very lead agency in the development of process safety management, so we will discuss about what did the, OSHA development and process safety management. Then we will discuss about the key elements of process safety management and later on we will summarise all the aspects which we will discuss in this particular module. So, let us have a first question to be asked by anybody that, what is the process safety management?

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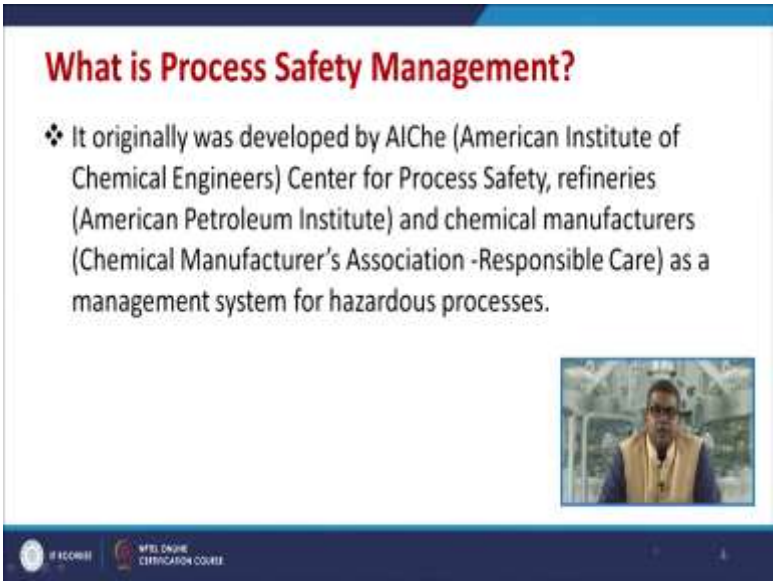

So, in a nutshell, the process safety management is the application of various management practices, principles, et cetera and system to the identification, understanding and control of various process hazard to protect the environment, to protect the employees, to protect the facility, assets, etc. So usually it integrates the different technology available for the process. It integrates the operating procedures or protocols and sometimes it may referred as a standard operating practices. And then it integrates the standard management protocols.

So, there is a difference between the operating protocols; it usually reflects with the measurable parameters like pressure, volume and temperature. And there are certain standard management protocols. So, we will discuss this thing in due course of time. So, it originally it was developed by American Institute of Chemical Engineers, that is an apex body of all chemical engineers. And they are having one centre for process safety refineries.

And it was in association with the two institutes, one is the American Petroleum Institute API, this is responsible for producing or responsible for making all kind of guidelines for various refineries. And the Chemical Manufacturer's Association, those who are responsible the responsible, care for all kind of chemical activities. So, they developed a management system for various hazardous processes.

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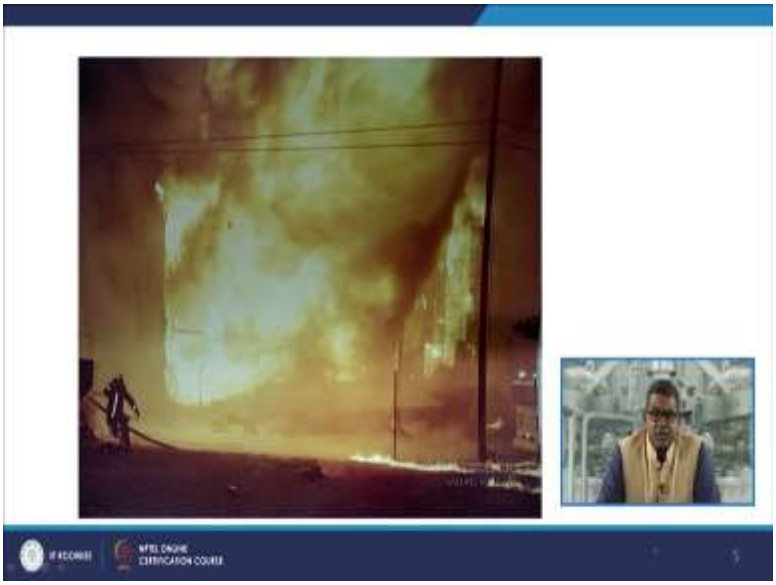

Now you cannot overlook the importance of those hazards as reflects in this particular photograph. Maybe the fire hazard, maybe the toxicological hazard, maybe the explosion hazards, et cetera.

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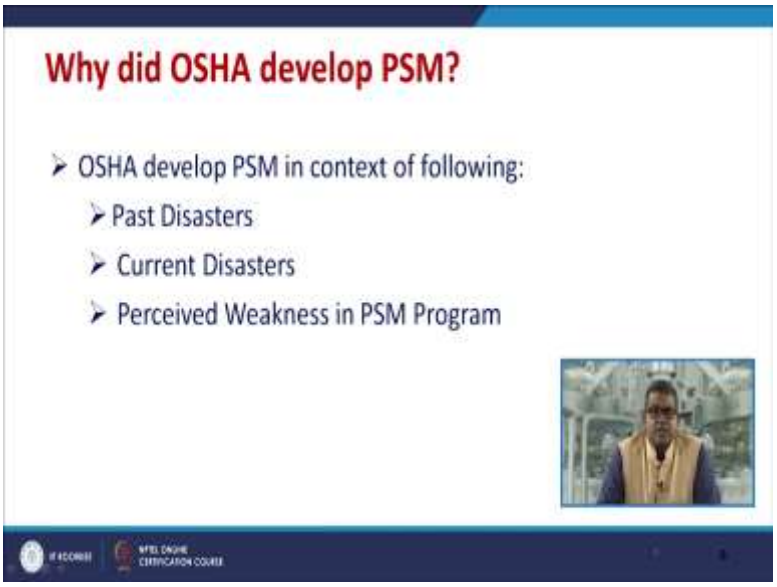

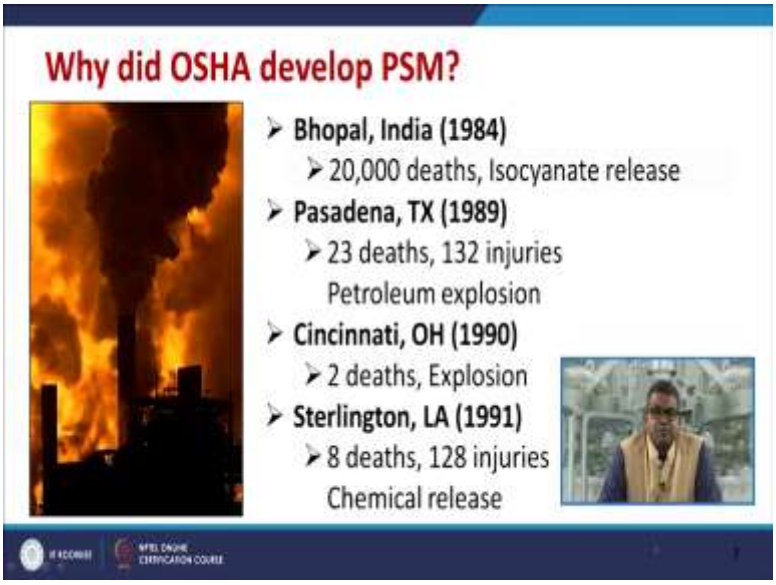

So, the question arises that, because in the first slide we had a discussion about that the OSHA, Occupational Safety and Health Administration, they are responsible for the development of process safety management. So, the question arises, why did OSHA develop the PSM? Now, OSHA developed this process safety management in the following contexts: like the various past disasters. So, they took the cognizance of all those disasters those who have taken place in the history. Then they are also taking the cognizance of the current disaster and they are responsible for the perceived weaknesses in the PSM program.

Now while we are considering the past disaster, so we are having different disasters which are enlisted in this particular slide. Like in Bhopal, it took place in 1984 and that was attributed to almost 20,000 deaths and just because of methyl isocyanate release.

Then the Pasadena in Texas in 1989, attributed to 23 deaths and 132 injuries, that was a petroleum explosion. Then Cincinnati, Ohio in 1990, there were 2 deaths and just because of an explosion. Then, Sterlington in Lafayette in 1991, 8 deaths and 128 injuries just because of chemical release.

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So based on this particular aspect in 1991, OSHA and Environmental Protection Agency respectively, they released the standard for PSM and risk management protocol or program. That applies to those companies that are usually affected by those standards. So, process safety management is a regulation by OSHA and intended to prevent an incident like in 1984, Bhopal. And one more objective is, this particular process safety management is to prevent the release of any kind of toxic material, any kind of reactive material, any kind of flammable material or explosive chemicals. So it is having a very wide spectrum of all these things.

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Now, let us have a look of this PSM versus RMP. Now let us discuss about that what is the difference between these two aspects. Now, PSM that is Process Safety Management is like hazard communication or HazCom, whereas RMP that is like Superfund Amendments and Reauthorisation Act (Sara). So the PSM protects the workforce, they protect the contractors those who are involved in that workplace, they protect the visitors to that particular facility those who are maybe casual visitor or maybe the regular visitors because sometimes these visitors they used to pay visit to the facilities, maybe educational tour, maybe some sort of other sampling, et cetera.

So basically in a nutshell they protects the workplace. Whereas RMP, they protects the community, maybe within the plant periphery or outside, they protect the general public around that particular facilities. So, like in Bhopal, the general public outside the facility was severely affected. They protect adjacent facilities such as school, hospitals, et cetera.

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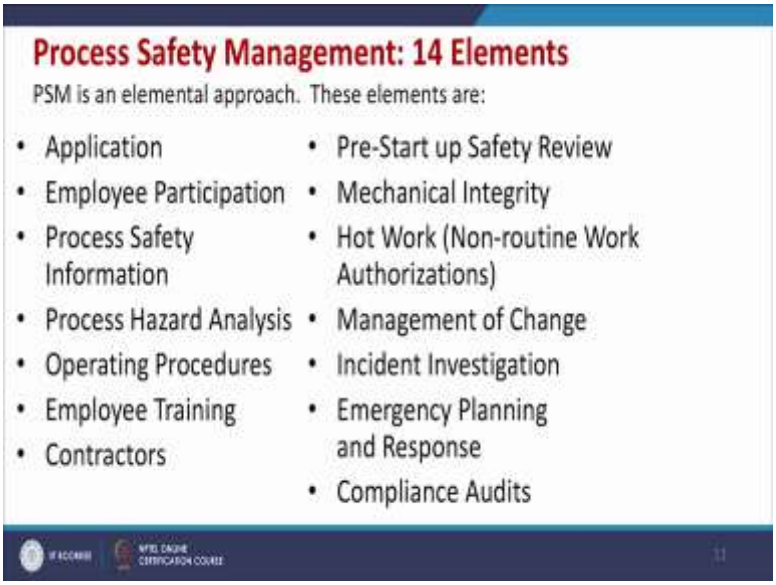

Now, the process safety management it consists of 14 integrated elements. Now this because this PSM is an elemental approach, so let us have a discussion about those elements. One is the application of this PSM, employee's participation, the process safety information, process hazard analysis, operating procedures, there are employee training and something related with the contractors, then the pre-start-up of safety review, the mechanical integrity, hot work that is non-routine work authorisation, then management of change, any kind of technological development, et cetera, incident investigation, emergency planning and response and there are certain compliance audits. So let us have a discussion about those elements for process safety management standard. So let us explore some of those elements.

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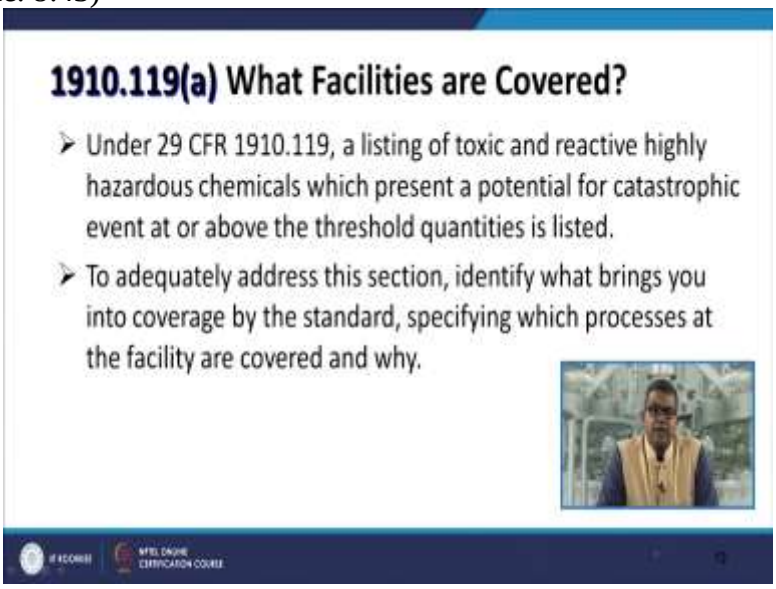

Now, first that let us discuss about the various OSHA guidelines under the head of those elements. So, OSHA developed various guidelines and various protocols, one is this 1910.119(a), that what facilities are covered? So, under this Act a listing of toxic and reactive highly hazardous chemicals which present a potential for catastrophic event at or above the threshold quantities are listed. So, you need to identify and then you need to list those elements.

Now the second aspect is to adequately address this particular section, identify what brings you into the coverage by the standards, maybe material safety data Sheets, et cetera and specifying which processes at the facility are covered and why. So, it covers the basic approach of that facility.

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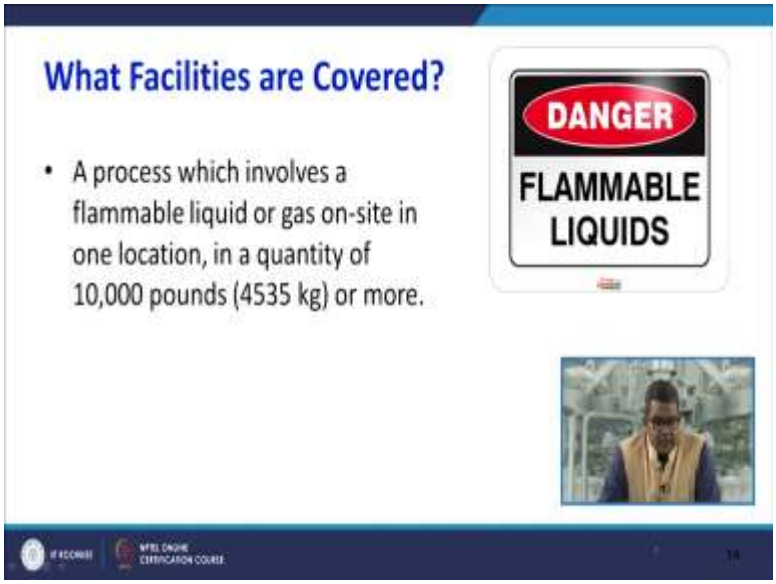

Then a process which involves a flammable liquid or gas on-site in one location, in quantity of say 1,000 pound or 4,535 kilograms or more. So, they specify this particular limit.

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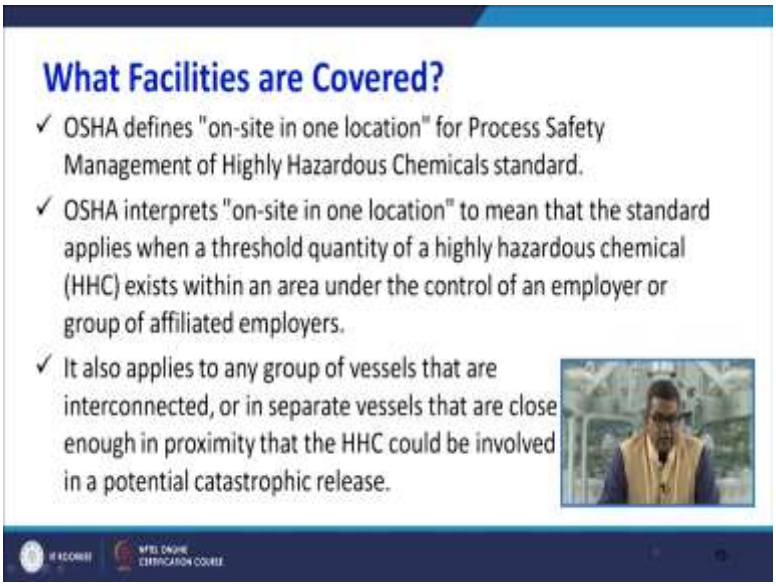

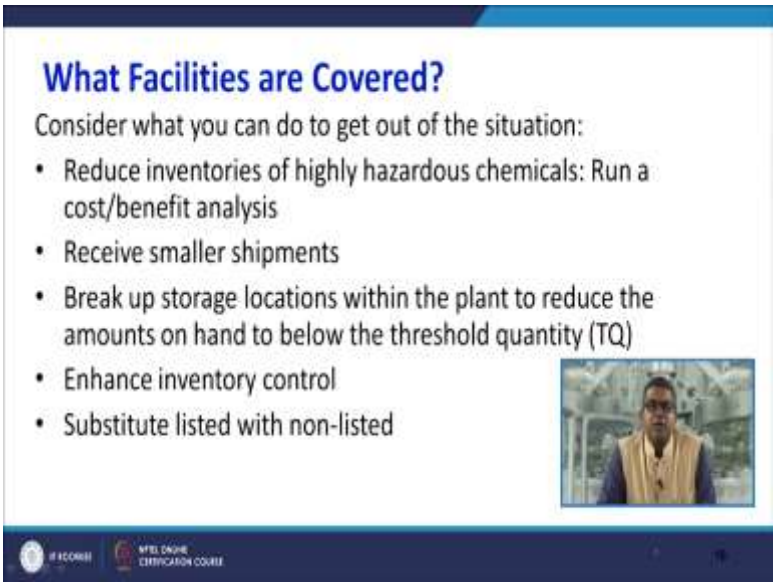

Now, OSHA defines "on-site in one location" for the process safety management of highly hazardous chemicals standard. They interpret on-site in one location to mean that the standard applies when a threshold quantity of highly hazardous chemical, those sometimes referred as HHC, they exist within an area under the control of an employer or a group of affiliated employers. So, sometimes some conglomerates, they too, they usually participate in different industrial activities. So, they cover this particular aspect also in this particular guideline.

So, it also applies to any group of vessels that are interconnected or in separate vessels that are close enough in proximity, that the highly hazardous chemicals could be involved in potential catastrophic release. Now, consider what you can do to get out of those situations. One thing is that to reduce the inventory of any kind of highly hazardous chemical. Run a

cost oblique benefit analysis, that means you need to optimise this thing. Then you receive smaller shipments, you may break up storage locations within the plant to reduce the amount on hand to below the threshold quantity, that is sometimes referred as TQ.

You may have improvised or enhanced inventory control and you may substitute the listed with non-listed one so that you can have other better alternative for those who are dangerous.

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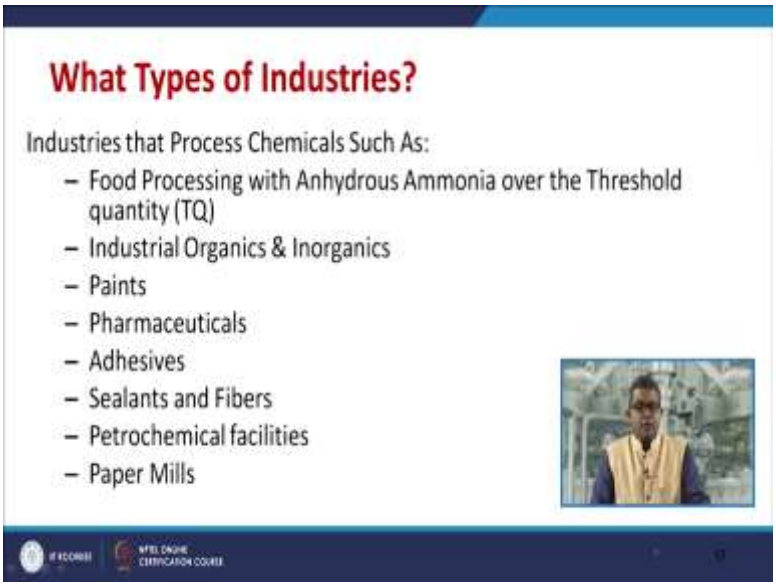

Now, let us have a discussion about that what types of industries involve in this particular aspect. So industries that process chemicals such as food processing with anhydrous ammonia over the threshold quantity. Then industrial organics and inorganics, paints, pharmaceuticals, adhesives, sealants and fibres, petrochemical facilities, paper mills.

Now, see the chemical engineering is a very versatile field, so you may have a large spectrum of industries associated with the chemical engineering. Not only our day-to-day affair but also in the broad spectrum.

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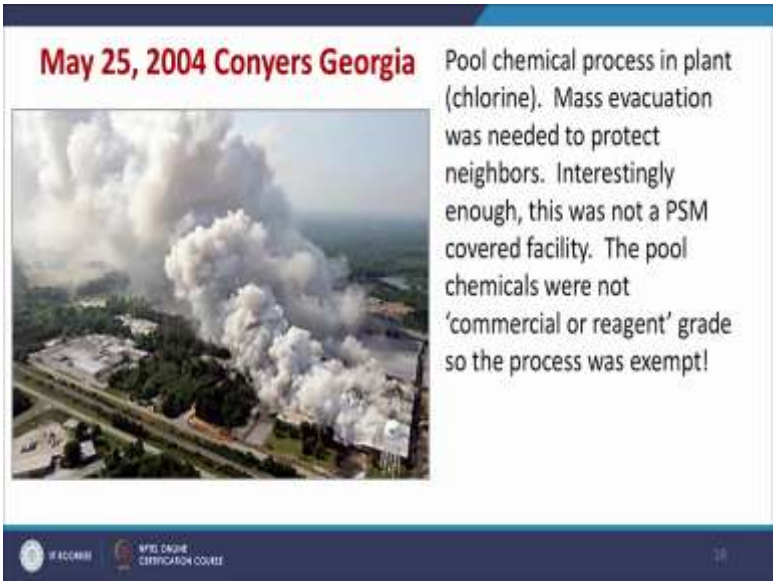

Like 25th May 2004, an accident took place because of the pool chemical process in plant, attributed to chlorine and a mass evacuation was needed to protect the neighbours. And interestingly enough, that this was not a PSM covered facility. Now, the pool chemicals were not commercial or reagent grade, so the process was exempted. So, you would be very specific about this listing of PSM.

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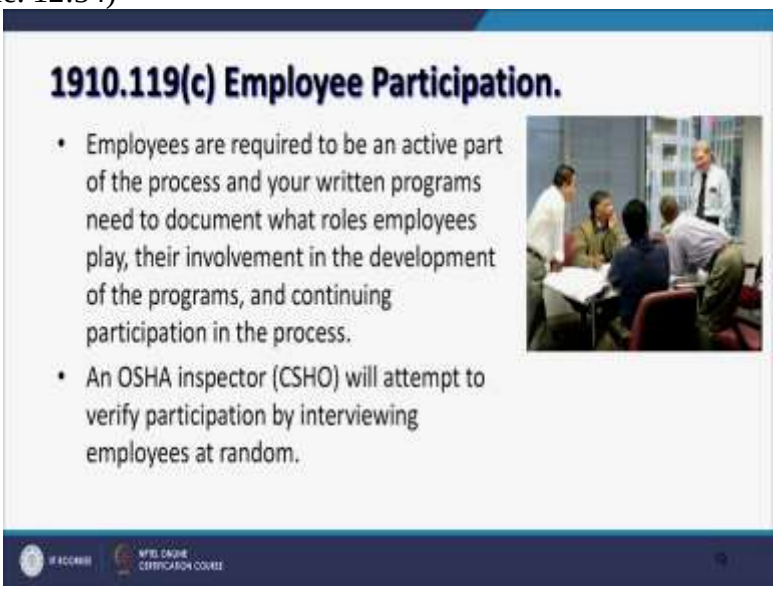

Another guideline is 1910.119(c). So, this reflects the employee participation. So, the employees are required to be an active part of the process and your written programs need to be documented that what roles of employees play, what are their involvement in the development of the programs and the continuing participation in that particular process. So, usually an inspector will attempt to verify the participation of those employees by

interviewing them at random so that they can check that whether the industry is following the norms or not.

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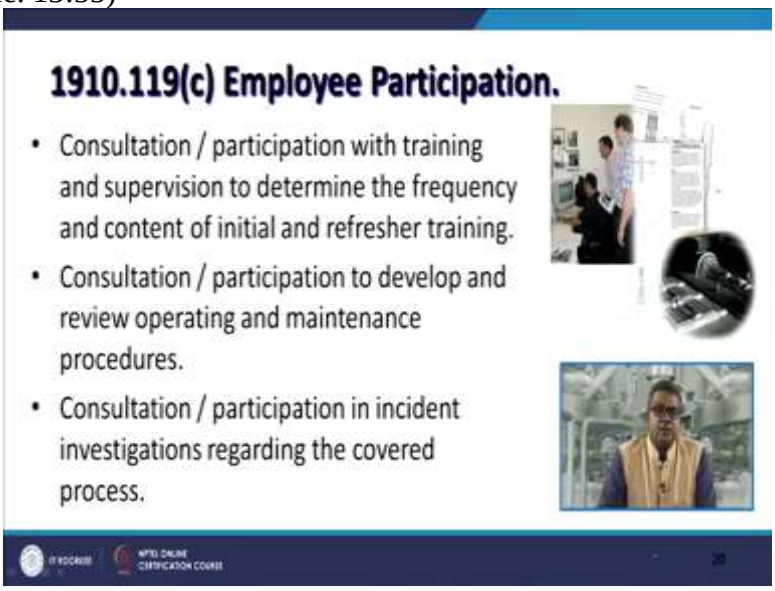

Now, consultation or participation with the training and supervision to determine the frequency and contents of initial and refresher training. Sometimes the consultation or participation to develop and review the operating and maintenance protocols. Sometimes the consultation or a participation in incident investigations regarding the covered processes, et cetera.

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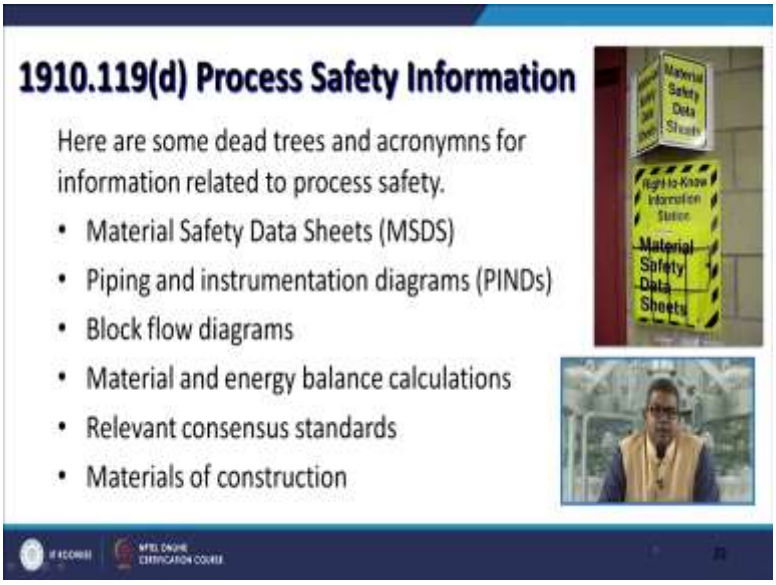

The next aspect is covered under subsection d, that is the process safety information. Now, the intent is to provide the complete and accurate information concerning the process which is essential for an effective process safety management program and for conducting process hazard analysis. There are some dead trees and acronyms for information related to process safety, like material safety data sheet, in the industrial hygiene module we have already discussed this one.

The piping and instrumentation diagram referred as P and I diagrams, block flow diagrams, these are the very good source of information. The material and energy balance calculations, this we need to perform by any engineer those who are involved in the process industry. The relevant consensus standards and the materials of construction.

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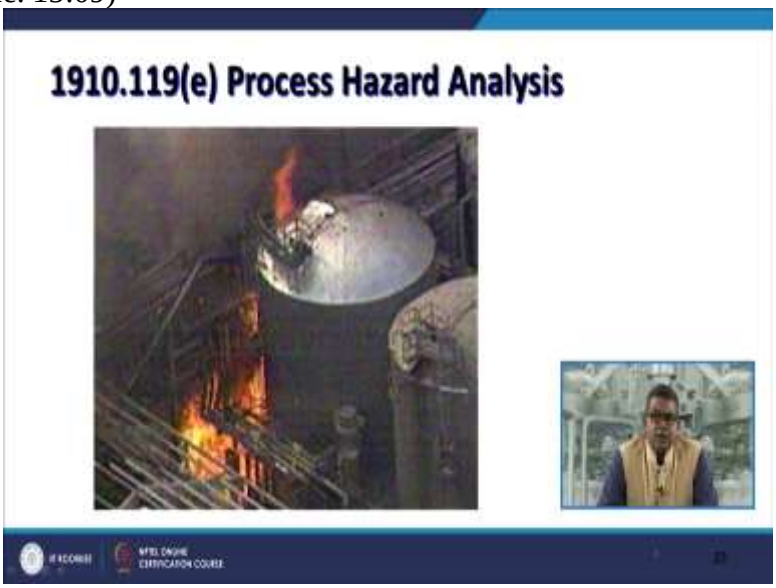

Now, next is that sometimes you may need to carry out the process hazard analysis. That what is the impact of that particular process with respect to the hazard or risk.

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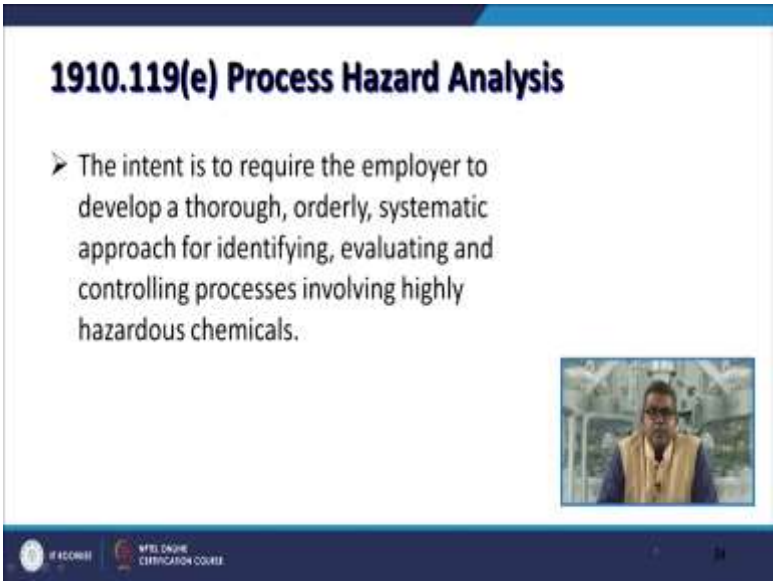

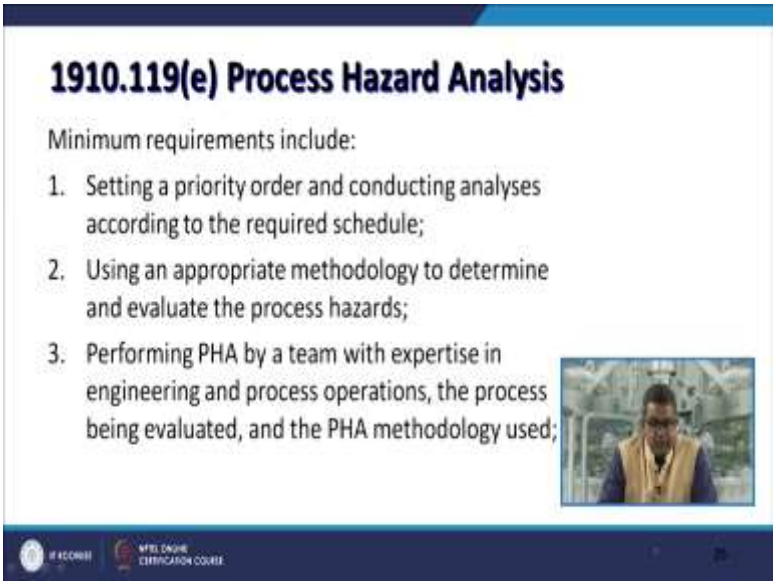

Now, the intent is to require the employer to develop a thorough, orderly, systematic approach for identifying, evaluating and controlling processes involving highly hazardous chemicals. There are certain minimum requirements for this particular analysis that the setting a priority order and conducting analysis according to the required schedule. Using an appropriate methodology to determine and evaluate the process hazard. And these methodologies and the protocols, they are very standard in nature and based on the theoretical aspect of chemical engineering.

The performing the process hazard analysis by a team with expertise in the engineering and process operations. And the process being evaluated and the process hazard analysis methodologies used. Now these minimum requirements include about this PHA, that is addressing process hazard, previously incident with the catastrophic potential, engineering and administrative control, consequences of failure of control, human factor and qualitative evaluation of a possible safety and health effect of failure of controls on employees.

Now, establishing system to address, finding and recommendation and assured solution of recommendation and documentation, develop a written schedule and communicate action to employees because the employees, those are the first stakeholder of that particular protocol. So those employees who work in the process might be affected by the action. This is the next aspect of PHA. Other are like updating and revalidating this process hazard analysis at least every 5 years but it is not necessary, it may be reduced, it may be on the higher side, depending on the process conditions.

Now retaining process health analysis and updates for the life of the process. So, OSHA has suggested a format for the analysis. One thing must be remembered that do not start process until all informations are gathered. Use a software tool to guide, record or manage process and these softwares are easily available in market.

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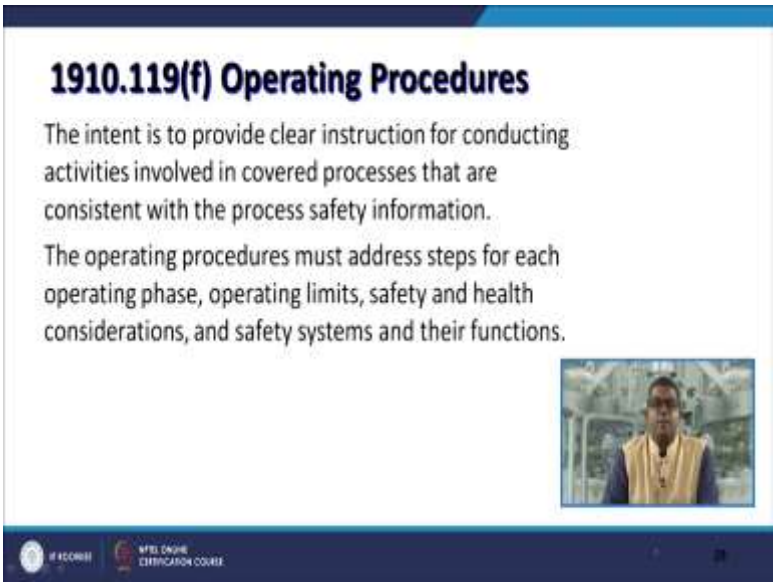

The next subsection is the operating procedures. Now the intent is to provide the clear instruction for conducting activities those involved in the covered processes that are consistent with the process safety information. So, the operating procedures, that must be

addressed for each operating phase, operating limit, safety and health consideration. And sometimes the system and their function information also plays a very vital role.

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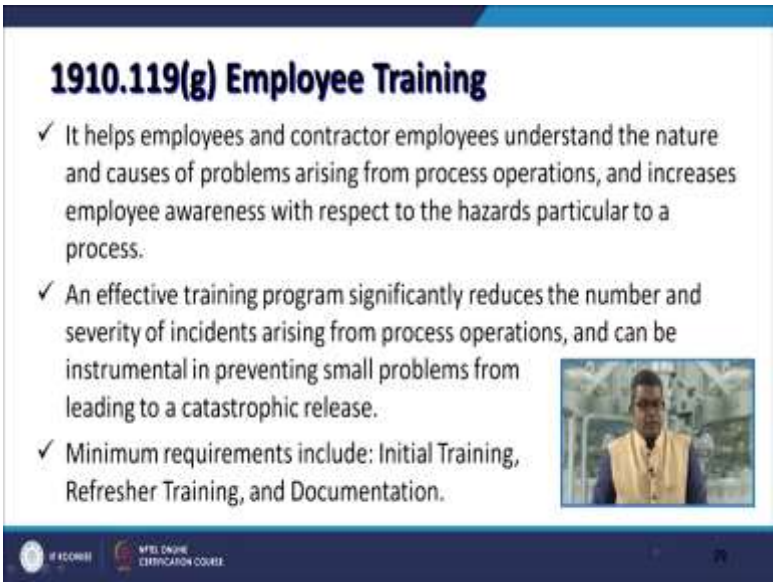

The next subsection under this head deals with the employee training. Now usually it helps employees and contractor employees understand that the nature and cause of the problem that might arise from the process operating conditions and increases the employee awareness with respect to the hazard particular to a process. And also an effective training program significantly reduces the number and severity of incident arising from the process operation. That can be instrumental in preventing small problem from leading to a catastrophic release.

So sometimes you refer as the near message, they do not convert into the major accident. Minimum requirement includes like initial training, sometimes a refresher course, sometimes continuing education and sometimes the documentation. So, these are the minimum requirement for this employee training program.

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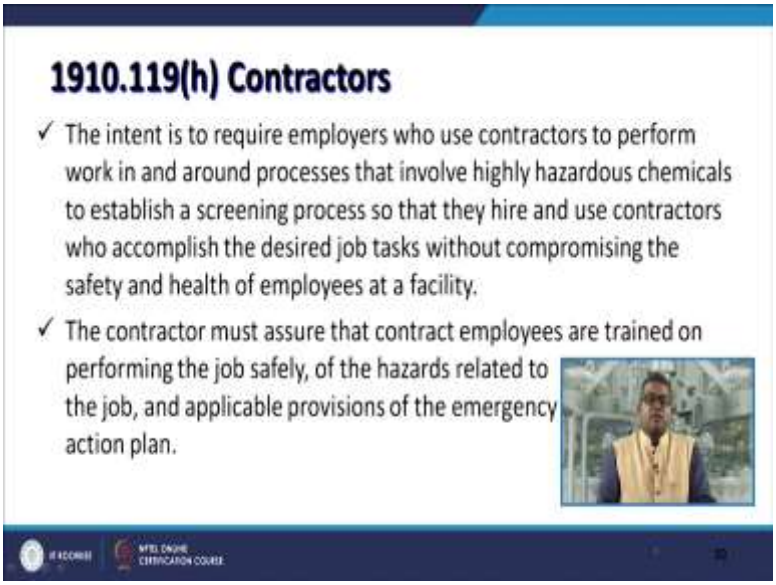

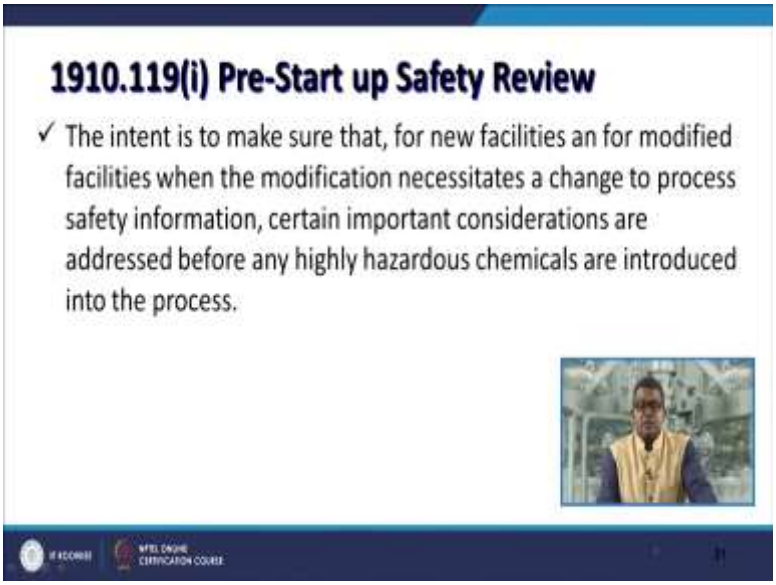

The next thing is attributed to the contractors. Now, the intent is to require employers who use contractor to perform work in and around processes. Sometimes those contractors may involve with highly hazardous chemicals to establish a screening process, so that to handle such type of scenario usually they hire and use contractors who accomplish the desired job task without compromising the safety and health standards or safety and health of employee at the facility.

And the role of contractor is sometimes, because sometimes they are the casual workers and sometimes they are very specialised persons and if you are having a very limited opportunity for those operation, then you may hire them for a very short period of time. Because sometimes it may not be feasible to hire those contractors on a regular basis. So, if they are

handling such hazardous jobs, then certainly the protocol must also be enlisted. So the contractor must assure that contract employees are trained on performing the job safety, of the hazard related to that particular job and applicable provisions for the emergency action plan. So, because every action supported by the emergency action plan, so the contractor they should ensure that their employees they are well trained for that particular assigned job.

The next subset is the pre-start up safety review. Now, the objective is to make sure for new facilities and for modified facilities when the modification necessitates a change to process safety information. Certain important considerations are addressed before any kind of hazardous chemicals they are introduced into the process. So, this type of aspect must be ensured by the employer.

There are certain minimum requirements for these pre-startup safety reviews, these are the construction and equipment is in accordance with the design specification. The safety operations, maintenance and emergency procedures are in place and adequate. For new facilities, the process hazard analysis has been performed and recommendation resolve are implemented. The modified facilities meet the requirements. So, these are the certain minimum requirements for this one.

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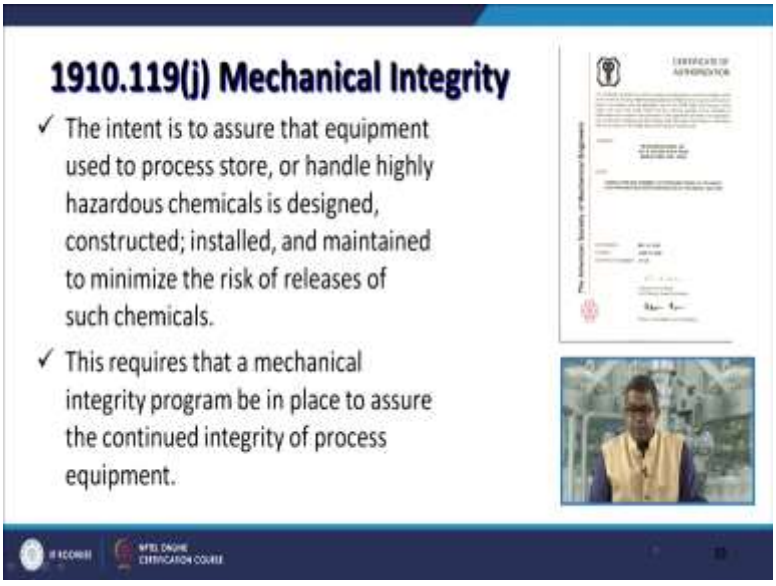

Now next is the mechanical integrity, this is just for the sake of an example. If you are dealing with the pressure vessel, then definitely you must know that what is the strength, whether they do meet the design pressure or not, etc. So, the mechanical integrity of any process is very important. So, the objective is to assure that equipment used to process, store

or handle highly hazardous chemical is well designed, constructed, installed and maintained to minimise the risk of releases of any kind of chemicals.

Now this requires that mechanical integrity program be in place to assure the continued integrity of process equipment. Sometimes they may require a certification from the competent authority that these vessels or these equipments, they are under the mechanical integrity supervision and they are well tested for the process which is going to, that particular process is going to use that particular vessel or equipment.

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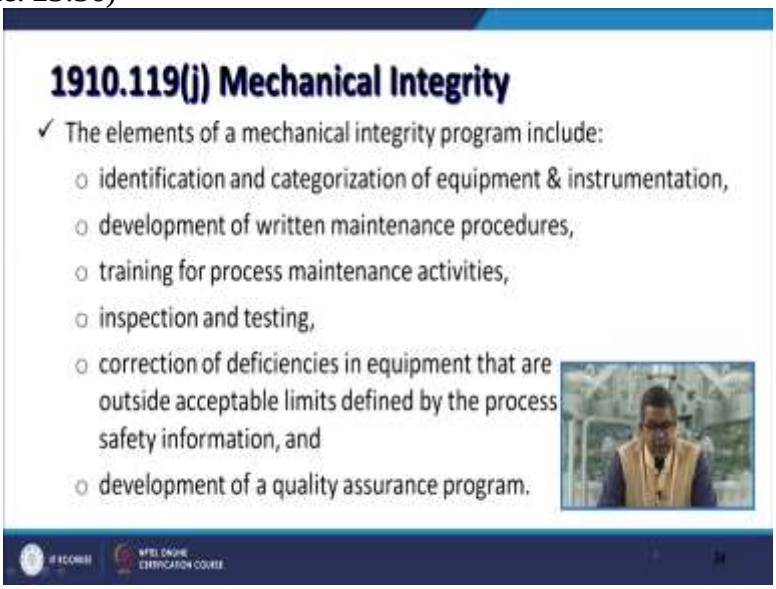

So the different elements of mechanical integrity program, this includes the identification and categorisation of equipment and instrumentation. The development of written maintenance procedure, and sometimes this written maintenance procedure may be clubbed with the standard operating protocol. The training of a process maintenance activities, the inspection and testing of different kind of equipments those involved in the process. The correction of various deficiencies in equipment that are outside acceptable limits defined by the process safety information. And the development of a quality assurance program. So, these aspects, they are the integral aspect of this mechanical integrity program.

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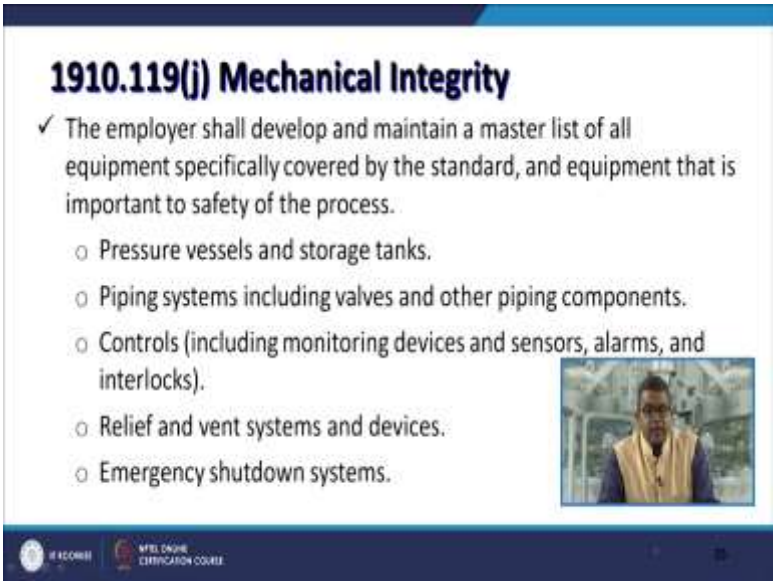

Now, apart from this, the employer shall develop and maintain a master list of all equipments, specifically covered by those standards. And the equipment that is important for the safety of the process. So, it must be properly categorized. Like pressure vessel and storage vessels, the piping system including valves and other piping components, sometimes control that might be including monitoring devices and a sensor, alarm and interlocks, et cetera. Relief and vent system and devices, emergency shutdown protocols, et cetera. So, these are the listed.

Apart from these the pumps, rotating equipments, sometimes heat exchanging equipments, electrical generation or power distribution equipments, uninterruptible power supplies, emergencies power supply equipments, there are certain fire protection equipments, so these are the part and parcel of the mechanical integrity.

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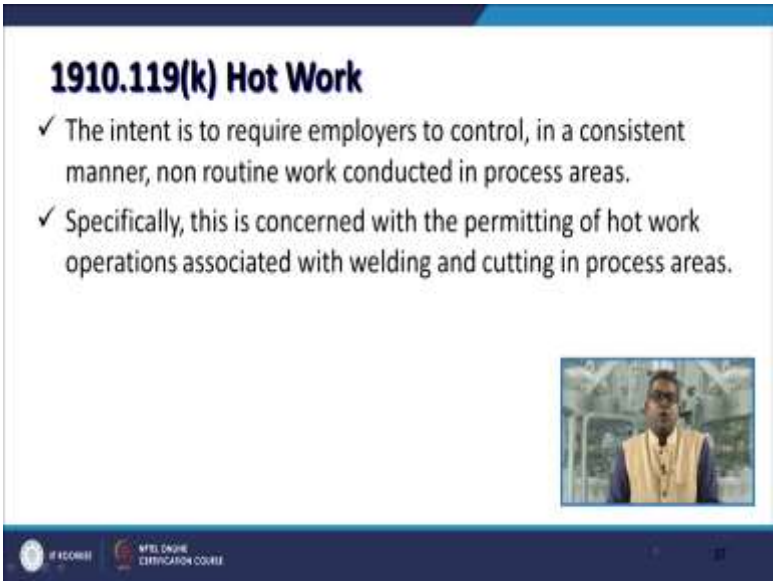

Now next is the hot work or the specified work. The objective is to require the employer to control and in consistent manner, non- routine work conducted in a process area. It is just like that you need to carry out the welding, then you need to get the proper permit to do so in within sometimes it may be a flammable zone and sometimes it may be a very controlled zone. Now, specifically this is concerned with the permitting of this such kind of work, operation associated like welding, cutting in the process area.

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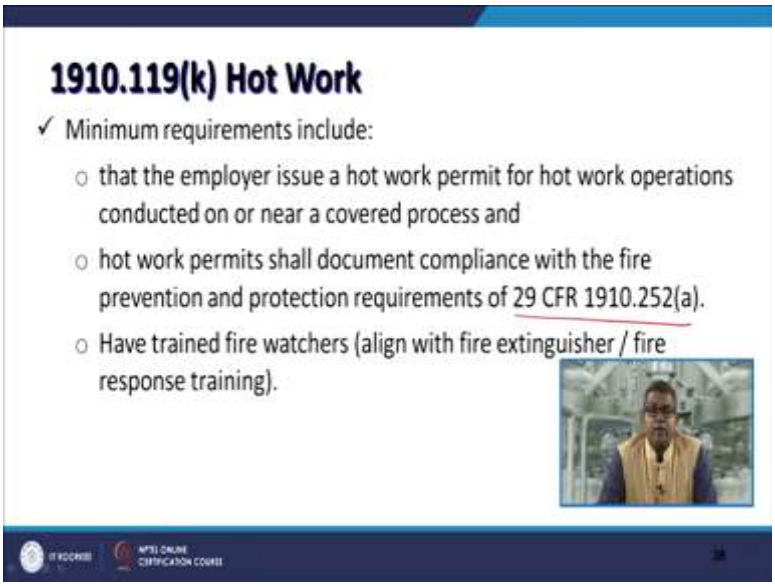

There are certain minimum requirements, those include that the employer issue a hot work permit for hot work operation conducted on or near a covered or controlled process zone. The hot work permits shall document compliance with the fire prevention and prevention

requirement and sometimes there is one standard requirement given by the OSHA, that is this one. Now they have the trained fire watchers, that is aligned with the fire extinguisher or a fire response training, so that in case of any eventuality they may approach to the problematic zone for the remedy.

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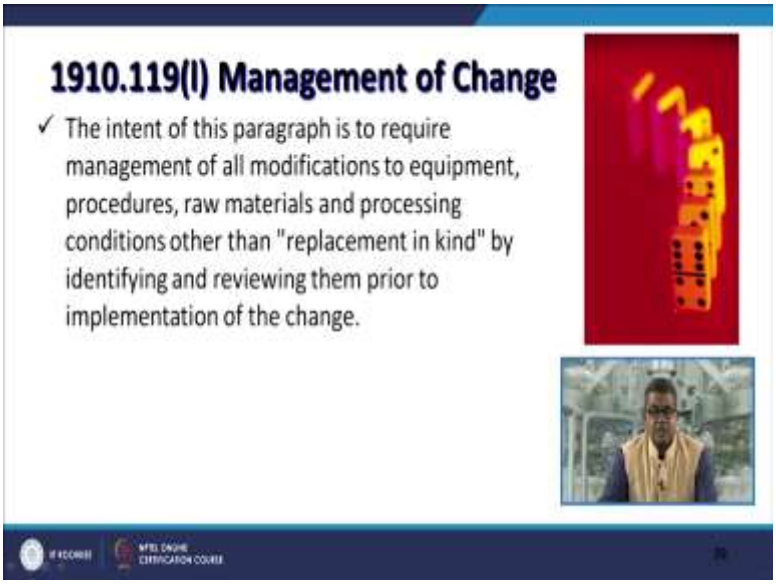

The next is the management of a change. The intent of this particular thing is to require management of all modification to equipment, procedure, raw material, processing conditions other than the replacement in kind by identifying and reviewing them prior to implementation of these changes. Because ultimately the management who usually takes all kind of decision for any kind of alteration.

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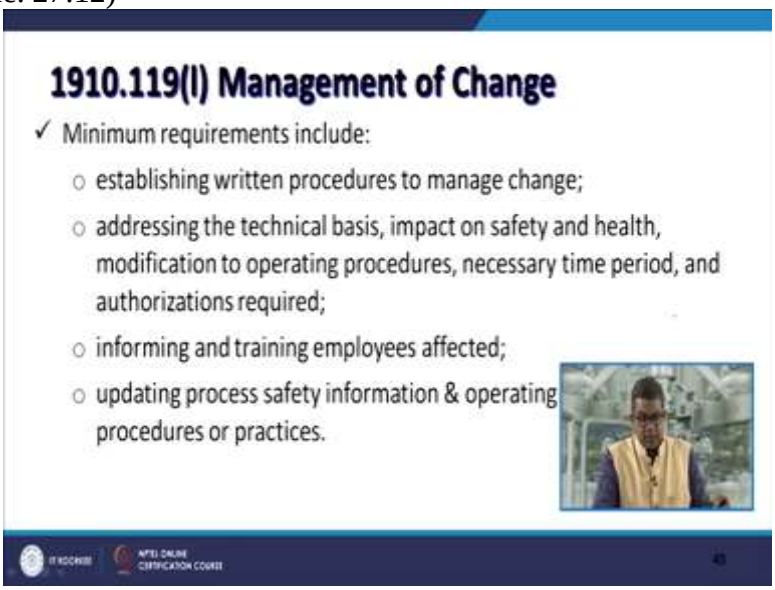

So, there are again certain requirement for this management of change, that is establishing the written protocol to manage change, sometimes addressing the technical basis impact on safety and health modification to operating procedures, necessary time period and authorisation if sometimes required, informing and training employee those who are affected. Sometimes updating process safety information and operating procedures or practices, so these are the integral part of management of change.

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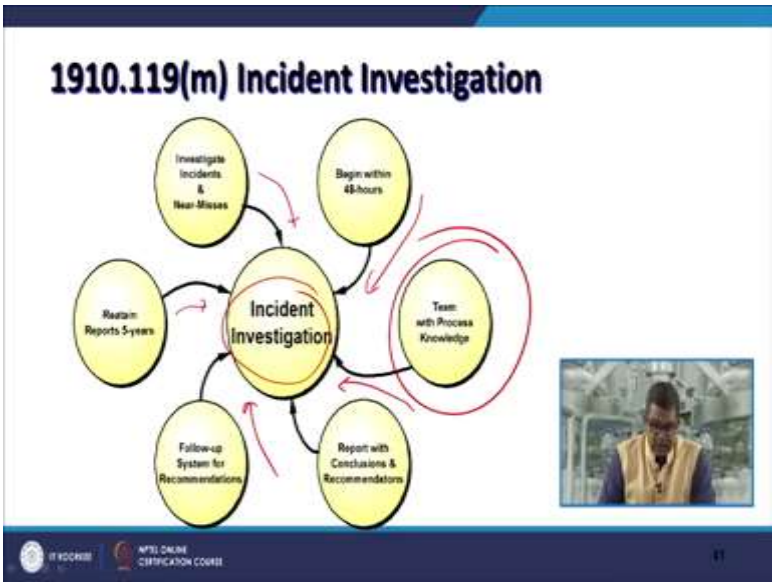

Now, this particular section deals with the incident investigation. Now this is the incident investigation because sometimes it may happen that some untoward incident may take place, than how to handle or how to investigate? Now sometimes you begin with the stipulated time, let us say at 48 hours, then investigate the incident and the near misses, that information may be available through the master log or other reviews or sometimes the records being available at the plant site. Then it is required that retain all those reports for 5 years, follow up the system for recommendations, sometimes those reports suggest certain recommendations.

So during investigation you may analyse that was there any follow-up for those recommendations or not. Then they must submit the report with the conclusion and proper recommendation. Now, all these things they do happen when you are having a team with a process knowledge. So, the formation of the team is quite essential, so once you form the team, then you start with the stipulated time, then investigate the accident and near misses and then review the reports and past recommendations and then you submit the report. So, this is the integral part.

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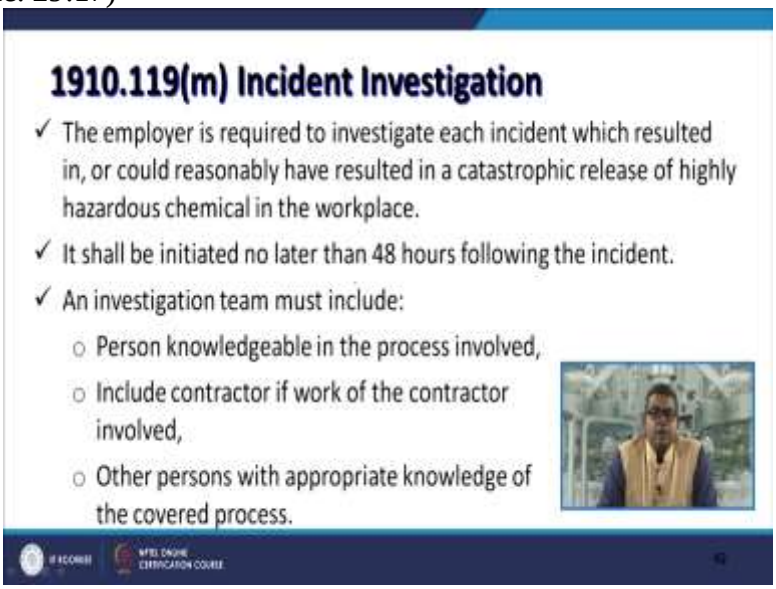

As far as this particular guideline is concerned, the employer is required to investigate each incident which resulted in or could reasonably have resulted in the catastrophic release of highly hazardous chemical at the workplace. So, it shall be initiated not later than 48 hours following the incident. And while we had discussion about the formation of investigation team, so this investigation team must include a person knowledgeable in the process involved, they may include the contractor if any for the work of the contractor where the contractor work is involved.

Other person with appropriate knowledge of the process in question. And report must be produced with the following things like date of incident, date of investigation began, description of any incident, then the factors that contributed to the incident and the recommendation from the investigation to avoid any kind of reoccurrence of that particular incident in future.

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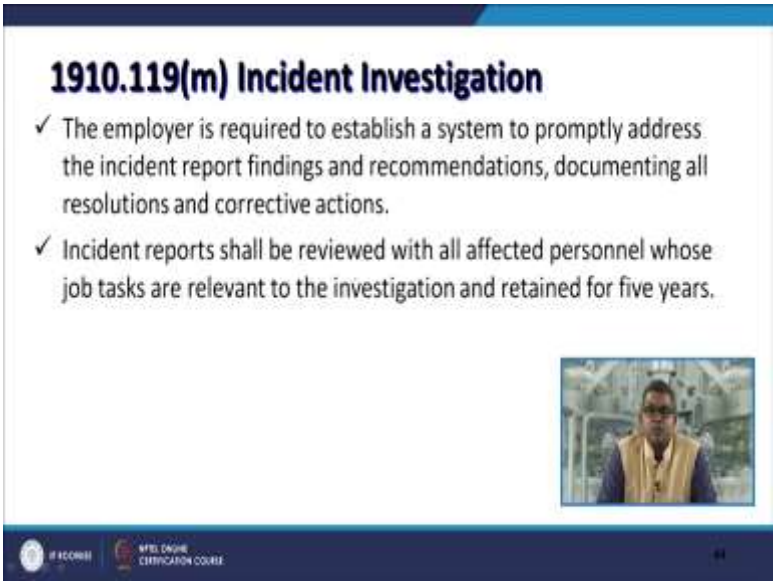

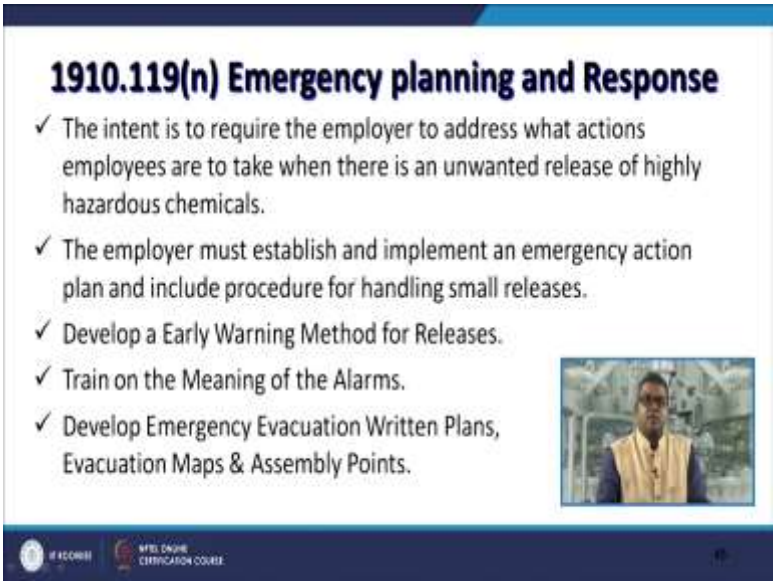

The employer is required to establish a system which promptly address the incident. Report fighting and a recommendation, documentation of all kind of resolutions and in situ corrective actions or follow-up corrective actions. Now, these incident reports shall be reviewed with all affected persons whose job task are relevant to the investigation and retained for almost 5 years. The next is the emergency planning and responses. Now the objective is to require the employer to address what action employees are to take when there is an unwanted release of any highly hazardous chemicals or incident.

The employer must establish and implement an emergency action plan and include the procedure of any kind of handling small releases. They develop an early warning method for the release, they must train the employees for the meaning of alarms, develop the emergency

evacuation written plans, evacuation map and the assembly points must be well-defined, et cetera.

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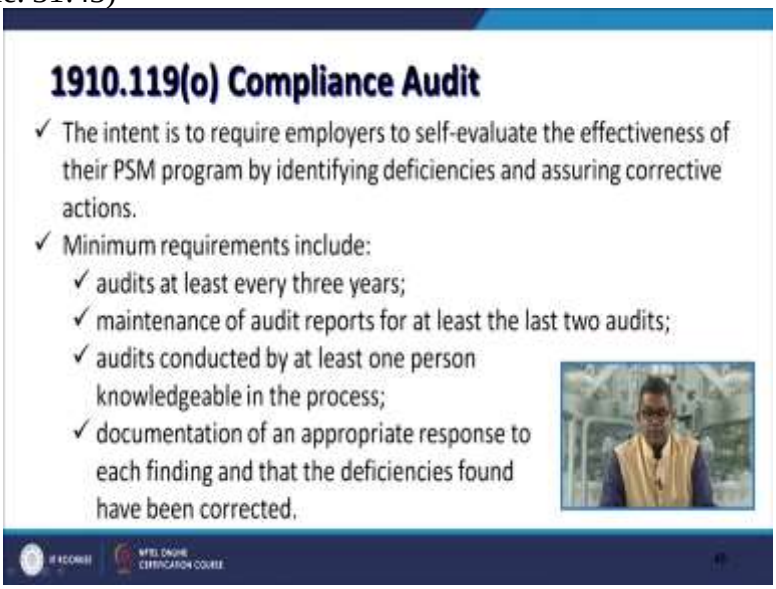

The next subsection that is the compliance audit. The objective is to require the employers to self-evaluate the effectiveness of their process safety management program by identifying the deficiencies and assuring corrective actions.

So there are again like other points, there are certain minimum requirements are like audit at least every 3 years, maintenance of audit report for at least the last 2 audits, audits conducted by at least one person knowledgeable in the process, the documentation of an appropriate responses to each finding and that is the deficiencies found must have been corrected. So, there is much more to with the PSM. So, now this the OSHA, PSM National Emphasis Program for Refineries and Chemical Facilities and the severe violator enforcement program et cetera, so these all the things which are attributed to the violation and this OSHA program.

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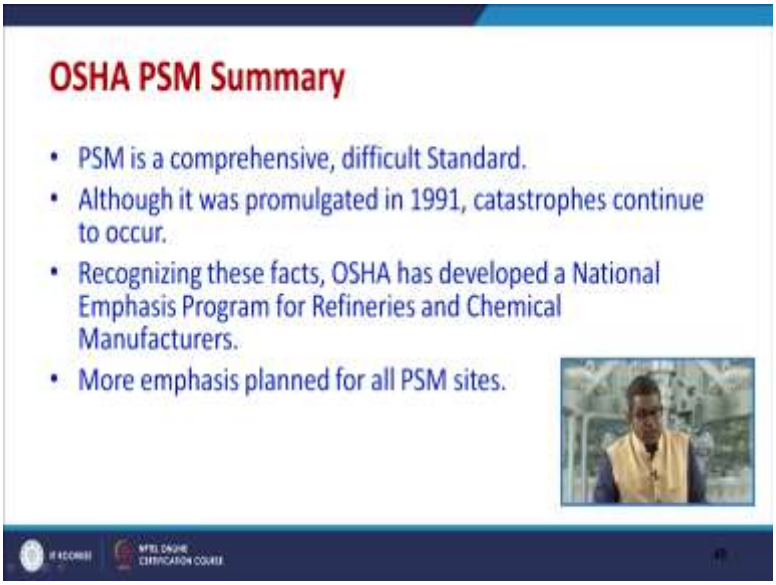

Now, let us have a look of the summary of this process safety management. Now, this process safety management is a comprehensive, or difficult standards. Although it was promulgated in 1991, the catastrophes continue to occur. The recognition of this fact that OSHA has developed a National Emphasis Program for Refineries and Chemical Manufacturers, so that they are very much aware about the catastrophes associated with these chemical plants.

So, more emphasis they are planned for all kind of, all PSM sites. So, in this particular module we have discussed about the different elements of process safety management, what is the process safety management, how we can apply these, what is the employer's responsibility, what are they management, et cetera. Now, again if you wish to have a further

reading of these process safety management aspects, you can have a look of these references enlisted in this particular slide. Thank you very much.