NPTEL

NPTEL ONLINE CERTIFICATION COURSE

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

Module 4: Safety measures in design and operations

Lecture 5: Review of Process Safety

Friends welcome to the fifth lecture on module 4 where we are going to discuss about review of process safety. This is the fifth lecture in the fourth module title safety measures in design and operation and the NPTEL course on HSE organized at IIT Madras. The content of the specific lecture are shared by Dr. V. Subba Rao where we express our sincere thanks to Dr. Subba Rao for giving some of the important points as discussed in this lecture.

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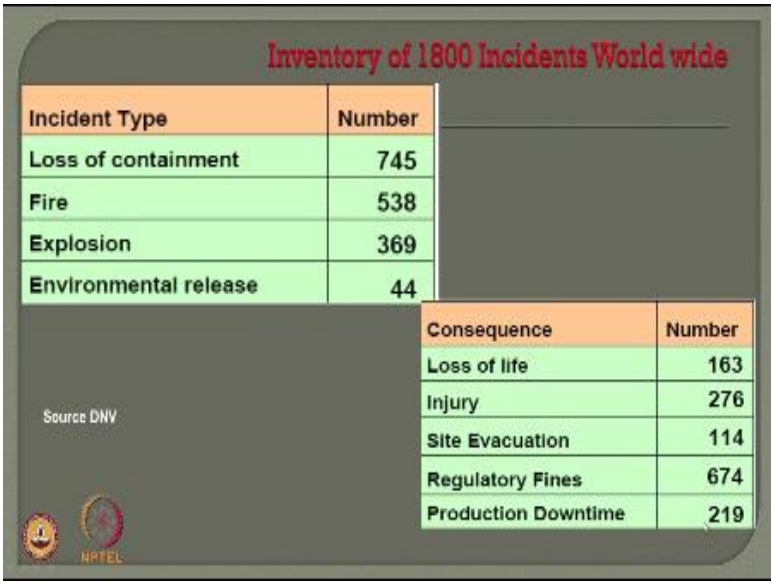

Friends if you look at safety in terms of process safety we must get an idea about what are those incidents occurred worldwide in the reason fast and how therefore process safety becomes very important. If you looked at various instant types and the number of incidents occurred in the

recent past as sourced from D&B the loss of containment was reported to be about 745. Whereas fire and explosion put together is about 900 and environmental release in the atmosphere is only very insignificant number of about 44.

Parallely if you look at the consequences and the corresponding numbers arising from those consequences, loss of life was reported to be 163, injury was around 276 whereas regulatory fines was as high as 674 and production down time which is resulted in economic loss is about 290. On the other hand friends if you look at both the statistics together in form of the table for about incidents occurred worldwide.

The major problem arises essentially from fire and explosion which is a consequence of violation of process safety and this generally can cause a majority of regulatory fines and production downtime which results both of course on commercial viability of any industry never the less applied to oil and gas industries also. However, interestingly if you look at the environmental release which occurred from the violation of these process are marginal or will say insignificant and it is not much resulted in fatality a loss of life.

But of course near misses as a resulted in injuries which is also substantial in terms of the other numbers so we must try to now understand inventory of these incidents which is occurred in the recent past give us a very important lesson that violation of process safety will cause fire and explosion which is a very serious consequence which can result in economic loss to the company.

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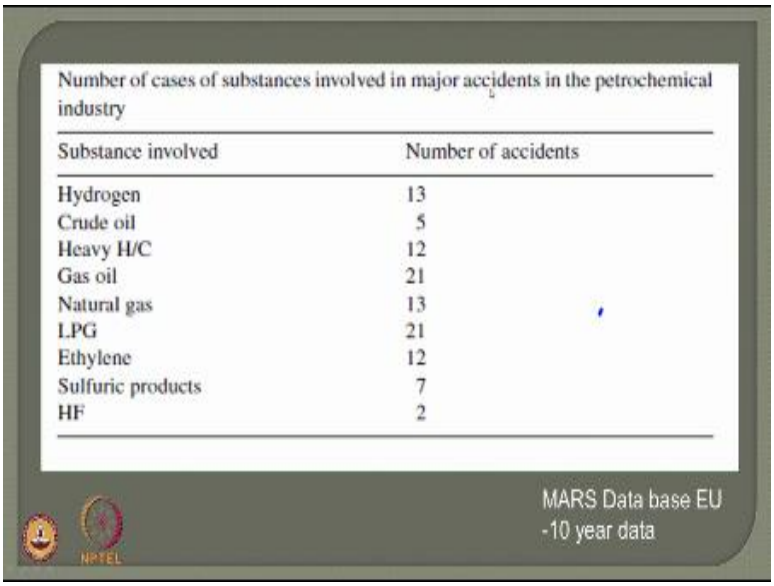

If you look at the number of cases of substances involved in major accidents in the petrochemical industry in the reason past as taken from Mars database European Union for the past 10 years. The majority essentially come from hydrogen, crude oil, heavy hydrocarbons about 12 whereas gas oil is about 21 and the majority essentially comes from gas oil and that of LPG. Whereas the sulfuric products, ethylene, crude oil are very marginal and insignificant in number of accidents are concerned.

So process industry where gas oil LPG extra are being processed manufactured produced extra. One has got to be very careful that hydro heavy hydrocarbons, hydrogen extra can cause serious consequences and these are the substances where in terms of inventory one has got to be careful because they are high potential of resulting in major accidents.

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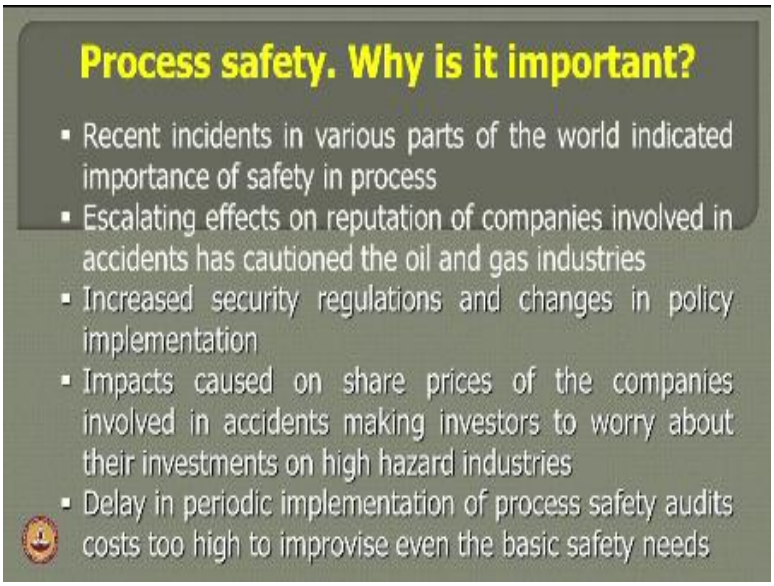

Then the fundamental question comes why process safety is important, region incidents as we saw in the two slides in various parts of the world indicated importance of safety in the process system. Escalating effects on reputation of the companies involved in accidents has cautioned the oil gas industries, because the reputation the brand name of the company is a now stake wherever a company faced an accident. Increase security regulations and changes in policy implementation in the recent past has compelled oil and gas industries to focus on process safety. The impacts cost on sharp prices of these companies which is undergone accidents in the recent past has made the investors to worry about their investments on high hazard industries which are not bothered about process safety.

Subsequently delay in periodic implementation of process safety audits costs too high to provide or improvise even the basic safety needs. Friends if process safety is not a regular routine in your entire process system or the industry you will notice very shortly that even implementing basic safety standards will cause.

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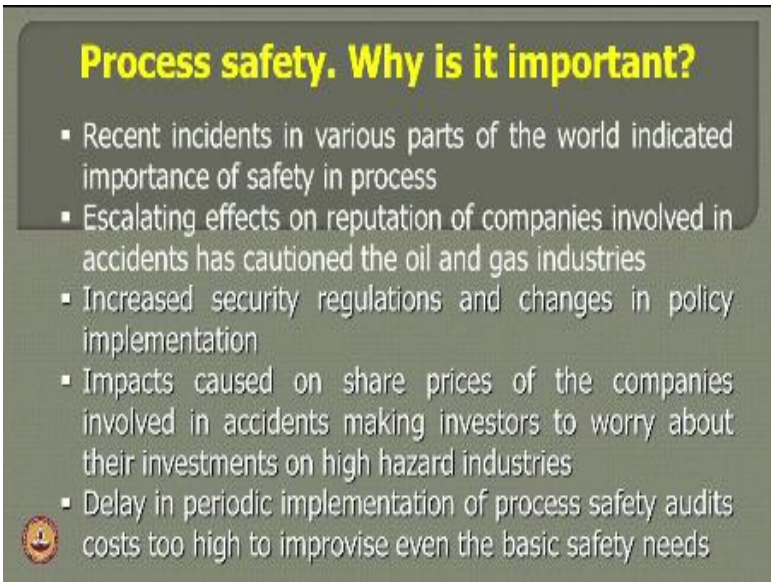

Skye because it will have a very serious cascading effect on the whole process.

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If it is understood and visualized that process safety is important let us now quickly see what are those golden rules of cross safety management. Ensure that we do not hurt anyone during the process. Ensure that we do not harm the environment based on the process what we are carrying out. Achieve a decent return on capital investment or employed. It is a very important factor for any financial sector of oil and gas industry that ROCE is one of the important index based on which the performance of a company is rated in the audit sheets.

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Passing of time without a process safety accident does not really mean that all is well in your plant.

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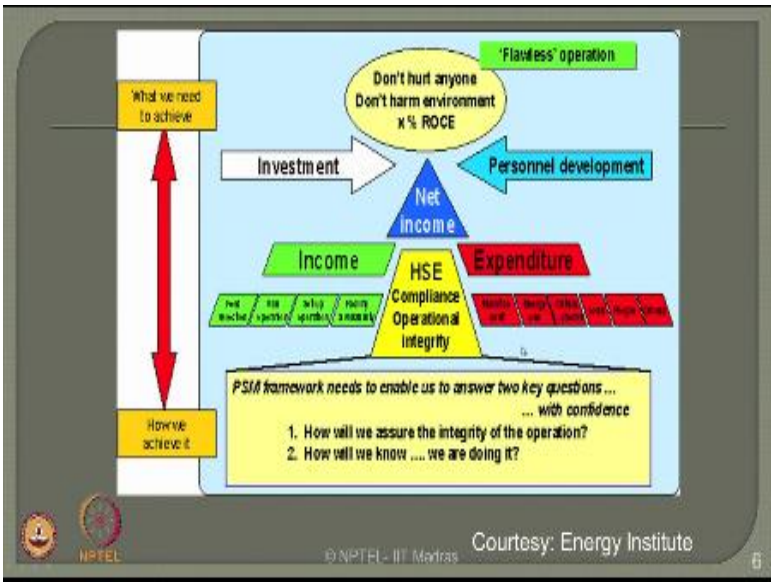

Let us quickly look at this flow diagram where the process safety management has got golden rules implied do not hurt anyone, do not harm environment look for a very high return on your capital investment this can occur only when you have got a flawless operation. However, any operation especially in oil gas industry cannot be called or termed as flawless because all of them have got high potential hazards in terms of their presence.

So now the question is if I have a non flawless operation which is of a high hazard sector then what can be the contributions which can come to control or limit the losses from the personnel sector or from the investment sector. Now from both the sides we look at the net income because that is what we do the expenditure and the income, so let us look at the next gain which I must achieve a very high possible return on the capital investment. Now this can occur only when you talk about HSE compliance in terms of operational integrity. However if you look at the expenditure it can come from the maintenance costs, energy, chemicals, loss people extra.

Whereas the income can come from the proper feed selection proper ran operation, proper setup operation and proper facility availability during operation. However, the process safety management framework needs to ensure that how we can be sure the integrity of operation is

carried out and how do we know that we are doing it in a proper manner. So the question is essentially between the two ends of boundaries. How we achieve it what we need to achieve, so it is between these two boundaries the whole process safety management is circumscribed.

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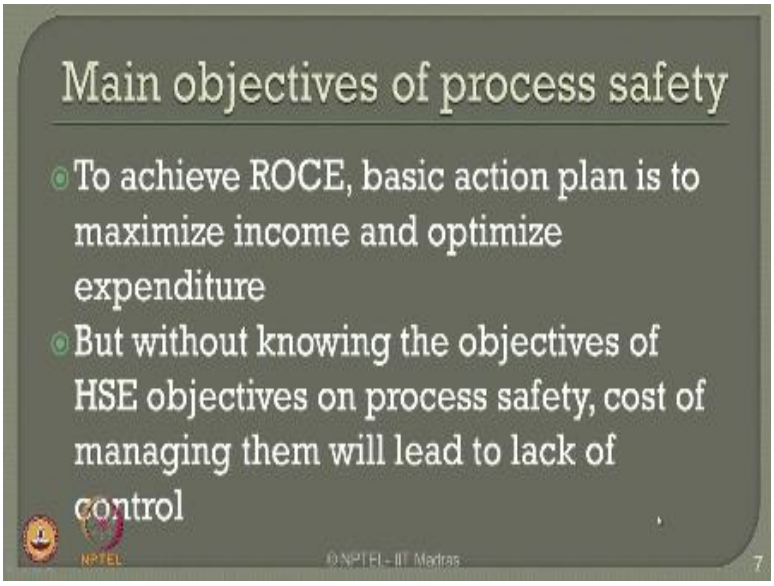

Now let us quickly ask a question what should be the main objectives of process safety. Process safety should essentially focus on return on capital employed, basic action plan is to maximize income and optimize the expenditure. But without knowing the objectives of HSE on process safety, cost of managing them will lead to a lack of control.

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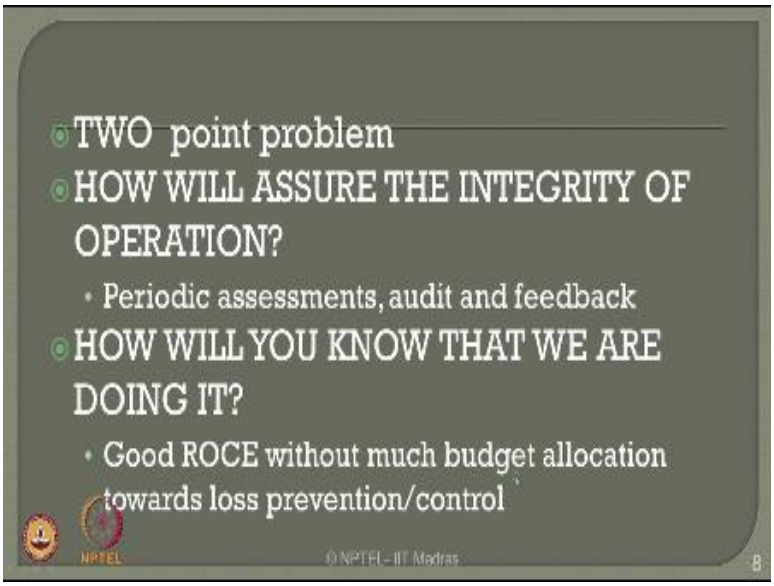

Therefore, the main objectives of a process safety management is actually a two façade problem. How will you assure the integrity of operation, this can be ensured with periodic assessments, audit and feedback? The second phase of the problem will be how will you know that we are doing it properly. A good return on your investment without much budget allocation towards loss prevention and control will be a very good indicator for ensuring that you are carrying out process safety management in a proper manner.

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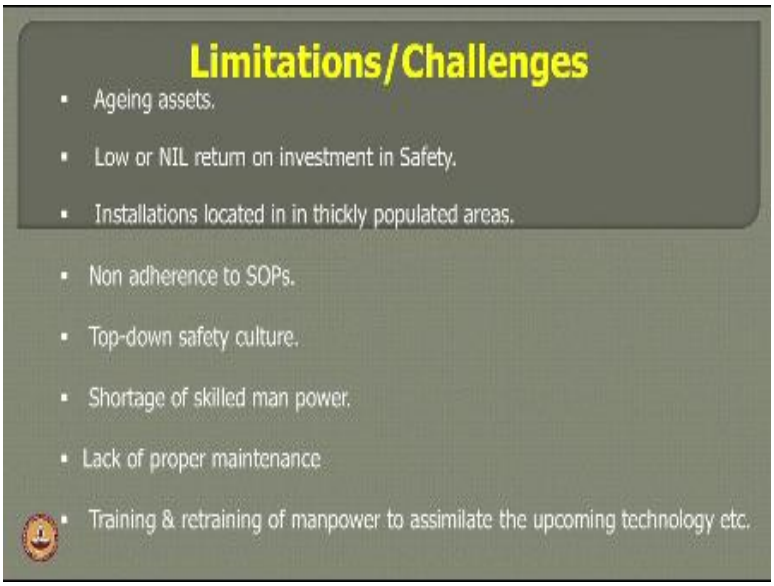

However while implementing process safety there are some limitations available what has been experienced by oil and gas industries. All platforms mostly has been in production for about 10-15 years let us say, so aging assets is one of the major problem which have been discussing in the previous modules and lectures of course they are challenges post to operations as well as design extra. Second important point which is facing a very important challenge to oil and gas industry is that essentially any investment in safety has very poor return.

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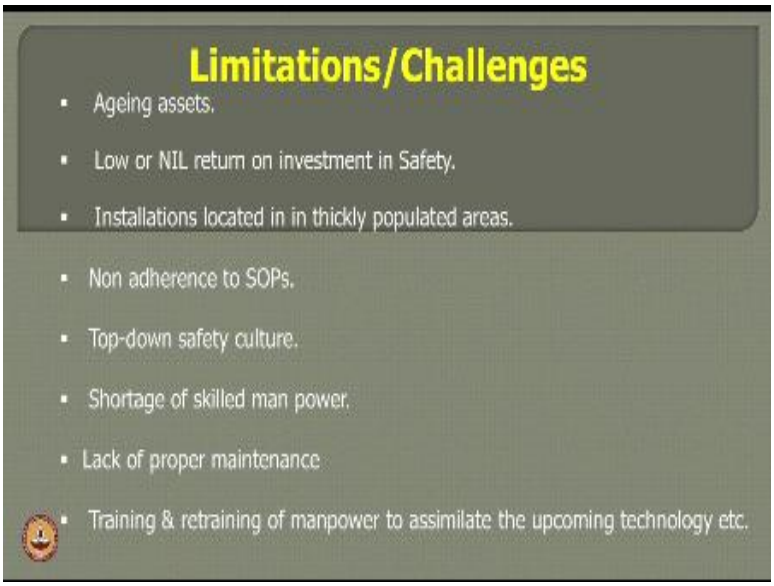

When you talk about high return on capital investment then a fundamental question comes in management mind either why should I invest in safety. However, if we ignore or sideline process safety the loss which will be encountered because of the other situation in the industry will cost you Skye therefore ROCE cannot be reiterated in the desired manner, when we talk about installations that are located in a thickly populated sector then they postal challenges because of societal risk involved in them. Sometimes we also talked about top-down safety culture.

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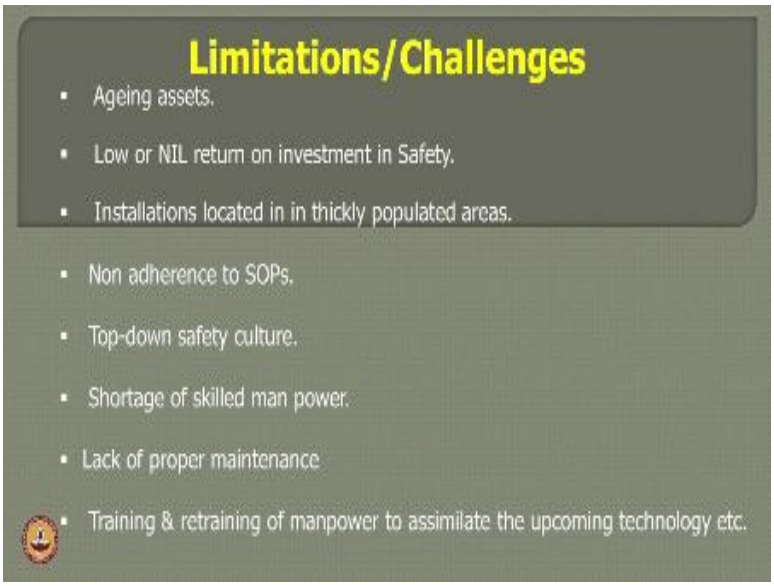

We implement safety in terms of rules and regulations to be practiced in the operational plan, however safety is not experienced and felt as important in the top-level management what we call blue sector management. However, an oil gas industries friends we all know there is a very acute shortage of skilled manpower, skilled manpower in since a manpower which is trained and can handle emergency situation in terms of any chemical releases.

Of course we also understand very thoroughly partly we all agree that lack of proper maintenance is a very serious concern of almost all process industries and this is a major challenge in terms of oil gas production units.

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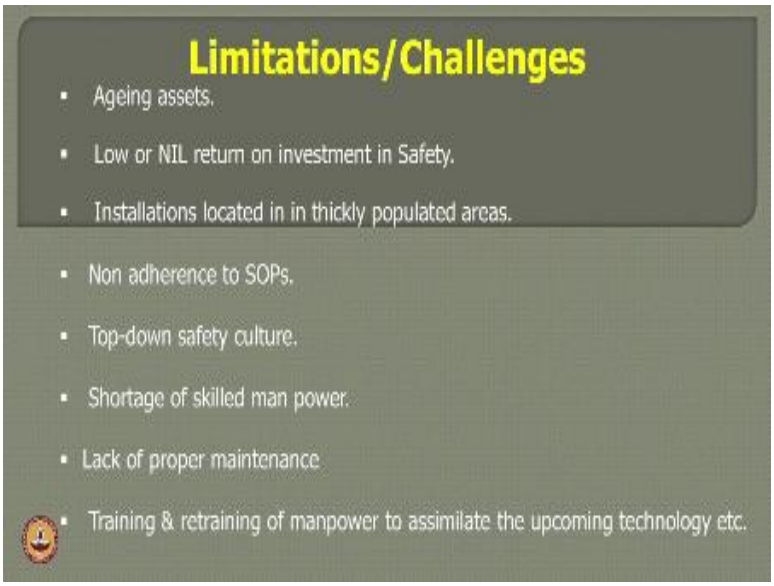

More importantly paying attention towards training and retraining of manpower to assimilate the upcoming technology is a very important sector where HSE can play a very important role in terms of capacity building that ensures safety in production operation in a general the entire process.

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Then one can ask a question in mind what should be a common tool for practicing or assessing or implementing process safety. Process safety is said to focus on various but interconnected systems, they may be mechanical, electrical, chemical extra. Man machine interface is an important keyword when we talk about implementation of process safety. A very interesting model available in the literature is Swiss Cheese model which can be easily applied and effectively turned out to be a good visual result for process safety management.

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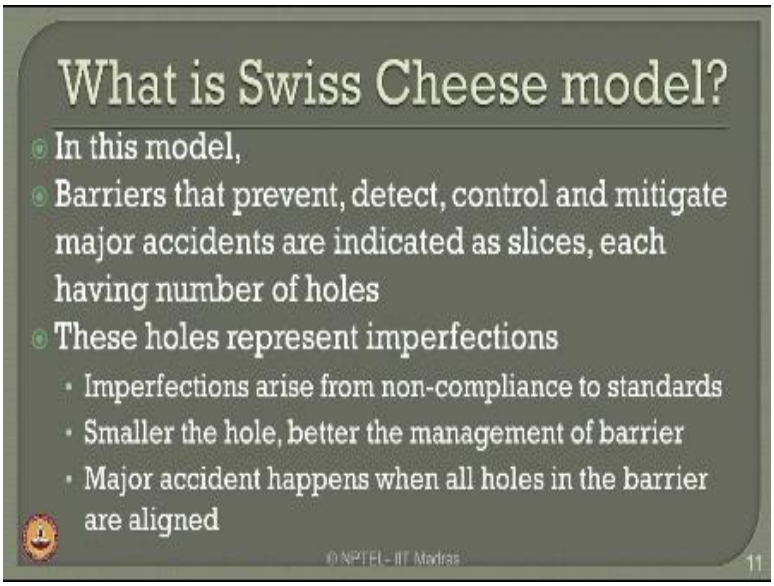

Then the question comes what is Swiss Cheese model. In this model barriers that prevent, detect, control and mitigate major accidents or indicated as slices each slice are marked with number of holes. These holes actually represent imperfections these imperfections may arise from non-compliance of these machineries or equipments to the standard procedures. Smaller the whole better the management of the barrier. Major accidents do happen when all these holes in the barrier are aligned what we call as a catastrophic incident or an event.

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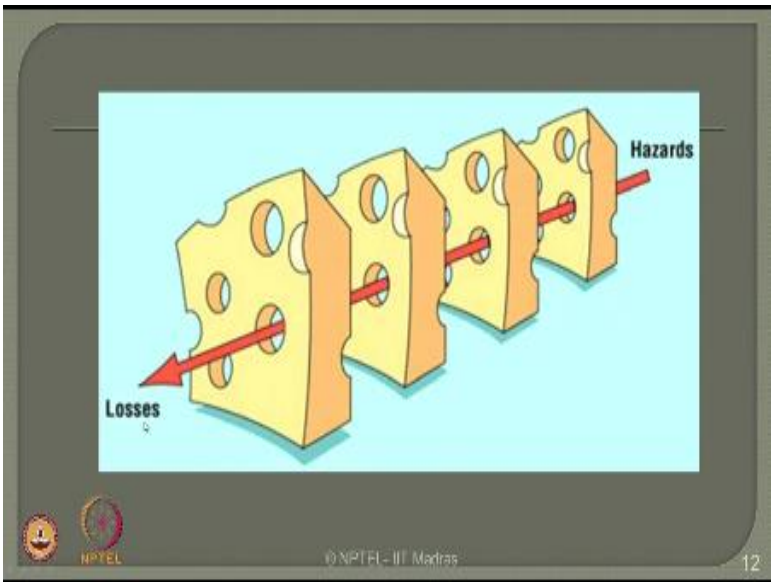

Now this picture shows how hazards which are scenarios will result in potential losses which becomes an economic threat to the company. So when the holes which are nothing but imperfections which are violations of standards at different stages in process industry, when they all get aligned a simple hazardous situation can become a serious potential loss or economic loss to the company itself.

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More importantly one should also focus on near miss events. What is a near miss event? Near miss even is actually an unplanned event that did not result in any injury, illness or damage. But very importantly friends please understand this had a very good potential to do so. near misses are therefore very important lessons that teach to improved process safety without paying for huge losses.

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Therefore the integrated feature of process safety is managing the whole issue what we call as process safety management. Process safety management refers to prevention of unintentional release of chemicals, energy or other potentially dangerous materials into environment. Process safety of course involves prevention of leaks, prevention of oil spills, prevention of equipment malfunction, avoiding overpressure, avoiding over temperature, avoiding metal fatigue extra.

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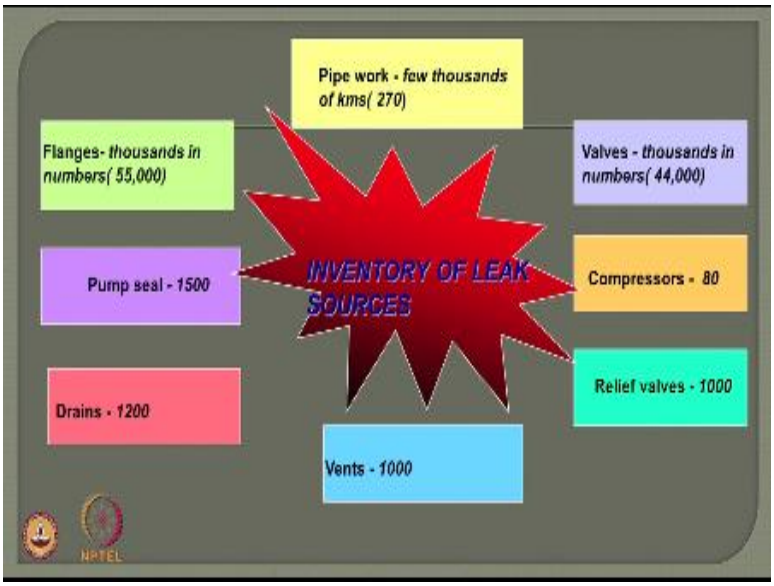

Look at this specific flow diagram which is talking about inventory of a league sources taken from a specific reason publication. The inventory of leak sources come from various scenarios what you see in the slide now it can come from a pipe work, it can come from valves, compressors, relief valves, vents, drains, pump seal and flanges. However, when you look at a process leak scenario in a given industry of an example take another slide now. Various appurtenances and specials like valves, compressors, relief valves, vents extra are generally considered to be important point of leak sources.

But people generally think that pipes which are laid underground or underwater which are very long may be running in few kilometers or potential source of serious hazards. Look at these numbers in the brackets the majority of these potential inventory of leak sources do not come from the pipe work because pipes are properly designed for to undertake such deviations in the design or violations in the process.

When they have been transporting oil from the production to process industry. The majority of failure which are seen as leak sources come from the flanges and the walls however, the vents the pump scenes, compressors which are equipment failure are not very significant contributors

as comparable to the top the flanges and the valves, so from this simple illustration one can easily focus that if you really want to pay attention to major loss prevention program in any process industry one should not focus on appurtenances in equipments which are major.

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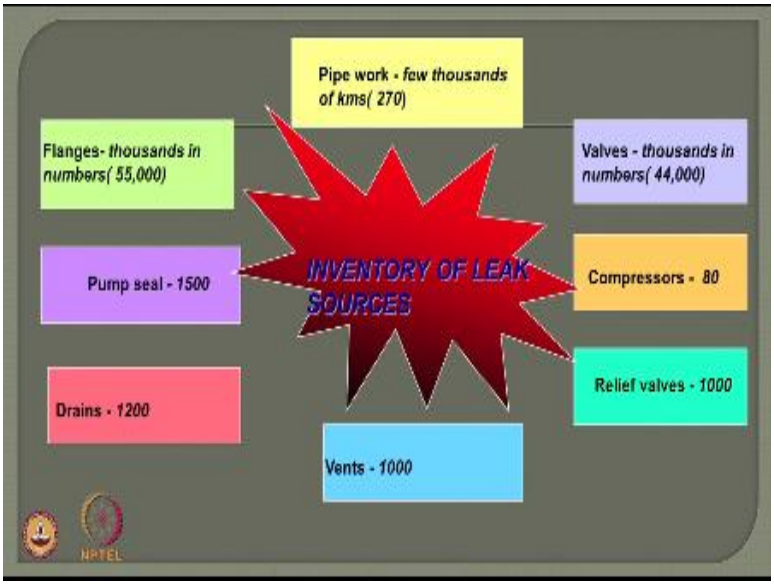

But focus on the connections which are very important because they are seemed to be a potential challengers for leak in any given process industry.

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Therefore, what should be the focus of my process safety management program? On design and engineering of facilities I should focus on of course maintenance of equipments in a periodic cycle, I should also design effective alarms and signal generator systems in a given process industry. I must establish effective control points where I can check the leak or at least the extension or spread of the leak if the leak has occurred.

One should also think of implementing proper safety training to the personal involved on board and one should also encourage implementation of proper safety procedures in the process industry.

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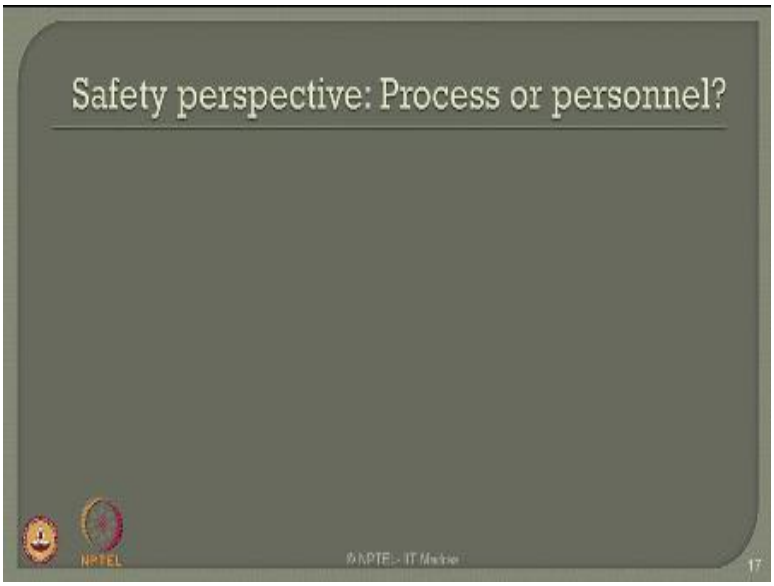

Now a major question comes what could be the deviation or differences between process or personnel. The moment we talk about safety in terms of its perspective should it focus on process safety or should it focus on personnel safety is a very interesting question is always along debate to focus on which is more important. Let us quickly compare them from the slide.

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Process safety actually results in hazards which can cause major accidents, it results in release a materials that can be a potential damage, it can result in fire and explosion, it can cause huge economic loss to the company, it can defame the brand name of the company when such accidents turn out to be a major catastrophic events, it can affect the shares in the stock market of the company. Most importantly friends process safety is a scenario which has got high consequence but very low frequency.

However, try to compare this with personnel safety, personnel safety can of course result in incidents such as minor injuries or even fatal accidents. They are scenarios related to low consequence but very high frequency. Now it is very interesting for a decision maker to challenge or address the scenario which have a very high consequence.

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Or a scenario which is a low consequence, however look at the frequency their contradictory so process safety and personnel safety both are equally weighted because both have the common risk in terms because risk is nothing but the product of these two where one is lower the other is higher of course risk which is generate as an outcome from violation of safety culture will be however equal when you violate both process safety and personnel safety.

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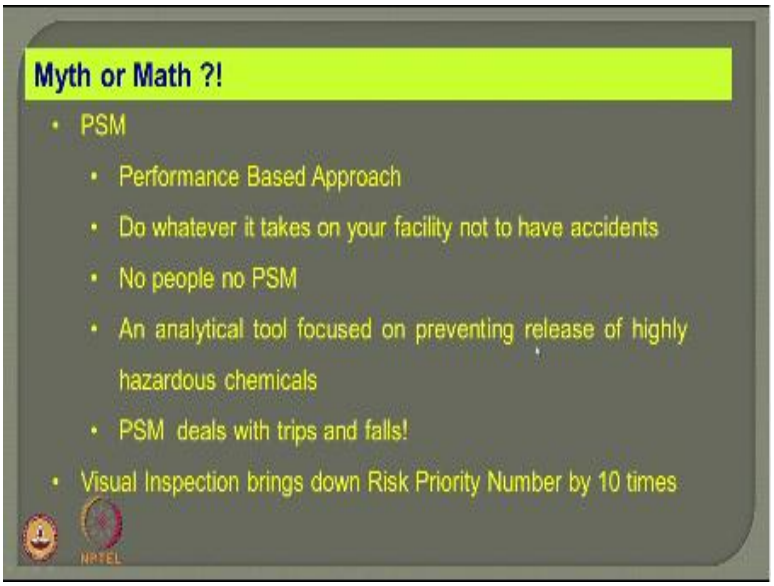

Now the question comes is process safety management is mathematical yes, this can be done because it has got a very interesting what we call performance based approach. Process safety management is an algorithmic skill which says we can do anything and everything on your facility which can avoid accidents. Process safety management is inherently built around only people, so process safety management focuses essentially on personnel safety as well. If there are no people therefore there is no PSM deploy.

PSM therefore is a very interesting analytical tool which is focusing on preventing release of highly hazardous chemicals into environment. PSM therefore deals with trips and falls of such incidents. Visual inspection can avoid process safety violation to a major level which can bring down the risk priority number at least by about 10 times.

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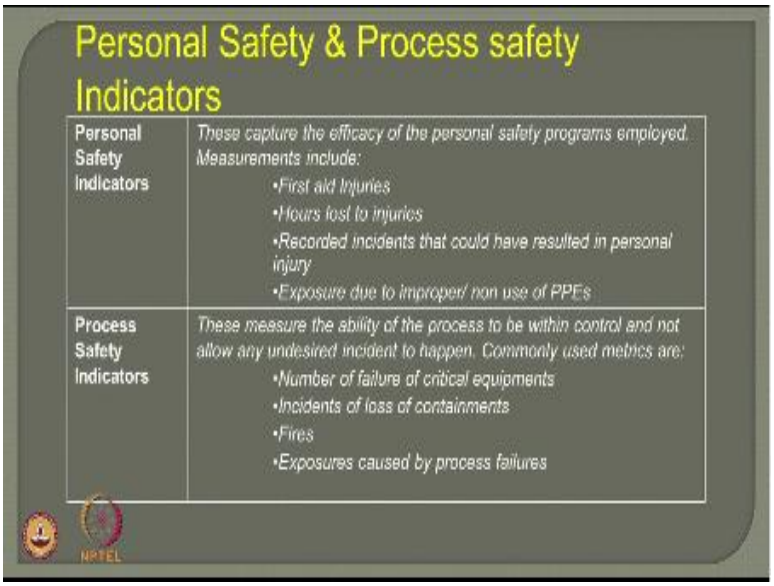

Now the question comes when process safety is circumscribing around personnel safety which takes care of an inbuilt feature of personal safety as well, then what are those indicators which will tell me am I practicing process safety in a proper manner. Personnel safety indicators however can be used to measure the efficacy of the personnel safety programs employed. The major factors which actually are indicators of personnel safety measurements or first aid injuries report of hours loss to injuries. Recorded incidents that could have resulted in personnel injury and of course they exposed duration due to improper or non-use of personnel protection equipments.

So these are some of the good indicators based on which a personnel safety implementation program can be measured and monitored in a given industry. On the contrary if you look at the process safety indicators these measure the ability of the process to be within control and not allow any undesired incident to happen, so on the upfront process safety indicators are focusing on blocking the whole occurrence of the instant itself.

If there is my instant occurrence therefore process safety will also take care of personnel safety inbuilt that is what we said in the previous slide. The commonly used matrix which are

measurable for project safety indicators are how many number of failure of critical equipments have occurred in the recent past. What are those instances of loss of containments reported in the recent past? What are the reports on fire and explosion occurred is there any exposure caused by process failures.

The answer to these questions which are nothing but indicators of process safety implementation program will tell the degree of compliancy of process safety management to a given system.

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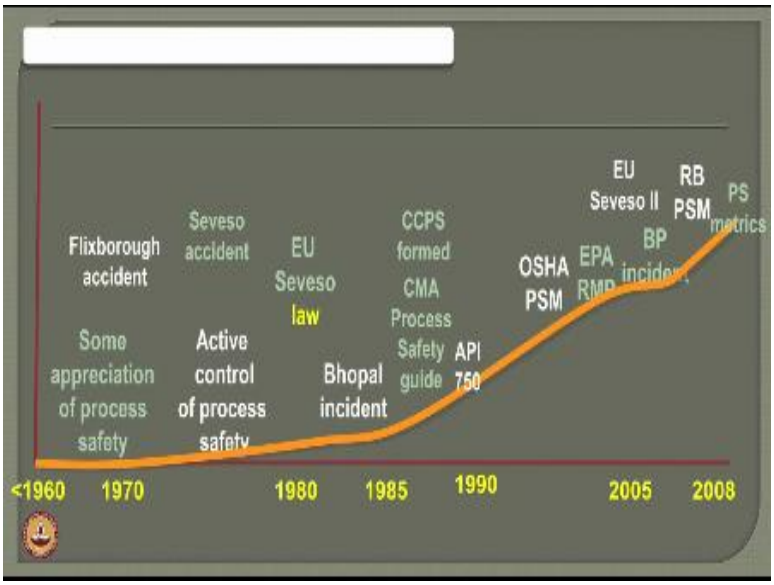

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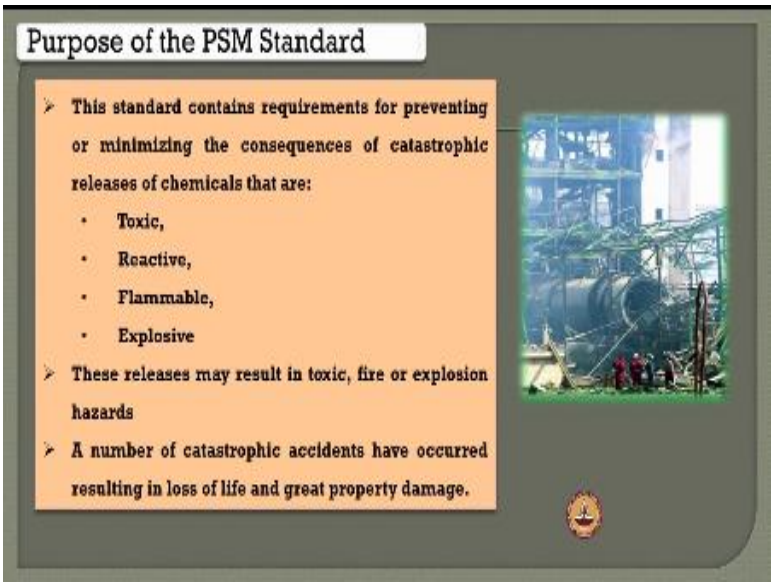

Now interestingly if you look at.

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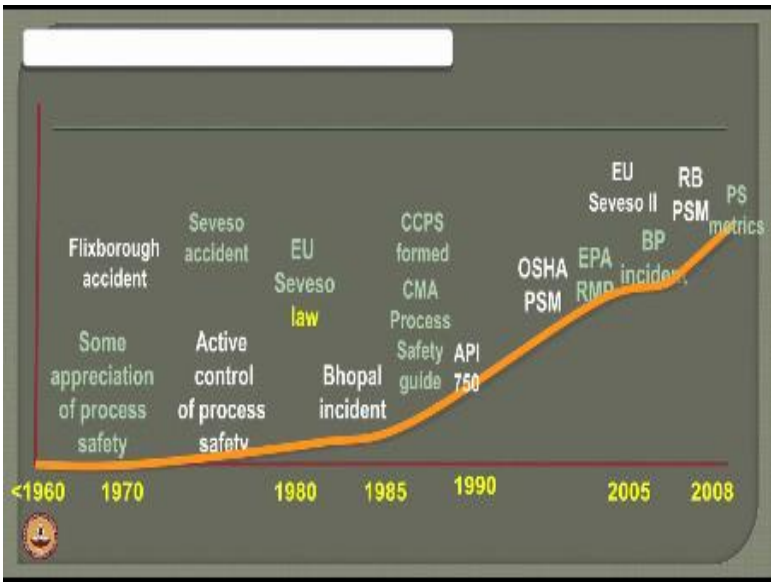

The process safety implementation scheme as such people have learned implementation of process safety as years passed the way. Up to 1960 or let us say early 70s there were only a marginal appreciation of process safety until the famous Flixborough accident occurred in oil industry. Subsequently when Seveso accident occurred then people thought of implementing some active control measures towards process safety.

In early 80s when European Union faced the Seveso law which is passed on in 1980 and subsequently in India when people faced an experienced and witnessed Bhopal incident then CMA process safety guidelines were implemented and brought into line rate strongly and early 90s then came API 750 then of course in early 2000s we had OSHA standards on process safety management implemented in the schemes, then European Union Seveso two accident confirm and the BP incident confirmed a strong implementation and follower on process safety management rules.

As you see from here than in the current standards in 2015 we have got different process safety matrix which I showed in the last slide as indicators to measure both the process safety and personnel safety and the successful implementation in a given industry.

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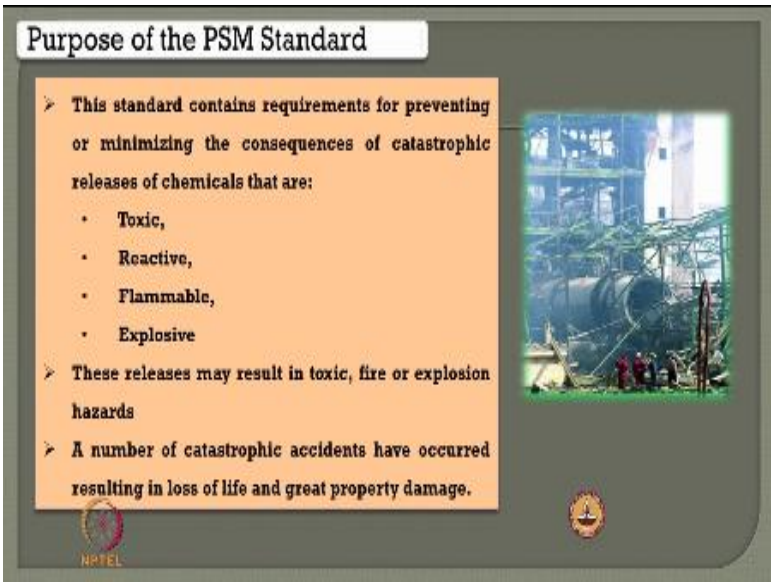

The question of what is the purpose of PSM standard is very interesting, this standard contains requirements for preventing or minimizing the consequences has of catastrophic release of chemicals which are toxic, reactive, flammable and explosive. These releases may result in toxic fire or explosion hazards. A number of catastrophic accidents have occurred resulting in loss of life and great property damage therefore it is very important that proper PSM standards must be implemented in place in at least process industry which are hazardous in nature for example oil and gas industries.

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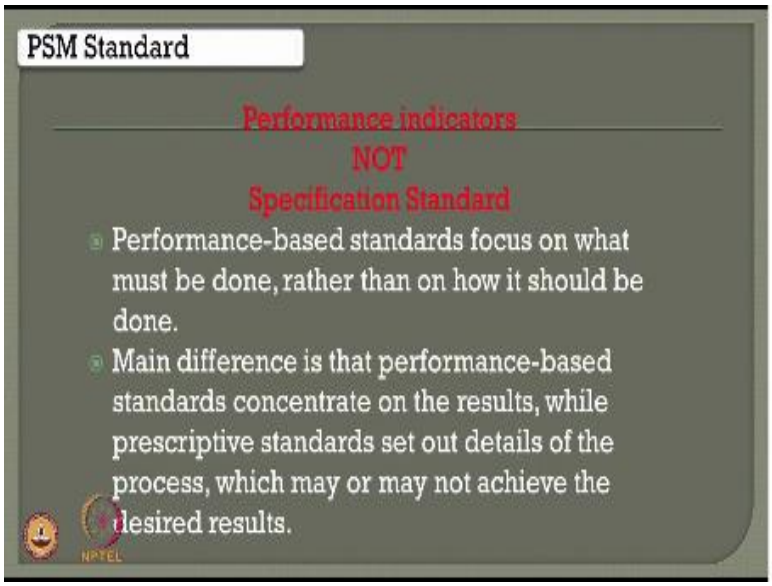

When we talk about PSM standard let us quickly see how these standards are circumscribed about. They are actually performance indicators and not specification standards. Performance based standards like PSM standards essentially focus on what must be done rather than how it should be done. There are no prescribe regulations of stating to people how you should do things, there are prescribe standards in PSM saying that what must be done to avoid certain consequences. Interestingly the main difference between the performance based standards and the conventional standards is that performance-based standards concentrate on the results.

While prescriptive standards set out details of the process which may or may not achieve the desired results, therefore process safety management standard our friends strongly suggested and implementable which are very highly practical.

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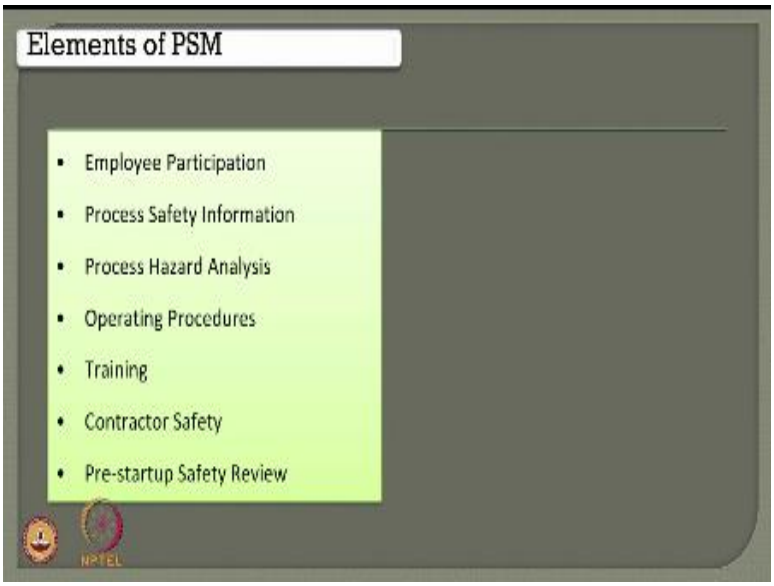

Then the question comes what are the elements of process safety management. Employee participation is a foremost feature of a process safety management because if there is no voluntary involvement of the employee working on board process safety cannot be as a time. Most importantly the information passed on by the employee what we call process safety information is helpful to do process hazard analysis.

of course the near miss events which come from operating procedures and which can be avoided by proper training and of course by implementing contractor safety as one of the important part of the hot work permits and pre startup safety review as an important tool can all form as important elements of a successful process safety management program.

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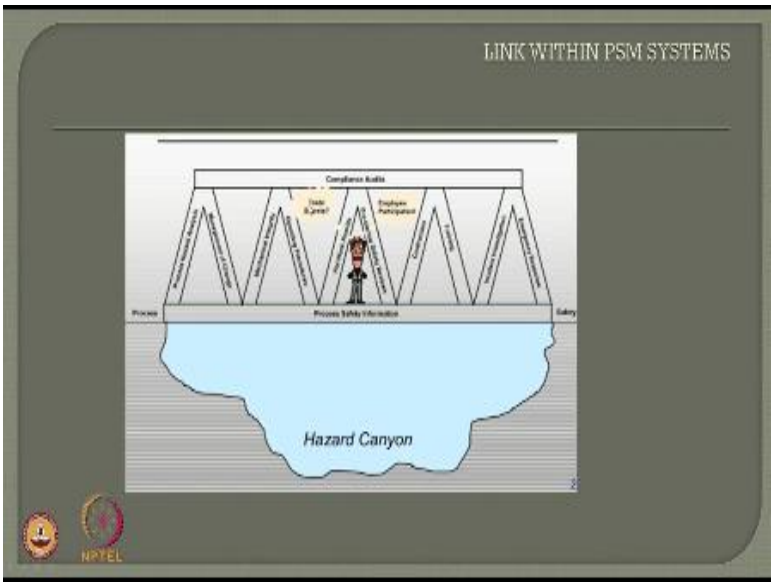

Therefore process safety management program is nothing but a link connecting the compliance audits and the process safety information. Of course this is nothing but the bridge which enables you to process to cross the process safety successfully over a bridge or over a river which is very hazardous in nature. So the links in this bridge which is useful or helpful in connecting or crossing or enabling the crossover of a bridge is processor analysis management of changes extra, which we saw in the last slide.

Of course while doing this there are some employee participation which are very important sector of the whole connectivity and while doing so they we will be in the process of generating what we call trade secrets.

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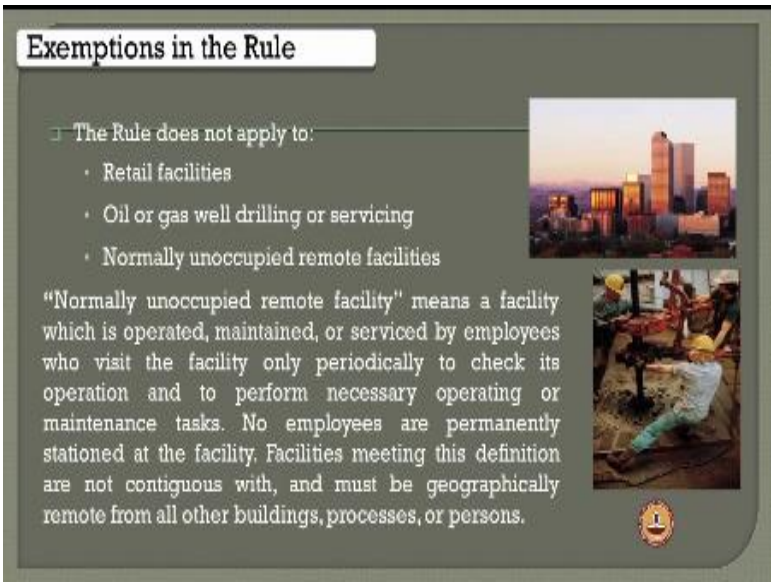

Of course in implementing process safety management there are some exemptions to the rule. The exemptions are that they do not apply to retail facilities, oil and gas well drilling or servicing units and normally unoccupied remote facilities. Now the interesting question comes how do you define unoccupied remote facilities? Unoccupied remote facility means a facility which is operated maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks.

It is very important to know friends that no employees are permanently stationed at that facility such facilities are called unoccupied remote facilities. Facilities meeting this definition are not contagious with and must be geographically removed from all other buildings process or persons from the near vicinity it is very important, therefore these are facilities which are physically, geographically, mathematically and economically isolated from the existing system.

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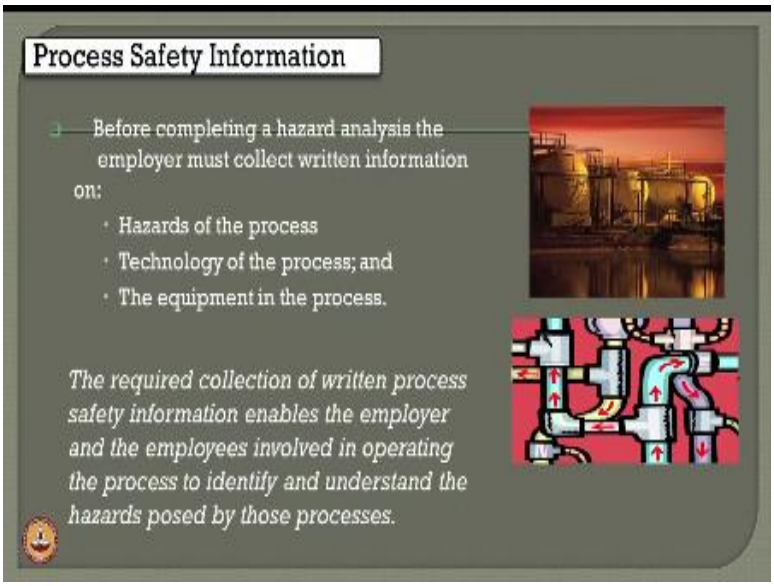

Most vital part of a successful process safety management program is the safety information related to process. Before completing a hazard analysis the employer must collect written information on the following, hazards of the process, technology of the process and equipment present in the process. The required collection of the return process safety information enables the employer and the employees involved in operating the process to identify and understand the hazards post by those processes.

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To successfully implement the process safety program we have something call safety integrity level studies which already seen partly as an overview in the previous modules. Let us quickly brief summarize this in say SIL studies in this lecture.

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Why SIL studies are important, because they speak about reliability of critical systems involved in the management of process safety. It will helpful to avoid over or under engineering. It can enable cost control without sacrificing reliability of the given system. It can have a mathematical tool call risk based approach. It meets the present and future government regulations for sure. It can mitigate the consequences significantly. It is very helpful to improve the overall safety of the facility and it can project a better corporate image and therefore it can boost the employees morale significantly.

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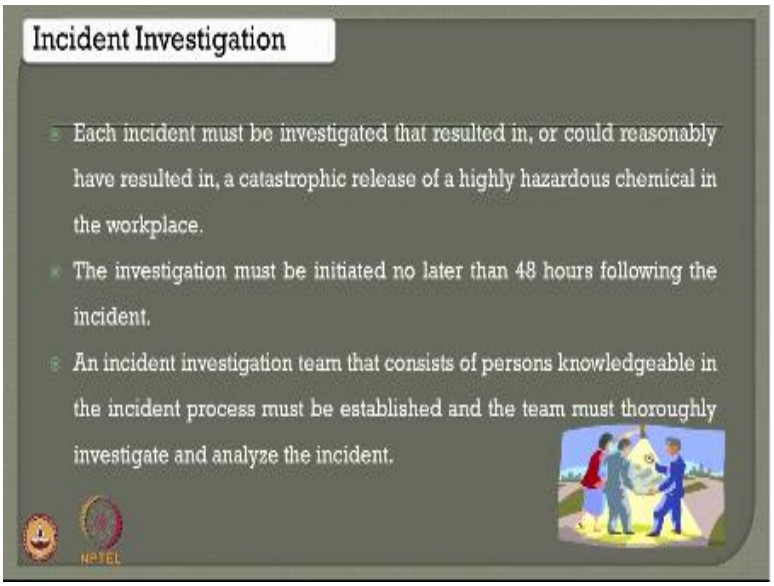

One important component of safety integrity level studies is instant investigation. Each incident must be investigated which is resulted in or could reasonably have resulted in a catastrophic release of a highly hazardous chemical in a given workplace. The investigation must be initiated no later than 48 hours following the incident. An instant investigation team that consists of persons knowledgeable in the instant process must be established and the team must thoroughly investigate and analyze the incident as per the rules of the present standards of PSM.

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You should also focus on what is call startup safety review which is a pre startup program. A review must be performed for any new facility and of course for all modified facilities. Prior to the introduction of highly hazardous chemicals to a given process system, the required review must confirm to construction equipments are in accordance with the design specifications, safety, operating, maintenance and emergency procedures are in place inadequate. New facilities must perform a processor analysis and implement recommendations before startup.

Modified facilities however must meet the requirements in the management of change very importantly.

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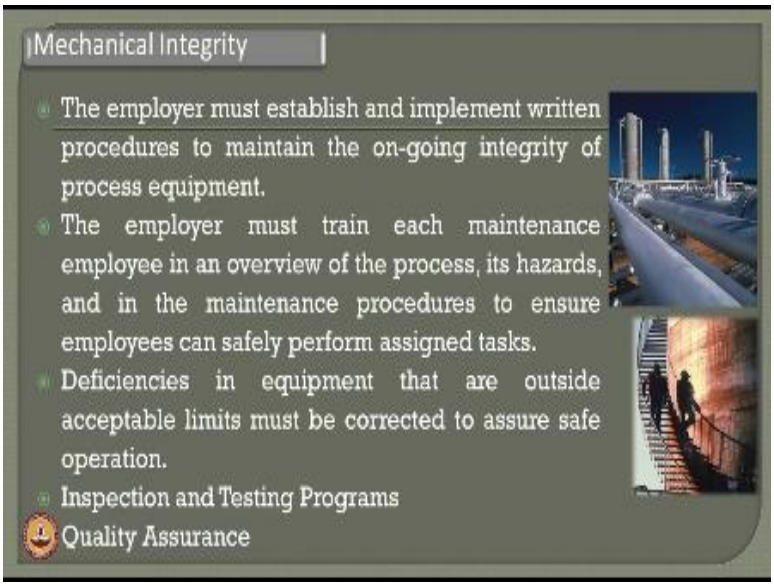

The next important facet of successful implementation of PSM is that mechanical integrity. The employer must establish and implement written procedures to maintain the ongoing integrity of the process. The employer therefore is bound to train each maintenance employee in overview of the process its hazardous, its maintenance procedures to ensure that employee handles the equipment and the assigned tasks very safely.

The deficiencies in equipment that are outside acceptable limits must be corrected immediately based upon the audit reports, because this will ensure safety operation for sure. This can be facilitated by a continuous and rigorous inspection and testing programs based on which the results and recommendations will be implemented strongly to ensure successful implementation of safe operations. More importantly any international certified quality assurance programs and certification will ensure that the mechanical integrity is achieved by following the points discussed in this slide.

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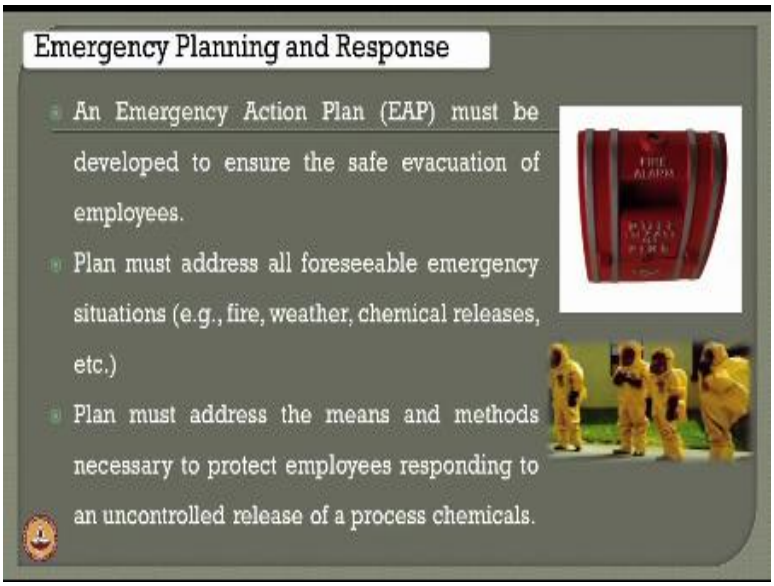

Most importantly friends accidents occur and the consequences become very severe when people are not prepared for emergency planning and response. An emergency planning and response it is actually a backbone of what we call emergency action plan which must be developed in for every industry to ensure safe evacuation of employees. The plan must address all foreseeable emergency situations like weather catastrophic, chemical releases extra. Plan must address the means in methods necessary to protect employees responding to any uncontrolled release of a given process release in a given industry.

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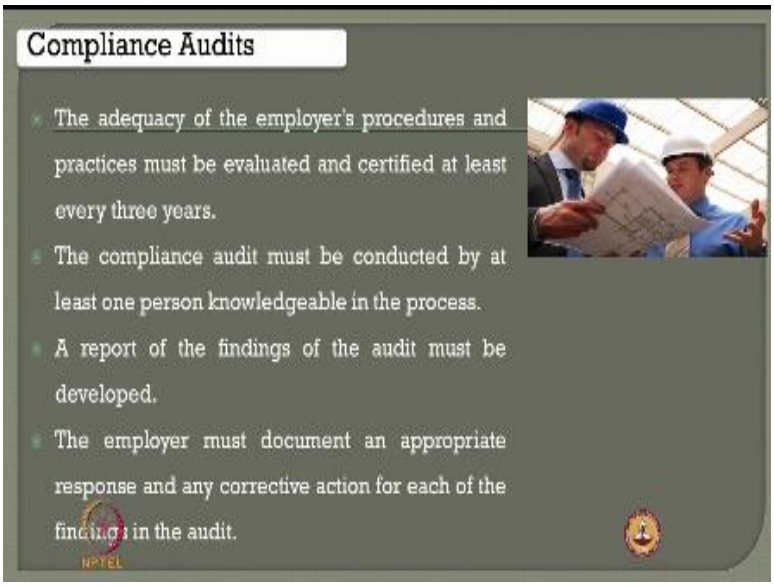

Of course this can be checked by what we call compliance audits. The adequacy of employers preparedness and procedures and practices must be evaluated periodically and certified at least once in three years. The complaints all it therefore must be conducted by at least one person who is knowledgeable in the process area. A report of the findings of the audit must be developed and practiced and implemented without any violation. The employer must document an appropriate response and any corrective action for each of the findings in the audit.

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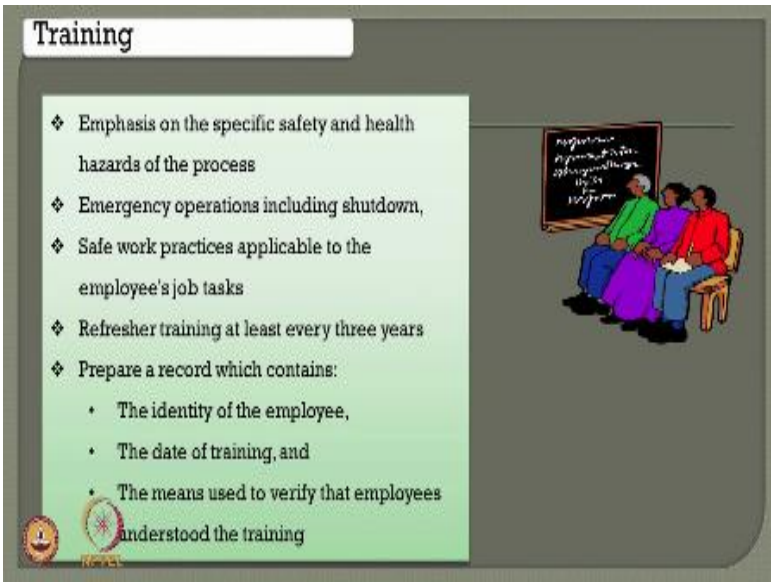

Training becomes a varietal part in successful implementation of any process safety management program. Emphasis should be on specific safety in health hazards of the process emergency operations including shutdown, should be told to them very clearly. Safe working practices applicable to the employees job tasks must be highlighted in the safety program. Refresher training should be conducted at least once in every three years. One should prepare a record of the identity of the employee, date of training the means used to verify whether employ as successfully understood the program is very important.

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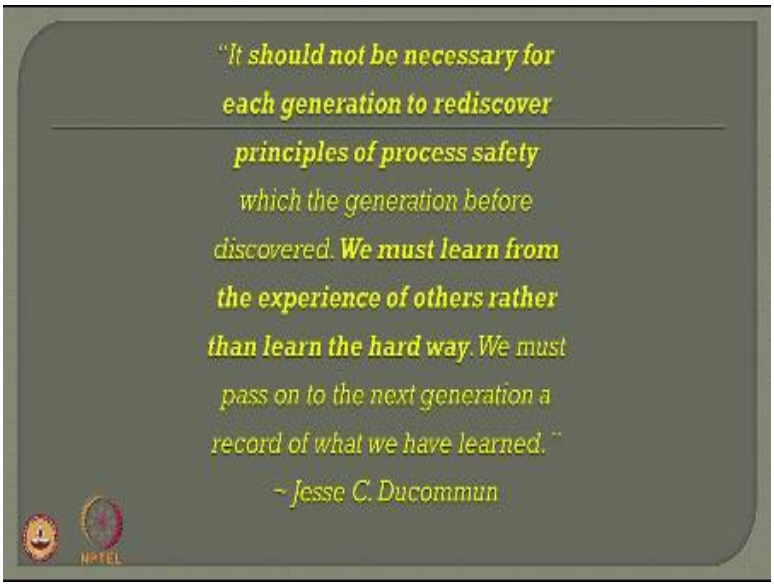

Finally please understand that it should not be necessary for each generation to rediscover principles of process safety which the generation before has already discovered. We must therefore learn from the experience of others rather than learn the hard way. We must pass on the experience based information to the next generation as a record of what we have learnt.

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Thank you very much.

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