
UNIT 2 SAFE WORKING PRACTICES

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2.1 INTRODUCTION

Safe working practices are generally included in any industries which are set of written instructions and methods that outline how to conduct a particular task or job which involves minimum risk and threat to the employees, labours, equipment, materials, nearby environment, as well as the opted processes. Almost all the industries now-a-days are advised to opt and exercise safe work practices in order to encounter the associated hazards or for redressing different circumstances that might occur during functioning of the jobs and this might furnish other liabilities for the industry. Industry's approach towards handling these hazards is represented by nature of handling them. Since owners of the industries are the responsible persons who need to assure that their staff and employees have a deep knowledge of performing their allotted tasks in a safe way. This inculcates that they are aware of the possible hazards which might occur or existing nearby their work station and job place, and are also familiar with the method of how to control these mishappening. All these instructions are provided in details in written form to the employee that is called as safe working procedures. These safety procedures are nothing but a set of guidelines to assist workers in performing their day-to-day tasks step by step from beginning to end in a proper and efficient way with the complete safety.

This unit will cover all the aspects of Safe working practices as well as safe work procedures, which is provided to the workers for guiding them to work in their work space with complete safety and hoe to deal with hazards when they are in situation of risks or threat. Various types of practices that are found to be useful while implementing safe work procedures are inculcated in

this chapter. You will also be introduced to the responsible personals that need to monitor the smooth running of and implication of safe working practices at work places. This unit also lets you have knowledge about the required procedure for conducting maintenance in confined space and importance of documents on safe work practices. This unit will inform what precautions and guidelines we should keep in mind while laying out the machines or laying out the plant and what are the benefits of following those principles.

Objectives

After studying this unit you should be able to:

- define the Safe working practices/ procedures;
- recognize proficient ways to outline the safe working procedures on paper;
- discuss the utilization of safety measures in case of fire, explosion and toxic gas cloud;
- describe the importance of safety manual, safety log for ensuring safety in a plant

2.2 PROCEDURE FOR MAINTENANCE IN CONFINED SPACE

Safety is a small word that encompasses a condition of being safe, free from any kind of hazard, injury or risk to accident. There is another word called reliability which is defined as a probability that component part, system or dedicated equipment will satisfactorily conduct its intended functions under the given situations for a specific period of time. In case of failure of any equipment or any accident which might include simple spillage of oil on floor or falls, slips, lockout etc., there comes the need for providing guidelines to the workers and employees about such mishappening and how to overcome and prevent these mishappening to reoccur in the plant. Before moving on to safety procedures or processes it is imperative to understand the difference between risk and safety. It all starts with the discussion of risk and eventually ends up connecting risk and safety together at the end. Risk is broadly categorized into two types namely;

- Individual risk

Individual risk is a probability of occurrence of death annually due to exposure to an individual person at a certain distance from the hazardous source. It mainly estimates in finding the risk of death. The individual person who encounters or possess risk to his life are expressed via this method. This evaluates fatality accident rate per year.

- Societal risk

Looking into another angle of risk called as societal risk is an estimation and assessment of risk to a large group of people. By this number of people affected by the entire incident can be calculated by using this method. Societal risk builds relationship between the frequency and the total number of people those suffer from hazard. By using FN curve the societal risks can be expressed as relationship amongst cumulative frequency and number of fatalities taking place. This type of study results into a convenient single measure of group which is at risk.

Whenever a manufacturing activity is taking place there are always huge chances of encountering accidents at the workplace. Therefore there is a great need to design the system in such a way so that even if a worker is not performing his duties according to the laid out principles in the manual, he may not encounter any accident. Because if an accident takes place, it has large number of implications like material loss, man hours loss, also the person might face some injury. So it is desirable to take all these aspects into account and have to design the systems in such a way that numbers of accidents occurring in the work place are minimized to a great extent or are closing to number zero. This is only possible if we design the system effectively, educating the works through training about the safety norms and practices as well as we keep into account that whenever there's any accident or some problem, that problem does not escalate into a catastrophic manner.

Sometime one accident leads to another accident and so on, such kinds of effects need to be checked in advanced and conveyed to the workers for their safety purpose. For this some principles must be designed whenever new machine is laid out in the buildings, and if those principles are followed on regular basis and religiously then the accident count is reduced and accident prevention can be done to a great extent. In this main role is played by the management people and they are aware of the costs involved in an accident, as there are direct cost involved, indirect costs involved whenever there is injury to any person, and as are the victims of the accidents. A person who is victim and suffered some accident knows what cost they have been through for their treatment, in case of severe injury they might lose some body part which is undesirable from both industry point of view as well as workers point of view also. The company has to bear other costs also for troubleshooting the machine in case of break down machine or sometime they may have to purchase a new machine in order to replace the obsolete machine. Similarly company has to bear the cost of hospitalization of the injured worker, and then there are other factors also like number of workers involved in transferring the injured worker to the hospital, transportation costs is affected, the man hour is lost, the productivity is reduced and there are other indirect costs also that company may have to pay compensation amount to the injured workers' family or insurance company may come into

the picture at that time. So all in all, there are huge costs involved in case of occurrence of accidents in the workplace. So these problems need to resolve by some means. So the question arises how these accidents can be minimized, and how an individual worker can be made to realize importance of following safety instructions. This can be done by getting the individual worker at the point of operation to realize his personal responsibilities and duties. Also these accidents can be reduced by organizing proper plant layout. But maximum number of accidents usually takes place due to negligence of the workers while performing their tasks or due to failure of the equipment.

If individual worker knows that due to his negligence some particular type of accident or mishappening may take place then if he is cautious and if he is performing his duty and job religiously by following the safety instruction during working hours then there are no chance that would lead to an accident to occur in a workplace.

Although there are still many chances in which equipment may fail and some accident may take place, which is beyond workers control. But the important part is to educate and train the workforces, that they willingly take the personal responsibility in preventing the accidents. The management person also plays a crucial role in designing the whole system in such a way that accident incidents are not likely to occur in workplace. So the designs of the system, plant, or building have to be such that there are least chances of accident cases. In order to fulfill these requirements there are few guidelines, precautions, principles, rules and regulations need to be followed while laying down the building or a plant.

The layout of the plant and the machines as well as the tools should be designed by keeping the accident prevention criterion in mind so that the chances of the accidents can be prevented. The general principles of the plant layout that should be kept in mind while designing the plant layout are as follows;

- Need to keep minimum distances for transfer of materials in between the plant or storage units to reduce costs and risks. Minimum transportation of the material within the plant because it adds to the cost as well as it may result into accidents also at some point.
- The geographical limitations of the site.
- Interaction with other plants on site.
- The need to locate hazardous materials facilities as far as possible from site boundaries and people living in the local neighborhood.
- The need for plant operability and maintainability.
- The need to prevent confinement where release of flammable substances may occur.

- The need to provide access for emergency services.
- The need to provide emergency escape routes for on-site personnel. The people who are working on the sites, they should be aware of the escape route from which they can escape in the case of emergency. So in a plant or industry whenever an emergency arises or whenever there is a catastrophe that destructs the industry or the plant there should be escape routes available. Workers should ensure the escape routes and there should be know-how to the workers that what are the available escape routes in case of emergency. Even on the floors also marking scan be done, that can help the workers to go out of the plant in case of emergency.
- The need to provide acceptable working conditions for operators.

At times whenever a problem is confronted or accident due to fire takes place or whenever there is some explosion in the plant, leads to power cut off. So in such cases where power is cut off due to mishappening and if employers are performing their night shift, there would be complete darkness and the workers wouldn't be able to identify the direction in which they should escape from the accidental arena. So, it is imperative that proper facilities to be provided for the workers to escape in case of emergency like provision of certain fluorescent path or some guidelines which would help the workers in tracing the route and escaping the plant in case of emergency. So to providing the escape route to onsite personals is very important whenever laying out the plant design. Proper working conditions for operators need to be insured because sometimes humidity levels are very high, in some plants the heat generated is very high, so considering all the aspects the plant layout should be such that acceptable working conditions are provided to the operators. Sometimes the workers have to perform some minute tasks and if the adequate lighting arrangement is not there then the worker may not feel comfortable and his eyes may not be lasting for too long or his eyesight may get defected or permanently impaired. So whenever a plant layout is planned or designed, all above mentioned particular aspects must be taken into account while planning any layout to provide acceptable working conditions to the operator. So the main important point that must be kept into mind while plotting any plant layout, there are certain guidelines and principles, if we keep those principles in mind then there are always chances that number of accidents that in a well-designed plant are minimal or are very close to zero.

From Safety Point of View

- Prevent, limit and/or mitigate acceleration of adjacent events (domino effect): this point states that in case that one event happens then it should not lead to another event and so on. It should be prevented in its initial phase only.

- Ensure safety within on-site occupied buildings: it signifies that if any single event occurs, it should not lead to another event in the workplace. So it is very important to ensure and provide safety within the onsite occupied infrastructure. Ultimately it is also important to accommodate safety for those nearby buildings also.
- Control access of unauthorized personnel: it states that only authorized persons should be allowed to enter the plant and they should have easy access to emergency services.
- Facilities access for emergency services: This means the in case of occurrence of accidents, workers should have information regarding the escape plan as well as adequate access should be provided for making the emergency services to enter the plant for the safety of people or workers struck inside the plant in case of accident.

2.3 INHERENT SAFETY

- **Intensification to reduce inventories**

Keep only those resources inventories that are actually required. Sometimes there are certain parts or materials that are still lying in the inventory which at present time are not at all required or which were in demand in past at some point of time and in present time those extra inventories might lead to some kind of accidents. So here intensification means that focus should be given to maintain the inventory to a proper amount or minimize the inventory as excess inventory is not desirable. From safety point of view also increased focus should be given on reducing the inventory in the plant is the foremost point.

- **Substitution of hazardous substances by less hazardous alternatives**

In designing of the plant it is desirable to keep a safe space for keeping hazardous substances and it should be kept away from work space, then inherent safety says that if it is important to keep certain hazardous substances due to frequent demands then keeping those substances that are less hazardous will eliminate or reduce the risk of explosion to some great extent. Replace the most hazardous substances with the less hazardous substances to prevent the possibilities of mishappening.

- **Attenuation to reduce hazardous process conditions i.e. temperature, pressure**

In cases where chances of rising temperatures are very high and it may lead to some kind of accident, so attention must be given to those types of conditions that such conditions do not prevail. Temperature and pressures need to be controlled and monitored on regular basis so that accidents do not take place due to these conditions.

- **Simpler systems/processes to reduce potential loss of containment or possibility of errors causing a hazardous event**

Sometimes complex systems lead to a hazardous event. System need to be designed in such a way that it is very simple and it does not lead to any kind of accident. Simpler systems need to be designed in order to reduce the potential loss of containment or possibility of errors instigating a hazardous event.

- **Fail-safe design e.g. valve position on failure**

Fail-safe design means that even if some system failure intervenes in the work place then there must be some sort of sensors or valves to check the possibility of failure in that part during the functioning and attack the problem before it tends to happen by stopping the equipment or machine in order to prevent the accident.

2.4 INHERENT SAFETY INDICES

The inherent safety index is another imperative aspect that need be understood thoroughly. Inherent safety index is the only one by which whole process routes can be assessed, and consecutively the most suitable route for further development can be found. There are many ways by which accidents may take place, so there is huge need to provide for a particular system or for particular working conditions in which the accidents do not take place and the operators feels safe while working on their jobs and perform their duties safely while working in the plant. There are still chances of accidents to happen, in that case there is need to have a enumerated technique which would help in checking and assessing the risk that how much is the risk involved in that particular type of system or process. It is the most suitable technique to minimize the risk. This method also compares the inherent safety index of the plant with the cost of capital and production- it is believed that inherently safe plants are cost-effective plants. Inherent safety index of the plant and cost of capital and production are interrelated with each other, so always there is risk involved with them and ultimate aim is to minimize the risk. A plant is entitled as a cost effective plant when it is designed in such a way that cumulative risks or chances of accidents associated with that particular plant are minimum or lees in number. Cost effective plant in one that do not involve direct or indirect cost of accidents.

Risk indices does not point out specific danger but it draws attention towards those areas which are prone to risk and it provides the required in depth analysis auxiliary-safety measures for those arena. So these risk indices are found to be helpful in finding out or in identifying the areas where chances of occurrence of risk is higher. It is but obvious that areas prone to higher risk are at much greater risk of accidents. These risk indices helps in recognizing

areas that are most prone to incidents of accidents and assists in eliminating them from the plant. Risk indices are based on qualitative and quantitative method. These methods are quite clear and can be utilized quickly. Quantitative means these risk indices will hold different numerical value for different areas within the plant and this ultimately gives a lead to track out that which area is having more chances of accidents and where are the least chances of happening incidents. On the other hand quantitative technique covers the range of hazardous materials process conditions and inventories. So by making use of quantitative method of risk indices one can attain a range by which person can point out that this thing is going to be hazardous. This mainly covers the range hazards of materials process conditions and inventory. There is another index which is called as OW-MOND index that pin point particular type of hazards and also evaluates different indices covering fire and other types of related explosions, in addition to overall rating. This overall rating helps and gives conformity to the level of danger or the level of risk associated with a particular area within the plant. So by means of method that makes use of equations or graphs to locate the related hazards. Comparatively graphs are easier to analyze and visualize. A quantitative technique assesses the risks linked with the different stages of the process and at different sites of the plant. Eventually these risk assessing techniques are helpful in providing better understanding of the accident prevention steps. As soon as these indices provide an idea of the area that is more susceptible to accidents, preventive steps can be undertaken by the management team to prevent that accident to happen. Accidental prevention policies and procedures should be implemented for those areas that are more prone to incidents of accidents. Risk indices are very important part of industrial safety where chances of accidents are more. These risk indices causes chances of occurrence of objectivity into the system in order to counter the subjectivity. Ultimately to avoid occurrence of any accidents these indices would aid in providing adequate management schemes for undertaking preventive measures. These is one effect known as Domino effect which could be better understood by considering an example of cycles parked in a row. In case if we push one cycle then it will lead to fall of second cycle, then circle and then ultimately all the cycles would fall with the slightest push. This effect is termed as domino effect.

The loss of containment as well as chances of escalating the accident in any form is monitored by assessment of the hazard in that particular plant layout. It is imperative that supervisors and higher authorities are capable of ensuring the escalation chances of the accidents by this it means that in case of occurrence of single incident, it should not lead to other incidents in chain. Also provision for some valve or some sensor control system is provided at the site of hazard in case of occurrence of two events which needs to be ignored. If these protective steps are not provided in advanced and some incident takes place then the Domino's effect will come into account and it

will lead to further catastrophe in the plant. It is very critical to conduct the hazard assessment of the plant or site layout in a plant to insure the minimum escalation of the incident. Event of fire, toxic gas cloud or explosion might lead to Domino effect at the site.

2.3.1 Different Events and their Occurrence

In subsequent sections different events (fire, explosion and toxic gas cloud) are discussed in a manner of their occurrence

1. Fire

Incident of fire and its spreading can take place owing to following factors;

- Direct burning (including running liquid fires)
- Convection
- Radiation
- Conduction

By splitting of vertical and horizontal sections by employing fire resisting walls as well as floors the spreading of fire from its originating source can be prohibited to a great extent. In this case compartmentation is another term which can be used to avoid spreading of fire. For example, in case a large hall is there in any plant and in that if any incident of fire happens at one specific area then it is clear that this fire will be spread to the entire hall. But this escalation of fire can be prevented if entire hall is divided by providing different compartments like four to five compartments in a single hall that too built with fire resistant walls and fire resistant roof. Then fire occurring at one specific area will not be able to proceed or spread into other areas due to splitting of entire hall in the form of fire proof compartments. Ultimately fire will remain in that specific compartment only thereby reducing the risks to other places. In this way fire can be arrested to one specific area of the plant.

Another thing is that more emphasis should be laid on the spread of flammable materials by means of ventilation systems, channels and pipes. In case of occurrence of fire the provision must be provided to deliver this fire from one place to another place through a proper channel like via ducts, drains or ventilation system to ensure the safety of employers and other personals working in the vicinity of the fire area. Consideration of these provisions must be taken into account while designing the layout of the plant or the building. Dispersed flammable gases and vapors are considered as a means of eruption sources that may promote the fire incident leading to Domino effect in one site where fire has taken place. So proper monitoring is necessary to check and ensure the flammable gases and vapors from leading further fire enhancement. Therefore, inherent safety principle helps in protecting and preventing the Domino effect happening due to convection,

conduction and radiation. By following the guidelines and principles provided during laying out the plant helps in reducing the Domino effect and ultimately huge damage that could be caused due to fire can be prevented. In other words the magnitude of destruction can be reduced to a great extent. Other modes include Active and/or Passive fire protection measures. Active and/or Passive fire protection measures are different in their working methods yet they are very important in providing the overall fire safety in a building or plant. The equipment or techniques utilized under active and passive fire protection measures are enlisted in Table 2.1.

Table 2.1: Fire protection measures: Active and Passive Fire protection Measures

Fire Protection Measures	
<p><i>Active Fire Protection Measures:</i></p> <p>Fire Extinguishers (Portable), Sprinkler system, Dry and wet riser systems, Hose reel system, Fire alarm, Fumes and Smoke alarms</p>	<p><i>Passive Fire Protection Measures:</i></p> <p>Fire Dampers, Escape routes with photo luminescent strips, Fire stops and seals, Compartmentation</p>

Active fire protection measures generally include manually operated or equipments that require some amount of action to be performed like portable fire extinguishers, water sprinklers. Others protection equipments included under AFP are fire/smoke alarm system, fire extinguishers (automatic) and sprinkler systems. Fire extinguishers are employed to shut down the fire altogether whereas fire/smoke alarms are employed to sense the presence of any fire or smoke related event inside the building. Similarly sprinkler systems aids in slowing down the fire till firefighters arrive at the incident site. AFP aids in taking action against putting out the fire but this system may confront failure sometimes at the time of operation. For example, sprinklers may fail due to frozen pipes which restrict water supply and adequate water pressure, lack of maintenance.

On the other hand, it is much more than just fire extinguishers and water sprinklers. Owing to maintenance issues water sprinklers might fail so in that case passive fire protection measures come into role. Passive fire protection team generally begins its work by compartmentalizing the entire building into different sections which prevents or slows down the growth of fire from one part to the other parts of the building. The preventive equipments that come into PFP include fire resistant doors, walls, roofs, floors and fire/smoke dampers. The coating of fire resistant material with fire protective coats is

also included in PFP preventive measures. Dampers generally help in preventing the outburst of fire throughout the building via ducts or drains. Providing photo luminescent path helps workers to escape the plant safely in case of fire event. However, PFP does not take any kind of preventive step by itself but with the assistance of AFP these both can be much helpful in preventing and spreading the fire in the building. The total duration of exposure determines the most suitable system for protection during the fire event. The passive fire protection measure is effective only for short duration of time, mostly one to two hours. But if fire exposure is for longer duration like more than 3 hours then active fire protection measures come into role.

Which safety measure (active or passive fire protection system) is to be undertaken depends upon the site factors. Site factors usually includes substance possessing fire hazards, substances' toxicity and the smoke/fumes produced, size of inventory, frequency of hazardous operations. The hazard possessed by substance will decide which type of protection system needs to be used whether it will require active or passive or a combination of both mode of protection. Therefore, it is also desirable to necessitate the need for conducting fire safety audit in plant once in every month. Figure 2.1 depicts all the checks that are conducted during fire safety audits.

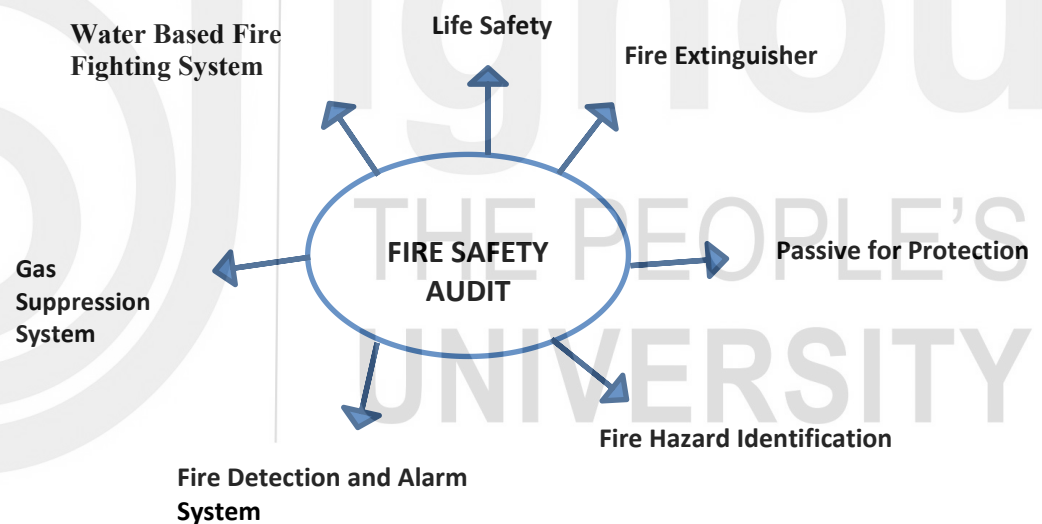


Figure 2.1: Diagram for Fire Safety Audit at a Plant

There are other criteria also which should be kept in mind while adopting the type of safety (active or passive) measures, like substances' toxicity and fumes produced during the fire. Similarly the size of the inventory also plays important role while adopting the type of preventive measures. Suppose fire outbursts into the plant and if it is not controlled within three to four hours then active fire protection systems are called for emergency services e.g. sprinklers. But if that fire is shut down within half to one hour then passive fire protection services could be thought of adopting in that time. Other than this there are other criteria also that should be kept in mind like frequency of hazardous operation, distance between different hazardous installations, and

available resources to fire brigade. All these parameters need to be kept in mind while calling for active or passive fire protection services.

2. Explosion

Some guidelines and principles must be followed to safeguard the plants or buildings against the incidents of explosion. The plant and related system should be safe whenever any explosion takes place. Pressure waves or missiles usually lead to explosion propagation. It is imperative to make a note of it that explosion going to occur, what are the possible causes and consequently what are the basic principles or guidelines that must be kept in mind while designing a building or a plant to safeguard it against explosion. As we have seen in case of fire in previous part that fire may spread from one starting point to another point via different modes of conduction, convection and radiation then similarly measures must be taken in case of explosion casualties also. A lot of factors promote the incident of explosion, like presence of combustible source, confinement of dust, dispersion of dust, oxidants, ignition sources etc. as shown in Figure 2.2. Preventive measures in case of explosion might include blast walls that prevent transfer of explosion from one site of the plant to the other part of the plant. In order to prevent severe damages caused due to explosion adequate safety procedures must be undertaken like some valves or sensors or some accident control devices that will not allow the explosion to occur or in case of explosion it will prevent the progress of explosion to the other parts of the building.

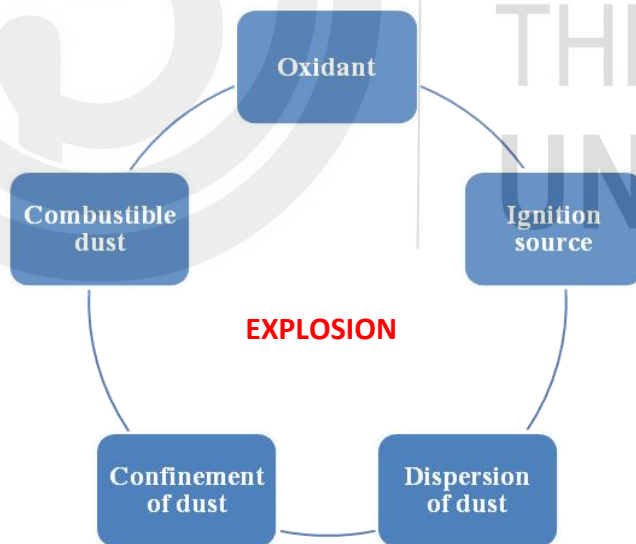


Figure 2.2: Factors Leading to Explosion

The plant damage can be prevented by providing vessels possessing thicker walls so that the damage caused due to explosion is least. Other important point to note regarding explosion prevention measure is that the explosion relief vents must be directed away from vulnerable areas like nearby other industries or buildings, roadways passing by site boundaries. By providing these explosions relief vents the damage caused due to explosion can be prevented to a great extent.

3. Toxic Gas Cloud or Release

Other type of hazard linked to the explosion is discharge of toxic gases in the environment that may lead to Domino effect by rendering neighboring industries, adjacent sites, plants and injuring workers working in the vicinity and leading to accidents. This type of Domino effect can be controlled by preventing, mitigating hazards associated with the explosion through the utilization of automatic control systems by adopting inherently safer guidelines and principles and a convenient control room for conducting all these required preventive steps. Ultimate requirement is stop these kinds of damages or hazards that may take place due to explosion. Explosion usually takes place due to release of gases and these leaked gases can be detected by using some sort of gas detector implanted in the areas prone to gas leakages. These gas detectors alerts the employers working in that area by generating an alarm and will warn the security checkers to take preventive steps in case of leakage of toxic gas in the environment. The control mechanism can be effective in that case where the defect or gas leakage is detected in shortest possible time. Consequently the damage will be minimal leading to the prevention of the possible damage and reduction of consequences of event on and off site.

The first foremost thing to keep in mind for reducing the consequences of event on and off site is storage of flammable or toxic materials well outside the processing areas. By locating all the high-volume storage of flammable or toxic substances at a distance from the processing areas can help in reducing the chances of explosion in the working area. Other thing to be noted is the plants those deal with the hazardous materials should be located far away from the main roadways and should be isolated from other nearby functioning industries. The consequences of the events can be minimized by placing and implanting remote actuated isolation valves where high inventories of hazardous materials can be discharged into vulnerable areas. By providing such provisions of control mechanism the number of accidents occurring due to high volume storage of hazardous materials can be obstructed. Ditches, embankments, dykes and slope terrain are provided to contain and control the release of toxic liquid from spreading from one point to other site of the plant and ultimately limiting the safety and environmental effects thereby reducing the resultant consequences of the event. Another preventive measure that can be taken for preventing explosion is by siting the plant as secondary containment within the building. The plants must be sited in open air so that even if any small leakage of gases and vapors tends to happen in the building rapid dispersion will be ensured for those released gases thus preventing the incidents of flash fire and explosion. It means that plants should be sited in open atmosphere conditions for easy release of flammable gases through provisions of vents.

Also when part in a plant is suspected with some toxic substances or flammable substances, then it will lead to creation of atmosphere full of those flammable gases. This will lead to an accident or huge explosion if preventive measures are not carried out on time. For preventing these incidents of explosion, open air ventilation should be provided in a plant for easy evacuation of vapors, flames, gases and dusts. In addition to these measures, care should be taken to avoid actions of ignition at these suspected areas. For the sake of example if a person visits any petrol pump, authorities advises all visiting customers not to smoke or light a match stick there, it is because such ignition sources might lead to the incident of fire explosion.

Figure 2.3 is enclosing all the necessary preventive steps that are required and must be adopted for avoiding possible hazards that might be confronted while working at work sites.

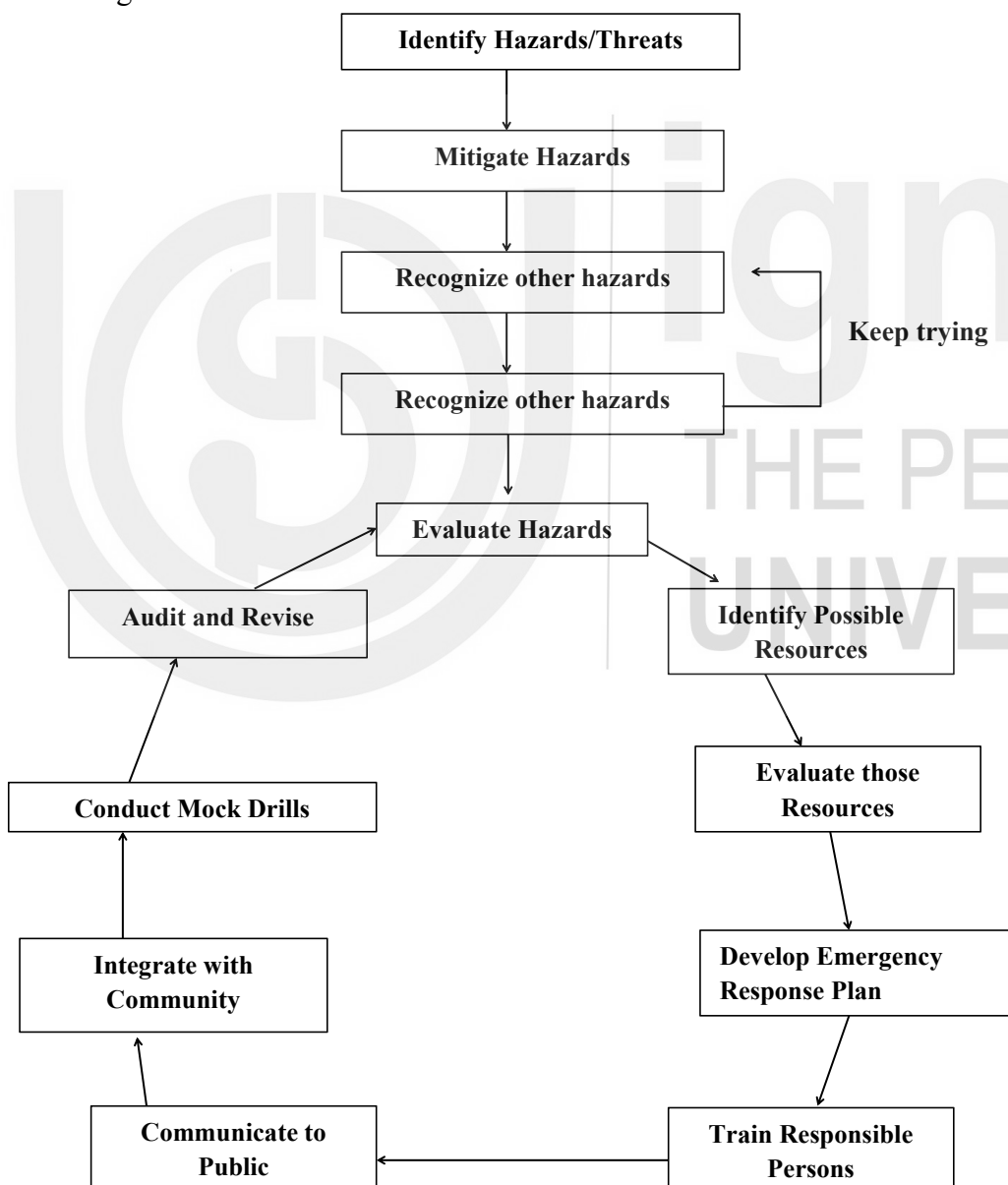


Figure 2.3: Preventive Steps for Avoiding Hazards at Work site

There are other methods also that can be opted for checking the leaks related to cylinders like soapy water solution for flammable gas leak check, testing with inert gas for toxic corrosive gas.

Adequate positioning of occupied buildings is also one such concern that is correlated with the incidents of accidents and taken into account while talking about the aspects of industrial safety. In order to evaluate and decrease the dangers associated with the events of fire, explosion and toxic gas release there is huge need for governing the distance between the occupied building as well as the plant building. The distance required for maintaining between the occupied building and plant building will be solely dependent upon the hazard and risk involved in fire, explosion, and toxicity.

Also poor plant layout may suppress the evacuation or escape route which might lead to catastrophe in case of accidents related to fire, explosion, and gas leak. Also the monitoring person should be aware of the escape route and his sitting should be provided in the building sited in non-hazard area. Also the responsible personal who has been assigned with the site responsibilities should be located near to main entrance. Non-hazard area should be occupied by all the authorities those holds the control of all safety regulations of the plants. Another aspect to be kept in mind while laying out plant is that the building where sitting of responsible personals are there it should not be sited downwind of the hazardous plant parts as it may lead to the Domino effect which has been discussed in previous section.

In case of absence of proper ventilations there are chances of trapping of flammable vapors, suffocation and explosion in the plants. So either forced ventilation or natural ventilation there should be provision for ventilation in a plant in all the parts for the smooth functioning of plant and labors working in hazardous environment.

2.3.2 Segregation of Incompatible Substance

This is another major aspect which should be taken under consideration before laying out any plant and should be inculcated in the inherent safety of plant. There are many industries that make use of different substances but they do not know their chemical reactions, properties and how these can affect the labors working nearby those substances. Provisions are provided for workers to make them understand the guidelines and precautions that must be undertaken to handle those hazardous substances, but there are many newly joined personals also that do not have much knowledge about handling that particular substance, so their proper training is a must before appointing them their jobs. Mishandling of these hazardous substances might lead to accidents. So proper measures must be undertaken while mixing such substances, the worker must have ample knowledge about the consequences of mixing such substances and their related Domino effects. There are sometimes chances that the worker who is mixing two substances does not

have knowledge about the reaction that would take place and as a result of mixing explosion might take place. So to avoid these accidents trained employers must be allowed to perform such tasks and they should have that kind of know how guidelines while working with those type of substances.

This same thing applies for the quality of the product manufactured. If a product is manufactured and its quality aspects are not ensured by the quality checking team then it may result in disaster that may be in the form of fire or explosion. Or sometimes it also can result in the form of vapors which may lead into a total failure along with the release of toxic gases leading to big hazard and ultimately leading to the incident of accident.

That's why segregation of incompatible substances is also considered as one of the most important aspect that needs attention in industrial safety. This can be done by adopting inventory management technique for managing the materials and substances for preventing accidents occurring to them.

2.5 IMPORTANCE OF DOCUMENTS ON SAFE WORK PRACTICES

Documentation of safe work instructions plays a vital role in any industry as these act as the foundation for that particular work place. A local management personal enrolled, is generally responsible for developing and implementing safe work practices in an industry. Figure 2.4 depicts all the possible checks that are conducted by safety management department in a plant. Safe work practicing is nothing but a set of instructions that are usually recommended for undertaking any process or activity safely. Those industries who have their safe working instructions in written format possesses safe working system, also they conforms overall health and safety of their employers.



Figure 2.4: Role of Safety Management Department in a Plant

These safety instructions in written format are an essential part of the system for ensuring safe working conditions during actual operation. Management team takes the responsibility of conducting and ensuring safe working environment for the employers. For achieving this motto, management team provides multiple safety trainings, orientation programs and induction trainings to the newly appointed workers as well as to the newly shifted workers.

Safe work practices can be categorized into following three basic practices that must be undertaken to minimize the incidents of accidents and inhibit injuries:

- **Task Hazard Analysis:** this generally compiles the processes that are responsible for analyzing and finding all the possible hazards associated with the current task, the details of the control actions that must be adopted in case of mishappening and circulating the safety practice instruction manual amongst the workers that need to be followed to reduce the possibility of accidents and injury.
- **Safe Work Procedures:** this category generally addresses and introduces the step-by-step and systematic procedures to the employers for making them aware of hazardous tasks that they are working for completing the task. The risks possessed with high hazard tasks are eliminated from day to day working sites by providing step-by-step procedures to the workers, so that they can follow those instructions while conducting their desired job and can complete their work with hundred percent safeties.
- **Codes of Practice:** this usually involves reviewing of those tasks that are identified as high or medium risk level tasks and development of safe work procedures and providing these manuals to the workers working with those tasks. Some risk level determination matrix is developed under this category and some guidelines associated with the identified risks are provided for proper safety precautions. These codes of practice gives practical solutions and guidance to the personals those are responsible for conducting some risk related work or business and makes them to understand their desired duties in case of accident. These practices can be applied to any type of workplaces whether it is remote, mobile or outdoors. These codes of practices gives information regarding first aid kits, related procedures, facilities and providing training for first aid providers.

The recording of safe procedures in documents form provides details regarding following;

- Details regarding policies, rule, regulations, guidelines and necessary procedures.

- Maintaining consistency and uniformity in the safety concerns of workplace.
- Checking for the up to date version available for the safety instruction manual.
- Evidence of past happenings or accidents, and information related to them for avoiding reoccurrence of such incidents again in future.
- Proper record handling and their management.
- Record retention time and their proper disposal in case of newly developed safety record manual. Obsolete documents and manuals must be discarded properly.
- It should also provide emergency escape routes.
- First aid treatments techniques must also be incorporated.
- Hazard/ Incident reports could also be enclosed.
- Training and induction programs checklist should be included.
- Performance management related plans.

These instructions once prepared can be recorded in hard copy or electronic media form for easy access and effective retrieval or replacement by an authorized personal for confronting purposes like examination/analysis, internal and external assessment, and evidence of legal compliance, evaluation as well as review, and training needs. The media in which the data related to safety are recorded must be useable, reliable and must be preserved for as long as required.

Emergency plan should also be provided in the safety booklet for ensuring easy escape routes to the employers. The role of first aider in case of emergency must be assigned in accordance to their acquired qualification and competence. The employers should be informed about the first aider so they are aware of what to do and who to communicate in case of sickness or injury while working in a plant. The information provided must be in easy understandable language, must be accessible and it must consider the literacy level of labours working there.

Different modes can be used for explaining the instructions like verbal methods or visual methods. A verbal method takes into account the methods of explanations and demonstrations whereas a visual method addresses instructions via posters and videos.

If a person is working in hazardous environment, the following (Figure 2.5) two types of permit procedures need to be kept in mind;

First air instruction and information must include few points like first air equipment location and dedicated facilities, name of affected person and

location of that person, the required step-by-step procedure to be followed in case of first aid requirement.

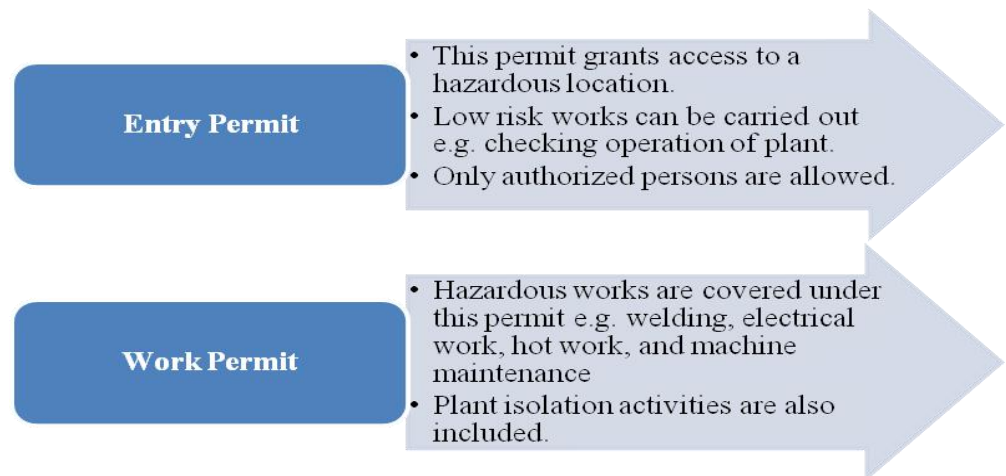


Figure 2.5: Types of Permit Procedures

All these information need to be delivered to the workers during induction training.

There is another way of recording day to day activities for ensuring safety aspects of workplace which is called as safety checklists or safety logs. A safety log is indeed a very essential record that should be provided to each and every employee of the industry for assessing their daily basis activities, their machines on which they are working for ensuring the smooth run of that machine. Safety should be considered as the first most priority which should be taken into consideration by each industrialist.

No matter what, it is responsibility of the management team to ensure the safety at workplace and safety of employer working in that work station. A workplace is said to have effective safety system when it consists of up-to-date safety checklists along with safety manual. These safety checklists encompass written steps for both the events of a work day as well as the training, and day activities.

A safety log may be comprise of different audits, inspections, sessions as well as other relevant information that may be related to weather and total workers working on a machine or project or work floor. There are many benefits that are associated with writing these safety logs on daily basis like:

- It aids in verifying the adopted safety measures
- It makes a list of factors influencing the safety of workers
- It provides information related to the factors that are confronted before, during and after an event has occurred
- Recorded information on safe log could be utilized during prosecution which might be faced in future.

- This record could be used as information for detecting weaknesses and faults that could be avoided in future.

Labour Attitudes: Workers are not interested or are obstructive



Staff does not analyze the risks or problems at worksite



Least involvement of workers in health and safety



Organizational resistance to change



Lacking Safety Culture



Figure 2.6: Main Barriers Confronted by Health and Safety Practices at Worksite

There are few obstructions that are confronted in attaining safety and health practices in a workstation. Figure 2.6 enlists various types of factors along with percentages that are leading to increase in number of accidents at plants.

A variety of factors contribute to organizational safety performance. The culture of organization is also affected by company values and beliefs. Organizational culture aids in recognizing and handling hazards via effective safety methods which indirectly helps in identifying and eradicating injuries and illness which might affect the organizations safety and health if not solved prior to actual happening. The overall safety and accident prevention is monitored by senior management’s leaders and desired actions are taken up under their supervisions.

SAQ 1

a) State True or False

i) Individual risk is a probability of occurrence of death quarterly due to exposure to an individual person at a certain distance from the hazardous source.

ii) Societal risk is an estimation and assessment of risk to a large group of people.

iii) While laying down the building, consideration of guidelines, precautions, principles, rules and regulations is not required.

iv) Blast walls that prevent transfer of explosion from one site of the plant to the other part of the plant.

- b) It all starts with the discussion of risk and eventually ends up connecting risk and safety together at the end. Explain types of risk associated with the manufacturing activity.
- c) Write down general principles which should be kept in mind while laying out the plant layout.
- d) Explain different events (fire, explosion and toxic gas cloud) in a manner of their occurrence.
- e) Explain inherent safety indices.
- f) Why documentation of safe work instructions plays a vital role in any industry?
- g) Write down the barriers that are confronted by health and safety practices at work site.

2.6 LET US SUM UP

An industry providing importance and greatly determining the safety culture is considered to be more employers' safety environment. Safety Manual focuses on accident prevention on a priority basis and preventing employees against injury or harm. A company's performance can be escalated by appointing dedicated supervisor for regularly monitoring, devoting and arranging training sessions for making understand labours, employees and new comers about safety aspects via orientation programs. When organization is systematic and organized its productivity and performance are automatically enhanced owing to providing training to employees, opportunity and right to participate during decision making process.

2.7 KEY WORDS

Dangerous goods – Also referred to as hazardous materials. Any solid, liquid, or gas that can harm people, other living organisms, property, or the environment.

Fire precautions: The measures taken and the fire protection features provided in a building (e.g. design, systems, equipment and procedures) to minimise the risk to the occupants from the outbreak of fire.

Fire prevention: The concept of preventing outbreaks of fire, of reducing the risk of fire spreading and of avoiding danger to persons and property from fire.

First aid: The skilled application of accepted principles of treatment on the occurrence of an accident or in the case of sudden illness, using facilities or materials available at the time.

OSHA Occupational Safety and Health Administration – A government agency in the department of Labor to maintain a safe and health work environment.

Safety Manager – Provides cost savings and staffing flexibility while ensuring you're in compliance with safety regulations.

Safety Strategy – The act of being safe, understand how strategy affects structure and how the choice of structure affects efficiency and effectiveness.

Active System - A system that uses mechanical means to satisfy load demand as opposed to passive systems.

Risk -When we refer to risk in relation to occupational safety and health the most commonly used definition is 'risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard.

Explosion -An **explosion** is the result, not the cause, of a rapid expansion of gases. It may occur from physical or mechanical change.

Toxic- It is a chemical that has a median lethal concentration (LC₅₀) in air of more than 200 parts per million (ppm) but not more than 2,000 parts per million by volume of gas or vapor, or more than 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for 1 hour.

2.8 ANSWERS TO SAQs

SAQ 1

- a)
- i) F
 - ii) T
 - iii) F
 - iv) F
- b) Individual risk

Individual risk is a probability of occurrence of death annually due to exposure to an individual person at a certain distance from the hazardous source. It mainly estimates in finding the risk of death. The individual person who encounters or possess risk to his life are expressed via this method. This evaluates fatality accident rate per year.

- Societal risk

Looking into another angle of risk called as societal risk is an estimation and assessment of risk to a large group of people. By this number of people affected by the entire incident can be calculated by

using this method. Societal risk builds relationship between the frequency and the total number of people those suffer from hazard. By using FN curve the societal risks can be expressed as relationship amongst cumulative frequency and number of fatalities taking place. This type of study results into a convenient single measure of group which is at risk.

- c) The general principles of the plant layout that should be kept in mind while designing the plant layout are as follows;
- Need to keep minimum distances for transfer of materials in between the plant or storage units to reduce costs and risks. Minimum transportation of the material within the plant because it adds to the cost as well as it may result into accidents also at some point.
 - The geographical limitations of the site.
 - Interaction with other plants on site.
 - The need to locate hazardous materials facilities as far as possible from site boundaries and people living in the local neighborhood.
 - The need for plant operability and maintainability.
 - The need to prevent confinement where release of flammable substances may occur.
 - The need to provide access for emergency services.
 - The need to provide emergency escape routes for on-site personnel. The people who are working on the sites, they should be aware of the escape route from which they can escape in the case of emergency. So in a plant or industry whenever an emergency arises or whenever there is a catastrophe that destructs the industry or the plant there should be escape routes available. Workers should ensure the escape routes and there should be know-how to the workers that what are the available escape routes in case of emergency. Even on the floors also marking scan be done, that can help the workers to go out of the plant in case of emergency.
 - The need to provide acceptable working conditions for operators.
- d) **Fire:** Incident of fire and its spreading can take place owing to following factors;
- Direct burning (including running liquid fires)
 - Convection
 - Radiation
 - Conduction

By splitting of vertical and horizontal sections by employing fire resisting walls as well as floors the spreading of fire from its originating source can be prohibited to a great extent. In this case compartmentation is another term which can be used to avoid spreading of fire. For example, in case a large hall is there in any plant and in that if any incident of fire happens at one specific area then it is clear that this fire will be spread to the entire hall. But this escalation of fire can be prevented if entire hall is divided by providing different compartments like four to five compartments in a single hall that too built with fire resistant walls and fire resistant roof.

- i) **Explosion:** Some guidelines and principles must be followed to safeguard the plants or buildings against the incidents of explosion. The plant and related system should be safe whenever any explosion takes place. Pressure waves or missiles usually lead to explosion propagation. It is imperative to make a note of it that explosion going to occur, what are the possible causes and consequently what are the basic principles or guidelines that must be kept in mind while designing a building or a plant to safeguard it against explosion.
 - ii) **Release of toxic gases:** Other type of hazard linked to the explosion is discharge of toxic gases in the environment that may lead to Domino effect by rendering neighboring industries, adjacent sites, plants and injuring workers working in the vicinity and leading to accidents. This type of Domino effect can be controlled by preventing, mitigating hazards associated with the explosion through the utilization of automatic control systems by adopting inherently safer guidelines and principles and a convenient control room for conducting all these required preventive steps. Ultimate requirement is stop these kinds of damages or hazards that may take place due to explosion. Explosion usually takes place due to release of gases and these leaked gases can be detected by using some sort of gas detector implanted in the areas prone to gas leakages. These gas detectors alerts the employers working in that area by generating an alarm and will warn the security checkers to take preventive steps in case of leakage of toxic gas in the environment.
- e) The inherent safety index is another imperative aspect that need be understood thoroughly. Inherent safety index is the only one by which whole process routes can be assessed, and consecutively the most suitable route for further development can be found. There are many ways by which accidents may take place, so there is huge need to provide for a particular system or for particular working conditions in which the accidents do not take place and the operators feels safe while working on their jobs and perform their duties safely while working in the plant. There are still chances of accidents to happen, in that case there

is need to have a enumerated technique which would help in checking and assessing the risk that how much is the risk involved in that particular type of system or process. It is the most suitable technique to minimize the risk. This method also compares the inherent safety index of the plant with the cost of capital and production- it is believed that inherently safe plants are cost-effective plants. Inherent safety index of the plant and cost of capital and production are interrelated with each other, so always there is risk involved with them and ultimate aim is to minimize the risk.

- f) Documentation of safe work instructions plays a vital role in any industry as these act as the foundation for that particular work place. A local management personal enrolled, is generally responsible for developing and implementing safe work practices in an industry. Figure 2.4 depicts all the possible checks that are conducted by safety management department in a plant. Safe work practicing is nothing but a set of instructions that are usually recommended for undertaking any process or activity safely. Those industries who have their safe working instructions in written format possesses safe working system, also they conforms overall health and safety of their employers. These safety instructions in written format are an essential part of the system for ensuring safe working conditions during actual operation. Management team takes the responsibility of conducting and ensuring safe working environment for the employers. For achieving this motto, management team provides multiple safety trainings, orientation programs and induction trainings to the newly appointed workers as well as to the newly shifted workers.
- g) Labour Attitudes: Workers are not interested or are obstructive
 - ii) Staff does not analyze the risks or problems at worksite
 - iii) Least involvement of workers in health and safety procedures
 - iv) Organizational resistance to change
 - v) Lacking Safety Culture

2.9 REFERENCES AND FURTHER STUDIES

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