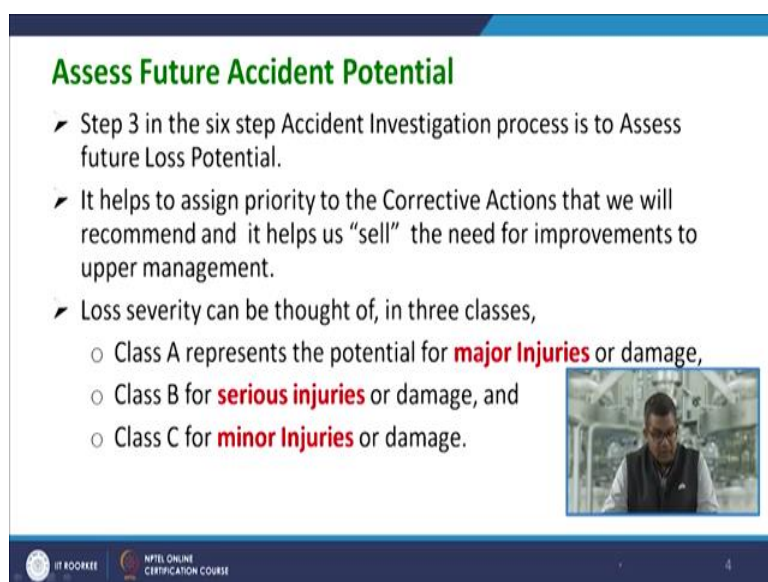


**Chemical Process Safety**  
**Professor Shishir Sinha**  
**Department of Chemical Engineering**  
**Indian Institute of Technology Roorkee**  
**Lecture – 49 Accident Investigation Procedure – II**

Now welcome to this Accident Investigation Procedure module. In the previous module we had gone through about the accident and related facts about accident, various outcomes of accident, accident causation theories and accident investigation protocol. So had we had studied earlier that the accident investigation protocol has the six step and then the previous module we have studied first two steps of this accident investigation protocol. Now, let us have a look about the third step.

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**Assess Future Accident Potential**

- Step 3 in the six step Accident Investigation process is to Assess future Loss Potential.
- It helps to assign priority to the Corrective Actions that we will recommend and it helps us “sell” the need for improvements to upper management.
- Loss severity can be thought of, in three classes,
  - Class A represents the potential for **major Injuries** or damage,
  - Class B for **serious injuries** or damage, and
  - Class C for **minor Injuries** or damage.

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Now this third step involves the assess the future accident potential. Now in this particular step, this particular process involves the assessment of the future loss potential now it helps to assign priorities of corrective action that we may recommend or we will recommend and it helps us to sell the need of any improvement and it gives the suggestive majors for those improvements to the upper management. Now loss severity can be thought of in three different classes. Class A, class B & class C. The class A represents the potential for major injuries or damage, the class B for the serious injuries or damage and class C for the minor injuries or damage.

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### Assess Future Accident Potential

#### Class "A" Hazard (Major)

- A condition or practice likely to cause permanent disability, loss of life, body part and/or extensive property loss or damage.
- Examples:
  - An unguarded machine with the potential to amputate a finger or hand,
  - An unprotected floor opening, that could lead to a fall from an elevation greater than 10 feet, and badly worn brakes on a motor vehicle that could lead to an intersection collision.



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So, let us have a look about a class A hazard that is major. Condition or practice likely to cause the permanent disability, loss of life that is fertility loss of body part or extensive property loss or damage. Let us have an example that an unguarded machine with the potential to amputate a finger or hand. And unprotected floor opening that could lead to a fall from an elevation greater than 10 feet or a and badly worn brakes on motor vehicle that could lead to an intersection collision.

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### Assess Future Accident Potential

#### Class "B" Hazard (Serious)

- A Class B Hazard represents a condition or practice that could cause serious injury or illness such as a temporary disability, or property damage that is serious but less severe than those under Class A.
- Examples:
  - An unguarded floor opening that may lead to a fall from an elevation of less than 10 feet,
  - An unguarded pinch points in a machine that may lead to serious bruises or broken bones but not amputations, and
  - Work procedures that allow an employee to move 4 litres drums with no assistance.



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Now, let us have a look about the class B hazard that is serious. The class B hazard represents a condition or practice that could cause serious injury or illness such as a temporary disability


or a property damage that is serious but less severe than those under we have club under the class A the example is the unguarded floor opening that might may lead to a fall from an elevation of less than say 10 feet. And unguarded pinch points in a machine that may lead to a serious problem or broken bones but not amputation and the work protocols that allow an employee to move 4 litres drum without any assistance.

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**Assess Future Accident Potential**

**Class "C" Hazard (Minor)**

- A Class C Hazard is minor in nature and is likely to cause non-disabling injuries or illnesses or non-disruptive property damage.
- Examples:
  - The use of a chemical that may cause dermatitis without the practice of using gloves or barrier creams,
  - A process that creates dust but work practices do not call for the use of ventilation or the wearing of eye goggles, etc.



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Let us have a look about the class C hazard those are cub under the head of the minor one. A class C hazard is minor in nature and is likely to cause non disabling injuries or illness or not non-destructive property damage. For example the use of a chemical that may cause dermatitis without the practice of using gloves or barrier creams, a process that creates dust but worker practices do not call for the use of any kind of ventilation or the wearing of any eye goggles etc.

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Let us have a look about the step no 4.

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### Correcting The Causes

- In order to make the corrective action successful, one need to have a corrective action for each and every root cause, identified.
- However, more than one control may be needed for each root cause depending on the circumstances.
- The “Control Hit List” is a simple tool that spells out the desired levels of controls available so that the “best” type of control may be selected as first choice and so that one consider all of the possible controls without just reaching for the most obvious one.




The slide has a white background with a blue header. The title 'Correcting The Causes' is in red. The list items are preceded by a blue arrow icon. A small video inset in the bottom right shows a man in a white shirt and dark vest. The footer is dark blue with the IIT ROORKEE logo and 'NPTEL ONLINE CERTIFICATION COURSE' text.

Now this system 4 involves the correcting the causes. Now in order to make the corrective action successful one need to have a corrective action for each and every root causes which we have identified, however more than one control may be needed for each root cause depending on the circumstances. Now the control hit list is the simple tool that is spells out the desired level of controls available so that the best type of control may be selected as first choice and so that one consider all the possible controls without just reaching for the most obvious one.

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## Correcting The Causes

- If the corrective actions are not likely to be implemented right away (because of such things as a large expenditure of money, a re-design of a workstation or purchase of different equipment or machinery), it is advantageous to propose and implement short term solutions that will minimize the immediate risk.
- The “Force Field Analysis” is simply a visual tool that helps us to realize that for every restraining force, we must identify and implement an opposing counteracting force.



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Now if the corrective actions are not likely to be implemented right away because maybe of the variety reason, because of such things as a large expenditure of money or may require redesign of a workstation or a workplace or purchase of different equipment or machinery. Now it is advantageous to propose and implement the short-term solution that will minimise the immediate risk. So the force field analysis being carried out, now this force field analysis is simply a visual tool that helps us to realise that for every restraining force we must identify and implement an opposing counter acting force.

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## Control Hit List

It helps to think of controls in six categories (listed in priority order, with the most effective control at the top and the least effective control at the bottom) because some categories have proven more effective than others.

1. Eliminate the Hazard
2. Substitute a less hazardous material
3. Use Engineering Controls
4. Use Administrative Controls
5. Personal Protective Equipment (PPE)
6. Training of Employees



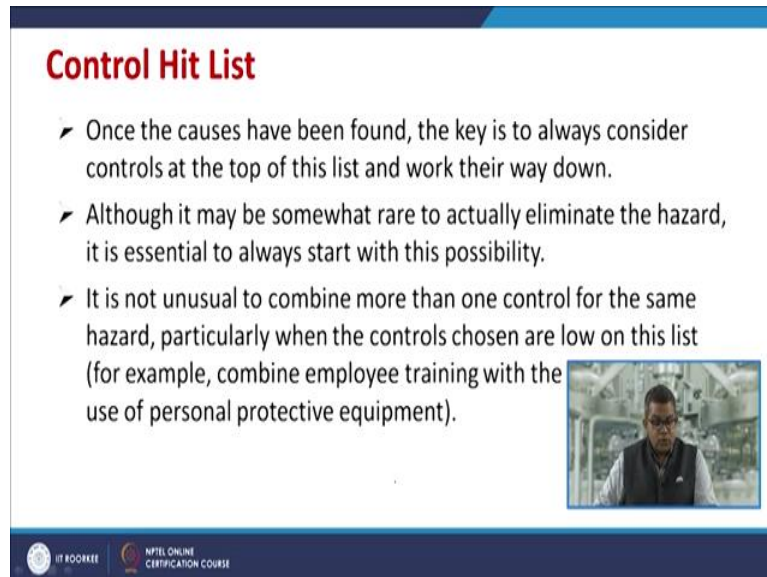
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So, let us have a look about the control hit list. Now it helps to think of control in 6 different categories, now they are listed in priority order with the most effective control at the top and the least effective control at the bottom, so this maybe because some categories have proven more effective than others so these are the like elimination of hazard this is the most effective control.

But you cannot eliminate all hazard at workplace so you can minimise those hazards. Now minimization may be achieved by the substitution of a less hazardous material. Number 3 may be use of proper engineering controls, you may use the administrative control sometimes there is an administrator may be included like controlled zones adopting the protocol of the control Zones.

So that the common people are those the people those who are not required that work place they may be cordoned off to go into the controlled zone, so these are the some of the example of use of administrative control. Then the use of personal protective equipments PPE and then the training of the employees.

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**Control Hit List**

- Once the causes have been found, the key is to always consider controls at the top of this list and work their way down.
- Although it may be somewhat rare to actually eliminate the hazard, it is essential to always start with this possibility.
- It is not unusual to combine more than one control for the same hazard, particularly when the controls chosen are low on this list (for example, combine employee training with the use of personal protective equipment).

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So once the causes have been found the keys to always consider the controls at the top of the list and work their way down. So sometimes it may be somewhat rare to actually eliminate the hazard now it is essential to always start with this particular possibility so if you recall in the industrial hygiene chapter we have discussed the four basic protocols like substitution, attenuation, isolation etc. Now it is not unusual to combine more than one control for the



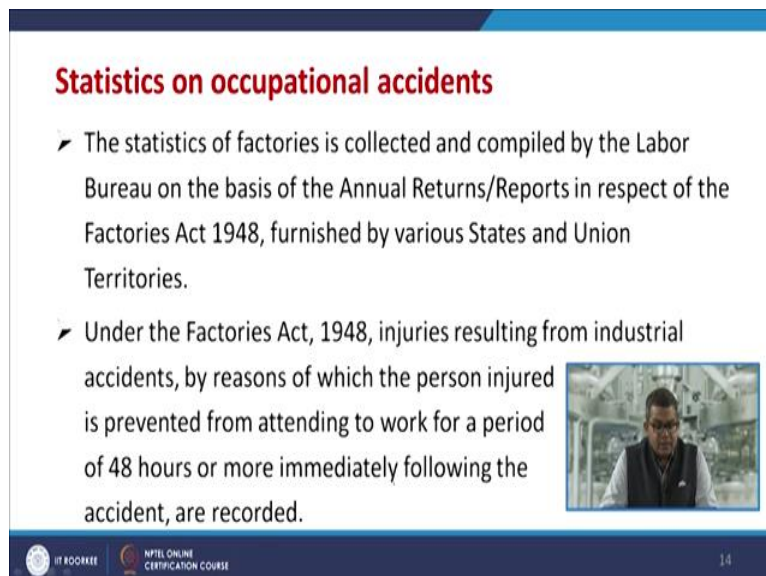
same hazard particularly when the controls chosen are low on this particular list like combine employee training with the use of personal protective equipment etc.

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Now, let us have a look about the fifth step.

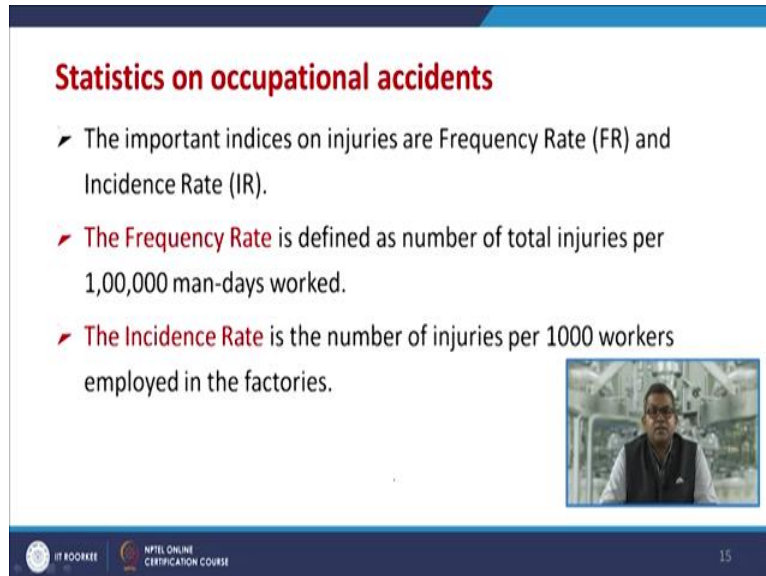
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That is their statistics on occupational accident now the statistics of factories or Industries is collected they are compiled by the Labour Department on the basis of annual returns reports with respect to the factories act 1948 and their furnished by the state and union territories.

Now this is very important that is the under the factories act 1948 injury is resulting from any industrial establishment under the head of industrial accident by reason for of which the person injured is prevented from attending to work for a period of let us say 48 hours or more immediately following the accident they are recorded. So it gives a proper data so that it in future then you are analysing those accidents may be used as a future reference.

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**Statistics on occupational accidents**

- The important indices on injuries are Frequency Rate (FR) and Incidence Rate (IR).
- **The Frequency Rate** is defined as number of total injuries per 1,00,000 man-days worked.
- **The Incidence Rate** is the number of injuries per 1000 workers employed in the factories.

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Now, the important indices on injuries are frequency rate that is FR and incidence rate that is IR now the frequency rate is defined as number of Total injuries per 100000 man-days worked. This one and the incidence rate is the number of injuries per 1000 worker employed in those factories or establishments.



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### Report Data & Recommendations

- All accidents to employees, however minor, should be recorded. This is a requirement under social security legislation. All near misses, incidents and accidents should be reported, no matter how slight they may appear.
  - Fatal accidents
  - Accidents causing major injuries.
  - Notifiable accidents & dangerous occurrences
  - Reportable accidents & dangerous occurrences
  - Written records



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Then there is a report of a data and recommendations so all accidents to employees however, maybe minor should be recorded that is very important. Now this is a requirement under the social security legislation so all near misses incidents and accident they should be reported, no matter how slight they may appear. So fatal accidents this may include the fatal accident, accidents causing the major injuries, notifiable accidents and dangerous occurrence, reportable accident and dangerous occurrence and some written records.

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### Report Data & Recommendations

- The company encourages employees to report all accidents no matter how minor.
- Accidents that involve very minor injuries like small cuts, non-extensive bruises etc. and would not normally require any action on behalf of the company (e.g. the breaking of a drinking glass) do not have to be reported (although employees could report them if they want).
- On the other hand, accidents that involve (or could have involved) more severe injuries and require investigation and action from the company must be dutifully reported.



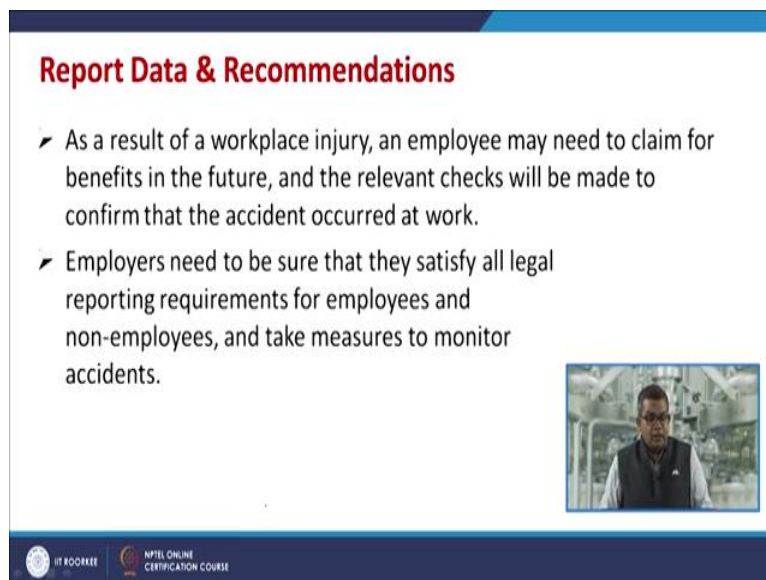
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So the company usually encourages employee to report all accident no matter how minor and sometimes they fail the reason is that if the accidents are reported in a proper manner then the

chances of paying compensation in terms of economy may be on the higher side so accidents that involve very minor injuries like small cuts non extensive process etc. and would not normally require any action on behalf of the company like the breaking of a drinking glass etc.

So they do not have to be reported all the employee could report them if they want so the quality of accident sampling is essential. Now on the other hand the accidents that involve for or could have involved more severe injuries and they may required investigation and action from the company must be dutifully reported.

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**Report Data & Recommendations**

- As a result of a workplace injury, an employee may need to claim for benefits in the future, and the relevant checks will be made to confirm that the accident occurred at work.
- Employers need to be sure that they satisfy all legal reporting requirements for employees and non-employees, and take measures to monitor accidents.



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So as a result of a workplace injury and Employee need to claim for benefits in future and the relevant checks will be made to confirm that the accident occurred at workplace. Now, the employer need to be sure that they satisfy all legal reporting requirements for the employees and non employees and take the measure to monitor those accident, so that is crucial as far as the employer perspective is concerned.

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### Report Data & Recommendations

- Accidents happen for a reason, it could be machine failure, unsafe work practices or poor housekeeping, but reporting these occurrences can help identify the cause and help prevent this accident reoccurring.
- As part of the reactive monitoring process, accident records are needed to assess whether the existing controls are adequate or to identify if trends are developing and to implement new procedures.



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Now accidents happened for a reason it could be machine failure, unsafe work practice or poor housekeeping but reporting this occurrences can help identifying the cause and help prevent the this accident reoccurring. So as a part of the reactive monitoring process accident records are needed to assess whether the existing controls are adequate or they need to identify trends are developing then sometimes it may give a very vital information it is just like that if the rise in temperature is recorded in any reactor then it may be serious thing. So it helps us to identify if there any kind of trend is developing and to implement any kind of new procedure.

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### Report Data & Recommendations

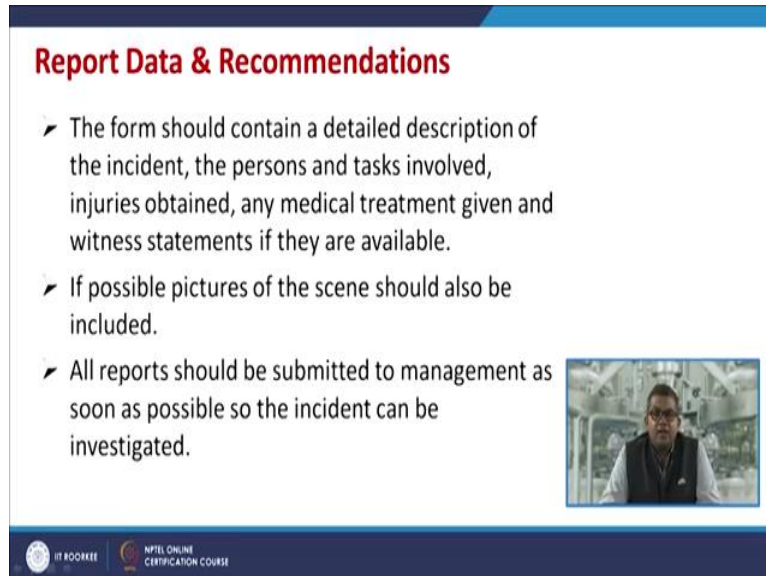
- Records may also have to be produced for the Health and Safety Executive, to parents/guardians, or in the course of civil proceedings if a claim is brought following an incident.
- Reporting and recording procedures varies from organization to organization as procedures are different. Usually the most effective way of reporting incidents/accidents is through a specific reporting form.



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Now, the record may also be produced for the health and safety executive to the parents or the guardians or in course of civil proceeding if a claim is brought following incident. Now reporting and recording procedures they vary from organisation to organisation as the procedures are a different, usually in most effective way of reporting incident accident is through a specific reporting form. So the design of that particular form is important.

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**Report Data & Recommendations**

- The form should contain a detailed description of the incident, the persons and tasks involved, injuries obtained, any medical treatment given and witness statements if they are available.
- If possible pictures of the scene should also be included.
- All reports should be submitted to management as soon as possible so the incident can be investigated.

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The slide features a blue header with the title 'Report Data & Recommendations' in red. Below the title, there are three bullet points with green arrowheads. To the right of the third bullet point, there is a small video inset showing a man in a white shirt and dark vest speaking. At the bottom of the slide, there is a dark blue footer containing the text 'IT 800888' and 'NPTEL ONLINE CERTIFICATION COURSE' next to a small logo.


Now the form should contain a detailed description of incident the person and a task involved injuries obtain any kind of medical treatment is given to them and witness statement if they are available sometimes people are better reluctant to give any kind of witness statement. Now, if possible picture of the scene there should be included if the investigation team is able to get any kind of picture then they should be included. So all report should be submitted to the management as soon as possible so the accident incident can be investigated.

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### Report Data & Recommendations

- The form is divided into some general sections to cover all relevant information.

- SECTION I. Background**
- SECTION II. Description Of Accident**
- SECTION III. Findings**
- SECTION IV. Recommendations**
- SECTION V. Summary**
- SECTION VI. Follow-up: Actions**
- SECTION VII. Comments/Attachments**



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Now, let us have a look about the basic feature of the form now the usually the form is divided into some of the general sections to cover all relevant information. Now these sections may include the section 1 may be the background, section two the description of detailed description of the accident, the section 3 may be the finding of investigating team.

The Section 4 is the recommendations been suggested by the investigation team, section fifth will be the summary and section sixth may the follow up the actions and section 7 may include the comment and various kind of attachments may be used for the reference of this particular report. Now, the important thing is that need to documents document the facts only.

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### Report Data & Recommendations

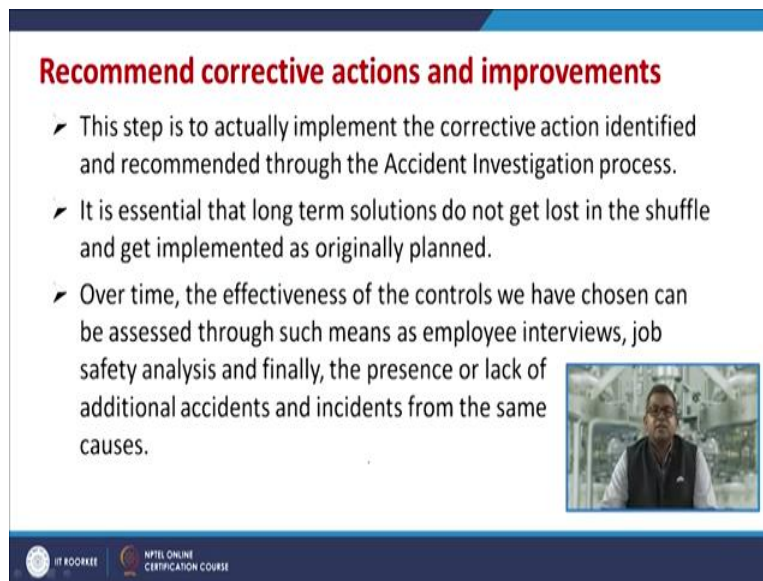
- Document facts only.
- Determine if the corrective action applies to more than one employee, more than one job function, more than one shift, etc.
- Prioritize corrective actions based on future accident potential.
- Submit both short term and long term solutions, if necessary.
- **Example:** If employees are exposed to an excessive vapor concentration, a short term control may be the wearing of PPE, while the long term control may be installing a ventilation system.



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Now determine if the corrective action applies to more than one employee, more than one job function or more than one shift, etc. Then the priorities the corrective action based on future accident potential you may submit the both short term and long term solution if required. Let us have an example like. If employees are exposed to excessive paper concentration a short-term control maybe the wearing the personal protective equipment while the long-term control maybe the by the installing ventilation system.

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**Recommend corrective actions and improvements**

- This step is to actually implement the corrective action identified and recommended through the Accident Investigation process.
- It is essential that long term solutions do not get lost in the shuffle and get implemented as originally planned.
- Over time, the effectiveness of the controls we have chosen can be assessed through such means as employee interviews, job safety analysis and finally, the presence or lack of additional accidents and incidents from the same causes.

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Now, let us have a look about the sixth step that is the last step that is recommend corrective action and improvement. Now this step is actually implement the corrective action identified and recommended through the accident investigation process. Now it is essential that long term solution do not get lost in shuffle and get implemented as originally plant. So over time the effectiveness of the controls we are chosen can be assessed through such means such as employee interviews, job, safety analysis and finally the presence of lack of additional accidents and incidents from the same cause.



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### Recommend corrective actions and improvements

➤ To make corrective actions, various control strategies can be used:

- **Engineering Controls:** Helps in eliminating or reducing hazards through equipment redesign, replacement, substitution, etc.
- **Management Controls:** It helps in eliminating or reducing exposure to hazards by controlling employee behaviors.
- **Interim Measures:** These include strategies that are used as a temporary fix while permanent controls are being developed.



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Now to make the corrective action various control strategies can be used, one is the engineering control this helps in eliminating or reducing hazard through equipment redesign and replacement, substitution, attenuation, isolation etc. Then the Management control it helps in eliminating or reducing exposure to hazard by controlling employee behaviour the third one is the interim measures. These include the strategies that are used as a temporary fix while permanent controls are being developed.

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### Recommend corrective actions and improvements

➤ Various improvements should be made to policies, programs, plans, processes, and procedures in order to have proper and better investigations and less accidents.

➤ It can be done within one or more of the following elements of the safety management system:

- Management commitment
- Employee involvement
- Hazard identification and control
- Education and training
- Incident and accident analysis
- System evaluation
- Accountability

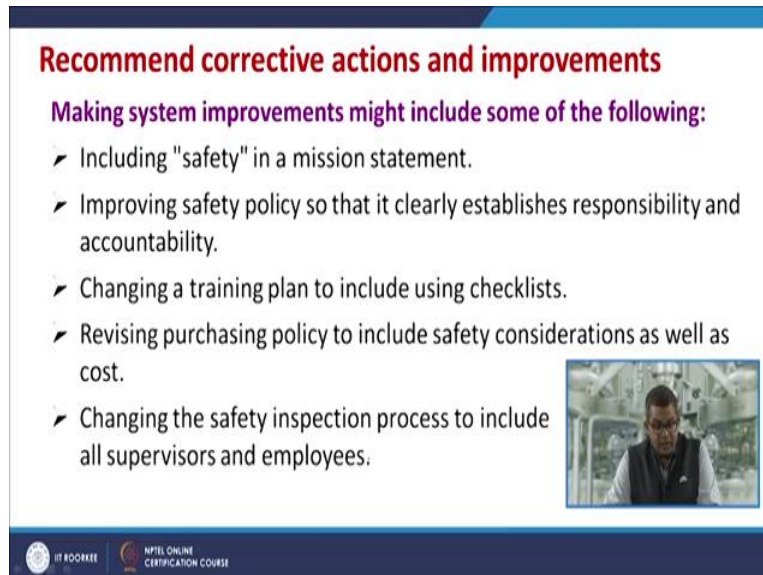


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Now various improvements should be made to policies programs plans processes and procedures in order to have proper and better investigation and less accidents. Now it can be

done within one or more of the following elements that does safety management system like managerial commitment, employee involvement, hazard proper hazard identification control, proper training and education, then incident and accidental analysis by adopting the proper system evaluation protocol, then by fixing the accountability etc.

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**Recommend corrective actions and improvements**

**Making system improvements might include some of the following:**

- Including "safety" in a mission statement.
- Improving safety policy so that it clearly establishes responsibility and accountability.
- Changing a training plan to include using checklists.
- Revising purchasing policy to include safety considerations as well as cost.
- Changing the safety inspection process to include all supervisors and employees.

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The slide features a blue header and footer. The main content is on a white background. A small video inset on the right shows a man in a white shirt and dark vest, possibly a safety officer, in an industrial setting.

Now the making a system improvement might include some of the following things like including the safety in a mission statement because you may find that in several good organisation there is a mission statement and there is a vision statement so the safety may include in the mission statement. Now improving safety policy so that it clearly establishes the responsibility and accountability.

The changing a training plan to include using checklist because checklist is a very vital source of finding the problems within the system. Revising the purchasing policy to include safety consideration as well as the cost so you may one example is that sometimes you may give allowances to the raw material contamination because sometimes the contaminants may create a future problem in further reaction.

So you may revise because sometimes the account section may say that you should compromise with 5 percent 6 percent purity of that particular component so you may revise the purchasing policy. Now the changing the safety inspection process to include all supervisors and employees.

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### Recommend corrective actions and improvements

- The investigation system should be examined from time to time to check that it consistently delivers information in accordance with the stated objectives and standards. This usually requires:
  - Checking samples of investigation forms to verify the standard of investigation and the judgements made about causation and prioritisation of remedial actions;
  - Checking the numbers of incidents, near misses, injury and ill-health events;
  - Checking that all events are being reported.




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Now the investigation system should be examined from time to time to check that it consistently delivers information in accordance with the stated objectives and standards. Now the usually requires that checking samples of investigation forms to verify the standards of Investigation and the judgement made about the causation and the prioritization of remedial actions, sometimes checking the number of incident near misses, injury or all ill health events now checking that all events are being reported that is very important.

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### Why Accident Investigations Fail...

- The investigation system should be modified time to time in order to avoid the failure of accident investigation.
- Some of the reasons of failure are:
  - Investigation stopped short and didn't reveal the root causes of the accident
  - No time to complete
  - No motivation to complete
  - Lack of accountability
  - Lack of skills & knowledge



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Now sometimes these accidents investigation fails so why this accident investigation fail? the investigation system should be modified time to time in order to avoid the failure of accident

investigation and some of the other reason of the failures maybe like investigation is stopped, short and did not reveal the root cause of accident. /there was no time to complete the accident investigation, there was no motivation towards the completeness of that particular accident investigation, there was a lack of accountability, lack of skill and knowledge so all these factors they are involved to the failure of accident investigation.

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**Accident Prevention**

Accidents can be prevented by early detection, reporting and abating!




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Now, let us have a look about the accident prevention now accident can be prevented by early detection, reporting and awaiting, so let us have a look about the various steps involved.

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**Step 1 Hazard Identification**

- Detection/identification of hazards before they cause injuries is important. To accomplish this, conduct periodic “walk around” inspections looking for items such as:
- Slip, trip and fall hazards (e.g., wires across a walk way)
- Broken/damaged equipment (e.g., stool with a broken leg)
- Machinery with missing guards (e.g., cutting machine with missing blade guard.)
- Exposed electrical wiring (e.g., frayed electrical cord)
- Damaged PPE (e.g., gloves with rips/tears)

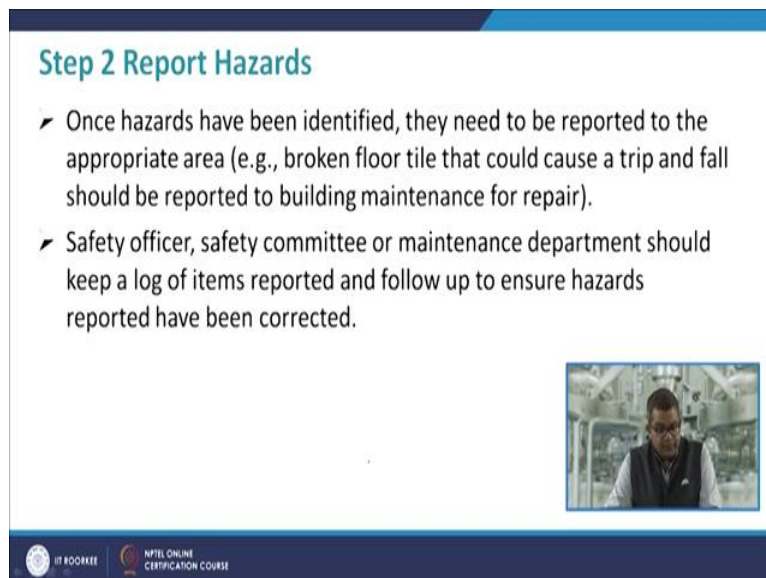


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Like hazard identification, detection, identification of hazard before they cause injuries is important now to accomplish this conduct the periodic walk around inspection looking for items may be such that like slip, trip and fall hazards maybe across may be wire across umm a walkway, sometimes you may observe the broken damage equipments for example, stool with broken leg.

Sometimes you may observe the machinery with the missing guard like cutting machine with the missing frayed guard. Sometimes you may experience the exposed electrical wiring may be frayed electrical cord sometimes you may experience that there is a damage of personal protective equipments like gloves with rips or tears etc. so this may create a problem.

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**Step 2 Report Hazards**

- Once hazards have been identified, they need to be reported to the appropriate area (e.g., broken floor tile that could cause a trip and fall should be reported to building maintenance for repair).
- Safety officer, safety committee or maintenance department should keep a log of items reported and follow up to ensure hazards reported have been corrected.

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Second is the step is the report hazard so once a hazard have been identified they need to be reported to the appropriate area that is that for example, the broken floor tiles that could cause a trip and fall that should be reported to the maintenance section for repairing. The safety officer, safety committee or maintenance department should keep a log of those item reported and follow-up to ensure the hazard reported have been corrected so this is again important issue.



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### Step 3 Hazard Abatement

- Hazard abatement can be defined as the elimination or reduction of a safety/health hazard by complying with applicable safety and health standards or taking equivalent protective measures.
- Take the steps necessary to abate hazards; this will provide a safer environment for employees, contractors and visitors alike.



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Then third one is that the hazard abatement. The hazard abatement can be defined as the elimination or reduction of a safety hazard by complying with applicable safety and health standards or taking accumulate protective measures so take the steps necessary to abate hazard now this will provide a safer environment for employees, contractor, visitors etc.

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### Accident Prevention

Here are some ways to prevent accidents:

- Ensure work areas are not cluttered and trash is removed regularly.
- Provide necessary training/retraining for all employees.
- Ensure that necessary controls are in place [engineering (e.g., machine guarding), administrative (e.g., labels/signs), PPE (e.g., safety goggles)].
- Have spills cleaned up immediately.



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Now, here are some ways to prevent the accidents one is to ensure the work areas they are not cluttered and trashes removed regularly because this lead to the good housekeeping. Now provide the necessary training, retraining of all employees. Now ensure that necessary controls they are in place like a machine guarding etc. administrative controls they are well in




place like label sign, play cards etc. The personal protective gears they are in place like safety goggles, mask, etc. Now have spills cleanup immediately that is a very good housekeeping practice.

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### Accident Prevention (cont...)

- Ensure proper lifting/carrying techniques are being used.
- Ensure mechanical handling equipment, or MHE, is being used properly.
- Ensure walking/working surfaces are free of slip, trip and fall hazards.
- Enforce safety rules, policies and procedures.
- Ensure safety inspections are being conducted regularly.




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Ensure proper lifting carrying techniques they are being used. One must ensure that mechanical handling equipment is being used properly one may ensure that walking working surfaces they are they all are free of slip trip and fall hazard. One must ensure that the safety rules policies and procedures they are well implemented, you may ensure that that safety inspection they are being conducted regularly.

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### Summary

- Regulatory requirements for investigating workplace incidents and dangerous occurrences.
- Collect evidence for an investigation.
- Analyze evidence for an investigation.
- Develop a workplace investigation report.
- Take action following a workplace investigation.

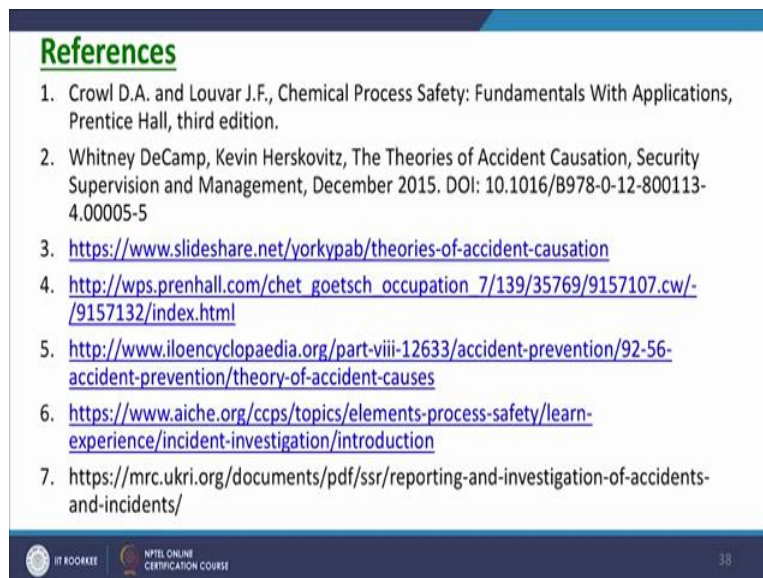


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So, in summary you may say that the regulatory requirement for investigating workplace incident and dangerous occurrence. You must collect all evidences for an investigation, analyse all evidences for an investigation. You must develop a workplace investigation report, a proper workplace investigation report, a detailed workplaces specification workplace investigation report.

Now you take the action following a workplace investigation report. So, in this particular chapter we have discussed about the accident investigation protocol. What are the different key factors? What are the different theories involve and how we can present the report? How we can go for the follow up action etc.?

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Now, if you wish to have for the reading then we have a listed a large number of references for your convenience. You can go through all those references, thank you!