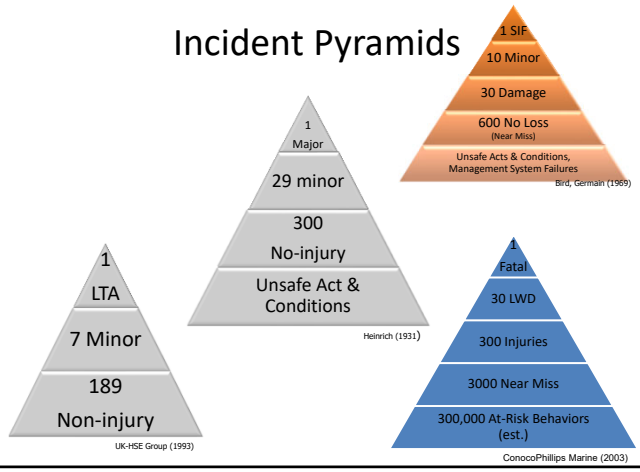
FPST 3013 – SAFETY MANAGEMENT
THE INCIDENT INVESTIGATION PROCESS

Lecture 6

Accident Causation Models and Root Cause Analysis

1

Incident Pyramids



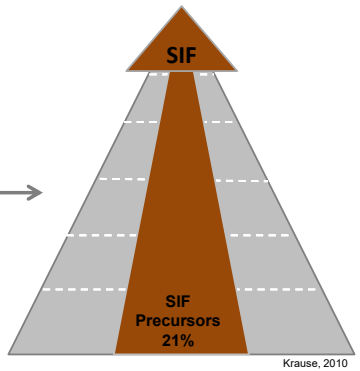
2

New Incident Pyramid

Accident Causation

High-Risk Exposure

- Process Instability
- Unexpected Changes
- High Risk Event Combinations



Precursor:

A high-risk situation in which management controls are either absent, ineffective, or not complied with, and which will result in a serious or fatal injury if allowed to continue.

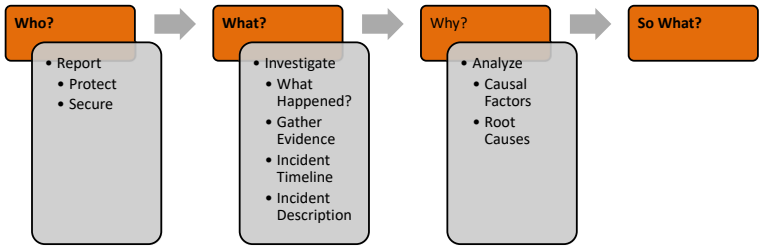
WATCH VIDEO: Why Do We Still Have Serious Injuries

Incident Investigation

3

The Incident Investigation Process

Phases of Incident Investigation



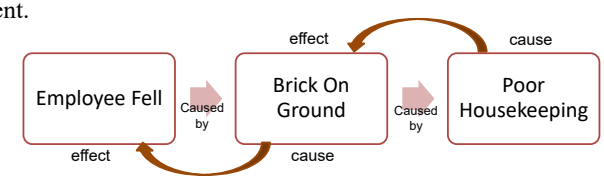
Incident Investigation

4

Accident Causation

Principle of Cause and Effect

- An action or event that will produce a response in the form of another event.



- Caution: does not necessarily mean that one event caused the other

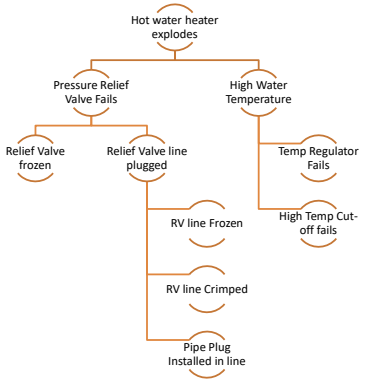
Incident Investigation

5

Accident Causation

Multiple Causation Principle

- Very seldom will just one root cause create a condition that results in an incident.
- In most cases, a chain of events occurs
  - ~ Substandard conditions
  - ~ Substandard acts
  - ~ Management system failures



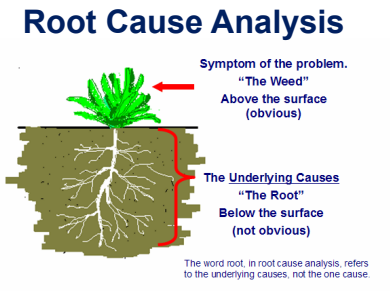
Incident Investigation

6

Causal Analysis

Analytical Techniques

- Fishbone (Cause and Effect)
- 5 Whys
- Cause Mapping
- Systematic Cause Analysis Techniques (SCAT) charts



Incident Investigation

7

In order to understand why something happened, we must first understand how something happens

8

Consider this situation…

- New maintenance trainee in the last three months

HELLO
my name is
Newbie

Incident Investigation

9

- Training was held to review, among other things, plant rule to wear a face shield while grinding

Incident Investigation

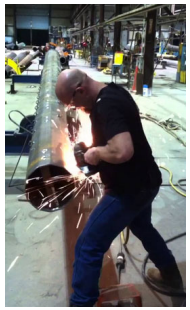
10

- New employee missed training due to illness

Incident Investigation

11

- A week after returning to work, Newbie was grinding on steel. The disc broke and he lost an eye.



Incident Investigation

12

Accident Causation Model

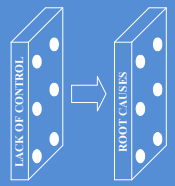
- Lack of Control - Inadequate Programs, Inadequate Program Standards, or Inadequate compliance to them

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

13

Accident Causation Model



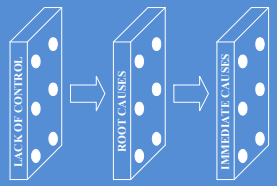
- Root Causes - Personal Factors and Job Factors (e.g. inadequate knowledge, inadequate skill, inadequate maintenance, inadequate engineering, etc.

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

14

Accident Causation Model



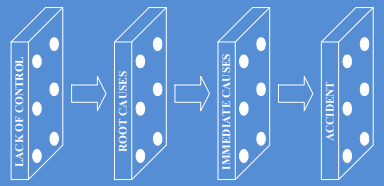
- Immediate Causes - unsafe Behaviors and unsafe Conditions

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

15

Accident Causation Model



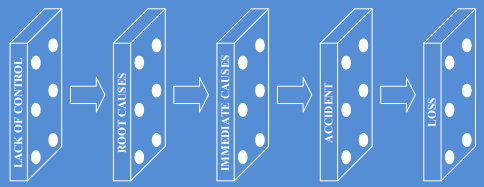
- Accident - Contact with Energy, Substance or People

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

16

Accident Causation Model



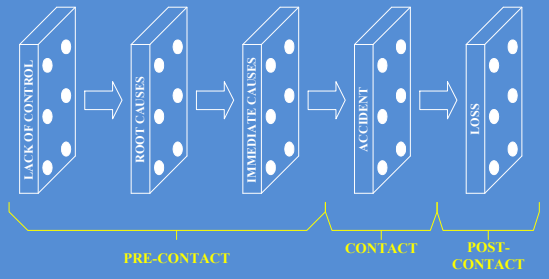
- Loss - People, Property, Product, Environment or Service

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

17

Accident Causation Model



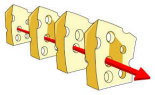
Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

18

Other Types of Accident Causation Theories

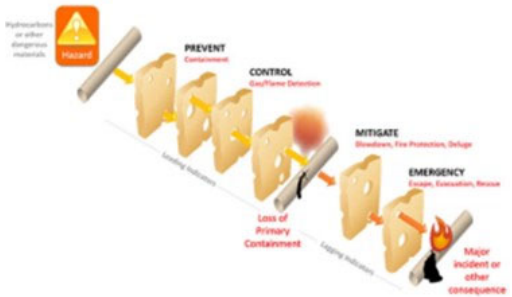
- Reason's Swiss Cheese Model (1990)



- Pure Luck models
- Accident Proneness
- Time Sequence Models
  - ~ Benner (1975)
    - four issues which not addressed in the domino theory
      - – need to define a beginning and end to an accident
      - – need sequential time line of events
      - – need structured method for discovering the relevant factors involved
      - – need to use a chart to define events and conditions

Incident Investigation

19



Incident Investigation

20

Other Types of Accident Causation Theories

- Systems Theoretic Accident Model and Process (STAMP)
  - ~ "interrelated components that are kept in a state of dynamic equilibrium by feedback loops of information and control"
    - Leveson, N. (2004). A new accident model for engineering safer systems. *Safety Science*,
    - 42, 237-270.
  - ~ safety management systems are required to continuously control tasks
  - ~ why did controls fail to detect or prevent changes that lead to an accident
- Functional Resonance Accident Model (FRAM)
  - ~ three dimensional
  - ~ systems are human error tolerant
  - ~ "forces (being humans, technology, latent conditions, barriers) do not simply combine linearly thereby leading to an incident or accident"
    - Hollnagel, E. (2004). *Barriers and Accident Prevention*: Aldershot:Ashgate,.

Incident Investigation

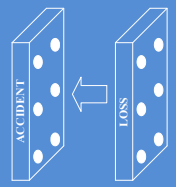
21

Incident Investigation is simply standing the dominos up backwards one at a time and asking "why" they fell.

22

Incident Investigation

- Describe the incident in detail including body positioning and the points in time where contact occurred. Be detailed and specific. Ask lots of questions.



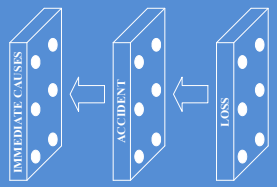
Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

23

Incident Investigation

- Ask "Why was there contact" to identify unsafe behaviors of both directly and indirectly involved employees as well as unsafe conditions.



Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

24

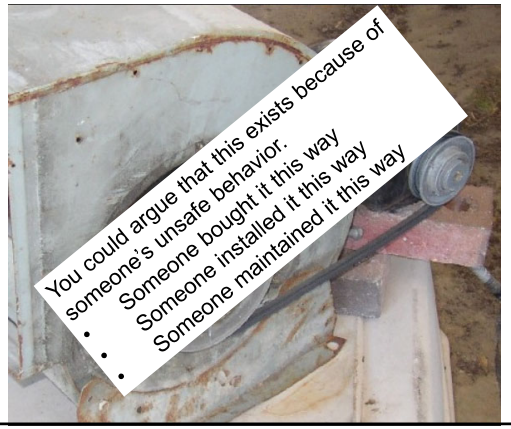
Immediate Causes – Indirect Causes – Causal factors– Symptoms

- Unsafe/Substandard Acts/Practices
  - ~ Operating equipment without authority
  - ~ Failure to warn
  - ~ Failure to secure
  - ~ Operating at improper speed
  - ~ Making safety devices inoperable
  - ~ Removing safety devices
  - ~ Using defective equipment
  - ~ Using equipment improperly
  - ~ Failing to use PPE
  - ~ Improper Loading
  - ~ Improper Placement
  - ~ Improper Lifting
  - ~ Improper position for task
  - ~ Servicing equipment in operation
  - ~ Horseplay
  - ~ Under the influence of a substance
- Unsafe/Substandard Conditions
  - ~ Inadequate guards or barriers
  - ~ Inadequate or improper protective equipment
  - ~ Defective Tools, equipment or materials
  - ~ Congestion or restricted action
  - ~ Inadequate warning systems
  - ~ Fire and Explosion hazards
  - ~ Poor housekeeping, disorderly workplace
  - ~ Hazardous Environmental Conditions
  - ~ Noise Exposures
  - ~ Radiation Exposures
  - ~ Hi/Lo temperature exposures
  - ~ Inadequate or excessive illumination
  - ~ Inadequate ventilation

Incident Investigation

25

Unsafe Conditions

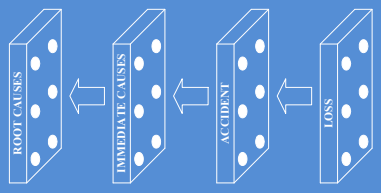


Incident Investigation

26

Incident Investigation

- Ask "Why?" again to identify personal and job factors that led to the employee(s) performing the unsafe behavior or creating the unsafe condition.



Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

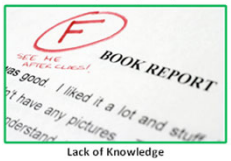
Incident Investigation

27

Personal Factors cause unsafe behaviors


Inadequate Physical Capability

Improper Motivation



Lack of Knowledge

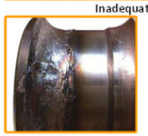

Stress

Incident Investigation

28

Job Factors cause unsafe conditions

Inadequate Maintenance



Wear and Tear

Inadequate Tools and Equipment

Inadequate Engineering

Incident Investigation

29

Root Causes

- Personal Factors
  - ~ Inadequate Physical/Physiological Capability
  - ~ Physical or Physiological Stress
  - ~ Inadequate Mental/Psychological Capability
  - ~ Mental or Psychological Stress
  - ~ Lack of Knowledge
  - ~ Lack of Skill
  - ~ Improper Motivation
- Job Factors
  - ~ Inadequate Leadership and/or Supervision
  - ~ Inadequate Tools and Equipment
  - ~ Inadequate Work Standards
  - ~ Inadequate Engineering
  - ~ Inadequate Purchasing
  - ~ Wear and Tear
  - ~ Inadequate Maintenance
  - ~ Abuse or Misuse

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

30

Personal Factors

Inadequate Physical/Physiological Capability
- inappropriate height, weight, size, strength, reach, etc.
- restricted range of body movement
- limited ability to sustain body positions
- substance sensitivities or allergies
- sensitivities to sensory extremes (temperature, sound, etc.)
- vision deficiency
- hearing deficiency
- other sensory deficiency (touch, taste, smell, balance)
- respiratory incapacity
- other permanent physical disabilities
- temporary disabilities

Mental or Psychological Stress
- emotional overload
- fatigue due to mental task load or speed
- extreme judgment/decision demands
- routine, monotony, demand for unwrenteful vigilance
- extreme concentration/perception demands
- "meaningless" or "degrading" activities
- conflicting directions
- conflicting demands
- preoccupation with problems
- frustration
- mental illness

Lack of Knowledge
- lack of experience
- inadequate orientation
- inadequate initial training
- inadequate update training
- misunderstood directions

Lack of Skill
- inadequate initial instruction
- inadequate practice
- infrequent performance
- lack of coaching

Inadequate Mental/Psychological Capability
- fears and phobias
- emotional disturbance
- mental illness
- intelligence level
- inability to comprehend
- poor judgment
- poor coordination
- slow reaction time
- low mechanical aptitude
- low learning aptitude
- memory failure

Improper Motivation
- improper performance is rewarding
- proper performance is punishing
- lack of incentives
- excessive frustration
- inappropriate aggression
- improper attempt to save time or effort
- improper attempt to avoid discomfort
- improper attempt to gain attention
- inappropriate peer pressure
- improper supervisory example
- inadequate performance feedback
- inadequate reinforcement of proper behavior
- improper production incentives

Physical or Physiological Stress
- injury or illness
- fatigue due to task load or duration
- fatigue due to lack of rest
- fatigue due to sensory overload -
- exposure to health hazards
- exposure to temperature extremes
- oxygen deficiency
- atmospheric pressure variation
- constrained movement
- blood sugar inefficiency
- drugs

Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

31

Job Factors

Inadequate Leadership and/or Supervision
- unclear or conflicting reporting relationships
- unclear or conflicting assignment of responsibility
- improper or insufficient delegation
- giving inadequate policy, procedure, practices or guidelines
- giving objectives, goals or standards that conflict
- inadequate work planning or programming
- inadequate instructions, orientation and/or training
- providing inadequate reference documents, directives and guidance publications
- inadequate identification and evaluation of loss exposures
- lack of supervisory/management job knowledge
- inadequate matching of individual qualifications and job/task requirements
- inadequate performance measurement and evaluation
- inadequate or incorrect performance feedback

Inadequate Tools and Equipment
- Inadequate assessment of needs and risks
- Inadequate human factors/ergonomics considerations
- Inadequate standards or specifications
- Inadequate availability
- Inadequate adjustment/repair/maintenance
- Inadequate salvage and reclamation
- Inadequate removal and replacement of unsuitable items

Inadequate Work Standards
- Inadequate development of standards
- ...inventory and evaluation of exposures and needs
- ...coordination with process design
- ...employee involvement
- ...Inconsistent standards/procedures/rules
- Inadequate communication of standards
- ...publication
- ...distribution
- ...translation to appropriate languages
- ...reinforcing with signs, color codes and Job aids
- Inadequate maintenance of standards
- ...tracking of work flow
- ...updating
- ...monitoring use of standards/procedures/rules

Inadequate Engineering
- inadequate assessment of loss exposures
- inadequate consideration of human factors/ergonomics
- inadequate standards, specifications and/or design criteria
- inadequate monitoring of construction
- inadequate assessment of operational readiness
- inadequate monitoring of initial operation
- inadequate evaluation of changes

Inadequate Purchasing
- inadequate specifications on requisitions
- inadequate research on materials/equipment
- inadequate specifications to vendors
- inadequate stocks or routs of shipment
- inadequate receiving inspection and acceptance
- inadequate communication of safety and health data
- improper handling of materials
- improper storage of materials
- improper transporting of materials
- inadequate identification of hazardous items
- improper salvage and/or waste disposal

Wear and Tear
- inadequate planning of use
- improper extension of service life
- inadequate inspection and/or monitoring
- inadequate control of use
- inadequate maintenance
- use by unqualified or untrained people
- use for wrong purpose

Inadequate Maintenance
- ...inadequate preventive
- ...assessment of needs
- ...lubrication and servicing
- ...inspection and test
- ...cleaning or resurfacing
- inadequate repairsrive
- ...communication of needs
- ...scheduling of work
- ...examination of units
- ...part substitution

Abuse or Misuse
- condoned by supervision
- ...intentional
- ...unintentional
- not condoned by supervision
- ...intentional
- ...unintentional

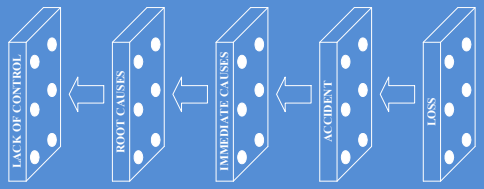
Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

32

Incident Investigation

- Ask "Why?" again to identify points where control was lost (inadequate programs, inadequate standards, and/or inadequate compliance to them).



Bird Jr., Frank E. and Germain, George L. *Practical Loss Control Leadership*. Loganville, Georgia: International Loss Control Institute, Inc., 1992. Print.

Incident Investigation

33

Lack of Control – Management System Failures Inadequate Programs, Inadequate Standards, and/or Inadequate Compliance to Them

- Leadership and Administration
- Management Training
- Planned Inspections
- Task analysis and procedures
- Incident Investigation
- Job Hazard Analysis
- Emergency Preparedness
- Personal Protective Equipment
- Health Controls
- Program Evaluations
- Hazard ID and Controls
- Employee engagement
- Employee Training

Incident Investigation

34

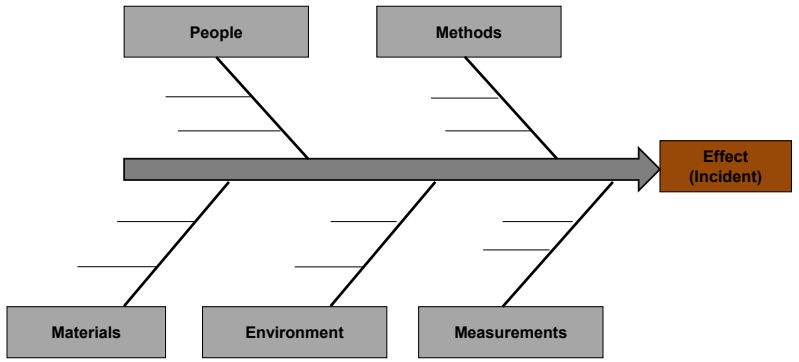
Fishbone Diagram (aka Ishikawa Diagram)

- Allows for brainstorming
- Categorizes many potential causes into orderly groups

Incident Investigation

35

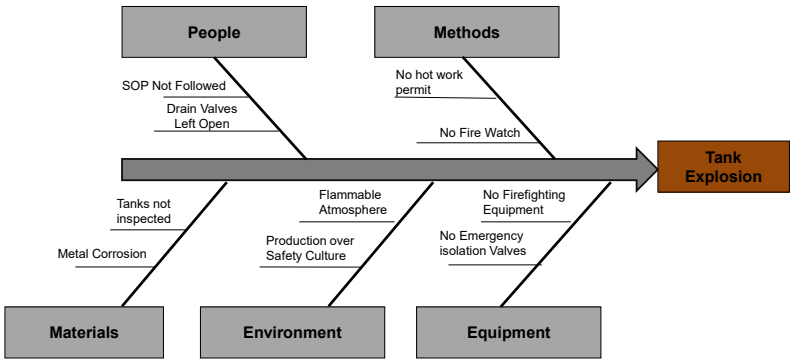
Fishbone Diagram (aka Ishikawa Diagram)



Incident Investigation

36

Fishbone Diagram (aka Ishikawa Diagram)



Incident Investigation

37

The 5 Whys

Incident Investigation

38

Cause Mapping

A Cause Map provides a simple visual explanation of all the causes that were required to produce the incident. The root is the system of causes that reveals all of the different options for solutions.

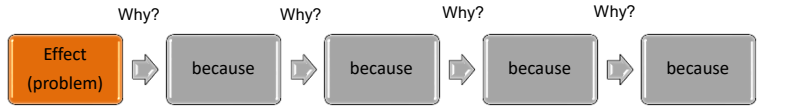
There are three basic steps to the Cause Mapping method:

1. Define the issue by its impact to overall goals
2. Analyze the causes in a visual map
3. Prevent or mitigate any negative impact to the goals by selecting the most effective solutions.

Incident Investigation

39

Cause Mapping



Incident Investigation

40

Case Study – Cause Mapping

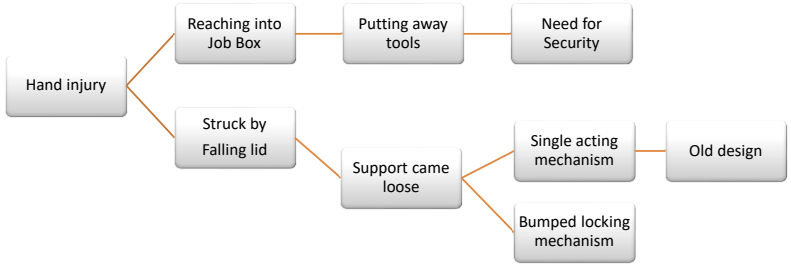
While placing material into a storage box, an employee inadvertently struck the storage box lid's locking mechanism which caused the lid to close. The lid fell and struck the employee on the hand causing a laceration.

Incident Investigation

41

41

Cause Map



Incident Investigation

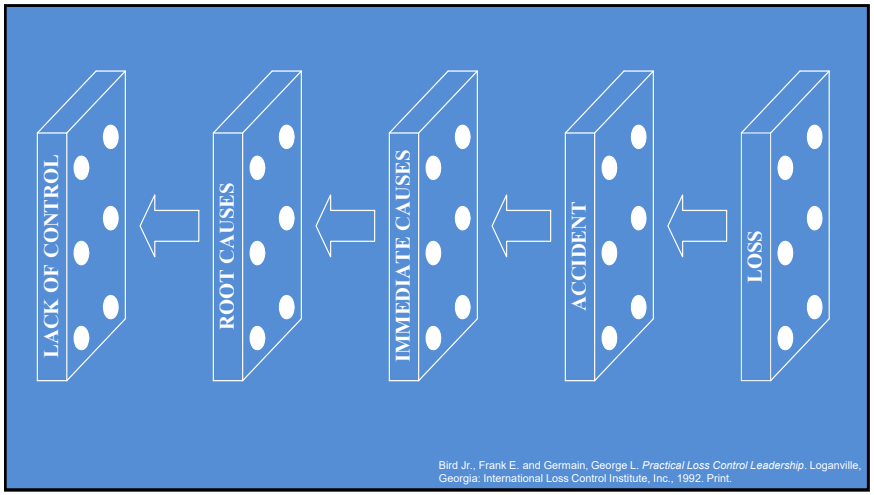
42

Complex Cause Mapping – the Titanic

Watch video: Cause Mapping – the Titanic

Incident Investigation

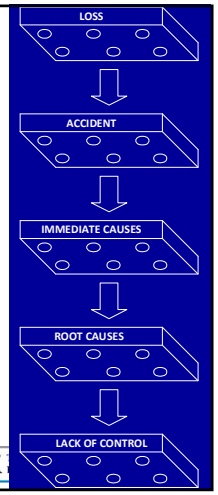
43



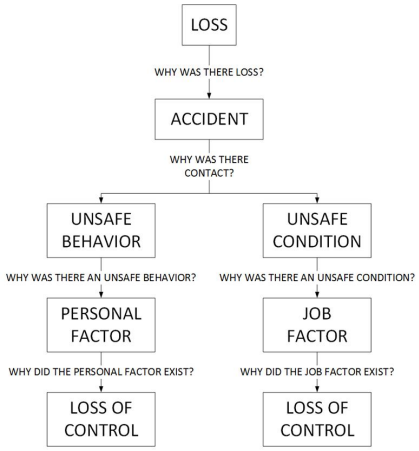
44

SCAT Charts

- Vertical version of the ILCI (Bird & Germain) model



45



46

SCAT Chart

47

What was the cause in the trim press accident?

- Employee was trimming a part in a press. He had already trimmed hundreds of parts that day. He pulled back the pull bars with his wrists on the handles. When the press closed, the tip of his right index finger was caught between the guide pin and bushing resulting in an amputation to the tip of the finger.

Incident Investigation

48

Fingertip amputation

Incident Investigation

49

Fingertip amputation

WHY?

Incident Investigation

50

Fingertip amputation

WHY?

Caught finger between guide pin and bushing

Incident Investigation

51

Fingertip amputation

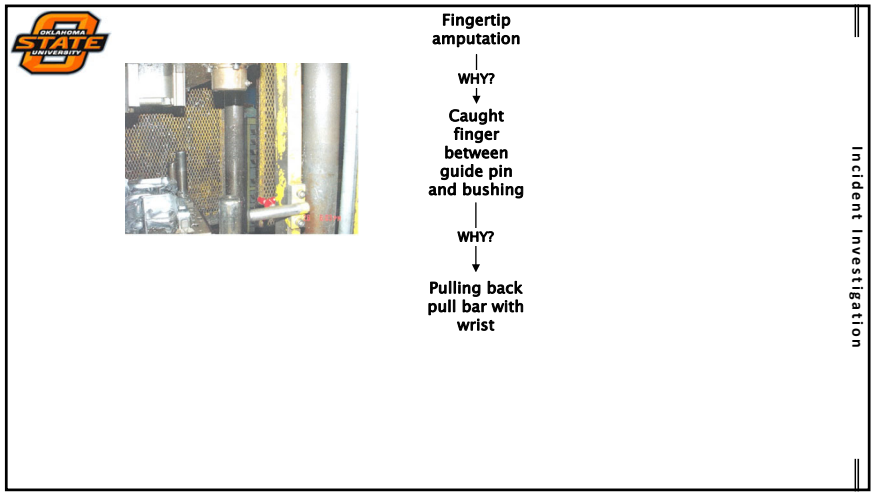
WHY?

Caught finger between guide pin and bushing

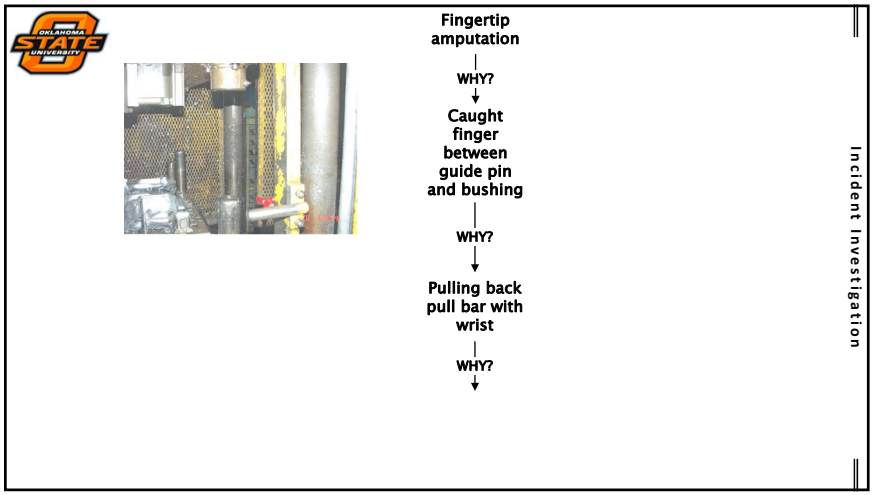
WHY?

Incident Investigation

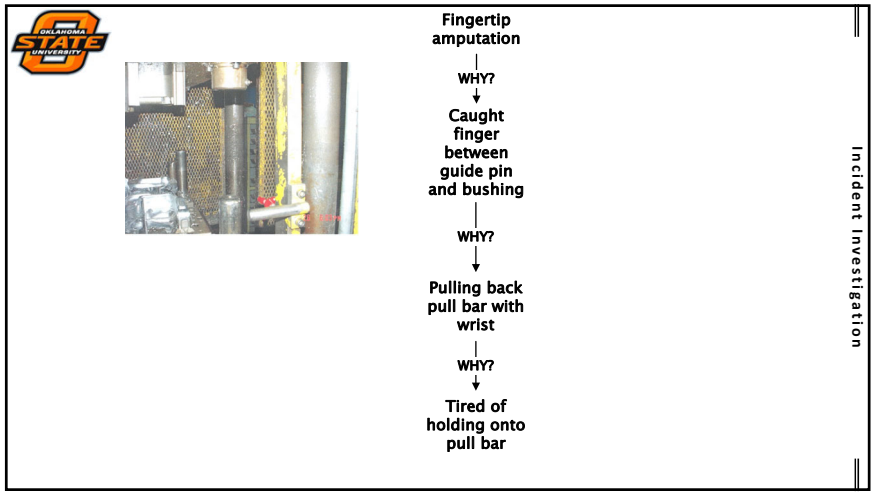
52


Fingertip amputation
WHY?
Caught finger between guide pin and bushing
WHY?
Pulling back pull bar with wrist
Incident Investigation

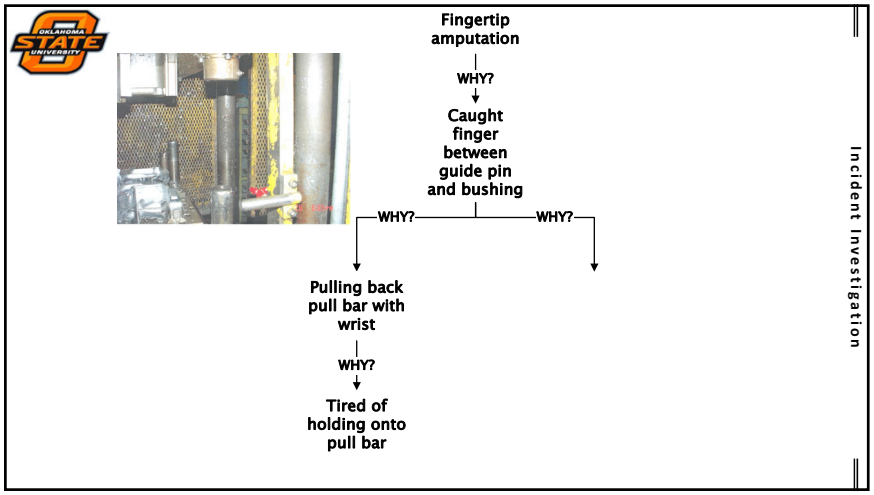
53


Fingertip amputation
WHY?
Caught finger between guide pin and bushing
WHY?
Pulling back pull bar with wrist
WHY?
Incident Investigation

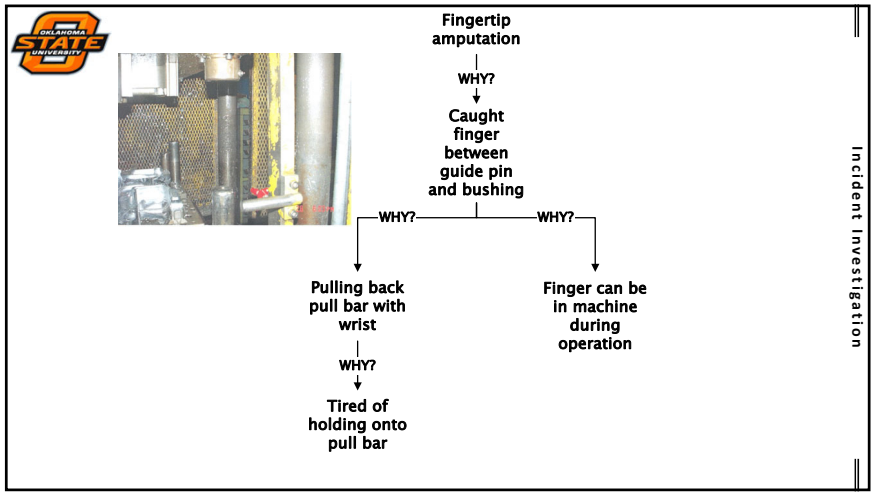
54


Fingertip amputation
WHY?
Caught finger between guide pin and bushing
WHY?
Pulling back pull bar with wrist
WHY?
Tired of holding onto pull bar
Incident Investigation

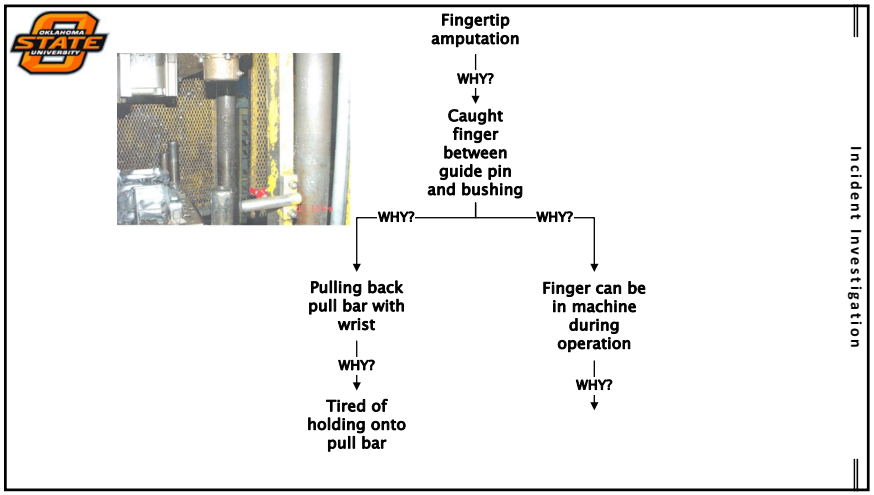
55


Fingertip amputation
WHY?
Caught finger between guide pin and bushing
WHY?
WHY?
Pulling back pull bar with wrist
WHY?
Tired of holding onto pull bar
Incident Investigation

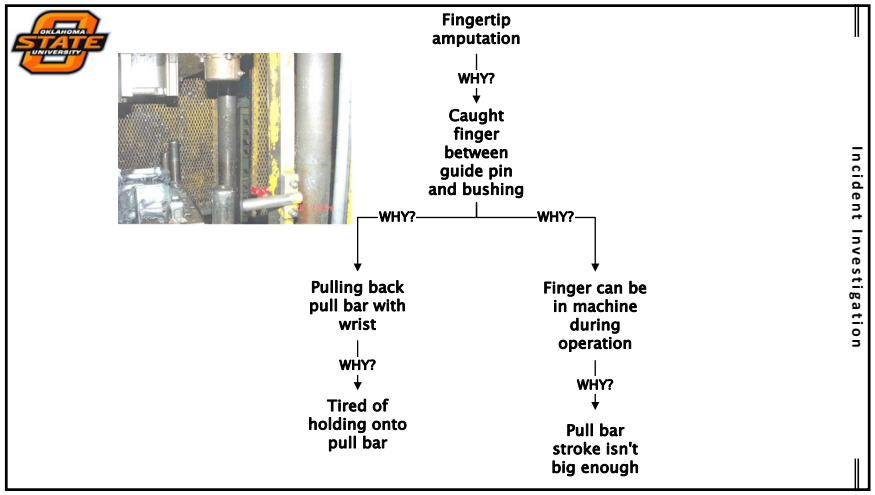
56



57



58



59

Ask "Why?" until points of control loss are factually identified

60

The Incident Investigation System

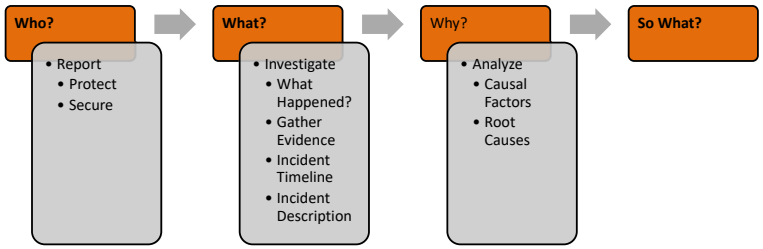
Levels of Investigation

Level of Incident	Severity	Type of Investigation
Minor	First Aid Injury, Minor property damage less than $1000.	1-2 person team, usually supervisor.
Major	Medical treatment Injury, major damage, process upset, $1K>$10K loss.	2-4 person team, may need to use analytical techniques and subject matter experts.
Severe	Lost Workday Injury, Severe property damage or process upset, $10K>$100K loss.	2-4 person team, use analytical techniques, subject matter experts,
Catastrophic	Fatality, Hospitalization, total loss of facility or process, greater than $100K property damage or loss.	Full team. May need 3rd party expertise. May involve regulatory intervention. Use multiple analytical techniques and subject matter experts. Legal protection may be necessary.
Near Miss	No actual injury, damage, or loss. But strong potential for loss.	Variable depending on potential severity of event. See incident levels above.

61

The Incident Investigation Process

Phases of Incident Investigation



62

FPST 3013 – SAFETY MANAGEMENT
THE INCIDENT INVESTIGATION PROCESS

Lecture 7

Accident Causation Models and Root Cause Analysis

63