CE 400 / CE 500

Process Safety Management

Lecture 39

Human Factors
Incident Investigations

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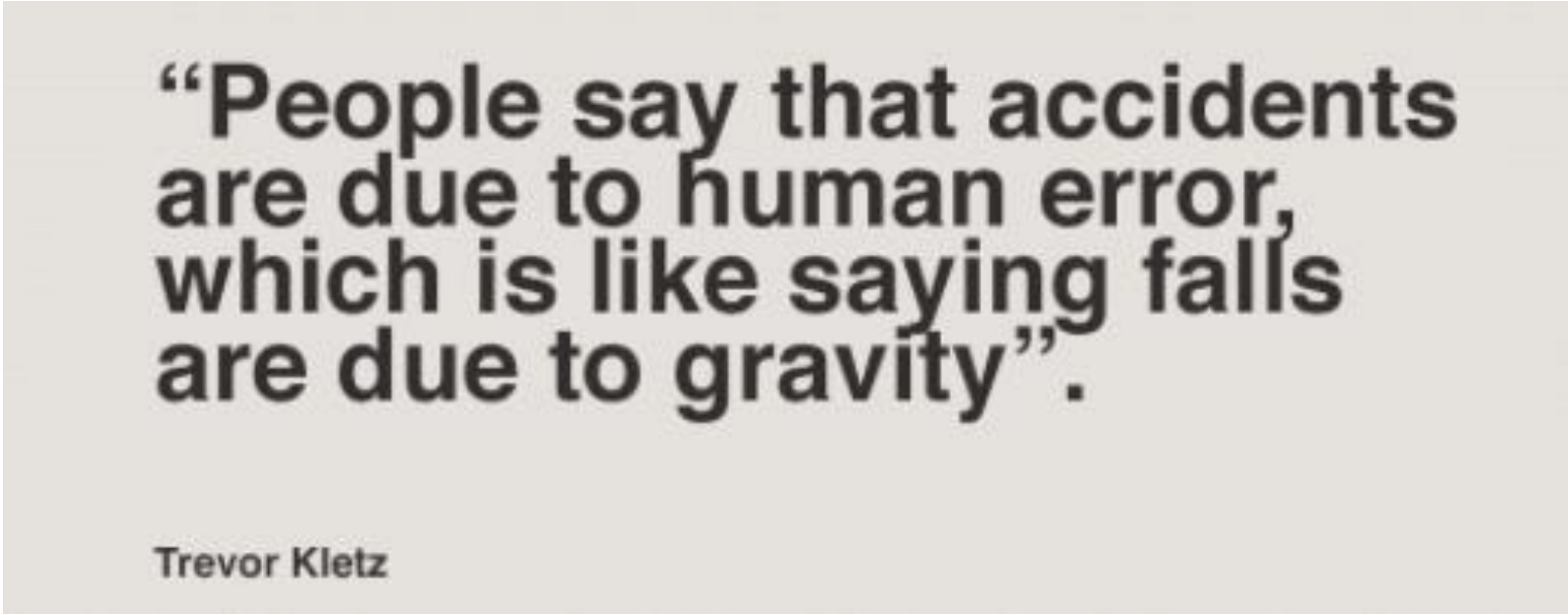
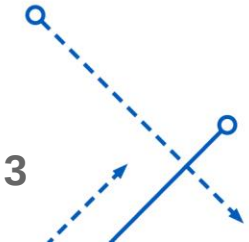
Human Factors



- This is a recognition that humans will inevitably make errors
- Which means that we must design our processes to:
  - Minimize the probability of errors
  - Be robust against likely errors

Classic Examples of Human Factors Traps

- Similar equipment lay out on various process units leads operators to perform task on the wrong unit
- Equipment designed against normal expectations
  - Valve closes in different position from all other valves on site
- Ambiguous labeling
- Overly complicated procedures
- Not having enough personnel
  - People with too many tasks at hand are more likely to error
- Fatique



Formosa Plastics Video

- https://www.csb.gov/videos/explosion-at-formosa-plastics-illinois/

Process Hazard Analysis Human Factors Checklist

Facility: _____ Date: _____

Team Members: _____

Item	Question	Answer (Y, N, N/A)	Justification	Recommendations
HOUSEKEEPING AND GENERAL WORK ENVIRONMENT				
1.	Are working areas generally clean?			
2.	Is normal and emergency lighting sufficient for all area operations?			
3.	Is there adequate backup power for emergency lighting?			
4.	Are provisions in place to limit the time a worker spends in an extremely hot or cold area?			
5.	Are employees protected from excessive noise (e.g., the noise does not affect mental workload and cognitive ability as opposed to physical harm – "It is so loud I cannot concentrate")?			
6.	Are alarms audible above background noise both inside the control room and in the process area?			
7.	Are adequate signs posted near maintenance, cleanup, or staging areas to warn workers of special or unique hazards associated with the areas?			
ACCESSIBILITY / AVAILABILITY OF CONTROLS AND EQUIPMENT				
8.	Are all controls accessible?			
9.	Is communications equipment adequate, easily accessible, and functional?			
10.	Is emergency equipment accessible without presenting further hazards to personnel?			
11.	Are adequate supplies of protective gear readily available and in good working condition for routine and emergency use?			
12.	Would others quickly know if a worker is incapacitated in a process area?			

Human Factors

Item	Question	Answer (Y, N, N/A)	Justification	Recommendations
13.	Is the workplace arranged so that workers can maintain a good working posture while performing necessary movements to conduct routine tasks?			
14.	Can operators/maintenance workers safely perform all required routine/ emergency actions, considering the physical arrangement of equipment (e.g., access to equipment, or proximity of tasks to rotating equipment, hot surfaces, and hazardous discharge points)?			
15.	Are valves that require urgent manual adjustments (e.g., emergency shutdown) easily identifiable and readily accessible?			
16.	Are the right tools (including special tools) available and used when needed?			
LABELING				
17.	Has responsibility for maintaining and updating labels been assigned?			
18.	Does the labeling program include components (e.g., small valves) that are mentioned in the procedures even if they are not assigned an equipment number?			
19.	Are all important equipment (vessels, pipes, valves, instruments, controls, etc.) legibly, accurately, and unambiguously labeled?			
20.	Are remote startup/shutdown switches clearly labeled and protected from inadvertent operation?			
21.	Are emergency exit and response signs (including wind socks) adequately visible and easily understood?			
22.	Are signs that warn workers of hazardous materials or conditions adequately visible and easily understood?			
FEEDBACK / DISPLAYS / CONTROLS				
23.	Are the displays adequately visible from all relevant working positions?			
24.	Do separate displays present similar information in a consistent manner?			

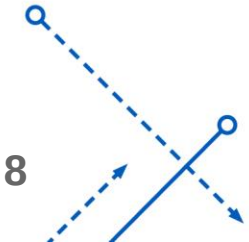
Human Factors

Item	Question	Answer (Y, N, N/A)	Justification	Recommendations
25.	Do the displays give adequate feedback for all operational actions?			
26.	Does the computer check that values entered by operators are within a valid range?			
27.	Is adequate information about normal and upset process conditions clearly displayed in the control room?			
28.	Are the alarms displayed by priority?			
29.	Is an alarm summary permanently on display?			
30.	Are critical safety alarms easily distinguishable from control alarms?			
31.	Are nuisance alarms corrected and redundant alarms eliminated as soon as practical to help prevent complacency toward alarms?			
32.	Are automatic safety features provided when a process upset requires rapid response?			
33.	Are automatic safety features provided when a process upset may be difficult to diagnose due to complicated processing of various information?			
34.	Is the layout of the consoles logical, consistent, and effective?			
35.	Are the controls distinguishable, accessible, and easy to use?			
36.	Do all controls meet standard expectations (color, direction of movement, etc.)?			
37.	Do the control panel layouts reflect the functional aspects of the process or equipment?			
38.	Does the control arrangement logically follow the normal sequence of operation?			
39.	Can operators safely intervene in computer-controlled processes?			
40.	Can process variables be adequately controlled with the existing equipment?			
41.	Do operators believe that the control logic and interlocks are adequate?			
42.	Does a dedicated emergency shutdown panel exist? If so, is it in an appropriate location?			
43.	Are instruments, displays, and controls promptly repaired after a malfunction?			

Why Investigate Incidents?

- It was close, but it didn't lead to really bad consequences…
- The safeguards all worked and nothing bad happened…

- All that means is that all of the necessary elements did not align to lead to a final consequence of injury or death
- This is a learning opportunity
  - We've seen a way for the basic design to fail
  - We can learn new ways to prevent that or to prevent it from progressing to horrible consequences



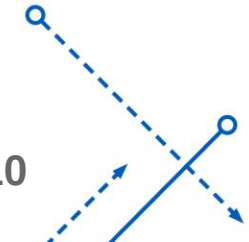
Investigation Basics

- Investigation is done by a team
  - Trained facilitator
  - Operators/Mechanics directly involved in the events
  - Technical staff, especially those who were present
  - Operations and Maintenance representatives
  - Outside experts, if appropriate
    - Usually occurs for larger incidents
- Collect basic information
  - What occurred?
  - Detailed Timeline of events leading up to, during, and immediately after the event

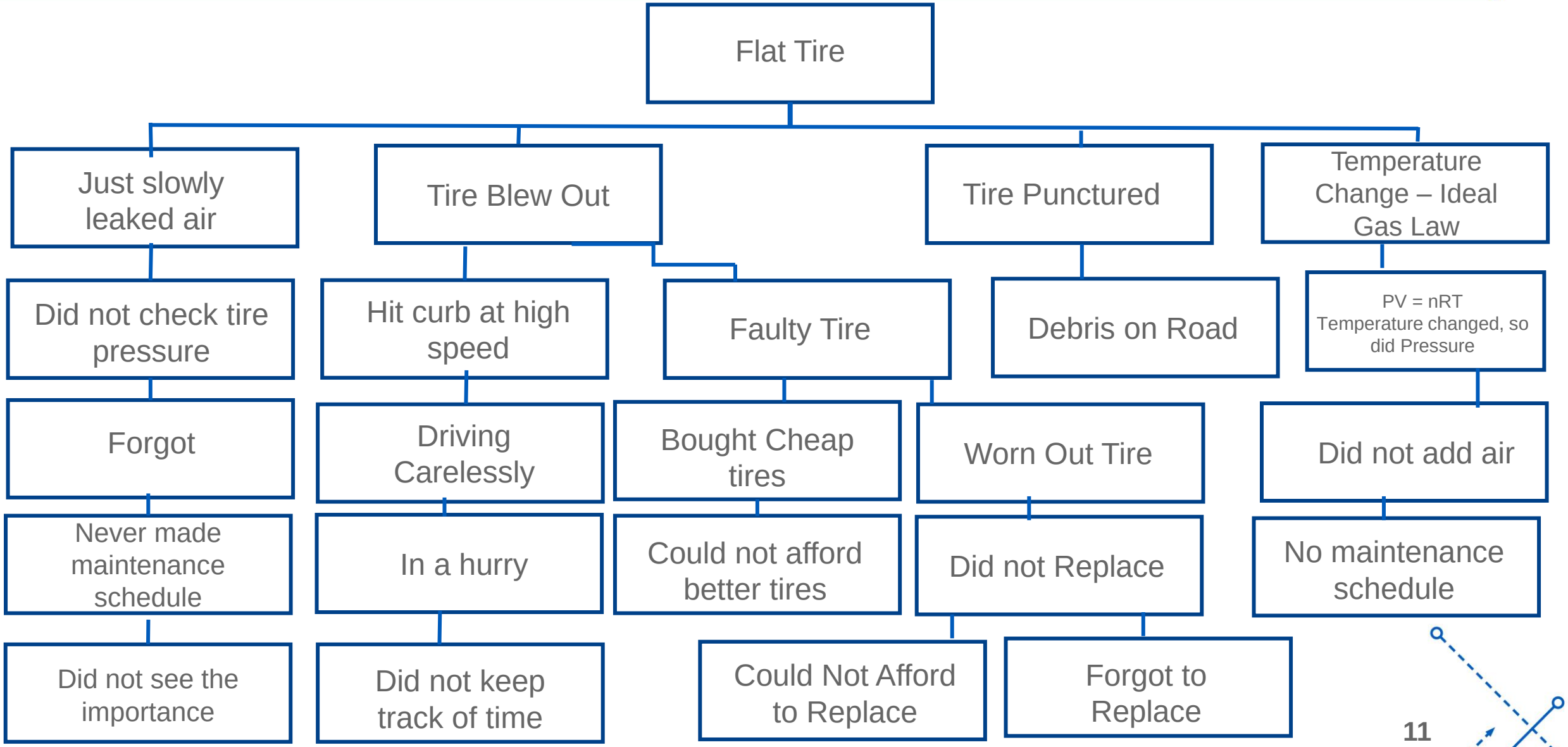
One Investigation Method

5Y

- Construct a fault tree
- Top event is the “Incident”
- List all possible causes for that to occur
  - It does not matter that a given cause did not occur, list it anyway
  - It will be marked off later
- Drive down until you have asked “Why” five times for each cause
- Meaning, you ask “why” would each possible cause occur
  - List all possible precursors for each of the initial causes
- Then ask “why” each of those would occur
- Continue until you have gone down five layers
  - Sometimes you simply run out of causes, sometimes you may see another layer. That’s OK



Incident Investigations



Investigation Outcome

- So now you understand why the incident occurred – what are you going to do to prevent its recurrence?
- It depends….
- What happened?
  - Was it equipment malfunction?
    - Was equipment not maintained?
      - Changes to maintenance schedule
      - Better tracking of compliance to schedule
    - Was equipment design not sufficient to the task?
      - Change to design
      - Change to materials of construction
    - Did it see conditions other than expected?
      - Steps to prevent process from exceeding design conditions
      - Change to design
      - Change to materials of construction

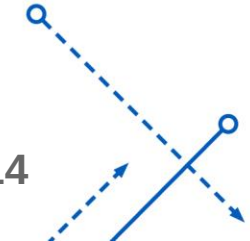
Investigation Outcome

- So now you understand why the incident occurred – what are you going to do to prevent its recurrence?
- It depends….
- What happened?
  - Were operating procedures not followed?
    - Are procedures difficult to understand or to carry out?
      - Update training
      - Simplify procedures
        - May require design changes to process…
    - Was it willful?
        - Communicate expectations of compliance to operating procedures
        - Disciplinary action
  - Were operating procedures insufficient?
  - Did you receive an incorrect raw material?

Investigation Outcome

- So now you understand why the incident occurred – what are you going to do to prevent its recurrence?
- It depends….
- What happened?
  - Were operating procedures insufficient?
    - Rewrite procedures so that the steps outlined will prevent this occurance
  - Did you receive an incorrect raw material?
    - Review your materials receiving procedures for necessary upgrades
    - Training to operators so that they also check for proper raw materials

Note: Any changes that are made will need to be undertaken via the Management of Change system!



Anticipate Other Issues

- If your investigation and recommendations were done well then this incident should not recur
- Don’t stop with the learnings there…
  - Think about if the vulnerabilities uncovered by this incident apply to other areas in your process or your plant (or your corporation…)
  - If they may, then consider extending the recommendations to other applicable areas of your organization

Investigation Report

- The final report needs to be made available to your entire organization
- Individuals not directly involved can then benefit from the learnings
  - Opportunity for others to adopt the recommendations/upgrades discovered by the investigation