Concepts of Hazard Avoidance

Hazard avoidance overview
- Dealing with chance
- Four strategies
  - Enforcement
  - Psychological
  - Engineering
  - Analytical

Enforcement approach
- Simple, direct
- Absolutes
- Judgment
- Corruption
- Alienation

Psychological approach
- Persuasion
- Top management support
- Young workers
- Training

Engineering approach
- 3 lines of defense
  - Engineering controls
  - Admin or work practice controls
  - Personal protective equipment

Engineering principles of safe design
- Eliminate
- Substitute
- Erect barriers
- Guard
- Control
- Warn
More engineering principles

- Consider the human interface
  - w/process
  - w/materials
  - Install filters
  - Ventilate
    - exhaust
    - dilute

Safety factors

- 4:1 scaffold hardware
- 5:1 overhead crane hoists
- 6:1 scaffold ropes

Fail-safe principles

- General Fail-Safe Principle
  - active mode
  - inert mode
  - “zero mechanical state”
  - deadman controls
- Fail-safe principle of redundancy
- Principle of worst Case
  - Murphy’s Law

Drawbacks to engineering approach

- Exception conditions
- Workers defeat guards
- False sense of security
- Cause other hazards

Summary

- Enforcement approach
- Psychological approach
- Engineering approach
- Next session: Analytical approach

Analytical approach
Hazard control approaches

- Enforcement
- Psychological
- Engineering
- Analytical

Analytical approach

- The analytical approach deals with hazards by studying their mechanisms, analyzing statistical histories, computing probabilities of accidents, conducting epidemiological and toxicological studies, and weighing costs and benefits of hazards elimination.

What is the purpose of hazard analysis?

- Identify hazards
- Determine causes
- Determine possible effects
- Prevention

More structured hazard analyses

- Accident analysis
  "a posteriori"
- FMEA
  "a priori"
- Fault-tree

Preliminary Hazard Analysis

- Identify system, machine, operation under analysis
- Identify (in a table)
  - possible hazards
  - their causes
  - their effects
  - likelihood of occurrence
  - control strategies
  - who is responsible
- Sign off occurs for individual hazards only when adequate controls are in place

Class Exercise

- A company wants to purchase a new hydraulic press. Conduct a preliminary hazard analysis.
Failure Modes and Effects Analysis (FMEA)

- **FMEA** is an inductive technique. It is used to determine how long a piece of complex equipment will operate satisfactorily and what the effects of any failure of individual component might be.
- Tool to evaluate potential failures and their causes
- Used to prioritize potential failures according to their risk, pointing to actions to eliminate or reduce the likelihood of occurrence
- Provides a methodology to document the analysis for future use and for continuous process improvement.

FMEA terms

- **Criticality:** The mathematical product of the Severity and Occurrence ratings. Number is used to place priority on items that require additional quality planning. Relative ranking.
- **Risk priority number:** severity X occurrence X detection. Relative ranking.
- **Failure Mode:** It is the mechanism by which a cause leads to an effect.
  - A potential Failure Mode describes the way in which a product or process could fail to perform its desired function as described by the needs, wants, and expectations of the internal and external Customers.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Occurrence</th>
<th>Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - Hazardous effect</td>
<td>10 - Almost Certain (&gt;1 in 2)</td>
<td>10 - Almost impossible to determine to detect</td>
</tr>
<tr>
<td>9 - Serious Effect</td>
<td>9 - Very high (1 in 3)</td>
<td>9 - Remote (1 in 10)</td>
</tr>
<tr>
<td>8 - Extreme Effect</td>
<td>8 - High (1 in 8)</td>
<td>8 - Very High</td>
</tr>
<tr>
<td>7 - Major Effect</td>
<td>7 - Moderately High (1 in 20)</td>
<td>7 - Slight</td>
</tr>
<tr>
<td>6 - Significant Effect</td>
<td>6 - Medium (1 in 100)</td>
<td>6 - Low</td>
</tr>
<tr>
<td>5 - Moderate Effect</td>
<td>5 - Low (1 in 1000)</td>
<td>5 - Very Low</td>
</tr>
<tr>
<td>4 - Minor Effect</td>
<td>4 - Slight (1 in 10000)</td>
<td>4 - Very Slight</td>
</tr>
<tr>
<td>3 - Slight Effect</td>
<td>3 - Very Slight (1 in 150,000)</td>
<td>3 - High</td>
</tr>
<tr>
<td>2 - Very Slight Effect</td>
<td>2 - Remote (1 in 150,000)</td>
<td>2 - Medium</td>
</tr>
<tr>
<td>1 - No Effect</td>
<td>1 - Almost Never (&lt;1 in 1,500,000)</td>
<td>1 - Almost Certain</td>
</tr>
</tbody>
</table>

FMEA traditional steps

- Identify subject of FMEA
- Assemble team
- Flow chart or system map
- Identify potential failures in processes (failure modes);
- Identify the possible effects of those failure modes;
- Identify the causes of the failure modes
- Identify the criticality or Risk Priority Number of each failure mode cause

**FMEA traditional steps continues**

- Prioritize on their criticality/RPN;
- Redesign the process to prevent the failure mode and/or put in place process controls to detect the failure mode before the effect occurs;
- Implement and test the new design or control process

HFMEA Example

Step 3B. Consecutively number each process step.

1. Medication ordered
2. Administered
3. Electronic transfer to pharmacy
4. Pharmacy fills script
5. Nurse administers
HFMEA Example

Step 3C. If the process is complex, choose an area to focus on.

- Process Step
- Process Step
- Process Step
- Process Step

HFMEA Example

Step 3D. Identify all sub-processes under each block. Consecutively letter these sub-steps.

1. Medication ordered
2. Auto electronic transfer to Pharmacy package
3. Pharmacy fills script; sends to floor
4. Nurse administers

Sub-processes:
A - Dummy terminal
B - PC’s

Sub-processes:
A - Check drug allergies
B - Check drug interactions
C - Check proper dosages
D - Orders Labs
E - order sent to auto dispensing

Sub-processes:
A - Automatically fills orders checked
B - Drugs pulled and script filled
C - Med cart filled
D - Cart sent to floor

Sub-processes:
A - Log on to laptop
B - Medcart
C - Medications scanned
D - Patient band scanned
E - Medication given to patient
F - Patient record updated

HFMEA Example


- Failure Modes:
  1. Laptop missing
  2. Network down
  3. No battery power
  4. CPRS not functioning
  5. Forget password
  6. Pharmacy sign down
  7. RF system not working
  8. Server off breakdown

- Failure Modes:
  1. Med cart not there
  2. Filled incorrectly
  3. Expired meds
  4. Wrong cart

- Failure Modes:
  1. Medication missing from cart
  2. Scan laptop missing
  3. No power for laptop
  4. Barcode label missing
  5. Barcode label not readable
  6. No power for scanner

- Failure Modes:
  1. Wrong ID
  2. Band missing
  3. Band not readable
  4. Patient not there

HFMEA Example


1. Log onto laptop
2. Get med cart
3. Scan meds
4. Give med
5. Update record

Failure Modes:
1. Patient wants to take med
2. Patient not there
3. Cannot update record
<table>
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<tbody>
<tr>
<td>Potential Failure Mode</td>
<td>4A1 – laptop unavailable</td>
</tr>
<tr>
<td>Potential Effect</td>
<td>Can’t match patient to medication</td>
</tr>
<tr>
<td>Potential Cause</td>
<td></td>
</tr>
<tr>
<td>Severity</td>
<td>7</td>
</tr>
<tr>
<td>Probability</td>
<td>4</td>
</tr>
<tr>
<td>Detectability</td>
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</tr>
<tr>
<td>Risk Priority Number</td>
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<tr>
<td>Description of Action</td>
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<tr>
<td>Outcome Measure</td>
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<td>Potential Failure Mode</td>
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<td>Potential Effect</td>
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**FMEA Importance**

- FMEA becomes important to the safety and health manager when the failure of a piece of equipment can result in an industrial injury or illness.
- FMEA can direct attention to critical components that should be set up on a preventive maintenance schedule that permits parts to be inspected and replaced before failure.
- FMEA is excellent for determining optimum points for improving and controlling product quality.

What if two failures have the same risk priority number, but the severity, occurrence, and detection scores are different? How do you prioritize? For example:
- S=8, o=5, d=1
- S=1, o=4, d=10
**FMEA Drawback**

- Because many component failures would have no effect on safety, that aspect of an FMEA does not involve accident possibilities.
- FMEA is limited to determination of all causes and effects, hazardous or not.
- FMEA does very little to analyze problems which could arise from operator errors, or hazardous characteristics of equipment created by bad design or adverse environments.

**Home Work**

- Conduct a FMEA analysis for ............
  Flow chart the major processes, then choose one component process on which to focus. Flow chart the steps in that component process. The create an FMEA worksheet and determine how to make the process safer.

**Fault tree analysis**

- AND
- OR
- Drawbacks
  - “maybe” situations
  - erroneous computations

**Loss-Incident Causation Models**

- Proximal causes
- Distal causes
- Point of irreversibility
- Aggravating factors
- Mitigating factors
- Diagramming

**Research**

- Toxicology
- Epidemiology

**Benefit-Cost Analysis**

- Expected cost: Cost of improvement
- Expected benefit: Reduction of hazard
  \[ \text{Expected benefit} = (\text{reduction in loss probability}) \times (\text{cost of loss}) \]
- Case Study 3.9
Hazard Classification Scale

- OSHA scale
- Scale of 1 to 10
- Risk Assessment Code (RAC)
- Standard Code of Practice for Safety of Machinery

1910.119(e)(2) (process safety management)

- The employer shall use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed.
  - What-If
  - Checklist
  - What-If/Checklist
  - Hazard and Operability Study (HAZOP)
  - Failure Mode and Effects Analysis (FMEA)
  - Fault Tree Analysis