Root Cause Analysis:
Mining for Answers/Delivering Prevention

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Objectives

▪ What is Root Cause Analysis (RCA)
▪ Why Use It
▪ What Drivers Influence Doing RCA
▪ What is the Objective
▪ Understanding Cause vs Correlation
▪ Methods
▪ Resources
▪ Delivering Prevention
What is Root Cause Analysis (RCA)

- RCA is a process used to uncover various contributing factors that led to an incident or non-conformance that resulted in a fatality or serious injury/illness (not appropriate for near miss events).
- A RCA considers the contribution of individual elements that additively (or multiplicatively) result in an undesired outcome and includes the influence of factors such as:
  - Leadership/supervision
  - Communication
  - Training
  - Distraction
  - Experience
  - Fatigue
  - Proper tools
  - Design
Why Use Root Cause Analysis
Why Use Root Cause Analysis

- A typical ore body has a copper content of 0.1% to 1.5+%-mining and processing transform that to 99+% pure copper by continuously removing the unwanted “overburden” of less desirable material (or focuses on the desirable material).

- An effective RCA considers the relevant details relating to causes, and concentrates and refines the information to arrive at the root causes. Any flaw or error may have relevance—the objective is to focus on the relevant factors, that if corrected or eliminated, would have prevented the incident from happening.

- Root causes become the focus of actions and measures taken to prevent repetition and/or minimize the severity of an incident.
Why Use Root Cause Analysis

Lagging indicators have failed to be reliable predictors of outcome

Heinrich’s Pyramid

The Arizona Mining Association (AMA) member companies are committed to an injury free workplace. The AMA insists upon health and safety of employees as a common value for member companies.

The AMA recognizes member companies may have differing safety programs in place at the respective operations. However, the goal of each of these programs is the same: Protect and enhance the health and safety of all employees.
Drivers: Why You Should Care

Injuries per 200,000 hours worked

2005: 3.92
2006: 3.64
2007: 3.43
2008: 3.25
2009: 3.01
2010: 2.81
2011: 2.75
2012: 2.56
2013: 2.49
2014: 2.46
2015: 2.29

Drivers: Why You Should Care

Fatalities in Metal/Non-Metal U.S. Mines, 1965-2015

Drivers: Why You Should Care

Aside from trade association or organizational commitments and reductions over time, other compelling reasons exist to prevent injury/illness in the work place:

- Governance (Board/Stockholders)
- Regulatory Attention
- TRIR
- Reputation
- Productivity
- Community Relations
- Sustainability
- ExMod
- Retention
- Corporate Culture

Injury & Illness

Human Consequences

Costs
Decision Time: What is the objective?

To effectively prevent injury and illness, the objective needs to be clear and unambiguous. The choices are to:

Determine the cause(s) and influencing factor(s) to be corrected or eliminated with the outcome of ultimately preventing or substantially reducing severity

OR

Assign blame/fault, not proactively recognizing and correcting the problem(s)—with the certainty that the incident will reoccur?
Correlation vs Cause

Don’t forget or misunderstand the objective—**Causation**

- Causation is an occurrence or action that can cause another occurrence/action
- With Causation, the results are predictable and certain
Methods

A number of methods have been developed, or adapted to conduct a RCA:

- Fishbone Analysis (Ishikawa Root Cause Analysis)
- Fault Tree Analysis
- Failure Modes and Effect Analysis
- Storytelling
- Pareto Analysis
- Why-Why Chart/The Five Whys
- Bowtie
- RealityCharting®

- No silver bullet, no perfect method. All require effort and time; all require follow-up; all require the commitment to proactively prevent injury and illness from occurring.
- Best results may come from combining methods and techniques.
- Every incident is unique and is the result of multiple contributory factors.
Method—Fishbone (Ishikawa RCA)

- Well known
- Useful when the results are needed quickly
- Works well with a large group of participants
- The question involves a single, well defined problem which is defined at the “head” of the fish
- Requires good upfront preparation and can involve utilization of the FMEA, HazOps, or other process-relevant methods that identify vulnerabilities (and corresponding controls)
- Focus areas, which can be further sub-categorized, include:
  - Manpower
  - Methods
  - Machinery
  - Environment
Method–Fishbone

Cause-Effect (Fishbone) Diagram

- Tertiary
- Secondary
- Effect

Cause

- Tertiary
- Secondary
- Tertiary
- Effect

- Tertiary
- Secondary
- Tertiary
- Effect

- Tertiary
- Secondary
- Tertiary
- Effect

- Tertiary
- Secondary
- Tertiary
- Effect

- Tertiary
- Secondary
- Tertiary
- Effect

- Tertiary
- Secondary
- Tertiary
- Effect
Methods—Fishbone

Root Cause Analysis

- Method
  - None Standard Procedures
  - Two many approvals
  - Changing Controls
  - No review limit
- Measure
  - No clear goal
  - No ability to measure
- People
  - Lack of Skill
  - Lack of Cooperation
  - Requirement Misunderstood
  - No SME’s
- Material
  - Material Delay
  - Incorrect Source Material
  - No Source Material
- Environment
  - Unclear Requirements
  - Evolving Technology
- Machine
  - Software Not compliant
  - Frequent system failure
  - Update delay

Root Cause
Methods—Fault Tree Analysis

- First introduced by Bell Laboratories
- Is one of the most widely used methods in system reliability, maintainability and safety analysis
- It is a deductive procedure used to determine the various combinations of hardware and software failures and human errors that could cause undesired events (referred to as top events) at the system level
- Begins with a general conclusion, then attempts to determine the specific causes of the conclusion by constructing a logic diagram called a fault tree
- The basic symbols used in an FTA logic diagram are called logic gates and are similar to the symbols used by electronic circuit designers. Two kinds of gates are used: "and" and "or"
Methods—Fault Tree

Wheel fragment impacts operator's eye

AND

1

2

3

Abrasive wheel disintegrated

Grinder operating

Operator's eye exposed

1.1

1.2

1.2.1

1.2.2

Wheel struck by object

Stress limit exceeded

Wheel overspeed

Operator's eye not protected

Operator in front of wheel

1.2.1.1

1.2.1.2

Wrong part

Wrong part

Speed not correct

Removed for operator convenience

Inadequate design

Tool impressed at excessive angle

Held at wrong angle

Tool rest not set correctly
Methods—Failure Modes and Effective Analysis

- Similar to Fault Tree, but its primary application is in the design of engineered systems, not specifically RCA and does not capture human aspects.
- Identifies components and lists possible failures, then assigns the consequences (effects) of that failure.
- Can use a ranking of the failures to prioritize.
- Could be a subset or element of a RCA.
- Can be a proactive, preventive tool that avoids incidents from occurring due to design or component failure.
Methods—Failure Modes and Effective Analysis

- **Methods**
- **Failure Modes and Effective Analysis**

**Diagram Description**:
- Metalsaice to Production Control via Daily Order and 6-week Forecast.
- Market Forecast to Customer.
- Daily Order from Customer to Metalsaice.
- Stamping: Changeover EPE = 1 Shift, C/O < 10 min.
- Weld + ASSY: Take = 58.6 sec, Uptime = 100%, 2 Shifts, total work time = 165 sec.
- Shipping: Staging

**Time and System Lead Time**:
- System Lead Time = 4.5 days
- Processing Time = 166 sec

**Notes**:
- C/O = Changeover Time, EPE = every time every -
Methods—Storytelling

- Not RCA, but is the most common form of incident “investigation”
- Typically utilizes a pre-printed form (Incident Report) that may be internally created, or based on codes used by insurers for actuarial purposes
- Fails to identify and address causation
- Primary objective is to document events and selected details, but does not include analysis of the incident
- Action items/follow-up typically not part of the process
Methods—Incident Report Form

Incident Reporting Form

Use this form to report any workplace accident, injury, incident, close call or
Return completed form to the Operations Supervisor, or Management

This is documenting an:

☐ Lost Time/Injury  ☐ First Aid  ☐ Incident  ☐ Close Call

Details of person injured or involved (to be filled in by person injured / involved if

Person Completing Report: ______________________  Date: ________________
Person(s) Involved: __________________________
Equipment or Truck ID: _______________________

Event Details

Date of Event: ______________________  Location of Event: ________________
Time of Event: ______________________  Witnesses: ______________________

Description of Events (Describe tasks being performed and sequence of events):
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

D R I V E N  B Y  V A L U E
Methods—Pareto Analysis

- Uses a database of “events” to quantify pre-determined causal factors
- Accuracy is limited by the quality of the data used/chosen to reflect cause
- Based on the 80-20 Rule (80% of incidents are caused by 20% of the causes)
- It directs resources at the most common causes
- Trends frequency
- Driven by the premise that all causes and effects are part of the same continuum (if A happens, B will occur)—the causal connection is lost
- Can mask larger, more systemic issues (can’t see the forest for the trees)
Methods—Pareto Analysis

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Methods—the Five Whys

- Comes from Six Sigma (a quality management system) that utilizes Define, Measure, Analyze, Improve, Control
- Does not require statistical analysis
- Is not a rigid process, but involves asking “Why” until the question becomes irrelevant or unproductive—the process can end after 3 “Whys” if the answer results at that point
- Is the most basic type of RCA
- Define the cause and effect factors using another method, such as Bowtie or Fish bone, then begin asking why....
Methods— Why-Why Chart

- Involves asking “WHY” multiple times (typically 5 times) until there is no answer—the most basic form of RCA
- Does identify causal factors/relationships
- Defines linear relationships, which may not get to root causes, and is not beneficial for more complicated events
Methods—Bowtie ("barrier analysis")
Methods—Bowtie ("barrier analysis")

Events that trigger the incident

- IE₁
- IE₂
- IE₃

Potential future Preventative control

Mitigating strategies reducing the impact of the incident

Frequency

Consequences

Consequences that occur if the incident happens

All MS Fail

- Consequences of Worst Case Scenario

One or more MS succeed

- Consequences of Next Worst Case Scenario

Preventative controls reducing the frequency of the triggering events

Potential future Mitigative control
Method—RealityCharting®

Each effect has at least two causes in the form of actions and conditions
Cause and effect are the same thing

<table>
<thead>
<tr>
<th>Effects</th>
<th>Causes</th>
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<tbody>
<tr>
<td>Injury</td>
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<tr>
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<tr>
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Causes and effects are part of a continuum of causes (an effect becomes a cause)
An effect exists only when causes occur in the same space and time.
# Methods—Comparison (full disclosure)

<table>
<thead>
<tr>
<th>Method/Tool</th>
<th>Type</th>
<th>Defines Problem</th>
<th>Defines All Known Causes</th>
<th>Provides A Causal Path To Root Causes</th>
<th>Delineates Evidence</th>
<th>Explains How Solutions Prevent Recurrence</th>
<th>Easy To Follow Report</th>
<th>Score</th>
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Resources

Any combination of the following perspectives/disciplines to provide input and details of the incident and identify causative factors:

- Supervisor
- H&S
- Maintenance
- Worker
- Technical Expert
- Facilitator
Preparation

- Commit to RCA and get management support and involvement
- Decide on the method or combination of methods
- List elements and define them—list is not fixed or inflexible
- Identify resources and alternates
- Conduct training on the process—modify process as needed
- Have system to track recommendations to conclusion/implementation
Delivering Prevention

—RCA is not the End, it’s a continuum

Prevent repetition and/or minimize the severity of an incident.
Thank you