Accident Investigations:

Finding the Root Cause is **NOT** Enough

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The typical flow and scope of an accident investigation:

1. **Accident**
2. **Conduct a root cause analysis accident investigation**
3. **Determine root causes & management system failures**
4. **Develop appropriate corrective actions & management system modifications to reduce the risk of recurrence**
5. **Implement & monitor corrective actions**
LET’S USE THAT METHODOLOGY FOR THE FOLLOWING ACCIDENT:

At 9:15AM on a Monday morning a pipe in a pipe rack to Production Unit A began to leak chlorine. The Emergency Alarm was sounded and the system containing the leak was isolated.

The chlorine traveled offsite causing nearby neighbors to “shelter in place” for about 30 minutes.

The accident investigation began...
The investigation team agreed on five areas to investigate as potential causes.
They immediately ruled out “Sabotage” and “Act of God” because of a complete lack of evidence that either had occurred.
They analyzed for procedural contributions to the accident but found no evidence that supported procedural causes.

- Procedures did exist
- Procedures were followed
- Procedures were adequate—at least while operating and that is all that mattered since the accident occurred during normal operations, not start up or shutdown.
And, they looked into how the plant was being operated---but found no evidence of incorrect actions being taken or critical steps being skipped.

The cause must be “mechanical.”
The investigation team agreed on four types of mechanical failures to investigate as potential causes:

- Fatigue
- Corrosion
- Fracture
- Mechanical Wear

Discounted as not a cause:
- Act of God
- Sabotage
- Procedures
- Operation S
After examining the section of pipe that failed, the team immediately ruled out “Fatigue” and “Fracture” because of a complete lack of evidence that either had occurred.
The team did find some corrosion—both internally and externally. They rationalized that external corrosion was common in any chlorine leak because of the acidic atmosphere created when chlorine contacts moisture. They had no explanation for the internal corrosion, but both were minimal and could not have caused this breach in the pipe. Corrosion was noted but listed as not the cause of this accident.
And finally, the team concluded that physical evidence pointed to mechanical wear. Eventually they determined that the pipe was resting directly on support steel and that the wear plate was not positioned on the pipe where it should have been. Temperature fluctuations caused the pipe to move and, over time, simply wore a hole in the pipe.
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MECHANICAL

Fatigue
- No Evidence

Corrosion
- Yes, but not the cause of this accident

Fracture
- No Evidence

Mechanical Wear
- Yes

ACT OF GOD

SABOTAGE

PROCEDURES

OPERATION

Fatigue

Corrosion

Fracture

Mechanical Wear

Internal
- No Evidence

External
- Yes

Caused by pipe movement on support steel

Thermal Changes

Wear plate in wrong place

Construction Error

Inadequate PSSR

Let’s fix those management systems and get back on stream— NOW!
AND THEY DID...

The piping system was dried by purging with plant supplied dry air and then chlorine was reintroduced in to the system.

Production was restarted. Within 24 hours, a leak developed at an elbow and a chlorine cloud formed. Just as before, the Emergency Alarm was sounded and the system containing the leak was isolated. The chlorine traveled offsite causing nearby neighbors to “shelter in place” again for about 30 minutes.

WHAT WENT WRONG????
FOCUSING ONLY ON THE ROOT CAUSE

• They focused on only the pathways that supported finding the Root Cause of that particular accident.
• Because of this, they discounted all of the hints that something else might be wrong not related to that accident.
• They failed to recognize the importance of indicators of “Near-misses” for other accident scenarios.
IN OTHER WORDS...

• They addressed the issues related to the accident that they had but did not recognize that several other near-misses had also taken place.

• By not recognizing the near-misses, they did not put appropriate safety systems in place to prevent them from becoming an accident.

• One of the unidentified Near-misses caused the new accident.
WHAT DID THEY MISS?

• The new accident was the result of internal corrosion caused by moisture left in the system after “dry air” purging. The moisture accumulated in areas where the piping changed direction from horizontal to upward vertical. When chlorine was introduced in to the system corrosion started immediately. The first accident occurred before the corrosion breached the piping. The new startup added additional moisture to the system accelerating corrosion.
CHLORINE RELEASE

By focusing only on the potential root causes of this particular accident...

- Fatigue
  - No Evidence
  - Internal
    - No explanation but did not cause this accident. Possible result of accident.
  - External
    - No Options

- Corrosion
  - Yes
  - Internal
    - Caused after the leak started. Did not cause accident. Possible result of accident.
  - External
    - No Evidence

- Fracture
  - No Evidence
  - Internal
    - Caused after the leak started. Did not cause accident. Possible result of accident.
  - External
    - No Evidence

- Mechanical Wear
  - Yes
  - Internal
    - Caused by pipe movement on support steel
  - External
    - Wear plate in wrong place

- Thermal Changes
  - No Options

- Construction Error
  - Cause

- Inadequate PSSR
  - Cause

- SABOTAGE
- PROCEDURES
- OPERATION
- GOAL
...and ignoring data that was not supportive, near miss information was not recognized or considered important. In fact, this information was foretelling of the next accident that would occur!
ACCIDENT

DETERMINE ROOT CAUSES & MANAGEMENT SYSTEM FAILURES

DEVELOP APPROPRIATE CORRECTIVE ACTIONS & MANAGEMENT SYSTEM MODIFICATIONS TO REDUCE THE RISK OF RECURRENTNESS

IMPLEMENT & MONITOR CORRECTIVE ACTIONS

CONDUCT A ROOT CAUSE ANALYSIS ACCIDENT INVESTIGATION

WHAT SHOULD THEY DO TO SUPPLEMENT THE CONVENTIONAL ROOT CAUSE ANALYSIS PROCESS?
ACCIDENT

CONDUCT A ROOT CAUSE ANALYSIS ACCIDENT INVESTIGATION

CATALOGUE IDENTIFIED POTENTIAL ACCIDENT SCENARIOS THAT DID NOT LEAD TO THE ACCIDENT BEING INVESTIGATED—but could cause one with similar consequences

DETERMINE ROOT CAUSES & MANAGEMENT SYSTEM FAILURES

DEVELOP APPROPRIATE CORRECTIVE ACTIONS & MANAGEMENT SYSTEM MODIFICATIONS TO REDUCE THE RISK OF RECURRENCE

IMPLEMENT & MONITOR CORRECTIVE ACTIONS

EVALUATE EACH POTENTIAL SCENARIO FOR PROBABILITY OF OCCURRENCE

IF PROBABLE, THEN...

IF DEEMED IMPROBABLE RECORD DECISION
THANK YOU FOR YOUR ATTENTION

• QUESTIONS?