AN INHERENT SAFETY BASED INCIDENT INVESTIGATION METHODOLOGY

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OUTLINE

- Introduction
- Incident Investigation
- Inherent Safety
- Principles of Inherent Safety
- Incident Investigation Methodology
- Case Study: Westray Mine Explosion
- Concluding Remarks
INTRODUCTION

Scope: Development of a methodology or protocol
  – For incident investigation
  – Explicitly incorporating principles of inherent safety via guidewords and checklist

Motivation:
  – Inherent safety focus within research group
  – Also emphasis on use of case studies for validation
  – In case of Westray, due to its extreme nature, use of case study for methodology development
INCIDENT INVESTIGATION

- The process by which underlying (root) causes of an incident are uncovered and steps are taken to prevent recurrence.

- A well-recognized and vital part of Process Safety Management (PSM).

- Element 9 in CSChE PSM Guide (based on CCPS approach).
INHERENT SAFETY

- Inherent, Engineered, Procedural Safety
- Elimination, Minimization, Substitution, Moderation, Simplification
INCIDENT INVESTIGATION METHODOLOGY

- Combination of
  - Syncrude Canada protocol
  - CCPS guidelines
  - Bird and Germain domino loss causation model
  - Kletz’s layered model

- Stages
  - Preparation and initial response
  - Data gathering
  - Data analysis
  - Recommendation reporting, implementation and follow-up
INCIDENT INVESTIGATION METHODOLOGY

- Integrated approach to loss management
  - People
  - Property (assets)
  - Production (business interruption)
  - Environment

- Incorporation of inherent safety
  - Guidewords
  - Checklist
INCIDENT INVESTIGATION METHODOLOGY

1. Team Planning
2. Incident
3. Loss
4. Notification to Activate Team
5. On-Site Investigation
6. Identification of Immediate Causes
7. Identification of Basic Causes
8. Lack of Management Control Factors
9. Recommendations
10. Implement Recommendations
11. Follow-Up

Inherent Safety Guidewords
- People
- Property
- Production
- Environment

Inherent Safety Checklist
- Position
- People
- Parts
- Paper

Inherent Safety Guidewords
- Immediate/
  Technical
- Avoid Hazards
- Improve
  Management System
CASE STUDY: WESTRAY MINE EXPLOSION
Coal mining has been an integral part of Pictou County (Nova Scotia) history since the first commercial mine opened in Stellarton in 1807, to the closing of the Drummond mine in Westville in 1974. On September 11, 1991 Westray opened a new mine in Plymouth.

At 5:20 am on May 9, 1992 after only eight months of operation, an explosion ripped through the mine killing 26 men who were underground at the time.
INCIDENT

There was an explosion in the Westray mine on the morning of May 9, 1992.

- Fuel
- Oxidant
- Ignition Source

Fire Triangle

- Fuel
- Oxidant
- Ignition Source
Losses resulting from Westray explosion include:

- Deaths of 26 miners
- Destruction of mining equipment and the mine itself
- Bankruptcy of the parent company
- Default of millions of dollars in government loans
ON-SITE INVESTIGATION

The objectives of on-site activities are to gather information used for determining root causes. Position, People, Parts, Paper – IS Guidewords

- **Methane**: Methane layering provided a rich source of fuel for the explosion in the presence of an ignition source.

- **Coal Dust**: According to Richard (1997) coal dust at least ankle-deep accumulated on many of the underground roadways, making foot travel difficult.
ON-SITE INVESTIGATION

- **Non-Flameproof vehicles**: According to Richard (1997) there were instances in which workers, supervisors and management employed non-flameproof vehicles underground.

- **Fuel Storage**: Fuel for mining machinery was improperly stored underground (Richard, 1997).

- **Auxiliary Ventilation System**: Westray used auxiliary fans in the exhaust mode (Richard, 1997).
**IMMEDIATE CAUSES**

Immediate causes are divided into two broad categories:

- **Substandard Practices**

<table>
<thead>
<tr>
<th>Guideword/Checklist</th>
<th>Substandard Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize</td>
<td>- Poor housekeeping with respect to clean-up and removal of coal dust</td>
</tr>
<tr>
<td></td>
<td>- Storing fuel and re-fuelling vehicles in non-flame-proof areas underground</td>
</tr>
<tr>
<td>Substitute</td>
<td>- Improper use of ventilation system; e.g., re-routing without provision for miners</td>
</tr>
<tr>
<td>Moderate</td>
<td>- Inadequate rock dusting</td>
</tr>
<tr>
<td>Simplify</td>
<td>- Continuation of mining in spite of inoperable methane detection devices</td>
</tr>
</tbody>
</table>
# IMMEDIATE CAUSES

**Substandard Conditions**

<table>
<thead>
<tr>
<th>Guideword/Checklist</th>
<th>Substandard Condition</th>
</tr>
</thead>
</table>
| Minimize            | ▢ High methane concentrations  
                        ▢ Thick layers of coal dust on the mine floor, having an unacceptably high level of combustible matter |
| Substitute          | ▢ Inadequate ventilation design and capacity |
| Moderate            | ▢ High concentration of airborne coal dust |
| Simplify            | ▢ Inadequate system to warn of high methane concentration in the mine atmosphere |
Basic causes are divided into two broad categories:

**Personal Factors**

<table>
<thead>
<tr>
<th>Guideword/Checklist</th>
<th>Personal Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize</td>
<td>Physiological stress caused by methane overexposure and fatigue due to 12-hour shift</td>
</tr>
<tr>
<td>Substitute</td>
<td>Lack of mining experience of personnel working in the mine</td>
</tr>
<tr>
<td>Moderate</td>
<td>Lack of knowledge of safe underground work practices</td>
</tr>
<tr>
<td>Simplify</td>
<td>Improper motivation by which production proceeded at the expense of safety</td>
</tr>
<tr>
<td></td>
<td>Psychological stress caused by fear of reprisal for reporting safety concerns</td>
</tr>
</tbody>
</table>
## BASIC CAUSES

### Job Factors

<table>
<thead>
<tr>
<th>Guideword/Checklist</th>
<th>Job Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize</td>
<td>Inadequate follow-through on recommendations from mine inspectorate personnel</td>
</tr>
<tr>
<td>Substitute</td>
<td>Inadequate engineering during mine ventilation design and planning</td>
</tr>
<tr>
<td>Moderate</td>
<td>Lack of safe work practices and procedures</td>
</tr>
<tr>
<td></td>
<td>Inadequate purchasing and maintenance of rock dust inventory</td>
</tr>
<tr>
<td>Simplify</td>
<td>Inadequate leadership in terms of assignment of responsibility</td>
</tr>
</tbody>
</table>
Inadequate Program Elements:

(adopted from Amyotte and Oehmen, 2002)

- Management commitment and accountability to safety matters
- Incident investigation
- Training (orientation, task-related, etc.)
- Task definitions and safe work practices and procedures
- Workplace inspections and more detailed hazard identification methodologies
- Program evaluation and audit
LACK OF MANAGEMENT CONTROL FACTORS

Inadequate Program Standards:
(adopted from Amyotte and Oehmen, 2002)

- Management’s concern toward safety matters
- Follow-through on inspections for substandard practices and conditions
- Action on hazard reports submitted by employees
- Job instructions for employees
- Equipment maintenance
- Scheduling of management/employee meetings to discuss safety concerns
LACK OF MANAGEMENT CONTROL FACTORS

Inadequate Compliance with Standards:
(adopted from Amyotte and Oehmen, 2002)

– Poor correlation between management actions and official company policy concerning the relationship between safety and production

– Compliance to industry practice and legislated standards concerning numerous aspects of coal mining: methane concentrations, rock dusting, control of ignition sources underground, etc.
RECOMMENDATIONS

Immediate Technical Recommendations:
Use of IS Guidewords

- Removal of coal dust accumulations would have immediate benefits.

- Relocation of the fuel and the vehicles to the surface would have an immediate positive effect.
RECOMMENDATIONS

Recommendations to Avoid the Hazard:

Use of Principle Minimize

- Methane
  - Degasification
  - Adequate ventilation design and system
- Coal Dust
- Length of shift
- Non-flameproof equipment (ignition sources)
- Storing fuel underground
RECOMMENDATIONS

Use of Principle Substitute

- Auxiliary ventilation system:
  forcing, rather than exhaust, system for adequate airflow to clear methane from the working face of the mine

- Main ventilation fan:
  alternate design and location so as not to pick up dust and other debris from the coal return conveyor belt
RECOMMENDATIONS

- Use of Principle Moderate
  - Purchase of adequate rock dust inventory
  - Implementation of rock dusting program
  - Roadway consolidation
RECOMMENDATIONS

- Use of Principle Simplify
  - Installation of a reliable, robust mine air monitoring system
RECOMMENDATIONS

Recommendations to Improve the Management System:
SYSTEM + ATTITUDE

- Program elements such as hiring procedures, training, safe work procedures, and hazard identification
- Program standards such as appropriate follow-through on inspection results
- Compliance issues relating to both internal and external standards.
CONCLUDING REMARKS

A methodology has been developed to enable the explicit use of inherent safety principles (minimize, substitute, moderate and simplify) in an incident investigation protocol.

Application of the methodology to the Westray coal mine explosion has demonstrated how a lack of inherent safety considerations played a key role in the incident occurrence and severity.
What can the CPI learn from a coal mine explosion?

- Westray was a process safety incident, not simply OH&S.
- “Worker safety not my responsibility, says ex-Westray engineer” (newspaper headline) is not an acceptable attitude.
- Management system deficiencies were at the core.
- “Lessons from Longford” by Andrew Hopkins (CCH Australia Limited, 2000) relates essentially the same story by drawing parallels between a coal mine explosion and a gas plant explosion in Australia.
- In Nova Scotia, the lessons learned have led to a new OH&S Act which is underpinned by the Internal Responsibility System.
- In Canada, the lessons learned have led to changes in the Criminal Code of Canada (Bill C-45) regarding criminal negligence charges for inappropriate corporate level behaviour.
- When educating ChE students at Dalhousie University, it is important to consider Westray as well as Flixborough, Bhopal,…