Using STPA to identify conflicts in coal mining safety procedures

Central Mining Institute, Katowice, Poland

Ninth MIT STAMP Workshop
June 21-30, 2021
INTRODUCTION

- The mining sector is characterised by the existence of many hazardous factors.
- Each mining company must implement the so-called internal safety procedures, establishing operational control measures.
PURPOSE OF THE ANALYSIS: METHANE

• A mix of methane and air in which methane is in a proportion between 4.5% and 15% could explode.

• Methane is completely odourless and can lead to suffocation.

• Ventilation control measures should set limits for methane content in the air.

• Mining companies must establish procedures for action when the limits of methane in the air are exceeded.
We will analyze the case of developing parallel entries (galleries) in longwall system mines.
• We will analyze the case of developing parallel entries (galleries) in longwall system mines.

Self-Advancing Hydraulic Roof Supports

Machinery photos: www.famur.com
IDENTIFYING LOSSES

L-1 Loss of human life - human injury

IDENTIFYING SYSTEM-LEVEL HAZARDS

H-1: Workplace environment is not suitable for human health [L-1]

H-1.1: Workplace ventilation integrity is lost

H-1.1: Workplace oxygen levels are not suitable (too low)

H-1.2: Workplace methane levels are not suitable (too high)
DEFINING SYSTEM-LEVEL CONSTRAINTS (arising from mining safety legislation)

SC-1.1: If ventilation turned off, the workplace must be abandoned immediately [H-1.1]

SC-1.2: If ventilation does not maintain oxygen level over 19%, this must be detected, and workers must use self-rescuers and abandon the workplace [H-1.2]

SC-1.3: If ventilation does not maintain methane level below 2%, this must be detected, electricity must be cut off, and workers must follow specific procedures to reduce the methane content [H-1.3]

SC-1.4: If ventilation does not maintain methane level below 3%, this must be detected, electricity must be cut off, and workers must abandon the workplace immediately [H-1.3]
MODELING THE CONTROL STRUCTURE

Mine Director

Safety control
- Supervision
- Reports
- Change: Yes/no
- Monitoring

Workplace supervisor
- Work assignment
- Incident reports
- Acknowledgement
- Continue/stop work
- Abandon workplace
- Use self-rescuers

Ventilation
- Control
- Methane evolution

Methane concentration
- Methane & O₂ content

Workplace
# IDENTIFYING UNSAFE CONTROL ACTIONS

**CONTROL ACTION:** Continue-stop work / abandon workplace / use self-rescuers

<table>
<thead>
<tr>
<th>Not providing causes hazard</th>
<th>Providing causes hazard</th>
<th>Too early/late or incorrect order</th>
<th>Applied too long or stopped too soon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UCA-1:</strong> Workers do not abandon the workplace when ventilation turned off [H-1.1] ...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UCA-4:</strong> Workers do not abandon the workplace when the methane level is above 3% [H-1.3] ...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td><strong>UCA-5:</strong> Workers abandon the workplace when methane is over 3%, but use too late the self-rescuers with an $O_2$ level below 19% [H-1.3] [H-1.2] ...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
IDENTIFYING LOSS SCENARIOS

Focusing only on UCA-5:

• Scenario 1 for UCA-5: the methane is over 3% and the workers abandon the workplace, but the workplace supervisor may not realise that, almost at the same time, the oxygen level goes below 19%, and he asks the miners to use the self-rescuers too late.

CONCLUSIONS

• Critical unsafe control actions detected by STPA appear when different system-level hazards occur simultaneously or very close to each other, and miners must take more than one control action without any delays.

• In these cases, applying the most restrictive control measure to both system-level hazards (in our case, to use the self-rescuers), although expensive, it will effectively eliminate these unsafe control actions.
Thank you for your attention