

Using STPA to identify conflicts in coal mining safety procedures

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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.

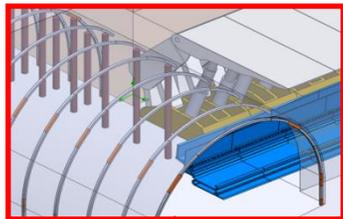
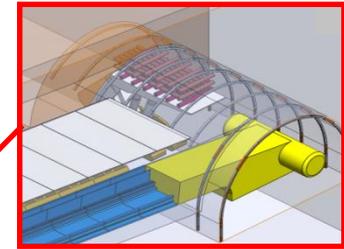


- We will analyze the case of developing parallel entries (galleries) in longwall system mines.

Longwall Mining Machine
(Works back and forth across coal face)

Armored Face Conveyor

Self-Advancing
Hydraulic Roof Supports



Gob Area
(Collapsed Roof Material)

Conveyor
Belt

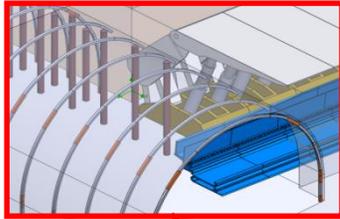
Coal

Direction
of mining

Gallery
(Gate Road)

- We will analyze the case of developing parallel entries (galleries) in longwall system mines.

Self-Advancing Hydraulic Roof Supports



Gob Area
(Collapsed Roof Material)



Gallery
(Gate Road)

Coal

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)

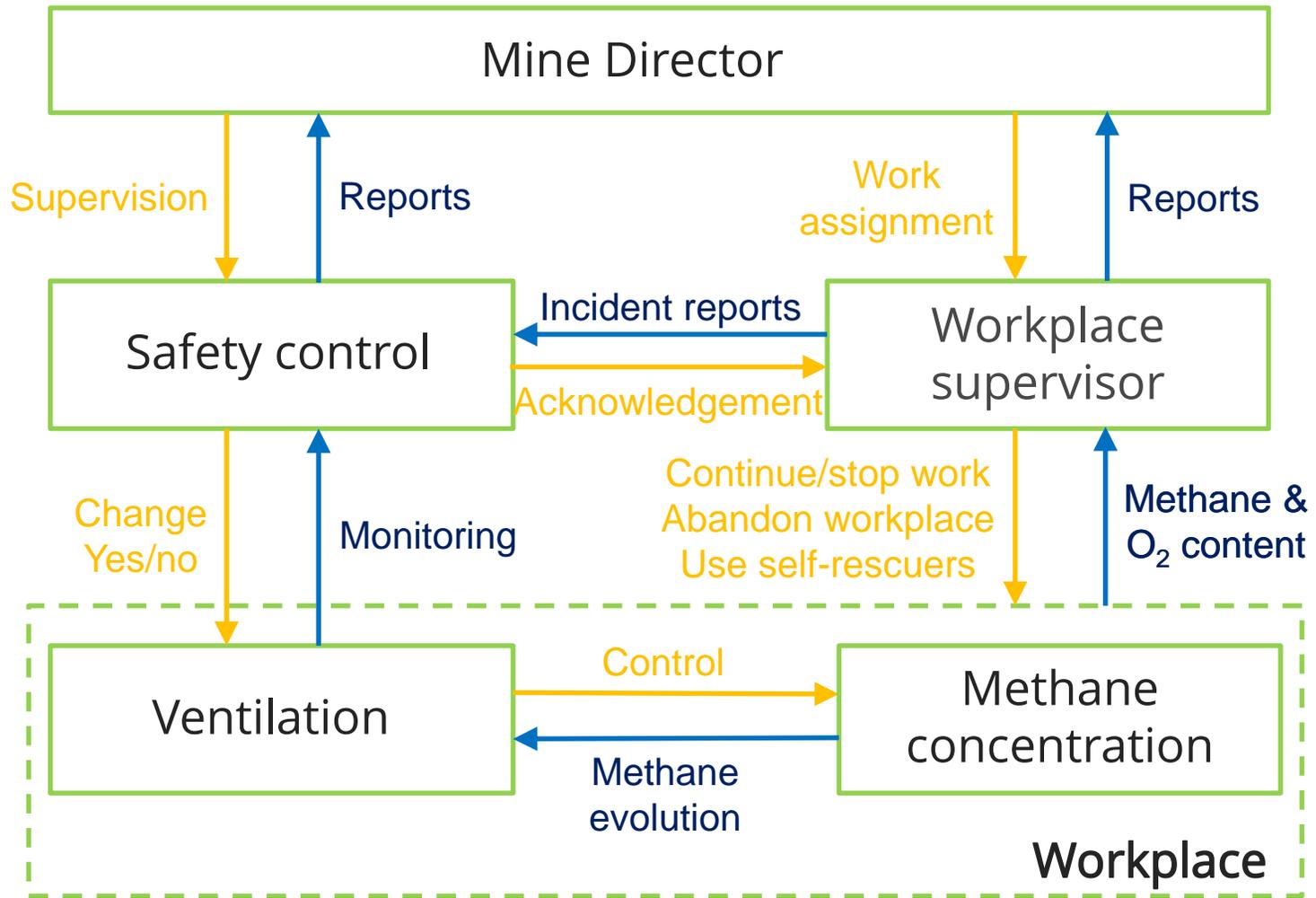
SC-1.1: If ventilation turned off, the workplace must be abandoned immediately [H-1.1]

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



IDENTIFYING UNSAFE CONTROL ACTIONS

CONTROL ACTION: Continue-stop work / abandon workplace / use self-rescuers			
Not providing causes hazard	Providing causes hazard	Too early/late or incorrect order	Applied too long or stopped too soon
<p>UCA-1: Workers do not abandon the workplace when ventilation turned off [H-1.1]</p> <p>...</p> <p>UCA-4: Workers do not abandon the workplace when the methane level is above 3% [H-1.3]</p> <p>...</p>	N/A	<p>UCA-5: Workers abandon the workplace when methane is over 3%, but use too late the self-rescuers with an O₂ level below 19% [H-1.3] [H-1.2]</p> <p>...</p>	...

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



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