Pressurization of Intake Escapeways with Parachute Stoppings to Reduce Infiltration of Smoke

FN Kissell, PhD and RJ Timko
5th US Mine Ventilation Symposium
1991
Section Airflow

- Escapeway airflow fell by 79%
- Face airflow fell by 6%
CONCLUSIONS

• Parachute stopping helps to keep smoke out of escapeway **IF** the fire source is not in the escapeway.
How Smoke Hinders Escape from Coal Mine Fires

FN Kissell, PhD and CD Litton
Mining Engineering
January 1992
## Relative CO (ppm) Values at a 0.1/meter OD Smoke Sensor Alarm Level
(visibility = 26 ft)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>CO flaming</th>
<th>CO smoldering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>11.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Coal</td>
<td>3.4</td>
<td>1.8</td>
</tr>
<tr>
<td>SBR belt</td>
<td>3.7</td>
<td>0.5</td>
</tr>
<tr>
<td>PVC belt</td>
<td>8.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Neoprene belt</td>
<td>6.3</td>
<td>1.4</td>
</tr>
<tr>
<td>PVC brattice</td>
<td>----</td>
<td>2.2</td>
</tr>
</tbody>
</table>
Fig. 3—Downstream smoke visibility and carbon monoxide levels during the growth of a typical SBR belt/coal test fire.
Fire

[Contaminants at concentration \(C_f\)]

Airflow, \(Q_e\)

Leakage, \(Q_l\)

[Contaminants at concentration \(C_e\)]

\[C_e = C_f \frac{Q_l}{Q_e + Q_l}\]
Fig. 5—Calculated escapeway smoke visibility, oxygen and carbon monoxide vs. leakage—SBR belt/coal fire at 60 minutes.
CONCLUSIONS ...

• Lack of visibility in smoke and the accompanying fumes are the greatest obstacle to safe escape.
Evaluating Those Factors that Influence Escape from Coal Mine Fires

GVR Goodman, PhD and FN Kissell, PhD
Transactions of the SME
Volume 286, 1989
Failure to escape

OR

Lost in smoke

OR

SCSR fails
## Top Event Values for Changes in SCSR Training And Escapeway Knowledge

<table>
<thead>
<tr>
<th>Probability of finding escapeway</th>
<th>SCSR error</th>
</tr>
</thead>
<tbody>
<tr>
<td>.10</td>
<td>.93  .44  .40  .10</td>
</tr>
<tr>
<td>.50</td>
<td>.63  .63  .63  .63</td>
</tr>
<tr>
<td>.90</td>
<td>.63  .61  .61  .60</td>
</tr>
<tr>
<td></td>
<td>.63  .60  .60  .57</td>
</tr>
</tbody>
</table>
Fatality Events Had Common Features

- Delayed evacuation
- Lack of lifelines
- Confusion in locating escapeway
- Malfunction of SCSR
Reducing the Top Event by 75%
Requires:

• Minimal delays
• Excellent chance of finding escapeway
• Excellent SCSR training
• Stopping resistance to smoke leakage and fire damage
CONCLUSIONS…

With the exception of delays, single factor changes have minimal impact.
Ranking Factors Impacting Survival during Coal Mine Fires

FN Kissell, PhD, RJ Timko, and CD Litton
Mining Engineering
August, 1993
Roberts, AF [1987]. A systematic strategy for assessing fire protection measures in a mine. First Mine Safety and Health Congress, Johannesburg, South Africa

\[ I_{\text{survival}} = T_{\text{toxic}} - (T_{\text{detection}} + T_{\text{decision}} + T_{\text{travel}}) \]
KEY

- 1500 ppm CO criterion (visibility = 2 in, 5 cm)
- 160 ppm CO criterion (visibility = 1.6 ft, 0.5 m)
- 12 ft, 3.7 m (O.D. = .218) smoke visibility criterion

Time from start of coal flame, min.

Leakage, $10^3$ cfm

60 minutes available from lifelines with SCSR

15 minutes available from lifelines alone

9 minutes available from change in leakage
<table>
<thead>
<tr>
<th><strong>Translated into Time:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple→CO</td>
<td>6-10min</td>
</tr>
<tr>
<td>CO alarm threshold 15→10 ppm</td>
<td>3 min</td>
</tr>
<tr>
<td>Sensor spacing 2000→1000 ft</td>
<td>≤ 5 min</td>
</tr>
<tr>
<td>Stopping leakage ↓80%</td>
<td>9 min</td>
</tr>
<tr>
<td>Walking vs. riding 5000 ft</td>
<td>10-20 min</td>
</tr>
<tr>
<td>Fire growth rate ↓75%</td>
<td>9 min</td>
</tr>
<tr>
<td>Lifelines without SCSR</td>
<td>15 min</td>
</tr>
<tr>
<td>Lifelines with SCSR</td>
<td>60 min</td>
</tr>
</tbody>
</table>
Fire Growth Rate ↓75%  9 min

• CO alarm threshold 15→10ppm  3 →12 min
• With lifelines and leakage ↓50%  56 min
CONCLUSIONS…

- Multiple factor changes have the most impact
- Consider non-technical factors such as training and management practices.
RELEVANCE OF THESE RESULTS TO BELT AIR AND BELT FLAMMABILITY

• Belt air: limited, because of other factors
  • Belt flammability: fire growth rate