Mine Rescue Ensembles for Underground Coal Mining

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Project Goals

- Develop appropriate design and performance requirements for ensembles worn by mine rescue teams during emergency response.
- Establish a best practice/guidance document and produce recommendations for standards for mine rescue ensembles.

Background

- Historically, there has been no consistency in protective clothing & equipment worn by various mine rescue teams, although they could respond to the same event (Fig. 1 & 2).
- No guidance documents, standards or recommended best practices exist that establish minimum design and performance criteria.
- There are established standards for similar tasks and hazards:

Materials

Mine Rescue Ensembles Elements Tested in Phase I(9):

<table>
<thead>
<tr>
<th>Component</th>
<th>Type-I</th>
<th>Type-II</th>
<th>Type-III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garments</td>
<td>6.0 oz/yd² 65/35 PET/Cotton</td>
<td>9.0 oz/yd² FR Cotton</td>
<td>6.0 oz/yd² Nomex® IIIA</td>
</tr>
<tr>
<td>Helmets</td>
<td>Low Profile Miner Helmet</td>
<td>Regular Miner Helmet</td>
<td>Nomex® IIIA</td>
</tr>
<tr>
<td>Hoods</td>
<td>6.0 oz/yd² Nomex®</td>
<td>8.5 oz/yd² Nomex®</td>
<td>6.0 oz/yd² 80/20 FR Rayon/Nomex®</td>
</tr>
<tr>
<td>Gloves</td>
<td>Regular Leather Miner Glove</td>
<td>Technical Rescue Glove (non FR)</td>
<td>Firefighter Glove (Nomex® IIIA 80/20 FR Rayon/Nomex®)</td>
</tr>
</tbody>
</table>

Procedure

Phase-I Bench-scale Testing:

- The performance testing of the most commonly used elements of mine rescue ensembles
- Test methods: NFPA, ASTM, & AATCC standards

Phase-II Whole Garment-Manikin Testing:

- Evaluation of thermal insulation and evaporative resistance properties of the most commonly used ensembles
- Test methods: ASTM F1291-05 & ASTM F2370-05

Report

- Prepare recommended minimum design assessment and performance criteria
- Submit recommendations to Standards Committees

Preliminary Results

Garments(9)

<table>
<thead>
<tr>
<th>Test</th>
<th>Type-I</th>
<th>Type-II</th>
<th>Type-III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material / Conditioning</td>
<td>FR Cotton</td>
<td>Nomex® IIIA</td>
<td>N/A</td>
</tr>
<tr>
<td>Fabric Weight (oz/yd²)</td>
<td>AR</td>
<td>Laundered</td>
<td>AR</td>
</tr>
<tr>
<td>Thermal Protective Performance (cal/cm²)</td>
<td>11.9</td>
<td>13.7</td>
<td>13.7</td>
</tr>
<tr>
<td>Heat &amp; Thermal Shrinkage Resistance (%)</td>
<td>-0.4</td>
<td>-0.9</td>
<td>-0.5</td>
</tr>
<tr>
<td>Tear Resistance (N)</td>
<td>200</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Cleaning Shrinkage Resistance (%)</td>
<td>N/A</td>
<td>4.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Abrasion Resistance (N)</td>
<td>378</td>
<td>418</td>
<td>418</td>
</tr>
<tr>
<td>Water Absorption (%)</td>
<td>64</td>
<td>91</td>
<td>75</td>
</tr>
<tr>
<td>Afterflame (s)</td>
<td>0.58</td>
<td>0.49</td>
<td>0.76</td>
</tr>
<tr>
<td>Char Length (mm)</td>
<td>74</td>
<td>79</td>
<td>69</td>
</tr>
<tr>
<td>Total Heat Loss Q, (W/m²)</td>
<td>568</td>
<td>634</td>
<td>677</td>
</tr>
</tbody>
</table>

Helments

- Both low profile and regular miner helmet failed in flame resistance and heat resistance tests conducted according to NFPA 1951-2007.
- Both types passed the physical penetration requirements of NFPA 1951-2007.

Gloves

- Type-I technical rescue glove failed flame resistance test conducted according to NFPA 1951-2007 as it melted and dripped (Fig. 3).
- Type-I, II, and III firefighter glove failed NFPA 1951-2007 glove hand function test.
- Type-I and II do not have any barrier for liquid and viral penetration.
- Both low profile and regular miner helmet failed in flame resistance and heat resistance tests conducted according to NFPA 1951-2007.

Future Work

- Finalize the research proposal
- Complete the data collection for Phase I and Phase II
- Document the findings and determine the minimum performance & design requirements based on field study, test results & other studies
- Publish the findings and share the results with Standards Development Organizations

Partnerships

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Image credits:

Fig. 1 Components of a typical mine rescue ensemble
Fig. 2 Different types of mine rescue ensembles used in the U.S.