# Survivability Evaluation of Mine Refuge Chambers

**Report Date:** Dec. 19, 2007

<table>
<thead>
<tr>
<th>Chamber Name</th>
<th>Life Shelter</th>
<th>Fresh Air Bay</th>
<th>Kennedy Chamber</th>
<th>Mine Refuge Chamber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Number</td>
<td>4042-20</td>
<td>MC36</td>
<td>MPRC-H12-8155-C</td>
<td>MMS - 26</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>ChemBio/AL Lee</td>
<td>Strata Products</td>
<td>Kennedy Metal Products</td>
<td>Modern Mine Safety Supply</td>
</tr>
<tr>
<td>City</td>
<td>Allentown</td>
<td>Marietta</td>
<td>Taylorville</td>
<td>Huntington</td>
</tr>
<tr>
<td>State</td>
<td>PA</td>
<td>GA</td>
<td>IL</td>
<td>UT</td>
</tr>
<tr>
<td>Zip Code</td>
<td>18109</td>
<td>30062</td>
<td>62568</td>
<td>84528</td>
</tr>
<tr>
<td>Telephone</td>
<td>610-266-6667</td>
<td>770-321-2501</td>
<td>217-287-7231</td>
<td>435-687-2244</td>
</tr>
<tr>
<td>Chamber Type</td>
<td>Inflatable</td>
<td>Inflatable</td>
<td>Steel</td>
<td>Steel</td>
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<tr>
<td>Capacity (persons)</td>
<td>20</td>
<td>36</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>CO2 Scrubbing System</td>
<td>Passive soda lime curtains</td>
<td>Powered soda lime cartridges</td>
<td>Passive lithium curtains</td>
<td>Powered soda lime</td>
</tr>
<tr>
<td>Basis to Change Scrubbing Materials</td>
<td>Specified time - 96 hrs</td>
<td>Specified time - 24 hrs</td>
<td>Specified time - Variable</td>
<td>Specified time - 16 hrs</td>
</tr>
</tbody>
</table>

| Arrival Date | 10/29/07 | 11/02/07 | 10/26/07 | 11/30/07 |
| Set-up Date  | 10/29/07 | 11/05/07 | 11/09/07 | 12/03/07 |
| Evaluation Start Date | 10/30/07 | 11/05/07 | 11/13/07 | 12/03/07 |
| Evaluation End Date | 11/03/07 | 11/09/07 | 11/17/07 | 12/05/07 |
| Clean-up Date | 11/03/07 | 11/09/07 | 11/17/07 | 12/06/07 |

### CO2 Scrubbing Criteria (0.5 l/min/man) (CO₂ level <= 0.5%) |
- **Evaluation 1:** Exceeded
- **Evaluation 2:** Met
- **Evaluation 3:** Exceeded
- **Evaluation 4:** Exceeded

**Comments**
- Exceeded 0.5% 42 hrs into test, remained above 0.5% from 44 hrs to end (See Comments C1, C2, C3)
- Stabilized at between 0.35% and 0.40% (See Comments S1, S2)
- Maximum reading was 0.72% (See Comments K1, K2, K3).
- Maximum recorded reading was 1.34% (See Comments M1, M2, M3, M4)

### O₂ Supply Criteria (0.62 l/min/man) (O₂ >= 19.5%) |
- **Evaluation 1:** Insufficient
- **Evaluation 2:** Met
- **Evaluation 3:** Met
- **Evaluation 4:** Insufficient

**Comments**
- O2 flow to zero at app. 71 hrs (See Comment C4)
- O2 flow and conc. starting dropping at 94.5 hrs (See Comment K4).
- O2 flow ended after 37 hrs (See Comment M5)

### Apparent Temperature Criteria (< 95 deg F) |
- **Evaluation 1:** Met
- **Evaluation 2:** Met
- **Evaluation 3:** Exceeded
- **Evaluation 4:** Exceeded

**Comments**
- Stabilized at app. 70°F apparent temperature (73°F and 62% RH)
- Apparent temperature max. of 124°F (90.5°F and 92.6% RH)
- Apparent temperature app. 110°F (87°F and 86% RH)

### Duration Criteria (96 hours) |
- **Evaluation 1:** Met
- **Evaluation 2:** Met
- **Evaluation 3:** Met
- **Evaluation 4:** Less Than Required

**Comments**
- O2 flow ran out prior to 96 hrs.
- O2 quit. Failed scrubber containers and loose soda lime forced early termination.
- Less Than Required

### Early Termination Time (hours) |
- **Evaluation 1:** NA
- **Evaluation 2:** NA
- **Evaluation 3:** NA
- **Evaluation 4:** 56 (See Comment M6)

**CO₂ levels to 2.0%, No O2**
Comments from Spreadsheet

ChemBio/AL Lee Comments
C1 Tent began collapsing at 7 hrs due to cut in main air tube. No instructions on how to reinflate. Curtains were knocked over, absorbed water and reduced their scrubbing efficiency.
C2 CO2 concentration at 96 hours was 1.20%.
C3 Tent collapsing began again at 80 hrs and was nearly completely collapsed by 96 hrs.
C4 O2 flow rate between 10 and 18.5 l/min. For 20 man chamber, flow rate should have been app. 12.4 l/min.

Strata Products Comments
S1 CO2 above 0.5% for first 16 hrs because CO2 flow rate into chamber was 28% greater than needed for 36 man chamber (App. 23.4 l/min vs. 18.3 l/min). Once correct CO2 flow rate attained, CO2 conc. remained below 0.5%.
S2 Scrubber fan motor seized and was changed out 73.5 hrs. into test (extra motor and complete instructions were included).

Kennedy Comments
K1 CO2 ranged from 0.24 to 0.72%. Pattern was the CO2 level went above 0.5% just prior to curtain change. After new curtains were hung, CO2 level dropped below 0.5%, then slowly climbed above 0.5% until next curtain change.
K2 For the first 3 curtain change outs (12, 24 and 36 hrs) the CO2 level dropped below 0.5% for between 7 and 9 hours afterward then went above 0.5%.
K3 For remaining curtain change outs (48, 60, 72 and 84) CO2 was below 0.5% for 4 hrs or less before climbing above 0.5%.
K4 The valve on one O2 bottle was never opened, thus more than enough O2 was available for 12 man capacity.

Modern Mine Safety Comments
M1 Maximum CO2 recorded reading occurred during first soda lime change out (1.94% was observed but not recorded).
M2 CO2 levels went above 0.5% after initial 4 hours of evaluation, reaching 0.61 just prior to first change out.
M3 After first change out CO2 levels dropped to 0.25 within 30 minutes.
M4 CO2 levels remained below 0.5% for nearly 32 hours without a second change out of scrubbing material.
M5 O2 flow rate fluctuated between 10.5 and 12.5 l/min, only 4 of 11 O2 cylinders were empty.
M6 Battery powered blower ran the full 96 hrs.