OMSHR

Office of Mine Safety and Health Research

Overview of Prior OMSHR Refuge Alternatives Research on Purging, Heat & Humidity, and Built-in-place

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Refuge Alternatives Partnership Meeting
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CDC Workplace Safety and Health NIOSH

Outline

1. Overview of RAs types in use
2. Prior OMSHR research on mobile RA purging
3. Prior OMSHR research on mobile RA heat and humidity
4. Prior OMSHR research on built-in-place RAs

Tent-Type Mobile RA

- Inflatable tent contained within a rigid metal box
- Miners deploy the tent and stay primarily in the tent
- Provide oxygen via compressed oxygen cylinders
- Largest holds up to 36 miners
- Roughly 1,400 tent-type RAs in US coal mines

Rigid Mobile RA

- Rigid metal structure
- Miners enter the steel box and stay in the steel enclosure
- Provide oxygen via compressed oxygen cylinders
- Generally hold fewer miners because of their size limitation
- About 300 rigid mobile RAs in US coal mines

Built-in-Place RA

- Permanent structures
- All BIP RAs in the US are outby the face
- All BIP RAs in the US use boreholes to provide breathable air
- Can be sized to accommodate large number of miners
- Approximately 30 BIP RAs in US coal mines

Prior OMSHR Research on Mobile RA Purging

MSHA Regulations relevant to purging (30 CFR 7.501 to 7.510 and 30 CFR 75.1506)

- Require maximum of 10 minutes to deploy and 20 minutes to enter
- Original regs required ability to purge airlock from 400 ppm CO to 25 ppm CO for all groups of entering miners in less than 20 minutes

OMSHR mobile RA purging research focused on two questions:

- How much time is needed to enter through airlocks?
- Can purging systems reduce the CO concentration to safe levels in the allotted time?

Prior OMSHR Research on Mobile RA Purging

OMSHR purging research to address these concerns consisted of the following:

- Reviewing data on post-disaster CO concentrations in mines
- Measuring the time required to enter RA airlocks
- Evaluating the ability of purging systems to reduce CO concentrations in airlocks in the allotted time
- Determining the concentration of contaminated mine air that could result from miners entering an airlock

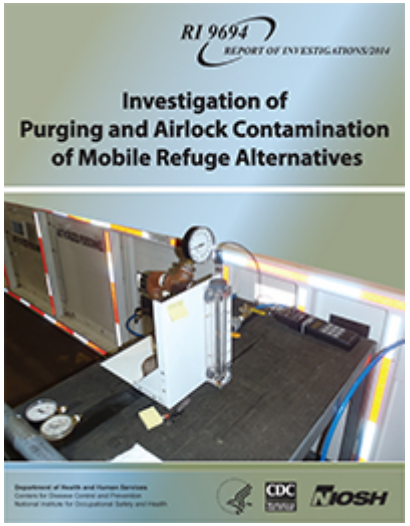
Prior OMSHR Research On Mobile RA Purging

SF_6 testing to determine amount of contaminated air that could enter an airlock

Key Findings from Prior OMSHR Research On Mobile RA Purging

- Small size of door opening and airlock may prevent miners from entering main chamber within the 20-minute time limit
- Current portable RA purging systems are able to reduce CO concentrations as designed
- The airlock CO concentration could reach up to 60% of the ambient mine air CO concentration as miners enter the RA
  - 10,000 ppm CO outside RA would result in 6,000 ppm CO in airlock

Testing and results discussed in *RI 9694: Investigation of Purging and Airlock Contamination of Mobile Refuge Alternatives*



Prior OMSHR Research on Mobile RA Heat and Humidity

MSHA Regulations relevant to RA heat and humidity (30 CFR 7.501 to 7.510 and 30 CFR 75.106)

- Maintain an apparent temperature (AT) of less than 95°F
- Provide breathable air, food, water, etc. 96 hours
- Provide carbon dioxide scrubbing (generates heat)
- Provide minimum floor space of 15 ft^2 per occupant
- Provide minimum volume of 30 - 60 ft^3 per miner (based on mine height)

OMSHR mobile RA heat and humidity research focused on several questions:

- Do mine air and strata temps change due to heat from an occupied RA?
- Does the test facility significantly affect the internal AT?
- At what mine temp could the interior AT of an occupied RA reach 95°F?
- What occupancy derating might be necessary to prevent an RA from reaching the 95°F AT limit?

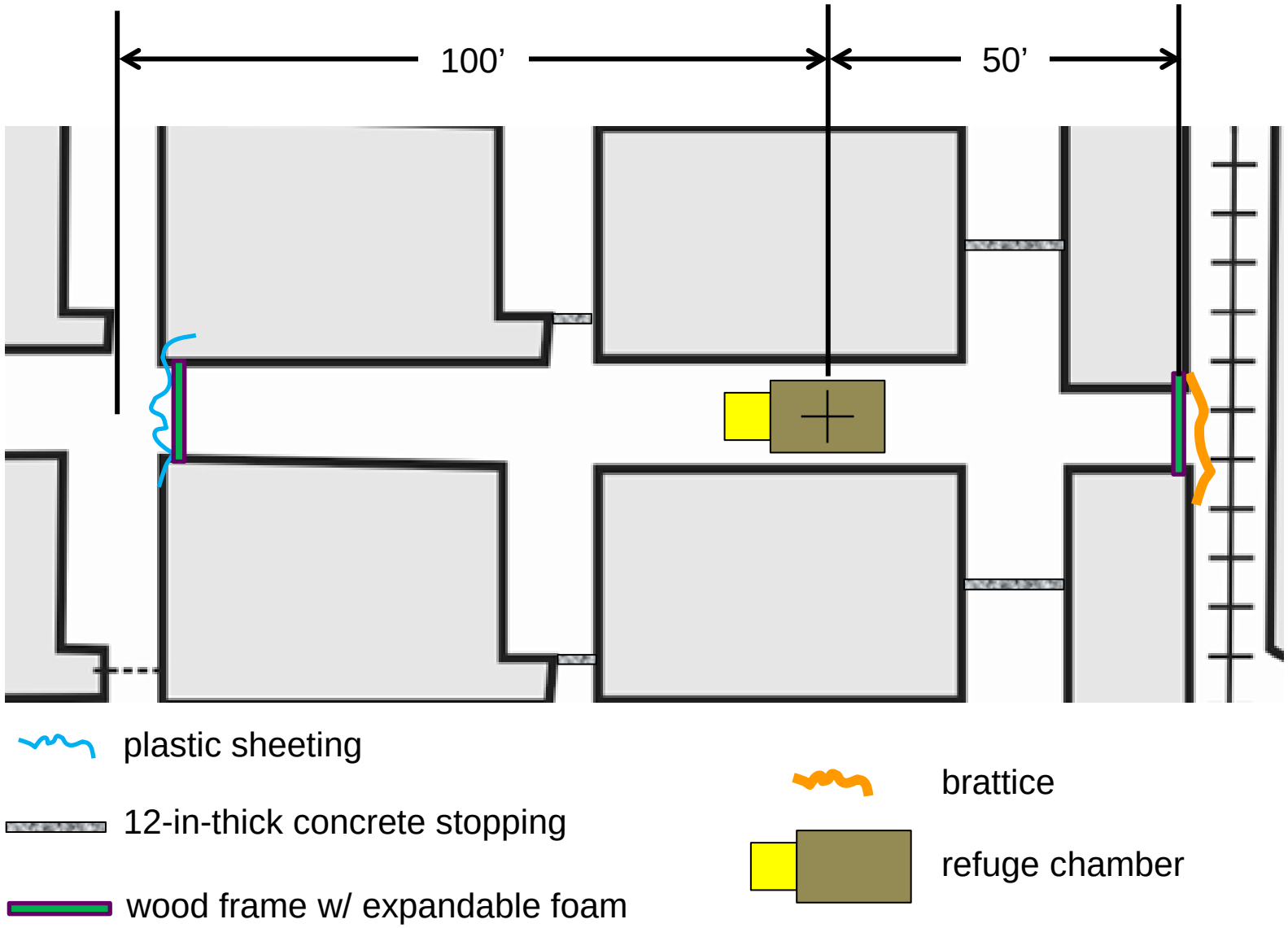
Prior OMSHR Research on Mobile RA Heat and Humidity

- 96-hour tests using a 10-man tent-type training RA

High bay, dry

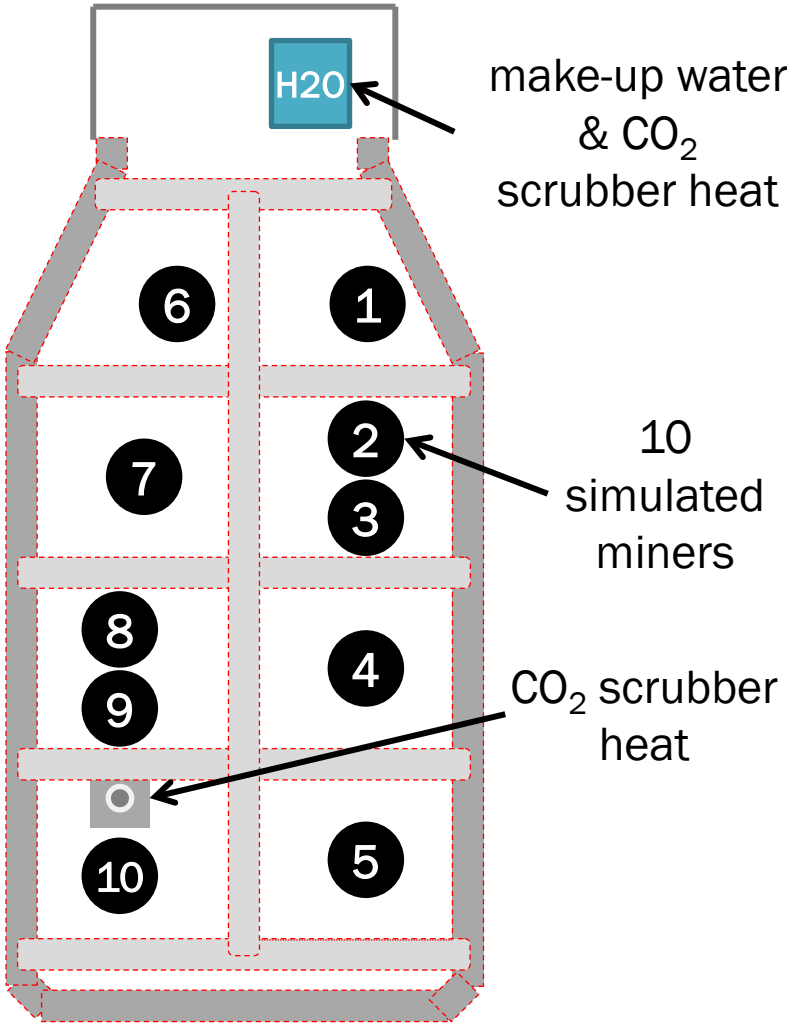
Safety Research Coal Mine, dry & wet

Test Area in OMSHR SRCM



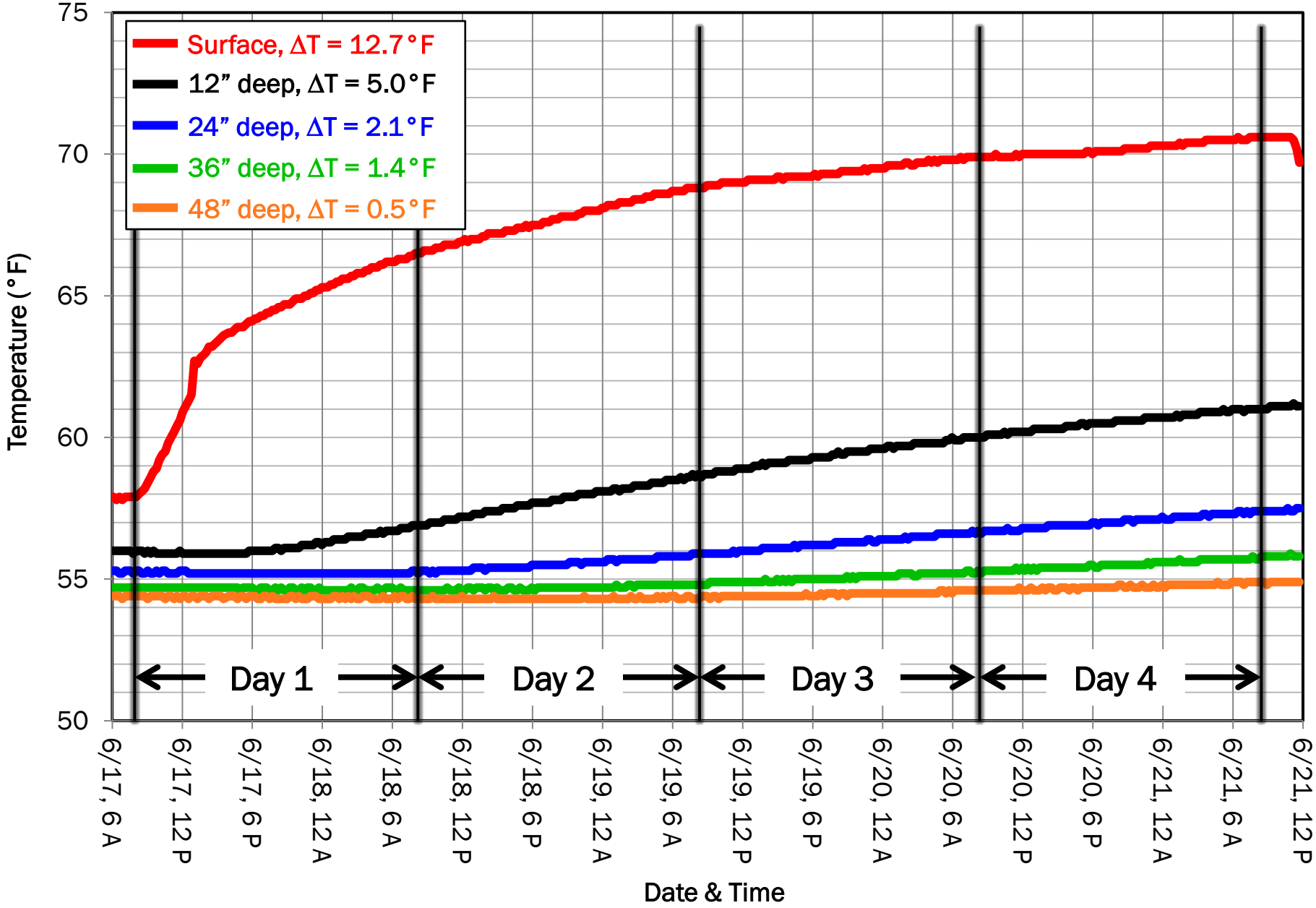
Prior OMSHR Research on Mobile RA Heat and Humidity

- Total heat input of 1670 watts (167 watts/miner) to represent metabolic heat and CO_2 scrubber heat (LiOH)



Prior OMSHR Research on Mobile RA Heat and Humidity

Mine Floor Strata Temperatures Measured Under Tent (Wet SRCM Tests)



Prior OMSHR Research on Mobile RA Heat and Humidity

Apparent Temperature Results from Wet SRCM Tests

- The internal air temperature increased by 22ºF and the interior reached 93 %RH
- This temperature increase and %RH would yield the following apparent temperatures as a function of the initial mine ambient temperature

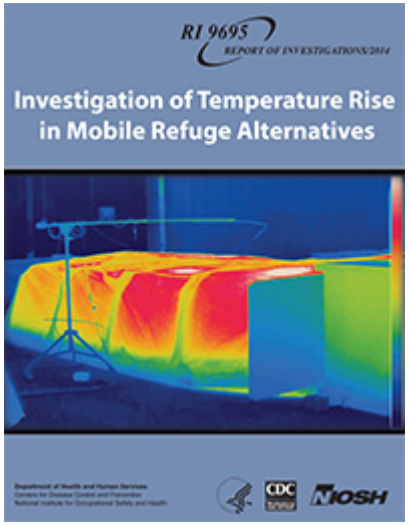
Mine Ambient Temperature (°F)	RA Interior Temperature (°F)	RA Apparent Temperature (°F)
55	77	79
60	82	94
61	83	97
65	87	113

These results are specific to this particular RA, but show the potential for problems

Key Findings from Prior OMSHR Research On Mobile RA Heat and Humidity

- Mine strata temperatures increase over the entire 96-hour duration
- RA heat testing must be done in a facility that mimics an actual mine, or the mine temperature increase must be accounted for by other means
- At initial mine ambient temperatures ≥60°F, the tested, fully occupied RA would exceed 95°F AT and derating would be necessary
- Significant wall and roof condensation and water pooling on the floor occurred during testing

Testing and results discussed in *RI 9695: Investigation of Temperature Rise in Mobile Refuge Alternatives*



Prior OMSHR Research on BIP RAs

MSHA Regulations that present challenges for BIP RAs (30 CFR 7.501 to 7.510 and 30 CFR 75.106)

- Must be within 1,000 ft of each working face and spaced within 1-hour travel distance in outby locations
- Must withstand a blast overpressure of 15 psi for 0.2 seconds and remain airtight
- Must provide 12.5 cfm (750 ft^3/hr) of breathable air or 1.32 ft^3/hr of oxygen per occupant

OMSHR BIP RA research focused on several areas:

- Potential advantages/disadvantages of BIP RAs
- Distance from the working face
- Stopping design criteria to meet 15-psi requirement
- Existing air delivery systems

Prior OMSHR Research on BIP RAs

Potential Advantages of BIP Refuge Alternatives

(Assuming the use of protected compressed air line or borehole)

- Quicker and easier to prepare and operate; no tent to roll out, fewer valves to open, no O_2 controls, may not require CO_2 scrubber
- Miners may not have to wait to enter while airlock is purged of CO
- Order of miner arrival may be less important, not a problem if some miners decide to leave
- May increase chances of communication system survival
- May eliminate heat and humidity issues
- Better chance of surviving a secondary explosion than a tent-type mobile RA
- May eliminate 96-hour ticking clock
- Provide more space per occupant; may reduce psychological & physiological stress

Prior OMSHR Research on BIP RAs

Potential Disadvantages of BIP Refuge Alternatives

- Must be economically viable, must be inexpensive enough to abandon or use reusable stopping/door system
- Not practical to keep within 1000 feet of the face
- Economical stopping & door systems that meet the 15-psi criteria must be developed
- Air delivery systems that meet the 15-psi criteria must be developed

Prior OMSHR Research on BIP RAs

OMSHR-conducted analyses to examine RA-to-face distance

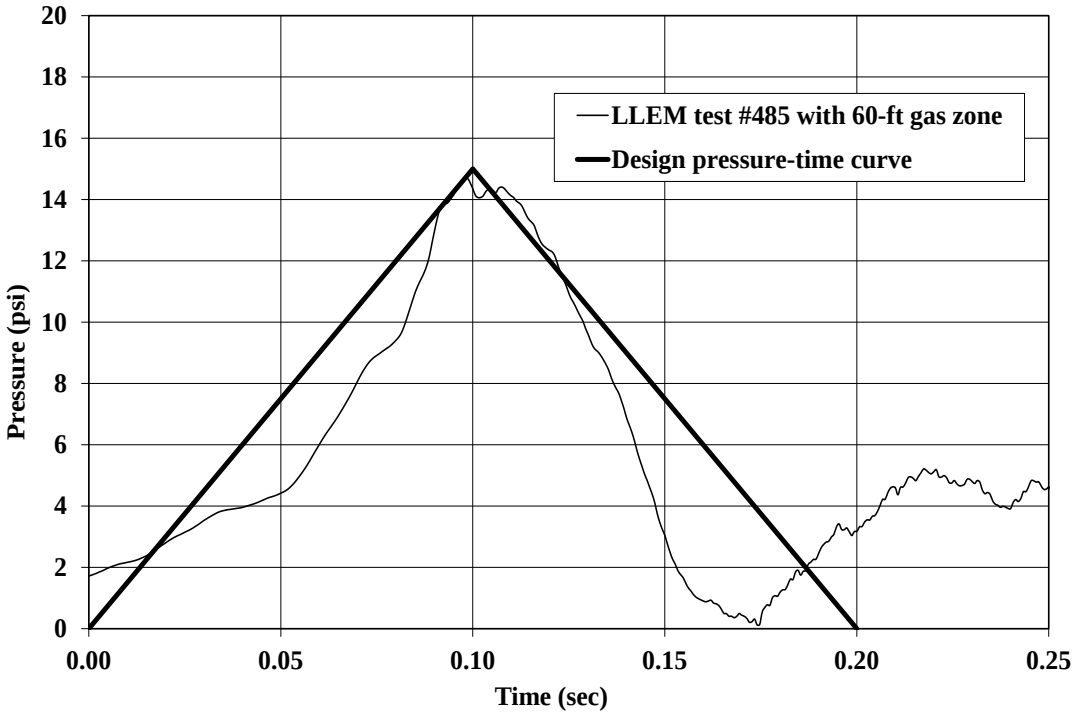
Entry Height	Approach 1: Based on mandated SCSR storage cache locations	Approach 2: Based on worst-case SCSR usage times	Approach 3: Based on NIOSH and BOM established travel times and escape probabilities	OMSHR-concluded maximum RA-to-face distance
< 40 inches	2,200 feet	2,640 feet	NA	2,000 feet
40 to 50 inches	3,300 feet	3,960 feet	NA	3,000 feet
50 to 65 inches	4,400 feet	5,280 feet	6,000 feet	4,000 feet
> 65 inches	5,700 feet	6,480 feet	6,500–7,000 feet	5,000 feet

RAs can be located more than 1,000 feet from the working face, and the distance depends on mine height

Prior OMSHR Research on BIP RAs

RA Stopping/Door System Designs

- To date, only two stopping/door system designs have been approved
- To facilitate the approval process, OMSHR has:
  - Reaffirmed its recommended design pressure-time curve of 15 psi over 0.2 seconds
  - Provided design guidelines for submitting BIP RA stopping/door systems for MSHA approval
  - Design guidelines were adapted from MSHA guidelines for coal mine seal design applications
  - Provided a detailed example of a stopping/door system that meets the 15-psi criteria (including all structural design calculations)



Prior OMSHR Research on BIP RAs

Breathable air delivery systems

- Most BIP RA advantages disappear without a reliable supply of breathable air
- Possible solutions include
  - Borehole to surface
  - Protected compressed air line
- Research is needed in this area

Key Findings from Prior OMSHR Research on BIP RAs

- BIP RAs offer many potential advantages over mobile RAs, but hurdles exist to make them a practical solution
- RAs can be located more than 1000 feet from the working face, and the distance depends on mine height
- Stopping/door system design guideline and example provided

BIP RAs discussed in detail in pending
Report of Investigations
expected to be published Spring 2015

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Questions?

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