Overview of NIOSH Refuge Alternatives Research

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Discussion Topics

- History of barricading and refuge
- MINER Act Mandates pertaining to NIOSH
- NIOSH Refuge Alternatives Research
  - Contract and In-house efforts
  - Survivability Evaluations of Refuge Chambers
  - Refuge Alternatives Report
  - Training
- Current Efforts
- Future Research

Commitment of Mining Industry

All participants in this endeavor deserve credit and respect for their cooperation and for what was accomplished:

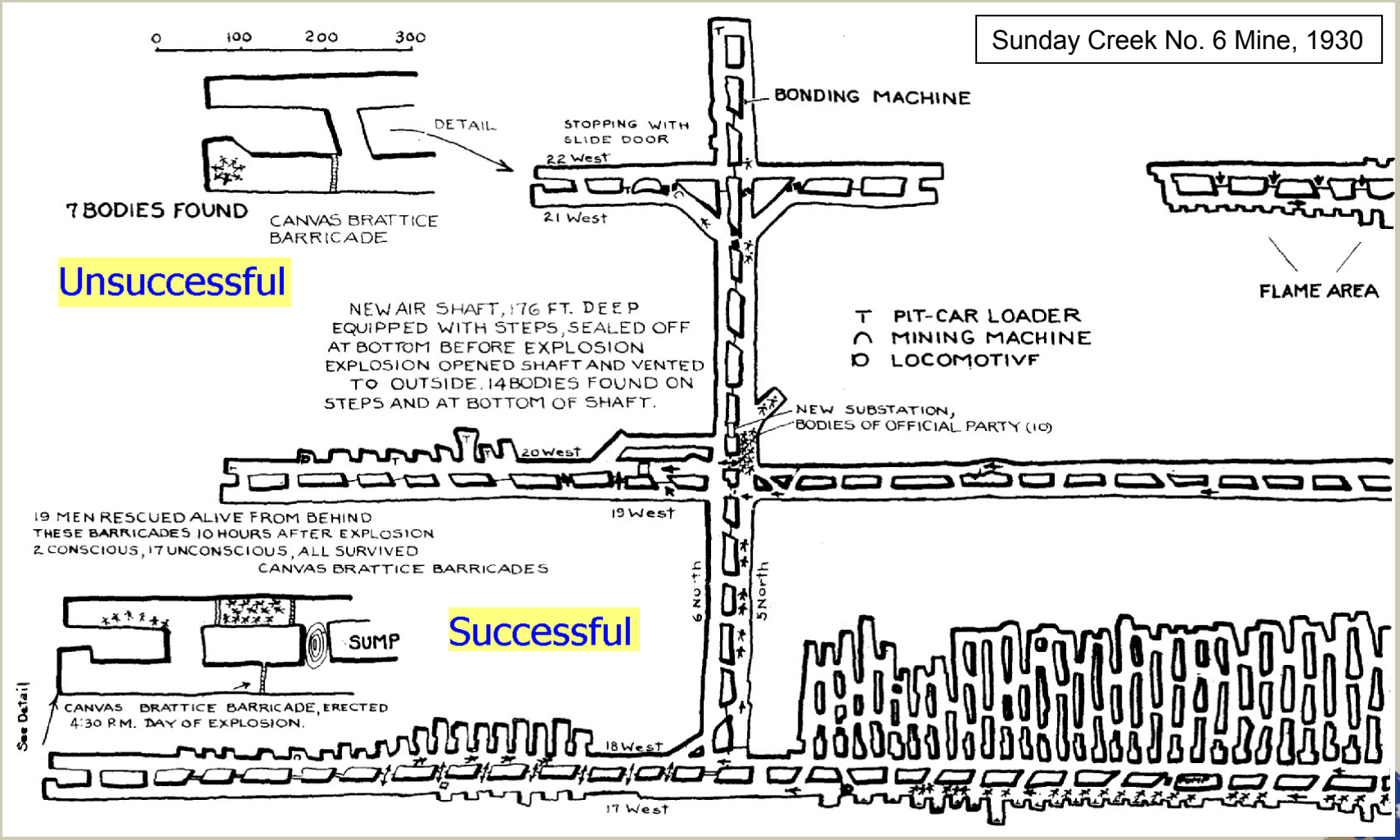
- UMWA
- Coal Companies
- States
- MSHA
- Chamber Manufacturers
- NMA

"We did what we thought was best for the worker, and for that, we should applaud ourselves!"

History - Barricading

- First described in 1912 Bureau of Mines Technical Paper #24
- In 1923, Miners' Circular #25 described 18 fires and explosions in which 441 miners survived behind barricades
- Good and bad barricades were documented and illustrated, and instances of survival were cited in Miners' Circular #42, 1941

History - Barricading



History - Barricading

Historical review of fires and explosions in coal mines.

Workers	1900-1958[1]	1958-1998[2]
Fatally Injured	4084	421
Escaped	2835	588
Rescued	381	23
Survived After Barricading	880	11
Died After Barricading	189	22

Source: [1]USBM Bulletin 586

[2]Misc. USBM Information Circulars

Since 1998, there have been 66 fatalities from 7 major coal mine explosions or fires. Only the 12 miners at Sago tried to barricade. 11 miners died, one survived.

History - Refuge

- As far back as the 1930's the Bureau of Mines advocated the building of refuge chambers in the main sections of mines.
- In the late 30's and early 40's, some small refuge chambers were established in some coal mines in the Central States.
- Ventilated 100-man capacity refuge chambers were constructed by the Harwick Coal and Coke Co. in the Harwick Mine near Pittsburgh around 1940. These chambers were 75 feet long, 8 feet high, and 11 feet wide, cut out of the coal, and connected to the surface via two boreholes.

History - Refuge

- The Bureau of Mines funded five major contract efforts between 1970 and 1983 that addressed mine rescue and survival, the design of explosion-proof bulkheads, post survival and rescue research needs, and guidelines for rescue chambers.

History - Refuge

History - Refuge

- Finally, following the Sago disaster and enactment of the MINER Act, refuge alternatives research was conducted.
- Refuge alternatives (portable chambers and in-place shelters) have been adopted by all underground coal mines.

NIOSH Refuge Responsibilities

Mandated in Mine Improvement and New Emergency Response (MINER) Act of 2006, Section 13

"NIOSH shall provide for the **conduct of research**, including field tests, concerning the utility, practicality, survivability, and cost of various refuge alternatives in an underground coal environment"

"No later than 18 months after the date of enactment of this Act, NIOSH shall **prepare and submit** to the Secretary of Labor, the Secretary of Health and Human Services, the Committee on Health, Education, Labor, and Pensions of the Senate, and the Committee on Education and the Workforce of the House of Representatives **a report** concerning the results of the research conducted"
►Completed December 2007◄

Past - Refuge Alternatives Research

- Contract and In-house efforts
  - NIOSH/MSHA Working Group
  - Refuge alternatives contract (Foster-Miller)
  - Mine curtain survivability system contract (Battelle)
  - Explosive forces, debris fields, and anchoring
  - Thermal analyses contracts (Raytheon UTD)
  - Heat and humidity (NASA, O'Donnell Consulting)
  - Refuge chamber moving issues
  - Best practices world-wide
  - Cost estimates
  - Location guidance
  - Survivability evaluations
  - Training issues

http://www.cdc.gov/niosh/mining/

Research Goal

To conduct research that provided mine workers with the best possible chance of surviving a mine disaster

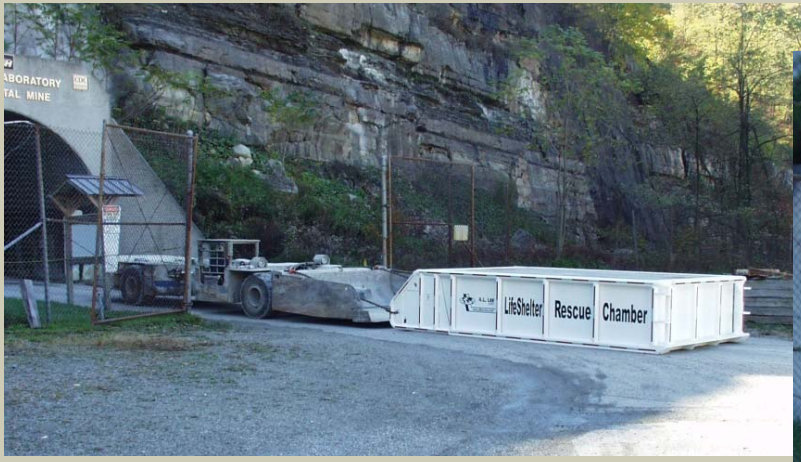
- Most survivable refuge alternatives
- Broker of honest science

Survivability Evaluations

Simulated survivability performance evaluations of chambers approved by WV at the designed occupancy

- CO_2 scrubbing (below 0.5%)
- O_2 supply (above 19.5%)
- Heat and humidity (below Apparent temp. of 95 deg F)
- Duration (96 hrs)

Survivability Evaluations – Lake Lynn

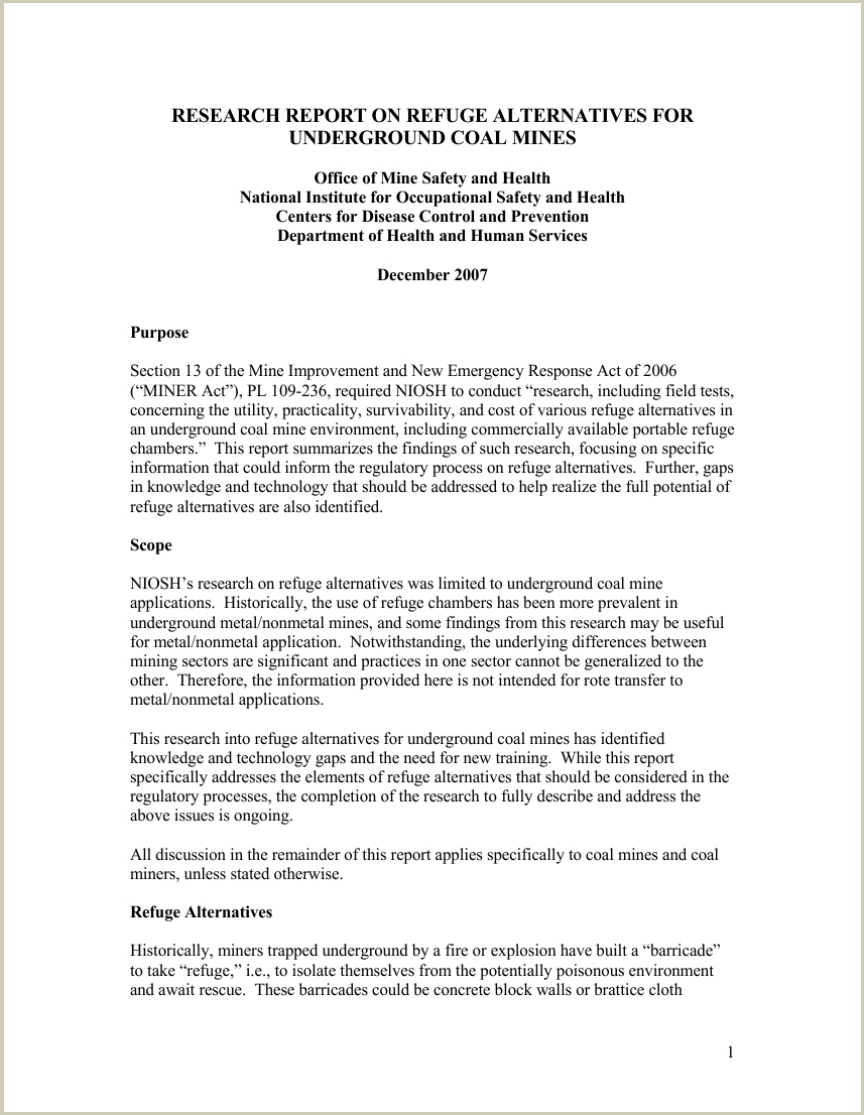


Survivability Evaluations – Lake Lynn

Survivability Evaluations - Results

- Minor problems with CO_2 scrubbing (maintaining below 0.5%)
  - Scrubber materials/container malfunctions
  - Curtains fell over and absorbed moisture
  - Mix-up on number of curtains to hang
- Minor problems with O_2 supply (depleted prior to 96 hrs)
  - Backward check valve installation
  - Fluctuating flow rates
- Questions about apparent temperature (above 95°F)
  - Steel chambers

Refuge Alternatives Recommendations



RESEARCH REPORT ON REFUGE ALTERNATIVES FOR UNDERGROUND COAL MINES

Office of Mine Safety and Health
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention
Department of Health and Human Services

December 2007

Purpose

Section 13 of the Mine Improvement and New Emergency Response Act of 2006 ("MINER Act"), PL 109-236, required NIOSH to conduct "research, including field tests, concerning the utility, practicality, survivability, and cost of various refuge alternatives in an underground coal mine environment, including commercially available portable refuge chambers." This report summarizes the findings of such research, focusing on specific information that could inform the regulatory process on refuge alternatives. Further, gaps in knowledge and technology that should be addressed to help realize the full potential of refuge alternatives are also identified.

Scope

NIOSH's research on refuge alternatives was limited to underground coal mine applications. Historically, the use of refuge chambers has been more prevalent in underground metal/nonmetal mines, and some findings from this research may be useful for metal/nonmetal application. Notwithstanding, the underlying differences between mining sectors are significant and practices in one sector cannot be generalized to the other. Therefore, the information provided here is not intended for rote transfer to metal/nonmetal applications.

This research into refuge alternatives for underground coal mines has identified knowledge and technology gaps and the need for new training. While this report specifically addresses the elements of refuge alternatives that should be considered in the regulatory processes, the completion of the research to fully describe and address the above issues is ongoing.

All discussion in the remainder of this report applies specifically to coal mines and coal miners, unless stated otherwise.

Refuge Alternatives

Historically, miners trapped underground by a fire or explosion have built a "barricade" to take "refuge," i.e., to isolate themselves from the potentially poisonous environment and await rescue. These barricades could be concrete block walls or brattice cloth

1

- Refuge Alternatives Report completed and delivered to Congress December 2007

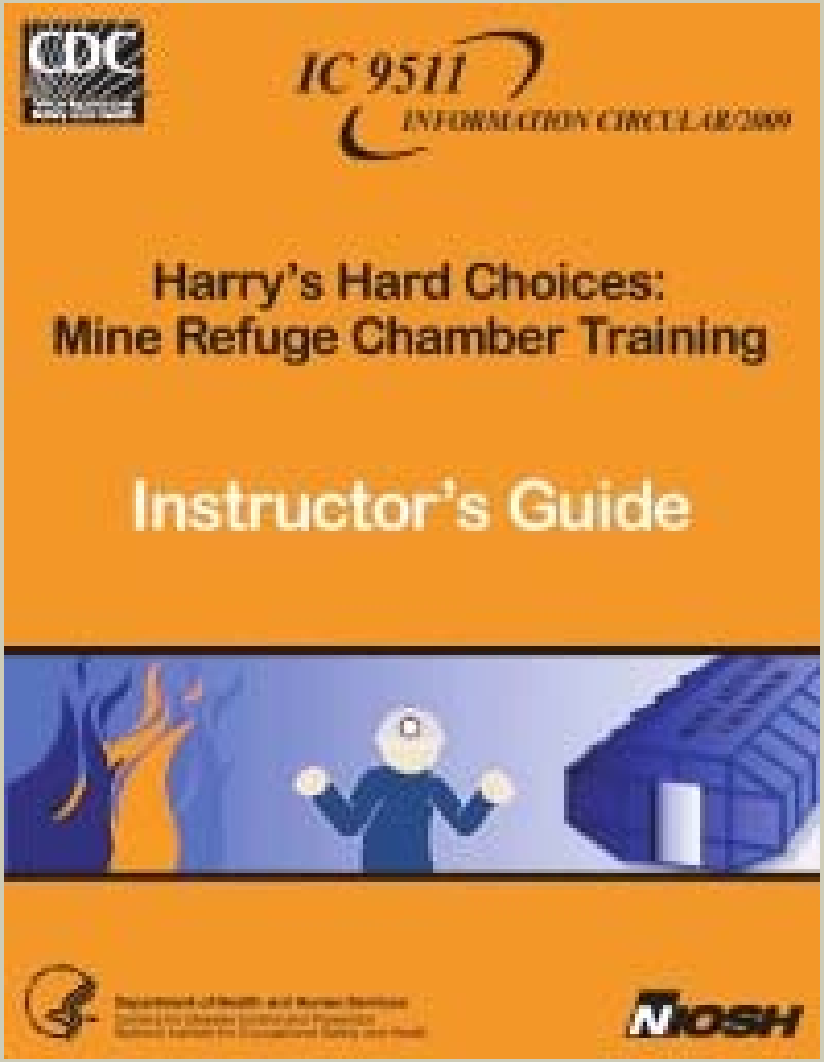
- Addressed the utility, practicality, survivability, and cost of various refuge alternatives in an underground coal environment, including field testing

Refuge Alternatives Research - Conclusions

- Extremely useful to facilitate escape from the mine as well as to serve as a safe haven of last resort
- Practical for use in most underground coal mines to facilitate escape and to serve as a refuge of last resort
- Able to provide a survivable atmosphere based on existing technology
- Costs of implementation and use are not a prohibiting factor for most mines

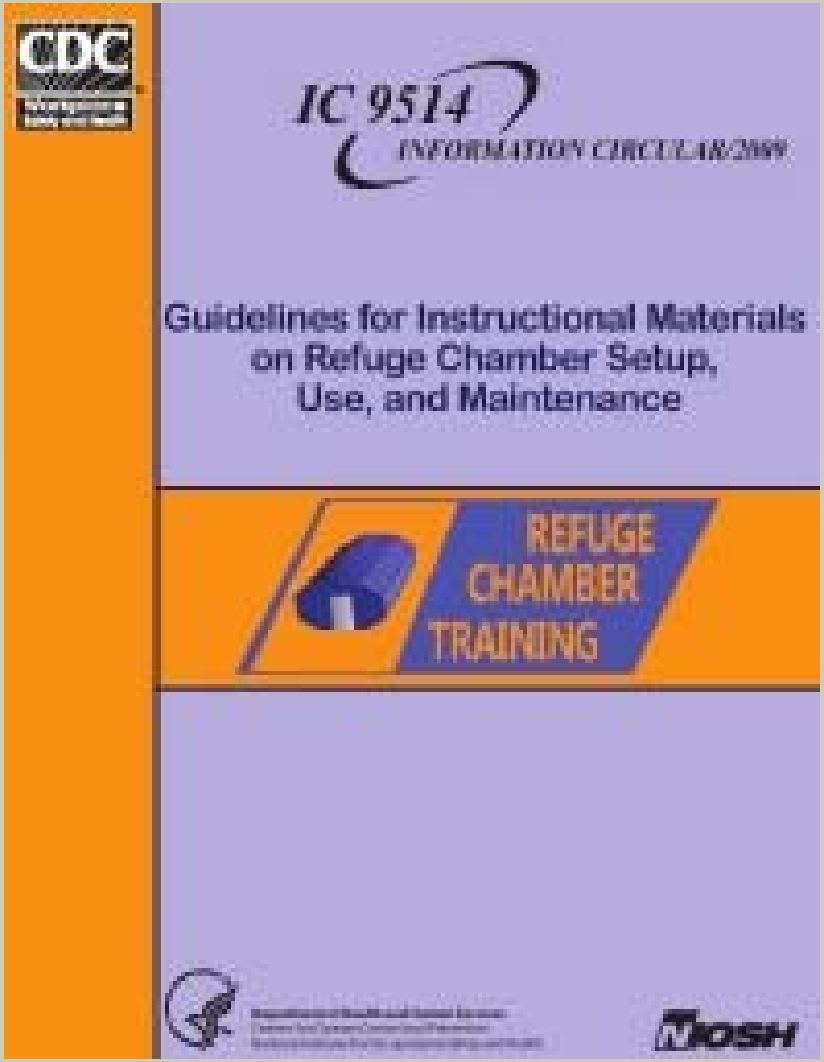
http://www.cdc.gov/niosh/mining/

Training Research



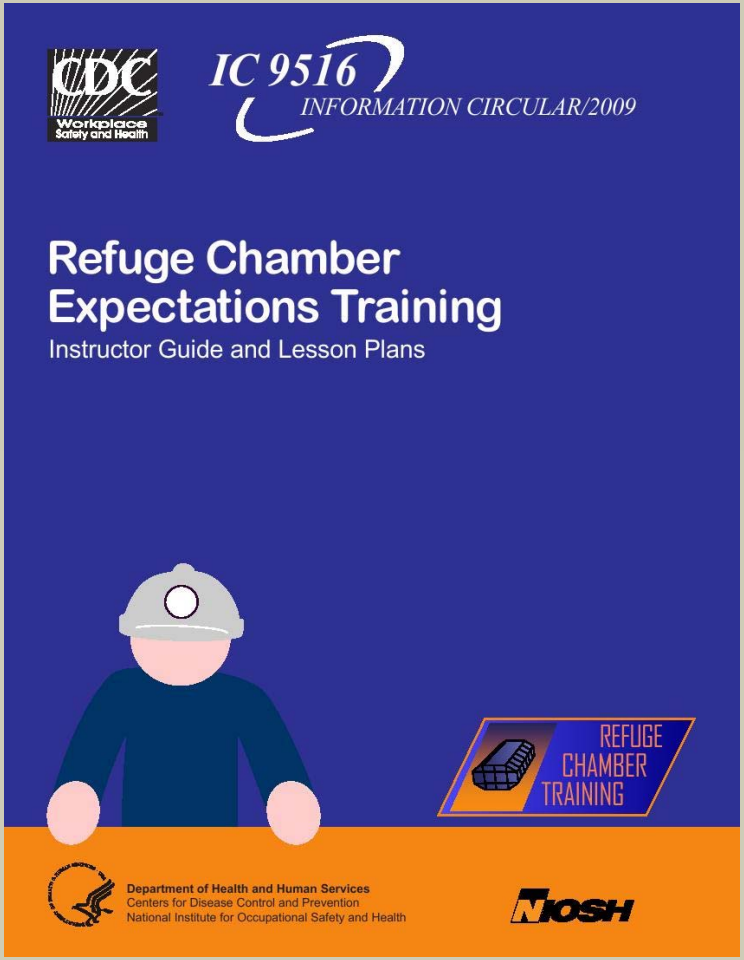
- Decision making - When to use a refuge chamber

Training Research



- Operational - How to use a refuge chamber, Improved instruction manuals

Training Research



- Expectations - Psychological & physiological aspects

http://www.cdc.gov/niosh/mining/topics/training/refugechambers.htm

Current Training Research

- When Do You Take Refuge?: A Computer-Based Training Module
- Best Practices for Operations Training
- Emergency Escape and Refuge Alternatives
- How to Operate a Refuge Chamber: A Quick Start Guide

http://www.cdc.gov/niosh/mining/topics/training/refugechambers.htm

Current Research - Heat Transfer

- Concern from survivability evaluations
- Mines with higher ambient temperatures, 75+°F
- Post disaster mine temperatures may be greater than 55-60°F
- At full capacity internal apparent temperature may exceed 95°F
- May require reducing number of occupants or time of occupancy

Heat Transfer Research

Goals:

1. Gain an understanding of the heat transfer processes occurring during refuge chamber use
2. Gain understanding of the effect that higher mine temperatures have on heat transfer out of refuge chambers
3. Develop general occupancy de-rating factors, time of occupancy reduction criteria, cooling requirements

Research:

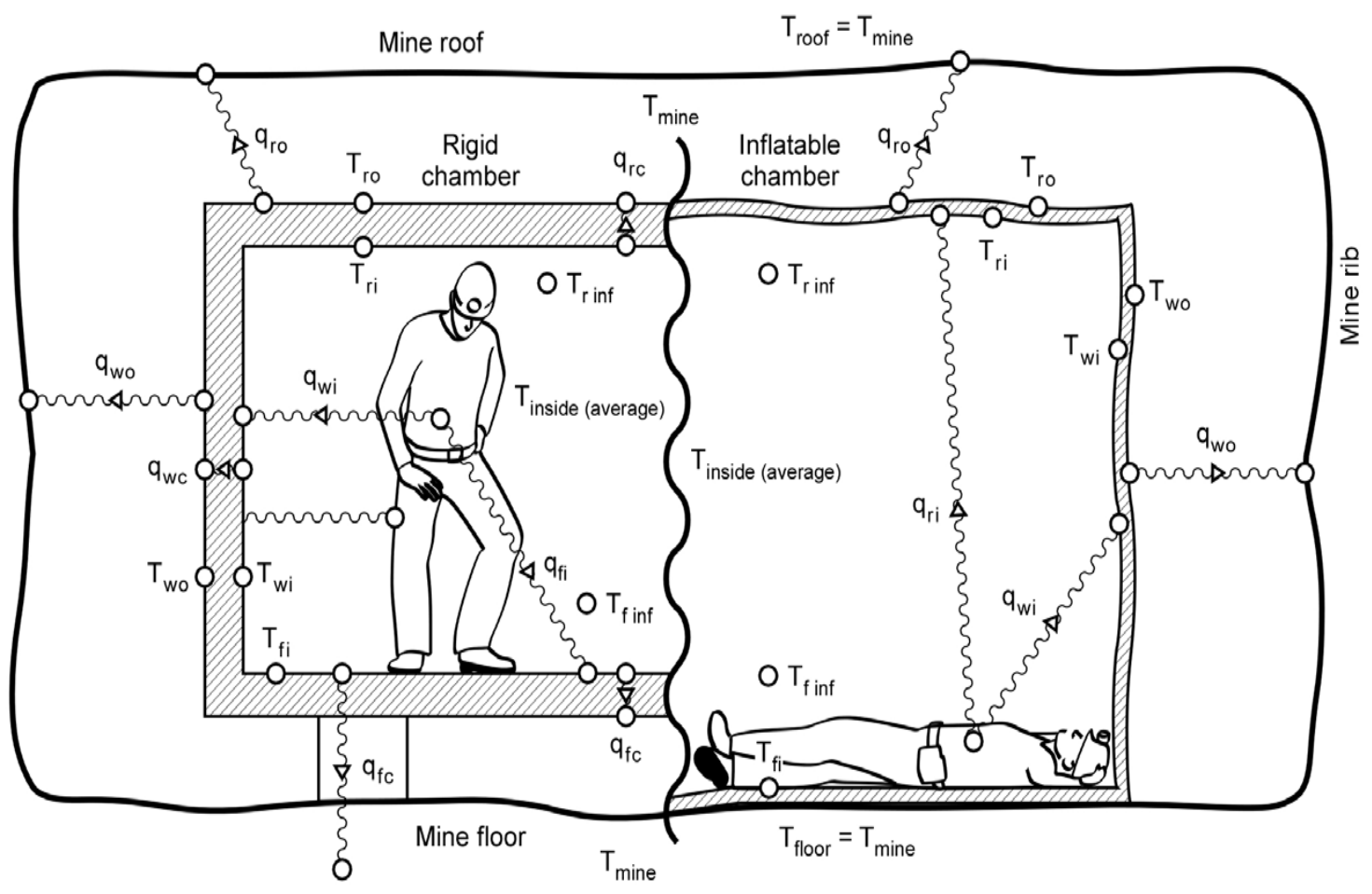
- Several modeling/simulation/calculation efforts underway – Internal and Contract (NASA, O'Donnell Consulting)

Fundamentals of Heat Transfer

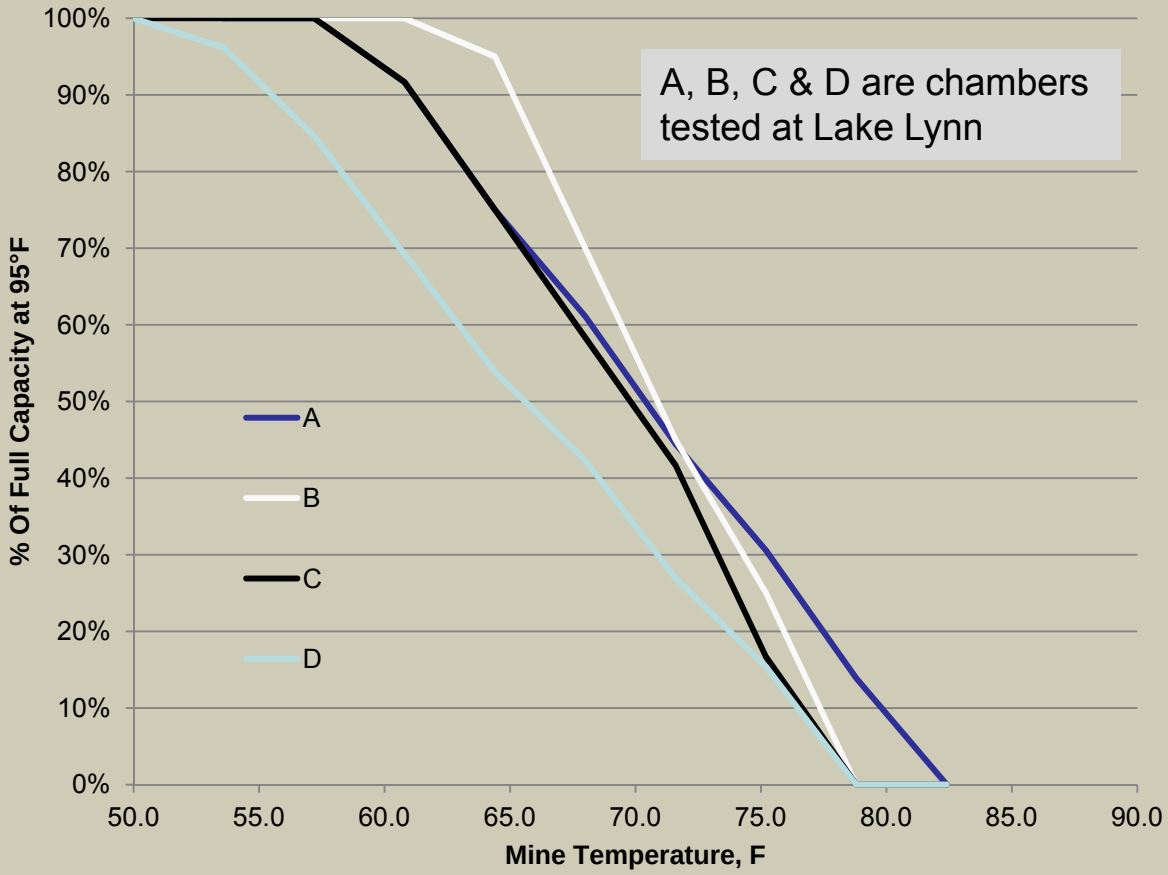
Heat flow from the chamber to the ambient air in the mine can be described in three separate thermodynamic processes:

1. Heat transfer from radiation – through the air
2. Heat transfer from convection
   - Convective heat transfer from the air inside the chamber to the chamber walls, roof and floor
   - Convective heat transfer from the outside walls and roof of the chamber to the mine air
3. Heat transfer from conduction
   - Conductive heat transfer through the roof, walls and floor of the chamber
   - Conductive heat transfer into the mine floor

Heat Transfer Research



Heat Transfer Research - Results



Future Research - Timing

"Next Generation" of refuge alternatives – Approaching the 5 year time frame for MSHA approval of grandfathered refuge alternatives

- Components approved by 2013
- Box approved by 2018

Initiating a 3-yr. project, starting October 2010

Future Research - Issues

The four main issues or focus for future refuge alternatives research include:

- Survivability
- Tolerability
- Engineering Design and Application
- Training

Future Research - Survivability

Survivability focuses on the workers being able to survive for a specific duration and involves primarily establishing and maintaining a life supporting atmosphere

- Purging
- Heat and humidity, cooling
- Oxygen supply and carbon dioxide scrubbing systems
- Carbon monoxide scrubbing

Future Research - Tolerability

Tolerability is an occupant's ability to withstand or tolerate the physical and psychological conditions inside a chamber during refuge

- Human Interface and Usage – Posture, controls, supplies
- Sickness and waste management
- Psychological and behavioral health issues of long duration refuge

Future Research – Engineering Design & Application

Because the industry is nearing a crossroads with respect to refuge alternatives approvals…

- Ideal time to begin a discussion and to implement comprehensive and integrated plans for using refuge alternatives to facilitate self escape as well as rescue
- In-place shelters can be used in lieu of portable chambers (provide economically feasible alternatives to portable refuge chambers)
- Mine rescue issues

The End

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