Closed-Circuit Escape Respirators (CCER) Proposed Concepts

Disclaimer: These concepts are being presented for discussion purposes only and do not represent any final determination or policy of the agency.

Colorado School of Mines
Golden, CO
September 28, 2006

Agenda

Time	Topic	Presenter
9:00 a.m.	Welcome/Opening Remarks	Les Boord, NIOSH
9:45 a.m.	History/Background of SCSRs	Les Boord, NIOSH
10:30 a.m.	Break	
10:45 a.m.	Proposed Concepts	Tim Rehak/Bob Stein, NIOSH
12:30 p.m.	Lunch	
1:30 p.m.	Presentation on SCSR Research	Frank Koh, Univ. of Maryland
2:15 p.m.	Outside Speakers	
2: 45 p.m.	Break	
3:00 p.m.	Comments	
4:00 p.m.	Adjourn	

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Administrative Details

- **Meeting Logistics**
  - Sign In Sheets
  - Meeting Recorded, Transcribed for Docket
  - Presentation in accordance with the Agenda
  - Q & A Period After Presentations
  - Who / Organization / Comment @ Microphone

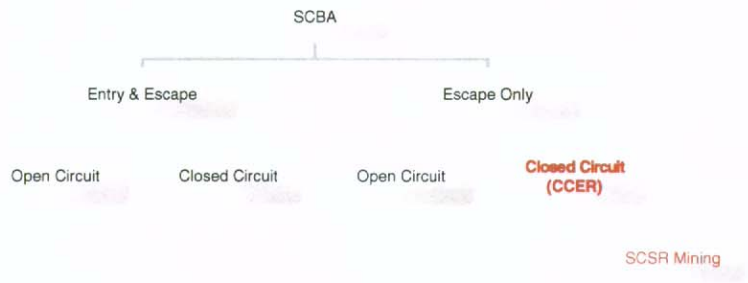
Closed Circuit Escape Respirator (CCER) Meeting

Meeting Purpose

- Present Concepts for Close-Circuit Escape Respirators
  - Breathing and Metabolic Simulators (BMS)
  - Ruggedness and Reliability Concepts
  - Safety Concepts
  - Eye Protection
  - Post Certification Testing
  - Registration
- CCER Concept Paper on Website
  - http://www.cdc.gov/niosh/npptl/resources/certpgmspt/meetings/091906/090706CCERconcept.pdf

Terminology

42 CFR, Part 84 Subpart H Self-Contained Breathing Apparatus



- **CCER = Closed Circuit Escape Respirator**
- **SCSR = Self Contained Self Rescuer = CCER for mining**

NIOSH/NPPTL CCER Public Meeting

The National Institute for Occupational Safety and Health, in consultation with the Mine Safety and Health Administration (MSHA), is in the process of developing a proposed rule on the performance and reliability requirements of close-circuit escape respirators (CCER).

Timeline

- **Public Meetings – Concepts**
  - September 19, 2006 - Arlington, VA
  - September 28, 2006 – Colorado School of Mines
- **Comments to the Docket – November 1st**

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Contact Information

Information Docket (Reference Docket # NIOSH 05)

- Mail: NIOSH Docket Office
  Robert A. Taft Laboratories, M/S C 34
  4676 Columbia Parkway
  Cincinnati, OH 45226
- Email: niocindocket@cdc.gov
- Fax: (513) 533-8285
- Phone: (513) 533-8303
- NPPTL Web Site: http://www.cdc.gov/niosh/npptl

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    - 412.386.6866
    - Email – ter1@cdc.gov

Mine Escape Respirator Program

Comprehensive program to advance mine escape respirator technology

- Provide respiratory protection with increased capacity (duration)
- Reduce physiological burden of escape respirators
- Improve ruggedness and durability of escape respirators
- Improve the capability to provide realistic training

Mine Escape Respirator Program

Program components:

- New Technology Workshops
- Evaluation of Deployed Mine Escape Respirators
- Escape Respirator Research
  - Hybrid Escape Respirator Research
  - Dockable Escape Respirator Research
- Mine Escape Respirator Training Support
- New Test and Evaluation Requirements

New Technology Workshops

New technology for escape respirators

- Oxygen generation
- Carbon dioxide removal
- Carbon monoxide elimination
- Materials for respirator components
- Materials for storing chemicals and high pressure gasses
- Test technology
- Training methods and materials
- Service and maintenance

New Technology Workshops

- **Collaboration with National Technology Transfer Center (NTTC)**
- **Series of workshops**
  - Two workshops during 2005 (June & December)
  - Third workshop July 2006
  - Fourth workshop planned
- **Innovative and creative approaches for all aspects of mine escape respiratory protection**

Evaluation of Deployed Mine Escape Respirators

Long Term Field Evaluation Program initiated >20 years ago U.S. Bureau of Mines

- Laboratory test to evaluate SCSR performance
- Minimum 200 escape respirators per year
- Annual respirator manufacturer quality site audits
- Annual report

Hybrid Self Rescuers

Hybrid Self Rescuer (HSR): Combination SCSR and FSR Respirator

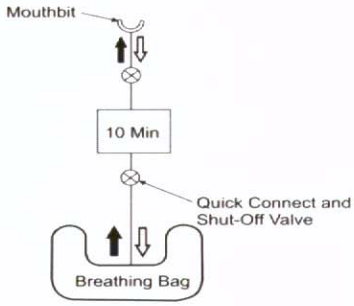
- Operation
  - SCSR
    - O_2 Supply & CO_2 Removal
    - KO_2, Chlorate or Compressed Gas
  - FSR
    - Traditional Technology → Hopcalite for CO removal
    - New Technology → CO Oxidation Catalysts is encouraged
- Advantages
  - Extended Protective Capacity
- Challenges
  - Sensing CO & O_2
  - Switching → Mode of Operation

Dockable Self Rescuers

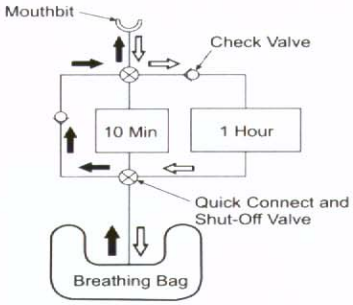
Dockable Short & Long Duration SCSR

- Operation
  - Chemical Based, or
  - Compressed Gas
- Advantages
  - Eliminates Multiple Donnings – breathing circuit not compromised
  - Extended Protective Capacity
  - Allows for Smaller, Lighter Carried SCSR
- Challenges
  - Docking operation in contaminated atmosphere
  - Maintain breathing circuit
  - Reliability of mechanism / operation

Schematic Dockable SCSR



SHORT DURATION SCSR



COUPLED SHORT AND
LONG DURATION SCSR

Escape Respirator Training Support

- **Collaboration with MSHA**
- **Develop training modules on inspection, care & use**
- **Update training modules for multiple donning**
- **Support MSHA with SCSRs for live training**

New Evaluation Concepts

- **Topic for public meeting**
  - Closed Circuit Escape Respirator (CCER)
  - Evaluation Concepts for NIOSH/MSHA Certification
- **Previous public meeting - 2003**
- **Staff level work to prepare rulemaking data for CCER evaluation concepts**
- **Reintroduce concepts development via public meetings and comments**

Wrap Up

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Closed-Circuit Escape Respirators (CCER) Proposed Concepts

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SCSR History

CCER Public Meeting
28 September 2006

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SCSR History

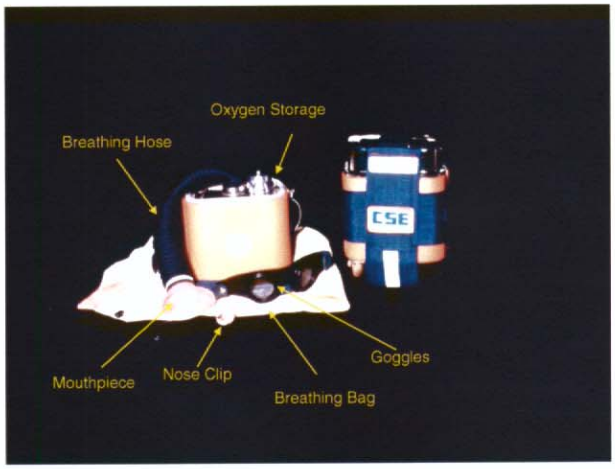
- **Pre-1981 miners rely on FSRs**
- **1981 1st generation SCSRs**
  - Joint MSHA/NIOSH approval under 30 CFR 11
  - MSHA (30 CFR 75.1714)
- **1983 LTFE begins (50/year)**
- **1989 2nd generation SCSRs**
  - Smaller, lighter weight
- **2001 NPPTL Established**
  - LTFE expands
    - 200 SCSRs/phase
- **2003 – Concepts developed for New SCSR Requirements**
- **NTTC Workshops (June 05, December 05, July 06)**
- **2006 MSHA Emergency Temporary Standard**
- **2006 Miner Act**
- **2006 – Request for Proposals Released**
  - Dockable SCSR
  - Hybrid SCSR

Lessons Learned From The 25 Year History Of SCSRs

- **Escape is the primary survival strategy.**
- **In some cases more than 1 SCSR per miner is needed for escape.**
  - 1 hr SCSR does not mean 1 hr for every miner under every circumstance
  - Actual duration depends upon
    - Miner – body weight , age, physical fitness
    - Difficulty of the escape – distance, escapeway factors

MSHA/NIOSH Approved SCSRs

SCSR Components

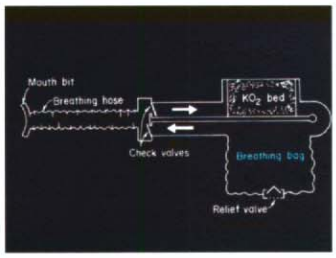


Self Contained Self Rescuer Operation

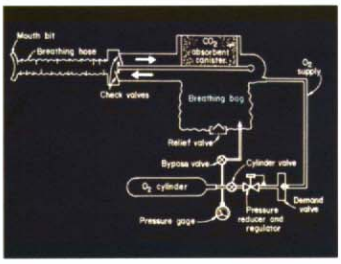
- **Chemical Based Systems**
  - Potassium Superoxide
  - CO_2 Removal
  - O_2 Generation
- **Compressed Oxygen Systems**
  - Compressed O_2 Supply
  - Chemical CO_2 Removal (LiOH)

How An SCSR Works

Chemical Oxygen



Compressed Oxygen



Partnerships

- **Stakeholders**
  - BCOA
  - NMA
  - UMWA
  - USWA
  - U.S. Navy
  - SCSR manufacturers: CSE, Draeger, MSA, and Ocenco
- **MSHA is co-approver**

Long-Term Field Evaluation (LTFE)

LTFE Publications

Pub #	Published	Test dates	Results
RI9051	1986 pub	First year of a 5 year program	
RI9401	1992 pub	Testing 82-90	Phase 1, 2, and 3
RI9499	1994 pub	Testing 89-93	Phase 4
RI9635	1996 pub	Testing Mid-93 to Early-96	Phase 5
IC 9451	2000 pub	Testing Mid-96 to early 98	Phase 6
RI9656	2002 pub	Testing May 99 – Aug 00	Phase 7
	in review	Testing Dec 00 - Apr 02	Phase 8
	in review	Testing Jun 02 - Apr 04	Phase 9

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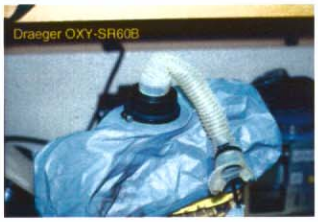
SCSRs (1st Generation)



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SCSRs (2nd Generation)

Non-Destructive Tests

High Temperature

CSE

Bed Degradation

CSE

Draeger

LTFE Conclusions

- **SCSRs that pass inspection criteria should provide for safe life support**
- **Some performance degradation observed in all apparatus**

LTFE Protocol

- **Objective**
  - Compare the performance of deployed SCSRs to new SCSRs.
- **Method**
  - Collection inspection
  - Sample
  - Replace
  - Laboratory inspection
  - Test
- **Report**
  - LTFE Report
  - Investigation reports

LTFE Testing

BMS

Man Test -Treadmill

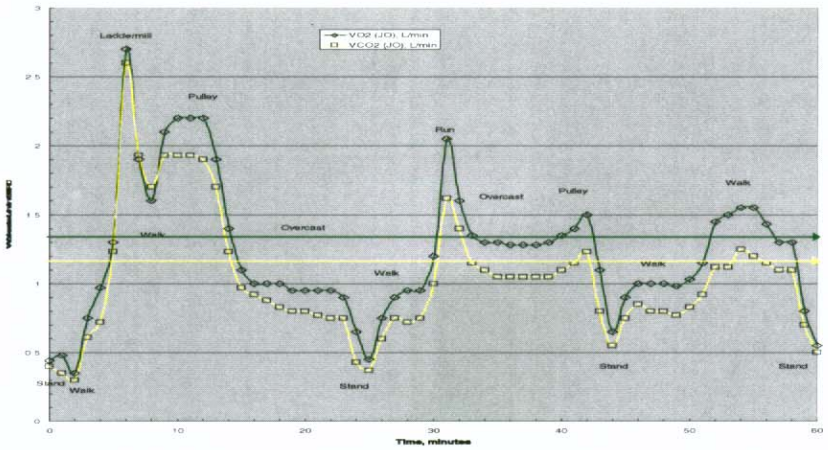
Metabolic workload	BMS	Treadmill
O_2 consumption rate L/min.	1.35	1.35
CO_2 production rate L/min.	1.15	*
Ventilation rate L/min.	30.0	*
Tidal volume L/breath	1.68	*
Respiratory frequency breaths/min.	17.9	*
Peak respiratory flow rate:		
Inhalation L/minute	89	*
Exhalation L/minute	71	*

* Pace of treadmill test is set to maintain oxygen consumption at the stated rate.

NIOSH Certification Testing Man Test #4

- **Test which assigns rated duration.**

Man Test #4 Metabolic Load



LTFE Data and Results

- The purpose of the LTFE is to obtain data to compare the performance of deployed to new SCSRs.
- Evaluations are based on experimental protocols not certification standards
- Test methods, protocols and results are not substitutes for nor superior to 42 CFR 84
- Process of discovery
  - Not based on a random sample
  - Discover problems that the existing standard may not have anticipated
  - Compare new to field deployed SCSRs
  - Practical improvements
- Results
  - Test results alone do not predict successful use in a mine escape

Reliability

- **Reliability = Will my SCSR work?**
  - How has it been handled?
  - How old is it?
- **Reliability = When should an SCSR be removed from service?**
  - Are the inspection criteria sound?
  - Are users well trained to inspect?

Actions

- **Inspect all field deployed SCSRs**
  - Remove non-conforming units from service
- **Voluntary Registration**
  - NPPTL Web-based model
- **Training**
  - Multiple donning
  - Training with "live" apparatus
- **Expanded LTFE**
  - Link LTFE to CPIP and Site Audits
  - Timely outcomes

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Applicable Sections of 42 CFR Part 84

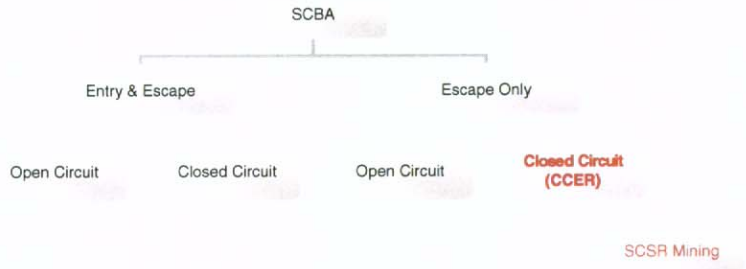
- Subpart A – General Provisions (entire subpart)
- Subpart B – Application for Approval (entire subpart)
- Subpart C – Fees (entire subpart)
- Subpart D – Approval and Disapproval (entire subpart)
- Subpart E – Quality Control (entire subpart)
- Subpart F – Classification of Approved Respirators; Scope of Approval; Atmospheric Hazards; Service Time – Paragraphs 84.50, 84.51, and 84.52
- Subpart G – General Construction and Performance Requirements (entire subpart)

CCER Concepts

- Description
- Applicability to new and previously approved CCERs
- Required components, attributes, and instructions
- General testing conditions and performance concepts
- Capacity tests
- Performance tests
- Wearability tests
- Environmental treatments
- Additional testing
- Post-certification testing
- Voluntary Registration

Terminology

42 CFR, Part 84 Subpart H Self-Contained Breathing Apparatus



- **CCER = Closed Circuit Escape Respirator**
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Technical Improvements

- **Research**
- **Long Term Field Evaluation (LTFE)**
- **Certification**
- **Certified Product Investigation Program (CPIP)**

Components, Attributes, and Instructions

- **Components**
  - NDT
  - Tamper-resistant/tamper-evident casing
  - Eye protection
- **Attributes**
  - Meet the general construction requirements of 42CFR84
  - Must not constitute a hazard
- **Instructions**
  - Hands–on Training
  - Service Life

General Testing Conditions and Performance Concepts

- **Breathing and metabolic simulator**
  - Capacity test
  - Performance tests
- **Human subject tests**
  - Used for qualitative evaluations
  - Wearability

General Testing Conditions and Performance Concepts

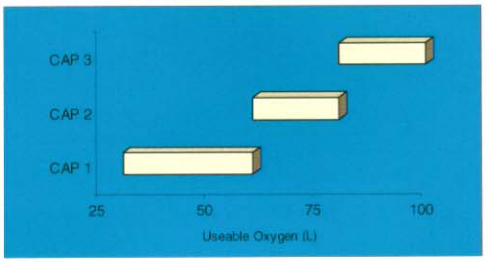
Stressor	*Acceptable Range Operating Average*	*Acceptable Range Excursion*
Average inhaled CO_2	<1.5%	_4%
Average inhaled O_2	>19.5%	_15%
Peak breathing pressures	ΔP _ 200 mm H_2O	-300 _ ΔP _ 200 mm H_2O
Wet-bulb temperature	<43°C	_50°C

Proposed Capacity Tests

- Tests
  - Continuously Monitored
    - Breathing and metabolic simulator (BMS)
    - BMS after environmental treatments
    - Human subject on a treadmill
- Cap 3 rating for mining SCSRs
  - 2 each – one-hour Man Test 4

Capacity Test Concepts

Capacity Rating	Capacity (L)	O_2 (L/min)	CO_2 (L/min)	Ve (L/min)	RF (Breaths/min)
Cap 1	30 _ L _ 59	2.50	2.50	55	22
Cap 2	60 _ L _ 79	2.00	1.80	44	20
Cap 3	L _ 80	1.35	1.15	30	18

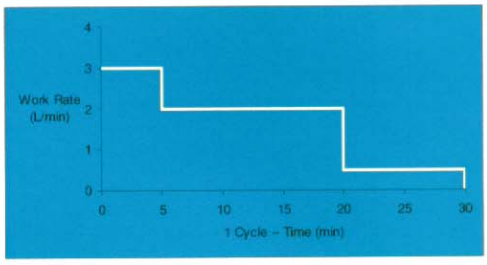


Proposed Performance Tests

- **Tests**
  - Variable work rates
  - Continuously monitored
    - BMS
    - BMS after environmental treatments
    - Human subject on treadmill

Performance Test Concepts

Work-Rate Test Sequence	Duration per cycle	O_2 (L/min)	CO_2 (L/min)	Ve (L/min)	RF (breaths/min)
1. Peak	5 min.	3.00	3.20	65.0	25
2. High	15 min.	2.00	1.80	44.0	20
3. Low	10 min.	0.50	0.40	20.0	12



Wearability Test Concepts

- Ensure the CCER can be easily and quickly donned.
- Ensure that, during any reasonably anticipated activity, the CCER:
  - Will not physically harm the user,
  - Will not significantly hinder the user,
  - Will provide an adequate and uninterrupted supply of breathing gas.

Activity	Minimum Duration
Sitting	1 min.
Stooped walking	1 min.
Crawling	1 min.
Lying on left side	1 min.
Lying on right side	1 min.
Lying on back	1 min.
Bending over to touch toes	1 min.
Turning head from side to side	1 min. (at least 10 times)
Nodding head up and down	1 min. (at least 10 times)
Climbing steps or a laddermill	1 min. (1 step/sec)
Carrying 50-lb bag on treadmill at 5 kph	1 min.
Lifting 20-lb weight from floor to an upright position	1 min. (at least 10 times)
Running on treadmill at 10 kph	1 min.

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Proposed Environmental Treatments

- Four units will be tested for capacity and performance - post treatment
- Treatments:
  - Extreme temperatures
    - 16-hours at -45°C
    - 48-hours at 71°C
  - Physical shock – dropped from a height of 1-meter on each axis
  - Vibration – 180 minutes along each axis
    - MIL Spec 810

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Proposed Additional Testing

- Safety hazard tests (15 additional new units) on apparatus that:
  - Stores more than 200 liters of oxygen
  - Stores compressed oxygen at pressures exceeding 3,000 psi
  - Bureau of Mines
- Eye protection:
  - Dust – ISO 4855, Clause 13
  - Gas – ISO 4855, Clause 14
  - Durability – ISO 4855, Sub-Clause 3.1
  - Fogging - EN 168: 2000

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Proposed Post-Certification Testing

- Test new and deployed for capacity and performance
- Failure may result in revocation of approval or remedial actions
- NIOSH will replace deployed units obtained for testing
- Approval holder must make units available for purchase

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Proposed Voluntary Registration

- **Purpose**
  - To provide information on numbers and locations
- **Support post certification testing and evaluation**
  - LTFE sampling
- **Basis for quick and effective reaction to field complaints**
  - Risk communication
  - Recalls
- **Manufacturer required to:**
  - Provide procedures
  - Purpose

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Proposed Registration Website

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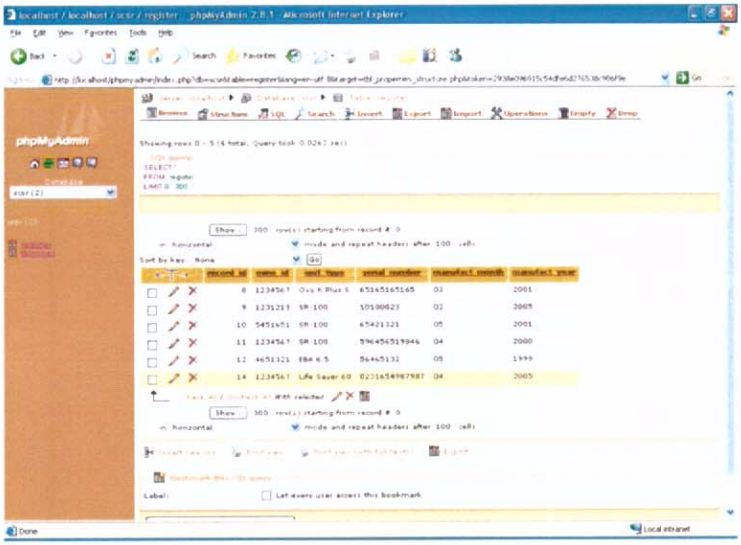
Registration Spreadsheet



Propose Applicability to New and Previously Approved CCERs

- **Manufacturers and distributors can continue to sell CCERs with current approvals for 3 years.**
- **CCERs with current approvals can remain in use for 6 years.**