



OFFICE OF THE DIRECTOR

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BUREAU OF MINES
2401 E STREET, NW.
WASHINGTON, D.C. 20241

December 22, 1987

Dr. Nelson Leidel
NIOSH Docket Office
Mail Stop E-23
1600 Clifton Road, NE.
Atlanta, Georgia 30333

Dear Dr. Leidel:

This is in response to the notice of proposed rule making by the National Institute for Occupational Safety and Health intending to replace 30 CFR 11 with 42 CFR 84. Our questions, comments and recommendations are enclosed.

The Bureau of Mines is conducting a vigorous research program for respiratory protective equipment used in mine escape and rescue. This type of equipment is exclusively closed-circuit, and infrequently used outside of the mining field. This being the case, it has been the Bureau, largely alone, that has investigated the improvement of closed-circuit apparatus for both escape and rescue, the physiological limits to stressors imposed by such apparatus, and the best ways to test the apparatus. It is with this background that we have reviewed the proposed changes in the Federal testing and certification program.

We would also like to present our recommendations at the public meeting in Washington, D.C., in January 1988.

Sincerely,

J. Morgan for David S Brown
Acting Director

Enclosures

*Rec'd Docket Office
1/5/88*

42 CFR 84 REVIEW

Bureau of Mines Questions

- 1) 84.31 - Workplace testing is proposed as part of the certification process. Is this meant to apply only to respiratory protective devices used routinely in the workplace or does it also apply to apparatus used in emergency escape and rescue work? And how will this improve the performance of such apparatus?
- 2) 84.232 - Will NIOSH require fit testing for closed-circuit breathing apparatus (CCBA)? And, if so, what procedures should be used, since test contaminants to the breathing circuit would accumulate in closed-circuit devices, thus, increasing over elapsed time? Also, given a certain size leak, would not leakage be related to negative mask pressure, which is related, in turn to inspired flow rate? If inspired flow rate is not quantified, then, how can such leak testing be considered quantitative?
- 3) 84.242 b - Will the restriction on positive-pressure CCBA to non-fire-exposure areas be removed?

Comments

- 1) We were happy to see our past suggestion for imposing a format on breathing apparatus operating manual contents in 84.50 a1, requiring certain aspects of operation and maintenance to be addressed, and also the adoption of vibration and shock testing in 84.248-12a and b which is very similar to that which we developed in our study on the mineworthiness of self-contained self-rescuers in 1982. It should be recognized, however, that these tests were developed specifically to simulate underground mining conditions and may be inappropriate for other types of equipment.

Recommendations

- 1) 84.100 - It is proposed in this section that MSHA review applications for apparatus to be used in mine escape and rescue. Since the Bureau is conducting all of the research in this area as it pertains to mining and serves MSHA's technical needs in the area of closed-circuit mine escape and rescue apparatus, we believe that the Bureau should play a direct role in this regard; perhaps by participating in the MOA between MSHA and NIOSH.
- 2) 84.248-3 - Rather than use gasoline as the vapor for the breathing bag permeability test, we recommend using whatever gases to which the user is expected to be exposed and that the levels leaking into the apparatus be kept below those known to adversely affect the human body.
- 3) 84.248-14 - We recommend substantial changes be made in this section. The key elements that we propose are that:
 - a) the described use-tests for CCBA be replaced with tests that are more quantitative and/or purpose-specific as follows:

- Normal-use test - to quantify the deliverable amount of breathing gas of a CCBA
 - High-performance test - to ensure acceptable performance at high work levels
 - Human factors test - to ensure compatibility with the human body
- b) continuous monitoring be employed in the first two of the proposed tests which are quantitative in nature.
 - c) rather than classifying apparatus by duration, which depends upon the actions and weight of the test subject, apparatus be classified by quantity of deliverable breathing gas. This would be determined in the Normal-use test at a constant metabolic rate similar to that which would be expected in normal use for a particular type of apparatus.
 - d) the use of a breathing and metabolic simulator (later described) be permitted to be used in the first two quantitative tests as a replacement for human subjects.
 - e) physiologically-appropriate stressor limits replace those that are deemed by physiological research to be inappropriate.

These elements of our proposal will now be described in more detail. The specific numbers we have suggested for metabolic loads and stressor limits are what we believe are reasonable based on our best judgment at this time.

THE NORMAL-USE TEST

Recognizing that duration depends upon breathing-gas use-rate which varies with user and work load, we recommend classifying CCBA by quantity of deliverable breathing gas, usually O₂, rather than by duration. These quantities would be determined by the Normal-use test, at a constant workload; the apparatus would be classified by the quantity of gas delivered to a human test subject or a breathing and metabolic simulator (later described), rounding off to the nearest lower increment of 5 liters.

The Normal-use test work load should approximate the breathing gas use-rate for the specific task to be performed only for the purpose of appropriately taxing the apparatus for evaluation of its characteristic O₂ and CO₂ concentrations, breathing pressures and inhaled gas temperature. It is suggested that apparatus for mine rescue and escape be tested at a VO₂ of 1.35 L/min STPD. This is the average rate used by the 50th percentile miner performing the 60-minute man-test 4, 30 CFR 11. This is also close to the rate used by miners in a simulated mine escape as described in a Bureau Contract final report¹. The metabolic levels other than O₂ consumption are given later.

Breathing and Metabolic Simulator vs. Human Subject

A breathing and metabolic simulator (BMS) is a machine that simulates both the breathing and metabolic functions of a human being. The Bureau has developed four such simulators since the early 1970's; these are described in

a Bureau publication². Such a machine is preferred by the Bureau over human-subject testing for CCBA due to its ability to quantify input metabolic levels. For those manufacturers without this capability, however, a human subject on a treadmill can be used by varying the speed and/or grade until the desired $\dot{V}O_2$ is achieved. The $\dot{V}CO_2$ and the \dot{V}_e should also be noted. For those with access to a BMS, the two sets of suggested parameters are as follows:

	<u>Medium</u>	<u>High</u>
$\dot{V}O_2$	- 1.35 L/min	- 2.5 L/min
$\dot{V}CO_2$	- 1.10 L/min	- 2.5 L/min
\dot{V}_e	- 30 L/min	- 55 L/min
F_r	- 18 Breaths/min	- 22 Breaths/min

Continuous Monitoring

The Normal-use test and the High-performance test should be continuously monitored, whether using a BMS or a human subject. The stressors that should be monitored are inhaled levels of CO_2 and O_2 , breathing pressures, and temperature. All of these should be monitored at the mouth/apparatus interface. Each will be discussed separately.

CO_2 and O_2 concentrations - The gas concentrations monitored at the mouth during both inhalation and exhalation do not reveal the actual concentrations inhaled by the user since they do not take into account apparatus dead space. The low values of CO_2 , for example, reveal only the best performance of the CO_2 scrubber. Average inhaled concentrations of both gases, as described in Bureau IC 9110, can be calculated either electronically or using a mixing box, both using a BMS. Otherwise, the manufacturer must pass the NIOSH dead-space test as described in 42 CFR 84.248-10 and is permitted inhaled CO_2 levels of $\leq 2\%$ and O_2 levels of $\geq 21\%$. The average inhaled levels of CO_2 are permitted to be $\leq 3\%$ and O_2 levels $\geq 21\%$. The recommended levels of CO_2 are based on Bureau-sponsored contract research^{3 4}.

Breathing pressures - The peak values recommended at a peak flow rate of 120 L/min are, for both inhalation and exhalation, 80mm H_2O . During the Normal-use test and the High-performance test, the peak pressures should remain below 200 mm H_2O for exhalation and 300 mm H_2O for inhalation regardless of ventilation rates. These recommendations are based on Bureau-sponsored contract research³.

Temperature - It has been found that human sensitivity to the combined stressors of dry-bulb temperature and relative humidity can be measured directly by the wet-bulb temperature in the inhaled gas. Until recently, breath-by-breath measurement of wet-bulb temperature was not possible due to the slow response time of humidity measuring instruments. The Bureau and Decagon Devices of Pullman, WA, have developed a fast-response wet-bulb thermocouple that can be used to serve this purpose. The highest tolerable wet-bulb temperature of inhaled air was found to be $45^\circ C$; this is recommended to be the limit for all respiratory protective devices. This is also based on Bureau-sponsored contract research^{3 5}.

THE HIGH-PERFORMANCE TEST

This test will ensure that, in cases of high metabolic work load, the apparatus will not catastrophically fail in some way. It is recognized that the apparatus may sacrifice some efficiency when used at very high work rates so that its quantity of delivered breathing gas should not be rated during this test. We recommend alternating the 1.35 L/min VO₂ for 10 min and the 2.5 L/min VO₂ for 5 min until the breathing gas supply is expended. If it is suspected that the gas supply will not extend to at least 15 minutes, we recommend that the workloads alternate for 2 and 1 min, respectively, until the gas supply is expended.

THE HUMAN-FACTORS TEST

This test will ensure that the apparatus design will not hinder the user in any anticipated activity or be harmful in any other way. At least the following activities shall be performed in any order for sufficient duration to assure compatibility with the human form and necessary activity: stooped walking, crawling, climbing a ladder and steps, crawling on stomach (if applicable), bending over to touch toes, turning head sideways, up and down, and handling anticipated equipment. Stressor monitoring is unnecessary for this test.

REFERENCES

- ¹Recommended Guidelines for Oxygen Self-Rescuers, Volume III, Escapetime Studies in Underground Coal Mines, Contract J0199118, Foster-Miller, Inc., June 1983.
- ²Information Circular 9110, Development of an Automated Breathing and Metabolic Simulator, Nicholas Kyriazi, 1986.
- ³Physiological Responses of Miners to Emergency, Volumes 1 and 2, Self-Contained Breathing Apparatus Stressors, Final Report for Contract J0100092, Pennsylvania State University, October 1984.
- ⁴Behavioral Effect of One-Hour Breathing of High Concentrations of CO₂ and O₂ While Doing Physical Work, Vercruyssen and Kamon, Journal of the International Society for Respiratory Protection, Volume 2, Issue 1, January 1984.
- ⁵Interaction of Temperature and Humidity in Inspired Air on Tissue Temperatures of the Tongue and Hard Palate, Gallagher and Vercruyssen, Journal of the International Society for Respiratory Protection, Volume 4, Issue 2, April-June 1986.