

Closed-circuit escape respirator (CCER) breathing gas capacity uses and limitations

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Background

The National Institute for Occupational Safety and Health (NIOSH) is in the process of developing new standards and test requirements for closed-circuit escape respirators (CCER) used to escape from atmospheres considered to be immediately dangerous to life and health, including such respirators required by the Mine Safety and Health Administration (MSHA) for use in underground coal mines. For specific details of the proposed regulations refer to NPPTL website: <http://www.cdc.gov/niosh/docket/archive/docket005.html>

NIOSH currently approves a CCER as providing protection for a specific duration. However, this information can be misleading since the actual duration and effective protection supplied to a miner during an escape can differ substantially from that received in laboratory testing. The new regulations will replace the breathing gas duration specification with volume of breathing gas (in liters of oxygen) that can be supplied by the CCER.

Management and respiratory protection administrators can select a CCER with a breathing gas capacity required for an effective escape by all miners for their specific mine escape plan by knowing the CCER capacity, along with its uses and limitations, miner weight and estimated oxygen requirements of the escape route. Hence, miners will be afforded more reliable protection during a mine emergency.

Breathing gas capacity- personal requirements

Any activity performed by a person requires oxygen obtained from the air we breathe. Oxygen is consumed by body tissues even while a person rests. The amount of oxygen consumed by a person increases as their activity becomes more physically demanding such as walking, running, climbing steps or other work that uses large muscles. The following table shows the oxygen consumption required by a person of about 190 pounds for three types of physical activities.

Activity	Oxygen Consumption L/min (STPD)
Resting	.315
Intense arm and trunk work: carrying heavy material, digging	1.115
Work at maximal intensity: climbing stairs or ladders at high speed	2.908

ISO/TS 16976-1 (2007) Technical Specification, Metabolic rates and respiratory flow rates, Table A.1, pages 13.

The amount of oxygen required by an individual depends primarily on a persons body weight and additional weight of personal protective equipment or tools being worn or carried. More oxygen is required by a larger person than a smaller one for the same physical activity. The following table illustrates this concept. NIOSH and MSHA currently use Man Test 4, whose activities approximate those similar to a mine escape, which is the basis of the comparison below:

Exercise One- hour Man Test 4	Body Size 190#	Body Size 155#	Body Size 132#
Oxygen consumed (Liters/hour)	80	71	65

Data was extrapolated from ISO/TS 16976-1 (2007) Technical Specification, Metabolic rates and respiratory flow rates, pages 9-11, for 42CFR84, "Man test 4" metabolic requirements.

As the table shows, the largest person requires approximately 23% more oxygen than the smallest person when conducting the same activities. In general, the larger the person's body size the greater the amount of oxygen is required for doing the same activity. Body posture also affects the amount of oxygen consumed by an individual. For miners, the seam height can affect body posture and have an impact on the amount of oxygen needed to escape. As additional muscles are involved in an activity more oxygen is needed to supply those muscles. Therefore, walking upright is the most efficient use of oxygen while conducting an escape followed by: walking bent at the head; walking bent at the waist; stooped walking; crawling; and the least efficient is duck walking.

Oxygen capacity – understanding and using the ratings

A CCER capacity level represents a minimum volume of breathing gas designated as CAP1 (20 - 59 liters); CAP2 (60 – 79 liters); and CAP3 ≥80 liters). The CCER capacity will be reported by its rating (CAP classification) and its available breathing gas volume in 5 liter increments. An approved CCER with CAP3 rating provides at least the same amount of oxygen as previously required for a test subject to pass the one-hour Man test 4.

Knowing the capacity of a CCER provides information that can be used to assure an adequate supply of oxygen is available to meet the estimated demand for an individual to complete specific physical activities. With effective training and trial escapes, a CCER with the proper oxygen capacity can be selected and used. During a mine fire or explosion, each miner must be confident that his CCER can support getting him to a safe location. One way to determine the capacity level required by all miners is to have the heaviest miner wear regular mine protective clothing, equipment, and tools, don the respirator, and travel the escape route to the planned safe location. If the respirator does not supply the required amount of oxygen, one with a greater capacity can be selected or additional respirators must be provided.



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