-----Original Message-----
From: RANDALL HARRIS [mailto:randall.j.harris@verizon.net]
Sent: Sunday, August 17, 2008 8:01 PM
To: zzMSHA-Standards - Comments to Fed Reg Group
Cc: 'RANDALL HARRIS'; tom.daley@microporeinc.com; rwooten@mines.state.wv.us; 'James Dean'; kathleen.m.harris@verizon.net
Subject: RIN 1219-AB58

RE: Concerning the August 13, 2008 email posted from Tom Daley of Micropore Inc concerning a comment
included in the August 1, 2008 submittal by Randall Harris

I appreciate Tom's thoughts concerning the comments I submitted, but believe his response implies
that he took my comment out of context.

The US Navy report referenced by myself and Tom do indeed discuss impairment of fine motor skills
and cognitive performance on exercises that simulated operating equipment. These exercises were
repeated periodically during extended exposure to high levels of CO2 and the changes in performance
were compared as a function of CO2 exposure.

However, in an emergency underground mine shelter operating the complicated controls systems
necessary to maintain a submarine are not the primary concern. Besides, no professional safety
person I know, including myself believes that exposure to 5% CO2 for a prolonged period is
advisable. Additionally, all carbon dioxide removal technologies reviewed by West Virginia
demonstrated the capability to reduce levels of 5% to acceptable ranges in short order.

The 2.5% CO2 maximum set within the MSHA proposed rule is adequate for protection against short
duration excursions. I do believe the lower limit as modified in the proposed rule is an
unnecessary modification and should be restored to the current CFR value.

In reality the critical issue in this discussion is not CO2 percentage rather it is the partial
pressure of CO2 of inhaled air.

CO_2 is carried in the blood in three forms. First CO_2 can be bound to hemoglobin or red blood cell (RBC). Second it is dissolved in the plasma components of the blood, and lastly it can combine with water in the blood stream to form carbonic acid which is then converted to bicarbonate.

Diffusion of CO_2 out the RBC occurs as a result of the partial pressure of carbon dioxide (PCO_2) gradient between the RBC and the alveolar air. The normal (PCO_2) in the RBC is between 36 and 44 mmHg. A 5% CO_2 level would result in a PCO_2 in inhaled air of 38 mm Hg. At that level the difference in PCO_2 in the blood an PCO_2 in air would not sufficient to drive diffusion of CO_2 from the RBC to the air even though CO_2 diffuses almost 20 times faster than O_2.

At 2.5% CO_2 that value is 19 mmHg still much higher than the typical 0.3 mmHg but sufficient to allow from some CO_2 exchange. The 0.5% CO_2 level would result in PCO_2 of 4 mmHg. For reference, normal air is 350ppm CO_2 or 0.035% CO_2 which is about 0.3 mmHg CO_2. Because of the inability to remove CO_2 a 5% CO_2 level for an extended period of time could reduced the number of hemoglobin binding sites for O_2 resulting in lower O_2 levels in the blood.

However both CO_2 diffusion and O_2 diffusion occur simultaneously as the RBC passes through the lung. When the RBC is oxygenated without changing the CO_2 content the PCO_2 of the RBC increases. This will increase the PCO_2 gradient and increase subsequent CO_2 diffusion rates. (A good mathematical treatment of this can be found in a 1986 paper by M Mochizuki, et al "A method for estimating contact time for red blood sells through lung capillary from O_2 and CO_2 concentrations in rebreathing", Japan J of Physio 37, 283-301)

In an emergency shelter an increase in carbon dioxide percentage will not be the result of a decrease in the partial pressure of oxygen (PO_2) because O_2 is constantly being added to maintain normal levels and at normal PO_2 levels, the diffusion of O_2 into the RBC would still function at rate sufficient to maintain the 1.34 to 1.40 mL/g O_2 RBC levels necessary for survival at rest. The fraction of inspired oxygen of 20% which would be present in a shelter should result in a normal 95% oxygen saturation of RBC in the 4.7 L of blood in the body. Thus the effective PCO_2 in the RBC will increase reducing the effects of increase PCO_2 of inhaled air.

While the effects of 5% CO_2 on plasma pH are import their effect, acidosis, in the time periods

being discussed in shelter occupancy would be overshadowed by the effects lowered oxygen saturation.

Bottom line, the body has enough oxygen reserves in the blood to survive short periods of 5% CO2 but
I doubt anyone familiar with respiratory physiology would reasonably believe it acceptable for a
prolonged period.

I appreciate all that Micropore has done to advance the science of CO2 removal, however, theirs is
not the only CO2 solution that works. For the purpose of emergency underground shelters such we are
all working toward here, the other solutions have also demonstrated their ability to achieve the
desired results.

Randall Harris
Health Physicist Engineering Advisor
WV Office of Miners Health Safety and Training

randall.j.harris@verizon.net

304-235-0042 Williamson, WV
304-558-1425 Charleston, WV
304-239-3760 Logan, WV
304-687-1425 mobile
866-790-6142 fax

Mail/Express:

For Mine Safety:
1615 Washington Ave
Charleston, WV 25301

All other:
1100 East 4th Ave
Williamson, WV 25661