

## **Effects of Reduced Oxygen**

**4/6/2011**

Table 7 in FESHM 5064 describes effects of exposure to reduced oxygen. The proposal is to replace it with an updated table. The present table includes loss of consciousness at 12%, inability to move at 10%, an apparent inconsistency

### **Comparison**

- Small changes in effects
- Neither MacManus nor “Environmental and Occupational Medicine” mentions reduced night vision
- Descriptions clearer in MacManus

Will mean that the testing and training needs revision

Table 7

Effect Thresholds for Exposure to Reduced Oxygen (Seated Individuals at Sea Level)		
Volume % Oxygen	Effects	
17	Night vision reduced. Increased breathing volume. Accelerated heartbeat.	
16	Dizziness. Time required for novel tasks doubled.	
15	Impaired attention. Impaired judgment. Impaired coordination. Intermittent breathing. Rapid fatigue. Loss of muscle control.	
12	Very faulty judgment. Very poor muscular coordination. Loss of consciousness. Permanent brain damage.	
10	Inability to move. Nausea. Vomiting.	
6	Spasmodic breathing. Convulsive movements. Death in 5 - 8	

Fermilab ES&H Manual

5064TA-21  
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Source “Oxygen Deficiency Hazards Associated With Liquefied Gas Systems: Derivation Of A Program Of Controls”, [Timothy M. Miller](#), [Pawel O. Mazur](#) (Fermilab), RX-1083, 1984

**TABLE 3.12**  
**Effects of Acute Exposure to Oxygen-Deficient Atmosphere**

Effect	Atmospheric Oxygen (dry air, sea level)	
	Concentration (%)	Pressure (mmHg)
No symptoms	16 to 20.9	122 to 159
Increased heart and breathing rate, some incoordination, increased breathing volume, impaired attention and thinking	16	122
Abnormal fatigue upon exertion, emotional upset, faulty coordination, impaired judgment	14	106
Very poor judgment and coordination, impaired respiration that may cause permanent heart damage, nausea, and vomiting	12	9
Nausea, vomiting, lethargic movements, perhaps unconsciousness, inability to perform vigorous movement or loss of all movement, unconsciousness followed by death	<10	<76
Convulsions, shortness of breath, cardiac standstill, spasmodic breathing, death in minutes	<6	<46
Unconsciousness after one or two breaths	<4	<30

Data from NIOSH 1976, Miller and Mazur 1984, ANSI 1992, and CSA 1993.

Ref: Safety and Health in Confined Spaces, McManus N., CRC Press, 1998, page 91

## **Environmental and Occupational Medicine**

Environmental and Occupational Medicine generally agrees with McManus, but uses more jargon.

“Human beings are asymptomatic while breathing air containing 16.5% to 21% oxygen by volume. Concentrations of O<sub>2</sub> in the inspired air of 12% to 16% cause tachypnea, tachycardia, and slight incoordination. At O<sub>2</sub> levels of 10% to 14%, emotional liability and exhaustion with minimal exertion can be expected. Breathing air containing 6% to 10% O<sub>2</sub> results in nausea, vomiting, lethargic movements, and perhaps unconsciousness. Breathing less than 6% O<sub>2</sub> produces convulsions, then apnea, followed by cardiac standstill. The aforementioned symptoms occur immediately on breathing an O<sub>2</sub>-deficient atmosphere.” “Environmental and Occupational Medicine”, 4th edition, Rom, editor, p. 556

## **American Optometric Association**

“The effect of altitudinal hypoxia on night vision is primarily one of an elevation of the rod and cone threshold. Although decreased cone function is clearly demonstrated by the loss of color vision at hypoxic altitudes, the decrement in central VA is usually insignificant. However, scotopic night vision at altitude can be significantly reduced. Scotopic vision has been reported to decrease by 5% at 3,500 feet, 20% at 10,000 feet, and 35% at 13,000 feet, if supplemental oxygen is not provided. Thus, the use of oxygen, even at low pressure altitudes, can be very important at night. ”The Eye and Night Vision, American Optometric Association”

Notes

Scotopic =vision in dim light

Altitude	Scotopic Vision loss	Pressure	Fraction of sea level O <sub>2</sub>
3500 ft	5%	12.941	18.4%
10000 ft	20%	10.108	14.4%
13000 ft	35%	8.9926	12.8%

Email communication with Dr. Svazas 3/23/2011

Questions:

1. Would it be medically correct to replace table 7 in FESHM 5064 with table 3.12 from Safety and Health in Confined Spaces?
2. Should the effect of reduced night vision at 17% be inserted?
3. Any other comments about the effect of reduced oxygen atmosphere?

Response

Looks good. The other issue raised in flight training regarding hypoxia are peripheral vision (in essence the performance of the rod cells) degradation. Tunnel vision might be worth a mention though it is variable in onset as is the night vision issue. However if you notice it one knows it's time to correct the situation.

## References

Miller and Mazur, <http://lss.fnal.gov/archive/test-tm/1000/fermilab-tm-1163.pdf>

The Eye and Night Vision, American Optometric Association, <http://www.aoa.org/x5352.xml>

FESHM 5064, <http://esh-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=387&version=5&filename=5064.pdf>

Dr. Svazas said