Hannaford Forensic Services (Asia) Limited

‘Safe’ oxygen levels – a short discussion

At standard atmospheric pressure and temperature, dry air, by volume is approximately composed of:

Nitrogen	78.1%
Oxygen	20.9%
Argon	0.9%
Other	0.1%

Whilst the composition of air is considered to be fairly consistent, the percentage of oxygen required to support life is dependent on pressure as this leads to changes in the partial pressure of the gases. At high altitude the partial pressure of oxygen in air becomes low such that it cannot support life (for example on Mount Everest). However, underwater the partial pressure increases and below 60 metres depth oxygen starts to becomes toxic. As such, any discussion on the minimum concentration of oxygen required will generally refer to altitude or depth. For the purposes of this discussion, it is assumed that work is being undertaken on ships and as such relates to air at sea level.

The United States Department of Labour, Occupational Safety & Health Administration (OSHA) document 29 CFR 1910.146(c) defines oxygen deficiency as ‘*A concentration of oxygen in the atmosphere equal to or less than 19.5% by volume’.* However, it should be noted that this DOES NOT mean that an atmosphere with 19.5% oxygen is safe to enter, it ONLY means that below this level it is not considered safe to enter based on the oxygen concentration. If an

atmosphere contains 19.5% oxygen, then 1.4% of another gas has replaced it and the atmosphere is potentially deadly[1]. For reference if this other gas was carbon monoxide, unconsciousness would occur within 2 -3 breaths, and death within 3 minutes. As such, the discussion below relating to the minimum oxygen levels to support human life assumes that the air has been analysed for any potential toxic or flammable gases.

The effects of low oxygen atmospheres are summarised in the table below (information from OSHA):

Oxygen percentage in air[2]	**Effect**
19.5 %	Minimum acceptable oxygen level
15 - 19%	Decreased ability to work strenuously May impair coordination and may induce early symptoms with individuals that have coronary, pulmonary, or circulatory problems
12-14%	Respiration and pulse increase; impaired coordination, perception, and judgment occurs
10-12%	Respiration further increases in rate and depth; poor judgment and bluish lips occur
8-10%	Symptoms include mental failure, fainting, unconsciousness, an ash-coloured-face, blue lips, nausea, and vomiting
6-8%	8 minutes -100% fatal 6 minutes - 50% fatal 4-5 minutes - possible recovery
4-6%	Coma in 40 seconds, convulsions, respiration ceases - death

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[1] If the oxygen has been replaced by an inert gas, then the nitrogen content will also have been reduced. As such, if the oxygen is reduced to19.5% then the nitrogen will be reduced by 5.2%, meaning that the 'other' gas will be approximately 6.6% by volume.
[2] This assumes that the oxygen has been replaced by an inert gas such as nitrogen.