Oxygen Depletion Calculations

To determine oxygen concentrations after normal evaporative and filling losses, the following calculations can be used.

Step 1: Normal Evaporative Losses

(a) $N_E = \frac{2 \times 682 \times (D_N \times D_E)}{24 \times 1000}$

(b) $A_D = \frac{N_E}{R_V \times R_A}$

(c) $O_D = 0.21 \times 100 \times A_D$

Where:

N_E is the nitrogen evaporation rate (in m^3h^{-1}).

- 2 safety factor to allow for the deteriation of the dewar's insulation.
- 682 expansion factor for liquid nitrogen to gaseous nitrogen.
- D_N is the number of dewars.
- D_E is the evaporation rate from the dewar (L/day) (obtained from the supplier of the dewar.
- A_D is the fractional reduction in the air concentration due to the conversion of liquid nitrogen to gaseous nitrogen.
- R_V is the volume of the room (m^3).
- R_A is the number of room air changes per hour.

Step 2: Filling Losses

(a) $O_V = 0.21 \times [R_V - (0.1 \times D_V \times 682 \times 0.001)]$

(b) $O_C = \frac{100 \times O_V}{R_V}$

Where:

- O_V is the volume of oxygen in the room (m^3).
- D_V is the volume of the dewars (L).
- O_C is the oxygen concentration (%)

Step 3: Total Oxygen Concentration in the Laboratory

$O_T = O_C - O_D$

Where:

- O_T is the total oxygen concentration in the room (%)

(Adapted from University of Oxford Policy Statement S4/03)

Example 1:

Step 1: Normal Evaporative Losses

(a) $N_E = \dfrac{2 \times 682 \times (D_N \times D_E)}{24 \times 1000}\ m^3h^{-1}$

$N_E = \dfrac{2 \times 682 \times [(2 \times 0.22) + (1 \times 0.49)]}{24 \times 1000}\ m^3h^{-1}$

$N_E = \dfrac{1364 \times (0.44 + 0.49)}{24000}\ m^3h^{-1}$

$N_E = 0.053\ m^3h^{-1}$

(b) $A_D = \dfrac{N_E}{R_V \times R_A}$

$A_D = \dfrac{0.053}{108 \times 6}$

$A_D = 0.000082$

(c) $O_D = 0.21 \times 100 \times A_D$

$O_D = 0.21 \times 100 \times 0.000082\ \%$

$O_D = 0.0017\%$

Step 2: Filling Losses

(a) $O_V = 0.21 \times [R_V - (0.1 \times D_V \times 682 \times 0.001)]\ m^3$

$O_V = 0.21 \times [108 - (0.1 \times 110 \times 682 \times 0.001)]\ m^3$

$O_V = 21.1\ m^3$

(b) $O_C = \dfrac{100 \times O_V}{R_V}\ \%$

$O_C = \dfrac{100 \times 21.1}{108}\ \%$

$O_C = 19.5\%$

Step 3: Total Oxygen Concentration in the Laboratory

$O_T = O_C - O_D$

$O_T = 19.5\ \% - 0.0017\%$

$O_T = 19.5\ \%$

Example 2:

Step 1: Normal Evaporative Losses

(a) $$N_E = \frac{2 \times 682 \times (D_N \times D_E)}{24 \times 1000}\ m^3h^{-1}$$

$$N_E = \frac{2 \times 682 \times [(4 \times 0.22) + (1 \times 1.10)]}{24 \times 1000}\ m^3h^{-1}$$

$$N_E = \frac{1364 \times (0.88 + 1.10)}{24000}\ m^3h^{-1}$$

$$N_E = 0.113\ m^3h^{-1}$$

(b) $$A_D = \frac{N_E}{R_V \times R_A}$$

$$A_D = \frac{0.113}{129.6 \times 6}$$

$$A_D = 0.000145$$

(d) $$O_D = 0.21 \times 100 \times A_D$$

$$O_D = 0.21 \times 100 \times 0.000145\ \%$$

$$O_D = 0.003\%$$

Step 2: Filling Losses

(a) $$O_V = 0.21 \times [R_V - (0.1 \times D_V \times 682 \times 0.001)]\ m^3$$

$$O_V = 0.21 \times [129.6 - (0.1 \times 170 \times 682 \times 0.001)]\ m^3$$

$$O_V = 24.8\ m^3$$

(c) $$O_C = \frac{100 \times O_V}{R_V}\ \%$$

$$O_C = \frac{100 \times 24.8}{129.6}\ \%$$

$$O_C = 19.1\%$$

Step 3: Total Oxygen Concentration in the Laboratory

$$O_T = O_C - O_D$$

$$O_T = 19.1\ \% - 0.003\%$$

$$O_T = 19.1\ \%$$

Example 3:

Step 1: Normal Evaporative Losses

(a) $N_E = \frac{2 \times 682 \times (D_N \times D_E)}{24 \times 1000}\ m^3h^{-1}$

$N_E = \frac{2 \times 682 \times (2 \times 0.18)}{24 \times 1000}\ m^3h^{-1}$

$N_E = \frac{1364 \times (0.36)}{24000}\ m^3h^{-1}$

$N_E = 0.020\ m^3h^{-1}$

(b) $A_D = \frac{N_E}{R_V \times R_A}$

$A_D = \frac{0.020}{36 \times 6}$

$A_D = 0.000093$

(e) $O_D = 0.21 \times 100 \times A_D$

$O_D = 0.21 \times 100 \times 0.000093\ \%$

$O_D = 0.0020\%$

Step 2: Filling Losses

(a) $O_V = 0.21 \times [R_V - (0.1 \times D_V \times 682 \times 0.001)]\ m^3$

$O_V = 0.21 \times [36 - (0.1 \times 20 \times 682 \times 0.001)]\ m^3$

$O_V = 7.27\ m^3$

(d) $O_C = \frac{100 \times O_V}{R_V}\ \%$

$O_C = \frac{100 \times 7.27}{36}\ \%$

$O_C = 20.2\%$

Step 3: Total Oxygen Concentration in the Laboratory

$O_T = O_C - O_D$

$O_T = 20.2\ \% - 0.0020\%$

$O_T = 20.2\ \%$