Incubator Ventilation

Aviagen Turkeys Ltd ®

Definition

- Incubators need to be ventilated (replacing air within the incubator with air from outside the machine) as the developing embryos inside the machine need to breath.
- While the primary purpose of ventilation is to supply the embryos with oxygen (O_2) and remove carbon dioxide (CO_2), in some incubator designs the ventilation system has a secondary role providing a supplemental cooling system or in some cases the only cooling system.
- Commercial incubators have a forced ventilation system; one or more fans that are used to stir the air within the incubator (to allow an efficient and uniform heat transfer between the eggs and air) and at the same time pull fresh air into the machine.
- This advice sheet will discuss the amount of air exchange between the inside and outside of the incubator rather than the amount of air moved within the machine.

Objectives

The level of ventilation used should be sufficient to meet the embryos' requirement to breath and, if needed, provide sufficient cooling to prevent overheating. However, it is also important not to over-ventilate the incubator so that it is difficult to maintain the required humidity and create a variable temperature within the machine.

Controlling Ventilation

- Published studies have described the pattern of turkey egg O_2 consumption through incubation. At the start of incubation, the O_2 consumption is negligible but it increases exponentially as the embryo grows until it hits a plateau phase just before hatching. On day 25 of incubation a typical turkey egg consumes 660 ml of O_2 per day.
- The amount of CO_2 and heat the embryo produces is directly proportional to the amount of O_2 consumed. For every 1 ml of O_2 consumed the embryo produces 0.75 ml of CO_2. For every 4.38 ml of O_2 the embryo consumes per day it will generate 1 mW of heat.
- Table 1 shows the amount of ventilation required to either control the level of O_2, CO_2 or cool the incubator in a room at either 25°C or 30°C.

Table 1: Ventilation requirement[1] per 1000 eggs (m^3 / hr)

		Incubator Type	
		Multi-stage[2]	Single-stage[3]
Oxygen	minimum = 20%	1.2	3.0
CO_2	maximum = 0.3%	3.1	7.6
Heat[4]	Room = 25°C	16.4	39.5
	Room = 30°C	27.3	66.4

1. Ventilation rates based on published O_2 consumption data +10%.
2. Calculation based on multi-stage machine containing 4, 11, 18 & 25-day embryos.
3. Calculation based on single-stage machine containing 25-day embryos, the level required will be less, earlier during incubation.
4. Ventilation required to remove heat is assuming that this is the only method of cooling, lower ventilation rates will be required if water cooling is also used.

- If ventilation is not required for heat removal then ventilating the incubator to control CO_2 concentration should also be sufficient to control O_2 concentration.
- The data shown in Table 1 should be taken as a guide; the actual levels chosen should be determined by measuring CO_2 levels and the ability of the incubator to control temperature and humidity.

Measuring Ventilation

- If ventilation is required to supply O_2 and remove CO_2 only, then measuring CO_2 levels within the machine can be used to check the ventilation level. This can be done using either:
  - A CO_2 sensor; these can be purchased but are expensive. Some modern incubators have CO_2 sensors fitted.
  - CO_2 diffusion tubes (Figure 1); these are tubes that can be placed in an incubator over a fixed time period (typically 8 – 12 hours) and will measure the average CO_2 levels within the machine. This is a relatively cheap system for checking CO_2.
  - CO_2 gas tubes; a similar system to the diffusion tube but the incubator air is pulled into the tube by a pump. The main problem in taking this measurement is because the machine needs to be opened or the tube inserted into the machine through a ventilation duct and this can give unrepresentative results.
- Target CO_2 levels are given in the Management Advice Sheets: Multi-stage Incubation and Single-Stage Incubation.
- An anemometer (Figure 2 - 3) can be used to measure actual ventilation rates through ventilation inlets and outlets. This is a useful piece of equipment for checking ventilation levels and is not very expensive. Calculating the airflow through a ventilation duct should be done as follows:
  - The anemometer reading should be made following the manufacturer's instructions.
  - Anemometers measure airspeed (m/sec) therefore, to calculate the volume of air; the area of the air inlet or exhaust duct must be multiplied by the speed measured.

Example 1

For a circular duct, the area needs to be calculated using the formula: area = πr^2, where π = 3.1416 and r = radius (diameter of duct ÷ 2). For example a 100mm diameter duct and a measured airspeed of 0.3 m/sec would result in the following calculation:

Area	= 3.1416 x (0.1 ÷ 2) 2 = 3.1416 x 0.052 = 0.007854 m^2
Ventilation	= 0.007854 m^2 x 0.3 m/sec = 0.0023562 m^3/sec x 60 x 60 = 8.48 m^3/hour

Example 2

For a rectangular duct, the area needs to be calculated using the formula: length x width. For example a duct measuring 100mm by 150mm with airspeed of 0.2 m/sec would result in the following calculation:

Area	= 0.1 x 0.15 m = 0.015 m^2
Ventilation	= 0.015 m^2 x 0.2 m/sec = 0.003 m^3/sec x 60 x 60 = 10.80 m^3/hour

- ➢ Where the area of the duct is much larger than the size of the anemometer head then readings must be taken across the duct area and the average airspeed calculated.

- Note that in incubators that are not completely sealed, there may be air entering the machine through poor door seals or from the fan belt slots in addition to the air inlets.


Figure 1: CO_2 diffusion tube.


Figure 2: Measuring airspeed through a circular duct


Figure 3: Measuring airspeed through a rectangular vent. Note that for a large vent the average airspeed over the whole vent area must be measured.

Related Management Advice Sheets

a. Multi-stage Incubation
b. Single-stage Incubation

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