

# Cleanroom Air Changes

by Jason Kelly

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**Author: Jason Kelly Vice President of Services Lighthouse Worldwide Solutions**

### Background Information

Cleanrooms are defined by their cleanliness level based on the absence of airborne particles present in a sample of a given volume. ISO 14644-1 is an international standard for cleanroom classification. Particle counters are used to take a sample of air and determine if the sample meets the design and in use specifications based on a classification table seen below.

**Table 1: ISO classes of air cleanliness by particle concentration**

ISO Class number (N)	Maximum allowable concentrations (particles/m <sup>3</sup> ) for particles equal to and greater than the considered sizes, shown below <sup>a</sup>					
	0,1 μm	0,2 μm	0,3 μm	0,5 μm	1 μm	5 μm
1	10 <sup>b</sup>	d	d	d	d	e
2	100	24 <sup>b</sup>	10 <sup>b</sup>	d	d	e
3	1 000	237	102	35 <sup>b</sup>	d	e
4	10 000	2 370	1 020	352	83 <sup>b</sup>	e
5	100 000	23 700	10 200	3 520	832	d, e, f
6	1 000 000	237 000	102 000	35 200	8 320	293
7	c	c	c	352 000	83 200	2 930
8	c	c	c	3 520 000	832 000	29 300
9g	c	c	c	35 200 000	8 320 000	293 000

**a** All concentrations in the table are cumulative, e.g. for ISO Class 5, the 10 200 particles shown at 0,3 μm include all particles equal to and greater than this size

**b** These concentrations will lead to large air sample volumes for classification. Sequential sampling procedure may be applied; see Annex D

**c** Concentration limits are not applicable in this region of the table due to very high particle concentration.

**d** Sampling and statistical limitations for particles in low concentrations make classification inappropriate

**e** Sample collection limitations for both particles in low concentrations and sizes greater than 1 μm make classification at this particle size inappropriate, due to potential particle losses in the sampling system

**f** In order to specify this particle size in association with ISO Class, the macroparticle descriptor M may be adapted and used in conjunction with at least one other particle size. (See C.7)

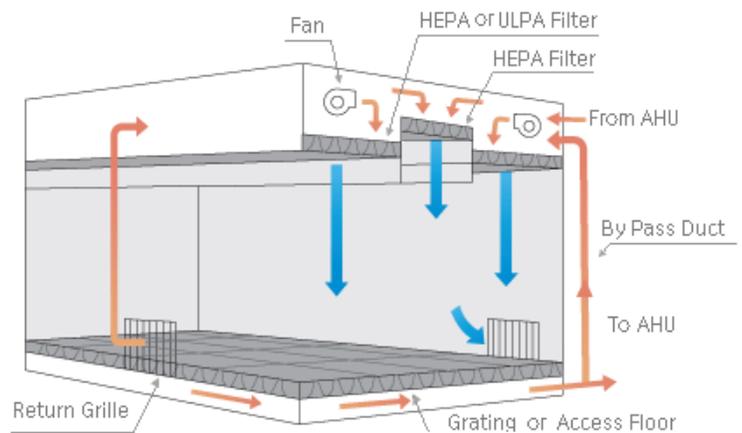
**g** This class is only applicable for the in-operation state.

In a cleanroom, depending on classification and usage, air change occurs anywhere from 10 to more than 600 times an hour. The ambient outdoor air in a typical urban area contains 35,000,000 particles for each cubic meter in the size range 0.5μm and bigger in measurement, equivalent to an ISO 9 cleanroom, while by comparison an ISO 1 cleanroom permits no particles in that size range and just 12 particles for each cubic meter of 0.3μm and smaller.

ISO Class	Air Changes Per Hour	Ceiling Coverage
ISO 1	500-750	80-100%
ISO 2	500-750	80-100%
ISO 3	500-750	60-100%
ISO 4	400-750	50-90%
ISO 5	240-600	35-70%
ISO 6	150-240	25-40%
ISO 7	60-150	15-25%
ISO 8	5-60	5-15%

### Why is Cleanroom Air Change Rate Important?

Air change rates are important factors in determining the design and performance criteria for a cleanroom HVAC system. The total rate, flow pattern, and exchange efficiency have far-reaching implications on cleanroom performance and cost. The performance and cost eventually determine the rate-of-return on investment for a cleanroom.



Airflow engineering is the primary method of contamination control for both viable (living) and non-viable particles or microbes. However, it's also a primary requirement for the comfort and safety of a cleanroom's most prized producers: its operators.

### ISO Definition of Cleanroom Air Exchange Rate

As defined by ISO 146144-4 standards: rate of air exchange is expressed as the number of air changes per unit of time and calculated by dividing the volume of air delivered in the unit of time by the volume of the cleanroom or clean zone.