

JIS

JAPANESE INDUSTRIAL STANDARD

**Measuring Methods for
Airborn Particles in Clean Room
and Evaluating Methods for
Air Cleanliness of Clean Room**

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In the event of any doubt arising,
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Measuring Methods for Airborne Particles in
Clean Room and Evaluating Methods for Air
Cleanliness of Clean Room

B 9920-1989

1. Scope

This Japanese Industrial Standard specifies the measuring methods for concentrations of the airborne particles in clean rooms, and the evaluating methods for the air cleanlinesses of clean room (hereafter referred to as the "cleanlinesses").

2. Definitions

For the purpose of this Standard, definitions in JIS Z 8122, JIS Z 8103 and JIS B 9921 apply, and others are in accordance with the following:

- (1) cleanliness class A grade of cleanliness classified according to the level of particle concentration of each particle size. It is expressed by an exponent of the number of small particles of $0.1 \mu\text{m}$ or over in particle size included in the air of 1 m^3 expressed by the number of power of 10.
- (2) upper limit concentration The upper limit value of the particle concentration defined on each particle size specifying the cleanliness class.
- (3) cleanliness class particle size range The particle size ranges of small particles which are the objects of evaluation for cleanlinesses defined in each cleanliness class.
- (4) as-built condition The condition of a clean room which is complete and ready for normal running, without installation of the manufacturing equipment for production, and where no operating person presents.
- (5) at-rest condition The condition where the erection of a clean room has been completed, the manufacturing equipment for production has been installed, and although the clean room is in a condition of capable of being operated normally, but no operating person presents.

Applicable Standards and Reference Standard: See page 30.

(6) at-operational condition The condition of a clean room in which the normal production is being carried out with operating person.

(7) successive sampling evaluation diagram A diagram to be used in the successive sampling evaluation, in which the conformable region and the un-conformable region to the cleanliness class are indicated at 95 % confidence factor by the relation between the measured cumulative number of small particles and the cumulative air volumes of sample.

3. Cleanliness Class of Clean Room

The cleanliness of a clean room, being expressed by the cleanliness class, shall generally express the cleanliness of the clean room as-built condition. Regarding at-rest condition and at-operational condition of the clean room, this may be applied, as appropriate, by clearly stating the condition thereof.

The cleanliness classes shall be expressed by cleanliness class numbers, as class 1, class 2, class 3, class 4, class 5, class 6, class 7 and class 8. The particle size ranges and upper limit concentrations of respective cleanliness classes are given in Table 1 and Fig. 1.

Table 1. Upper Limit Concentrations for Cleanliness Classes (particles/m³)

Particle size size (μm)	Cleanliness class							
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
0.1	10 ¹	10 ²	10 ³	10 ⁴	10 ⁵	(10 ⁶)	(10 ⁷)	(10 ⁸)
0.2	2	24	236	2 360	23 600	—	—	—
0.3	1	10	101	1 010	10 100	101 000	1 010 000	10 100 000
0.5	(0.35)	(3.5)	35	350	3 500	35 000	350 000	3 500 000
5.0	—	—	—	—	29	290	2 900	29 000
Particle size range of cleanliness	0.1 to 0.3		0.1 to 0.5		0.1 to 0.5	0.3 to 5.0		

- Remarks 1. Class 3, class 4, class 5, class 6, class 7 and class 8 are equivalent to class 1, class 10, class 100, class 1000, class 10000 and class 100000 of the Federal Standard 209 D (Clean Room and Work Station Requirements Controlled Environments) respectively.
2. The upper limit concentrations express the particle concentrations of not smaller than objective particle size.
3. The upper limit concentrations are based on the values of particle sizes of 0.1 and 0.5 μm .
4. The upper limit concentrations within the particle size ranges of cleanliness class not given in Table 1 shall be obtained from the following formula:

$$N_c = 10^N \times \left(\frac{0.1}{D}\right)^{2.08}$$

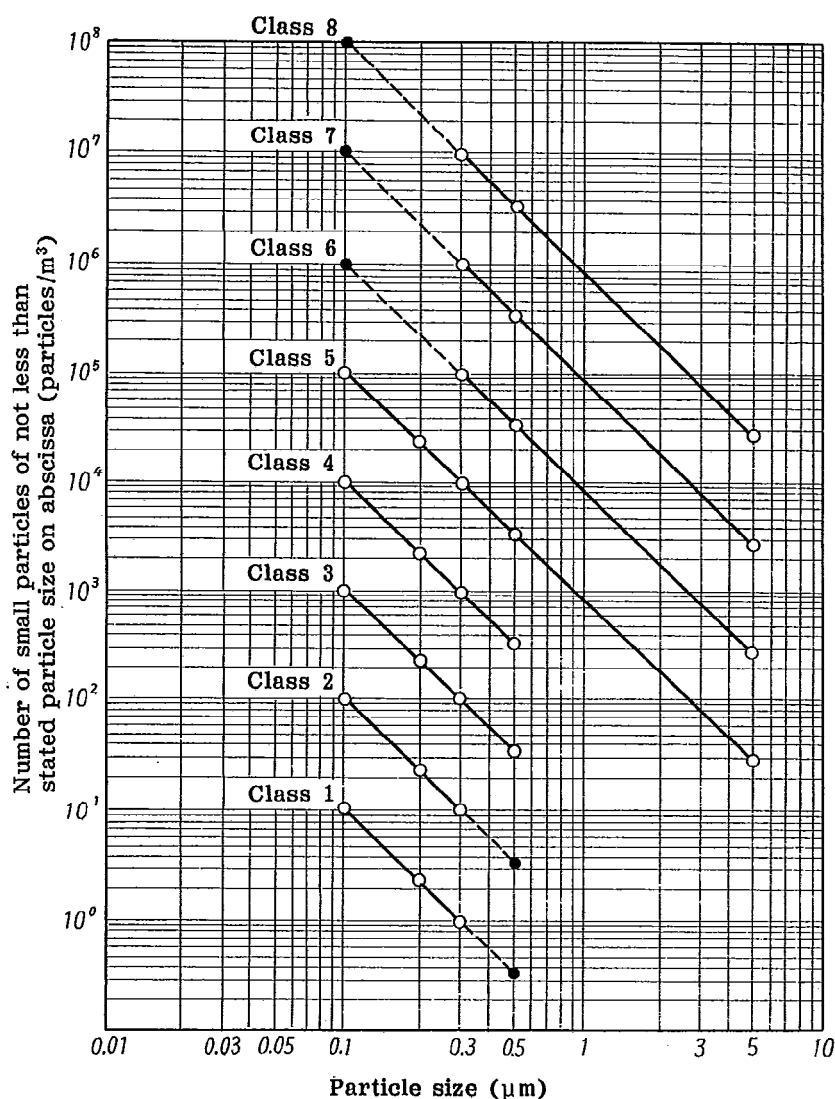
where, N_c : upper limit concentration of particles not smaller than objective particle size (particles/m³)

N : cleanliness class (-)

D : particle size (μ)

5. The numerals given in parentheses are the values for the particle sizes other than the objective particle sizes for evaluating cleanliness classes, and are the reference values.

Fig. 1. Upper Limit Concentrations of Cleanliness (particles/m³)



Remark: Marks ● indicate the objective particle sizes for evaluating cleanliness classes.

4. Types of Evaluating Methods on Cleanliness of Clean Room

The evaluating methods on cleanliness shall be of the following 2 types.

- (1) Regular Evaluating Method This method shall be used for evaluating overall cleanliness classes, in which the cleanliness is evaluated on the basis of the mean particle concentration in a clean room taking the entire clean room space as the object. Select appropriate number of measuring points in the clean room, in the case where the mean concentration at respective points is not more than the upper limit concentration of a certain class and the mean upper confidence limit of the mean concentration of respective measuring points obtained at 95 % confidence factor is not more than the upper limit concentration, this is the method to evaluate that the clean room is defined to be at its cleanliness class.
- (2) Successive Sampling Evaluating Method This is the evaluating method, in which air is sampled continuously at each measuring point in a clean room, and at the time when the cumulative number of small particle has just entered into the conformable region, the measuring point is deemed to be satisfying the upper limit concentration with confidence factor 95 %, and in the case where the total measuring points conform to the upper limit of a certain class, the clean room is defined to be in its cleanliness class.

This method is the simple evaluating method, and this may be used only for the evaluation of cleanliness class cleaner than class 4.

5. Measuring Method for Concentration of Airborne Particles

5.1 Measuring Methods The measuring methods of particle concentration shall be one of the following four types. In the measurements of particle shapes and the like, microscopic method shall be employed.

- (1) Light Scattering Particle Counter Method A measuring method for airborne small particles by the light scattering type automatic particle counter specified in JIS B 9921.
- (2) Condensation Nuclear Particle Counter Method A measuring method for small airborne particles by the condensation nuclear particle counter method, and Annex 1 shall be applied.
- (3) Electron Microscopic Method A measuring method using the electron microscope, collecting the airborne particles of 5 μm or under in particle size on a filter, and Annex 2 shall be applied.
- (4) Optical Microscopic Method A measuring method using the optical microscope, collecting the airborne particles of 5 μm or over in particle size on a filter, and Annex 3 shall be applied.

5.2 Objective Particle Size of Measurement The objective particle size of measurement shall generally be one of the particle sizes given in Table 1.

5.3 Measuring Positions and Number of Measuring Points Measurements shall generally be carried out on the positions given in the following, and the number of measuring points shall not be less than 6.

- (1) Measuring positions shall be at the same height as the working plane.
- (2) Draw equidistance lines on the floor surface with interval of not more than 3 m in longitudinal and lateral directions, and measure at the center points of the sections enclosed by the longitudinal and lateral lines.
- (3) In case where the number of measuring points becomes considerably large due to a larger floor area, the defined distance of 3 m may be extended. However, in this case, respective distances shall be taken equally. The number of measuring points should be 20 to 30 as the aim.
- (4) In case where a measuring point overlaps with an equipment placed in the room, the measuring point shall be omitted.

5.4 Preparation for Measurement For the sampling pipe through which the sample air is introduced into the particle counter, any material which is not liable to be charged with electricity shall be selected, and the length shall be as short as possible.

The suction probe of the sampling pipe, shall be so fixed at the measuring point that the air flow direction aligns with the axis of probe, and the sectional area of the probe shall be selected so that the air flow velocity at the measuring point and the suction flow velocity are equal as far as possible.

In the case where a particle counter is used, carry out the preheat running under the connection of the sampling pipe to be used in the measurement, sucking-in the clean air specified in JIS B 9921, until the meter becomes stabilized. Then, set the suction flow rate at the objective value, suck for 30 min, and then suck the clean air of specified volume in Table 2, and confirm that the count for this air volume is not larger than 1. However, in the case where the sucking air volume is larger than $300 \times 10^{-3} \text{ m}^3$, this may be lessened upon an agreement.

Table 2. Minimum Air Volume of Sampling ($\times 10^{-3} \text{ m}^3$)

Particle size (μm)	Cleanliness class							
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
0.1	2 000	200	20	3	3	—	—	—
0.2	10 000	1 000	100	10	3	—	—	—
0.3	20 000	2 000	200	20	3	3	3	3
0.5	(60 000)	(6 000)	600	60	6	3	3	3
5.0	—	—	—	—	600	60	6	3

Remark: The numerals given in parentheses are the values for the particle sizes other than the objective particle sizes for evaluating cleanliness classes, and are the informative reference value.

5.5 Measurements

5.5.1 In the Case of Regular Evaluating Method The measurement, in the case of the regular evaluating method, shall be as follows:

- (1) **Air Volume of Sampling and Number of Times of Measurement** The air volume of sampling shall be not less than the minimum air volume of sampling given in Table 2, and the number of times of measurement at respective measuring points shall be not less than 3.
- (2) **Mean Particle Concentration at Each Measuring Point** The particle concentration C_{ij} (particles/m³) of the number j -th measurement at a measuring point i shall be obtained from formula (1).

$$C_{ij} = \frac{P}{Q} \dots\dots\dots (1)$$

where, P : measured number of small particles (particle)
 Q : air volume of sampling (m³)

Next, the mean particle concentration $\bar{C}_i$ at this point shall be obtained by using formula (2).

$$\bar{C}_i = \frac{C_{i1} + C_{i2} + \dots\dots\dots + C_{ij} + \dots\dots\dots + C_{im}}{m} \dots\dots\dots (2)$$

where, m : number of times of measurement
 C_{ij} : particle concentration of j -th measurement at i measuring point (particles/m³)
 $\bar{C}_i$: mean particle concentration at measuring point i (particles/m³)

5.5.2 In the Case of Successive Sampling Evaluating Method The measurement in the case of the successive sampling evaluating method shall be as follows:

- (1) **Air Volume of Sampling** For the air volume of sampling in the successive sampling evaluating method, carry out continuous sampling of air, plot the cumulative air volume which has been sampled and the cumulative number of the small particles of not less than the objective particle size on Fig. 2, and continue the sampling until the coordinate point has entered into the conformable region or unconformable region. Number of times of measurement shall be not less than one time. The scales of the air volumes of the cumulative samplings given in Fig. 2 are different according to the cleanliness class and objective particle size. Within the particle size ranges for each cleanliness class given in Table 1., the scale of the cumulative air volume of sampling for the particle sizes other than 0.1 μm shall be obtained by multiplying the correction factor given in formula (3) to the scale given in Fig. 2.

$$K = \left(\frac{D}{0.1} \right)^{2.03} \dots\dots\dots (3)$$

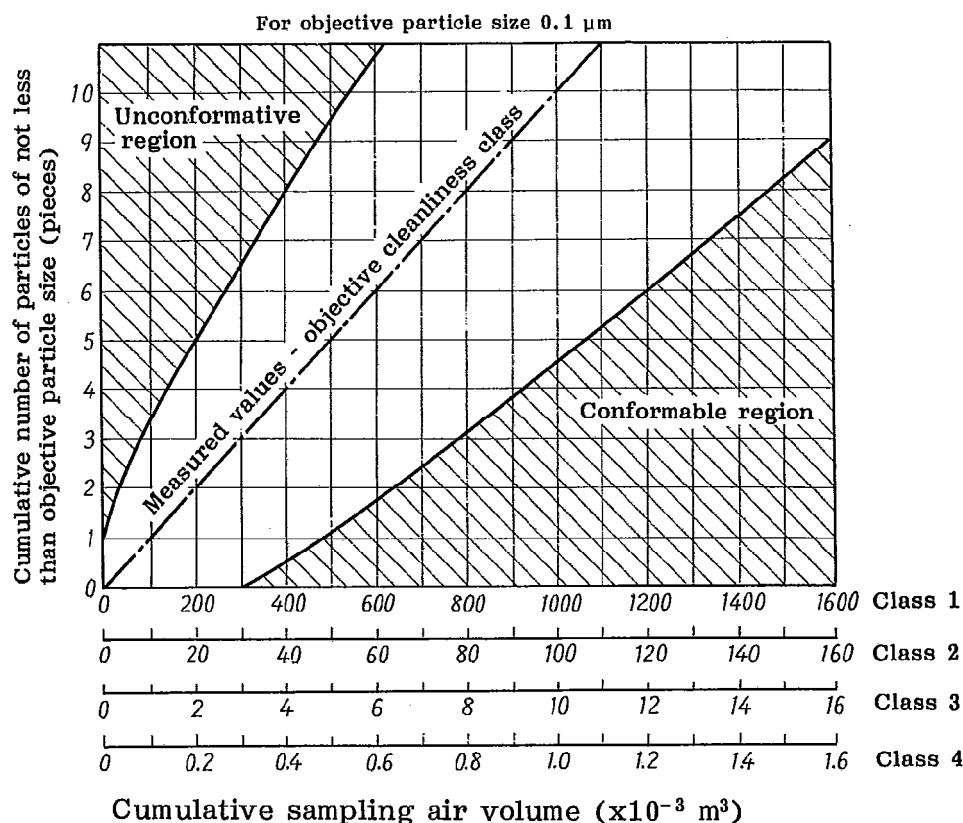
where, K : correction factor
 D : particle size (μm)

- (2) Particle Concentration at Each Measuring Point Carry out the measurement of (1), and terminate the measurement at the time when the co-ordinate point has entered into the conformable region or unconformable region of the successive sampling evaluating diagram. In case where co-ordinate point does not enter into the conformable region or unconformable region even through the measurements carried out in the range given in Fig. 2, repeat measurements again. The limit of re-measurement shall be one time. In the case where it can not be evaluated after the remeasurement, carry out sampling of 3 times the air volume of the minimum sampling given in Table 2, and calculate the mean particle concentration $\bar{C}$ at the measuring point from formula (4).

$$\bar{C} = \frac{P}{3 \times Q_m} \dots \dots \dots (4)$$

where, Q_m : minimum air volume of sampling (m^3)

Fig. 2. Successive Sampling Evaluating Diagram of Classes 1 to 4 for Particles of $0.1 \mu\text{m}$ in Particle Size



Remark: In the case where particle sizes are different, correction factor K shall be obtained from the following formula:

$$K = \left(\frac{D}{0.1} \right)^{2.08}$$

where, K : correction factor (-)
 D : particle size (μm)

Furthermore, cumulative sampling air volume V shall be obtained from the following formula:

$$V = V_0 \times K$$

where, V : air volume of sampling of particles of D (μm)
 in particle size (m^3)
 V_0 : air volume of sampling of particles of $0.1 \mu\text{m}$
 in particle size (m^3)

6. Cleanliness Evaluating Methods of Clean Room

6.1 Cleanliness Evaluation of Space by Regular Evaluating Method

The cleanliness evaluation of a clean room by the regular evaluating method shall be carried out in accordance with the following:

- (1) The mean value $\bar{X}$ of the mean particle concentrations of respective measuring points shall be obtained by using formula (5).

$$\bar{X} = \frac{\bar{C}_1 + \bar{C}_2 + \dots + \bar{C}_i + \dots + \bar{C}_n}{n} \dots \dots \dots (5)$$

where, n : total number of measuring points

- (2) The 95 % upper confidence limit of $\bar{X}$ shall be obtained from the following:

The standard deviation s of mean particle concentration $\bar{C}_i$ at total measuring points shall be obtained by using formula (6).

$$s = \sqrt{\frac{[(\bar{C}_1 - \bar{X})^2 + \dots + (\bar{C}_i - \bar{X})^2 + \dots + (\bar{C}_n - \bar{X})^2]}{n-1}} \dots \dots \dots (6)$$

The 95 % upper confidence limit $\bar{X}_u$ shall be obtained by using formula (7).

$$\bar{X}_u = \bar{X} + t(f, 0.05) \times \frac{s}{\sqrt{n}} \dots \dots \dots (7)$$

For values of $t(f, 0.05)$, the values of the following Table shall be employed.

Number of measuring point (n)	6	7 to 9	10 to 16	17 to 29	> 29
$t(f, 0.05)$	2.0	1.9	1.8	1.7	1.65

$$f = n - 1$$

- (3) In the case where the upper confidence limit $\bar{X}_u$ has satisfied formula (8), and mean particle concentrations at respective measuring points satisfy formula (9), it shall be defined that the clean room is of the cleanliness class.