Group Quality Certification System of Performance Test for Clean Rooms
(CR Mark)

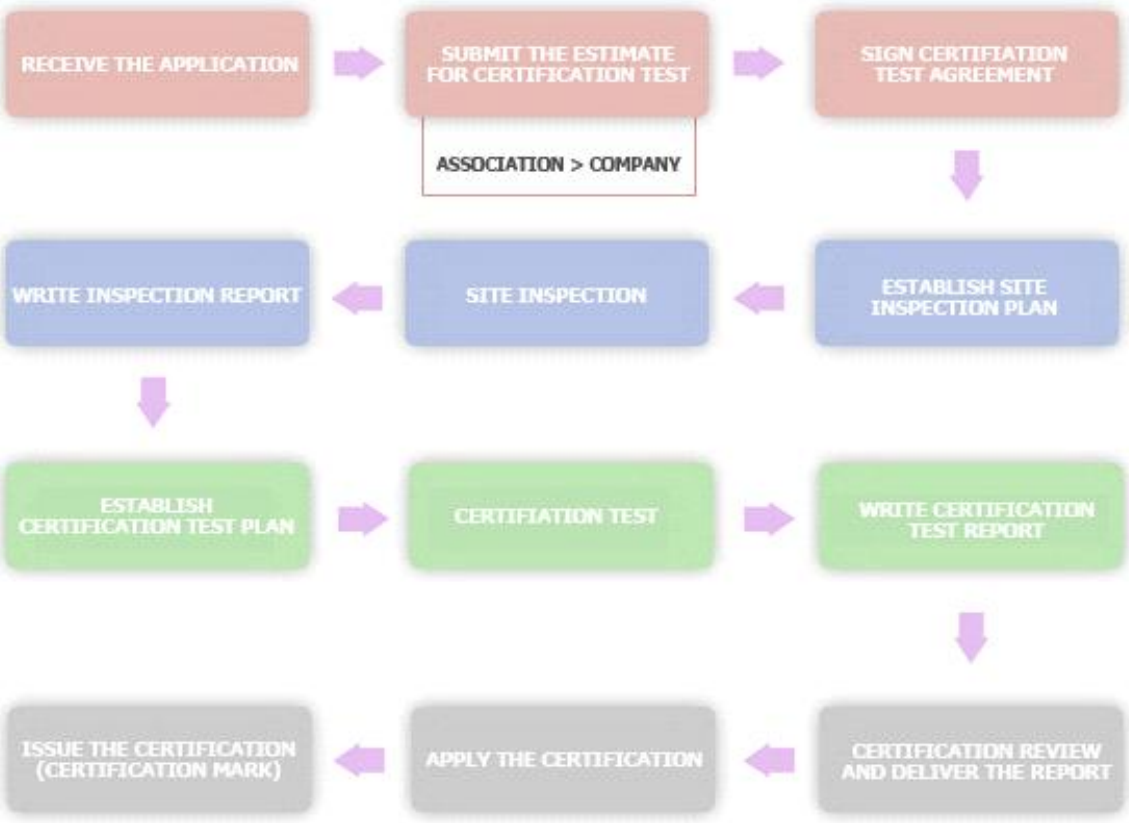
KOREA AIR CLEANING ASSOCIATION

1. Overview

■ What is the group quality certification mark of performance test for clean rooms (CR mark)?

It is the certification system for the purpose of upgrading clean room quality by enforcing technical competitiveness, enhancing production and yield of manufacturers, securing reliability for the clean room through evaluating and certifying clean room performance based on test methods specified in 14644-1, 2 and 3 (clean room standard) for clean rooms constructed for the semiconductor, LCD, electric and electronic, aerospace, pharmaceutical, hospital and food industries.

■ Procedure for the CR mark certification



[Figure 1] Procedure for certifying the CR mark

1. Application for the CR certification (company > association)
2. Check the reception of the application form and submit the certification test estimate (association > company)
3. Sign the agreement on the certification test 4. Establish plan on site inspection
5. Site inspection 6. Write the report 7. Establish the certification test plan
8. Perform the certification test 9. Write the report on the certification test result
10. Open the certification review board and write the report 11. Apply for the certificate
12. Issue the certificate (certification mark)

2. Items of performance evaluation for clean room certification

■ Classification and performance evaluation on the clean room status

- Classification depending on the clean room status

1. Construction
   Installed all the clean room facilities and ready for operation but with no production facilities, materials or operators
2. Non-operation
   All the facilities inside the clean room are installed and operated based on the agreement between the purchaser and the supplier but there is no operation and operator.
3. Operation
   The clean room is operated based on the design specification with the designated number of operators.

- Test and evaluation items of the performance test for clean rooms

1. Construction

Test item	Airflor		
	Unidirectional flow	Non-unidirectional flow	Mixed flow
Group of air cleanness for a clean room and the number of floating air particles for test	O	O	O
Airflow speed	O	Select	Select
Pressure difference for areas	O	O	O
Leakage of the system with filters installed	O	O	O
Airflow direction	O	Select	Select
Temperature	O	O	O
Humidity	O	O	O
Restore air cleanness	Select	Select	Select
Indoor penetration of pollutants	Select	Select	Select
Noise	O	O	O
Static	Select	Select	Select

2. Non-operation

Test item	Airflow method		
	Unidirectional flow	Non-unidirectional flow	Mixed flow
Group of air cleanness for a clean room and the number of floating air particles for test	O	O	O
Airflow speed	O	Select	Select
Pressure difference for areas	O	O	O
Leakage of the system with filters installed	O	O	O
Airflow direction	O	Select	Select
Temperature	O	O	O
Humidity	O	O	O
Restore air cleanness	Select	Select	Select
Indoor penetration of pollutants	Select	Select	Select
Noise	O	O	O
Static	Select	Select	Select

3. Operation

Test item	Airflow method		
	Unidirectional flow	Non-unidirectional flow	Mixed flow
Group of air cleanness for a clean room and the number of floating air particles for test	O	O	O
Airflow speed	O	Select	Select
Pressure difference for areas	O	O	O
Airflow direction	Select	Select	Select
Temperature	O	O	O
Humidity	O	O	O
Restore air cleanness	Select	Select	Select
Noise	O	O	O
Static	Select	Select	Select

* The table above shows recommendation of performance evaluation items on the clean room.

■ Certification item and test method for the performance evaluation of the clean room

- Evaluation items for the basic test (5): Air cleanness, airflow speed, pressure difference in areas, temperature, humidity
- Evaluation items for the optional test (6): Leakage of the system with filters installed, airflow direction, air cleanness, restoration, indoor penetration of pollutants, noise, static

[Air cleanness]

1) Purpose and application of the test The purpose is to evaluate the air cleanness level of a clean room in accordance with the KS M ISO 14644-1. The test defines the concentration measurement of floating air particles within the range of 0.1 - 5㎛.

2) Test procedure Refer to the KS M ISO 14644-1 on the specific items including the number of measuring points, selecting measuring locations, evaluating air cleanness in a clean area and required data amount. The standard proposes how to set up the benchmark for air sampling on each measuring point.

1) Install a particle counter in each measuring point, adjust the sampling air amount of the counter and configure the range of particle diameters based on the KS M ISO 14644-1.

b) Select the sample probe to make one with constant velocity in the single direction flow and adjust that the sample probe velocity does not make difference more than 20% from the sampling air velocity. Otherwise, install the sample probe entrance along with the major airflow direction to make coaxial sampling.

c) Install the sample probe entrance in the vertical direction if the sampled airflow cannot be controlled or the air does not flow in uni-direction.

d) Make the tube which connects the sample probe and the particle counter as short as possible. The tube length shall not exceed the length and the diameter recommended by the manufacturer when the particles larger than 1㎛ are sampled.

e) The sampling error due to losses of small particles by diffusion and big particles by gravitational sedimentation and collision shall be within 5%.

3) Instrument measuring the number of particles floating in the air

a) The instrument shall be an individual particle counter with light scattering function defined in 1.1 of the annex, select the diameters of particles related to the clean room grade and count the number and sizes of the particles in the air. In addition, the instrument shall show and record the measurement results within the range of preset diameters.

b) The items not defined in the annex 1.1 for the light scattering particle counter follow the regulations in the KS B 6336.

c) The calibration report on the instruments issued by certified agency shall be equipped.

4) Performance evaluation It evaluates the grade of air cleanness in the clean room in accordance with the KS M ISO 14644-1. Refer to the attachment D of the KS M ISO 14644-1 for specific calculation procedure for the grades of air cleanness.

[Airflow test]

1) Purpose and application of the test The purpose of the test is to evaluate the uniformity of the wind and the volume of air supply in the clean room and the clean area. The wind speed shall be measured in the clean room with single direction air flow

and the clean area and the air supply volume shall be measured in the clean room with non-single direction air flow. The air supply volume is measured to check the air volume supplied to the clean room per unit time and the volume is used to calcuate the air changes in the clean room. The air supply volume may be measured on the downstream of the last filter or the air supply duct and both method are used to calculate the air supply volume by mutiplying the wind speed and the area after measuring the air speed passing thought the known cross-section. Selecting the test procedure is based on the agreement signed in and between the purchaser and the supplier. This test may be applied to all the 3 test status.

2) Test procedure for the clean room with single direction flow

a) General

1) The air speed in the single direction flow determines the performance of the clean room with the same type.

2) The air speed may be measured near the final air supply filter or in the space and is measured by selecting the measuring cross-section perpendicular to the air supply flow and configuring the grid system of the isocontent.

b) Wind speed of the air supply

1) It shall be measured a point 150 - 300mm apart from the filter surface.

2) The number of measuring points shall be sufficient to determine the air supply volume in the clean room and the clean area, larger than the root square of the test cross-section [m2] and at least 4.

3) It shall be measured on at least 1 point on the exit of each filter or the fan filter.

4) The curtain may be used to exclude the disturbance against the single direction flow.

5) It shall be measured for a sufficient time to obtain reproductive results for each measuring point. Time average wind speed shall be recorded from various measuring points.

c) Uniformity of the wind speed in the clean room

1) The wind speed uniformity shall be measured 150 - 300mm apart from the filter surface and the grid gap on the test surface follow the agreement in and between the purchaser and the supplier.

2) It is important to notify that the air current may seriously change if the production facilities and workshops are installed. Therefore, the air current uniformity shall not be measured near these obstructions.

3) The measured data may not show features of the clean room or the area itself. The wind speed uniformity shall be determined by the data (wind speed distribution) agreed by the purchaser and the contractor.

4) It shall be measured for a sufficient time to obtain reproductive results for each measuring point.

d) Air supply volume from measuring the wind speed on the filter surface

1) The total air supply volume is calculated as below by using the result of the wind

speed measurement based on the procedure in 4.3.2 b).

$$Q = \Sigma\ (U_c \cdot A_c)$$

Here, Q is the total air volume, U_c is the wind speed from the center of each grid, A_c is the area of each grid and (sum) is the operator of summation.

e) Air supply volume from the air duct

1) The air supply volume may be measured at the duct by volume airflow meters like the orifice airflow meter or the venturi airflow meter or vein-type anemometer.

2) Inside the duct is separated by grids with equal grids and the wind speed is measured from the center of each grid if the measurement is performed by the pitot tube, differential manomenter, hot-wired anemometer or vein-type anemometer from the square duct. The number of grids follows the agreement between the purchaser and the contractor and is generally 9 or 16. The air supply volume shall be evaluated in accordance with the methods defined in 4.3.2 d).

3) Test procedure for the clean room with single direction flow

a) General

1) The most important factors are the air supply volume and the air changes.

2) In some cases, it is required to measure the air supply speed from each exit to determine the air volume for each exit.

b) Measure the air supply volume from the entrance

1) It is recommended to use the flowhood which may measure all the airs supplied from the air supply diffuser or each final filter due to jet speed ejected from the exit or the turbulence of the local air flow.

2) The air supply volume is calculated by multiplying the effective area with the air supply volume from the flowmeter or the air speed ejected from the flowhood.

3) The entrance of the flowhood shall completely cover the filter or the diffuser and the hood surface shall contact the hood surface on the flat surface to prevent the air from bypassing and inaccurate measurement.

4) The air volume from each final filter or the air supply diffuser shall be measured directly at the hood exit if the hood flowmeter is used.

c) Calculate the air supply volume by the filter face velocity

1) The air supply volume is evaluated by measuring the wind speed with the hot-wired anemometer at the downstream of each final filter if the flowhood is not used.

2) The air supply volume is determined by multiplying the wind speed with the exit area.

3) The curtain may be used to exclude the disturbance against the single direction flow.

4) The calculation of the number of measuring points and air supply volume follows the methods in 4.3.2 b) and 4.3.2 d).

5) The average wind speed weighted with the area is used if the grid is not devided by the same area.

d) The air supply volume of the air volume duct in the air duct is evaluated by the method in 4.3.2 d).

4) Instrument to test the air current

a) Ultrasonic anemometer, hot-wired anemometer, vein-type anemometer or other equivalent meters may be used to measure the wind speed.

b) Orifice airflow meter, venturi airflow meter, pitot static tube, average pitot static tube, differential manomenter or equivalent meters may be used to measure the air volume.

c) The wind speed shall be measured by using the instrument without being affected by velocity changes among measuring points at a short distance. The hot-wired anemometer may be used if the grid interval is short and a measuring point is added. Meanwhile, the vein-type anomemeter may be used if the varying speed range is sensitive and large enough to measure the average wind speed.

d) The calibration report on the instruments issued by certified agency shall be equipped.

5) Data handling

a) Record the measured values and measuring point numbers on the drawing of the clean room or the area.

b) Calculating the average wind speed and relative standard deviation

1) The average wind speed is calculated by using the arithmatic mean of the wind speeds measured in 4.3.2 c) and the standard deviation is calculated.

2) The relative standard deviation of the wind speed expressed as the percent of the average value is calculated as below.

$$\text{relative standard deviation} = \frac{\text{standard deviation}}{\text{Calculating the average wind speed}} \times 100\%$$

c) Calculating the average air volume and the relative standard deviation

1) Take the arithmatic mean of the air volume masured from 4.3.2 d), 4.3.3 b) or 4.3.3 d), find out the average air volume per diffuser or filter and calculate the standard deviation.

2) The relative standard deviation (uniformity) of the wind speed expressed as the percent of the average value is calculated as below.

$$\text{relative standard deviation} = \frac{\text{standard deviation}}{\text{Calculating the average wind speed}} \times 100\%$$

d) The total air volume supplied to the clean room or the clean area is calculated by adding each air volume measured from 4.3.2 d), 4.3.3 b) or 4.3.3 d).

6) Performance evaluation

a) The average wind speed, average air volume or the total air volume in the clean room or area shall be within 5% of the designed values or within the allowable range specified

by the purchaser and the manufacturer.
b) The relative standard deviation (uniformity) shall be within 20% or the allowable range specified by the purchaser and the manufacturer.

[Differential pressure test among intervals]

1) Purpose and application of the test The purpose of the test is to prove the completed clean room performance to maintain the pressure difference specified among internal areas separated in the clean room, external environment and the clean room. This test may be applied to all the 3 test status.

2) Test procedure for the pressure difference among intervals

a) Check whether the air supply and ejection volumes of the clean room meet the design values before the test.
b) The pressure difference between inside the clean room and the external environment is measured and recorded with all the doors closed.
c) The pressure difference between the most external area and its adjacent area is measured if the clean room is separated by more than 2 rooms. This measurement continues until the pressure difference between the most internal area and its adjacent area is measured. Then, the pressure difference is measured between the adjacent area and the external environment.
d) The operator shall consider issues below because the measurment errors may happen due to very small pressure difference and inaccurate measurement.
1) Fix the measuring points in the clean room.
2) Measure from a point far from the air supply inlet or return outlet which may affect the local pressure of the measuring point and around the center of the clean room.

3) Measuring instrument to test the pressure difference among zones

a) Electronic fine differential manomenter, tilted differential manomenter or mechanical differential manomenter may be used.
b) The calibration report on the instruments issued by certified agency shall be equipped.

4) Performance evaluation

a) The pressure difference between inside the clean room and the external environment shall be higher than 10Pa.
b) The sectional pressure difference in the clean room shall be higher than the configured value defined in the agreement between the purchase and the supplier.

[Temperature test]

1) Purpose and application of the test The purpose of the test is to show the air-conditioning system performance for the clean room to maintain the air temperature

within the limit for the specified time between the purchaser and the supplier for a certain zone. There are 2 test methods. First is the general test and procedure for the primary test of the clean room after the construction. Second is the specific test and applied to non-operating or operating status and the zone which requires more accurate temperature performance.

2) Temperature test procedure

a) General temperature test

1) This test is performed after completing the air current uniformity test and adjusting the air-conditioning system control.

2) Perform the test after stabilizing the conditions through operating the air-conditioning system.

3) The temperature shall be measured at least one point in every controlled area.

4) The sensor shall be installed at a designated location at the working height.

5) The temperature measured from each position after a sufficient period of time for the sensor stabilization shall be recorded.

6) The measurement shall be sufficiently done for the purpose, recorded at every 1 minute and measured for every 5 minutes at least.

b) Specific temperature test

1) The test is recommded to the area with strict environment control specification.

2) The test shall be performed 1 hour later after the condition becomes stabilized through operating the air-conditioning system.

3) The working area shall be divided with grids with the same size.

4) Each test zone shall be selected through the agreement between the purchaser and the supplier.

5) There shall be more than 2 measuring points at least.

6) The temperature probe shall be installed at a working height farther than 300mm from the ceiling, wall or floor of the clean room.

7) The probe location shall be selected while considering the heat source.

8) The measurement shall be sufficiently done for the purpose, recorded at every 1 minute and measured for every 5 minutes at least.

4) Instrument to test the air current

a) The temperature test shall be performed by the sensor with the accuracy defined in the KS A 0511 (ex, resistance thermometer, thermistor, thermel and glass thermometer).

b) The minimum resolution required for the measuring instrument is 1/5 between the configured and allowed temperatures.

c) The calibration report on the instruments issued by certified agency shall be equipped.

4) Performance evaluation

a) The recommended temperature in the clean room is 23oC and the benchmark

temperature may be altered by the agreement between the purchaser and the supplier.
b) The fluctuation from the benchmark temperature shall be within the allowed width specified in the table depending on the grade.

Allowed temperature fluctuation

Grade	Allowed fluctuation (±°C)
1	0.1
2	0.5
3	1
4	2

[Humidity test]

1) Purpose and application of the test The purpose of the test is to show the performance of the clean room air-conditioning system which maintains the air humidity expressed as the relative humidity or dew point within the control limit for a period of time specified in the agreement between the purchaser and the contractor for tested zones.

2) Temperature test procedure

1) This test is performed after completing the air current uniformity test and adjusting the air-conditioning system control.
b) The test shall be performed after stabilizing the condition through fully operating the air-conditioning system.
c) The humidity sensor shall be installed for a point in each humidity control area at least and shall sufficiently wait until the sensor becomes stabilized.
d) The measurement shall be done for the purpose after the sensor is stabilized at least for 5 minutes.
e) The measuring points, frequencies, intervals and period for the data record shall follow the agreement between the purchaser and the supplier.
f) The humidity test shall be done with the temperature test.

3) Instrument to test the air current

a) The humidity test shall be performed by the sensor defined in the KS A 0078 (ex, ventilated psychrometer, electronic hygrometer and hair hygrometer).
b) The minimum resolution required for the measuring instrument is 1/5 between the configured and allowed humidities.
c) The calibration report on the instruments issued by certified agency shall be equipped.

4) Performance evaluation

a) The recommended relative temperature in the clean room is 45% and the benchmark relative humidity may be altered by the agreement between the purchaser and the supplier.
b) The fluctuation from the benchmark relative humidity shall be within the allowed width specified in the table depending on the grade.

Allowed fluctuation on the relative humidity

Grade	Allowed fluctuation (±%)
1	1
2	2
3	3
4	5
5	10

3. List of review board

■ Special board of clean room technology

No	Name	Title	Company Name	Position	Remarks
1	**Myungdo Oh**	Professor	University of Seoul	Department of Mechanical and Information Engineering	
2	**Guinam Bae**	Chief	Korea Institute of Industrial Technology	Environment and welfare research group	
3	**Gangho Ahn**	Professor	Hanyang University	Department of Mechanical Engineering	
4	**Byungho Yoon**	Vice CEO	Handok Pharmaceuticals Co., Ltd.		
5	**Yongtaek Kwon**	Director	HCT		
6	**Insoo Cho**	Executive director	Shinsung E&G Co., Ltd.	Technology research institute	
7	**Junhwan Byun**	Vice CEO	Wonbang Tech Co., Ltd.		
8	**Gwonbin Lim**	CEO	Samwoo TECM		
9	**Kyunghoon Yoo**	Chief researcher	Korea Institute of Industrial Technology	Converged production technology research division	
10	**Youngjae Won**	Professor	Korea University (Chinese Southeast University)		
11	**Kyusaeng Kim**	Professor	Woosong College	Building/clean room facilities	
12	**Gwangchul Roh**	Doctor	Yonsei University	Department of Mechanical Engineering	
13	**Taesung Kim**	Professor	Sungkyunkwan University	Department of Mechanical Engineering	
14	**Sejin Yook**	Professor	Hanyang University	Department of Mechanical Engineering	

4. Status of Certified Test Organizations

■ Status of certified test organizations as of 2013

(Period of consignment: January 1, 2013 - December 31, 2014)

No	Organization	Remarks
1	HCT	
2	Shinsung E&G Co., Ltd.	

5. Certification status

■ Clean room certification status

- Certification status of clean room (as of Dec 31, 2012)

○ Total: 4