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Method for helium leak testing

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japanese Society for Non-Destructive Inspection (JSNDI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently JIS Z 2331:1992 is replaced with this Standard.

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Method for helium leak testing

1 Scope This Japanese Industrial Standard specifies the leak testing to detect the leakage and the leak location by using helium gas and mass spectrometer type helium leak detector.

The testing methods, the criteria for assessment and formulas are considered from the standpoint of importance in practical use.

2 Normative reference The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including the amendments) indicated below shall be applied.

JIS Z 2300 *Terms and definitions of nondestructive testing*

JIS Z 2330 *Standard recommended guide for the selection of helium leak testing*

JIS Z 8754 *Vacuum technology—Mass-spectrometer-type leak-detector calibration*

3 Terms and definitions For the purposes of this Standard, definitions given in JIS Z 2300 and JIS Z 2330 apply.

4 Classification of testing methods The following seven methods are used for testing.

- a) Spray method
- b) Vacuum hood method
- c) Sniffer method
- d) Pressure accumulation method
- e) Suction cup method
- f) Bell jar method
- g) Bombing method

The specific selection of above testing methods shall be in accordance with clause 5 of JIS Z 2330.

5 Principle of measurement An example of operating principle of mass spectrometer tube is shown in figure 1. The very small amount of helium gas which flowed in (or out)

through a leak location of the test object is led into helium leak detector and ionized in the ion chamber in the mass spectrometer tube by the electron beam emitted from filament. These generated ions which are accelerated by accelerating voltage and run out from the accelerating slit form the different orbits according to the difference of the mass at the time of passing through the magnetic field, so the helium ions only are collected by ion collector and amplified by ion current amplifier to be indicated on a meter. As the indication of meter is in proportion to the leak rate, the quantification of leak rate becomes possible.

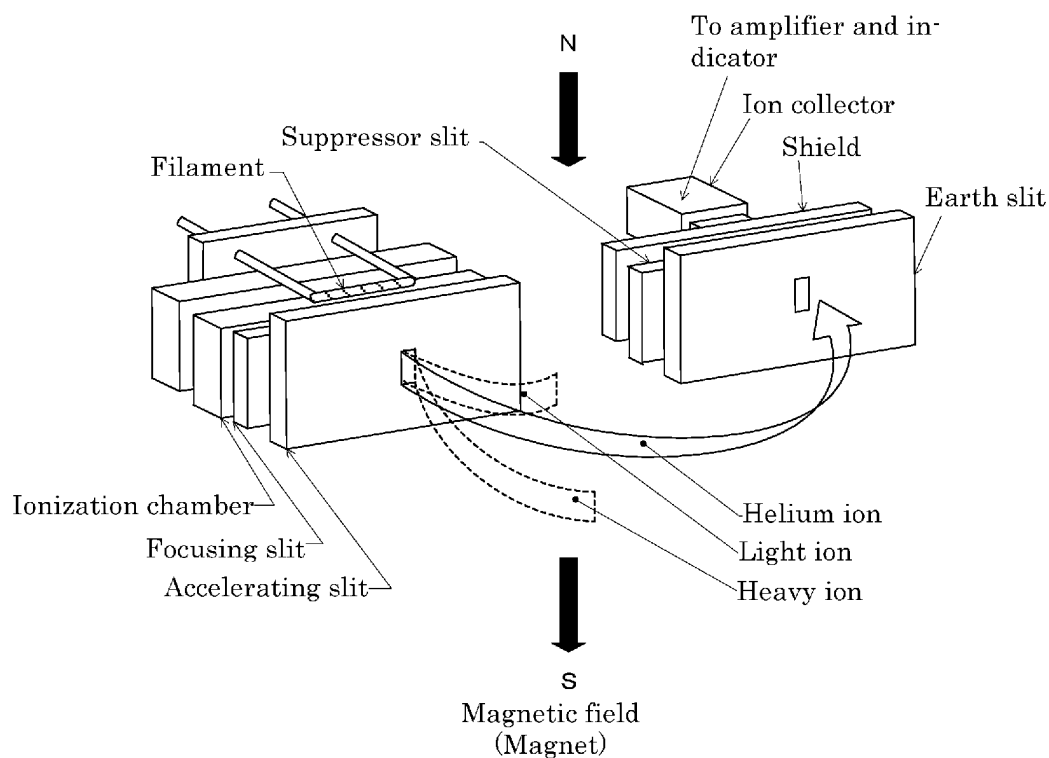


Figure 1 Operation principle of analytical principle—Example

6 Testing apparatus In helium leak testing, the following kinds of apparatus are used in appropriate combination according to the testing method :

- a) **Helium leak detector** This shall be the mass spectrometer-type leak detector using the helium gas being detected and in which the vacuum exhaust system for keeping the mass spectrometer tube in operational vacuum condition is built-in and is calibrated in accordance with JIS Z 8754. An example of helium leak detector is shown in figure 2.

Several models of the helium leak detector are automated for its unit calibration and enable the direct reading of leak rate from the electric output. However, the helium leak detector shall be calibrated to obtain correct leak rate of direct reading value depending on the testing method.

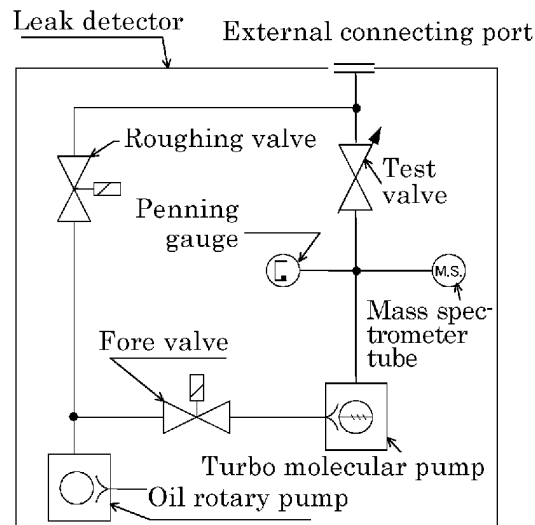


Figure 2 Example of helium leak detector

- b) **Calibration leak** The calibration of sensitivity of helium leak detector uses a calibration leak for vacuum method and a calibration leak or mixture gas whose helium concentration is known clearly for pressurizing method. The calibration leak has two types of channel type and membrane type, and for the membrane type that uses the permeation of helium gas, the calibration leak of which traceability of measurement by the authorized verification organization is ensured or the calibration leak which is confirmed by the user that there was no dispersion to be problem in practical use by comparing the calibration leaks with each other is used.
- c) **Auxiliary exhaust system** This system consists of vacuum pumps for vacuating the test object, larger pumping speed pump, vacuum gauge, etc.
- d) **Test materials** Search gas and cold trap, if needed, shall be used.
 - 1) **Search gas** Helium gas shall be used as search gas. When helium mixture gas is used, the test results obtained from the measurement shall be corrected by the mixture ratio of the helium gas.
 - 2) **Cold trap** When the helium leak detector is equipped with a cold trap, the liquid nitrogen is used to prevent moisture or oil content from reaching the mass spectrometer tube. If it is possible to condense moisture or oil content fully, other materials may be used.
- e) **Others** The following are used as the accessory for helium leak testing:
 - 1) Thermos flask for putting liquid nitrogen in.
 - 2) Helium gas cylinder for supplying search gas.
 - 3) Compressor and pressure reducing valve.
 - 4) Various kinds of joint and piping for assembling of vacuum system and pressur-

izing system.

- 5) Pressure gauge for measurement of the pressure of the test object (including vacuum gauge).

7 Testing method The testing methods shall be in accordance with Annexes 1 to 7.

8 Record At least the following items shall be recorded.

- a) Name of product and its quantity
- b) Product number
- c) Testing method
 - 1) Name of testing method
 - 2) Test pressure and temperature in the case of pressurizing method
 - 3) Apparatus number of testing apparatus
 - 4) Volume of test object
 - 5) Concentration of search gas
 - 6) Detection sensitivity
- d) Date of test carried out
- e) Place where test was carried out
- f) Name of a person who carried out the test
- g) Test result

Annex 1 (normative)

Spray method

1 Application This Annex specifies the spray method which vacuates the inside of the test object and sprays helium gas on the outside of the test object by using spray probe in order to detect the helium gas which leaked into the inside of the test object. This method is optimum for the detection of small quantities of leakage and is applied to the detection of relatively small leakage. When the quantification of leakage of the whole test object is necessary, the vacuum hood method is recommended.

2 Test procedure

2.1 Test condition The test condition shall be as follows.

- a) **Test temperature** If the test temperature is specified, it shall be used.
- b) **Calibration leak** The calibration leak that has been calibrated in advance shall be used.

The calibration leak shall be confirmed by mutual comparison among a few calibration leaks and verified normal. The value of the calibration leak shall be corrected to the ambient temperature when testing.

- c) **Search gas** Helium gas of the volume fraction of 90 % or higher shall be used.
- d) **Test pressure** If the test pressure is specified, it shall be applied. If not specified, the pressure capable of being exhausted by the exhaust system associated with helium leak detector and by the auxiliary exhaust system used in testing shall be applied.

2.2 Preparation The preparation shall be as follows.

- a) Helium leak detector, helium gas, spray probe, calibration leak, etc. shall be prepared. The auxiliary exhaust system shall also be prepared according to the volume of the test object.
- b) Pretreatment and opening portion treatment of the test object shall be done.
 - 1) **Pretreatment** From the inside and outside surfaces of the test object, moisture, oil content, organic solvent, grease, paint, etc. which is likely to affect the leak shall be removed.
 - 2) **Opening portion treatment** The opening portion shall be sealed with the appropriate material able to be promptly and completely removed after testing.
 - 3) The material for sealing shall not affect the test object.
- c) A helium leak detector shall be connected to the test object. Measuring instruments such as vacuum gauge and vacuum exhaust system shall be attached as well where

appropriate.

- d) A calibration leak shall be attached at the location as far as possible on the test object (the most distant location from the helium leak detector). However, for the test object to which the calibration leak can not be attached, the calibration leak shall be attached to the piping. When the leak testing is carried out on the test object of small capacity, which does not use auxiliary exhaust system, by using the helium leak detector with built in calibration leak, the calibration leak may be used.

2.3 Exhaust The exhaust shall be as follows.

- a) The test object shall be vacuated by means of the exhaust system of the helium leak detector and other auxiliary exhaust system connected with the test object.
- b) When the auxiliary exhaust system is used, it shall be connected to the helium leak detector under the pressure that enables the operation of helium leak detector but not exceeding this pressure.

2.4 Sensitivity calibration and measurement of response time The sensitivity calibration and the measurement of response time shall be determined by the output of calibration leak connected to the test object. The sensitivity calibration uses the indicated value that is measured using the calibration leak connected to the test object as the corrected value. Calculation shall be done by the following formula.

$$Q_T = X_T \times \frac{Q_C}{X_C} \dots\dots\dots (1)$$

where, Q_C : Leak rate of the calibration leak connected to the test object

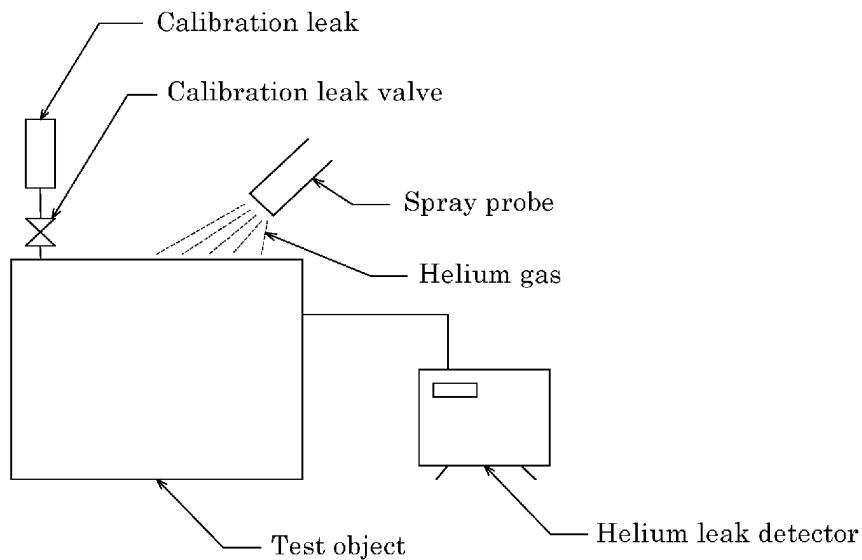
X_C : Output of the leak detector to the calibration leak connected to the test object

X_T : Output of the helium leak detector to the measured leak

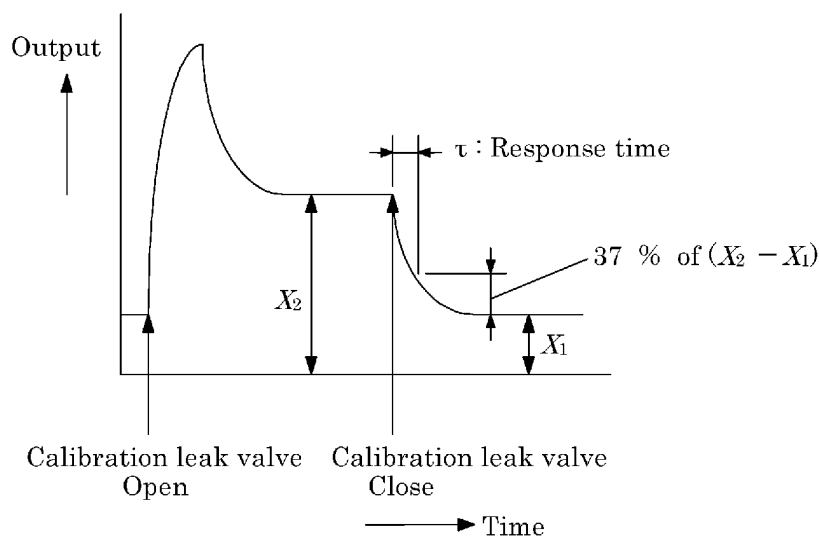
Q_T : Actual leak rate of the measured leak

Also the response time shall be measured when confirming the output of the calibration leak in accordance with 2.4 a).

- a) **Carrying out the leak test by helium leak detector only** An example of the connection of each instrument to the test object is shown in Annex 1 figure 1 and of the relation between the output value of the helium leak detector and the lapse of time in Annex 1 figure 2 respectively. Since the test object is directly connected to the helium leak detector in this method, the helium leak detector indicates the true value of the calibration leak. Since the response time depends on the characteristics of the test object, the response time shall be carefully measured.



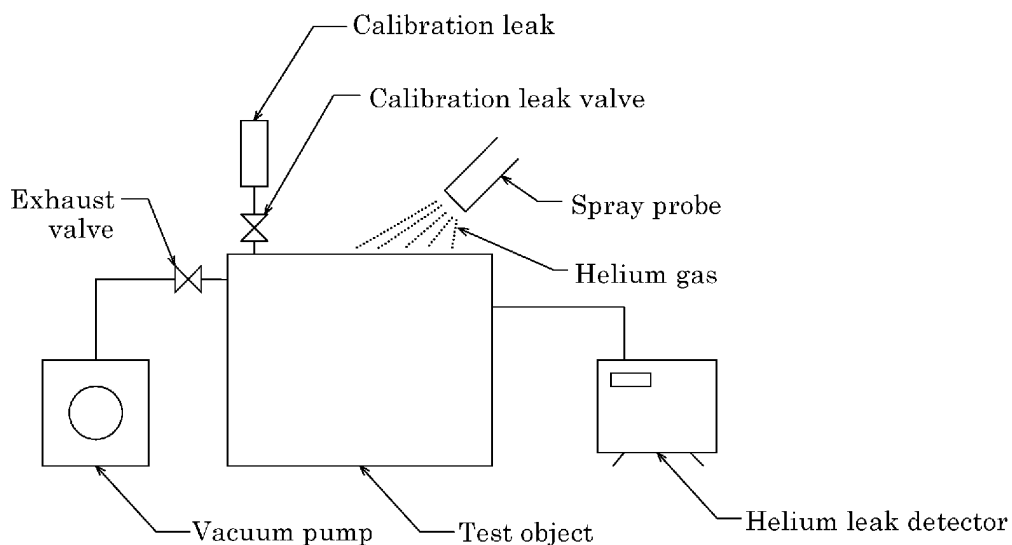
Annex 1 Figure 1 Example of connection for tests using helium leak detector only



Annex 1 Figure 2 Output value of the helium leak detector and lapse of time at the time of measurement

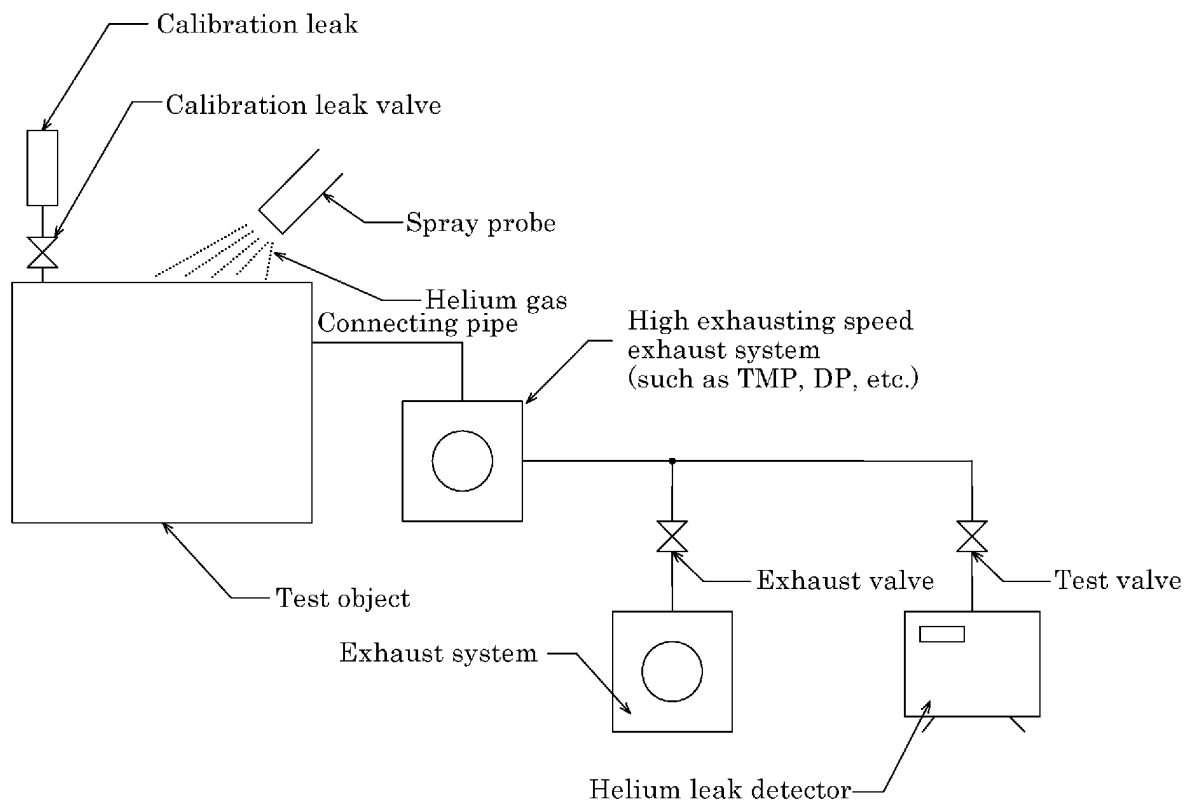
- 1) Open the valve of calibration leak and introduce helium gas into the vacuum system. In the system with long response time, the partial pressure of helium gas in the test object may not be stabilized for a long time due to the inflow of helium gas accumulated between the valve and the calibration leak. When the long response time is expected, the space between the calibration leak and the valve should be evacuated by another exhaust system in advance.

- 2) Introduce helium gas from the calibration leak and record the output of the helium leak detector after output is stabilized. This output value is specified as the equilibrium indicated value (X_2).
 - 3) Close the valve of calibration leak and record the output of the helium leak detector after the output is stabilized. This output value (X_1) is specified as the background. In addition, the lapse of time and the output value (X_1) during this time shall be recorded. But, if the background is not stabilized, its maximum value ($X_{1,max}$) and minimum value ($X_{1,min}$) shall be recorded and their average value $\left(\frac{X_{1,max} + X_{1,min}}{2} \right)$ be the background.
 - 4) The lapse of time from closing the valve of the calibration leak to the time when the output value comes to 37 % of ($X_2 - X_1$) is specified as the response time (τ). Record it.
 - 5) In the case of leak testing which uses an auxiliary exhaust system, if the calibration leak cannot be attached to the distant location on the test object due to the structure of the test object and the connecting piping, the calibration leak shall be attached to the location where the attachment is possible (on the test object or connecting piping). Correct the obtained values of the sensitivity and the response time in accordance with formula (1) and record that the value is corrected.
- b) **In the case of using auxiliary exhaust system in parallel** An example of composition of the vacuum system of the leak test is shown in Annex 1 figure 3. This method is used when the test object cannot be sufficiently vacuated by the pumping system of the helium leak detector alone. The auxiliary exhaust system and the pumping system of the helium leak detector are connected to the test object in parallel, the helium gas from the calibration leak is divided by these two pumping systems not to show the true value. Therefore the indicated value shall be corrected in accordance with formula (1). The response time shall be measured in the manner similar to 2.4 a).



Annex 1 Figure 3 Example of composition in the case of using auxiliary exhaust system in parallel

- c) **In the case of parallel or series connection to the back pressure side of high exhausting speed vacuum pump** An example of composition of the vacuum system of the leak test is shown in Annex 1 figure 4. When performing the evacuation of the test object using the vacuum pump and the helium leak detector in parallel, measure the leak rate with the exhaust valve and the test valve in the figure opened. This method of parallel connection is applied to the leak test of large vacuum apparatus and the vessel of large capacity of a few cubic metres. However in the case of parallel connection, the helium gas from the calibration leak is divided by these two pumping systems not to show the true value. Therefore the indicated value shall be corrected in accordance with formula (1). When performing the evacuation of the test object with the high speed pumping system with only the helium leak detector connected in series as a fore pump, evacuate the test object sufficiently with only the exhaust valve is opened. Then close the exhaust valve and open the test valve. The response time shall be measured in the manner similar to 2.4 a).



Annex 1 Figure 4 Example of composition in the case of connection in parallel or in series with back pressure side of high exhausting speed vacuum pump

2.5 Measurement of leakage The measurement of leakage shall be carried out in accordance with the following.

- a) Spray helium gas on every leak testing location one by one by using the spray probe and judge from the output of helium leak detector (pointer, digital display, recorder, etc.) whether there is a leak or not. Calculate the leak rate using the formula (1) and detect the position of leakage taking the time for spraying the helium gas and the waiting time when any leak was detected (the interval from the time to spray the helium gas for the first time to the time to spray the helium gas for the next time) into account.

Spraying time = Response time τ measured in 2.4 a) or longer

Waiting time = Response time τ measured in 2.4 a) $\times 2$

- b) **Precautions** The following precautions shall be taken.

- 1) The order of testing shall start from the upper part of the test object toward the lower part because the helium gas is likely to diffuse upward in nature.
- 2) If organic high polymeric material is used for the sealed portion of the test object, the helium gas may permeate through the sealed portion to result in the erroneous recognition to be a leak. In order to prevent this, after spraying the helium gas, the compressed air and the like shall be immediately sprayed to remove the helium gas at the position of organic high polymeric material.
- 3) The work shall be done in the circumstance of good ventilation to avoid the increase of background caused by the residence of helium gas.
- 4) For the test object with the complicated shape which makes helium gas difficult to reach the tested portion, the parallel use with vacuum hood method is recommended.
- 5) When searching for the location of leakage, spray helium gas to wide area of the surface of the test object. Reduce the flow of helium spray to identify the location after detecting the leak.
- 6) The indicated value of the helium leak detector is affected by the concentration of helium near the leak. For quantification it is preferable to spray sufficient helium to the identified location, or the parallel use with vacuum hood method is recommended.
- 7) If the calibration leak cannot be attached to the test object, the calibration leak built in the helium leak detector may be used. However, carry out the test taking the conductance of the test object fully into account.
- 8) It is preferable that the background during the leak test is less than 1/10 of the target measured value.
- 9) When the passage of leak is expected to have void to cause the delay of response time, consider sufficient spraying time.

2.6 Opening and post-treatment The opening work and the post treatment shall be in accordance with the following :

- a) Finish evacuating the test object, introduce the air or dry nitrogen into the test object for the test object to return to the atmospheric pressure.
- b) Remove the attached apparatus to carry out the helium leak test such as helium leak detector, calibration leak, auxiliary exhaust system, etc. from the test object.
- c) If the opening portion was sealed for testing by the sealing material, it shall be removed after testing.

2.7 Assessment When the measured leak rate is equal to or less than that given in the specification, the result is acceptable.