

ICS 23.020

CCS J74



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 18443.6-2010

**Testing method of performance for vacuum insulation
cryogenic equipment - Part 6: Heat-leak rate measurement**

真空绝热深冷设备性能试验方法 第6部分：漏热量测量

Issued on: September 26, 2010

Implemented on: February 1, 2011

**Issued by: General Administration of Quality Supervision, Inspection and
Quarantine of the People's Republic of China;
Standardization Administration of China**

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1 Scope

GB/T 18443.6-2010 is the Chinese national standard on testing method of performance for vacuum insulation cryogenic equipment - part 6: heat-leak rate measurement, in the field of fluid systems and general-purpose components. The /T suffix marks it as a recommended standard: it is not compulsory by itself, but it becomes binding as soon as a contract, a tender or a customer specification calls it up - which in practice is how most foreign buyers meet it. It was issued on 26 September 2010 by the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China; Standardization Administration of China, and has been in force since 1 February 2011. Classification: ICS 23.020, CCS J74. This page is published from the official record of the standard held by the Chinese standards administration: the identification, the dates, the classification and the issuing body are taken from there. The clause text, the tables and the numeric limits are in the document itself, which is delivered complete in English translation.

This Part of GB/T 18443 specifies test principles and methods, test devices, equipment and instruments, test conditions and test preparation, test procedures, data processing and test record and test report for the heat-leak rate measurement of vacuum insulation cryogenic equipment. This part applies to the heat-leak rate measurement of vacuum insulation cryogenic pressure vessels, vacuum insulation cryogenic welded gas cylinders, vacuum insulation pipes and their pipe fittings, except the liquid hydrogen storing and transporting equipment. Other equipment can refer to this document for the implementation. The

flowmeter measurement method is suitable for the heat-leak rate measurement of vacuum insulation cryogenic pressure vessels, vacuum insulation cryogenic welding gas cylinders and other vacuum insulation cryogenic equipment. The surface temperature measurement method is suitable for the heat-leak rate measurement of vacuum insulation pipes and their fittings.

2 Normative references

The provisions in following documents become the provisions of this Part of

GB/T 18443 through reference in this Part. For dated references, the subsequent amendments (excluding corrigendum) or revisions do not apply to this Part, however, parties who reach an agreement based on this Part are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 18443.1-2010, Testing method of performance for vacuum insulation cryogenic equipment - Part

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 18443.1~GB/T 18443.5 as well as the followings apply.

3.1 heat-leak rate The heat transferred from the surrounding environment to the storage medium of the vacuum insulation cryogenic equipment per unit time, in watts (W).

3.2 test heat-leak rate After the vacuum insulation cryogenic equipment is fully cooled and reaches thermal equilibrium, the heat transferred from the surrounding environment to the storage medium of the vacuum adiabatic cryogenic equipment per unit time, in watts (W).

3.3 heat-leak rate of standard ambient condition The test heat-leak rate is converted to the value of the heat-leak rate under the standard environmental state, in watts (W).

4 Test principles and methods

4.1 Flowmeter measurement method The test principle, method and device conform to the provisions of

4.2.2 in GB/T 18443.5-2010.

4.2 Surface temperature measurement method

4.2.1 Test principle and method Measure the outer surface temperature of the vacuum insulation pipe and the corresponding ambient temperature. Calculate the heat-leak rate into the vacuum insulation pipe according to the natural convection in the large space.

Calculate the heat conduction heat-leak rate of the joint according to the difference between the measured temperature of the air side of the joint and the temperature of the liquid. Or establish the finite element heat transfer model of the joint to solve the heat-leak rate of the joint. The schematic diagram of the test device is shown in Figure 1.

- b) The rated flow rate of the flowmeter shall be compatible with the gas flow rate evaporated by the tested vacuum insulation cryogenic pipe;
- c) There shall be ambient temperature, ambient atmospheric pressure and flowmeter inlet temperature and pressure measurement devices.

6 Test conditions and test preparation

6.1 Test conditions and test preparation shall comply with the provisions of GB/T 18443.1.

6.2 When using the surface temperature method, the measurement shall be carried out in a room protected from light, natural convection and no wind.

6.3 The effective length of the test vacuum insulation pipe shall not be less than 5m. No less than 6 temperature measurement points are evenly distributed at the bottom of the surface of the outer pipe with a length of 3m in the middle.

6.4 The inner volume of the auxiliary test section shall be greater than twice the inner volume of the test vacuum insulation pipe. The height of the auxiliary test section shall be less than 1.5m.

7 Test steps

7.1 Flowmeter measurement method The test procedures, test process and data record shall comply with the provisions in

7.1 of GB/T 18443.5.

7.2 Surface temperature measurement method

7.2.1 Liquid nitrogen is generally used as the test medium. The actual delivered cryogenic liquid can be used as the test medium.

7.2.2 Open valve

10. Use the cryogenic container 11 to continuously deliver cryogenic liquid to the test vacuum insulation pipe and its pipe fittings until they are full. When the liquid level in the auxiliary test section drops to half, it shall be refilled with liquid. Ensure that the test vacuum insulation pipe is filled with test medium liquid.

7.2.3 The data can be recorded only after the vacuum insulation pipe and its fittings have been continuously conveying cryogenic liquid for 24h.

7.2.4 The data recording shall be based on the time interval of not more than 10min, collection surface and ambient temperature, until the relative error of the collected data within 1h is less than $\pm 5\%$. Where, Q_0 - Total heat-leak rate of the joint pair, in watts (W); D_1 - The outer diameter of the outer pipe of the male joint, in meters (m); D_2 - The inner diameter of the outer pipe of the male joint, in meters (m); δ_1 - The outer pipe wall thickness of the male joint, in meters (m); δ_2 - The inner pipe wall thickness of the female joint, in meters (m); T_{wj1} - The average temperature of the outer surface of the male joint in contact with the environment, in Kelvin (K); T_{wj2} - The average temperature of the outer surface of the female joint in contact with the environment, in Kelvin (K); T_2 - The saturation temperature of the cryogenic liquid corresponding to the average pressure in the test piece during the test, in Kelvin (K); λ_1 - The average thermal conductivity of the outer pipe material of the male joint in the temperature zone from T_{wj1} to T_2 , in watts per meter Kelvin (W/m·K); λ_2 - The average thermal conductivity of the inner pipe material of the female joint in the temperature zone from T_{wj2} to T_2 , in watts per meter Kelvin (W/m·K); L_1 - The length of the outer pipe of the male joint, in meters (m); L_2 - The length of the inner pipe of the female connector, in meters (m).

b) When calculating the heat-leak rate of other joint pairs in the pipeline, consider the heat conduction structure of the actual size. The temperature difference is the difference between the measured surface temperature and the saturated liquid temperature. For complex structures, it shall use finite element thermal analysis and calculation.

8.2 Calculation of heat-leak rate Q_{20} of standard state (standard ambient condition)

8.2.1 The heat-leak rate Q_{20} of high vacuum multi-layer insulation of the standard state shall be calculated according to formula (9). Where, Q_{20} - The heat-leak rate of standard state, in watts (W); Q_0 - The total heat-leak rate of the joint pair, in watts (W); T_s - The cryogenic liquid saturation temperature under standard atmospheric pressure (101.325kPa), in Kelvin (K); T_1 - The average ambient temperature during the test, in Kelvin (K); T_2 - The saturation temperature of the cryogenic liquid corresponding to the average pressure in the test piece during the test, in Kelvin (K).

8.2.2 The powder or fiber vacuum insulation heat-leak rate Q_{20} of the standard state shall be calculated according to formula (10). Where, Q_{20} - The heat-leak rate of the standard state, in watts (W); Q_0 - The total heat-leak rate of the joint pair, in watts (W); T_s - The cryogenic liquid saturation temperature under standard atmospheric pressure (101.325kPa), in Kelvin (K); T_1 - The average ambient temperature during the test, in Kelvin (K); T_2 - The saturation temperature of the cryogenic liquid corresponding to the average pressure in the test piece during the test, in Kelvin (K).