ICS 49.020
CCS V 71

NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 47377-2026

Comprehensive test methods for the air environment of manned spacecraft assemblies

载人航天器组合体空气环境综合试验方法

Issued on: April 30, 2026 **Implemented on: November 1, 2026**

Issued by: State Administration for Market Regulation;
Standardization Administration of the PRC

Table of Contents

7 Test Conditions

7.1 Test Condition Settings The requirements for the integrated air environment test conditions of the manned spacecraft assembly are as follows:

a) It should include at least the following conditions. high heat load with human metabolism, high heat load without human metabolism, low heat load with human metabolism, and low heat load... Unmanned metabolic operation;

b) All manned metabolic operating conditions should cover various occupant residence modes and metabolic levels;

c) If the atmospheric pressure test method is used, at least one high heat load unattended metabolic condition and one low heat load unattended metabolic condition should be set up. Furthermore, it forms a benchmark condition with the high-temperature and low-temperature conditions of the thermal vacuum test, and is used to correct the thermal boundary conditions of the sealed chamber in the normal pressure test;

d) It should include possible failure conditions that affect the air temperature and component control functions of the test model.

7.2 Sequence of Test Conditions The required sequence for implementing the test conditions is as follows:

a) Unmanned metabolic operation should be prioritized. Once the system is running stably, the O2 and CO2 generation and processing devices should be started. Once the system stabilizes, restart the steam generation and treatment equipment.

b) If a thermal vacuum test is used, the high-heat-load condition should be combined with the high-temperature condition of the thermal vacuum test, and the low-heat-load condition should be... It was carried out in conjunction with the cryogenic conditions of thermal vacuum testing;

c) If the test is conducted under normal pressure, a benchmark test should be performed first to adjust the thermal boundary conditions of the sealed chamber. Then, the formal experiment will begin;

d) Normal operating conditions should be carried out first, followed by fault operating conditions.

7.3 Stability Criteria for Test Conditions The stability criteria for the test conditions are as follows:

a) If the atmospheric pressure test method is used, it should first be ensured that the simulated heat leakage of the sealed chamber reaches a stable level, and the criterion should meet GB/T 38201- Requirements of

b) The criteria for air temperature stability are as follows: 1) Within a continuous 4-hour period, the fluctuation value should not exceed ±0.5°C; 2) The monotonic change value is no greater than 0.1°C/h within 4 consecutive hours.

c) The criteria for stable relative humidity are as follows: 1) Within a continuous 4-hour period, the weight difference between the water vapor released by the occupant metabolic simulation device and the weight of the condensate collected in the cabin does not exceed [a certain value]. ±2%; 2) The relative humidity fluctuation value does not exceed ±2% within 4 consecutive hours.

8.1.1 Thermal boundary simulation of the sealed chamber

8.1.1.1 Thermal vacuum test The thermal boundary simulation method for sealed chambers should meet the requirements of

6.1 in GB/T 34515-2017.

8.1.1.2 Atmospheric Pressure Test The requirements for thermal boundary simulation of the sealed chamber are as follows:

a) The method for determining the ambient temperature under normal pressure is as follows: 1) Determine the total heat leakage of the sealed chamber. Select similar test conditions from the thermal vacuum thermal test as benchmark conditions, and statistically analyze the heat leakage of various components within the sealed chamber. The sum of various heat loads (including heat generated by equipment operation, waste heat from power supply and distribution systems, and heat generated by passenger metabolism) is used to calculate the internal circuit heat load. The heat collected is used to calculate the total heat leakage of the sealed chamber under each working condition according to formula (1).

8.1.2 Simulation of inter-cabin ventilation flow field The requirements for simulating the flow field between the modules of a manned spacecraft assembly are as follows:

a) The ventilation system inside the test model cabin should meet the requirements of the manned spacecraft assembly development status.

b) If the test conditions permit, the real-state test model should be used to form a manned spacecraft assembly for the test.

c) If constrained by factors such as model state, space environment, and simulation chamber space, it is not possible to form a combined body using a real-state experimental model. For testing, a single real-state test model can be paired with a scaled-down chamber to simulate the inter-chamber flow field. The scaled-down chamber requires... as follows: 1) The envelope dimensions of the manned spacecraft assembly configuration and the effective volume envelope dimensions of the space environment simulation chamber should be analyzed to determine the scaled-down cabin. Upper limit of feature size; 2) The lower limit of the characteristic dimensions of the scaled-down compartment should be determined through fluid dynamics simulation analysis; 3) The scaled-down compartment should be selected from the upper limit of the characteristic dimensions determined in 1) and the lower limit of the characteristic dimensions determined in 2). 4) The scale-down chamber should ensure airtightness under test pressure conditions; 5) The scale-down chamber should be equipped with the same thermal insulation measures as the sealed chamber of the test model; 6) If the gas inside the sealed chamber needs to be collected for harmful gas detection during the test, the materials contained in the scaled-down chamber should not interfere with the test. Hazardous gas detection.

d) If it is not feasible to use a single real-world test model in conjunction with a scaled-down chamber for testing, alternative test models can be selected based on the actual situation. The test model simulates cabin ventilation in certain functional areas, with the following requirements. 1) The selected functional area should not be a primary area for personnel activity; 2) The selected functional area should not affect the implementation of other verification items in the experiment; 3) Fluid dynamics simulation analysis should be used to compare the differences between the simulated flow field and the actual flow field in the functional area.

8.1.3 Simulation of Air Components The requirements for air composition simulation are as follows:

a) If experimental conditions permit, the generation, transport, and handling of O_2, CO_2, and water vapor within a sealed chamber should be simulated realistically;

b) If the experimental system needs to be scaled down due to experimental constraints, it can simulate both water vapor and CO_2, or only the generation and transport of water vapor. Transport and processing, as targets for other air components;

c) A weighing device should be provided to weigh the condensate collected in the sealed chamber in real time during the test.

8.2 Test Preparation The following preparatory work should be carried out during the experiment preparation phase.

8.3 Status Setting and Checking

8.3.1 Before entering the space environment simulation room The following are the setup and inspection procedures for the test model and scaled-down cabin before they enter the space environment simulation chamber.

a) All sensors, occupant metabolism simulation devices, and other experimental equipment were installed in the sealed chamber of the test model, and cables and pipes were installed. Road layout;

b) Conduct system-wide commissioning or trial operation of test models and test equipment.

8.3.2 After entering the space environment simulation room The following are the status settings and inspection items after the test model and scaled-down cabin enter the space environment simulation chamber.

a) Connect all types of pipes and cables;

b) Connect the various sealed chambers of the test model, or the test model and the scaled-down chamber;

c) Conduct airtightness checks on all types of pipelines and sealed chamber connections;

d) Conduct system-wide commissioning or trial operation of the test model, test equipment, space environment simulation room, etc.

8.4 Test Start The requirements for starting the test are as follows:

a) When conducting tests using the thermal vacuum test method, the start-up of the test shall be carried out in accordance with the provisions of

10.4 in GB/T 34515-2017.

b) When conducting a test using the atmospheric pressure method, the test initiation should include. 1) Replace the gas in the space environment simulation chamber to lower the dew point temperature; 2) Activate the floor cooling source after the indoor dew point in the simulated space environment drops to the lowest temperature of the floor cooling source, to avoid triggering the external circuit pipes. Condensation on roads and equipment; 3) Activate pipeline heating measures as needed; 4) Start the test model and test equipment according to the first unmanned metabolic condition benchmarked against the thermal vacuum test; 5) Activate the temperature control system of the space environment