NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA



# GB/T 38231-2019

# Corrosion of metals and alloys - Test method for thermal-cycling exposure oxidation testing under high-temperature corrosion conditions for metallic materials

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## 1 Scope

This Standard stipulates the equipment, gas supply, samples, test process, calculation and analysis of mass change, post-test sample evaluation and test report of isothermal exposure oxidation testing of metallic materials under high-temperature corrosion conditions.

This Standard is applicable to test method for thermal-cycling corrosion testing (namely, cyclic oxidation test) of metallic materials from the ambient temperature to high-temperature gas environment (each sample shall receive a series of repeated, regular and controlled temperature cycles). After proper adjustments are made, the test method may also be adopted in the testing of other materials.

This Standard is not applicable to testing that adopts extremely short holding time (a few minutes or a few seconds).

## 2 Normative References

The following documents are indispensable to the application of this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 1598 Platinum - 10% Rhodium/Platinum Thermocouple Wires - Platinum - 13% Rhodium/Platinum Thermocouple Wires - Platinum - 30% Rhodium/Platinum - 6% Rhodium Thermocouple Wires

GB/T 9258.3 Coated Abrasives - Grain Size Analysis - Part 3: Determination of Grain Size Distribution of Micro-grits P240 to P2500 (GB/T 9258.3-2017, ISO 6344-3:2013, IDT)

GB/T 13298 Inspection Methods of Microstructure for Metals

GB/T 16701 Methods for Measuring the Thermoelectric Force of Noble Metal and Base Metal Thermocouple Wires 4---humidity regulator (electronic);

5---hygrometer;

6---heating device with non-equilibrium gas mixture catalyst;

7---heating zone with heating belt;

8---heating device;

9---sample chamber;

10---sample;

11---sample holder;

12---thermocouple;

13---power/temperature control device;

14---moving direction of heating stove;

15---gas emission;

16---measurement device.

Figure 2 (continued from previous page)

4.1.2 In the design of the heating device, the isolation of the sample chamber from the external environment shall be guaranteed.

4.1.3 It shall be guaranteed that flow that passes through the sample is continuous and within the stipulated range.

4.1.4 The sample chamber shall not adopt any materials that would react with the test environment during the testing process and lead to changes of the composition of the test environment.

4.1.5 If the sealed test system with sample chamber cannot be used, it is also allowable to conduct the test under the atmospheric environment in the laboratory. Atmospheric humidity shall be recorded; try to maintain at a constant temperature and be free from the effect of weather conditions in the laboratory.

4.1.6 Before the test, examine the heating stove at the exposure temperature of the test; determine the dimensions of the uniform temperature zone in the heating stove.

Generally speaking, the method of independent activity thermocouple shall be adopted.

4.1.7 The temperature regulating device shall be able to guarantee that sample temperature maintains within the allowable deviation range that is stipulated in Table

4.2.5 Thermocouple wire shall adopt thermowell for protection. Thermowell shall be able to be used at the test temperature and under the test environment.

5 Gas Supply of Sealed System

5.1 Gas supply system shall be able to steadily provide gas for testing at a constant rate to the sample chamber.

5.2 Gas flow meter shall be adopted to monitor the gas flow. Flow meter shall be placed near the entrance of the sample chamber. However, when humidity regulator is used, flow meter shall be placed at the upstream of the humidifier.

5.3 When humidity regulator is used, humidity regulator shall be able to adjust humidity to an expected value. Unless it is otherwise stipulated, deionized water, whose conductivity is lower than 1 uS/cm shall be used. In order to prevent from condensation, the temperature of the space between the humidity regulator and the sample chamber shall be maintained above the dew point.

5.4 After gas is humidified, water vapor content shall be tested. Testing methods include: use a hygrometer to measure in front of sample chamber, or, measure water content after the condensation of the discharged gas, or, measure the amount of water consumption in the humidifier during the test.

5.5 When the test is conducted in the air, it is recommended to adopt 20 g/kg specific humidity ratio (namely, mass fraction of water content in the air). This specific humidity ratio is the relative humidity 100% at 25 °C (dew point), which can be easily obtained through bubbling in water bath at 25 °C. If other humidity values are adopted, the consent of various relevant parties shall be obtained.

5.6 In the cooling stage, prevent test gas from generating condensed phase. It may be implemented by turning off the humidifier or switching into inert gas.

6 Samples

6.1 The shape of samples shall be plate, disc or cylinder. Surface area shall be not less than 300 mm2; thickness shall be not less than 1.5 mm. If the above-mentioned requirements cannot be satisfied, the shape and the dimensions of samples shall comply with the requirements in the agreement reached among the various relevant parties.

6.2 The surface of samples shall be mechanically polished, so as to guarantee that the layer that would affect machining is eliminated. The final polishing of the surface of samples shall adopt polishing materials, whose average particle diameter is around 15 um; P1200 polishing materials that comply with the requirements in GB/T 9258.3 may be used. If it is requested by relevant parties to adopt other surface polishing methods, in the time period when the temperature approaches the heating holding temperature.

c) Cooling time: the time from the stopping of heating (for example, taking sample out of the heating furnace) to the time that the actual temperature of the sample decreases to below 50 °C;

d) Cooling holding time: the time from the moment when the actual temperature is lower than 50 °C to the re-heating of the sample.

7.4 Thermal Cycle Type and Holding Time

7.4.1 Thermal cycle type There are two typical types of thermal cycle in industrial application:

a) Long-term thermal cycle: it is used to simulate the service of large-scale industrial equipment in practical application, for example, power plant, waste incineration or chemical industry. In the above-mentioned application, metal components are designed to have an extremely long service life, for example, generally over 100,000 h. Planned factory shutdown (for example, routine maintenance) or accidental shutdown caused by abnormal situations would all lead to thermal cycle of materials. Therefore, in comparison with the long service life of components, the time interval of different thermal cycles is relatively long; the number of cycles is relatively small (generally around 50 times).

b) Short-term thermal cycle: typical application of short-term thermal cycle includes: industrial gas turbines, jet engines, automotive parts and thermal treatment equipment, etc. In comparison with long-term application, the time interval between equipment turning-on and turning-off is generally much shorter. Meanwhile, the designed service life and (or) the time needed for thorough overhauling/maintenance (generally, 3,000 h ~ 30,000 h) is even shorter (depend on specific situation of practical application); the number of cycles is larger.

7.4.2 Heating and cooling time The heating and cooling rate will affect the test result to a very large extent, and it depends on the detail features of test equipment. Controlling factors include: system thermal mass, transmission mechanism, and whether or not there is strong cold. The recommended heating time does not exceed 30 min; the recommended cooling time does not exceed 60 min.

7.4.3 Standard test parameters of long-term test When the thermal cycle defined in 7.3 is used in long-term thermal cycle test, in 1---spalling after primitive protective stage;