GB

NATIONAL STANDARD OF THE

PEOPLE'S REPUBLIC OF CHINA

ICS 19.100

J 04

GB/T 38894-2020

Non-destructive testing - Electrochemical testing - General principles

无损检测 电化学检测 总则

Issued on: June 02, 2020 **Implemented on: December 01, 2020**

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

Table of Contents

Non-destructive testing - Electrochemical testing - General principles

1 Scope

This standard stipulates the general principles of non-destructive electrochemical testing such as selective electrodes, electrochemical impedance, multiple potential scanning for metal materials and products, as well as steel in infrastructure.

This standard applies to non-destructive testing of the corrosion state, corrosion tendency and corrosion rate of metal equipment and components in the service environment.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this standard.

GB/T 10123 Corrosion of metals and alloys - Basic terms and definitions

GB/T 33373 Anticorrosion - Electrochemical protection - Terminology

3 Terms and definitions

The terms and definitions as defined in GB/T 10123 and GB/T 33373 as well as the following terms and definitions apply to this document.

3.1

Service environment

The environment in which metal equipment and its components are in use.

3.2

Multi circle potential dynamic polarization

At a certain potential scanning speed, apply repeated potential polarization

with an IrO_2 film, where the metal titanium is a conductor and the IrO_2 film is a hydrogen ion sensitive film. In an aqueous environment, the following electrochemical reactions occur on the surface of the Ti/IrO_2 electrode:

$$2IrO_2 + 2H^+ + 2e \rightarrow Ir_2O_3 + H_2O$$

In the equilibrium state, the potential of the Ti/IrO_2 electrode has a linear relationship with the concentration of hydrogen ions in the solution. By measuring the potential of the Ti/IrO_2 electrode in a series of standard pH solutions, the working curve of the pH sensor can be obtained. Measure the potential of the pH sensor. According to the slope and intercept value of the working curve, the pH value of the service environment can be converted.

4.1.4 Features

Selective electrode's testing has the following features:

- Easy and fast operation, not affected by the color or turbidity of the environmental medium;

- It may carry out tracking monitoring and automatic testing.

4.1.5 Limitations

Selective electrode testing has the following limitations:

- Other species in the environmental medium may interfere with the testing;

- The selective electrode has temperature deviation in the testing of species in the environment, which needs to be compensated and corrected.

4.2 Corrosion potential testing

4.2.1 Overview

Corrosion potential is an important corrosion electrochemical parameter, which can judge the corrosion tendency of metals; it is also an important parameter in electrochemical protection.

4.2.2 Selection of reference electrode

The selection of the reference electrode shall meet the following requirements:

- High stability in the service environment;

- Allows a small current to pass without electrode polarization;

- It has good durability in the service environment;

4.3.1 Overview

Apply a small amplitude AC disturbance signal to the metal corrosion system; measure the corresponding AC response signal; calculate the ratio of voltage to current (that is, the impedance of the corrosion system) or the phase angle change with the frequency of the sine wave; then analyze the dynamic process of the metal corrosion system and corrosion rate.

4.3.2 Basic conditions for testing

Electrochemical impedance measurement shall meet the following conditions:

- Causality conditions: When a sine wave potential signal is used to perturb the corrosion system, the corrosion system only responds to the potential signal;

- Linearity conditions: There is an approximately linear relationship between the response signal output by the corrosion system and the input disturbance signal;

- Stability conditions: After stopping the disturbance to the corrosion system, the corrosion system can return to its original state.

4.3.3 Electrochemical impedance spectroscopy

Use a small amplitude sine wave potential (or current) in a certain frequency range as a disturbance signal, to excite the metal system in the service environment. By measuring the corresponding alternating current (or potential) response signal, the electrochemical impedance spectroscopy of the metal in the service environment is obtained in situ. Based on the electrochemical electrode process theory and the fitting of the equivalent circuit, explore the mechanism of the corrosion reaction kinetic process, estimate the corrosion electrode's reaction speed and step-by-step kinetic parameters. Electrochemical impedance measurement should use special instruments and analysis software. For the testing of metal corrosion rate in a specific environment, sometimes the characteristic frequency's fixed frequency measurement can be selected, to realize the electrochemical impedance method to quickly detect the metal corrosion rate.

Electrochemical impedance spectroscopy usually uses an equivalent circuit to analyze the value of its components, which reflects the interface structure of the metal corrosion process and the kinetic parameters of each reaction step. The equivalent circuit of the most common metal corrosion system is as shown in Figure 1, where R_s is the resistance of the environmental medium; C is the capacitance of the metal surface; R_p is the polarization resistance, which reflects the resistance of the metal to the corrosion reaction. The value is inversely proportional to the corrosion rate of metal.

Selective electrode testing equipment shall include selective ion potential detection module, control module and communication module, etc.

Electrochemical impedance testing equipment shall include a constant potential module, a signal generator, a current signal acquisition module, a control module, a communication module, etc.

Multiple potential scanning testing equipment shall include a constant potential module, a polarization current testing module, a control module, a communication module.

6.2 Testing/monitoring system

According to the purpose of testing, select the appropriate testing method and system; various technical parameters shall be stated in the application documents, meanwhile meet the applicable standard requirements. When choosing a testing system, other factors to consider include:

- The production process conditions of the equipment under test;
- Whether there is cathodic protection and stray current influence around the component or structure under test;
- The temperature and humidity of the service environment;
- Chemical, electrical or mechanical interference conditions in the service environment;
- According to testing needs, multiple testing instruments can be integrated.

6.3 Electrochemical sensor probe

The electrochemical sensor probe is selected according to the purpose of testing. The selection and installation of the electrochemical sensor probe shall be based on the detection system and environment; it shall be based on the principles of non-destructive, accurate, efficient, fast and economical. The probe parameters related to detection/monitoring shall be stated in the application file and comply with the corresponding standard requirements.

6.4 Signal transmission and processing system

According to the selected non-destructive testing technology, the process regulations shall be formulated in accordance with the corresponding non-destructive testing standards.

The signal transmission and processing system shall follow the principles of reliability, effectiveness, advancement, durability, economy. It shall be selected according to the test environment and user requirements. The following factors

d) Standards, regulations or technical documents cited for testing;

e) Requirements for testing personnel;

f) Testing plan;

g) Environmental conditions for testing;

h) The layout of testing system;

i) The calibration cycle of testing instruments and probes;

j) Evaluation requirements for testing signals;

k) Testing process and testing procedures;

l) Acceptance criteria and evaluation of test results;

m) Information contained in the test report.

7.2 Evaluation of test results

7.2.1 Testing of selective electrode

Test results include corrosive environment, such as pH value, chloride ion concentration, etc.

7.2.2 Testing of corrosion potential

The test results include corrosion potential and so on.

7.2.3 Electrochemical impedance testing

Test results include polarization resistance, corrosion current, corrosion rate, etc.

7.2.4 Multiple potential scanning polarization testing

Test results include polarization current, impedance, etc.

8 Test report

8.1 Overview

The general requirements for electrochemical testing are contained in the application documents, such as:

a) Product standards;

This is an excerpt of the PDF (Some pages are marked off intentionally)

------ The End ------