INTERNATIONAL STANDARD

ISO 24239

First edition
2022-11

Corrosion control engineering life cycle in fossil fuel power plants — General requirements

Ingénierie du contrôle de la corrosion au cours du cycle de vie dans les centrales électriques à combustibles fossiles — Exigences générales

Reference number
ISO 24239:2022(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, Subcommittee SC 1, *Corrosion control engineering life cycle*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Corrosion control engineering life cycle in fossil fuel power plants — General requirements

1 Scope

This document specifies general requirements for each element in the life cycle of corrosion control engineering in fossil fuel power plants.

This document is applicable to corrosion control engineering of all types of fossil fuel power plants.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8044, *Corrosion of metals and alloys — Vocabulary*

ISO 23123, *Corrosion control engineering life cycle — General requirements*

ISO 23222, *Corrosion control engineering life cycle — Risk assessment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044, ISO 23123, ISO 23222 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
corrosion control engineering in fossil fuel power plants
process of controlling the metal corrosion rate of fossil fuel power plant equipment, facilities and systems within the required range by applying various corrosion control technologies

3.2
water and steam quality regulation and control
process of controlling metal corrosion by adding chemical agents into the water and steam system to regulate the water and steam quality

3.3
combustion adjustment
process of adjusting the combustion conditions of a boiler to avoid corrosion of heat exchange tubes

3.4
flow accelerated corrosion
corrosion in which the wall thickness of metal pipe is reduced due to dissolution of oxidation film on the inner wall of the pipe accelerated by medium flow under a particular operating condition

3.5
high-temperature steam corrosion
corrosion on the metal component surface under high-temperature steam conditions

3.6
high temperature corrosion on the fire side
corrosion at high temperature on the external wall of metal tubes for the water-cooled wall, superheater and reheater on the fire side of the boiler heating surface

3.7
low temperature corrosion
corrosion due to condensation of sulfuric acid gas in the flue gas on a metal surface at a temperature below the sulfuric acid dew point

3.8
lay-up corrosion
corrosion during lay-up of fossil fuel power plant equipment

4 General principles

4.1 This document specifies all elements related to the fossil fuel power plants corrosion control engineering life cycle, including objectives, corrosion sources, materials, technology, design, research and development, manufacturing, storage and transportation, construction and installation, commissioning, acceptance, operation, maintenance, overhaul, scrapping and disposal, documents and records, resource management and comprehensive assessment. The requirements of all the elements are specified in accordance with holistic, systematic, coordinated and optimized principles.

4.2 The main systems associated with corrosion control engineering in fossil fuel power plants include boiler and its auxiliary system, turbine and its auxiliary system, electrical equipment, water and wastewater treatment system and civil facilities. An example of a fossil fuel power plant is depicted in Annex A. The crucial points of corrosion control in fossil fuel power plants include, but are not limited to:

— high temperature corrosion on the fire side, stress corrosion, flow accelerated corrosion, high-temperature steam corrosion of boiler and its auxiliary system;

— high-temperature steam corrosion and flow accelerated corrosion of turbine and its auxiliary system;

— generator hollow conductor corrosion, acid and alkali corrosion of water and wastewater treatment system;

— atmospheric corrosion and soil corrosion of civil facilities.

4.3 A system to oversee corrosion control shall be established to achieve overall control and continuous improvement of all aspects of corrosion of each system in fossil fuel power plants. An example of a continuous improvement cycle for corrosion control engineering in a fossil fuel power plant is illustrated in Annex B.

4.4 The organization of corrosion control shall include establishing the owner, technical management team, operation team and maintenance team, and the responsibilities and authorities of personnel shall be clearly defined.

5 Objectives

5.1 Implementation of this document is intended to help control effectively the corrosion of each system in fossil fuel power plants, eliminate or slow down the corrosion hazards, and optimize the benefits of safe, economical and long-cycle operation and environmental protection in fossil fuel power plants.

5.2 The objective of corrosion control of fossil fuel power plants shall be implemented as appropriate into all elements in the life cycle of all equipment and systems of fossil fuel power plants, communicated, implemented and maintained in all links of the life cycle, and its continuous suitability shall be reviewed and improved.

6 Corrosion sources

6.1 The technical management team shall establish procedures for identifying corrosion sources of each system in the life cycle of fossil fuel power plants. The operation team and maintenance team shall investigate and analyse corrosion sources, and identify corresponding corrosion sources comprehensively, accurately and concretely in accordance with the procedures.

6.2 The internal corrosion sources of each system in fossil fuel power plants are as follows:

a) the corrosion sources of boiler and its auxiliary system, including, but not limited to, atmosphere, flue gas, water, steam, molten salt, acid, ash;

b) the corrosion sources of steam turbine and its auxiliary system, including, but not limited to, atmosphere, water, steam, impurities in oil;

c) the corrosion sources of electrical equipment, including, but not limited to, atmosphere, soil, water, hydrogen, impurities in oil and impurities in insulating gas, current;

d) the corrosion sources of water and wastewater treatment system, including, but not limited to, atmosphere, soil, water, acid, alkali and oxidant;

e) the corrosion sources of civil structure, including, but not limited to, atmosphere, soil and water.

6.3 The impact of external environment of each system on corrosion shall be considered, including, but not limited to, temperature, pressure, flow rate, stress state and other external environment.

6.4 Reasonable and effective management requirements and technical measures for corrosion control engineering in fossil fuel power plants shall be formulated for corrosion sources of each system.

7 Materials

7.1 Service environment of materials for the fossil fuel power plant equipment and systems shall be investigated and the optimal materials resistant to corrosion sources shall be selected according to corresponding standards.

7.2 Materials for the fossil fuel power plant equipment and systems shall be selected on the basis of ensuring the service life and due consideration shall be given to the materials' corrosion resistance, processability and welding performance, economy and environmental protection.

7.3 Materials shall be selected using the following procedures.

a) The corrosion sources and corrosion magnitude of materials for each system shall be determined.

b) Corresponding standards and manuals shall be referred to so that materials that meet corrosion resistance requirements shall be selected.

c) Corrosion resistance of materials shall be assessed.

7.4 The selected materials shall have corresponding specific achievements and supporting implementation cases as references. In the absence of same performance or similar application, laboratory simulation or field test is required for material selection.

7.5 The selected materials shall be reviewed and assessed by established procedures.

7.6 Boiler and its auxiliary system shall use the optimal materials resistant to corrosion sources such as flue gas, high temperature and high-pressure steam and stress. The requirements include, but are not limited to, the following.

a) High-temperature steam pipes, high-temperature headers and high-temperature pipe fittings should be resistant to oxidation and high temperature corrosion. ASTM A335 may be referred to for information on the selection of materials.

b) Boiler heating surface tubes should be resistant to flue gas corrosion, coal ash corrosion, steam-water corrosion and stress corrosion.

c) Boiler drums and steam-water separators should be resistant to steam-water corrosion.

d) Boiler heating surface fixtures should have appropriate thermal strength and shall be resistant to oxidation and corrosion.

e) Soot blowers shall possess excellent oxidation resistance and good corrosion resistance performance.

f) The denitration device shall be made of materials resistant to corrosion of denitration reductants, such as liquid ammonia, ammonia water or urea.

g) The desulfurization device should be made of materials resistant to corrosion of desulfurized slurry or flue gas. Anti-corrosion materials in direct contact with desulfurized wet flue gas shall be acid-resistant, impermeable, aging-resistant and durable with firm adhesion. When there is desulfurization bypass, the anti-corrosion material shall be able to stand the rapid and alternative changes of flue gas temperature and humidity.

7.7 The steam turbine and its auxiliary system shall use the optimal materials resistant to corrosion sources such as high temperature and high-pressure steam, vibration and stress. The requirements include, but are not limited to, the following.

a) High and medium pressure rotors shall be resistant to high-temperature steam corrosion. For the selection of materials, reference should be made to ASTM A470.

b) Steam turbine blades shall be corrosion-resistant and possess excellent anti-fatigue performance, especially the performance to resist corrosion fatigue. Low pressure blades served in wet steam area should be made of materials with good corrosion resistance performance. Materials for low-pressure last stage moving blades may be selected with reference to ASTM A564 and ASTM A473.

c) Fasteners shall be resistant to oxidation.

d) Titanic materials or stainless steel shall be preferred for wet condenser tubes. Non-aluminium materials should be selected for heat exchange tubes of indirect air-cooling systems and air heat exchangers. Materials with good resistance to flow accelerated corrosion shall be selected for heat exchange tubes of direct air-cooling systems.

e) Materials with good resistance to flow accelerated corrosion shall be selected for heat exchange tubes of high-pressure heaters. Stainless steel may be used for heat exchange tubes of low-pressure heaters. Alloy sensitive to ammonia corrosion shall not be selected.

7.8 The influence of corrosion sources such as current, moisture in hydrogen, SF_6 and impurities in oil, soil and water shall be considered for material selection of electrical equipment.

7.9 The optimal materials resistant to corrosion sources such as acid and alkali, as well as to heavy salt water, shall be selected for the water and wastewater treatment system. The inner surface of the equipment, pipes, valves and drainage ditches contacting corrosive media or affecting effluent quality, and the outer surface of the equipment, pipes and valves affected by corrosive environment, shall be coated with appropriate corrosion-resistant paintings and made of corrosion-resistant materials.

7.10 The optimal materials resistant to corrosion sources such as atmosphere, water and soil shall be selected for civil structures. The requirements include, but are not limited to, the following.

a) Isolation and anti-corrosion measures, such as lining rubber to prevent inner wall corrosion, or cladding with polyurethane and other anti-corrosion materials for external wall corrosion, should be taken for buried pipes.

b) Corrosion control protective layer shall be designed for buried components, and corrosion-resistant steel bars should be selected.

c) Materials resistant to wet flue gas corrosion shall be selected for chimneys.

d) Materials resistant to atmospheric corrosion shall be selected for steel structures.

8 Technology

8.1 When selecting corrosion control technologies for each system of fossil fuel power plants, comprehensive evaluation shall be carried out according to corresponding technical standards or specifications, and the following principles shall be followed.

a) The safety of corrosion control technologies, including their safety relative to equipment, systems, personnel and environment, shall be assessed.

b) The advancement and economy of corrosion control technologies shall be assessed.

c) The selected corrosion control technology shall meet the operation requirements of the system and equipment under various conditions, ensuring that equipment and parts can operate in accordance with the objectives of long-life cycle operation and environment protection.

d) One or more technologies suitable for corrosion sources corresponding to various systems in fossil fuel power plants can be selected to impose corrosion control.

8.2 Corrosion control technologies for systems of fossil fuel power plants include, but are not limited to, the following.

a) Water and steam quality regulation and control: The material properties, corrosion medium, operating conditions and other aspects of water and steam circulation system in fossil fuel power plants shall be fully understood, to ensure the selection of appropriate water and steam quality regulation agents and control strategy to mitigate the corrosion of system materials, and the cost shall be evaluated if this technology is adopted. This technology generally applies to the corrosion control of boiler and its auxiliary system, steam turbine and its auxiliary system, and water and wastewater treatment system. The technologies include, but are not limited to:

   — all-volatile treatment (reduction) of boiler feedwater;

   — all-volatile treatment (oxidization) of feedwater;

   — oxygenated treatment of feedwater;

   — phosphate treatment of boiler water;

   — sodium hydroxide treatment of boiler water;

   — all-volatile treatment of boiler water;

   — corrosion and scale inhibition treatment of circulating water;

— acid treatment of circulating water;

— by-pass weak acid treatment of circulating water;

— electrochemical treatment of circulating water;

— condensate polishing treatment;

— drying, nitrogen filling, pH adjustment and corrosion inhibitor filling technologies avoiding lay-up corrosion;

— online water quality purification and water quality regulation technologies such as nitrogen filling and alkalescency adjustment of generator cooling water.

b) Coating protection: It is advisable to select the coating suitable for the operating conditions and the feasible construction technology and adopt a coating protection scheme with optimal environmental protection and technical economy. This technology generally applies to the corrosion control for each system in fossil fuel power plants, including boiler and its auxiliary system, steam turbine and its auxiliary system, electrical equipment, water and wastewater treatment system, and civil structures. ISO 2063-1 provides information on thermal spraying. The technologies include, but are not limited to:

— spraying metal, alloy, ceramic or other wear-resistant, corrosion-resistant and high-temperature-resistant materials on outer surface of water-cooled wall of boiler;

— spraying zinc or other anti-corrosion coatings on steel structures;

— cladding buried pipes with organic materials;

— painting anti-corrosion paint on surface of system equipment.

c) Combustion adjustment: The purpose is to achieve complete combustion and uniform heat release of fuel in the boiler, control component temperature within a reasonable range, prevent slagging on the heating surface, improve reducing atmosphere in the water-cooled wall surface area, etc. This technology is mainly used for corrosion protection on the fire side of boiler. The technologies include, but are not limited to:

— adjusting ratio of fuel feeding and water quantity;

— adjusting air distribution parameters;

— adjusting spraying water quantity.

d) Cleaning: In the case of chemical cleaning, the deposit composition and amount shall be analysed, and the optimal cleaning process and time shall be selected to control under-deposit corrosion. This technology generally applies to the corrosion control for each system in fossil fuel power plants, including boiler and its auxiliary system, steam turbine and its auxiliary system, electrical equipment, water and wastewater treatment system, and civil structures. The technologies include, but are not limited to:

— acid cleaning;

— high-pressure water flushing.

e) Cathodic protection: This technology can be used for the corrosion prevention of steam turbine and its auxiliary system, electrical equipment, water and wastewater treatment system, and civil structures. For the corrosion prevention of underground pipe network and grounding grid, impressed current or sacrificial anode can be adopted. ISO 12473, ISO 12696 and ISO 13174 may be referred to for information on cathodic protection. The technologies include, but are not limited to:

— impressed current;

— sacrificial anode;

— the combination of both.

f) Compound technology. Various anti-corrosion technologies are used in combination to optimize the corrosion control effect. This technology generally applies to the corrosion control for each system in fossil fuel power plants, including boiler and its auxiliary system, steam turbine and its auxiliary system, electrical equipment, water and wastewater treatment system, and civil structures. The technologies include, but are not limited to:

— selecting high-temperature-resistant materials for boiler superheater and reheater tubes, adopting combustion adjustment to control steam temperature within a reasonable range, and adopting water and steam quality regulation to control high-temperature steam corrosion;

— selecting high-temperature-resistant materials for water-cooled wall of boiler and adopting combustion adjustment and water and steam quality regulation and control to control inner wall corrosion;

— selecting glass flake lined steel for desulfurizing tower and controlling the chloride ion concentration of desulfurized slurry to prevent tower wall corrosion;

— adopting surface galvanization and cathodic protection (impressed current or sacrificial anode) for corrosion control of grounding grid materials.

8.3 The selected technologies shall be proved by corresponding specific achievements and supporting cases as reference; otherwise, they shall be verified by experiments before application.

8.4 The selected corrosion control technologies shall be reviewed and evaluated by established procedures.

8.5 The typical corrosion control technologies in fossil fuel power plants are listed in Annex C.

9 Design

9.1 In the design of systems of a new fossil fuel power plant, the elements and corresponding risks associated with corrosion control engineering life cycle shall be taken into full account, according to ISO 23222. The corrosion control design for the systems (including corrosion source identification, material selection, corrosion detection, and corrosion control technology design and optimization) shall be implemented according to applicable codes or standards, and corrosion control requirements for subsequent stages such as manufacturing, storage, transportation, installation, commissioning, operation, maintenance and scrapping shall be set out.

9.2 In the design of corrosion control of systems of fossil fuel power plants, materials shall be selected according to 7.6 and appropriate anti-corrosion technology shall be selected according to 8.2. Targeted anti-corrosion measures shall be designed considering the specific characteristics of corrosion sources of systems and equipment.

9.3 In the anti-corrosion design of boiler and its auxiliary system, measures shall include, but are not limited to, the following.

a) Measures for the prevention of high temperature corrosion on the fire side of water-cooled wall shall be designed. Such measures include, but are not limited to:

— adopting suitable fuel or coal blending technology to control the sulfur content of coal fed into the boiler;

— selecting appropriate boiler combustion mode and burner arrangement;

— selecting suitable furnace characteristics and furnace structural parameters to control furnace outlet temperature;

— optimizing burner design to prevent flame from impacting the wall;

— designing a closing-to-wall air system;

— spraying wear-resistant anti-corrosion coatings on the heating surface tubes;

— optimizing the nitrogen oxide emission indexes of the furnace outlet and the boiler-tail denitration post-treatment unit outlet to prevent high-temperature corrosion caused by dry low NOx combustion.

b) Measures for the prevention of high temperature corrosion of convection heating surface shall be designed. Such measures include, but are not limited to:

— adopting suitable fuel or coal blending technology to control the sulfur content of coal fed into the boiler;

— appropriately arranging the heating surface with high working medium temperature in the area with relatively low flue temperature;

— reducing temperature difference between tubes to control heating surface wall temperature;

— for boilers that are Π-shaped, taking measures to reduce the residual rotation strength of flue gas in the upper furnace to reduce unevenly distribution of flue gas flow energy at the furnace outlet, so as to prevent local overtemperature of superheater and reheater;

— designing sufficient boiler heating surface wall temperature monitoring devices; designing complete soot blowers to prevent tube wall corrosion caused by contamination or coking of convection heating surface.

c) Measures for the prevention of low temperature corrosion on low temperature heating surfaces such as air pre-heater and low temperature economizer shall be designed. Such measures include, but are not limited to:

— adopting enamelled elements for the heating surface at the cold end of the air pre-heater and selecting corrosion-resistant materials for the low temperature economizer;

— designing higher integrated temperature for the air pre-heater to ensure sufficient safety margin;

— adopting hot air recirculation, air heaters or other methods of increasing the water temperature at the low temperature economizer inlet to ensure the operating temperature of the low temperature economizer is higher than the safe temperature;

— designing effective cleaning and soot blowing devices to prevent clogging of air pre-heater and low temperature economizer.

d) Measures for prevention of corrosion of water and steam system shall be designed. Such measures include, but are not limited to:

— selecting high temperature Fe-Cr-Ni alloy with good resistance to high-temperature steam corrosion for the convection heating surface of ultra (super) critical boiler;

— selecting low-chrome steel and other materials resistant to flow accelerated corrosion for feedwater pipes and connecting pipes;

— designing boiler feedwater dosing and oxygenation device, boiler water dosing device, lay-up protection inhibitor dosing device, nitrogen filling protection device or air-drying device;

— setting water and steam sampling and water and steam quality monitoring devices for the water and steam circulating system.