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Pipeline corrosion control engineering life cycle — General requirements

Ingénierie du contrôle de la corrosion des conduites au cours du cycle de vie — Exigences générales

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Foreword

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

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Pipeline corrosion control engineering life cycle — General requirements

1 Scope

This document specifies the general requirements for control elements in the life cycle of pipeline corrosion control engineering.

This document is applicable to all types of pipeline corrosion control engineering programmes.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
pipeline corrosion testing and monitoring system
online technology for the real-time testing and feedback of corrosion conditions on both external and internal pipelines

3.2
temporary decommissioning
suspended operation of a system due to emergencies (such as natural disasters, corrosion leakage, etc.)

Note 1 to entry: The decommissioning system will continue to operate after the emergency measures are taken.

3.3
permanent decommissioning
permanent shutdown of a system

Note 1 to entry: The system has been assessed to have significant technical and economic risks via rigorous procedures and will no longer continue to operate.

4 General principles

4.1 This document summarizes all the aspects of the pipeline corrosion control engineering life cycle to provide general requirements for selecting technical and management standards. This document does not provide specific techniques and management procedures for pipeline corrosion control.

4.2 A traceable and supportive management system shall be established to achieve full control and sustainable improvement on all aspects of the pipeline corrosion control engineering life cycle.

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5 Objectives

5.1 To optimize and coordinate all aspects of the pipeline corrosion control engineering life cycle, the life cycle of pipeline corrosion control engineering shall be suitable for the full life cycle of the protected pipeline.

5.2 The objectives of corrosion control engineering shall be communicated, implemented and maintained at all stages of the pipeline life cycle. The objectives shall be regularly reviewed and improved to ensure their suitability.

6 Corrosion sources

6.1 Corrosion sources include:

a) internal corrosion sources, including, but not limited to, pipeline transmission medium, flow rate, temperature and pressure;

b) external corrosion sources, including, but not limited to, environmental factors and corrosive medium that potentially reacts with pipes under different environmental conditions;

c) new corrosion sources during pipeline operation, including, but not limited to, cathodic disbondment and pipeline maintenance-related and replacement-related electrochemical corrosion;

d) corrosion sources caused by working conditions changes, including working conditions changes in both pipeline and pipeline corrosion control facilities.

EXAMPLE Cathodic disbondment caused by a current overload of cathodic protection.

6.2 By referring to the implementation cases and relevant standards, all corrosion sources shall be accurately identified according to the life cycle requirements of the pipeline system.

NOTE 1 For corrosion sources of pipelines in atmospheres, refer to ISO 9223.

NOTE 2 For corrosion sources of buried pipelines, refer to EN 12501-1.

7 Pipeline materials

7.1 The selection of a pipeline shall be based on the corresponding standards.

NOTE For the selection of a pipeline in petroleum and natural gas industries, refer to ISO 13623.

7.2 The following pipeline selection principles shall be fulfilled.

a) The selected pipeline and its applied environment shall be investigated to ensure corrosion resistance as well as environmental protection.

b) Once the application requirements are satisfied, the processability, versatility and cost-effectiveness of the pipeline shall also be considered.

7.3 The pipeline shall be selected using the following procedures.

a) A field investigation on the pipeline working environment shall be carried out to determine corrosion sources, corrosion factors and corrosion magnitude.

b) With reference to corresponding standards and manuals, an appropriate pipeline that meets the corrosion resistance requirements shall be selected.

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c) The pipeline resistance shall be evaluated. In the absence of relevant data for the same or a similar engineering application, a laboratory simulation or field test is required for the pipeline selection.

d) When a satisfactory durability of the pipeline operation has been achieved, versatility shall be considered next. It shall take precedence over cost-effectiveness.

7.4 The selected pipeline shall be reviewed and assessed by established procedures. The process of pipeline selection shall be documented and archived.

8 Technology

8.1 One or more appropriate technologies shall be implemented for pipeline corrosion control according to the corrosion sources. Considerations of pipeline corrosion control technologies include, but are not limited to, the following.

a) Reasonable structure design: insulation techniques, the installation of electrical isolation points and isolation devices, a detailed integrated plan of sleeve, facilities and other electrical affected zones, and the prevention of unpredicted corrosion, such as shielding of cathodic protection or cathodic disbondment.

b) Coating protection: selecting coatings materials suitable to the expected operating conditions and construction process, taking into account budgetary and environmental considerations.

c) Electrochemical protection: evaluating the current density required to resist corrosion via pipeline polarization or the current flow required for the cathodic protection system, taking total electricity costs into consideration.

d) Corrosion inhibitor selection: fully investigating the cause of the internal corrosion and the chemical property of the pipeline transmission medium to select the inhibitor type, frequency and dose, taking into account the total cost of the use of corrosion inhibitors, if applicable.

e) Cleaning, including chemical and physical cleaning. The type and amount of pollutants pigged from the pipeline shall be analysed to detect the inhibiting effect and to determine the required pigging frequency.

f) Environmental protection: environmental-friendly pipeline corrosion control technology and construction technology shall be preferred.

g) Composite technology: composite pipeline technology without electrochemical corrosion shall be preferred.

8.2 The selection of pipeline corrosion control technology shall be based on the corresponding technical standards or specifications followed by a comprehensive evaluation. The general principles are as follows.

a) Considering the safety of the corrosion control process operation as a priority and evaluating whether safety requirements can be met.

b) In cases where all the technical requirements have been met, state-of-the-art technology, process, equipment and materials shall be selected preferentially, while minimizing the costs of corrosion control.

c) The selected pipeline corrosion control engineering technology shall meet the operating requirements for different working conditions as well as have a sufficient service life without generating pollutants.

d) The risk and associated hazards of a pipeline corrosion control technical failure shall be considered. Pre-controls are required to decrease risks and minimize potential losses from technical failures.

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NOTE For techniques of risk management, refer to ISO 31000.

8.3 The selected technologies shall have corresponding supportive cases as references. Otherwise, they shall be verified by appropriate experiments.

8.4 When the requirements of the pipeline system have been met, the selected technologies shall be coordinated and optimized with other aspects in the pipeline corrosion control system to achieve the goals of safety, cost-effectiveness, and long-term and environmental-friendly operation.

8.5 All adopted corrosion control technologies shall be reviewed and evaluated via established procedures, then documented and archived.

9 Design

9.1 All elements, links and nodes in the entire life cycle of the pipeline corrosion control engineering shall be systematically designed according to the influence of the pipeline operating environment and transmission medium.

9.2 The principles of pipeline corrosion control engineering design are as follows.

a) Protect the environment and save energy.

b) The site of the pipeline engineering shall avoid environments with interference factors, such as populated regions, highways, railways, rivers and power lines. The appropriate distance between the pipeline and such environments shall be kept. The physical space occupied by pipeline infrastructure shall not be exploited for other purposes.

c) Optimize the design with key materials, facilities and processes according to specific corrosive environments. Determine the most cost-effective design.

d) It is acceptable to use state-of-the-art technologies, processes, facilities and materials.

e) Pipeline corrosion control engineering design for reconstruction and extension projects shall rationally use the original facilities.

f) It is acceptable that the expected life cycle of serviceable or replaceable materials and devices are shorter than the life cycle of the pipeline. The life cycle of unserviceable and unreplaceable materials and devices shall be consistent with the life cycle of the protected pipeline.

9.3 A green plan for temporary and permanent decommissioning, abandonment and disposal shall be developed in the stage of design.

9.4 The applicability of the design system shall be evaluated in accordance with the objectives of safety, cost-effectiveness, and long-term operation and environmental protection. The system design shall be improved constantly to meet the requirements of pipeline professional standards.

9.5 The design documents shall be reviewed and evaluated by established procedures, then documented and archived.

10 Research and development

10.1 All elements, links and nodes in the entire life cycle of pipeline corrosion control engineering shall be continuously researched, improved and developed during the implementation process to achieve the optimum benefits of safety, cost-effectiveness, and long-term operation and environmental protection.

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10.2 Research and development mainly includes research of materials and technologies, process improvement, equipment and product development. The entire research and development process shall be carried out in accordance with established procedures, evaluated by experts and supported by experiments.

10.3 All research and development processes shall be documented and archived for future audits.

11 Manufacturing

11.1 The manufacturing of a new pipe for pipelines shall be based on relevant technical specifications, product standards, inspection standards, design documents and drawings.

11.2 The selection of a manufacturing supplier shall include its previous performance and supportive cases of the same type of pipeline engineering programme.

11.3 The manufacturing supplier shall develop a series of regulations to ensure pipeline quality and production safety as well as environmental protection. Processes, parameters and inspection records of manufacturing shall be documented and archived.

11.4 The product shall be marked with a product label and qualified certificate.

11.5 When the requirements of the protected pipeline have been met, the manufacturing procedures shall be optimized to achieve the goals of safety, cost-effectiveness, and long-term operation and environmental protection.

12 Construction and installation

12.1 The construction and installation of pipes, pipeline corrosion control facilities and system shall include protective measures (including emergency measures) based on corresponding standards, to avoid damage and corrosion. The whole process shall be documented and archived.

NOTE For the construction and installation of cathodic protection for pipelines on land, refer to ISO 15589-1.

12.2 Pipeline corrosion control facilities and systems with special requirements shall be provided with specific installation devices. Protective measures shall be established.

12.3 Safety and protective measures for the construction and installation of the pipeline and corrosion control facilities and systems shall be established to ensure the safety of personnel, equipment and the environment.

12.4 The construction and installation of pipeline corrosion control equipment and systems shall follow installation procedures based on design documents and corresponding standards.

12.5 The pipe fittings' corrosion control grade and performance shall be compatible with the corrosion control requirements of the protected pipeline.

12.6 For the construction of the pipeline connection, appropriate process technologies shall be adopted. The connecting material shall be identical to the material of the pipeline, or other materials used in same type of construction engineering. Measures shall be taken to avoid galvanic corrosion if different materials are used for connection. Local heat treatment shall be adopted to eliminate stress if the stress corrosion occurs in connected positions.

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12.7 A pipeline corrosion testing and monitoring system shall be installed simultaneously with the construction of the pipeline.

12.8 For the selection of a construction and installation company, its previous performance or supportive reference cases shall be taken into consideration.

12.9 The construction and installation site shall be supervised. The construction and installation shall be reviewed and evaluated by established procedures. The process shall be formally documented and archived.

13 Handling, storage and transportation

13.1 The handling, storage and transportation methods of new pipes shall be established on corresponding standards and norms to prevent physical damage or loss.

13.2 When there are special requirements for the pipeline corrosion control system, the corresponding handling, storage and transportation devices shall be prepared, and specific environmental protection measures shall be established.

13.3 The selection of a pipeline handling, storage and transportation company shall refer to its previous performance or supportive cases.

13.4 Optimal handling, storage and transportation methods shall be selected to protect the pipe and pipeline corrosion control engineering system from damage or corrosion, achieving the goals of safety, cost-effectiveness, and long-term operation and environmental protection.

13.5 The handling, storage and transportation process shall be documented and archived.

14 Commissioning

14.1 Commissioning for pipeline corrosion control engineering, such as cathodic protection engineering and corrosion inhibitor injection systems, shall be operated based on the corresponding standards, design documents or operation norms.

14.2 The preliminary commissioning process shall include:

a) developing commissioning procedures and criteria for acceptance;

b) personnel training;

c) checking and inspecting commissioning tools and instrumentation;

d) evaluating potential risks and developing corresponding measures of control and emergency;

e) preparing commissioning record files.

14.3 The commissioning process control process shall include:

a) a strict implementation of the commissioning procedures or corresponding specifications, standards and design documents;

b) supervision;

c) avoidance of safety risks including electric shocks and mechanical injuries;

d) detailed documentation;

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e) three levels of countersignatures for the compilation, auditing and approval of documents.

14.4 The commissioning procedure shall be as follows.

a) Before commissioning, the pipeline corrosion control engineering system shall be inspected in detail and documented.

b) During commissioning, the commission parameters shall be adjusted based on design documents or the required protection principles of corresponding standards.

c) After commissioning, the effectiveness of the pipeline corrosion control engineering system shall be evaluated when the system runs steadily according to design documents or corresponding standards.

14.5 Commissioning shall not cause damage to the protected pipeline or cause new corrosion.

14.6 The pipeline system shall be reformed, repaired or reconstructed if the commissioning result does not meet the design requirements.

14.7 The commissioning process and result shall be documented and archived.

15 Acceptance inspection

15.1 The pipeline corrosion control system shall be inspected and accepted in accordance with the relevant design standards before being put into operation.

15.2 If the quality of pipeline corrosion control system does not meet the design requirements, it shall not be accepted until the requirements are met.

15.3 The following materials shall be submitted with the acceptance inspection of the pipeline corrosion control system:

a) corrosion sources and corrosion data;

b) original and modified documents of investigation and design;

c) manufacturing process quality control documents;

d) handling, storage and transportation process control documents;

e) pipeline construction and installation process control documents;

f) construction supervision control documents;

g) pipeline corrosion control system and commissioning process control documents;

h) records of nonconformity processing;

i) documents of completing acceptance;

j) ecological environmental impact assessment reports and green plans;

k) supervision documents of safety.

15.4 The acceptance inspection of the pipeline corrosion control system shall be documented and archived.

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16 Operation

16.1 Pipelines shall be placed under systematic corrosion control to ensure safety, cost-effectiveness, and long-term operation and environmental protection.

16.2 The following aspects shall be considered during the pipeline corrosion control operation.

a) Systematic corrosion control, including, but not limited to, coating protection, electrochemical protection and corrosion inhibitor injection, which shall be implemented according to the conditions of the pipeline and corrosion sources.

b) Pipeline operation and maintenance staff shall have basic pipeline corrosion control skills and participate in regular training and assessment.

c) Multiple departments and various specialists shall participate in resolving complicated pipeline corrosion problems.

d) Establishing internal and external communications and experience feedback mechanisms.

e) Establishing a pipeline corrosion control operation management manual.

f) Establishing a management database for the pipeline corrosion control engineering operation system.

16.3 The management method of pipeline corrosion control operation is as follows.

a) The management method shall be designed in accordance with the pipeline corrosion control management manual and relevant standards. Regulations can apply.

b) The operating company shall provide sufficient resources to meet the pipeline corrosion control requirements.

c) Specific contents of the control management method include on-site inspection, problem solving, process recording, process analysis and experience feedback.

16.4 The operation of the pipeline corrosion control includes external corrosion control and internal corrosion control.

a) For external corrosion control, the following requirements apply.

   1) The external corrosion control procedures shall be established following the requirements of corresponding standards and specifications.

   2) The pipeline corrosion testing and monitoring system shall be regularly inspected. If the inspection results do not meet the pipeline corrosion control engineering protection criteria, the causes shall be investigated and corrective measures shall be taken.

   3) The environmental factors influencing the pipeline corrosion control shall be identified and tested. The control measures shall be adjusted if the environmental factors change.

   4) Any discovered defects of the pipeline corrosion control shall be addressed promptly.

b) For internal corrosion control, the following requirements apply.

   1) The corrosivity of the pipeline transmission medium shall be detected regularly, and appropriate corrosion control measures shall be selected based on the evaluation results.

   2) The corrosion of the critical position inside the pipeline can be monitored by installing probes and a resistance monitoring device, or by directly measuring wall thickness and corrosion potential.

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16.5 The recorded operation files of the pipeline corrosion control engineering shall be documented and archived.

17 Maintenance

17.1 Maintenance shall be carried out in accordance with the corresponding maintenance manual and standards.

17.2 According to the condition of the pipeline system and corrosion sources, establish a daily, regular and comprehensive maintenance period and plan, and corresponding maintenance procedures, including, but not limited to:

a) daily maintenance that includes a patrol, inspection and cleaning;

b) regular maintenance that includes checking the state of the pipeline corrosion control system and planned repairs;

c) maintenance procedures that shall be in accordance with material or equipment maintenance manuals, technical specifications and related standards;

d) maintenance personnel who shall have the corresponding skills and experiences;

e) appropriate task-specific tools, which shall be used for maintenance;

f) an evaluation of the potential risks before any maintenance and the establishment of corresponding emergency measures.

Relevant inspection and maintenance records shall be kept.

17.3 The maintenance shall not cause damage or new corrosion on the pipeline and the pipeline corrosion control engineering devices and facilities.

17.4 For electrochemical protection and corrosion inhibitors, the pipeline corrosion testing and monitoring system shall be set to enable pre-control and forewarning.

17.5 Any problems shall be tracked and solved promptly to ensure the effectiveness of the pipeline corrosion control engineering.

17.6 The maintenance of the pipeline corrosion control engineering shall be documented and archived.

18 Repair

18.1 An investigation plan on corrosion control operation and a corresponding regular evaluation of the operating pipeline shall be included in pipeline daily operation management.

18.2 The pipeline corrosion control defects that are evaluated to be unacceptable shall be repaired according to the relevant standards.

18.3 Risk shall be assessed and minimized before selecting the optimal repair method. A qualified company shall be responsible for pipeline corrosion control maintenance.

18.4 Repairs shall be carried out without affecting the overall function of the pipeline and shall conform to the relevant standards or specifications.

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18.5 The standards of the repaired construction shall not be declined compare to the original construction requirements. The repair and other elements shall be coordinated and optimized with each other to achieve the goals of safety, cost-effectiveness, and long-term operation and environmental protection.

18.6 Any interim repairs of pipeline defects shall be permanently fixed in time.

18.7 Emergency support (including emergency resources) shall be provided to repair the pipeline corrosion control system. Emergency plans for pipeline maintenance shall be established in accordance with the relevant standards. Meanwhile, emergency measures shall be formulated and emergency resources shall be prepared.

18.8 An acceptance inspection shall be conducted in accordance with the relevant standards, specifications and design requirements after the completion of the pipeline corrosion control engineering repair. The repair shall then be reviewed and evaluated by using specific standards and procedures. Records shall be documented and archived.

19 Decommissioning, abandonment and disposal

19.1 Pipeline decommissioning includes temporary and permanent decommissioning.

19.2 Corrosion control shall be implemented on a temporary decommissioned pipeline by established procedures.

19.3 Pipelines and their corrosion control systems which meet the condition of permanent decommissioning and abandonment after evaluation shall be disposed of in accordance with the green plan proposed at the initial design stage.

19.4 Abandonment and disposal shall follow the principle of environmental safety and circular economy. For the recycling of pipelines and corrosion control facilities, corresponding recycling plans shall be established for recyclable equipment and materials.

19.5 According to the social and environmental conditions of different pipelines, each pipeline with its corresponding corrosion control system could be abandoned on site or recycled, after taking into account factors including, but not limited to the following:

a) land use management;

b) environmental pollution;

c) the degradation treatment of corrosion protection materials;

d) the corrosion of abandoned pipelines across rivers;

e) the corrosion caused by the environment;

f) the safety of pipeline disposal across roads, railways and public facilities;

g) the pollution of abandoned pipelines caused by water infiltration;

h) ancillary facilities;

i) the cost of disposal.

NOTE For the asset management of pipes and pipeline corrosion control system disposal, refer to ISO 55001.

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