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Oil and gas industries including lower carbon energy — Cathodic protection of pipeline transportation systems —

Part 1: On-land pipelines

Industries du pétrole et du gaz y compris les énergies à faible teneur en carbone — Protection cathodique des systèmes de transport par conduites —

Partie 1: Conduites terrestres

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Foreword

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 2, *Pipeline transportation systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 219, *Cathodic protection,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 15589-1:2015), which has been technically revised.

The main changes are as follows:

— cathodic protection criteria have been extended with further clarification on the application of the criteria;

— requirements for design have been more detailed; periodicities for inspection of cathodic equipment have been enlarged; and the option for remote monitoring has been added;

— requirements for measurements and testing during commissioning have been further detailed.

A list of all parts in the ISO 15589 series can be found on the ISO website.

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.

Introduction

Pipeline cathodic protection is achieved by the supply of sufficient direct current to the external pipe surface, so that the steel-to-electrolyte potential is lowered to values at which external corrosion is reduced to an insignificant rate.

Cathodic protection is normally used in combination with a suitable protective coating system to protect the external surfaces of steel pipelines from corrosion.

Oil and gas industries including lower carbon energy — Cathodic protection of pipeline transportation systems —

Part 1: On-land pipelines

1 Scope

This document specifies requirements and gives recommendations for the pre-installation surveys, design, materials, equipment, installation, commissioning, operation, inspection, and maintenance of cathodic protection systems for the external surface of on-land pipelines.

This document is applicable to on-land pipelines and piping systems used in other industries and transporting other media such as industrial gases, waters, or slurries.

Throughout this document, on-land pipelines mean:

— pipelines that are buried;

— landfalls of offshore pipeline sections protected by onshore based cathodic protection installations;

— immersed sections of on-land pipelines such as river or lake crossings.

This document is applicable to pipelines of carbon steel, stainless steel, cast iron, galvanized steel, and copper.

This document does not apply to pipelines made of reinforced concrete (see ISO 12696).

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 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment*

ISO 13623, *Petroleum and natural gas industries — Pipeline transportation systems*

ISO 13847, *Petroleum and natural gas industries — Pipeline transportation systems — Welding of pipelines*

ISO 21809-3, *Oil and gas industries including lower carbon energy — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field joint coatings*

ISO 21809-5, *Oil and gas industries including lower carbon energy — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 5: External concrete coatings*

ISO 21857, *Petroleum, petrochemical and natural gas industries — Prevention of corrosion on pipeline systems influenced by stray currents*

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 62561-3, *Lightning protection system components (LPSC) - Part 3: Requirements for isolating spark gaps (ISGs)*

EN 1594, *Gas infrastructure — Pipelines for maximum operating pressure over 16 bar — Functional requirements*

EN 12007-3, *Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar – Part 3: Specific functional recommendations for steel*

EN 14161, *Petroleum and natural gas industries — Pipeline transportation systems from 2011+A1 from 2015 (ISO 13623:2017)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044 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
anode backfill
added material immediately surrounding a buried anode

3.2
bond
conductor connecting two points on the same structure or between different structures

3.3
cathodic protection system
impressed current and galvanic anode system consisting of all the equipment necessary for the application of cathodic protection, such as impressed current installations, power supplies, *impressed current anodes* (3.12), galvanic anodes, monitoring facilities, *bonds* (3.2) and cables

3.4
coupon
metal sample of defined surface area and thickness made of a metal equivalent to the metal of the pipeline

3.5
coating defect
anomaly in the coating that results in the steel surface making direct contact with the surrounding electrolyte

3.6
DC decoupling device
direct current decoupling device
equipment that provides a low-impedance path for alternating current and high resistance for direct current

EXAMPLE *Polarization* cells, capacitors, or diode assemblies.

3.7
drain point
location of the cable connection to the protected pipeline through which the protective current returns to its source

3.8
drainage
transfer of *stray current* (3.24) between structures by means of a deliberate *bond* (3.2)

Note 1 to entry: See ISO 21857 for drainage devices (direct drainage bond, resistance drainage bond, unidirectional drainage bond and forced drainage bond).

3.9
drainage station
equipment and materials required to provide *drainage* (3.8) of *stray currents* (3.24) from affected systems

3.10
galvanic anode station
equipment and materials required to provide cathodic protection by the use of galvanic anodes

Note 1 to entry: Such materials and equipment include galvanic anodes and cables.

3.11
ground bed
system of buried or immersed anodes

3.12
impressed current anode
electrode that delivers cathodic protection current in combination with an *impressed current station* (3.13)

3.13
impressed current station
equipment and materials required to provide cathodic protection by impressed current

Note 1 to entry: Such materials and equipment include *impressed current anodes* (3.12), cables, and a DC source.

3.14
IR drop
voltage that is the product of all currents flowing through the cathodic protection circuit and the resistance of the current path (mainly the electrolyte and the pipeline)

Note 1 to entry: This is derived from Ohm's law ($U = I \times R$).

3.15
IR free potential
polarized potential
coating defect (3.5) or *coupon* (3.4) to electrolyte potential without the voltage error caused by the *IR drop* (3.14) due to the protection current or any other current

3.16
isolation joint
electrically insulating component inserted between two lengths of pipe to prevent electrical continuity between them

EXAMPLE Monobloc isolation joint, insulated flange.

3.17
spark gap
component with discharge distance for isolating electrically conductive installation sections

Note 1 to entry: In the event of lightning strike, the installation sections are temporarily connected conductively as the result of response of the discharge.

3.18
local earth
conductive mass of the electrolyte, whose voltage between two reference electrodes at any point is not equal to zero

3.19
measuring point
location where the actual potential measurement takes place

Note 1 to entry: In the case of pipe-to-electrolyte potential measurement, this refers to the location of the reference electrode.

3.20
pipeline-to-electrolyte potential
difference in potential between a pipeline and a specified reference electrode in contact with the electrolyte

3.21
probe
device incorporating a *coupon* (3.4) that provides measurements of parameters used to assess the effectiveness of cathodic protection and/or corrosion risk

3.22
remote earth
conductive mass of the electrolyte, whose voltage between two reference electrodes at any point is conventionally taken as equal to zero

Note 1 to entry: This condition generally prevails outside the zone of influence of an earth electrode, an earthing system, an anode *ground bed* (3.11), or a protected pipeline.

3.24
stray current
current flowing through paths other than the intended circuit

3.25
telluric current
current in the earth as a result of geomagnetic fluctuations

3.26
test station
monitoring station
installation that provides measuring and test facilities

Note 1 to entry: Such installations include cabling and pipeline connections.

3.27
trenchless installation
buried pipe installation methodology that does not require an open ditch

3.28
utilization factor
fraction of the anodic material weight of an anode that can be consumed before the anode ceases to provide the minimum required current output

3.29
on-land pipeline
pipeline laid on or in land, including lines laid under inland water courses

Note 1 to entry: From the EN 14161 scope are excluded on-land supply systems used by the European gas supply industry from the input of gas into the on-land transmission network up to the inlet connection of gas appliances.

3.30
coating breakdown factor
ratio of current density required to polarize a coated steel surface as compared to a bare steel surface

4 Symbols and abbreviated terms

4.1 Symbols

D_a	anode diameter
D_b	backfill diameter
E	potential measured at the metal/electrolyte interface
ΔE	potential shift due to cathodic protection current measured against a remote reference electrode
E_a	open-circuit potential of a galvanic anode
E_c	design protection potential
E_{cor}	free corrosion potential (also called natural potential)
E_{IRfree}	potential at the metal/electrolyte interface, i.e. the potential that is free from the IR drop in the corrosive environment
E_l	critical negative potential limit
E_{ON}	on-potential
E_{OFF}	instant-off potential
E_p	protection potential criterion
E_{ref}	ON potential required to achieve effective cathodic protection
I_{tot}	total current demand
I_{af}	actual end-of-life individual anode current output
I_{cm}	mean current demand
I_{cpn}	measured current on a coupon
I_f	required end-of-life individual anode current output
j	current density for bare steel
j_c	current density for coated pipelines
J_{cpn}	calculated current density on a coupon
J_{ref}	reference value for current density (analogous to I_{ref})
k	contingency factor
L	length of the pipeline
m	total net anode mass
m_a	individual net anode mass
n	number of anodes
r_{co}	average coating resistance

R_a	total circuit resistance for a galvanic anode cathodic protection system
$R_{a/b}$	anode resistance relative to backfill
$R_{b/s}$	backfill bed resistance relative to the natural electrolyte
ρ	resistivity of an electrolyte
T	temperature
t_{dl}	design life
U	voltage
u	utilization factor

4.2 Abbreviated terms

AC	alternating current
ACVG	alternating current voltage gradient
CIPS	close interval potential survey
CP	cathodic protection
CSE	copper–copper sulphate (saturated) reference electrode
DC	direct current
DCVG	direct current voltage gradient
ER	electrical resistance
FBE	fusion-bonded epoxy
I/J	isolation joint
MMO	mixed metal oxide
SRB	sulphate reducing bacteria
UV	ultraviolet
3LPE	three-layer polyethylene
3LPP	three-layer polypropylene
rms	root mean square

5 Competence

Persons who undertake the design, supervision of installation, commissioning, supervision of operation, measurements, monitoring, and supervision of maintenance of cathodic protection systems shall have the appropriate level of competence for the tasks undertaken.

NOTE 1 Competence of cathodic protection persons to the level appropriate for tasks undertaken can be demonstrated by certification in accordance with prequalification procedures such as ISO 15257 or by any other equivalent scheme and issued by a certification body conforming with ISO/IEC 17024.

NOTE 2 This does not preclude documented confirmation of task-specific competence by bodies that are not certification bodies.

6 Cathodic protection criteria

6.1 General

The corrosion rate of a metal in soil or water is a function of the electrode potential, E, of the material in its surrounding media. The protection potential, E_p, depends on the metal in its environment. For carbon steel and cast iron, the corrosion rate corresponding to E_p is considered to be 0,01 mm per year in the absence of AC or fluctuating DC interference (in case of AC interference, see 6.4 or 6.5).

The criterion for CP is therefore, given by the condition in Formula (1):

$$E_{IRfree} \leq E_p \quad (1)$$

The protection potential of a metal depends on the corrosive environment (e.g electrolyte) and on the type of metal used (see Table 1).

Application of potentials that are too negative can result in coating disbondment and blistering and hydrogen embrittlement of some metals.

The IR free potential, E_{IRfree}, should not be more negative than the critical negative potential limit, E_l.

If E_l is defined, the criterion for CP is given by the conditions in Formula (2):

$$E_l \leq E_{IRfree} \leq E_p \quad (2)$$

If the conditions in Formula (2) cannot be achieved to avoid coating disbondment or blistering, then Formula (1) shall be applied.

NOTE 1 If the protection potentials according to Table 1 are not fulfilled at all times or to all coating defects, the corrosion rate can be higher than 0,01 mm per year.

NOTE 2 Corrosion can be expected to present as pitting or localised corrosion. The corrosion rate considered above is a general, uniform corrosion rate; but pit depths can be expected to be greater.

6.2 Protection potentials

The IR free potential, E_{IRfree}, shall meet the criteria given by Formula (1) and, if applicable, Formula (2). Table 1 presents free corrosion potentials, E_{cor}, protection potentials, E_p, and critical negative potential limit, E_l, for different metals in different environmental conditions.