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Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems —

Part 1: On-land pipelines

Industries du pétrole, de la pétrochimie et du gaz naturel — Protection cathodique des systèmes de transport par conduites — Partie 1: Conduites terrestres

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

This second edition cancels and replaces the first edition (ISO 15589-1:2003), which has been technically revised with the following changes:

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

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

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

ISO 15589 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems*:

— *Part 1: On-land pipelines*

— *Part 2: Offshore pipelines*

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.

It is necessary that users of this part of ISO 15589 be aware that further or differing requirements can be needed for individual applications. This part of ISO 15589 is not intended to inhibit the use of alternative equipment or engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. It is necessary that, where an alternative is offered, any variations from this part of ISO 15589 be identified and documented.

Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems —

Part 1: On-land pipelines

1 Scope

This part of ISO 15589 specifies requirements and gives recommendations for the pre-installation surveys, design, materials, equipment, installation, commissioning, operation, inspection, and maintenance of cathodic protection systems for on-land pipelines, as defined in ISO 13623 or EN 14161 for the petroleum, petrochemical, and natural gas industries, and in EN 1594 or EN 12007-1 and EN 12007-3 used by gas supply industries in Europe.

All contents of this part of ISO 15589 are applicable to on-land pipelines and piping systems used in other industries and transporting other media such as industrial gases, waters, or slurries.

This part of ISO 15589 applies to buried pipelines, landfalls of offshore pipeline sections protected by on-shore based cathodic protection installations, and to immersed sections of on-land pipelines such as river or lake crossings.

This part of ISO 15589 specifies requirements for pipelines of carbon steel, stainless steel, cast iron, galvanized steel, or copper. If other pipeline materials are used, the criteria to apply are defined under the responsibility of the pipeline operator.

This part of ISO 15589 does not apply to pipelines made of reinforced concrete for which EN 12696 can be applied.

NOTE Special conditions sometimes exist where cathodic protection is ineffective or only partially effective. Such conditions can include shielding (e.g. disbonded coatings, thermal-insulating coatings, rocky soil, etc.) and unusual contaminants in the electrolyte.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 — Basic terms and definitions*

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 (all parts), *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems*

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)*

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

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

EN 12496, *Galvanic anodes for cathodic protection in seawater and saline mud*

EN 14161 *Petroleum and natural gas industries — Pipeline transportation systems (ISO 13623:2009 modified)*

EN 50164-3, *Lightning Protection Components (LPC) — Part 3: Requirements for isolating spark gaps*

3 Terms and definitions

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

3.1
anode backfill
added material immediately surrounding a buried anode

3.2
bond
metal conductor, usually copper, connecting two points on the same or on different structures

3.3
cathodic protection system
all active and passive components associated with the provision of active external corrosion protection and its monitoring

Note 1 to entry: Cathodic protection is obtained either by impressed current or by galvanic anodes using one or more stations.

Note 2 to entry: Impressed current and galvanic anode systems consist of all the equipment necessary for the application of cathodic protection, such as impressed current stations, galvanic anodes, bonds, and isolating joints.

3.4
coupon
metal sample of defined dimensions made of a metal equivalent to the metal of the pipeline

3.5
coating breakdown factor
ratio of current density required to polarize a coated steel surface as compared to a bare steel surface

3.6
d.c. decoupling device
equipment that provides a low-impedance path for a.c. and high resistance for d.c.

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 between structures by means of a deliberate bond

Note 1 to entry: See EN 50162 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 of stray currents from affected systems

3.10
galvanic anode
electrode that provides current for cathodic protection by means of galvanic coupling

3.11
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.

3.12
geological cell
corrosion cell constituted between two different parts of a single metallic pipeline in contact with different soils

3.13
groundbed
system of buried or immersed galvanic or impressed current anodes

3.14
impressed current anode
electrode that provides current for cathodic protection by means of impressed current

3.15
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, cables, and a d.c. source.

3.16
instant-OFF potential

OFF potential measured with a short delay after interruption with the aim of approaching as much as possible the IR-free potential

Note 1 to entry: A typical delay for direct measurements on pipeline is about 300 ms to prevent the influence of voltage spikes. On coupons, shorter delays are used.

3.17
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 ($U = I \times R$).

3.18
IR-free potential
polarized potential
pipe to electrolyte potential without the voltage error caused by the IR drop due to the protection current or any other current

3.19
isolating joint
electrically insulating component inserted between two lengths of pipe to prevent electrical continuity between them

EXAMPLE Monobloc isolating joint, isolating flange.

3.20
isolating spark gap
ISG
component with discharge distance for isolating electrically conductive installation sections

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

3.21
local earthing
earthed metallic electrode not directly electrically connected to any other main earthing system

3.22
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.

3.23
ON potential
pipe-to-electrolyte potential measured while the cathodic protection system is continuously operating

3.24
OFF potential
pipe-to-electrolyte potential measured after interruption of all sources of applied cathodic protection current with the aim of approaching an IR-free potential

Note 1 to entry: The delay before measurements varies according to the circumstances.

3.25
pipe-to-electrolyte potential

difference in potential between a pipeline (or coupon) and a specified reference electrode in contact with the electrolyte at a point sufficiently close to, but without actually touching, the pipeline

3.26
pitting resistance equivalent number
PREN
number, developed to reflect and predict the pitting resistance of a stainless steel, based upon the proportions of Cr, Mo, W, and N in the chemical composition of the alloy

3.27
polarization
change of pipe-to-electrolyte potential caused by the application of an external electrical current

3.28
probe
device incorporating a coupon that provides measurements of parameters used to assess the effectiveness of cathodic protection and/or corrosion risk

3.29
protection potential
pipe-to-electrolyte potential at which the metal corrosion rate is acceptable for the pipeline

3.30
reference electrode
electrode, having a stable and reproducible potential that is used as a reference in the measurement of electrode potentials

[SOURCE: ISO 8044]

3.31
remote earth
part of the electrolyte in which no measurable voltages, caused by current flow, occur between any two points

Note 1 to entry: This condition generally prevails outside the zone of influence of an earth electrode, an earthing system, an anode groundbed, or a protected pipeline.

3.32
rock jacket coating
coating that provides mechanical protection to the pipeline and is applied as bendable flexible coating

3.33
stray current
current flowing through paths other than the intended circuits

[SOURCE: Adapted from ISO 8044]

3.34
surge protective device
SPD
device intended to limit transient overvoltages and direct surge currents

Note 1 to entry: It contains at least one nonlinear component.

[SOURCE: IEC 62305-1]

3.35
telluric current
current in the earth as a result of geomagnetic fluctuations

3.36
test station
monitoring station
installation that provides measuring and test facilities

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

3.37
utilization factor
fraction of the anodic material weight of a galvanic anode that can be consumed before the anode ceases to provide the minimum required current output

4 Symbols and abbreviations

4.1 Symbols

D_a	anode diameter
D_b	backfill diameter
ε	electrochemical capacity of the anode material
E	potential measured at the metal/electrolyte interface
ΔE	potential shift due to cathodic protection current measured against a remote reference electrode
E_a	design closed-circuit potential of a galvanic anode

E_c	design protection potential (minimum negative potential)
E_{cor}	free corrosion potential (also called natural potential)
E_{IRfree}	IR free potential
E_l	limiting critical potential
E_{ON}	ON-potential
E_{OFF}	OFF-potential
E_p	protection potential
f_c	coating breakdown factor
f_f	final coating breakdown factor
f_i	initial coating breakdown factor
Δf	average yearly increase in the coating breakdown factor
I_{tot}	total current demand
I_{af}	actual end-of-life individual anode current output
I_{cf}	total current demand for the cathodic protection of a specific pipeline section at the end of life (for maximum coating breakdown factor)
I_{cm}	mean current demand
I_f	required end-of-life individual anode current output
j	current density for bare steel
j_c	current density for coated pipelines
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 (assumed to be equivalent to the anode resistance)
$R_{a/b}$	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 Abbreviations

a.c.	alternating current
ACVG	alternating current voltage gradient
CIPS	close interval potential survey
CP	cathodic protection
CSE	copper–copper sulphate (saturated) reference electrode
d.c.	direct current
DCVG	direct current voltage gradient
ER	electrical resistance
FBE	fusion-bonded epoxy
LPC	lightning protection component
MMO	mixed metal oxide
PREN	pitting resistance equivalent numbers
SCC	stress corrosion cracking
SCE	saturated calomel reference electrode
SRB	sulphate reducing bacteria
UV	ultraviolet
3LPE	three layer polyethylene
3LPP	three layer polypropylene

5 CP personnel competence

Personnel 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.

EN 15257 or NACE Cathodic Protection Training and Certification Programme constitute suitable methods of assessing and certifying competence of cathodic protection personnel.

Competence of cathodic protection personnel to the level appropriate for tasks undertaken should be demonstrated by certification in accordance with prequalification procedures such as EN 15257, NACE Cathodic Protection Training and Certification Programme, or by any other equivalent scheme.