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**Naftna in plinska industrija, vključno z nizkoogljično energijo - Vplivi visokonapetostnih motenj enosmernega toka (DC) na vkopane cevovode - Ukrepi za izvajanje (ISO/DIS 24695:2026)**

Oil and gas industries including lower carbon energy - The effects of High Voltage DC interference to buried pipelines - Measures to be implemented (ISO/DIS 24695:2026)

Öl- und Gasindustrie einschließlich kohlenstoffarmer Energieträger - Auswirkungen von Hochspannungs-Gleichstrom-Interferenzen auf erdverlegte Rohrleitungen - Umzusetzende Maßnahmen (ISO/DIS 24695:2026)

Les effets de l'interférence de la Haute Tension CC sur les pipelines enterrés - Mesures à mettre en oeuvre (ISO/DIS 24695:2026)

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# DRAFT International Standard

## ISO/DIS 24695

### Oil and gas industries including lower carbon energy — The effects of High Voltage DC interference to buried pipelines — Measures to be implemented

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### Foreword

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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](http://www.iso.org/directives)).

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

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# Oil and gas industries including lower carbon energy — The effects of High Voltage DC interference to buried pipelines — Measures to be implemented

## 1 Scope

This document describes technical measures to be carried out at crossings and parallelisms of buried metal pipelines influenced by **HVDC** systems. It provides guidance on how the design, construction, operation, maintenance, and decommissioning phases of **HVDC** systems affect buried metal pipelines. Electromagnetic, DC interference and thermal influences on pipeline coatings are described.

Acceptable levels of interference are discussed.

Guidance is provided for calculation methods to establish an acceptable separation distance between the pipeline and the source of interference.

The following aspects are not covered in this document:

- Interference from other AC sources
- Contractual responsibilities
- Personnel safety.

## 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 15589-1:2015, *Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems — Part 1: On-land pipelines*

ISO 18086:2019, *Corrosion of metals and alloys — Determination of AC corrosion — Protection criteria*

ISO 21857:2021, *Petroleum, petrochemical and natural gas industries — Prevention of corrosion on pipeline systems influenced by stray currents*

IEC 60479-1:2018 ED1:2018, *Effects of current on human beings and livestock - Part 1: General aspects*

IEC 61936-2:2023 ED1:2023, *Power installations exceeding 1 kV AC and 1,5 kV DC - Part 2: DC*

EN 50443:2011, *Effects of electromagnetic interference on pipelines caused by high voltage a.c. electric traction systems and/or high voltage a.c. power supply systems*

## 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:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

## ISO/DIS 24695:2026(en)

### 3.1

#### **High-voltage direct-current system (HVDC system)**

power transmission system that transfers energy using direct current at high voltage between two or more grid connection points. The system consists of at least two converter substations with corresponding earthing systems and direct current transmission lines (overhead lines or buried or immersed cables)

### 3.2

#### **conductive coupling**

transfer of energy occurring when a part of the current belonging to the interfering system returns to the system earth via the interfered system

Note 1 to entry: Also, when the voltage to the reference earth of the ground in the vicinity of the influenced object rises because of a default in the interfering system, and the results of which are conductive voltages and currents.

### 3.3

#### **Electromagnetic Interference (EMI)**

interference phenomenon resulting from conductive, capacitive and inductive coupling between systems and which can cause disturbance, malfunction, damage and danger

[SOURCE: EN 50443:2011]

### 3.4

#### **earth electrode**

structure with a conductor or a group of conductors embedded in the soil or immersed in sea water, directly or surrounded with a specific conductive medium

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.5

#### **pond electrode**

electrode usually placed outside but within 100 m of the waterline, having electrodes directly in contact with the seawater, within a small area which is usually protected against waves and possible ice damage by a breakwater

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.6

#### **sea electrode**

electrode located away from the shoreline at a distance deeper than 100 m into the sea

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.7

#### **electrode station**

whole facility which transfers current to/from the *electrode line* (3.8) to/from the earth or sea water, usually including the feeding cable, towers, switchgear, fencing and any necessary auxiliary equipment in addition to the electrode itself

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.8

#### **electrode line**

overhead line or underground cable used to connect the neutral bus in a converter station to the *earth electrode* (3.4) station

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

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### 3.9

#### **earth return operation mode**

operation mode in the [HVDC](#) power transmission system, using DC lines and earth (or seawater) as the current loop

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.10

#### **earth return system**

set of devices designed and built specifically for *earth return operation mode* ([3.9](#))

Note 1 to entry: It mainly consists of the *electrode line* ([3.8](#)), *earth electrode* ([3.4](#)), current guiding system, and other auxiliary facilities.

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.11

#### **unbalanced current**

difference of current between two poles during operation of a bipolar *DC system* ([3.16](#))

Note 1 to entry: For balanced bipolar operation mode, the unbalanced current flowing can be controlled automatically by the control system with about 1% of the related current.

Note 2 to entry: For balanced bipolar operation mode, the current flowing through the *earth electrode* ([3.4](#)) is the difference in currents between the two poles.

[SOURCE: IEC TS 62344:2022 ED2:2022 [\[1\]](#)]

### 3.12

#### **cathode**

electrode capable of emitting negative charge carriers to and/or receiving positive charge carriers from the medium of lower conductivity

Note 1 to entry: The direction of electric current is from the medium of lower conductivity, through the cathode to the external circuit.

Note 2 to entry: In some cases (e.g. electrochemical cells), the term “cathode” is applied to one or another electrode, depending on the electric operating conditions of the device. In other cases, (e.g. electronic tubes and semiconductor devices). The term “cathode” is assigned to a specific electrode.

[SOURCE: IEC 60050-151:2001/AMD3:2019 ED2:2019 [\[2\]](#)]

### 3.13

#### **anode**

electrode capable of emitting positive charge carriers to and/or receiving negative charge carriers from the medium of lower conductivity

Note 1 to entry: The direction of electric current is from the external circuit, through the anode, to the medium of lower conductivity.

Note 2 to entry: In some cases (e.g. electrochemical cells), the term “anode” is applied to one or another electrode, depending on the electric operating condition of the device. In other cases (e.g. electronic tubes and semiconductor devices), the term “anode” is assigned to a specific electrode.

[SOURCE: IEC 60050-151:2001/AMD3:2019 ED2:2019 [\[2\]](#)]

### 3.14

#### **DC neutral point**

common point of two monopoles forming a bipole converter or the earthed point of a monopole converter

[SOURCE: IEC 61936-2:2023 ED1:2023]

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### 3.15

#### **DC electrode line**

electrical connection between a *DC earth electrode* (3.20) and the DC installation

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.16

#### **DC system**

all interconnected parts of a power system installation that is installed between and including the DC side windings of the interface/converter transformers at each terminal except for the valve hall or converter hall

Note 1 to entry: Components connected to the AC side windings of the converter/interface transformers including the AC windings themselves are not considered to be part of the DC system as defined for this standard.

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.17

#### **high voltage**

DC voltage exceeding 1500 V DC

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.18

#### **converter unit**

indivisible operative unit comprising all equipment between the point of connection on the AC side (or DC side for DC/DC converters) and the point of connection on the DC side, essentially one or more converters, together with converter transformers, control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.19

#### **converter station**

part of a *DC system* (3.16) which consists of one or more *converter units* (3.18) including DC switchgear, DC fault current controlling devices, if any, installed in a single location together with buildings, reactors, filters, reactive power supply, control, monitoring, protective, measuring and auxiliary equipment

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.20

#### **DC earth electrode**

array of conductive elements placed in the earth, or the sea, which provides a low resistance path between a point in the *DC system* (3.16) and the earth and is capable of carrying continuous current for some extended period

Note 1 to entry: An *earth electrode* (3.4) may be located at a point some distance from the *HVDC* substation.

Note 2 to entry: Where the electrode is placed in the sea, it may be termed as a *sea electrode* (3.6).

[SOURCE: IEC 61936-2:2023 ED1:2023]

### 3.21

#### **Voltage source converter (VSC)**

electronic device that converts DC voltage into AC voltage, or vice versa, by controlling the voltage and frequency of the output AC waveform

Note 1 to entry: Usually using an Insulated Gate Bipolar Transistor (*IGBT*) and an AC filter.

### 3.22

#### **thermal conductivity**

measure of the ability of a material to conduct heat

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### 3.23

#### normal operation

operational state in which the system functions within its prescribed design parameters, without activation of protective actions or alarms, while all subsystems operate as intended

### 3.24

#### maintenance operation

operational state in which the system functions within its prescribed design parameters for routine maintenance

Note 1 to entry: This can include a bipolar system operating in monopolar configuration.

### 3.25

#### abnormal operation

operational state in which the system functions outside its prescribed specified design parameters

Note 1 to entry: This includes commissioning, and testing.

### 3.26

#### fault conditions

condition initiated by the detection of an electrical fault within an [HVDC](#) system, where automated protection systems activate to isolate, clear, or mitigate the fault while preserving equipment integrity and grid stability

## 4 Abbreviations and symbols

AGI Above Ground Installation

CP Cathodic Protection

CSC Current Source Converters

csv Comma Separated Value

EMI Electromagnetic interference

EPR Earth Potential Rise

NOTE Synonymous with ROEP (rise of earth potential) and GPR (ground potential rise).

FFT Fast Fourier Transform

HVAC High Voltage AC

HVDC High Voltage DC

IGBT Insulated Gate Bipolar Transistor

LCC Line Commutated Converter

RMS Root Mean Square

VSC Voltage Source Converter

## 5 Definition of an [HVDC](#) transmission system

A typical [HVDC](#) (High Voltage Direct Current) transmission system consists of two main terminals ([Figure 1](#)), the sending terminal and the receiving terminal.

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At the sending terminal, there is a converter that functions as a rectifier, converting alternating current (AC) power from the grid into direct current (DC).

Conversely, at the receiving terminal, there is another converter acting as an inverter, which converts the DC power back into AC for distribution into a local grid.

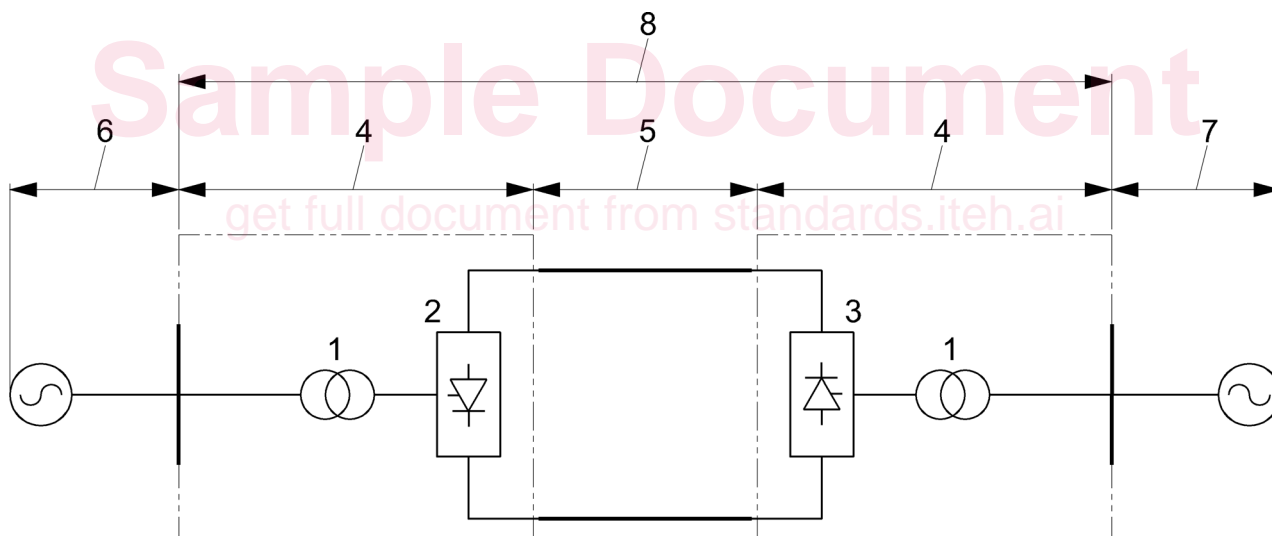
The connection between the sending and receiving terminals can be established using overhead lines, underground/submarine cables, or a combination of both, depending on factors such as distance, environmental considerations, and project requirements.

Inside the converters, power electronic valves, which are essentially high-powered electronic switches, facilitate the control of power flow. These valves enable precise regulation of the electricity being transmitted, allowing for efficient and reliable operation.

Modern [HVDC](#) systems use two main converter technologies, conventional line-commutated current source converters ([CSCs](#)) and self-commutated voltage source converters ([VSCs](#)), which can be part of different systems like back-to-back, monopolar, bipolar, homopolar, and multi-terminal setups. Additional schematic diagrams and explanatory notes can be found in [Annex A](#).

Depending on the technology, [HVDC](#) systems can operate differently under normal, emergency, and fault condition.

One key feature of [HVDC](#) systems is their ability to reverse the direction of power flow as needed. This is achieved by configuring the converters at the terminals to operate as either rectifiers or inverters interchangeably. As a result, power can be transmitted bi-directionally, providing flexibility and enhancing the system's overall reliability. More details on [HVDC](#) configurations can be found in [Annex A](#).



### Key

- 1 converter transformer
- 2 converter (I)
- 3 converter (II)
- 4 converter station
- 5 DC Line
- 6 AC grid (I)
- 7 AC grid (II)
- 8 DC power transmission system

**Figure 1 — [HVDC](#) Power Transmission Structure (Simplified Layout)**

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### 6 Sources of Interference

#### 6.1 General

The technology of [HVDC](#) systems entails topologies, components and operating characteristics that affect the interference situations (DC interference and Electromagnetic Interference (EMI)) and impacts on pipeline systems.

#### 6.2 DC Interference

DC interference, caused by [HVDC](#) systems, is a disturbance that primarily affects metallic pipelines through conduction via the earth or other electrolytes. For buried or submerged pipelines, this interference can accelerate corrosion on their external surfaces. The corrosive effect is mainly due to the combination of the earth/seawater return current's magnitude and the duration of exposure [\[3\]](#).

DC interference can arise from:

- The normal operation of unbalanced monopole configurations, using electrodes to facilitate current return through the earth or sea.
- The normal operation of bipolar configurations, where electrodes are used to conduct any unbalanced current that arises between the two poles of the system. This unbalanced current, typically limited to 0.5% to 1% of the rated current of each pole, results from minor differences between the converter units at each station.
- Temporary operation (e.g. maintenance or emergencies) of bipolar configurations that are run as monopolar systems, using electrodes to facilitate current return through the earth or sea.

#### 6.3 Electromagnetic Interference (EMI)

- Close proximity of [HVDC](#) and pipeline systems can result in circumstances that give rise to increased external corrosion risks to the pipeline, hazardous electrical conditions (e.g. touch voltages) on the interfered pipelines and associated systems.
- Consideration should be given to:
  - the impact of harmonic currents and voltages on the DC side, under the normal operating conditions of the [HVDC](#) systems
  - the impact of DC-side fault conditions of the [HVDC](#) systems

NOTE The DC-side fault conditions are described in §10.3.2 of IEC 61936-2:2023 ED1:2023

- monopolar operations.

DC side faults within the [HVDC](#) installation site shall be assessed to identify the worst-case scenario for Electromagnetic Interference (EMI) affecting nearby pipeline systems. The types of faults that can be relevant, include:

- Pole-to-earth fault
- Two-pole-to-earth fault
- Metallic-return-to-earth fault
- Electrode-line-to-earth fault.

The [HVDC](#) operator can provide the pipeline operator or owner with waveform data for short-circuit currents for each type of DC fault type, including the fault time duration for each case.