
**Carbon dioxide capture, transportation
and geological storage — Pipeline
transportation systems**

*Captage du dioxyde de carbone, transport et stockage géologique —
Systèmes de transport par conduites*

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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).

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 on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 265, *Carbon dioxide capture, transportation, and geological storage*.

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Introduction

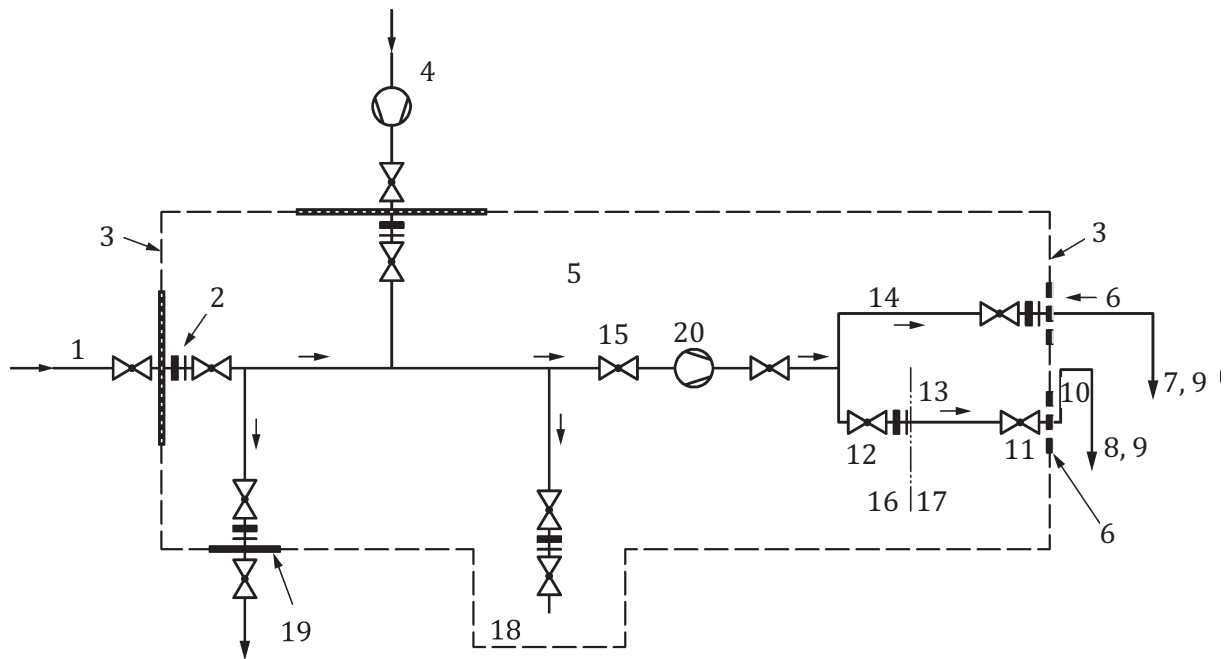
Carbon dioxide (CO₂) capture and storage (CCS) has been identified as a key abatement technology for achieving a significant reduction in CO₂ emissions to the atmosphere. Pipelines are likely to be the primary means of transporting CO₂ from the point-of-capture to storage (e.g. depleted hydrocarbon formations, deep saline aquifers), where it will be retained permanently or used for other purposes [e.g. Enhanced Oil Recovery (EOR)] to avoid its release to the atmosphere. While there is a perception that transporting CO₂ via pipelines does not represent a significant barrier to implementing large-scale CCS, there is significantly less industry experience than there is for hydrocarbon service (e.g. natural gas) and there are a number of issues that need to be adequately understood and the associated risks effectively managed to ensure safe transport of CO₂. In a CCS context, there could be a need for larger CO₂ pipeline systems in more densely populated areas and with CO₂ coming from multiple sources. Also, offshore pipelines for the transportation of CO₂ to offshore storage sites are likely to become common.

The objective of this document is to provide requirements and recommendations on certain aspects of safe and reliable design, construction and operation of pipelines intended for the large scale transportation of CO₂ that are not already covered in existing pipeline standards such as ISO 13623, ASME B31.4, EN 1594, AS 2885 or other standards (see Bibliography). Existing pipeline standards cover many of the issues related to the design and construction of CO₂ pipelines; however, there are some CO₂ specific issues that are not adequately covered in these standards. The purpose of this document is to cover these issues consistently. Hence, this document is not a standalone standard, but is written to be a supplement to other existing pipeline standards for natural gas or liquids for both onshore and offshore pipelines.

Transport of CO₂ via ship, rail and road is not covered in this document.

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Key

- | | | | |
|---|---|----|---------------------------------------|
| 1 | source of CO ₂ from capture, e.g. from power plant, industry; see ISO/TR 27912 (capture) | 10 | riser (out of transport scope) |
| 2 | isolating joint | 11 | subsea valve (inside transport scope) |
| 3 | boundary limit | 12 | beach valve |
| 4 | other source of CO ₂ | 13 | offshore pipeline |
| 5 | ISO 27913 (transportation system inside) | 14 | onshore pipeline |
| 6 | boundary to storage facility | 15 | valve |
| 7 | onshore storage facility | 16 | landfall |
| 8 | offshore storage facility | 17 | open water/sea |
| 9 | EOR | 18 | third party transport system |
| | | 19 | export to other uses than 7, 8 and 9 |
| | | 20 | intermediate compression or pumping |

Figure 1 — Schematic illustration of the system boundaries of this document

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Carbon dioxide capture, transportation and geological storage — Pipeline transportation systems

1 Scope

This document specifies additional requirements and recommendations not covered in existing pipeline standards for the transportation of CO₂ streams from the capture site to the storage facility where it is primarily stored in a geological formation or used for other purposes (e.g. for EOR or CO₂ use).

This document applies to

- rigid metallic pipelines,
- pipeline systems,
- onshore and offshore pipelines for the transportation of CO₂ streams,
- conversion of existing pipelines for the transportation of CO₂ streams,
- pipeline transportation of CO₂ streams for storage or utilization, and
- transportation of CO₂ in the gaseous and dense phases.

The system boundary (see [Figure 1](#)) between capture and transportation is the point at the inlet valve of the pipeline, where the composition, temperature and pressure of the CO₂ stream is within a certain specified range by the capture process or processes to meet the requirements for transportation as described in this document.

The boundary between transportation and storage is the point where the CO₂ stream leaves the transportation pipeline infrastructure and enters the storage infrastructure.

This document also includes aspects of CO₂ stream quality assurance, as well as converging CO₂ streams from different sources.

Health, safety and environment aspects specific to CO₂ transport and monitoring are considered.

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 3183:2012, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 20765-2, *Natural gas — Calculation of thermodynamic properties — Part 2: Single-phase properties (gas, liquid, and dense fluid) for extended ranges of application*

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

3.1

arrest pressure

internal pipeline pressure where there is sufficient mechanical strength to arrest or, there is not enough energy to drive a *ductile fracture* ([3.8](#))

3.2

CO₂ stream

stream consisting overwhelmingly of carbon dioxide

3.3

corrosion allowance

extra wall thickness added during design to compensate for any reduction in wall thickness by corrosion (internal/external) during the design operational life

3.4

critical point

highest temperature and pressure at which a pure substance (e.g. CO₂) can exist as a gas and a liquid in equilibrium

Note 1 to entry: For a multicomponent fluid mixture of a given composition, the critical point is the merge of the bubble and the dew point curves.

3.5

critical pressure

vapour pressure at the *critical temperature* ([3.6](#))

Note 1 to entry: The critical pressure for pure CO₂ is 7,28 MPa.

3.6

critical temperature

temperature above which liquid cannot be formed simply by increasing the pressure

Note 1 to entry: The critical temperature of pure CO₂ is 304,03 K.

3.7

dense phase

CO₂ in its liquid or supercritical phases

3.8

ductile fracture

mechanism which takes place by the propagation of a crack or stress-raising features, linked with a considerable amount of plastic deformation

Note 1 to entry: A “ductile fracture” is sometimes referred to as “shear fracture”.

3.9

flow coating

internal coating to reduce internal roughness, and hence minimize friction pressure loss

3.10

fracture arrestor

additional pipeline component that may be installed around portions of a pipeline designed to resist propagating fractures

Note 1 to entry: Fracture arrestor is also called crack arrestor.

3.11

free water

water (pure water, water with dissolved salts, water wet salts, water glycol mixtures or other mixtures containing water) not dissolved in the gaseous or dense CO₂ phase, i.e. a separate water phase

3.12**internal cladding**

pipe with internal metal liner where the bond between the line pipe and liner is metallurgical

3.13**internal lining**

pipe with internal coating where the bond between the line pipe and coating is mechanical

3.14**maximum design temperature**

highest possible temperature to which the equipment or system may reasonably be exposed locally during installation and operation

3.15**maximum operating pressure**

highest possible pressure to which the equipment or system may reasonably be exposed locally during installation and operation

3.16**minimum design temperature**

lowest possible temperature to which the component or system may reasonably be exposed locally during installation and operation

3.17**minimum operating pressure**

lowest possible pressure to which the equipment or system may reasonably be experienced locally during installation and operation

3.18**non-condensable gases**

chemical substances that are partially in the vapour state at pipeline operating conditions

3.19**operating envelope**

limited range of parameters over which operations will result in safe and acceptable performance of the equipment or system during operation

3.20**pipeline commissioning**

activities associated with the initial filling and pressurization of the pipeline system with the fluid to be transported

3.21**pipeline dehydration**

process of removing water from a *CO₂ stream* (3.2) to a level below saturation such that the design maxima for the transportation system can be achieved

3.22**pipeline dewatering**

removal of water after hydraulic testing of the pipeline system

3.23**rapid gas decompression**

phenomenon brought about by a fluid migrating at a molecular level into a polymer, and collecting as a bubble and bursting following pressure reduction

3.24**saturation pressure**

pressure of a vapour which is in equilibrium with its liquid at a given temperature

Note 1 to entry: The term “saturation pressure” is also referred to as “saturation vapour pressure”.

3.25

short-term storage reserve

accumulation of the fluid in a pressurized section of a pipeline additional to the fluid that is extracted from the pipeline, for the purpose of temporary storage of that fluid

3.26

threat

activity or condition that alone or in combination with others has the potential to cause damage or produce another negative impact if not adequately controlled

3.27

triple point

temperature and pressure at which three phases (gas, liquid and solid) of a substance coexist in thermodynamic equilibrium

4 Symbols, abbreviated terms and units

4.1 Symbols

C_v	Notched-bar impact value of the pipeline steel (J)
c_{cf}	Correction factor (—)
E	Young's modulus (MPa)
A_C	Test patch = 80 mm ²
σ_f	Flow stress (MPa)
R	Average pipe radius (mm)
t	Minimum wall thickness of the pipe (mm)
σ_a	Arrest stress (MPa)
P_s	Maximum saturation pressure (gauge pressure) in MPag; for pure CO ₂ critical pressure = 7,28 MPag
OD	External diameter of the pipe (mm)

4.2 Abbreviated terms

CCS	Carbon dioxide Capture and Storage
EOR	Enhanced Oil Recovery
GERG	Groupe Européen de Recherches Gazières (European Gas Research Group)
IMP	Integrity Management Plan
MAOP	Maximum Allowable Operating Pressure
PIG	Pipeline Inspection Gauge
SCADA	Supervisory Control And Data Acquisition
SI	Système International d'unités (International System of Units)