
**Carbon dioxide capture, transportation
and geological storage — Carbon
dioxide storage using enhanced oil
recovery (CO₂-EOR)**

*Captage, transport et stockage géologique du dioxyde de carbone —
Stockage du dioxyde de carbone au moyen de la récupération assistée
du pétrole (RAP-CO₂)*

iTech Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 27916:2019

<https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabab2d/iso-27916-2019>



iTeh Standards
(<https://standards.itih.ai>)
Document Preview

ISO 27916:2019

<https://standards.itih.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabab2d/iso-27916-2019>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
1.1 Applicability	1
1.2 Non-applicability	1
1.3 Standard boundary	1
1.3.1 Inclusions	1
1.3.2 Exclusions	1
2 Normative references	2
3 Terms and definitions	2
4 Documentation	4
4.1 Purpose	4
4.2 Use of existing data	4
4.3 Initial documentation	5
4.4 Periodic documentation	5
5 EOR complex description, qualification, and construction	5
5.1 General	5
5.2 Geological characterization and containment assessment of the EOR complex	6
5.3 Description of the facilities within the CO ₂ -EOR project	6
5.4 Existing wells within the EOR complex	6
5.5 Operations history of the project reservoir	7
6 Containment assurance and monitoring within the EOR complex	7
6.1 Containment assurance and EOR operation management plan	7
6.1.1 EOR operations management plan	7
6.1.2 Initial containment assurance	7
6.1.3 Operational containment assurance	8
6.2 Monitoring program, methods, and implementation	8
6.2.1 Monitoring of potential leakage pathways	8
6.2.2 Monitoring methods	8
6.2.3 Monitoring program implementation	9
7 Well construction	9
7.1 New well construction	9
7.2 Well intervention	9
8 Quantification	10
8.1 General	10
8.2 Quantification principles	10
8.3 Quantification of input [m_{input}]	11
8.4 Quantification of loss	11
8.4.1 Quantification of operational loss [$m_{\text{loss operations}}$]	11
8.4.2 Leakage from facilities	12
8.4.3 Venting and flaring from operations	12
8.4.4 Entrained CO ₂ in products	12
8.4.5 Transfer of CO ₂	12
8.4.6 Loss from EOR complex	12
8.5 Allocation ratio for anthropogenic CO ₂	13
8.6 De minimis losses	13
8.7 Avoidance of double-counting	13
9 Recordkeeping and missing data	13
9.1 Record retention	13
9.2 Missing data procedures	13

10	Project termination	13
10.1	General	13
10.2	Periodic assurance of containment	14
10.3	Termination plan	14
10.4	Requisites for termination	14
10.5	CO ₂ -EOR project termination	14
10.6	Post termination	15
Annex A	(informative) Introduction to CO₂-EOR	16
Annex B	(informative) Example quantification calculation	33
Annex C	(informative) Unit conversion	41
Bibliography		42

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 27916:2019

<https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabab2d/iso-27916-2019>

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 voluntary nature of standards, 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.

This document was prepared by Technical Committee ISO/TC 265, *Carbon dioxide capture, transportation, and geological storage*.

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.

<https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabb2d/iso-27916-2019>

Introduction

This is the first edition of the standard entitled: *Carbon dioxide capture, transportation and geological storage — Carbon dioxide storage using enhanced oil recovery (CO₂-EOR)*. The subject matter of this document is a new work product and does not cancel or replace any other documents in whole or in part related to the subject of CO₂-EOR.

Carbon dioxide enhanced oil recovery (CO₂-EOR) is a technique for increasing the recovery of hydrocarbons from an oil field.

The process involves using wells to inject volumes of CO₂ at pressures where the injected CO₂ usually mixes with the oil, changing the properties of the oil and enabling it to flow more freely to production wells. In most cases, a CO₂-EOR project is designed as a closed-loop system whereby some of the injected CO₂ is co-produced with the oil and then separated in above-ground recycling facilities prior to being reinjected into the oil reservoir. CO₂ that is injected into the project reservoir is contained as an inherent element of the injection and production operations, and this document requires that such containment be demonstrated. CO₂ that is injected and remains trapped in the project reservoir (or EOR complex) during and after oil production activities is not released to the atmosphere, and this trapping is referred to as “associated storage”. [Annex A](#) provides a detailed description of the CO₂-EOR process as presently used (and potential “next generation” uses) and the associated storage that occurs as an intrinsic part of those operations. Although methane is often present in EOR project reservoirs, this document does not specifically address methane or other greenhouse gases. The demonstration requirements for safe, long-term containment, however, address assessment of trapping and potential leakage pathways that would likely assure containment of methane as well as CO₂. As detailed in [Annex A](#), CO₂-EOR has been deployed internationally for several decades and has potential to expand. CO₂-EOR is commercially valuable today because it allows for the additional recovery of hydrocarbon resources while simultaneously trapping injected CO₂ for safe, long-term containment as a part of the process.

This document applies to quantifying and documenting the total CO₂ (and optionally the anthropogenic portion of the CO₂) that is stored in association with CO₂-EOR. The document recognizes that CO₂-EOR is principally an oil recovery operation. Associated with this oil recovery, however, safe and long-term CO₂ storage occurs. The absence of an accepted standard for demonstrating the safe, long-term containment of CO₂ in association with CO₂-EOR and documenting the quantity of associated stored CO₂ constitutes one of the barriers to the increased use of anthropogenic CO₂ in CO₂-EOR operations. The purpose of this document is to remove that barrier and thereby facilitate the exchange of goods and services related to the increased use and emissions reductions through associated storage by providing methods for demonstrating the safe, long-term containment of, and determining the quantity of CO₂ stored in association with CO₂-EOR. The document does not address the financial consequences that may or may not result from documenting storage of CO₂ in association with CO₂-EOR operations.

This document does not provide requirements for the selection, characterization or permitting of sites for CO₂-EOR projects because those sites are selected, characterized, and permitted pursuant to requirements and standards applicable to oil and gas exploration and production. Likewise, this document does not specify environment, health and safety protections or corrective action and mitigation requirements that are provided by the regulations and standards applicable to all hydrocarbon production operations. (A list of many of the existing standards applicable to CO₂ injection wells and oil and gas operations is presented in the Bibliography.) This document does provide requirements for demonstrating that the site in question is adequate to provide safe, long-term containment of CO₂, for demonstrating that the CO₂ flood is operated in a way to assure containment of the CO₂ in the EOR complex, and for quantifying associated storage.

This document provides for the quantification of the CO₂ that is stored in association with CO₂-EOR operations. The results of quantifications under this document could be used as input for calculations conducted in accordance with a number of other standards, protocols or programs for the quantification or reporting of greenhouse gas emissions, mitigation, or reductions, including those complying with ISO 14064-1, ISO 14064-2 and ISO 14064-3. Specifically, this document provides for the identification and quantification of CO₂ losses (including fugitive emissions) and quantification of the amount of CO₂

stored in association with CO₂-EOR projects. Such quantification could be used in a broader scheme for the quantification and verification of emissions and emission reductions over the entire carbon capture, transportation and storage chain. Specifically, using this document will provide quantification results that could be used as input to approaches described in ISO/TR 27915 for Quantification & Verification (Q&V). In addition, the quantification of CO₂ stored in association with a CO₂-EOR project pursuant to this document could be combined with the quantifications generated under ISO 27920, Carbon dioxide capture, transportation, and geological storage — Quantification and Verification, which is currently under development. The quantification of the storage associated with a CO₂-EOR project that occurs as part of a CCS project chain could be combined with the quantification of one or more capture, transportation and geological storage systems to produce a total quantification for the entire CCS project chain. Under some emissions quantification and reporting regimes, CO₂ quantities stored in association with CO₂-EOR are either treated as not emitted and excluded from calculations or subtracted as offsets.

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO 27916:2019](https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabab2d/iso-27916-2019)

<https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabab2d/iso-27916-2019>

Carbon dioxide capture, transportation and geological storage — Carbon dioxide storage using enhanced oil recovery (CO₂-EOR)

1 Scope

1.1 Applicability

This document applies to carbon dioxide (CO₂) that is injected in enhanced recovery operations for oil and other hydrocarbons (CO₂-EOR) for which quantification of CO₂ that is safely stored long-term in association with the CO₂-EOR project is sought. Recognizing that some CO₂-EOR projects use non-anthropogenic CO₂ in combination with anthropogenic CO₂, the document also shows how allocation ratios could be utilized for optional calculations of the anthropogenic portion of the associated stored CO₂ (see [Annex B](#)).

1.2 Non-applicability

This document does not apply to quantification of CO₂ injected into reservoirs where no hydrocarbon production is anticipated or occurring. Storage of CO₂ in geologic formations that do not contain hydrocarbons is covered by ISO 27914 even if located above or below hydrocarbon producing reservoirs. If storage of CO₂ is conducted in a reservoir from which hydrocarbons were previously produced but will no longer be produced in paying or commercial quantities, or where the intent of CO₂ injection is not to enhance hydrocarbon recovery, such storage would also be subject to the requirements of ISO 27914.

1.3 Standard boundary

ISO 27916:2019

<https://standards.iteh.ai/catalog/standards/iso/eb4fafd3-1aa5-41d1-a5d8-6bac6aabb2d/iso-27916-2019>

1.3.1 Inclusions

The conceptual boundary of this document for CO₂ stored in association with CO₂-EOR includes:

- a) safe, long-term containment of CO₂ within the EOR complex;
- b) CO₂ leakage from the EOR complex through leakage pathways; and
- c) on-site CO₂-EOR project loss of CO₂ from wells, equipment or other facilities.

1.3.2 Exclusions

This document does not include the following:

- a) lifecycle emissions, including but not limited to CO₂ emissions from capture or transportation of CO₂, on-site emissions from combustion or power generation, and CO₂ emissions resulting from the combustion of produced hydrocarbons;
- b) storage of CO₂ above ground;
- c) buffer and seasonal storage of CO₂ below ground (similar to natural gas storage);
- d) any technique or product that does not involve injection of CO₂ into the subsurface; and
- e) emissions of any GHGs other than CO₂.

NOTE Some authorities might require other GHG components of the CO₂ stream to be quantified.

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 <https://www.electropedia.org/>

3.1 anthropogenic carbon dioxide

carbon dioxide that is initially produced as a by-product of a combustion, chemical, or separation process (including separation of hydrocarbon-bearing fluids or gases) where it would otherwise be emitted to the atmosphere (excluding the recycling of non-anthropogenic CO₂)

Note 1 to entry: The chemical symbol “CO₂” is synonymous with “carbon dioxide”. Accordingly, the two ways of writing out “carbon dioxide” and “CO₂” are used interchangeably in this document.

Note 2 to entry: If CO₂ that meets the definition of anthropogenic CO₂ is not included in a supplemental quantification of associated storage of anthropogenic CO₂ (e.g., because it was received and injected by a CO₂-EOR project prior to the quantification period) it will generally be treated as non-anthropogenic CO₂ in that quantification.

3.2 associated storage

CO₂ stored in association with CO₂-EOR (3.4) that occurs as an inherent result of a dedicated hydrocarbon production operation

Note 1 to entry: The requirements of this document are intended to ensure that CO₂ stored in association with a CO₂-EOR operation is stored as effectively as CO₂ stored in a geologic storage operation that complies with ISO 27914.

3.3 authority

competent governmental entity or entities with legal power to regulate or permit CO₂-EOR (3.4), to regulate storage of CO₂ in association with a CO₂-EOR (3.4) operation, or to regulate quantification of the storage of CO₂ in association with a CO₂-EOR (3.4) operation

3.4 CO₂ enhanced oil recovery CO₂-EOR

process designed to produce hydrocarbons from a reservoir using the injection of CO₂

Note 1 to entry: The process of CO₂ enhanced oil recovery is explained in detail in [Annex A](#)

3.5 CO₂ enhanced oil recovery project CO₂-EOR project

EOR complex (3.10), underground equipment, wells, surface or above seabed equipment, activities and rights necessary to an enhanced oil recovery operation, including any necessary or required surface or subsurface rights regulated by the authority

3.6 CO₂ injection well

well used to inject CO₂ into a *project reservoir* (3.19)

3.7**CO₂ stream**

stream consisting overwhelmingly of carbon dioxide

Note 1 to entry: The CO₂ stream typically includes impurities and may include substances added to the stream to improve performance of hydrocarbon recovery operation and/or to facilitate CO₂ detection.

[SOURCE: ISO 27917:2017, 3.2.10, modified — Note revised to added “to improve performance of hydrocarbon recovery operation”.]

3.8**containment**

status of CO₂ being confined within the *EOR complex* (3.10) by an effective *trap* (3.23) or combination of traps

3.9**containment assurance**

demonstration that the features and geologic structure of the *CO₂-EOR project* (3.5) are adequate to provide *safe, long-term* (3.21) *containment* (3.8) of CO₂, and that the CO₂ flood is operated in a way to assure containment of the CO₂ in the *EOR complex* (3.10)

3.10**EOR complex**

project reservoir (3.19), *trap* (3.23), and such additional surrounding volume in the subsurface as defined by the *operator* (3.16) within which injected CO₂ will remain in *safe, long-term* (3.21) *containment* (3.8)

3.11**injection-withdrawal ratio**

ratio, during a defined period, of the volume of all fluids and gases injected into the *project reservoir* (3.19) to the volume of all fluids and gases produced from the project reservoir as determined using consistent temperature and pressure conditions

3.12**leakage**

unintended release of CO₂ to the atmosphere or out of the *EOR complex* (3.10)

[SOURCE: ISO 27917:2017, 3.2.14, modified — Added to the atmosphere or out of the EOR complex.]

3.13**leakage pathway**

geological or artificial conduit for *leakage* (3.12) of CO₂ out of the *EOR complex* (3.10)

3.14**loss**

leakage (3.12), intended releases, and transfers of CO₂ from the *CO₂-EOR project* (3.5)

3.15**native CO₂**

CO₂ present and indigenous within the *project reservoir* (3.19) prior to hydrocarbon production or any CO₂ injection

Note 1 to entry: Native CO₂ is also known as “in situ CO₂”.

3.16**operator**

entity responsible for the *CO₂-EOR project* (3.5)

3.17

plug & abandon

permanently close a well or wellbore to prevent inter-formational movement of fluids into strata, into freshwater aquifers, and out of the well

Note 1 to entry: In most cases, a series of cement plugs is set in the wellbore, with an inflow or integrity test made at each stage to confirm hydraulic isolation.

3.18

post-termination

period of time after *termination* (3.22)

3.19

project reservoir

geologic reservoir in to which CO₂ is injected for production of hydrocarbons in paying or commercial quantities

3.20

quantification period

period of time during which *associated storage* (3.2) is being quantified

3.21

safe, long-term

period necessary for *associated storage* (3.2) to be considered environmentally safe by the system under which the quantification is being implemented

3.22

termination

process beginning with the cessation of quantification of *associated storage* (3.2), and ending with both the termination of hydrocarbon production from the *project reservoir* (3.19), and the plugging & abandonment of wells unless otherwise required by the *authority* (3.3)

3.23

trap

any feature or mechanism that alone or in combination provides *safe, long-term* (3.21) *containment* (3.8) below a low-permeability confining geologic layer (cap rock or seal), including in the pore spaces of the *EOR complex* (3.10) (physical, stratigraphic, or structural trapping), by capillary pressure from the water in the pore spaces between the rock (residual trapping), by dissolution in the in situ formation fluids (solubility), by hydrodynamic trapping, by adsorption onto organic matter or by reacting in geologic formations to produce minerals (geochemical trapping)

4 Documentation

4.1 Purpose

The provisions of this clause are intended to facilitate documentation of the safe, long-term containment, and the quantification of associated storage.

4.2 Use of existing data

Documentation and demonstration requirements throughout this document may be satisfied by information that has already been required, is held, approved by, and available from the authority, because in many cases EOR operations are addressed by existing oil and gas regulations. To the extent that information fully satisfies the requirements, has already been provided and is available from the authority, such information is not required to be developed again for purposes of this document. References to information that is available do not include information held by another entity but not available to the operator.

4.3 Initial documentation

At the beginning of the quantification period, initial documentation shall be prepared and shall include:

- a) a description of the EOR complex and engineered systems (see [Clause 5](#));
- b) the initial containment assurance (see [6.1.2](#));
- c) the monitoring program (see [6.2](#));
- d) the quantification method to be used (see [Clause 8](#) and [Annex B](#)); and
- e) the total mass of previously injected CO₂ within the EOR complex at the start of quantification period (see [8.5](#) and [Annex B](#)).

The initial documentation shall be offered to the authority.

4.4 Periodic documentation

Periodic documentation should be prepared at least annually and shall provide the following information:

- a) the quantity of associated storage in specified units of CO₂ mass, or volumetric units convertible to mass, (see [8.2](#) m_{stored}) during the period covered by the documentation;
- b) the cumulative quantity of associated storage in specified units of CO₂ mass, or volumetric units convertible to mass, (see [8.2](#) m_{stored}) since the beginning of the quantification period;
- c) the formula and data used to quantify the mass of associated storage, including the mass of CO₂ delivered to the CO₂-EOR project and losses during the period covered by the documentation (see [Clause 8](#) and [Annex B](#));
- d) the methods used to estimate missing data and the amounts estimated as described in [9.2](#);
- e) the approach and method for quantification utilized by the operator, including accuracy, precision and uncertainties (see [Clause 8](#) and [Annex B](#));
- f) a statement describing the nature of validation or verification of the statement including the date of review, process, findings, and responsible person or entity; and
- g) source of each CO₂ stream quantified as associated storage (see [8.3](#)).

The periodic documentation shall be offered to the authority.

NOTE The operator can determine that more frequent recordkeeping and documentation are required to meet the goals or requirements of the CO₂-EOR project.

5 EOR complex description, qualification, and construction

5.1 General

A general EOR operations management plan shall be prepared and periodically updated; shall provide a description of the EOR complex and engineered system [see [4.3 a\)](#)], shall establish that the EOR complex is adequate to provide safe, long-term containment of CO₂ and shall include site-specific and other information pertaining to:

- a) geologic characterization of the EOR complex;
- b) a description of the facilities within the CO₂-EOR project;
- c) a description of all wells and other engineered features in the CO₂-EOR project; and

- d) the operations history of the project reservoir.

5.2 Geological characterization and containment assessment of the EOR complex

The general geologic characterization of the EOR complex shall be based on subsurface and other data collected at the site (augmented where appropriate with data from analogous fields), including any features that may affect safe, long-term containment of CO₂ and evidence of the integrity of the reservoirs and traps. The operator shall define the EOR complex in the geologic description to contain all likely subsurface locations to which the CO₂ could reasonably move beyond the project reservoir. For projects desiring to quantify associated storage, the geological characterization and engineering description shall provide evidence of the integrity of the reservoirs and traps that supports a conclusion that the EOR complex is suitable for safe, long-term containment. The description of the EOR complex should include, but not necessarily be limited to:

- a) general lithologic description of the stratigraphic column above the EOR complex;
- b) depth to the top of the EOR complex;
- c) thickness of the defined stratigraphy within the EOR complex;
- d) structural and geophysical properties;
- e) lateral boundaries and any spill points relevant to containment;
- f) hydraulic/petrophysical/geochemical/geomechanical properties;
- g) associated storage capacity of CO₂ in the project reservoir, recognizing that EOR operations are typically designed for maximum economic hydrocarbon production; and
- h) engineering data as described in [6.1.3](#).

5.3 Description of the facilities within the CO₂-EOR project

The description of the facilities within the CO₂-EOR project shall provide an overview of the equipment, downstream of the CO₂ custody transfer meter, used to handle CO₂ and production, including design specifications. This should typically include piping, separators, processing and dehydration equipment, pumps, compressors, and any other equipment relevant to CO₂ handling and production. It should specifically address vent, release, sampling, and metering points, including a description of metering accuracy and estimation techniques.

5.4 Existing wells within the EOR complex

The description of wells shall identify each well penetrating the EOR complex and shall provide evidence it has been constructed and/or plugged & abandoned in such a manner as to provide safe, long-term containment of CO₂. Such wells include injection, production, monitoring, temporarily abandoned, shut-in, and plugged & abandoned wells. The following information shall be provided where available:

- a) well name;
- b) unique well identifier;
- c) spud and completion dates;
- d) well status (e.g. injection, production, monitoring, temporarily abandoned, shut-in, plugged & abandoned);
- e) surface or seabed location;
- f) total and measured depth;
- g) plugging & abandonment information;