International Standard

ISO 27916

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

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

Second edition
2026-06

Reference number
ISO 27916:2026(en)

COPYRIGHT PROTECTED DOCUMENT

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

Published in Switzerland

Contents

Page

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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity, or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 27916:2019), which has been technically revised.

The main changes are as follows:

— Clause 3 clarifies distinctions between definitions of “loss" and “leakage”;

— Clause 4 has been reorganized to reflect observed actual practices;

— Clause 5 has been reorganized to reflect observed actual practices;

— Clause 7 has been reorganized to reflect observed actual practices;

— Clause 8 has been updated and reorganized to better incorporate verification criteria, and graphics have been updated;

— Annex A has been reorganized, eliminating selected common EOR project description information found in other source documents and has been updated;

— the entire text has been editorially revised.

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

Carbon dioxide enhanced oil recovery (CO_2-EOR) is a technique for increasing the recovery of hydrocarbons through the injection of carbon dioxide (CO_2). At present, the technique is used principally for increased recovery of liquid hydrocarbons (i.e. oil) but can also be used for recovery of gaseous hydrocarbons. This document focuses primarily on the recovery of liquid hydrocarbons, but applies regardless of whether the production stream is predominantly liquid or gaseous.

The process involves using wells to inject volumes of CO_2 at pressures where the injected CO_2 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 CO_2-EOR project is designed as a closed-loop system whereby some of the injected CO_2 is co-produced with the oil or other hydrocarbon and then separated in above-ground recycling facilities prior to being reinjected into the oil reservoir.

CO_2 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. CO_2 that is injected and remains trapped in the "EOR complex" during and after oil production activities is referred to as "associated storage" when the CO_2 is not released to the atmosphere. Associated storage occurs as an intrinsic part of CO_2-EOR 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 CO_2. CO_2-EOR has been deployed internationally for several decades and has potential to expand. CO_2-EOR is commercially valuable today because it allows for the additional recovery of hydrocarbon resources while simultaneously trapping injected CO_2 for safe, long-term containment as a part of the process.

This document provides requirements for the quantification of the CO_2 (and optionally the portion of any anthropogenic CO_2) that is stored in association with CO_2-EOR operations. The purpose of this document is to 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, CO_2 stored in association with CO_2-EOR. The document does not address any financial consequences that result from documenting storage of CO_2 in association with CO_2-EOR operations.

This document does not provide requirements for the selection, characterization, or permitting of sites for CO_2-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 CO_2 injection wells and oil and gas operations is presented in the Bibliography.

The results of quantifications under this document can be used as input for calculations conducted according to a number of other standards, protocols, or programs for the quantification or reporting of greenhouse gas emissions, mitigation, or reductions, including those conforming with ISO 14064-1, ISO 14064-2 and ISO 14064-3. Specifically, this document provides methodology for the identification and quantification of CO_2 losses (including fugitive emissions) and quantification of the amount of CO_2 stored in association with CO_2-EOR projects. Such quantification can 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. The quantification of the storage associated with a CO_2-EOR project that occurs as part of a carbon capture and storage (CCS) project chain can 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, CO_2 quantities stored in association with CO_2-EOR are either treated as not emitted and excluded from calculations or subtracted as offsets.

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

1 Scope

This document provides requirements for demonstrating that the site in question is adequate to provide safe, long-term containment of CO_2, for demonstrating that the CO_2 flood is operated in a way to assure containment of the CO_2 in the EOR complex, and for quantifying associated storage.

This document applies to CO_2 that is injected in enhanced recovery operations for oil and other hydrocarbons, including natural gas, (CO_2-EOR) for which quantification of CO_2 that is safely stored long-term in association with the CO_2-EOR project is sought. Recognizing that some CO_2-EOR projects use non-anthropogenic CO_2 in combination with anthropogenic CO_2, the document also shows how allocation ratios can be utilized for optional calculations to quantify the portion of associated storage comprised of anthropogenic CO_2 (see Annex A).

This document does not apply to quantification of CO_2 injected into reservoirs where no hydrocarbon production is anticipated or occurring.

Storage of CO_2 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 CO_2 is conducted in a reservoir from which hydrocarbons were previously produced but will no longer be produced in paying or commercial quantities, such storage would be subject to the requirements of ISO 27914.

This document addresses:

a) safe, long-term containment of CO_2 within the EOR complex;

b) CO_2 leakage from the EOR complex through leakage pathways; and

c) on-site CO_2-EOR project loss of CO_2 from wells, equipment, or other facilities.

This document does not address the following:

d) lifecycle emissions, including but not limited to CO_2 emissions from capture or transportation of CO_2, on-site emissions from combustion or power generation, and CO_2 emissions resulting from the combustion of produced hydrocarbons;

e) storage of CO_2 above ground;

f) buffer and seasonal storage of CO_2 below ground (similar to natural gas storage);

g) any technique or product that does not involve injection of CO_2 into the subsurface; and

h) emissions of any greenhouse gases (GHGs) other than CO_2.

NOTE Some authorities can require other GHG components of the CO_2 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 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
anthropogenic carbon dioxide
anthropogenic CO_2
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)

3.2
associated storage
CO_2 stored in association with *CO_2-EOR* (3.4) that occurs as an inherent result of a hydrocarbon production operation

Note 1 to entry: The requirements of this document are intended to ensure that CO_2 stored in association with a CO_2-EOR operation is stored as effectively as CO_2 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 *CO_2-EOR* (3.4), to regulate storage of CO_2 in association with a *CO_2-EOR* (3.4) operation, or to regulate quantification of the storage of CO_2 in association with a *CO_2-EOR* (3.4) operation

3.4
CO_2 enhanced oil recovery
CO_2-EOR
process designed to produce liquid or gaseous hydrocarbons from a reservoir using the injection of CO_2

3.5
CO_2 enhanced oil recovery project
CO_2-EOR project

EOR complex (3.9), underground equipment, wells, surface or above seabed equipment, activities, and rights necessary to an enhanced oil recovery operation

3.6
CO_2 injection well
well used to inject CO_2 into a *project reservoir* (3.17)

3.7
CO_2 stream
stream consisting overwhelmingly of carbon dioxide

Note 1 to entry: The CO_2 stream typically includes impurities and can include substances added to the stream to either improve performance of hydrocarbon recovery operation, or facilitate CO_2 detection, or both.

3.8
containment assurance
demonstration that the features and geologic structure of the *CO_2-EOR project* (3.5) are adequate to provide *safe, long-term containment* (3.19) of CO_2, and that the CO_2 flood is operated in a way to assure containment of the CO_2 in the *EOR complex* (3.9)

3.9
EOR complex
project reservoir (3.17), *trap* (3.21), and such additional surrounding volume in the subsurface as defined by the *operator* (3.15) within which injected CO_2 will remain in *safe, long-term containment* (3.19)

3.10
injection-withdrawal ratio
ratio, during a defined period, of the volume of all fluids and gases injected into the *project reservoir* (3.17) to the volume of all fluids and gases produced from the project reservoir as determined using reservoir temperature and pressure conditions

3.11
leakage
unintended release of CO_2 out of the *EOR complex* (3.9)

3.12
leakage pathway
geological or artificial conduit for *leakage* (3.11) of CO_2 out of the *EOR complex* (3.9)

3.13
loss
leakage (3.11), intended and unintended releases of CO_2 from the *CO_2-EOR project* (3.5) and transfers of the *CO_2 stream* (3.7) out of the CO_2-EOR project

3.14
native CO_2
CO_2 present and indigenous within the *project reservoir* (3.17) prior to hydrocarbon production or any CO_2 injection

3.15
operator
entity responsible for the *CO_2-EOR project* (3.5)

3.16
plug and abandon
plugging and abandonment
process designed to 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.

3.17
project reservoir
geologic formation into which CO_2 is injected for production of hydrocarbons in paying or commercial quantities

3.18
quantification period
period of time during which *associated storage* (3.2) is being quantified

3.19
safe, long-term containment
associated storage (3.2) for the period necessary to be considered secure by the system under which the quantification is being implemented

3.20
termination
process ending with *operator* (3.14) demonstrating conformity

Note 1 to entry: The criteria for conformity are outlined in 10.5.

3.21
trap
feature or mechanism that alone or in combination provides *safe, long-term containment* (3.19)

4 Documentation

4.1 Purpose

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

4.2 Use of existing data

Documentation and demonstration requirements throughout this document can 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 and has already been provided to and is available from the authority, such information is not required to be developed again for purposes of this document.

4.3 Initial documentation

Initial documentation for the quantification period shall include:

a) a description of the EOR complex and engineered systems (see Clause 5);

b) the initial containment assurance (see 6.1.1);

c) the monitoring program (see 6.2);

d) the maximum allowable bottom hole injection pressure;

e) the total mass of previously injected CO_2 within the EOR complex at the start of quantification period (see 8.5 and Annex A);

f) the estimated associated storage mass within the EOR complex over the life of the project;

g) the quantification method to be used (see Clause 8 and Annex A); and

h) an initial termination plan (see 10.3).

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 mass, or volumetric units convertible to mass (see 8.2) during the period covered by the documentation;

b) the cumulative quantity of associated storage in specified units of mass, or volumetric units convertible to mass (see 8.2) since the beginning of the quantification period;

c) the formula and data used to quantify the mass of associated storage, including the mass of CO_2 delivered to the CO_2-EOR project and losses during the period covered by the documentation (see Clause 8 and Annex A);

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 A);

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;

g) termination plan; and

h) source of each CO_2 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 CO_2-EOR project.

5 EOR complex description, qualification and construction

5.1 General

An EOR operation management plan shall provide a description of the EOR complex and engineered system, establish that the EOR complex is adequate to provide safe, long-term containment of CO_2, and include site-specific and other information pertaining to:

a) geologic characterization of the EOR complex;

b) a description of the facilities within the CO_2-EOR project;

c) a description of all wells and other engineered features in the CO_2-EOR project;

d) the operations history of the project reservoir;

e) procedures for setting and managing engineering controls that support safe operation and containment assurance during injection and production;

f) periodic assessment of reservoir performance as compared with expected behaviour in accordance with 6.1.2;

g) assessment of containment by geologic features and engineering systems in accordance with 6.1.2;

h) assessment and management of monitoring technologies and procedures (see 6.2), including definition of detection thresholds that are sufficient to meet the requirements of 8.6;

i) method of quantification of CO_2 below the detection threshold in accordance with 8.6;

j) corrective measures for potential loss or unintended releases of CO_2;

k) data for associated storage quantification; and

l) termination plan for the CO_2-EOR project that specifies criteria for termination and outlines the termination qualification process sufficient to meet the requirements of Clause 10.

The EOR operation management plan shall be periodically updated.

5.2 Geological characterization of the EOR complex

The general geologic characterization of the EOR complex shall be based on site-specific subsurface and other data collected at the site (augmented where appropriate with data from analogous fields), including any features that can affect safe, long-term containment of CO_2 and evidence of the integrity of the reservoirs and traps. 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 rock properties;

e) lateral boundaries and any spill points relevant to containment;

f) hydraulic/petrophysical/geochemical/geomechanical properties;

g) associated storage capacity in the EOR complex; and

h) engineering data as needed for initial characterization (6.1.1) and during operations (6.1.2).

5.3 Description of the facilities within the CO_2-EOR project

The description of the facilities within the CO_2-EOR project shall provide an overview of the equipment, downstream of the CO_2 custody transfer meter used to handle CO_2 and production, including design specifications. This should typically include:

a) piping;

b) separators;

c) processing and dehydration equipment;

d) pumps;

e) compressors; and

f) any other equipment relevant to CO_2 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 provide evidence it has been constructed, remediated, or plugged and abandoned in such a manner as to provide safe, long-term containment of CO_2. Such wells include injection, production, monitoring, temporarily abandoned, shut-in, and plugged and 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 and abandoned);

e) surface or seabed location;

f) total and measured depth;

g) plugged and abandoned well information;

h) well construction, completion, and well integrity technical details;

i) significant equipment remaining in the well; and

j) well intervention details and history.

In some cases, remote sensing methods or field or aerial surveys to locate old wells can be necessary.

5.5 Operations history of the project reservoir

The operations history of the EOR complex shall include available:

a) production and injection data for the project reservoir;

b) temperature and pressure history, including current distribution;