TECHNICAL REPORT

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Carbon dioxide capture, transportation and geological storage — Injection operations, infrastructure and monitoring

Captage, transport et stockage géologique du dioxyde de carbone — Opérations d'injection, infrastructure et surveillance

PROOF/ÉPREUVE

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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).

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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 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.

Introduction

Carbon capture and storage (CCS) is a key technology to reduce CO_2 emissions to the atmosphere and contribute to the abatement of global warming. To have a significant impact it needs to be deployed globally. ISO 27914 on geological storage of carbon dioxide presents the elements necessary to define performance expectations for onshore and offshore geological storage of carbon dioxide with an aim to establish investor and other stakeholder confidence, regulatory support, and public credibility to encourage deployment of CCS around the globe. ISO 27916 on CO_2-EOR presents the elements for confirming and quantifying associated storage of CO_2 during the production of hydrocarbons, to encourage increased use of anthropogenic CO_2.

The application of these International Standards by project developers for planning, design, and operation will be assisted by information based on existing operational practices and infrastructural requirements for both onshore and offshore geological storage projects. This document supports the implementation of ISO 27914 and ISO 27916 by providing information from selected existing CCS projects that are operated under a variety of geological settings.

Carbon dioxide capture, transportation and geological storage — Injection operations, infrastructure and monitoring

1 Scope

This document covers:

— A description of the existing legal frameworks and associated laws and directives covering current and planned projects.

— Specific information about CO_2 injection facilities based on existing and planned projects that include storage of CO_2 in both saline aquifers and CO_2-EOR as relevant. This information includes aspects of materials used, surface infrastructure, well design considerations, concepts around well placement strategies, considerations for downhole monitoring tool deployment, well completions, and well and infrastructure maintenance and remediation practices.

— Descriptions of current practices regarding operating projects including monitoring, safety, and reporting activities associated with both surface and downhole components of the projects.

— Discussion on operational aspects of storing CO_2 in hydrocarbon reservoirs including depleting gas fields and reusing facilities.

— A description of monitoring requirements and methods including measurements to establish baselines.

— A description of existing and emerging tools, accuracy, and expectations for quantification.

— A description of regulatory requirements for operating and decommissioning CO_2-EOR with associated storage and CCS projects around the world.

— A description of decommissioning activities and timelines associated with end-of-project.

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
abandonment
process and procedures used to permanently end the operation of a well

Note 1 to entry: Well abandonment is designed to eliminate the physical hazard of the well (the hole in the ground), eliminate a pathway for migration of contamination, and prevent changes in the hydrogeologic system, such as the changes in hydraulic head and the mixing of formation fluids between hydraulically distinct strata.

[SOURCE: ISO 27914:2017, 3.1]

3.2
acceptable risk
risk borne by the project operator and others having regard to legal obligations and management policies

Note 1 to entry: A tolerable risk is a risk of significant level considered as temporarily or conditionally acceptable. It is tolerated in order to facilitate a gradual response (e.g. monitoring of risk treatment) until the risk has been reduced.

[SOURCE: ISO 27917:2017, 3.4.7]

3.3
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) where it would otherwise be emitted to the atmosphere (excluding the recycling of non-anthropogenic CO_2)

Note 1 to entry: The chemical symbol "CO_2" is synonymous with "carbon dioxide". Accordingly, the two ways of writing out "carbon dioxide" and "CO_2" are used interchangeably in this document.

[SOURCE: ISO 27916:2019, 3.1]

3.4
area of review

geographical area(s) of a *storage project* (3.76), or part of it, designated for assessment of the extent to which a storage project, or part of it, could affect life and human health, the environment, competitive development of other resources, or infrastructure

Note 1 to entry: The delineation of an area of review defines the outer perimeters on the land surface or seabed and water surface within which assessments will be conducted as may be required by regulatory authorities.

[SOURCE: ISO 27917:2017, 3.3.10]

3.5
associated storage
CO_2 stored in association with CO_2-EOR that occurs as an inherent result of a dedicated hydrocarbon production operation

Note 1 to entry: The requirements of ISO 27916 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.

[SOURCE: ISO 27916:2019, 3.2]

3.6
authority
governmental entity or entities with legal power to regulate or permit CO_2-EOR, to regulate storage of CO_2 in a CCS project or in association with a CO_2-EOR operation, or to regulate quantification of the storage of CO_2 in a CCS project or in association with a CO_2-EOR operation

[SOURCE: ISO 27916:2019, 3.3, modified to add "a CCS project or in" and delete "competent"]

3.7
baseline
reference basis for comparison against which project status or performance is monitored or measured

[SOURCE: ISO 27917:2017, 3.3.2]

3.8
carbon dioxide capture and storage
CCS
process consisting of the separation of CO_2 from industrial and energy-related sources (or capture directly from the atmosphere), transportation and injection into a geological formation, resulting in long-term isolation from the atmosphere

Note 1 to entry: CCS is often referred to as Carbon Capture and Storage. This terminology is not encouraged because it is inaccurate: the objective is the capture of carbon dioxide and not the capture of carbon. Tree plantation is another form of carbon capture that does not describe precisely the physical process of removing CO_2 from industrial emission sources.

Note 2 to entry: The term "sequestration" is also used alternatively to "storage". The term "storage" is preferred since “sequestration” is more generic and can also refer to biological processes (absorption of carbon by living organisms).

Note 3 to entry: Long-term means the minimum period necessary for geological storage of CO_2 to be considered an effective and environmentally safe climate change mitigation option.

Note 4 to entry: CCS should also ensure long-term isolation of CO_2 from oceans, lakes, potable water supplies and other natural resources.

[SOURCE: ISO 27917:2017, 3.1.1, modified to add " (or capture directly from the atmosphere)"]

3.9
carbon dioxide capture and storage project
CCS project
consists of one or more connected CO_2 capture systems, transportation systems, and geological storage systems

Note 1 to entry: Each system (capture, transportation, or storage) might be operated by independent operators.

[SOURCE: ISO 27914:2017, 3.56]

3.10
carbon dioxide enhanced oil recovery
CO_2-EOR
process designed to produce hydrocarbons CO_2 from a reservoir using the injection of CO_2

Note 1 to entry: The process of CO_2 enhanced oil recovery is explained in detail in ISO 27916:2019.

[SOURCE: ISO 27916:2019, 3.4]

3.11
carbon dioxide enhanced oil recovery project
CO_2-EOR project
EOR complex, 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

[SOURCE: ISO 27916:2019, 3.5]

3.12
carbon dioxide injection well
CO_2 injection well
well used to inject CO_2 into a project reservoir

[SOURCE: ISO 27916:2019, 3.6]

3.13
carbon dioxide plume
CO_2 plume
region within geologic strata where injected CO_2 is present in free phase

[SOURCE: ISO 27914:2017, 3.6, modified to add "injected"]

3.14
carbon dioxide stream
CO_2 stream
stream consisting overwhelmingly of carbon dioxide

Note 1 to entry: The CO_2 stream typically includes impurities and may include substances added to the stream to improve the injection process or performance of hydrocarbon recovery operation and/or to facilitate CO_2 detection.

[SOURCE: ISO 27916:2019, 3.7, modified to add "the injection process or"]

3.15
carbon dioxide stream composition
CO_2 stream composition
comprehensive description of the CO_2 stream contents that lists the fraction of each component

Note 1 to entry: The CO_2 stream composition is usually subject to regulatory discretion and approval. It is commonly documented on a volumetric basis but may also be documented as a mass fraction.

3.16
casing
pipe material placed inside a drilled hole to prevent the surrounding strata from collapsing into the hole

Note 1 to entry: There are many acceptable variations on casing design but typical types of casing in most injection wells are:

a) surface casing, i.e. the outermost casing that extends from the surface to the base of the lowermost *protected groundwater* (3.58);

b) intermediate casing is one or more strings of casing installed between the surface and long-string casing for various design reasons;

c) long-string casing, which extends from the surface to the bottom of the well.

[SOURCE: ISO 27914:2017, 3.8, modified to delete "to or through protected groundwater"]

3.17
closure period
period between the cessation of CO_2 injection and the demonstration of compliance with the criteria for site closure

[SOURCE: ISO 27917:2017, 3.1.7]

3.18
communication plan
document describing when, what and how to communicate with project stakeholders

Note 1 to entry: A communication plan may provide information relating to issues such as monitoring and verification, environmental impacts, risk treatment.

[SOURCE: ISO 27917:2017, 3.5.4]

3.19
containment
status of CO_2 being confined within the *storage complex* (3.74) or *EOR complex* (3.30) by an effective trap or combination of traps

[SOURCE: ISO 27916:2019, 3.8, modified to add "storage complex or"]

3.20
containment assurance
demonstrating that the features and geologic structure of the CO_2 storage project or CO_2-EOR project are adequate to provide safe, long-term containment 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

[SOURCE: ISO 27916:2019, 3.9, modified to add "the CO_2 storage project or"]

3.21
corrective action
action taken to correct material irregularities or to contain breaches in order to prevent or minimize damage to, or release of CO_2 from, a *storage complex* (3.74) or *EOR complex* (3.30)

Note 1 to entry: Corrective actions are implemented after an irregularity has occurred to help prevent or minimize damage.

[SOURCE: ISO 27914:2017, 3.12, modified to add "or EOR complex"]

3.22
decommission
take an engineered system or component out of service, render it inoperative, dismantle and decontaminate it

[SOURCE: ISO 27914:2017, 3.13]

3.23
demulsifiers or emulsion breakers
specialty chemicals used to break emulsions (that is, to separate the two phases), for example, water in oil

Note 1 to entry: They are commonly used in the processing of crude oil, which is typically produced along with significant quantities of saline water.

Note 2 to entry: The type of demulsifier selected depends on the type of emulsion, either oil-in-water or water-in-oil.

Note 3 to entry: Demulsifiers are used in the chemical analysis of oil and synthetic muds and to treat produced hydrocarbons.

3.24
dense phase CO_2
CO_2 in its liquid or supercritical phases

Note 1 to entry: Compression and transport of dense phase CO_2 are commonly achieved using compressors and pumps.

Note 2 to entry: Because liquid CO_2 is also considered dense phase, not all dense phase CO_2 is supercritical.

[SOURCE: ISO 27917:2017, 3.2.2, modified Note 1 to entry to add "compressors and" and delete "Compression and transport at lower densities are commonly achieved with turbo-compressors." Note 2 to entry - "Not all supercritical CO2 is in a dense phase and" has been modified to "Because liquid CO2 is also considered dense phase" - Note 3 to entry has been deleted.]

3.25
detection threshold
smallest value of a property of a substance that can be reliably detected by a specified method of measurement in a specified context

[SOURCE: ISO 27917:2017, 3.3.3, modified to change “limit” to “threshold”]

3.26
element of concern
valued element or objective for which *risk* (3.60) is evaluated and managed

[SOURCE: ISO 27914:2017, 3.14]

3.27
emergency response plan
systematic procedures that clearly detail what is to be done, how, when, and by whom before, during and after the time an emergency occurs

Note 1 to entry: In some jurisdictions, it can be called “emergency and remedial response plan”, “contingency plan”, etc.

Note 2 to entry: Emergency response plans often also cite preparations to be completed before an emergency occurs.

[SOURCE: ISO 27917:2017, 3.4.12]

3.28
emissions
CO_2 stream releases to the atmosphere over a specified period of time

3.29
environmental impact
change, which may be adverse or beneficial, to the environment, wholly or partially resulting from CCS project activities

[SOURCE: ISO 27917:2017, 3.4.13]

3.30
EOR complex
project reservoir (3.57) *trap* (3.84), and such additional surrounding volume in the subsurface as defined by the operator within which injected CO_2 will remain contained long-term

[SOURCE: ISO 27916:2019, 3.10, modified from "in safe, long-term containment" to "contained long-term"]

3.31
event
material occurrence or change in a particular set of circumstances

[SOURCE: ISO 27914:2017, 3.16]

3.32
geological storage
long-term *containment* (3.19) of CO_2 streams in subsurface geological formations

Note 1 to entry: Long-term means the minimum period necessary for CO_2 geological storage to be considered an effective and environmentally safe climate change mitigation option.

Note 2 to entry: The term “sequestration” has been used by a number of countries and organizations instead of “storage” (e.g. the international “Carbon Sequestration Leadership Forum”). The two terms are considered to be synonymous, and only “storage” is used in this document.

[SOURCE: ISO 27914:2017, 3.17, modified to delete Note 3 to entry]

3.33
greenhouse gas
GHG
gaseous constituent of the atmosphere, natural or anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds

Note 1 to entry: The most common greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), nitrogen trifluoride (NF_3) perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Emissions from these gases are reported under the UNFCCC and aggregated into carbon dioxide equivalents (CO_2 -e) using factors called global warming potentials (GWPs).

[SOURCE: ISO 14064-2:2019, 3.1.1]

3.34
impurities
non- CO_2 substances that are part of the CO_2 stream that may be derived from the source materials or the capture process, or added as a result of commingling for transportation, or released or formed as a result of sub-surface storage and/or leakage of CO_2

Note 1 to entry: As a subset of impurities, contaminants are non- CO_2 substances whose presence in the CO_2 stream is generally unwanted.

Note 2 to entry: As a subset of impurities, additives are substances added to the stream for the purposes of managing its physical or chemical behaviour (e.g. hydrate and corrosion inhibitors), for or from interaction with equipment (e.g. lubricants), and to track its distribution in the subsurface after injection (geochemical tracers).

[SOURCE: ISO 27917:2017, 3.2.12]

3.35
injectivity
rate and pressure at which fluids can be pumped into the storage unit without fracturing the storage unit

[SOURCE: ISO 27914:2017, 3.19]

3.36
Joule-Thomson effect
thermodynamic process that occurs when a fluid expands from high pressure to low pressure at constant enthalpy such as across a valve

Note 1 to entry: Under the right conditions, this can cause cooling of the fluid.

3.37
leak
leakage
unintended release of CO_2 out of a pre-defined containment

Note 1 to entry: Containments can include both surface containers (e.g. compressors, pipelines, trucks, ships, trains) and subsurface containments (e.g. storage complex).

[SOURCE: ISO 27917:2017, 3.2.14]

3.38
leakage pathway
geological or artificial conduit for leakage of CO_2 out of the storage complex or EOR complex

[SOURCE: ISO 27916:2019, 3.13, modified to add “storage complex or”]