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Carbon dioxide capture, transportation and geological storage — Cross cutting issues — Flow assurance

National foreword

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

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Introduction

Flow assurance can be defined as an engineering discipline that is required to understand the behaviour of fluids inside vessels, pipes or porous media at flowing and at static conditions. Flow assurance provides input to design activities, such as pipeline design or risk analysis. It emerged as an engineering discipline in the oil and gas industry in the 1990s. Flow assurance analysis is delivered in the oil and gas industry by methodical numerical simulation of each pipeline and injection/production well operating case, often using flow assurance software to facilitate the analysis.

In relation to carbon dioxide capture and storage (CCS), flow assurance seeks to maintain the continuous supply of the CO_2 stream from the capture plant, through the transportation system and into the geological reservoir via injection wells. Flow assurance is required to demonstrate that all foreseeable operating modes of all components of CCS projects, planned and unplanned, are predictable, reliable and safe. It achieves this through analysis of the CO_2 stream flowing as a fluid in the various components of a CCS project's systems, from capture through to geological storage (capture, transport, injection and storage).

Some of the key issues of interest addressed by flow assurance analysis include:

— the total network or project hydraulic capacity requirements necessary for determining pipeline, injection well and reservoir operating parameters;

— management of transient operations, such as those caused by varying injection rates, varying CO_2 stream supply and during slugging, surging and start-up and shut-down operations;

— thermal management under various operational scenarios to ensure that the variations of fluid temperature are within the operating constraints of the system;

— fluid phase behaviour and physical properties as a function of CO_2 stream composition;

— hydrate management and control, resulting from Joule-Thomson effects such as pressure drop across pressure reducing valves, orifice plates and flow metering devices; and

— planned and unplanned de-pressurization of systems, such as that resulting from a pipeline rupture, well blowout or controlled venting of pipeline and equipment during maintenance activities.

Most of the above issues can be addressed by dedicated flow assurance modelling software and tools, in which both thermodynamic and hydrodynamic behaviours of fluids in technical components such as pipelines or wells are modelled. The thermodynamic properties and transport properties of fluids are closely related to their chemical composition and their associated amount or concentration. Significant differences in thermodynamic behaviour of fluid of different compositions can be observed and these differences can lead to different hydrodynamic behaviour of the flow. Therefore, fluid thermodynamic properties are a critical input to the dynamic flow models.

Existing CCS system modelling of technical components has mainly been limited to single phase CO_2. Given significant storage capacity suitable for permanent CO_2 storage exists in depleted hydrocarbon reservoirs, which can be initially at pressures where CO_2 can be subject to two-phase flow conditions, the CO_2 stream in the pipeline and injection well can be subject to two-phase flow conditions, i.e. a combination of two CO_2 phases, gas and liquid. Two-phase flow can also occur during transient operations such as opening up, closing in or depressurization of pipelines or wells. Within underground reservoirs two-phase flow is generally expected involving the injected CO_2 stream as well as formation fluids that will have to be mobilized. Facilitating unhindered flow of the CO_2 streams in CCS projects requires the inclusion of reservoir fluids (natural gas, water or crude oil) and relevant processes in the storage reservoir in the flow assurance analysis. Two-phase flow cases, such as in the examples mentioned, are a more complex challenge for flow assurance modelling compared to flow assurance in oil and gas transportation and injection/production well infrastructure.

Existing commercial software tools for flow assurance analysis are utilized for modelling the planned and unplanned operation modes for the various components of the CCS system, including the reservoir management component. These tools predict fluid behaviour and properties in the operating system. As

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input, this modelling requires input data such as the CO_2 stream composition, the physical geometry of relevant infrastructure such as pipelines, injection wells and the receiving reservoir, and the operating conditions which include:

— steady-state and transient processes;

— single-phase and multiphase flow;

— pressure, temperature, phase fraction, velocity, etc., and their distribution in space and time; and

— distribution of fluid phase compositions in both time and space.

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TECHNICAL REPORT **ISO/TR 27925:2023**

Carbon dioxide capture, transportation and geological storage — Cross cutting issues — Flow assurance

1 Scope

This document describes and explains the physical and chemical phenomena, and the technical issues associated with flow assurance in the various components of a carbon dioxide capture and storage (CCS) system and provides information on how to achieve and manage flow assurance. The gaps in technical knowledge, limitations of the tools available and preventative and corrective measures that can be taken are also described.

This document addresses flow assurance of CO_2 streams in a CCS project, from CO_2 capture via transport by pipeline and injection well through to geological storage. It does not specifically address upstream issues associated with CO_2 sources and capture, although flow assurance will inform CO_2 capture design and operation, for example, on constraints on the presence of impurities in CO_2 streams, as there are too many different capture technologies to be treated in detail in this document.

Vessel transport and buffer storage that are considered in integrated CCS projects under development, are not covered in this document. Flow of material in the supply chain of a CO_2 source, even if delivered by a pipeline (e.g. blue hydrogen generation), and flow of gas streams within facilities generating and feeding these into a capture facility can impact flow assurance in CCS projects and networks. These are out of the scope of this document as well.

This document also examines the impact of impurities on the phase behaviour and physical properties of the CO_2 stream which in turn can ultimately affect the continuous supply of the CO_2 stream from the capture plant, through the transportation system and into the geological reservoir via injection wells.

Flow of fluids in oil reservoirs for the purpose of enhanced oil recovery is not within the scope of this document.

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 27917, *Carbon dioxide capture, transportation and geological storage — Vocabulary — Cross cutting terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 27917 and the following 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
carbon dioxide capture and storage network
CCS network
connections of multiple CO_2 sources and storage sites

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