
**Carbon dioxide capture — Carbon
dioxide capture systems, technologies
and processes**

*Capture du dioxyde de carbone — Systèmes de capture du dioxyde de
carbone, technologies et processus*

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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).

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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 capture and storage (CCS) is a technology to mitigate climate change. Many demonstration projects have been conducted worldwide, and CO₂ capture is an important process in CCS and is cost and energy intensive.

CO₂ capture in power industry could be classified through pre, post and oxy combustion. Technologies such as chemical and physical absorption, adsorption, and membrane separation are currently under development and are in various stages of maturity from commercial (110 MW)^[1] large-scale demonstrations to laboratory-scale evaluation, and should be delivered at low cost and low energy consumption.

The objectives of this Technical Report are to specify and review existing capture technologies, equipment and processes and comprehend CO₂ capture systems so that this Technical Report can provide stakeholders with the guidance and knowledge necessary to develop a series of standards for CO₂ capture and build consensus on this standardization work in advance.

This Technical Report describes CO₂ capture systems based on published papers and other documents and then summarizes the different issues deemed most important by ISO/TC 265. This includes the following:

- boundary for CO₂ capture systems;
- technologies, equipment and processes;
- CO₂ streams, gas streams and emissions, processes and waste products;
- evaluation procedures for capture performance;
- safety issues on each capture system;
- reliability issues on each capture system;
- management system.

Carbon dioxide capture — Carbon dioxide capture systems, technologies and processes

1 Scope

This Technical Report describes the principles and information necessary to clarify the CO₂ capture system and provide stakeholders with the guidance and knowledge necessary for the development of a series of standards for CO₂ capture. This Technical Report also covers technologies, equipment and processes specific to CO₂ capture from the viewpoints of the international standardization for the implementation of CCS.

The purpose of this Technical Report is to provide guidance for the development of an ISO document related to CO₂ capture as part of a CCS chain. This Technical Report covers CO₂ capture systems applicable to CO₂ emission sources and their respective boundaries, as well as capture technologies, equipment and processes. In addition, it can be used for the development of International Standards under TC 265.

The following issues are to be excluded from this Technical Report:

- industrial use of CO₂;
- compression of CO₂ (not described in detail);
- terminologies not used in this Technical Report.

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.

3.1

absorbent

substance able to absorb liquid or gas

3.2

affinity

tendency of substances to react with each other

Note 1 to entry: Also defined as the decrease in Gibbs energy on going from the reactants to the products of a chemical reaction.

[SOURCE: IUPAC Compendium of Chemical Terminology]

3.3

air separation unit

unit separating oxygen, nitrogen and other inert gases from air which delivers the required oxygen for gasification or combustion applications in the context of CCS

3.4

alkanolamine

chemical compound that carries hydroxy (–OH) and amino (–NH₂, –NHR, and –NR₂) functional groups on an alkane backbone

3.5

amine

chemical compound consisting nitrogen atoms bound to hydrogen and/or carbon atoms having the general formula R_3N

3.6

amino acid

any of a class of organic compounds in which a carbon atom has bonds to an amino group, a carboxyl group, a hydrogen atom and an organic side group

3.7

antioxidant

substance that inhibits oxidation or reactions promoted by oxygen, peroxides, or free radicals

3.8

Brayton cycle

thermodynamic cycle that describes the workings of a constant pressure heat engine such as gas turbine engine

3.9

capital cost

sum of direct equipment costs to capture CO_2 which is also known as investment cost or first cost

[SOURCE: IPCC Special Report on Carbon Dioxide Capture and Storage]

3.10

capital requirement

sum of direct equipment costs and indirect costs to capture CO_2

3.11

catalyst

substance that increases the rate of reaction without itself being consumed in the reaction

3.12

CCS energy consumption

total energy used for the development and operation of a CCS project

3.13

chemical absorption

process in which CO_2 is absorbed by chemical reaction

3.14

circulating dry scrubber

type of semi-dry FGD using hydrated lime as chemical reagent which is based on a circulating bed reactor set up to desulfurize the flue gas

3.15

clinker

mass of incombustible matter fused together

3.16

CO_2 capture

separation of CO_2 in such a manner as to produce a concentrated stream of CO_2 that can readily be transported for storage

3.17

CO_2 capture rate

ratio of the captured CO_2 mass flow rate at CO_2 capture system to the inlet CO_2 mass flow rate to CO_2 capture system

3.18**CO₂ processing unit**

group of processes used in the purification of the CO₂ rich gas to a desired CO₂ specification

Note 1 to entry: Also known as compression and purification unit (CPU), CO₂ purification unit (CPU), cryogenic purification unit, gas processing unit (GPU).

3.19**critical pressure**

vapour pressure at the critical temperature

3.20**critical temperature**

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

3.21**decarboxylation reaction**

chemical breakdown of compounds containing carbonates

3.22**degradation**

act or process of chemical which makes its functional effectiveness or chemical purity decrease towards the failure to meet the performance of the plant through physical and chemical breakdown or reaction with other substances

3.23**dehydration**

process of removing water from a stream or material

3.24**demineralized water****demin water**

water of which the mineral matter or salts have been removed

Note 1 to entry: Sometimes designated as demin water.

3.25**demister**

device, often fitted with vapour-liquid separator vessels, to enhance the removal of liquid droplets or mist entrained in a vapour stream

3.26**desorption**

release of CO₂ from absorbent or adsorbent

3.27**direct quench**

process where hot gas is cooled by injection of water, cool gas or water immersion

3.28**effluent**

flow of waste material discharged into the environment

3.29**equilibrium**

state of balance between opposing forces or actions that is either static or dynamic

3.30**flash gas**

gas separated from a liquid by pressure reduction

3.31

flue gas

gases produced by combustion of a fuel that are normally emitted to the atmosphere

3.32

flue gas condenser

process of removing water from the flue gas by cooling

3.33

flue gas desulfurization

equipment normally used in the removal of SO_x in the flue gas by using chemical reagents

3.34

flue gas processing unit

unit of processes used to remove different criteria pollutants (SO_x, NO_x, PM, etc.) from flue gas of boilers or fired heaters

Note 1 to entry: Also known as environmental island, air quality control system (AQCS), gas quality control system (GQCS).

3.35

forced oxidation wet flue gas desulfurization

type of wet FGD using limestone as chemical reagent

3.36

gas turbine

machine in which a fuel is burned with compressed air or oxygen and mechanical work is recovered by the expansion of the hot products

3.37

gasification

reaction that coal, biomass, petroleum coke, or natural gas is converted into a syngas composed mainly of carbon monoxide (CO) and hydrogen (H₂)

3.38

gasifier

reactor in which coal, biomass, petroleum coke, or natural gas is converted into a syngas composed mainly of carbon monoxide (CO) and hydrogen (H₂)

3.39

membrane

permeable solid material that selectively separates the components of a fluid mixture

3.40

mist

stream of liquid in the form of very small drops

3.41

nitrosamine

any of various organic compounds which are characterized by the grouping NNO

3.42

nitramine

any of various organic compounds which are characterized by the grouping NNO₂

3.43

off-gas

gas that is produced as a by-product of a process

3.44**oxy-combustion****oxyfuel combustion**

process involving combustion of a fuel with pure oxygen or a mixture of oxygen and re-circulated flue gas

3.45**oxy-CFB boiler**

CFB boiler using technology based on oxyfuel combustion with recycled flue gas

3.46**oxy-PC boiler**

PC boiler using technology based on oxyfuel combustion with recycled flue gas

3.47**particulate emission**

solid and liquid particles that are by-products of combustion entrained in flue gas exiting the stack of a fossil fueled boiler

3.48**permeability rate**

quantity of flow of gas (or liquid) through a membrane per unit of time and area

3.49**permeance**

measure of gas actually flowing through a membrane per unit of pressure differential

Note 1 to entry: In general, it is expressed in gas permeance units (GPU).

Note 2 to entry: $1 \text{ GPU} = 10^{-6} \text{ cm}^3(\text{STP})/\text{scm}^2(\text{cmHg})$.

3.50**physical absorption**

process where a solvent absorbs a gas physically with pressure and without chemical reaction

3.51**post-combustion capture**

capture of carbon dioxide from flue gas stream produced by fuel air combustion

3.52**power output**

electricity which is produced or supplied from a power plant

3.53**pre-combustion capture**

capture of carbon dioxide following the processing of the fuel before combustion

3.54**pressure swing adsorption**

method of separating gases using the physical adsorption of one gas at high pressure and releasing it at low pressure

3.55**pulverized coal**

finely ground coal

3.56**pulverized coal boiler**

utility boilers using pulverized fuel or coal as fuel

3.57**pulverized fuel**

finely ground solid fuels such as coal or biomass

3.58

quench

to cool hot gas suddenly

3.59

radiant quench design

design of the process where hot gas is cooled by radiant cooler

3.60

reaction rate

speed of a chemical reaction

3.61

reclaimer

process or unit that regenerates deteriorated absorbent

3.62

recycled flue gas

flue gas recycled to moderate the combustion temperature

3.63

regenerator

see *stripper* (3.79)

3.64

reliability

ability of an item to perform a required function, under given environmental and operational conditions and for a stated period of time

[SOURCE: ISO 8402]

3.65

retrofit

modification of the existing equipment to upgrade and incorporate changes after installation

[SOURCE: IPCC Special Report on Carbon Dioxide Capture and Storage]

Note 1 to entry: See IEA Technology Roadmap: Carbon Capture and Storage.

3.66

saturation

point of a solution condition at which a solution of a substance can dissolve no more of that substance and additional amounts of it will appear as a separate phase at the stable condition

3.67

scrubber

gas liquid contactor device, normally used to remove gaseous and solid emissions from flue gas streams

3.68

selectivity

degree that one substance is absorbed in comparison to others

[SOURCE: US Department of Energy/National Energy Technology Laboratory, Advanced Carbon Dioxide Capture R&D Program: Technology Update, February 2013]

3.69

shift conversion

see *shift reaction* (3.71)

3.70

shift converter

reactor in which the water-gas shift reaction, $\text{CO} + \text{H}_2\text{O} = \text{CO}_2 + \text{H}_2$, takes place

3.71**shift reaction**

chemical formation of carbon dioxide and hydrogen from carbon monoxide and water

3.72**sludge**

semi-liquid (or semi-solid) residue or solids separated from suspension in a liquid in industrial processes and treatment of sewage and waste water

3.73**slurry**

thick, flowable mixture of solids and a liquid, usually water

3.74**solute**

dissolved substance in a solution

3.75**solvent**

liquid substance capable of dissolving CO₂

3.76**sorbent**

substance that absorbs CO₂ or to which CO₂ is adsorbed

3.77**sour shift (reaction)**

shift reaction without removing H₂S or COS

3.78**steam reforming**

catalytic process in which a hydrocarbon is reacted with steam to produce a mixture of H₂, CO and CO₂

3.79**stripper**

gas-liquid contacting device, in which a component is transferred from liquid phase to the gas phase

Note 1 to entry: Can also be referred to as “regenerator” or “desorber”.

3.80**sweet shift (reaction)**

shift reaction after removing H₂S or COS

3.81**syngas**

synthetic gas produced through gasification process

3.82**treated gas**

gas finally discharged from the CO₂ capture process in the emission side after being processed to have a lower CO₂ concentration than the feed gas

3.83**waste water**

water for which there is no use in the process anymore

3.84**water gas shift**

see *shift reaction* ([3.71](#))