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Carbon dioxide capture —

Part 1: Performance evaluation methods for post-combustion CO_2 capture integrated with a power plant

Captage du dioxyde de carbone —

Partie 1: Méthodes d'évaluation des performances pour le captage du CO_2 post-combustion intégré à une centrale thermique

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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. 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*.

A list of all the parts in the ISO 27919 series can be found on the ISO website.

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

It is very important to reduce atmospheric carbon dioxide (CO_2) emissions in order to meet climate change mitigation targets. Inclusion of carbon dioxide capture and storage (CCS) among the variety of available emission reduction approaches enhances the probability of meeting these targets at the lowest cost to the global economy. CCS captures CO_2 from industrial and energy-related sources and stores it underground in geological formations. It can capture emissions from carbonaceous fuel-based combustion processes, including power generation, and is the only technology capable of dealing directly with emissions from several industrial sectors, such as cement manufacture and fertilizer production.

This document is the first in a series of standards for CO_2 capture. It is limited to evaluation of key performance indicators (KPIs) for post-combustion CO_2 capture (PCC) from a power plant using a liquid-based chemical absorption process. New or revised standards focused on other capture technologies and approaches will be developed at a later date.

PCC is applicable to all combustion-based thermal power plants. A simplified block diagram illustrating the PCC is shown in Figure 1.

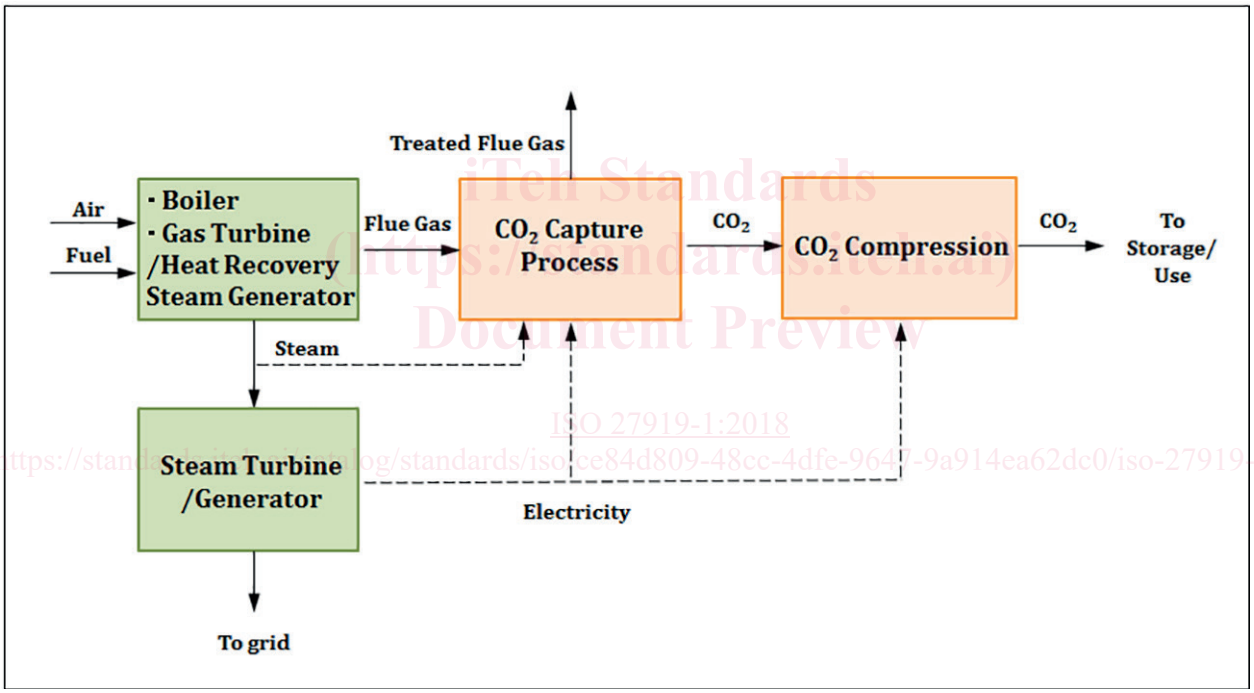

Figure 1 — Simplified block diagram for PCC

In a typical power generation facility, carbonaceous fuel (e.g. coal, oil, gas, biomass) is combusted with air in a boiler to raise steam that drives a turbine/generator to produce power. In a gas turbine combined cycle system, the combustion occurs in the gas turbine to drive power generation, and steam generated through a heat recovery steam generator (HRSG) contributes to additional power generation. Flue gas from the boiler or gas turbine consists mostly of N_2, CO_2, H_2O and O_2 with smaller amounts of other compounds depending on the fuel used. The CO_2 capture process is located downstream of conventional pollutant controls. Chemical absorption-based PCC usually requires the extraction of steam from the power plant's steam cycle or, depending on the absorption liquid/process employed, the use of lower grade heat sources for absorption liquid regeneration.

The intended readership for this document includes power plant owners and operators, project developers, technology developers and vendors, regulators, and other stakeholders. The document will provide several benefits, as outlined in the clauses below. In brief, it provides a common basis to estimate, measure, evaluate and report on the performance of a PCC plant integrated with a power

plant. It can help various stakeholders to identify potential efficiency improvements among different plant components. It can help to guide the selection of measurement methodologies, and serve as a resource in development of regulations. Finally, it provides the basis for future standards development.

Carbon dioxide capture —

Part 1:
Performance evaluation methods for post-combustion CO_2 capture integrated with a power plant

1 Scope

This document specifies methods for measuring, evaluating and reporting the performance of post-combustion CO_2 capture (PCC) integrated with a power plant, and which separates CO_2 from the power plant flue gas in preparation for subsequent transportation and geological storage. In particular, it provides a common methodology to calculate specific key performance indicators for the PCC plant, requiring the definition of the boundaries of a typical system and the measurements needed to determine the KPIs.

This document covers thermal power plants burning carbonaceous fuels, such as coal, oil, natural gas and biomass-derived fuels, which are producing CO_2 from boilers or gas turbines, and are integrated with CO_2 capture.

The PCC technologies covered by this document are those based on chemical absorption using reactive liquids, such as aqueous amine solutions, potassium carbonate solutions, and aqueous ammonia. Other PCC concepts based on different principles (e.g. adsorption, membranes, cryogenic) are not covered. The PCC plant can be installed for treatment of the full volume of flue gas from the power plant or a fraction of the total (i.e. a slip stream). Captured CO_2 is processed in a compression or liquefaction step as determined by the conditions for transportation and storage.

The KPIs considered in this document are the following:

a) Specific thermal energy consumption (STEC);

b) Specific electrical energy consumption (SEC);

c) Specific equivalent electrical energy consumption (SEEC);

d) Specific reduction in CO_2 emissions (SRCE);

e) Specific absorbent consumption (SAC) and specific chemical consumption (SCC).

The calculations are based on measurements at the boundaries of the considered system, particularly of energy and utilities consumption. The integrated system includes the definition of interfaces between the PCC plant and the power plant.

This document includes the following items:

— The system boundary which defines the boundaries of the PCC plant and identifies which streams of energy and mass are crossing these boundaries to help power plant operators identify the key streams that are applicable for their particular case.

— Basic PCC plant performance which defines the parameters that describe the basic performance of the PCC plant.

— Definition of utilities and consumption calculation which lists the utility measurements required and provides guidance on how to convert utility measurements into the values required for the KPIs.

— Guiding principles - Basis for PCC plant performance assessment which describes all guidelines to prepare, set-up and conduct the tests.

— Instruments and measurement methods which lists the standards available for the relevant measurements and considerations to take into account when applying measurement methods to PCC plants.

— Evaluation of key performance indicators which specifies the set of KPIs to be determined and their calculation methods to provide a common way of reporting them.

This document does not provide guidelines for benchmarking, comparing or assessing KPIs of different technologies or different PCC projects.

NOTE For the purposes of this document, thermal energy and electric energy are expressed by the unit of "J" (Joule) and "Wh" (Watt hour) respectively unless otherwise noted, with a prefix of International System of Units (SI) if necessary. (1 J = 1 W·s, 1 Wh = 1 W·h = 3 600 J).

2 Normative references

There are no normative references in this document.

3 Terms, definitions and symbols

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 http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
absorbent
substance able to absorb liquid or gas

[SOURCE: ISO/TR 27912:2016, definition 3.1]

3.1.2
measurement accuracy
accuracy of measurement
accuracy
closeness of agreement between a measured quantity value and a true quantity value of a measurand

[SOURCE: ISO/IEC Guide 99:2007, definition 2.13]

3.1.3
auxiliary unit
unit providing heat, power and/or other utilities for the PCC plant

3.1.4
boiler feed water
water consisting of the condensate and the make-up water that is sent to the boiler

3.1.5
carbon dioxide capture and storage
CCS
process consisting of the separation of CO_2 from industrial and energy-related sources, 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 CO_2 geological storage to be considered an effective and environmentally safe climate-change-mitigation-option.

Note 4 to entry: The term carbon dioxide capture, utilization (or use) and storage (CCUS) includes the concept that isolation from the atmosphere could be associated with a beneficial outcome. CCUS is embodied within the definition of CCS to the extent that long term isolation of the CO_2 occurs through storage within geological formations. CCU is Carbon Capture and utilization (or use) without storage within geological formations.

Note 5 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, definition 3.1.1]

3.1.6
carbonaceous fuels
any solid, liquid or gaseous fuels containing carbon atoms

3.1.7
capture plant
process and associated equipment that produces a CO_2 stream

3.1.8
chemical absorption
process in which CO_2 is absorbed by chemical reaction

3.1.9
CO_2 capture efficiency
capture efficiency
CO_2 removal efficiency of the capture plant calculated as the amount of CO_2 captured divided by the total amount of CO_2 contained in the flue gas at the inlet of the capture plant

Note 1 to entry: The CO_2 capture efficiency is expressed as a percentage.

3.1.10
CO_2 captured
absolute amount of pure CO_2 captured by the capture plant

3.1.11
CO_2 stream
stream consisting overwhelmingly of carbon dioxide

[SOURCE: ISO 27917:2017, definition 3.1.1, modified — The Note was deleted.]

3.1.12
condensate
water produced by condensation of steam, e.g. a boiler of PCC return to the steam cycle and/or auxiliary boiler

3.1.13
deep flue gas desulfurization
deep FGD
SO_2 removal unit placed downstream of the main flue gas desulfurization process intended to lower the SO_2 content to the level required by the CO_2 capture plant

Note 1 to entry: Also called a "polishing" FGD.

Note 2 to entry: In the case where no FGD is required by local regulations, and FGD is installed for the purposes of CCS, the new unit will be considered as deep FGD.

3.1.14
dehydrator
moisture removal system and/or equipment

3.1.15
demineralized water
water from which the mineral matter or salts have been removed

[SOURCE: ISO/TR 27912:2016, definition 3.24, modified — The second term "demin water" was removed and in the definition the word "of" was replaced by "from".]

3.1.16
DeNO*x*
process or equipment used to remove NO*x* from the flue gas

3.1.17
effluent
liquid discharged to the environment

3.1.18
fuel specific emission
amount of component generated from complete combustion per unit of heat energy released

3.1.19
host power plant
power plant from which flue gas is sent to the PCC plant

3.1.20
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

[SOURCE: ISO 27917:2017, definition 3.2.12, modified — Notes 1 and 2 were deleted.]

3.1.21
interface
mechanical, thermal, electrical, or operational common boundary between two elements of a system

[SOURCE: ISO 10795:2011, definition 1.120, modified — The abbreviation "I/F" was deleted.]

3.1.22
key performance indicator
measure of performance relevant to the PCC plant integrated with a power plant

3.1.23
measurement uncertainty
uncertainty of measurement
uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

Note 1 to entry: Measurement uncertainty includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of physical properties, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for; associated measurement uncertainty components are incorporated instead.

Note 2 to entry: The parameter may be, for example, a standard deviation called standard measurement uncertainty (or a specified multiple of it), or the half-width of an interval, having a stated coverage probability.

Note 3 to entry: Measurement uncertainty comprises, in general, many components. Some of these may be evaluated by Type A evaluation of measurement uncertainty from the statistical distribution of the quantity values from a series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by Type B evaluation of measurement uncertainty, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

Note 4 to entry: In general, for a given set of information, it is understood that the measurement uncertainty is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

Note 5 to entry: "Type A evaluation of measurement uncertainty" is defined as an evaluation of a component of measurement uncertainty by a statistical analysis of measured quantity values obtained under defined measurement conditions. "Type B evaluation of measurement uncertainty" is defined as an evaluation of a component of measurement uncertainty determined by means other than a Type A evaluation of measurement uncertainty".

[SOURCE: ISO/IEC Guide 99:2007, definition 2.26, modified — "measurement standards" in Note 1 was changed to "physical properties" and a Note 5 was added.]

3.1.24
PM
particulate matter including $PM_{2,5}$, PM_{10}, and/or total suspended particulate matter

[SOURCE: ISO 25597:2013, definition 3.21]

3.1.25
particulate removal
action to remove particulate matter from the flue gas stream

3.1.26
PCC plant
process and associated equipment that produces a CO_2 stream from combustion gases

3.1.27
permanent plant instrument
instrument installed in the power plant and capture plant for control and monitoring

3.1.28
post-combustion CO_2 capture
capture of carbon dioxide from flue gas stream produced by carbonaceous fuel combustion

[SOURCE: ISO/TR 27912:2016, definition 3.51, modified — In the term, "CO_2" was added and "fuel air combustion" was modified to "carbonaceous fuel combustion" in the definition.]

3.1.29
product CO_2 stream
stream produced by a CO_2 capture and compression/liquefaction process

3.1.30
reclaiming system
system used to recover CO_2 absorbents for use in the PCC plant to remove the heat stable salts produced by the reaction of organic and inorganic acids with the amine(s) in the absorbents

3.1.31
redundant instrument
duplicate instrument necessary to plant functioning in case of failure of similar instruments for measurement of the same parameters

3.1.32
reference power plant
power plant that is considered to be representative of power generation without CO_2 capture

Note 1 to entry: The power plant is either real or hypothetical.

3.1.33
regeneration
process to regenerate an activity of absorbent after use to its operationally effective state

3.1.34
rejected heat
heat dissipated to the environment by cooling equipment

3.1.35
specific absorbent consumption
amount of CO_2 absorbent consumed to capture and compress/liquefy a tonne of CO_2

3.1.36
specific reduction in CO_2 emissions
calculated net decrease of the CO_2 emissions per unit output of a reference power plant by implementing the PCC process to the host power plant

Note 1 to entry: This measure of emission reduction is normalised with respect to the output of the power plant.

[SOURCE: ISO 27917:2017, definition 3.2.8, modified — "baseline scenario and the CCS project output" has been replaced by "per unit output of a reference power plant by implementing the PCC process to the host power plant".]

3.1.37
specific chemical consumption
amount of chemical consumed to capture and compress/liquefy a tonne of CO_2

3.1.38
specific equivalent electrical energy consumption
overall electrical energy consumption attributed to capture and compression/liquefaction of a tonne of CO_2

3.1.39
specific electrical energy consumption
electrical energy consumed to capture and compress/liquefy a tonne of CO_2

3.1.40
specific thermal energy consumption
thermal energy consumed to capture and compress/liquefy a tonne of CO_2