DRAFT INTERNATIONAL STANDARD

ISO/DIS 27919-2

ISO/TC **265**

Secretariat: **SCC**

Voting begins on:
2020-08-27

Voting terminates on:
2020-11-19

Carbon dioxide capture —

Part 2:
Evaluation procedure to assure and maintain stable performance of post-combustion CO2 capture plant integrated with a power plant

ICS: 13.020.40

This document is circulated as received from the committee secretariat.

Reference number
ISO/DIS 27919-2:2020(E)

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Published in Switzerland

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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*.

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

Introduction

It is very important to reduce atmospheric carbon dioxide (CO_2) emission 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. CO_2 capture from gases produced by combustion of carbonaceous fuels is the only technology capable of dealing directly with emissions from power plants and other industrial sectors, such as cement manufacture and fertilizer production.

This document is the second in a series of standards for post-combustion CO_2 capture (PCC) from a power plant using a liquid-based chemical absorption process. Building on the first standard on evaluation of key performance parameters (KPIs), this document provides an evaluation procedure to assure and maintain reliable performance of a PCC plant integrated with a power plant. New or revised standards focusing on other CO_2 capture technologies and approaches will be developed later.

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

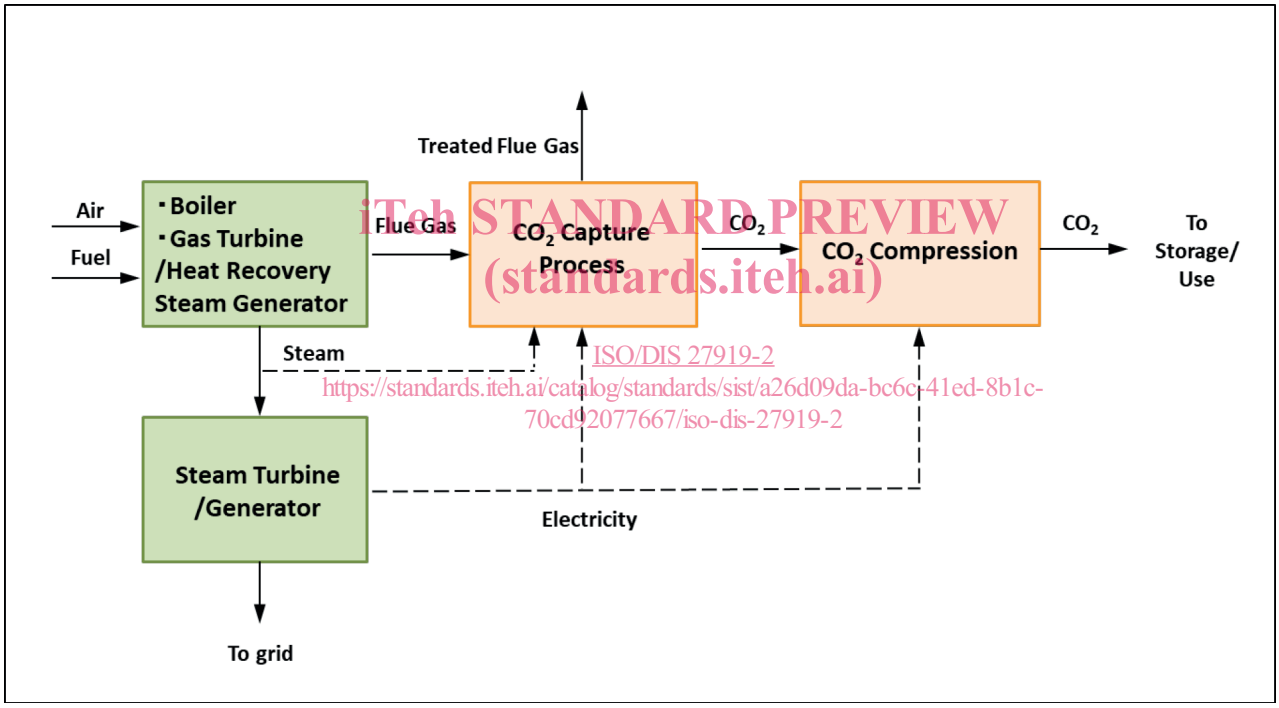

Figure 1 — Simplified block diagram for PCC

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 economic and environmental value of a PCC plant is not only determined by its technical performance, but also by its ability to achieve and maintain stable operation as required by its owners/stakeholders. The owner of the flue gas source has an interest in sustained CO_2-emission reductions; the owner of the CO_2-product has an interest being able to supply CO_2 at the desired rate regardless of external conditions; The CO_2 receiver has an interest in CO_2-product availability for its own operations.

The provision of a framework for quantifying and assessing the stability of a PCC plant operation according to this standard will clarify PCC plant availability at the design and operational stage. It will also underpin the quantification of plant reliability and maintainability.

Carbon dioxide capture —

Part 2: Evaluation procedure to assure and maintain stable performance of post-combustion CO2 capture plant integrated with a power plant

1 Scope

This document provides definitions, guidelines and supporting information for evaluating and reporting (in respect of the basic design items ongoing and the operational results of a reference plant or unit as feedback to ensure) the (designed) performance of a PCC plant integrated with the host power plant which separates CO_2 from the power plant flue gas in preparation for subsequent transportation and geological storage. The physical system being addressed is a single power plant, optionally with an auxiliary unit to provide thermal energy required for the PCC plant, and a single PCC plant as described in ISO 27919-1.

The formulas and methods presented in this document describe issues that are addressed during the design and construction phases (to assure reliable performance) and to practices that can document reliability and availability during routine operation. These practices would also guide ongoing maintenance programs.

This document does not provide guidelines for benchmark, comparison or assessment studies for PCC plant operations using different capture technologies (i.e. absorbents), nor does it specify appropriate operating conditions such as temperature etc.

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 27919-1:2018, *Carbon dioxide capture — Part 1: Performance evaluation methods for post-combustion CO2 capture integrated with a power plant*

3 Terms and definitions

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
administrative delay
delay to maintenance incurred for administrative reasons

[SOURCE: IEC 60050-192 (192-7-12), modified]

3.1.2
availability
ability of a PCC plant integrated with the power plant to be in a state to perform as required under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

3.1.3
corrective maintenance
maintenance carried out after fault detection to effect restoration

Note 1 to entry: Corrective maintenance of critical items disrupts the plant availability.

3.1.4
critical item
item that needs to be available and operating in order for the PCC plant to be available

3.1.5
downtime
time interval for which the item is in a state of being unable to perform as required due to internal faults, or preventive maintenance

[SOURCE: IEC 60050-192 (192-02-21), modified]

3.1.6
emergency operation
type of sudden shut-down operation to protect hardware from damage. If the cause of the emergency trip shut-down is solved without corrective maintenance repair, such as adjustment of operating conditions or control parameter, it is linked by sudden restoration or resumption

3.1.7
external influence
critical items occurring outside of the PCC plant evaluation boundary

3.1.8
failure mechanism
process that leads to failure

Note 1 to entry: The process may be physical, chemical, logical, or a combination thereof.

[SOURCE: IEC 60050-192 (192-03-12), modified]

3.1.9
item
subject being considered

Note 1 to entry: An item may be an individual part, component, device, functional unit, equipment, subsystem, or system.

Note 2 to entry: An item may consist of hardware, software, people or any combination thereof.

Note 3 to entry: An item is often comprised of elements that may each be individually considered.

[SOURCE: IEC 60050-192 (192-01-01), modified]

3.1.10
logistic delay
delay, excluding administrative delay, incurred for the provision of resources needed for a maintenance action to proceed or continue

[SOURCE: ISO 20815:2018, definition 3.1.24]

3.1.11
maintainability
ability to be retained in, or restored to, a state in which the required function can be performed under given conditions

3.1.12
maintenance
combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

Note 1 to entry: Management is assumed to include supervision activities.

[SOURCE: IEC 60050-192:2015, 192-06-01]

3.1.13
mean downtime
MDT
expectation of the downtime

[SOURCE: IEC 60050-192 (192-08-10)]

3.1.14
mean time between failures
MTBF
average time between failures which initiate a forced outage, i.e. the ratio of attempted operating hours to the number of forced outages

3.1.15
mission time
duration of the mission

[SOURCE: ISO 10438-1:2007(en), 3.1.19]

3.1.16
net dependable capacity
NDC
gross dependable capacity minus the unit capacity using for that unit's station services or auxiliaries

[SOURCE: ISO 3977-9]

3.1.17
nominal product CO_2 capacity
highest continuous flow rate of delivering captured CO_2 under typical representative conditions defined by the plant operator

3.1.18
normal operation
operation where the product CO_2 is exported to the transporting system maintaining the required performance based on ISO 27919-1

3.1.19
on-stream factor
ratio of the summation of all on-stream time to the reference period, with both expressed as hours

3.1.20
outage
time interval for which the item is in a state of being unable to perform as required, for any reason

[SOURCE: IEC 60050-192 (192-02-19), modified]

3.1.21
PCC plant
process and associated equipment that produces a CO_2 stream from combustion gases

[SOURCE: ISO 27919-1:2018(en), 3.1.26]

3.1.22
PCC plant capacity availability
availability of PCC plant from a perspective of product CO_2 amount during a reference period

Note 1 to entry: It is mathematically defined by Formula (3)

[SOURCE: ISO 3977-9:1999(E), modified]

3.1.23
PCC plant load
ratio of 'the product CO_2 capacity (in operation) to the 'nominal product CO_2 capacity (flow rate)', expressed as a percentage

3.1.24
planned (scheduled) maintenance
maintenance carried out in accordance with a specified time schedule

Note 1 to entry: Scheduled maintenance may identify the need for some corrective maintenance action.

[SOURCE: IEC 60050-192 (192-06-12), modified]

3.1.25
preventive maintenance
maintenance carried out in accordance with an established time schedule and performing according to a prescribed criteria

Note 1 to entry: See also condition-based maintenance (192-06-07), and scheduled maintenance (192-06-12).

[SOURCE: ISO 23815-1]

3.1.26
project cycle
series of phases of which a project consists, e.g. basic design, engineering, manufacturing, commissioning and operation

3.1.27
product CO_2 amount
volume, moles or mass of CO_2 resulting from the PCC process

3.1.28
product CO_2 capacity
total flow rate of the captured CO_2 exported

Note 1 to entry: It is generally expressed as product CO_2 amount per hour.

3.1.29
product CO_2 producibility
ratio of the product CO_2 produced to the total amount of produced nominal product CO_2

3.1.30
proven technology element
element with low or acceptable uncertainty levels

3.1.31
redundancy
item where an equivalent unit can be put online to provide the same function should the principal item fail to provide the service

Note 1 to entry: Redundancy is related to a strategy of design, where a spare system or component is provided so that, even if one critical item fails, the spare system or component will operate in place of the deficient item such that plant performance is not affected.

3.1.32
reference period
period of time between an initial time and an end time over which all historical or projected performance metrics are measured or projected

Note 1 to entry: Reference period is equivalent to period hours (PH).

3.1.33
reliability
measure of the probability of success for an operation to perform its intended function and the ability of each item to perform its intended function in an assembled PCC plant during a given interval.

3.1.34
reliable performance
ability of a PCC plant to function as intended

3.1.35
schedule compliance
ratio of the product CO_2 amount to the scheduled CO_2 product amount requirement met (historical) or to be met (projected) by the PCC plant within a given time period

3.1.36
service hours
accumulated period of time from main flame ignition through to flame extinction

[SOURCE: ISO 3977-9:1999(en), 3.98]

3.1.37
shut-down
event during which all required function of a PCC plant, and its equipment, is brought from an operating state to a stoppage state under the control of a programmed sequence

3.1.38
stand-by state
non-operating state during the required period

3.1.39
starting reliability
probability of successful start-up when the PCC plant is on stream within a specified period

3.1.40
start-up
act of getting a PCC plant and its equipment from a stoppage state ready to activate its items to an operation state

3.1.41
technical delay
accumulated time necessary to perform auxiliary technical actions associated with the maintenance action itself

3.1.42
time availability
ratio of PCC plant unavailable time (excluding external influences) subtracted from the reference period to the reference period

Note 1 to entry: an available time is calculated by subtraction of the unavailable time from reference period.

3.1.43
time reliability
ability of a system to perform

3.1.44
unavailability
PCC plant is not in a state to perform as required due to the internal reason or preventive maintenance

3.1.45
uptime
time interval during which a PCC plant is in a state of being able to perform as required

Note 1 to entry: Absence of necessary external resources may prevent operation, but do not affect the up state.

[SOURCE: IEC 60050-192 (192-02-02), modified]

3.2 Abbreviations

CCS	carbon dioxide capture and storage
DSS	daily start and stop
EHS	environment, health and safety
EOR	enhanced oil recovery
EPC	engineering, procurement and construction
ESD	emergency shut-down
KPIs	key performance indicators
MDT	mean downtime
MR	mission reliability
MTBF	mean time between failure
MTPM	mean time for preventive maintenance
MTTR	mean time to repair
PCA	PCC plant capacity availability
PCC	post-combustion CO_2 capture
RAM	reliability, availability and maintainability
SR	starting reliability
TA	time availability

TQ technology qualification

TR time reliability

TRL technology readiness level

4 Principles

4.1 Introduction

The evaluation procedure described in this document assumes the following:

a) A PCC plant shall be designed, manufactured and constructed in line with proven and established engineering practices during the whole project life cycle.

b) A PCC plant design may be a combination of proven technology items with some novel ones which can contribute to improve performance and/or economy in construction or operation. The level of novelty is closely related with the technological readiness of the applied technology items.

c) A shut-down of the PCC plant will not cause immediate stoppage of the upstream power plant or the downstream side CO_2 transportation.

d) A PCC plant is a maintainable system and availability may be improved if maintainability as well as reliability of each technology item is improved through feedback of operational results.

4.2 General

This document describes a procedure that combines technology-item evaluation methods with reliability, availability, and (in some cases) maintainability evaluation methods.

4.3 Reliable performance

Reliable performance depends on having a PCC plant that functions as intended.

Reliable performance has two aspects:

a) that the required performance is satisfied at the initial conditions and

b) that it is maintained during a defined period.

4.4 Ensuring and maintaining reliable performance

To perform as required, this document provides the following as part of the PCC's plant's project life cycle:

a) basic concepts of reliability, availability and maintainability – refer to Clause 5

b) guidelines for ensuring reliable performance at delivery in terms of design – refer to Clause 6.

c) guidelines for adequate monitoring and for evaluating reliable performance in terms of operation and maintenance – refer to Clause 7 and Clause 8

d) guidelines for reporting availability – refer to Clause 9 based on Clause 6, Clause 7 and Clause 8

4.5 Procedure outline

4.5.1 Outline of procedure flow

The evaluation procedure consists of process step 1 to 6 crossing through actions in the related project life cycle phases and its block flow should be referred to Figure 2. Process step 1, 2 (Summary) and 3 are