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Carbon dioxide capture —

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

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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/TC265, *Carbon dioxide capture, transportation, and geological storage*.

A list of all 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

Atmospheric carbon dioxide (CO_2) emissions must be reduced to meet climate change mitigation targets. Including carbon dioxide capture and storage (CCS) in current emission reduction approaches increases 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 ISO 27919-1 on evaluation of key performance indicators (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 process is shown in Figure 1.

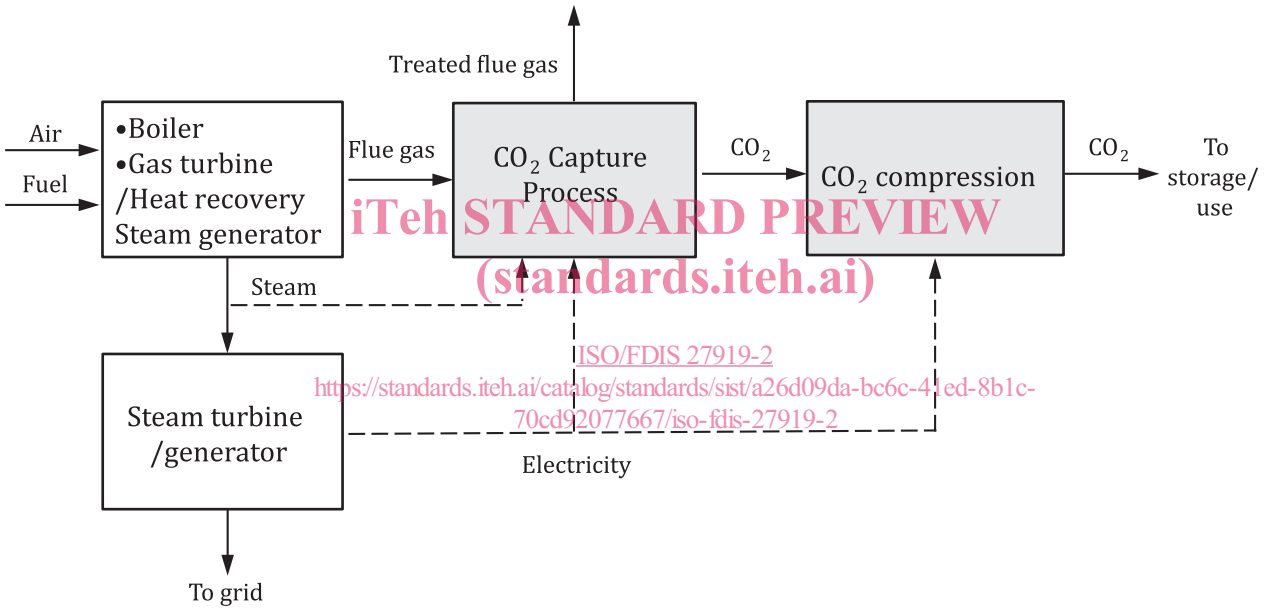

Figure 1 — Simplified block diagram of PCC

In a typical power generation facility, carbonaceous fuel (e.g. coal, oil, gas, biomass) is combusted with air in a boiler to raise steam. The steam drives a turbine or generator to produce power. In a gas-turbine combined-cycle system, the combustion in the gas turbine drives power generation, while steam generated through a heat-recovery steam generator produces additional power. 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 PCC process is located downstream of conventional pollutant controls. Chemical-absorption-based PCC usually requires steam to be extracted from the power plant's steam cycle or the use of lower-grade heat sources for absorption liquid regeneration, depending on the absorption liquid and process employed.

The economic and environmental value of a PCC plant is determined by its technical performance, as well as its ability to achieve and maintain stable operation as required by its owners/stakeholders, as follows:

— 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.

Thus, this document describes a procedure that combines technology item evaluation procedure with reliability, availability, and in some cases maintainability evaluation methods.

Carbon dioxide capture —

Part 2:
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1 Scope

This document provides definitions, guidelines and supporting information for evaluating and reporting (with respect to 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 a host power plant. The PCC plant 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, with an optional 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 to assure and maintain reliable performance, presented in this document, describe issues addressed during the design and construction phases and practices that 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

There are no normative references in this document.

3 Terms, definitions and abbreviations

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 https://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 -“maintenance action” was changed to “maintenance”]

3.1.2
availability
ability of a *PCC plant* (3.1.20) 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 items disrupts the plant availability.

3.1.4
derating/derated
difference between the maximum and the dependable one, or such a condition

Note 1 to entry: For derated hours, it means operating time with the rated output lowered.

3.1.5
downtime
time interval for which the *item* (3.1.9) is in a state of being unable to perform as required due to internal faults, or *preventive maintenance* (3.1.24)

Note 1 to entry: unavailable time

3.1.6
emergency operation
type of sudden *shut-down* (3.1.36) operation to protect hardware from damage

3.1.7
external influence
critical subjects occurring outside the *PCC plant* (3.1.21) 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)]

3.1.9
item
subject being considered

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

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

[SOURCE: IEC 60050-192 (192-01-01), modified – "functional unit" was changed to "functional or process unit" and "system" was changed to "related with technology" in Note1. Note3 through Note 5 were deleted.]

3.1.10
logistic delay
delay, excluding *administrative delay* (3.1.1), incurred for the provision of resources needed for a *maintenance* (3.1.12) action to proceed or continue

[SOURCE: ISO 20815:2018, 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* (3.1.9) 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
average of the *downtime* (3.1.5)

[SOURCE: IEC 60050-192:2015, 192-08-10]

3.1.14
mean time between failures
MTBF
average time between failures that initiate a forced *outage* (3.1.20), i.e. the quotient of attempted operating hours to the number of forced *outages* (3.1.20)

3.1.15
meantime between maintenance
MTBM
average time between *maintenance* (3.1.12), i.e. the quotient of attempted operating hours to the number of *maintenance* (3.1.12)

3.1.16
mission time
duration of the mission

Note 1 to entry: Mission is the state that the equipment or system is 100 % operational.

[SOURCE: ISO 10438-1:2007, 3.1.19]

3.1.17
nominal product CO_2 capacity
NC
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
OSF
ratio of the summation of all on-stream time to the *reference period* (3.1.31), with both expressed as hours

3.1.20
outage
time interval for which the *item* (3.1.9) is in a state of being unable to perform as required, for any reason

[SOURCE: IEC 60050-192:2015, 192-02-19, modified – "a disabled state" was changed to "a state of being unable to perform as required, for any reason"]

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

[SOURCE: ISO 27919-1:2018, 3.1.26]

3.1.22
PCC plant capacity availability
PCA
availability (3.1.2) of *PCC plant* (3.1.21) from a perspective of *product CO2 amount* (3.1.26) during a *reference period* (3.1.31)

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

3.1.23
PCC plant load
ratio of the *product CO2 capacity* (3.1.27)' in operation to the *'nominal product CO2 capacity'* (3.1.17)

3.1.24
preventive maintenance
maintenance (3.1.12) carried out in accordance with an established time schedule and performed according to a prescribed criterion

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

[SOURCE: ISO 23815-1]

3.1.25
project cycle
series of phases of which a project consists, e.g. basic design, engineering, manufacturing, commissioning and operation

3.1.26
product CO_2 amount
volume, moles or mass of CO_2 resulting from the PCC process

3.1.27
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.

3.1.28
product CO_2 producibility
PCPB
ratio of the *product CO2 amount* (3.1.26) produced to the *nominal product CO2 capacity* (3.1.17) accumulated during the *reference period* (3.1.31)

3.1.29
proven technology element
element with low or acceptable uncertainty levels

3.1.30
redundancy
item (3.1.9) where an equivalent unit can be put online to provide the same function if the *item* (3.1.9) 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 item fails, the spare system or component will operate in place of the deficient item such that plant performance is not affected.

3.1.31
reference period
RP
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.

3.1.32
reliability
measure of the probability of success for an operation and, the ability of each *item* (3.1.9) to perform its intended function as needed in an assembled *PCC plant* (3.1.20) during a given time interval within the designed conditions without failure

3.1.33
reliable performance
ability of a *PCC plant* (3.1.21) to function reliably as required

3.1.34
schedule compliance
SC
ratio of the *product CO2 amount* (3.1.26) produced to the scheduled CO_2 product amount requirement met (historical) or to be met (projected) by the *PCC plant* (3.1.21) within a given time period

3.1.35
service hours
accumulated period of time during stand-by and *normal operation* (3.1.18) including *start-up* (3.1.39) and *shut-down* (3.1.36) in between

[SOURCE: ISO 3977-9:1999, 3.98]

3.1.36
shut-down
event during which all required function of a *PCC plant* (3.1.21), and its equipment, is brought from an operating state to a stoppage state under the control of a programmed sequence

3.1.37
stand-by state
non-operating up state ready to start

3.1.38
starting reliability
SR
probability of successful *start-up* (3.1.39) when the *PCC plant* (3.1.21) is on stream within a specified period

3.1.39
start-up
act of getting a *PCC plant* (3.1.21) and its equipment from a stoppage state ready to activate its *items* (3.1.9) to an operating state

3.1.40
technical delay
accumulated time necessary to perform auxiliary technical actions associated with the *maintenance* (3.1.12) action itself

3.1.41
time availability
TA
ratio of the subtraction of the summation of each element of the *PCC plant* (3.1.21) unavailable time from the *reference period* (3.1.31) to the *reference period* (3.1.31)

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

3.1.42
time reliability
TR
ratio of the subtraction of *PCC plant* (3.1.21) unavailable time from the time between preventative *maintenance* (3.1.12) to the time between preventative *maintenance* (3.1.12)

3.1.43
unavailability
PCC plant (3.1.21) is not in a state to perform as required due to an internal faults or *preventive maintenance* (3.1.24)

3.1.44
uptime
time interval during which a *PCC plant* (3.1.21) is in a state of being able to perform as required

Note 1 to entry: Absence of necessary external resources may prevent operation but does not affect.

Note 2 to entry: Available time.

3.2 Abbreviations

CCS	carbon dioxide capture and storage
DSS	daily start-up and stop
EHS	environment, health and safety
KPIs	key performance indicators
MDT	mean downtime
MR	mission reliability
MTBF	mean time between failure
MTPM	mean time to preventive maintenance
MTTR	mean time to repair
NC	nominal product CO_2 capacity
NPC	nominal product CO_2
OSF	on-stream factor
OST	summation of each element of on-stream time

PCA	PCC plant capacity availability
PCC	post-combustion CO_2 capture
PCP	product CO_2 produced
PCPB	product CO_2 producibility
PCNP	product CO_2 not produced
RAM	reliability, availability and maintainability
RP	reference period
SC	schedule compliance
SPC	scheduled product CO_2
SR	starting reliability
TA	time availability
TQ	technology qualification
TR	time reliability
UT	unavailable time

3.3 Symbols

n_{FO}	number of forced outages;
n_{FS}	number of failures to start-up;
n_{SA}	number of starting attempts;
n_{SS}	number of successful start-ups;
$PC_{nominal}$	nominal product CO_2 capacity[t/h]
PR_{BSPC}	bonus production in excess of the planned capacity to make up the shortage of product CO_2 production compared with SPC [t]
PR_{NPC}	amount [t] of NPC accumulated during the RP[t], calculated using Formula (4)
PR_{PCP}	product CO_2 amount produced [t]
PR_{PCU}	accumulation of the amount [t] of PCNP due to PCC plant capacity unavailability (excluding external influences) during the RP[t], calculated using Formula (5)
PR_{SPC}	scheduled product CO_2 amount [t]
PR_{SSPC}	shortage in product CO_2 amount compared to the scheduled during the RP [t]
t	mission time in hours[h]
$t_{preventive}$	time period for preventive maintenance (planned) [h]
t_{repair}	time period for repair as corrective maintenance (unplanned) [h];