TECHNICAL REPORT

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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

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The committee responsible for this document is ISO/TC 265, *Carbon dioxide capture, transportation, and geological storage*.

Introduction

Carbon capture and storage (CCS) is a technology to mitigate climate change. Many demonstration projects have been conducted worldwide, and CO_2 capture is an important process in CCS and is cost and energy intensive.

CO_2 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 CO_2 capture systems so that this Technical Report can provide stakeholders with the guidance and knowledge necessary to develop a series of standards for CO_2 capture and build consensus on this standardization work in advance.

This Technical Report describes CO_2 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 CO_2 capture systems;

— technologies, equipment and processes;

— CO_2 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 CO_2 capture system and provide stakeholders with the guidance and knowledge necessary for the development of a series of standards for CO_2 capture. This Technical Report also covers technologies, equipment and processes specific to CO_2 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 CO_2 capture as part of a CCS chain. This Technical Report covers CO_2 capture systems applicable to CO_2 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 CO_2;

— compression of CO_2 (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 reqired oxygen for gasification or combustion applications in the context of CCS

3.4
alkanolamine
chemical compound that carries hydroxy (–OH) and amino ($–NH_2$, –NHR, and $–NR_2$) 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
CO_2 processing unit
group of processes used in the purification of the CO_2 rich gas to a desired CO_2 specification

Note 1 to entry: Also known as compression and purification unit (CPU), CO_2 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 CO_2 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 (H_2)

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 (H_2)

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 NNO_2

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 GPU = 10^{-6} cm^3(STP)/scm^2(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, $CO + H_2O = CO_2 + H_2$, 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 CO_2

3.76
sorbent
substance that absorbs CO_2 or to which CO_2 is adsorbed

3.77
sour shift (reaction)
shift reaction without removing H_2S or COS

3.78
steam reforming
catalytic process in which a hydrocarbon is reacted with steam to produce a mixture of H_2, CO and CO_2

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 H_2S or COS

3.81
syngas
synthetic gas produced through gasification process

3.82
treated gas
gas finally discharged from the CO_2 capture process in the emission side after being processed to have a lower CO_2 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)