

ISO/TR 27912:2016-05 (E)

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

| Contents | | Page |
|--------------------|--|-------------|
| Foreword | | vii |
| Introduction | | viii |
| 1 | Scope | 1 |
| 2 | Normative references | 1 |
| 3 | Terms and definitions | 1 |
| 4 | Symbols and abbreviated terms | 8 |
| 5 | Carbon dioxide (CO ₂) capture system | 12 |
| 5.1 | General | 12 |
| 5.2 | Classification of CO ₂ capture systems | 14 |
| 5.3 | System boundary | 16 |
| 6 | Review and documentation | 16 |
| 6.1 | General | 16 |
| 6.2 | Separation processes | 18 |
| 6.2.1 | Separation with sorbents/solvents | 18 |
| 6.2.2 | Separation with membranes | 21 |
| 6.2.3 | Separation by cryogenics or flash evaporation | 22 |
| 7 | Post-combustion capture in the power industry | 22 |
| 7.1 | System boundary | 22 |
| 7.1.1 | Boundary with power plant or other process stream (cooling water, steam, flue gas, product CO ₂) | 22 |
| 7.1.2 | Boundary of the PCC plant | 25 |
| 7.1.3 | Boundary with transport and storage of CO ₂ | 25 |
| 7.2 | Technologies, equipment and processes | 25 |
| 7.2.1 | Chemical absorption process based on (alkanol-) amines (amine process) (A) | 25 |
| 7.2.2 | Chilled ammonia process (CAP) (B) | 26 |
| 7.2.3 | Amino acid salts (AAS) process (C) | 27 |
| 7.3 | Carbon dioxide streams, flue gas streams and emissions, process and waste products ... | 28 |
| 7.3.1 | Flue Gas streams | 28 |
| 7.3.2 | Composition of carbon dioxide streams | 32 |
| 7.3.3 | Solvent streams, reclaiming waste products | 34 |
| 7.3.4 | Waste (process) water streams | 35 |
| 7.3.5 | Emission determination and calculation | 36 |
| 7.3.6 | Process by-products | 37 |
| 7.4 | Evaluation procedure for capture performance | 37 |
| 7.4.1 | Clarification of the evaluation basis | 38 |
| 7.4.2 | Basic performance | 38 |
| 7.4.3 | Utility consumption | 40 |
| 7.4.4 | Operability (operational requirements) | 41 |
| 7.4.5 | Economic evaluation index | 42 |
| 7.5 | Safety issues | 43 |
| 7.5.1 | Safety categories | 43 |
| 7.5.2 | Relevant equipment and manifestations | 44 |
| 7.5.3 | Chemical substances and their behaviours | 46 |

| | | |
|--------|---|-----|
| 7.5.4 | Environmental Impact Assessment (EIA) | 49 |
| 7.5.5 | Preventive measures | 49 |
| 7.6 | Reliability issues | 52 |
| 7.6.1 | Need for reliability assessment | 52 |
| 7.6.2 | Operational reliability | 53 |
| 7.6.3 | Reliability evaluation methods | 54 |
| 7.6.4 | Parameters of reliability | 54 |
| 7.7 | Management system | 57 |
| 7.7.1 | Management system between capture plant and emission source | 57 |
| 7.7.2 | Operational management | 58 |
| 7.7.3 | Relationship with other areas for CCS standardization | 59 |
| 7.8 | Reference plants | 59 |
| 8 | Pre-combustion capture in power industry | 60 |
| 8.1 | General | 60 |
| 8.2 | System boundary | 61 |
| 8.3 | Technologies, equipment and processes | 62 |
| 8.3.1 | Establishment of CO ₂ capture rate | 62 |
| 8.3.2 | CO ₂ capture process | 62 |
| 8.4 | Carbon dioxide streams, gas streams and emissions, process and waste products | 65 |
| 8.4.1 | CO ₂ streams | 66 |
| 8.4.2 | Synthetic gas streams | 68 |
| 8.4.3 | Waste products | 69 |
| 8.5 | Evaluation procedure for capture performance | 69 |
| 8.5.1 | Definition of greenhouse gas (GHG) capture rate | 69 |
| 8.5.2 | Evaluation procedure for capture performance[96] | 70 |
| 8.6 | Safety issues | 73 |
| 8.7 | Reliability issues | 74 |
| 8.8 | Management system | 74 |
| 8.8.1 | Management system between capture plant and emission source | 74 |
| 8.8.2 | Operational management | 75 |
| 8.8.3 | Relationship with other areas for CCS standardization | 76 |
| 9 | Oxyfuel combustion power plant with CO ₂ capture | 76 |
| 9.1 | System boundary | 77 |
| 9.2 | Technology, processes and equipment | 78 |
| 9.2.1 | Boiler island and auxiliary equipment | 78 |
| 9.2.2 | Steam turbine island and generators | 79 |
| 9.2.3 | Air separation unit (ASU) | 80 |
| 9.2.4 | Flue gas processing units (environmental island) | 86 |
| 9.2.5 | Flue gas condenser (flue gas cooler) | 89 |
| 9.2.6 | CO ₂ processing unit (CPU) | 91 |
| 9.2.7 | Balance of plant | 110 |
| 9.3 | Product CO ₂ , other major gas streams, emissions and waste products | 111 |
| 9.3.1 | Product CO ₂ | 111 |
| 9.3.2 | Other gas streams | 114 |
| 9.3.3 | Emissions and waste products from oxyfuel combustion power plant | 118 |
| 9.4 | Evaluation procedure for CO ₂ capture performance | 119 |
| 9.5 | Safety issues | 119 |
| 9.5.1 | Safe operation of the ASU and handling of oxygen on site | 120 |
| 9.5.2 | Prevention procedure of known risks to fire and/or explosion in the boiler or mills should be revisited for oxyfuel combustion operation | 121 |
| 9.5.3 | Accidental release of CO ₂ , flue gases, or other inert gases including liquid gas products | 121 |
| 9.5.4 | Prevention of any low temperature corrosion that could compromise the structural integrity of equipment | 121 |
| 10 | Capture from cement production processes[176][177] | 121 |
| 10.1 | System boundary | 122 |
| 10.2 | Technologies, equipment and processes | 123 |
| 10.2.1 | Post-combustion method (PCC) | 125 |
| 10.2.2 | Oxy-combustion method | 125 |

| | | |
|--------|---|-----|
| 10.3 | Carbon dioxide streams, gas streams and emissions, process and waste products | 126 |
| 10.3.1 | NOx | 129 |
| 10.3.2 | SOx | 129 |
| 10.3.3 | Dust | 129 |
| 10.3.4 | HCl (Hydrogen chloride) | 130 |
| 10.4 | Evaluation procedure for capture performance | 130 |
| 10.5 | Safety issues | 130 |
| 10.6 | Reliability issues | 131 |
| 10.7 | Management system | 132 |
| 11 | CO2 Capture in the iron and steel industry | 132 |
| 11.1 | Overview -- Global steel production | 132 |
| 11.2 | Point sources of CO2 emissions within the iron and steel production | 133 |
| 11.2.1 | Calculation of CO2 emissions from the steel mill | 133 |
| 11.2.2 | Direct CO2 emissions in an integrated mill producing steel through the BF-BOF route ... | 133 |
| 11.2.3 | Overview of CO2 emissions from alternative steel making processes | 136 |
| 11.3 | CO2 reduction and CCS deployment strategy in the steel industry | 138 |
| 11.4 | Review of major CO2 breakthrough programmes worldwide | 139 |
| 11.4.1 | ULCOS programme | 139 |
| 11.4.2 | COURSE50 programme | 140 |
| 11.4.3 | POSCO/RIST programme | 141 |
| 11.5 | System boundary | 141 |
| 11.6 | Capture of CO2 from blast furnace gas | 142 |
| 11.6.1 | Development of chemical absorption technology under the COURSE50 programme | 142 |
| 11.6.2 | Development of chemical absorption technology under the POSCO/ RIST programme ... | 144 |
| 11.6.3 | Development of physical adsorption technology under COURSE50 programme | 145 |
| 11.6.4 | ULCOS BF -- Oxygen-blown BF with top gas recycle | 146 |
| 11.6.5 | Other commercial development | 148 |
| 11.7 | Specific energy consumption of CO2 captured | 150 |
| 11.8 | Gas streams | 153 |
| 11.8.1 | Conventional blast furnace gas (BFG) | 153 |
| 11.8.2 | BFG from an oxygen-blown BF with top gas recycle (ULCOS BF) | 153 |
| 11.9 | CO2 capture from alternative ironmaking process | 154 |
| 11.9.1 | Direct reduction ironmaking process | 154 |
| 11.9.2 | Smelting reduction ironmaking process | 160 |
| 11.10 | Evaluation procedures for capture processes | 166 |
| 11.11 | Reliability issues | 166 |
| 11.12 | Safety issues | 166 |
| 12 | Capture from industrial gas production processes | 167 |
| 12.1 | System boundary | 168 |
| 12.1.1 | Natural gas sweetening process | 168 |
| 12.1.2 | Ammonia production process | 169 |
| 12.1.3 | Hydrogen production process | 169 |
| 12.2 | Technologies, equipment and processes | 171 |
| 12.3 | Carbon dioxide streams, gas streams and emissions, process and waste products | 172 |
| 12.3.1 | Chemical absorption | 172 |
| 12.3.2 | Physical absorption process | 173 |
| 12.3.3 | Membrane separation | 173 |
| 12.3.4 | Evaluation procedure for capture performance | 173 |
| 12.4 | Safety issues | 174 |
| 12.5 | Reliability issues | 175 |
| 12.6 | Management system | 175 |
| 12.6.1 | Management system between capture plant and emission source | 175 |
| 12.6.2 | Operational management | 177 |
| 12.6.3 | Relationship with other areas for CCS standardization | 177 |
| 13 | Discussion on possible future direction | 177 |
| 13.1 | General | 177 |
| 13.2 | Possible area of standardization | 178 |
| 13.3 | Discussion | 178 |

| | |
|--|------------|
| Annex A (informative) Chemical absorption processes | 181 |
| Annex B (informative) Examples of flue gas compositions | 186 |
| Annex C (informative) Physical absorption processes | 190 |
| Annex D (informative) CO₂ capture terms and definitions list | 193 |
| Bibliography | 209 |