GUIDANCE NOTES
GD24-2023

CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR SURVEY OF OFFSHORE OIL AND GAS CARBON CAPTURE, UTILIZATION AND STORAGE SYSTEMS

2023

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Beijing

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Chapter 1 General

Section 1 General Provisions

1.1.1 General Requirements

1.1.1.1 The *Guidelines for Survey of Offshore Oil and Gas Carbon Capture, Utilization and Storage Systems*, hereinafter referred to as "the Guidelines", provide acceptable criteria for the design, construction, installation and survey of offshore oil and gas carbon capture, utilization and storage (CCUS) systems. The Guidelines seek to minimize the risks of the system to human, environment and property, and serve the purposes of low carbon and low pollution by reducing carbon emissions from offshore oil and gas and effectively recycling the resources.

1.1.1.2 The Guidelines provide a basis on which China Classification Society could conduct its survey, certification and technical services for offshore oil and gas CCUS systems.

1.1.1.3 In addition to the provisions as defined in the Guidelines, a CCUS system shall further meet the requirements of administration.

1.1.2 Scope of Application

1.1.2.1 The Guidelines apply to CCUS systems installed in fixed platforms, floating installations, mobile units, onshore terminals and artificial islands.

1.1.2.2 The CO_2 capture system, as specified in the Guidelines, operates to capture and process CO_2 associated with oil and gas fields, CO_2 in flue gas, or CO_2 from submarine pipelines and ships, excluding underground structures such as production wells, injection wells and well bore structure.

1.1.2.3 The CO_2 utilization and storage systems as specified in this guideline are those installed in fixed platforms, floating installations, mobile units, onshore terminals and artificial islands for systems of geological utilization, chemical utilization, physical utilization, biological utilization or CO_2 geological storage systems. See Figure 1.1.2.3 for the survey scope of the Guidelines.

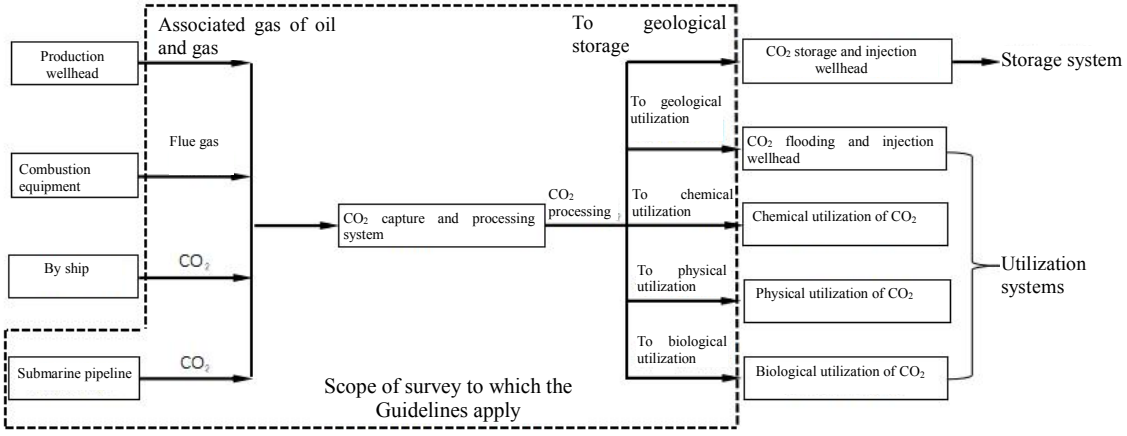

Figure 1.1.2.3 Schematic Scope of Survey

1.1.2.4 The Guidelines may be used for reference by offshore non-oil-gas CCUS system.

1.1.3 Equivalent and Exemption

1.1.3.1 Any design requirement in conflict with the Guidelines (including the requirement of acceptance criteria) may be accepted as a replacement of the corresponding requirement in the Guidelines, provided there are evidences or indications in written documents that it specifies a safety level not lower than that in the Guidelines.

1.1.3.2 With the consent of China Classification Society, CCUS system with novel characteristics may be exempted from any requirement of the Guidelines that may hinder the study of such characteristics.

1.1.4 Application of Risk Assessment

1.1.4.1 Where an owner, operator, designer or other organization intends to design, construct and operate the system or unit through risk assessment, its risk control measures and solutions employed in the assessment may replace the requirements of the Guidelines, in full or part, provided that the risk assessment documents are deemed satisfactory upon review of China Classification Society.

1.1.4.2 The risk assessment may be conducted in accordance with the *Guidelines for Quantitative Risk Assessment of Oil and Gas* issued by China Classification Society or the standards and methods accepted by China Classification Society.

Section 2 Definitions and Abbreviations

1.2.1 Definition

1.2.1.1 Unless otherwise specified, the following definitions shall apply to the Guidelines:

(1) Offshore oil and gas CO_2: CO_2 generated by offshore exploration, development, drilling, production and other related activities for the purpose of exploiting offshore oil and gas.

(2) Critical pressure: saturated vapor pressure at the critical temperature. The critical pressure of CO_2 is 7.3773MPa.

(3) Critical temperature: the highest temperature at which a liquid can maintain its liquid state. Above this temperature, the gas cannot be liquefied simply by increasing the pressure. The critical temperature of CO_2 is 30.9782℃.

(4) Supercritical CO_2: CO_2 at a temperature higher than the critical temperature and a pressure higher than the critical pressure.

(5) Dense phase CO_2: CO_2 at a temperature lower than the critical temperature and a pressure higher than the critical pressure, which is different from ordinary gas CO_2 and liquid CO_2.

(6) CO_2 leakage: accidental escape of CO_2 from closed equipment or pipelines.

(7) CO_2 capture: the process of separating and recovering high-concentration and easy-to-transport, utilize or store CO_2 from CO_2 stream associated with oil/gas fields and/or CO_2 in flue gas.

(8) CO_2 transport: the process of transporting the captured CO_2 to the utilization or storage site. There are two transport means: ship transport and pipeline transport.

(9) CO_2 storage: the process of storing CO_2 in geological reservoirs or other forms of reservoirs to isolate it from the atmosphere for a long time.

(10) CO_2 utilization: the process of recycling the captured CO_2. By engineering and technical means, it can be divided into geological utilization, chemical utilization, biological utilization and physical utilization.

(11) Flue gas: Exhaust gas generated by fuel combustion, which is usually discharged into the atmosphere after deSO_x, deNO_x and dust collection.

(12) Buildings and structures: refer to buildings or structures. Buildings are spaces and entities constructed by building materials for human's living and activities. Structures are engineering entities or ancillary building facilities built for a certain purpose but generally not for direct production or living activities.

1.2.2 Abbreviation

1.2.2.1 Unless otherwise specified, the abbreviations adopted for the purpose of the Guidelines are as follows:

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
CCUS	Carbon Capture, Utilization and Storage

CSES	Chinese Society for Environmental Sciences
GB	China National Standards
ISO	International Organization for Standardization
JB	China Machinery Industry Standards
NACE	National Association and Corrosion Engineers
NB	China Energy Industry Standards
SH	China Petrochemical Industry Standards
SY	China Oil and Gas Industry Standards
TEMA	Tubular Exchanger Manufacturers Association

Section 3 Applicable Standards

1.3.1 General Requirements

1.3.1.1 In addition to the applicable standards, offshore oil and gas CCUS systems shall further meet the codes and standards as referenced by the system-applied platforms or installations.

1.3.1.2 In addition to the requirements of the Guidelines, China Classification Society accepts all applicable parts of international standards, China national standards and industry standards about design, construction, installation, survey and testing of mechanical equipment, vessels, piping and instruments within an offshore oil and gas CCUS system.

1.3.1.3 One equipment or system shall be based on a same standard.

1.3.1.4 In case of any inconsistency between the referenced standard and the Guidelines, the Guidelines requirement shall prevail. In case of any inconsistency between the referenced standards, the standard finally referenced shall be fully demonstrated and approved by the owner and CCS.

1.3.1.5 Unless otherwise specified, the latest editions shall apply.

1.3.2 Main applicable standards

1.3.2.1 China Classification Society accepts the currently effective international standards, China national standards and industry standards applicable to offshore oil and gas CCUS systems. Their latest editions shall apply to the Guidelines:

(1)	GB 150	Pressure Vessels
(2)	GB/T 151	Heat Exchangers
(3)	GB/T 3215	Centrifugal Pumps for Petroleum Petrochemical and Natural Gas Industries
(4)	GB/T 3216/XG1	Rotodynamic Pumps—Hydraulic Performance Acceptance Tests—Grades 1, 2 and 3
(5)	GB/T 7782	Metering Pump
(6)	GB 12337/XG1	Steel Spherical Tanks
(7)	GB/T 20972	Petroleum and Natural Gas Industries—Materials for Use in H_2S-Containing Environments in Oil and Gas Production
(8)	GB 50183	Code for Fire Protection Design of Petroleum and Natural Gas Engineering
(9)	GB 50264	Code for Design of Industrial Equipment and Pipeline Insulation Engineering
(10)	GB/T 51316	Flue Gas Carbon Dioxide Capture and Purification Engineering Design Standards
(11)	GB/T 20801	Pressure Piping Code
(12)	GB/T 6052	Industrial Liquid Carbon Dioxide
(13)	GB/T 50770	Code for Design of Safety Instrumented System in Petrochemical Engineering
(14)	GB/T 25359	Petroleum and Natural Gas Industries—Packaged Reciprocating Gas

		Compressors
(15)	GB/T 20322	Petroleum and Natural Gas Industries—Reciprocating Compressors
(16)	NB/T 47004	Plate Heat Exchangers
(17)	NB/T 47013	Nondestructive Testing of Pressure Equipment
(18)	NB/T 47041	Vertical Vessels
(19)	NB/T 47042	Horizontal Vessels
(20)	NB/T 47003.1	Steel Welded Atmospheric vessels
(21)	JB 4732	Steel Pressure Vessels—Analysis and Design Standards
(22)	SY/T 0011	Code for Design of Natural Gas Conditioning Plant
(23)	SY/T 0077	Design Specification of Natural Gas Liquid Recovery
(24)	SY/T 6565	Safety Code for Carbon Dioxide Injection in Oil and Gas Development
(25)	SY/T 7440	Design Specifications for CO_2 Flooding Oilfield Injection and Recovery Systems
(26)	SY/T 10043	Pressure Relief and Pressure Relief Systems Guide
(27)	SY/T 10047	Environmental Protection Design Specifications for Offshore Oil (Gas) Field Development Projects
(28)	SY/T 6650	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
(29)	SY/T 6651	Axial and Centrifugal Compressors and Expander-Compressors for Petroleum, Chemical and Gas Industry Services
(30)	SH/T 3092	Specification of Design for Distributed Control System in Petrochemical Industry
(31)	T/CSES 41	Terms of Carbon Dioxide Capture, Utilization and Storage (CCUS)
(32)	No.64 [2016] of Technology, General Office of Ministry of Environmental Protection	Technical Guidelines for Environmental Risk Assessment of Carbon Dioxide Capture, Utilization and Storage (CCUS)
(33)	ISO 13631	Petroleum and Natural Gas Industries—Packaged Reciprocating Gas Compressors
(34)	ISO 27914	Carbon Dioxide Capture, Transport and Geological Storage—Geological Storage
(35)	ASME B31.3	Process Piping
(36)	ASME VIII	Pressure Vessels
(37)	API RP14E	Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems
(38)	API RP14C	Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms
(39)	API Std 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
(40)	API Std 617	Axial and Centrifugal Compressors and Expander-Compressors
(41)	API Std 618	Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services
(42)	API Std 619	Rotary-type Positive Displacement Compressors for Petroleum, Petrochemical and Natural Gas Industries
(43)	API Std 674	Positive Displacement Pumps—Reciprocating
(44)	API Std 675	Positive Displacement Pumps—Controlled Volume for Petroleum, Chemical, and Gas Industry Services
(45)	API Std 676	Positive Displacement Pumps—Rotary
(46)	API Std 672	Packaged, Integrally Geared Centrifugal Air Compressors for Petroleum, Chemical, and Gas Industry Services
(47)	TEMA STANDARDS	Shell-and-Tube Heat Exchangers

Chapter 2 Surveys and Certification

Section 1 General Provisions

2.1.1 General Requirements

2.1.1.1 In addition to the provisions of the Guidelines, the survey of CCUS systems shall also meet the codes and standards as referenced by the system-applied platforms or installations.

2.1.1.2 The owner or operator shall apply to China Classification Society in a timely manner for surveys to maintain the validity of the certificate, make preparation for the survey items and provide safety measures for the survey in accordance with the requirements of the Guidelines.

2.1.2 Survey Types and Certificates

2.1.2.1 The CCUS system survey types encompass construction survey, annual survey, periodic survey (renewal survey) and occasional survey.

2.1.2.2 According to the specifications on survey types of CCUS system, the owner or operator may apply for survey by China Classification Society. After the system has been verified to meet the requirements of the Guidelines, China Classification Society will issue/renew or sign corresponding certificates and/or reports. The validity period of the certificate is usually not more than 5 years and may be shortened appropriately in special circumstances. Specifically, with the consent of the owner or operator, the survey cycle and anniversary date of the CCUS system can be coordinated to be consistent with the system-applied platforms or installations.

2.1.2.3 Any damage, failure and repair that may affect the validity of the certificates shall be reported to China Classification Society in time. China Classification Society will make evaluation and/or survey, and give requirements and comments.

2.1.2.4 In case of any of the following cases, the CCUS system certificate and/or report issued by China Classification Society will automatically become invalid:

(1) Failure to apply for or complete the survey and testing within the specified survey interval;

(2) Failure to apply for survey in time for the loss of integrity of CCUS system due to environmental and accident damage;

(3) Reconstruction and repair of CCUS system that alter the system integrity without the consent of China Classification Society; and

(4) Pending CCUS system problems found in survey but not eliminated within the specified time.

2.1.2.5 After the certificate expires, the validity of the certificate may be restored in any of the following cases:

(1) In the case of 2.1.2.4 (1), after the survey is completed according to the scope of the latest annual/ periodic survey (renewal survey);

(2) In the case of 2.1.2.4 (2), after the operator applies for survey and completes the repair;

(3) In the case of 2.1.2.4 (3), after the operator’s supplementary reconstruction and repair data is qualified in drawing review, and the site supplementary survey is satisfactory;

(4) In the case of 2.1.2.4 (4), after all defects are eliminated and the survey is satisfactory.

Section 2 Drawing Review

2.2.1 General Requirements

2.2.1.1 Before the commencement, the applicant shall submit the drawings as specified in this Section in triplicate or electronic drawings to China Classification Society for review. When necessary, China Classification Society may request extending the scope of design document to be submitted for review.

2.2.1.2 Process documents, system operation manuals, system debugging and testing outlines shall be submitted to China Classification Society for review.

2.2.1.3 If there is any substantial modification or supplement of approved drawings and documents, the applicant shall submit the modified or supplemented parts for review.

2.2.2 Design Documents Submitted for Review

2.2.2.1 The applicant shall submit the following drawings and data. When necessary, China Classification Society may request extending the scope of design documents to be submitted for review.

(1) General specifications;

(2) Component size and layout;

(3) Structural strength analysis report;

(4) Legends, symbols and descriptions of the system diagrams;

(5) Equipment layout;

(6) Division of dangerous areas;

(7) Process flow diagram (PFD);

(8) Piping and instrumentation diagram (P&ID);

(9) Heat & mass balance sheets;

(10) JSA tables;

(11) Causality matrix diagram;

(12) Piping specification;

(13) Piping stress analysis report;

(14) Calculation report for piping diameter and wall thickness;

(15) Specifications and datasheets for skid-mounted equipment;

(16) Sizing calculation report for pressure safety relief valve;

(17) Sizing calculation report for pressure reducing valve;

(18) Design calculation report for vent;

(19) Instrument & control system specification;

(20) Control system diagram;

(21) Combustible gas detection and alarm system diagram;

(22) Electric related drawings.

Section 3 Product Survey

2.3.1 General Requirements

2.3.1.1 The equipment involved in the offshore oil and gas CCUS system shall be subject to product survey to verify its compliance with the requirements of the Guidelines or the client.

2.3.1.2 If no technical requirements are made for the products involved in the Guidelines, such products may be designed, manufactured, surveyed and tested in accordance with the standards recognized by China Classification Society.

2.3.1.3 For the products specified in the Guidelines, appropriate standards may be accepted as substitutes. But they must be qualified in design evaluation, survey during construction, testing and functional tests to prove its equivalence to requirements of the Guidelines.

2.3.1.4 After the equipment involved in the offshore oil and gas CCUS system has passed the survey, relevant certificates and/or other survey documents will be issued to the applicant.

2.3.2 Inspection and Certificate Category

2.3.2.1 Products are surveyed by categories A, B and C.

The equipment shall be surveyed for certification by categories A, B and C (Table 2.3.2.1). It is required that categories A and B equipment should obtain the certificates of China Classification Society, and equipment types shall be indicated in the prominent positions in the certificates; It is enough for Category C equipment to obtain factory certificates. Table 2.3.2.1 presents the minimum requirement for equipment qualified for certification and classification. The applicant and China Classification Society may adjust this table according to the specific production requirements. CA stands for product survey certificate issued by China Classification Society, and W stands for certificate of conformance issued by the manufacturer.

(1) Requirements for certification of Category A equipment

① Design documents shall be reviewed and approved by China Classification Society;

② Before commencement, relevant construction documents shall be reviewed and approved by China Classification Society;

③ Representatives from the interested party and China Classification Society shall attend the kick-off meeting;

④ During the manufacturing process, the survey shall be applied for according to the quality assurance plan;

⑤ Performance, function test, pressure test and load test shall be submitted for survey;

⑥ China Classification Society shall review the equipment manufacturing records.

(2) Requirements for certification of Category B equipment

① Design data related to safety shall be reviewed and approved by China Classification Society;

② The performance test, function test, pressure test and load test shall be submitted for survey;

③ China Classification Society shall review the equipment manufacturing records.

For Category A and Category B equipment, China Classification Society shall audit the quality management system and quality assurance/quality control (QA/QC) system of the manufacturer, further audit the quality plan of the manufacturer before commencement, and identify QC points and survey activity categories.

(3) Requirements for factory certificates of Category C equipment

For safety-related equipment with product certificates provided by the manufacturer and accepted by China Classification Society, the factory shall manufacture in accordance with recognized codes, standards and manufacturing methods.

(4) The equipment not covered by Table 2.3.2.1 shall be surveyed in accordance with the relevant laws and regulations of the competent authority and the requirements of China Classification Society for marine product survey and certification.

(5) The classed marine products in the CCUS system installed on platforms or installations shall be approved according to the Type Approval B of China Classification Society, and shall obtain marine product certificates.

Equipment Survey and Certificate Classification **Table 2.3.2.1**

Equipment name	Survey type			Certificate type	
	A	B	C	CA	W
CO_2 separator skid		×		×	
CO_2 separator		×		×	
Regenerated gas separator skid		×		×	

Equipment name	Survey type			Certificate type	
	A	B	C	CA	W
Regenerated gas separator		×		×	
CO_2 compressor skid		×		×	
CO_2 compressor		×		×	
Regenerated gas compressor skid		×		×	
Regenerated gas compressor		×		×	
Heat exchanger skid		×		×	
Heat exchangers		×		×	
Electric heater skid		×		×	
Electric heater		×		×	
Gas dehydrator skid		×		×	
Gas dehydrator		×		×	
Coalescent filter		×		×	
CO_2 manifold		×		×	
Absorption tower		×		×	
Scrubber		×		×	
Desorber		×		×	
Dryer		×		×	
Rectifier		×		×	
CO_2 storage tank		×		×	
CO_2 barge pump		×		×	
CO_2 condenser		×		×	
Gas detection alarm system		×		×	
Explosion-proof equipment		×		×	
High voltage switchgear		×		×	
Medium voltage switchgear		×		×	
Low voltage switchgear		×		×	
Transformer		×		×	
Non-Exp field instruments (level, pressure and temperature transmitters, including PT, PDT, TT, SDY, LT, LG, XI)			×		×

Section 4 Construction Survey

2.4.1 General Requirements

2.4.1.1 Before the construction of the offshore oil and gas CCUS system, the applicant shall submit a written application to China Classification Society for construction survey, or both parties shall sign a survey contract.

2.4.1.2 Survey of builder's self-made equipment

(1) The builder's self-made equipment shall be designed, reviewed and surveyed according to the requirements for product survey in Section 3 of this Chapter;

(2) When the equipment is assembled into a skid or module, the surveyor shall survey the equipment assembly, piping and electrical installations according to the approved drawings and test procedures, and witness the pressure and functional tests of the equipment or piping within the skid or module.

2.4.1.3 Survey of purchased equipment

(1) Check the certificates of purchased equipment according to the relevant requirements in 2.3.2 of this Chapter;

(2) Check the consistency between the equipment nameplates and the certificates.

2.4.2 Preparation before Survey

2.4.2.1 For the builder undertaking the building task of the offshore oil and gas CCUS system for the first time, the site surveyor shall evaluate the builder's production capacity in aspects of the QA system of production site, facilities and builder, the overall qualification of construction personnel, the subcontracting, etc.

2.4.2.2 Before commencement, the site surveyor shall check and confirm all preparations for the commencement of construction and survey of the builder, including construction preparation work plans, construction/welding procedures, welder/NDT personnel qualifications, product certificate requirements list, welding specifications, NDT charts, tightness test charts, survey/test item tables, relevant construction materials, construction tolerance standards, subcontractors (if applicable) and necessary drawings, documents and technical data before the construction. For some items hardly affect the commencement of construction, the surveyor may check and confirm them before the appropriate construction stage.

2.4.2.3 The site surveyor shall examine the site construction drawings, construction technologies and test programs to verify their compliance with the requirements of the approved drawings and data (including drawing review comments) and relevant rules, and conduct survey according to the approved drawings, data, technologies and test programs.

2.4.3 Survey Requirements during Construction

2.4.3.1 Welding, heat treatment and NDT

Welding, heat treatment and NDT of pressure vessels, pressure pipes and important components shall be in accordance with relevant documents approved by China Classification Society.

2.4.3.2 Set pressure test of safety valve

(1) Verify the installation of the safety valve meets the relevant requirements of the safety protection system in Chapter 6 of the Guidelines;

(2) Verify the safety valve has been verified and calibrated by a qualified professional organization;

(3) Verify the opening/closing pressure of the safety valve meets the requirements;

(4) When the safety valve is debugged in an unauthorized organization, the surveyor shall witness the safety valve test on the spot to verify the safety valve has been debugged and meets the requirements, and is sealed with lead if necessary.

2.4.3.3 Piping prefabrication and installation survey

(1) Verify the piping prefabrication meets the relevant requirements in Chapter 4 of the Guidelines;

(2) Verify the piping installation meets the relevant requirements in Chapters 3 and 4 of the Guidelines.

2.4.3.4 Hydraulic test

(1) The surveyor shall witness the hydraulic test of the system and verify the following conditions are met before the hydraulic test:

① The installation of piping system meets the requirements of design and construction drawings;

② Piping brackets and hangers have been installed, materials and installation positions are correct, connections are reliable and welds are qualified;

③ Welding, heat treatment and NDT have all been completed and qualified;

④ Welds are not painted; dismantling joints are not wrapped and insulated and easy to check;

⑤ Items outside the scope of test, such as safety valves and instruments, shall be effectively isolated before the test.

(2) Verify the types and quality of liquid used in the hydraulic test meet the requirements. Clean fresh water is generally used. When the production process has special requirements, Other liquids, such as flammable liquids, may be used, but their flash points shall be ≥60℃;

(3) Verify the ambient temperature of the hydraulic test meets the requirements. The hydraulic test should be carried out at an ambient temperature above 5℃. When the ambient temperature is ≤5℃, anti-freezing measures shall be taken;

(4) Verify the temperature of the liquid used in the hydraulic test meets the requirements:

① Non-alloy steel and low-alloy steel pipes: ≥5℃;

② High-alloy steel pipes: ≥15℃ and higher than the ductile-brittle transition temperature of the corresponding metal material.

(5) When the system made of austenitic stainless steel is subjected to pressure test with water, the Cl^- in the water shall be ≤25mg/L;

(6) Verify the hydraulic test pressure meets the design requirements;

(7) Verify the system has been purged and cleaned before and after the hydraulic test;

(8) Verify all the air in the system has been vented before the hydraulic test;

(9) Verify the pressurization and depressurization are carried out slowly during the hydraulic test;

(10) Conduct a comprehensive and detailed check of the system during the pressure holding period of the hydraulic test and verify no leakage. The pressure holding duration shall be no less than 10 minutes;

(11) The surveyor shall sign the test record after confirming that the hydraulic test has been completed and meets the requirements.

2.4.4 Comprehensive check before commissioning

2.4.4.1 For the qualified construction and installation of equipment/skids and systems before commissioning, the CCUS system shall be surveyed according to the approved documents.

2.4.4.2 Check of mechanical completion data

The check of mechanical completion data mainly involves the following items:

(1) Check the construction inspection report details, including piping hydraulic test, piping tightness test, construction material certificates, construction party inspection reports, welding quality inspection report, electric system insulation resistance withstand voltage test report and other necessary inspection reports. Confirm there are no remaining items, especially as proposed in the rectification comments of China Classification Society;

(2) Check the factory certification documents of the equipment and confirm there are no remaining test items;

(3) Check the purging records of equipment and piping and ensure the cleanliness inside the equipment and piping.

2.4.4.3 Equipment check

(1) Verify the equipment nameplate is firm, durable, clear and correct;

(2) Verify the equipment, signs or codes are correct;

(3) Verify the position, direction and quantity of the equipment are correct;

(4) Verify the special tools of the equipment are complete;

(5) Verify the equipment, accessory parts, piping, instruments and wires are intact;

(6) Verify all rotating parts are provided with safety protection measures and the mechanical seals are in good condition;

(7) Verify all connecting bolts have been tightened;

(8) Verify the equipment has been assembled and installed according to the installation procedures and the manufacturer's instructions;

(9) Verify the equipment is firmly connected with the base;

(10) Verify the equipment base is firmly connected with the main structure;

(11) Verify all piping and electric connections between the skid and the equipment are normal;

(12) Verify all coatings, insulations, brackets and bracket installations are qualified;

(13) Verify appropriate heat insulation and anti-freezing measures have been taken;

(14) Verify the operation and maintenance passages and spaces meet the design requirements;

(15) Verify the operating platform, railings and ladders meet the design requirements;

(16) Verify there are no sundries and dangerous goods around the site;

(17) Verify there is no foreign matters or liquid accumulation inside the equipment or vessels, and the coating is intact;

(18) Verify all internal structures, partitions, devices, piping are securely installed and correctly arranged;

(19) Verify all vessel manhole and handhole covers have been tightened;

(20) Verify the anti-corrosion lining inside the equipment is intact;

(21) Verify all lubricating oils, heat exchange fluids and additives used for equipment commissioning are available.

2.4.4.4 Check of piping

(1) Verify the piping arrangement is neat and easy for inspection and maintenance;

(2) Verify the dismantling joints within the piping are kept at the minimum quantity as required;

(3) Verify there is no additional stress on the piping after free alignment of piping installed on the equipment;

(4) Verify all piping supports are qualified;

(5) Verify the quantity, type and diameter of valves meet the design requirements;

(6) Verify the valve inlet/outlet and the flow direction are correct;

(7) Verify the valve rotating direction and opening/closing state are indicated correctly;

(8) Verify the safety valve is mounted vertically;

(9) Verify the size and installation of the inlet and outlet pipes of the safety valve;

(10) Verify the installation direction of the filter is correct;

(11) Verify it is easy to replace the filter and to clean the filter element;

(12) Verify the quantity, arrangement and quality of shutdown valves meet the design requirements;

(13) Verify the heat insulation and heat tracing of the piping meet the requirements.

2.4.4.5 Check of electric systems

(1) Verify the wiring of power, control, safety and signal circuits is correct;

(2) Verify the safety circuit is independent of the control circuit;

(3) Verify the alarm and safety circuits conform to the fail-safe principle;

(4) Verify the cable model and specifications meet the design requirements;

(5) Verify the cable is arranged reasonably, not easy to be damaged, and far away from heat sources and liquid leakage sources;

(6) Verify the cable is installed firmly and neatly, and it is convenient to check the line;

(7) Verify the conductive connection and grounding connection are effective and correct;

(8) Verify the equipment, instruments and instrument cables meet the design requirements;

(9) Verify the control panel of the equipment is in good condition, reasonably arranged and easy to operate;

(10) Verify the system control and alarm instructions in the central control room are complete and intact;

(11) Verify the operating position of emergency shutdown meets the design requirements.

2.4.4.6 Check of instrument and control systems

(1) Verify all instruments installed in the system have been verified and calibrated by professional departments;

(2) Verify the instrument appearance is neat and the digital symbols are clear;

(3) Verify the instrument installation positions are correct;

(4) Verify the instrument indications are back to zero or in normal indication.

2.4.5 Check/Test of Equipment and Skid-Mounted Equipment

2.4.5.1 Check the installation of equipment and system, and verify the performance and operation of the equipment meet the design requirements. Check/test items generally include but not limited to appearance inspection, internal inspection, insulation inspection, simulation test, start-stop test, operation test, vibration and noise test, etc.

2.4.5.2 Pumps

(1) Visual inspection;

(2) Insulation testing, i.e. testing the insulation resistance of the motor in cold and hot states;

(3) Alarm and shutdown function tests of the safety device;

(4) Start- stop test;

(5) Check the performance parameters of the pump and the parameters of the motor or diesel engine. The running performance of the pump shall meet the requirements of the Q-H curve of the manufacturer;

(6) Measure and make sure the bearing temperature meet the manufacturer’s requirements or the specifications;

(7) Measure the vibration values and noise values.

2.4.5.3 Compressors

(1) Visual inspection;

(2) Insulation inspection: test the insulation resistance of the motor at cold and hot states;

(3) Test the following alarm and shutdown protections by simulation test method. The test generally includes:

① Lubricating oil low pressure alarm and shutdown;

② Gas - high temperature alarm and shutdown;

③ Gas - high and low pressure alarms and shutdown;

④ Gas filter and oil-gas separator - high pressure difference alarm and shutdown;

⑤ Dew point - high temperature alarm;

⑥ Cooler outlet - high temperature alarm and shutdown;

⑦ Central control shutdown and local emergency shutdown test.

(4) Start- stop test;

(5) Check the automatic unloading and loading function of the compressor during the running test, and measure the parameters of the compressor, motor and auxiliary equipment;

(6) Measure the vibration values and noise values.

2.4.5.4 Heat exchanger

(1) Visual inspection;

(2) The pressure and temperature at the inlet and outlet of the heat exchanger meet the design requirements;

(3) The alarm and shutdown function tests of the safety device are qualified.

2.4.5.5 Pressure vessels

(1) Visual inspection and internal inspection;

(2) Test the following alarm and shutdown protections by simulation test method. The test generally includes:

(1) High and low pressure alarms and shutdown protection;

(2) High and low level alarms and shutdown protection;

(3) High temperature alarm and protection.

2.4.5.6 Towers

(1) Visual inspection and internal inspection;

(2) Test the following alarm and shutdown protections by simulation test method. The test generally includes:

(1) High and low pressure alarms and shutdown protection;

(2) High and low level alarms and shutdown protection;

(3) High temperature alarm and protection.

2.4.5.7 Gas detection and alarm system

(1) Verify the installation of gas detection and alarm system meets the relevant requirements in Chapter 5 of the Guidelines;

(2) Verify the gas detector has been verified and calibrated by a qualified professional organization;

(3) Verify the gas detection and alarm system has been debugged and meets the requirements.

2.4.5.8 CO_2 manifolds

(1) External inspection;

(2) Check whether there is leakage or looseness at the joints such as flanges, valves and fittings;

(3) Hydraulic test;

(4) Verify the safety alarm and shutdown function tests are qualified.

2.4.6 Check/test of submarine CO_2 pipeline system

2.4.6.1 The construction survey of submarine CO_2 pipeline system shall meet the applicable requirements of the *Rules for Submarine Pipeline Systems* issued by China Classification Society.

2.4.7 Trial operation

2.4.7.1 Before trial operation, the CO_2 gas source shall be accessed step by step according to the approved procedures. The surveyor shall verify the access procedures are implemented and meet the design requirements of system operation.

Section 5 Post-construction Surveys

2.5.1 General Requirements

2.5.1.1 In order to ensure the safety of CCUS system in production, surveys as specified in this Section shall be fulfilled.

2.5.1.2 The owner or operator shall apply to China Classification Society for surveys in a timely manner to maintain the validity of the certificates, make good preparations for the survey items and provide safety measures for the surveys according to the requirements of the Guidelines.

2.5.1.3 In case of any damage or defect affecting the validity of the certificate found during the survey, the surveyor shall promptly notify the applicant of the handling comments and handle the damage or defect.

2.5.2 Survey Types and Cycles

2.5.2.1 Annual surveys

The CCUS system shall be surveyed annually. The annual survey shall be carried out within 3 months before and after the date of the first periodic survey after the construction survey or the date of the last periodic survey (renewal survey).

2.5.2.2 Periodic surveys (renewal survey)

The CCUS system requires a periodic survey (renewal survey). The survey interval shall not exceed 5 years and may be within 3 months before or after the existing certificate expires.

2.5.2.3 Occasional surveys

When the CCUS system is damaged and may affect the system safety, or it is modified, repaired or replaced, or the conveying medium or conditions are changed, the owner/operator shall timely apply to China Classification Society for occasional survey of the CCUS system.

2.5.3 Annual surveys

2.5.3.1 Survey items

(1) Civil/structure

① Verify there are no changes in civil/structures that affect safety of buildings and structures;

② Check the overall civil/structures of the onshore terminals, with special focus on the settlement of large-scale buildings and structures and structural frames;

③ Check the settlement of tanks or towers;

④ Check the anticorrosive coatings and fireproof coatings;

⑤ Check the connections at bolt connectors and weldments;

⑥ Check the changes of structures or loads that may affect the structural integrity.

(2) CCUS system

① General

a. Ask the operators about the operation of the whole system;

b. Check the operation logs and maintenance records of the CCUS system;

c. Check whether the general arrangement has changed.

② Safety protection device

a. Check the technical status of high pressure and low pressure control systems, and carry out alarm and shutdown action tests under permitted conditions;

b. Check the temperature control system, and conduct alarm and shutdown action tests if conditions permit;

c. Check the level gauges and level control system, and conduct alarm and shutdown action tests if conditions permit;

d. Check the technical status of the safety valves externally and check the verification or calibration certificate of the safety valves;

e. Check the stop valves before the safety valves and check the locking devices;

f. Check the technical status of the pressure reducing valves;

g. Check the technical status of the shutdown valves externally;

h. Check the emergency shutdown station externally, and conduct shutdown action tests if conditions permit;

i. Check the integrity of gas detectors and alarm devices, conduct function tests on gas detectors and alarm devices, and check whether the wiring of detectors and junction box meets the requirements of applicable IP grade and explosion-proof grade.

③ Pressure vessels (including tanks and towers)

a. Check the safety operation manuals of vessels;

b. Implement the requirements of the last periodic survey (renewal survey) or annual survey;

c. Check the insulation wrapping conditions of the vessels;

d. Check the un-insulated vessels for corrosion, deformation, cracks and other defects;

e. Check the outer surfaces of tank or tower wall plates and top plates for deformations, structural damages, corrosion and leakage;

f. Check the manholes, handholes, flanges, pup pieces and other accessories of the vessels for leakage and screw looseness;

g. Check the welds and conduct NDT when necessary;

h. Measure the thickness of the severely corroded parts of the structure when necessary;

i. Check whether the supporting structures, operation platforms, ladders and handrails are in good condition;

j. Check the grounding condition;

k. Record the instrument parameters;

l. Check and test the liquid level indication and monitoring system;

m. Check and test the heating, temperature indication and monitoring system.

④ Rotary machinery

a. In the running state, conduct external inspection on the rotary machinery to check whether the moving parts are operating normally and whether there is leakage;

b. Record the parameters.

⑤ Piping

a. Check whether there are serious defects such as deformation and corrosion;

b. Check whether there is leakage or looseness at the joints such as flanges, valves and accessories;

c. Check whether the supports and pipe clamps are fastened;

d. Check whether the insulation is intact;

e. Check whether the piping is severely vibrating;

f. Check the expansion compensation of the piping.

(3) Electric equipment and automatic control

① Conduct overall inspection for electric machinery, distribution panels, switchgears, etc. and the inspection in the running state;

② Check the integrity of preventive measures against electric shock, electric fire, static electricity, lightning and other disasters caused by electricity;

③ Conduct function test on general alarm system;

④ Check the electric equipment in hazardous areas to verify these equipment are in good working condition and the explosion-proof grades meet the explosion-proof requirements of each area;

⑤ Conduct an overall inspection of automatic equipment, check operation records and verify its safety system and control system are in normal state;

⑥ Check the electric heat tracing system:

a. Visually check the integrity of the electric heat tracing system;

b. Check the operation and maintenance records to learn about the system operation and component replacement;

c. Check whether all control systems are in good and normally operating conditions;

d. Test the grounding failure alarm devices of electric heat tracing system;

e. Check the electric connections in the system for looseness and seals for damages.

(4) Check the corrosion prevention, heat insulation and cold insulation

① Check the cathodic current protection system and check the records of output voltage, output current and protection potential;

② Check or try to learn about the appearance of locally sacrificial anodes;

③ Check the corrosion prevention, heat insulation and cold insulation of equipment and piping.

(5) Submarine pipeline system for CO_2 transport

The annual survey shall meet the requirements of Chapter 2, Section 2 of the *Guidelines for Survey of In-Service Submarine Pipelines* issued by China Classification Society.

2.5.4 Periodic Survey (Renewal Survey)

In addition to the annual items specified in this Section, the following items shall also be surveyed:

2.5.4.1 Pressure vessels (including tanks and towers)

(1) The pressure vessel shall be surveyed internally in open state whenever possible. If internal survey can hardly made for small heat exchangers, scrubbers or pressure vessels with pressure ≥0.7MPa, the internal survey can be replaced by hydraulic tests at 1.25 times of working pressure or thickness measurement when approved by China Classification Society.

(2) Check the base structures of pressure vessels and other equipment.

(3) Clean the tank interior when possible, and check the internal structures and welds. In special circumstances, an alternative survey method may be adopted but it shall be approved by China Classification Society.

(4) Thickness measurement and structural evaluation

① Measure the thickness of the tank and base structure. The quantity of thickness measurement points shall reflect the overall corrosion of the structure;

② The corrosion addition of tank structure shall not exceed the designed value;

③ The corrosion allowance of the base structure shall meet the design requirements;

④ Carefully analyze the thickness measurement report, and make overall evaluation of the tank structure. Evaluation calculation may be required if necessary. The surveyor shall, on the basis of evaluation, present necessary repair requirements, use restrictions and expanded survey requirements for annual survey.

(5) NDT

100% magnetic particle testing shall be conducted for longitudinal butt welds of the bottom ring steel plates of tank or tower walls, as well as the fillet welds between tank walls and tank bottom plates. The testing percentage for welds at other positions may depend on site conditions.

(6) After heavy repairs or when the surveyor thinks necessary, a strength test may be required for the tank or tower. The requirements for strength test are consistent with those of construction survey.

2.5.4.2 Dismantle the rotatory machinery for survey when possible.

2.5.4.3 Electric equipment

(1) Conduct insulation test for electric circuits in the hazardous areas;

(2) Whenever possible, conduct function tests on key motors and their control devices under working conditions;

(3) Check the damages of guards of main cables and electric equipment, and measure the insulation resistance of power supply cables of important electric equipment.

2.5.4.4 Submarine pipeline system for CO2 transport

Periodic survey (renewal survey) shall meet the requirements of renewal survey in Chapter 2, Section 3 of the *Guidelines for Survey of In-Service Submarine Pipelines* issued by China Classification Society.

Chapter 3 General Rules for System Design

Section 1 General Provisions

3.1.1 General Requirements

3.1.1.1 CCUS system shall have the following functions:

(1) The system design shall adapt to the external environment of marine and the internal environment of transported fluid;

(2) The designed strength and tightness of the system shall be sufficient for the transported fluid;

(3) The system shall have redundant safety protection measures and the capability to prevent undesireble events;

(4) The system shall have the capability to shutdown after fluid leakage;

(5) The system shall have the capability of collection and harmless emergency treatment after fluid leakage;

(6) The system shall have the capability to dispose of the released fluid (liquid separation and cold venting);

(7) The system shall have redundant capacity of CO_2 storage;

(8) Equipment of the system, including elements and instruments, shall be suitable for the intended purposes;

(9) The system installation shall be firm, reliable and free of additional stress;

(10) The system layout shall benefit for safety, environment and easy operation and maintenance.

3.1.1.2 Asbestos materials are prohibited in offshore oil and gas CCUS system.

3.1.1.3 CO_2 utilization process shall consider all impacts of possible phase changes during its processing.

3.1.2 Design Pressure

3.1.2.1 The design pressure of CCUS system equipment and piping shall meet the relevant requirements of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

3.1.3 Design Temperature

3.1.3.1 The design temperature of CCUS system equipment and piping shall meet the relevant requirements of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

3.1.4 Personal Protection

3.1.4.1 Guards, railings or other safety protection facilities shall be set for the moving parts that may cause harm to staff.

3.1.4.2 All unprotected open deck areas, walkways and the edges of deck openings shall be provided with reliable safety protection railings.

3.1.4.3 Anti-skid measures shall be considered for all floors of workplaces and walkways and the ladder surfaces where people often access, so as to ensure the safety of people.

3.1.4.4 Eye-catching signs shall be set at all places where fetters, bumps and falls may occur.

3.1.4.5 Walkways shall have appropriate clearance height; Handrails and railings shall be set on both sides of the ladder. The treads shall be non-slip, and the included angle between the ladder

and the floor shall not be greater than 50°.

3.1.4.6 In order to avoid personnel burning, the high-temperature surface shall be insulated and wrapped to control its surface temperature below 60℃. If this requirement cannot be met, fences shall be erected to prevent personnel from touching the high-temperature surface. Appropriate heat insulation protection shall be taken for the surface below 0℃.

3.1.4.7 Preventive measures shall be taken to prevent electric shock, electric fire and other electric disasters.

3.1.5 Prevention of Misoperation

3.1.5.1 The equipment shall be arranged to prevent facilities and personnel from being in danger due to single operation error.

3.1.5.2 The equipment and piping shall be arranged to prevent equipment and personnel from being threatened by leakage or valve misoperation.

3.1.5.3 ESD and other similar manual buttons shall have protective covers to prevent misoperation.

3.1.5.4 Valves shall be provided with obvious opening and closing identifications.

3.1.5.5 In order to avoid mistakes of mechanical equipment and systems in operation and conversion, safety operation instruction signs and labels shall be set at conspicuous places.

3.1.6 Heat Insulation and Heat Tracing

3.1.6.1 The pipes, flanges and valves transporting high temperature or easily frozen media shall be thermally insulated. The insulation materials shall be nonflammable or flame retardant.

3.1.6.2 Effective cold insulation measures shall be taken for cryogenic equipment.

3.1.7 Low temperature prevention measures

3.1.7.1 When necessary, the cryogenic piping and its adjacent steel structures shall be thermally isolated to prevent the temperature of steel structures from dropping below the design temperature of their materials. When some liquid piping is frequently disconnected or may be subjected to liquid leakage (such as at joints and cargo pump shaft seals), protective measures shall be taken for the steel structure below it.

3.1.8 Drainage and Venting Devices

3.1.8.1 All systems shall be fitted with drain valves or plugs on equipment such as pumps and filters, as well as piping as required.

3.1.8.2 Vent valves shall be set on equipment, components and piping for the purposes of system operation and maintenance.

3.1.8.3 The vent outlet shall be kept away from places of personnel activities.

3.1.9 Electrostatic Control

3.1.9.1 The equipment and piping in hazardous areas shall be reliably grounded, and the resistance between them and the platform structure shall not exceed 1MΩ.

Section 2 General Arrangement

3.2.1 General Requirements

3.2.1.1 The general arrangement of CCUS systems on fixed platforms shall meet the relevant requirements of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

3.2.1.2 The general arrangement of CCUS systems on mobile units shall meet the relevant

requirements of the *Rules for Classification of Mobile Offshore Units* issued by China Classification Society.

3.2.1.3 The general arrangement of CCUS systems on floating installations shall meet the relevant requirements of the *Rules for Classification of Offshore Floating Installations* issued by China Classification Society.

3.2.1.4 The general arrangement of CCUS systems on the onshore terminal shall meet the relevant requirements of the *Guidelines for Certification and Survey of Offshore Oil Onshore Terminals* issued by China Classification Society.

3.2.1.5 The general arrangement of CCUS systems on artificial islands shall meet the applicable requirements of relevant laws, regulations, codes and standards.

3.2.2 Equipment Layout

3.2.2.1 Equipment shall be set on an open deck with good ventilation.

3.2.2.2 The equipment layout shall be such that the risk of personal injury caused by the CO_2 accumulation after leakage can be lowered. If it is unavoidable, effective ventilation shall be provided.

Chapter 4 Equipment and Piping

Section 1 General Provisions

4.1.1 General Requirements

4.1.1.1 The design, construction, installation and test of equipment and piping of offshore oil and gas CCUS system shall meet applicable requirements of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

4.1.2 Design load

4.1.2.1 The design of equipment and piping of offshore oil and gas CCUS system shall consider all applicable environmental, operation and test loads or their combined effects, including but not limited to:

(1) Environmental load

① Earthquake;

② Wind;

③ Snow (if applicable);

④ Temperature.

(2) Operation load

① Static pressure;

② Bending;

③ Instantaneous pressure fluctuation;

④ Vibration;

⑤ Temperature fluctuation;

⑥ Inertia force generated by movement of offshore installation or unit where the equipment is located;

⑦ Hydrostatic head;

⑧ Pulling force.

(3) Loads generated during equipment transport;

(4) Load generated during equipment installation;

(5) Load generated during equipment commissioning;

(6) Test load.

Section 2 Materials

4.2.1 General Requirements

4.2.1.1 The chemical composition, mechanical properties, construction and test of equipment and piping materials shall conform to the relevant requirements of the *Rules for Material and Welding* issued by China Classification Society or the rules and standards accepted by the Guidelines.

4.2.1.2 The equipment and piping materials shall fit their internal media and their purposes, and slow down the occurrence of corrosion, hardening and decomposition.

4.2.1.3 The design of equipment and piping shall consider the low temperature conditions that

may occur when CO_2 leaks or vents.

4.2.1.4 Materials (including paints) of equipment, pipelines and parts in contact with seawater shall be harmless to marine life.

4.2.2 External Corrosion Prevention

4.2.2.1 Equipment and piping exposed to marine environment or other corrosive environment shall be made of corrosion-resistant materials or provided with effective external corrosion prevention measures.

4.2.2.2 Where corrosion-resistant coatings are applied, the selected external corrosion-resistant coatings shall have excellent heat and low temperature resistance and meet other design requirements.

4.2.2.3 Aluminum-containing coatings shall not be used in hazardous areas.

4.2.3 Internal Corrosion Prevention

4.2.3.1 Generally, one or more of the following measures shall be taken for internal corrosion prevention of steel equipment and piping:

(1) Selection of corrosion-resistant materials, including high-alloy materials;

(2) For carbon steel materials, corrosion addition shall be considered in the design;

(3) Addition of corrosion inhibitor;

(4) Dehydration treatment;

(5) Internal lining or coating (if applicable).

4.2.3.2 Corrosion-resistant materials are recommended for piping and equipment before CO_2 dehydration.

4.2.3.3 The equipment and piping for treating H_2S-containing media shall meet the requirements of the requirements of the *Petroleum and Natural Gas Industries—Material for Use in H_2S-Containing Environments in Oil and Gas Production* (GB/T 20972).

4.2.3.4 Where there are different metals mutually connected within the system, measures shall be taken to prevent electrochemical corrosion.

4.2.3.5 When the pressure of CO_2 piping is released, the temperature in the pipeline will drop sharply, and the coating will peel off from the pipe wall. Therefore, internal coating is not suitable for corrosion prevention or drag reduction.

4.2.4 Welding and NDT

4.2.4.1 The welding and NDT of equipment and piping shall conform to applicable requirements in Part 3 of the *Rules for Material and Welding* issued by China Classification Society or the rules and standards accepted by the Guidelines.

Section 3 Equipment

4.3.1 General Requirements

4.3.1.1 The design of equipment shall consider the design scale, process flow, fluid characteristics, design pressure and temperature.

4.3.1.2 The equipment shall be designed, constructed, installed and tested in accordance with the codes and standards listed in 1.3.2 of the Guidelines.

4.3.1.3 The equipment shall also meet applicable requirements of main equipment in Chapter 9 of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

4.3.2 Pressure Vessels, Towers and Heat Exchangers

4.3.2.1 The design of pressure vessels, towers and heat exchangers shall conform to the relevant requirements of the standards accepted by the Guidelines.

4.3.2.2 In addition to the requirements of strength and stability, the pressure vessels, towers and heat exchangers shall meet the rigidity requirements for lifting and transport.

4.3.2.3 The design of storage tanks shall meet the following requirements:

(1) The filling coefficient of the storage tank shall not be greater than 0.9;

(2) Cold insulation measures shall be taken for the storage tanks. The calculation of the cold insulation thickness shall conform to the relevant requirements of the current national standard: *Code for Design of Industrial Equipment and Pipeline Insulation Engineering* (GB 50264).

4.3.2.4 The installation of auxiliary equipment for storage tanks shall meet the following requirements:

(1) The storage tank shall be fitted with a full-lift sealed safety valve and a standby safety valve. The relief capacity of the standby safety valve shall not be less than that of the main safety valve;

(2) A cut-off valve shall be set between the safety valve and the storage tank. The cut-off valve shall be in the lead seal open state during normal operation;

(3) The inlet and outlet pipes of a storage tank shall be fitted with a remotely operated cut-off valve;

(4) The gas discharge pipe of the liquid storage tank with a single tank volume greater than 200m^3 shall be fitted with a remotely operated relief valve;

(5) The storage tank shall be fitted with local and remote temperature instruments. High-temperature alarm shall be set for temperature detection;

(6) The gas part of the storage tank shall be fitted with local and remote pressure instruments. The pressure detection shall be provided with the high-pressure alarm, as well as the high-pressure alarm automatically interlocked with relief valve opening;

(7) The storage tank shall be fitted with local and remote level meters. The liquid level detection shall be fitted with the high & low level alarms, the HH level alarm interlocked with closing shut-off valve at the storage tank inlet, and LL level alarm interlocked with opening shut-off valve at the storage tank outlet or stopping the pump.

4.3.2.5 The selection of heat exchangers shall meet the following requirements:

(1) The temperature difference between the cold ends of plate heat exchanger and shell-and-tube heat exchanger shall meet the process design requirements;

(2) Plate heat exchangers should be used for lean and rich liquid heat exchangers;

(3) Thermosyphon or kettle reboilers should be selected.

4.3.3 Compressors

4.3.3.1 The compressor sets shall meet the following requirements:

(1) Inlet and outlet pipes shall be fitted with automatic cut-off valves and automatic vent valves;

(2) Compressor inlet and outlet shall be fitted with pressure limit alarms interlocked with shutdown;

(3) The lubricating oil and cooling water system of the compressor sets shall be fitted with pressure and temperature alarms. The lubricating oil system shall be fitted with LL pressure alarm interlocked with shutdown, and the cooling water system shall be fitted with HH temperature alarm interlocked with shutdown;

(4) The air cooler fan in the compressor sets shall be provided with vibration overrun alarm interlocked with shutdown;

(5) Centrifugal compressor shall be provided with surge monitoring and control measures;

(6) The dry gas sealing system of centrifugal compressor shall be provided with a relief alarm;

(7) Safety valves shall be fitted on the inlet pipe and outlet pipes of the reciprocating or centrifugal compressor.

4.3.3.2 When CO_2 is injected in gaseous state, the injection equipment shall be compressor, and the following requirements shall be met:

(1) The models and quantity of gas injection compressors shall depend on the design scale, such as total flow, total pressure ratio and injection pressure, as well as the standby mode of equipment;

(2) The reciprocating compressor should be used for gas injection; For large gas injection and acceptable efficiency services, centrifugal compressors should be used;

(3) CO_2 gas detectors shall be set around the compressor sets to detect CO_2 leakage in real time.

4.3.4 Pumps

4.3.4.1 Pumps shall meet the following requirements:

(1) Mechanical seals should be selected as shaft seals of centrifugal pumps and rotor pumps;

(2) Centrifugal pumps should be self-venting;

(3) A safety valve shall be set at the outlet of the positive displacement pump. The relief capacity of the safety valve shall not be less than the maximum displacement of the pump;

(4) The positive displacement pump should adopt packing or piston ring seals. For the positive displacement pump installed in a closed space, a seal leakage collection and drainage device shall be set;

(5) The inlet and outlet of the positive displacement pump shall be provided with pressure pulsation buffer tanks;

(6) The pump shall be fitted with necessary safety protection devices, such as monitoring and alarm of vibration and temperature, and override and overrun shutdown.

4.3.4.2 When the CO_2 is injected in liquid state, the injection equipment shall be pump.

4.3.4.3 The models and quantity of injection pumps shall depend on the design scale, such as total flow, total head, NPSH, injection pressure and medium temperature, as well as the standby mode of equipment.

4.3.5 CO_2 Manifolds

4.3.5.1 The layout of manifold shall make each valve easy to access and operate.

4.3.5.2 The design of manifold shall limit the maximum flow velocity. The length of piping directed to the production header should be as short as possible, and the quantity of bends shall be kept at a minimum.

4.3.5.3 The ends of all trunk pipes of the manifold shall be plugged with blind flanges, so as to provide buffer for fluids and provide chances for later expansion of manifold.

4.3.5.4 There shall be a reinforced welding socket for the welding of each branch pipe and trunk pipe. After welding, the pipe interior from branch pipe to trunk pipe shall have smooth transition without burr.

Section 4 Piping

4.4.1 General Requirements

4.4.1.1: This section is applicable to the piping of offshore oil and gas CCUS systems for treating CO_2 medium, but not to long-distance CO_2 pipelines.

4.4.1.2 Utility and other system piping, which serves but is not included in the offshore oil and gas CCUS system, shall meet the applicable requirements of CCS rules or acceptance standards applicable to the platforms or installations where the offshore CCUS system is located.

4.4.2 Piping Design

4.4.2.1 The piping shall be designed to withstand the most severe combination of pressure, temperature, loads and working environment.

4.4.2.2 In addition to the danger of transporting media, the piping design and its defect evaluation after operation shall consider the following factors but not limited to:

(1) Internal and external pressures;

(2) Flow velocity and erosion;

(3) Corrosion;

(4) Vibration, including stress caused by instantaneous vibration;

(5) Water hammer;

(6) Pressure pulsation;

(7) Extreme temperature, including the impact of high and low temperatures of medium and environment;

(8) External impact loads;

(9) Leakage;

(10) Transfer stress from the connected equipment or supports.

4.4.2.3 The pipe wall thickness can be calculated and determined with reference to a recognized standard, but the calculation result shall be approved by China Classification Society.

4.4.2.4 Failure mechanism, fatigue effect and thermal stress shall be considered for piping with diameter-thickness ratio $D/\delta \leq 6$ or design pressure $\geq$ 42MPa.

4.4.2.5 The selection of piping and fittings shall consider the characteristics of medium, various possible operating conditions and the requirements of external environment.

4.4.2.6 The materials of piping and its components shall have good toughness and weldability. The toughness index requirements shall be based on fluid properties, operating conditions and external environment.

4.4.2.7 The materials of pipe fittings and flanges shall be compatible with the materials of the piping connected with them.

4.4.2.8 The valves shall be selected considering the following requirements:

(1) The type and structure of the valve and the materials of its components shall depend on fluid properties, design temperature and design pressure;

(2) Grease or sealing grease should not be used for valves. If it must be used, petroleum-based or synthetic grease at valves and pumps shall be optimized according to the composition, pressure and temperature of CO_2 medium, so as to prevent grease deteriorating and ensure its normal performance;

(3) Valves on the low-temperature medium piping should be installed on the horizontal sections, and the valve stems shall be vertically upward;

(4) Valves with closed cavity structures shall have overpressure relief function;

(5) If ammonia is used for refrigeration, the valve on the ammonia piping shall be a stop valve special for ammonia rather than a gate valve, and shall not contain copper and alloy parts.

4.4.2.9 For piping sensitive to stress corrosion, measures shall be taken to prevent stress corrosion cracking in material selection, construction and construction technical requirements.

4.4.2.10 The dismantling joints in piping shall be kept at a minimum quantity required for maintenance and inspection.

4.4.2.11 Stress analysis is required for piping. It is necessary to take into consideration all stresses caused by piping and its frosting weight, including accelerated load, internal pressure, thermal shrinkage and loads caused by hogging and sagging of each branch of the piping system.

4.4.2.12 The materials of all piping in evaporator shall consider the influence of the physical and chemical properties of the medium in the piping.

4.4.3 Piping Layout

4.4.3.1 The piping layout shall be kept neat and orderly, concentrated in rows, and provided with a certain distance from the floor, roof and wall plate to facilitate maintenance and inspection.

4.4.3.2 In order to ensure piping tightness, welding should be adopted for piping connection if possible.

4.4.3.3 The piping shall be designed and arranged to prevent gas pockets formed in the liquid piping and liquid pockets formed in the gas piping.

4.4.3.4 The arrangement of flanges, fittings and valves in piping shall be convenient for inspection, maintenance and operation.

4.4.3.5 The arrangement of equipment, components and piping shall prevent leaked or overflowed liquid from spraying onto charged objects.

4.4.3.6 The installation of piping on the equipment shall be centered and aligned without additional stress on the equipment arising from piping installation. Vibration compensation measures shall be provided for the equipment with large vibration.

4.4.3.7 The prevention of piping vibration shall not limit piping expansion and maintenance.

4.4.3.8 The pipe supports of high-pressure piping system shall be fitted with shock and energy absorption devices.

4.4.3.9 No CO_2 piping shall pass through living quarters, control stations or other service premises.

Chapter 5 Electricity, Instruments and Control Systems

Section 1 General Provisions

5.1.1 General Requirements

5.1.1.1 The electric equipment, cables, instruments and control systems of offshore oil and gas CCUS system shall meet the codes and standards as referenced by the system-applied platforms or installations.

5.1.1.2 Offshore oil and gas CCUS systems shall be fitted with automatic monitoring and control systems.

5.1.1.3 Instrument and control system, gas detection and alarm system and emergency shutdown system shall be powered by the main power supply. When the main power supply fails, they can be automatically connected to the standby battery pack or continuously powered by uninterruptible power supply (UPS). Battery pack or UPS capacity shall be sufficient for supplying power for at least 30 min.

5.1.1.4 Gas detection and alarm system

Gases (e.g. CO_2 and NH_3) may be generated in the production process and may cause suffocation or toxicity. Gas detection and alarm system shall be set up at places where gas may leak or accumulate.

Section 2 Technical Requirements

5.2.1 Gas Leakage Detection

5.2.1.1 CO_2 gas detectors shall be set at places where CO_2 may leak or accumulate. Visual and audible alarm devices shall be set at local and centralized control rooms.

5.2.1.2 Detectors shall be installed at places without impact, vibration or strong electromagnetic interference, where it is easy to repair. The clearance between the installed detector and the surrounding process piping or equipment shall not be less than 0.5m. The detector shall be 0.3m~0.6m higher than the deck/floor.

5.2.1.3 Ammonia refrigeration plant area shall be provided with fixed ammonia detection devices (if applicable).

5.2.2 Instrument Explosion-Proofing and Protection

5.2.2.1 The test and detection devices installed in hazardous areas shall meet the explosion-proof requirements of the hazardous areas.

5.2.2.2 The IP grades of instruments and equipment installed outside the premises shall not be lower than IP56.

Chapter 6 Process Safety System

Section 1 General Provisions

6.1.1 Scope of Application

6.1.1.1 The safety system in this Chapter may only apply as a safety protection measure in case of accidents in the process of offshore oil and gas CCUS, and a shutdown measure in case of accidents.

6.1.1.2 The safety system requirements for inflammable and explosive hazardous media in the system shall meet applicable requirements of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

6.1.2 Design and Analysis of Safety System

6.1.2.1 In the design of safety systems, safety analysis should be conducted for each process unit to identify potential unexpected events, analyze the causes and consequences of such events, identify detectable abnormal states, and determine corresponding safety protection measures.

6.1.2.2 Safety protection measures shall meet the following requirements:

(1) The safety system shall have two levels of protection (primary or secondary) to prevent or minimize the failure impact of equipment in the process system;

(2) If a single safety device cannot provide complete primary or secondary protection, several safety devices may be combined to provide the desired protection;

(3) The safety devices for two-level protection shall be independent of the control devices used in normal process operation;

(4) The primary protection shall be faster, safer and more reliable than the secondary protection. The primary protection device provides the highest order, and the secondary protection device provides the next highest order.

6.1.2.3 If a processing unit is unimpeded till its upstream/downstream unit and is not isolated in the operating state, but it can be protected by the safety device of its upstream or downstream unit, the safety device required by the processing unit can be omitted.

6.1.2.4 When the safety device detects an accident, it shall give an audible and visual alarm in the manned control station.

6.1.2.5 The safety analysis function table should be used to list the safety devices required by each process unit and the safety functions to be performed by each safety device (shutdown, input source switching, pressure relief, etc.), so as to comprehensively verify the rationality of the design logic of the safety system.

6.1.3 Shutdown Design

6.1.3.1 The shutdown of offshore oil and gas CCUS systems shall be designed in conjunction with the shutdown design of other systems (e.g. production process) on the platforms or installations. Integrated design shall be adopted.

Section 2 Safety Protection System

6.2.1 General Requirements

6.2.1.1 This section is applicable to the installation of unit safety devices in offshore oil and gas CCUS systems. For units with novel features, design and analysis can be made in accordance with the requirements of 6.1.2 in this Chapter.

6.2.2 Pressure Vessels

6.2.2.1 Pressure protection

(1) Pressure switch high (PSH) shall be set for pressure vessel protection, but it may be omitted in any of the following cases:

① The input sources are pumps or compressors, but the pressure generated will never be greater than the maximum allowable working pressure of the vessel;

② The input sources are not wellheads or submarine pipelines, and each input source is protected by PSH, which can protect the vessel;

③ The vessel's gas outlet piping connecting the downstream unit is large enough in size and free of isolation or regulation valves, and the downstream unit is protected by PSH, which can protect the upstream vessel;

④ The vessel is the final KO drum of the torch, release or venting system, and can withstand the maximum back pressure;

⑤ The vessel works at atmospheric pressure and has sufficient venting system.

(2) Pressure switch low (PSL) shall be set for pressure vessel protection, but it may be omitted in any of the following cases:

① The minimum working pressure in operation is normal pressure;

② Each input source is provided with PSL, and there is no pressure control device or restriction between PSL and the vessel;

③ The vessel is a KO drum or small liquid trap instead of a process unit, and it is effectively protected by downstream PSL or design function;

④ The piping connecting the vessel with the gas outlet of the downstream equipment is not fitted with a shutdown valve (SDV) or regulating valve, and the equipment is protected by a PSL that can protect the upstream vessel.

(3) Pressure safety relief valve shall be set for pressure vessel protection, but it may be omitted in any of the following cases:

① Each input source is protected by PSV at the opening pressure not higher than the maximum allowable working pressure of the vessel, and the vessel is fitted with PSV to protect against fire and thermal expansion;

② Each input source is protected by PSV at the opening pressure not higher than the maximum allowable working pressure of the vessel, and at least one PSV is not isolated from the vessel;

③ The PSV on the downstream equipment meets the relief requirements of the vessel and is not isolated from the vessel;

④ The vessel is the final KO drum of the torch, pressure relief or venting system, and can withstand the maximum accumulated back pressure without any internal or external barriers;

⑤ The vessel is the final KO drum of the torch, relief or venting system, can withstand the maximum accumulated back pressure, and is fitted with rupture disks or fusible plugs that can bypass the internal and external barriers.

6.2.2.2 Level safety protection

(1) Level switch high (LSH) shall be set for pressure vessel protection, but it may be omitted in any of the following cases:

① The downstream equipment of the gas outlet is not a torch or venting system, and it can safely process the maximum liquid volume carried by the gas;

② The vessel has no function of separating fluid phases;

③ The vessel is a small liquid trap, and the liquid is manually drained.

(2) Level switch low (LSL) shall be set for pressure vessel protection, but it may be omitted in any of the following cases:

① The level is not automatically maintained, and there is no immersed heating element in the vessel that suffers from overheat;

② The downstream equipment of the liquid outlet can safely process the maximum gas flow discharged through the fluid outlet, there is no immersed heating element in the vessel that suffers from overheat, and a limit can be set on the discharge line to reduce the gas flow.

6.2.2.3 Temperature safety protection

When the vessel has a heat source, a temperature switch high (TSH) shall be set, but it may be omitted if the heat source is unlikely to cause overheat.

6.2.2.4 Flow safety protection

A check valve/flow safety valve (FSV) shall be set at each outlet of the vessel, but it may be omitted in any of the following cases.

(1) The maximum capacity of backflow from downstream equipment is negligible;

(2) The control device on the piping will effectively reduce the backflow.

6.2.2.5 Safety device positions

(1) Pressure safety device

PSH/PSL sensors and PSVs shall be installed in positions that can detect or release the pressure in the gas chamber of the vessel, generally at or near the top of the vessel. If the pressure drop from the vessel to the detection point is negligible and these safety devices are not separated from the vessel, it is allowed to install these devices at the outlet of the gas piping.

(2) Level safety device

The LSH sensor shall be located at a sufficient distance above the highest operating level to prevent false shutdown, but there shall be appropriate vessel space above the LSH sensor to prevent overflow before shutdown.

The LSL sensor shall be located at a sufficient distance below the minimum operating level to prevent false shutdown, but there shall be an appropriate liquid space between the LSL sensor and the liquid outlet to prevent gas channeling before shutdown. In the fire tube unit, LSL shall be located above the fire tube.

LSH and LSL sensors should be installed outside the vessel.

(3) Flow safety device

FSVs shall be installed on the outlet piping.

(4) Temperature safety device

Temperature sensors, except fusible type or surface contact type, shall be installed in thermowell for easy removal and testing. Thermowell shall be installed in an easily accessible place and allow continuously immersing in heated fluid.

6.2.3 Atmospheric Vessels

6.2.3.1 Pressure protection

(1) Atmospheric vessels shall be fitted with vent protection;

(2) The atmospheric vessel shall be protected by the pressure-vacuum relief device, but it may be omitted in any of the following cases:

① The atmospheric vessel is fitted with a second vent device and sufficient for processing the maximum gas flow;

② The atmospheric vessel is designed to withstand collapse under vacuum, work at atmospheric pressure, and have vent pipes with adequate sizes;

③ The atmospheric vessel has no pressure source (except for sealed cover gas and/or manual relief) and have vent pipes with adequate sizes.

6.2.3.2 Level safety protection

(1) The atmospheric vessel shall be protected by LSH, but it may be omitted in any of the following cases:

① The liquid filling to atmospheric vessel is continuously monitored;

② The overflow of the atmospheric vessel is split or accommodated by other units.

(2) The atmospheric vessel shall be protected by LSL, but it may be omitted in any of the following cases:

① The atmospheric vessel is fitted with sufficient collection and accommodation system;

② The level is not automatically maintained, and there is no immersed heating element suffering from overheat in the atmospheric vessel;

③ The atmospheric vessel is the final vessel of the collection and accommodation system.

6.2.3.3 Temperature protection

TSH shall be set when the vessel has a heat source, but it may not be set if the heat source is unlikely to cause overheat.

6.2.3.4 Safety device positions

(1) Pressure safety device

Breather valves and pressure-vacuum relief valves (PVSVs) shall be set at the top of the atmospheric vessel.

(2) Level safety device

The LSH sensor shall be set at a sufficient distance above the maximum operating level to avoid false shutdown. However, an appropriate vessel space shall be left above the LSH sensor to accommodate the inflow liquid during shutdown.

The LSL sensor shall be located at a sufficient distance below the minimum operating level to avoid false shutdown. In the fire tube heating equipment, LSL shall be located above the fire tube.

(3) Temperature safety devices

Temperature sensors, except fusible type or surface contact type, shall be installed in thermowell for easy removal and testing. Thermowell shall be installed in an easily accessible place and allow continuously immersing in heated fluid.

6.2.4 Pumps

6.2.4.1 Pressure protection

(1) CO_2 output pump

① PSH and PSL protection shall be set on the discharge line of the pump;

② PSV shall be set on the discharge line of the pump. When the kinetic energy pump is used, PSV can be omitted as the discharge pressure cannot be greater than the maximum allowable pressure of the discharge line.

(2) Other pumps

① The pump discharge line shall be fitted with PSH protection, but it may be omitted in any of the following cases:

a. The maximum discharge pressure of the pump does not exceed 70% of the maximum allowable working pressure of the discharge line;

b. It is a manual pump continuously monitored by personnel;

c. It is a small low-volume pump, such as chemical injection pump;

d. The liquid is pumped into an atmospheric vessel;

e. The pump is a glycol pump driven by glycol (if applicable).

② The pump discharge line shall be fitted with PSL protection, but it may be omitted in any of the following cases:

a. It is a manual pump continuously monitored by personnel;

b. There are sufficient accommodation devices;

c. It is a small low-volume pump, such as chemical injection pump;

d. The liquid is pumped into an atmospheric vessel.

③ The pump discharge line shall be fitted with PSV, but it may be omitted in any of the following cases:

a. The maximum discharge pressure of the pump is lower than the maximum allowable working pressure of the discharge line;

b. The pump body has internal pressure relief function;

c. The pump is a glycol pump driven by glycol, and its maximum discharge pressure is not higher than the rated value of the wet glycol low-pressure discharge line;

d. The pump is a glycol pump driven by glycol (if applicable), and the wet glycol low-pressure discharge line is protected by the PSV of the downstream unit and is isolated from it (if applicable).

6.2.4.2 Safety device positions

(1) Pressure safety device

① PSH and PSL sensors shall be located upstream of the FSV or any SDV on the pump discharge line;

② For a glycol pump powered by glycol, the PSL on the rich glycol high-pressure piping shall be located between the pump and SDV (if applicable);

③ If a PSV is required, the PSV shall be located upstream of any SDV on the pump discharge line.

(2) Flow safety device

FSV shall be installed on the pump discharge line and near the pump end to minimize backflow.

(3) Shutdown device

A shutdown device shall be set between the output pump and the storage unit (tank, separator, etc.) and close to the outlet end of the storage unit.

6.2.5 Compressors

6.2.5.1 Pressure protection

(1) PSH and PSL protection shall be set on each suction line of the compressor, except when each input source is provided with PSH and PSL to protect the compressor;

(2) PSH and PSL protection shall be set on each discharge line of the compressor, except when the downstream PSH and PSL can protect the compressor and are not isolated from the compressor;

(3) PSV protection shall be set on each suction line of the compressor, except when each input source is fitted with PSV to protect the compressor;

(4) PSV protection shall be set on each discharge line of the compressor, but it may be omitted in any of the following cases:

① The compressor is protected by the downstream PSV, which is arranged upstream of any cooler and not isolated from the compressor;

② The compressor is kinetic energy type, and its discharge pressure cannot exceed the maximum allowable working pressure of the compressor itself or the discharge line.

6.2.5.2 Flow protection

FSV protection shall be set on the final discharge line of the compressor to minimize backflow.

6.2.5.3 Temperature protection

TSH protection shall be set on each cylinder or casing of the compressor.

6.2.5.4 Safety device positions

(1) Pressure safety device

PSH and PSL sensors on all suction lines shall be as close to the compressor as possible. PSH and PSL sensors set on all discharge lines shall be located upstream of FSV and any SDV.

PSVs set on all suction lines shall be as close to the compressor as possible, and all discharge line PSVs shall always be unimpeded till the compressor. If PSV is located in enclosed premises, its discharge port shall be directed to a safe place outside the enclosed premises by a pipe.

(2) Flow safety device

The FSV shall be installed on the final discharge line of the compressor sets to minimize backflow. If the compressor sets ares installed in the enclosure, the FSV shall be placed outside the enclosure.

(3) Temperature safety devices

TSH sensors shall be installed on the discharge lines of all compressor cylinders or casings, and as close as possible to the cylinders or casings.

(4) Shutdown device

SDV shall be installed in the compressor suction line of each process so as to cut off the input source of the compressor.

The relief valve shall be installed on the final discharge line of the compressor sets. The relief valve can be activated by signals from fire detection, gas detection, installation/unit ESD system or compressor ESD system.

6.2.6 Export Pipeline

6.2.6.1 Pressure protection

(1) The export pipeline shall be protected by PSH, but it may be omitted in any of the following cases:

① The output line is protected by PSH installed on its upstream equipment;

② Each input source is protected by PSH, and such PSH can protect the output or bidirectional line;

③ The pipe is protected by PSH installed on a parallel unit.

(2) PSL protection shall be set for the export pipeline, but it may be omitted in any of the following cases:

① The output line is protected by PSL installed on its upstream unit;

② Each input source is protected by PSL, and such PSL can protect the output or bidirectional line;

③ The line is protected by PSL installed on a parallel unit.

(3) PSV protection shall be set for the send-out line, but it may be omitted in any of the following cases:

① The maximum allowable operating pressure of the line is higher than that of all input sources;

② Each input source with a pressure higher than the maximum allowable operating pressure of the line has a set of PSV protection, and the set pressure of such PSV is not higher than the maximum allowable operating pressure of the line;

③ Pipeline does not use platform process system as its input source.

6.2.6.2 Flow protection

(1) FSV protection shall be set for submarine pipeline, but it may be omitted in any of the following cases:

① The output pipeline is fitted with SDV controlled by PSL;

② All input sources on the pipeline are protected by FSVs, and their positions can avoid backflow in all effective pipeline sections;

③ The pipeline allows bidirectional flow.

6.2.6.3 Safety device positions

(1) Pressure safety device

PSH and PSL sensors shall be located downstream of all input sources and upstream of output line FSVs. PSV, if needed, shall be located downstream of all input sources and shall always be unimpeded till the input sources.

(2) Flow safety device

FSV shall be installed on the input line to the process station, and its position shall be close to the upstream of the process station.

The export pipeline FSV shall be located as far downstream as possible, but upstream of the SDV.

(3) Shutdown device

The position of export pipelineSDV shall minimize the line sections exposed to the installation or platform. All SDVs shall be activated by sensors in the ESD system of the installation or platform

where the SDV is located, fusible plug loops or any downstream equipment where line liquid flows.

The SDV on the line connected with the output line shall be activated by PSH/PSL sensors, ESD system or fusible plug loops on the output line.

Bidirectional lines shall be fitted with SDV at the boundary of all platforms or installations.

6.2.7 Heat Exchangers (Shell and Tube Type)

6.2.7.1 Pressure protection

(1) Both the heating and heated sections of the heat exchanger shall be provided with PSH protections, but they may be omitted in any of the following cases:

① The pressure generated by the input source of each section will never be greater than its maximum allowable working pressure;

② Each input source has PSH protection, and can protect this section of the heat exchanger;

③ The downstream equipment is protected by PSH, and there is no block valve or control valve to isolate the heat exchanger section.

(2) PSL protections shall be set for both heating or heated sections of the heat exchanger, but it may be omitted in any of the following cases:

① PSL on another equipment will protect this section of the heat exchanger and will not be isolated from it during operation;

② During operation, the minimum operating pressure is normal pressure.

(3) PSV protections shall be provided for both the heating and heated sections of the heat exchanger, but they may be omitted in any of the following cases:

① Each input source is fitted with PSV, with opening pressure not higher than the maximum allowable working pressure of the section of the heat exchanger, and the section is fitted with PSV for fire and heat release;

② Each input source is fitted with PSV, with opening pressure not higher than the maximum allowable working pressure of the corresponding section of the heat exchanger, and the PSV is not isolated from this section;

③ PSV on downstream equipment meets the release requirements of this section of the heat exchanger and always be unimpeded till this section;

④ The input source of this section of the heat exchanger will not generate pressure greater than its maximum allowable working pressure, and this section will not be subjected to overpressure due to the temperature or pressure of other sections;

⑤ Each input source is protected by PSV, with set pressure not higher than the maximum allowable working pressure of this section of the heat exchanger, and this section will not be subjected to overpressure due to the temperature or pressure of other sections.

6.2.7.2 Pressure safety device positions

PSH/PSL sensors and PSVs shall be at the positions where detection or pressure relief can be performed on each section of the heat exchanger. If there is little pressure drop from this section of the heat exchanger to the detection point, and these safety devices are always be unimpeded till the heat exchanger, these safety devices can be installed on the inlet or outlet line.

6.2.8 Cold Boxes and Evaporators

The cold box used in the liquefaction system and the evaporator used in the liquefied gas

regasification system are heat exchangers. The safety protection devices on them shall at least conform to the requirements of 6.2.7 in this Chapter.

6.2.9 CO_2 Storage Tanks

The safety protection devices on the CO_2 storage tank shall at least conform to the requirements of 6.2.2 in this Chapter. However, for a temperature protection device, the high-level alarm shall be set on the storage tank.

Chapter 7 CO_2 Capture

Section 1 General Provisions

7.1.1 General Requirements

7.1.1.1 In addition to the requirements of this Chapter, offshore oil and gas CO_2 capture system shall also meet the relevant requirements in Chapters 4~6 of the Guidelines.

7.1.1.2 Common methods for CO_2 capture encompass physical absorption, chemical absorption, adsorptive separation, membrane separation and cryogenic method. Appropriate separation methods shall depend on the actual conditions.

Section 2 Capture of CO_2 in Wellhead Stream

7.2.1 General Requirements

7.2.1.1 This section is applicable to the capture of high-concentration CO_2 in wellhead stream.

7.2.1.2 Wellhead stream CO_2 capture system mainly involves CO_2 separation, CO_2 compression and CO_2 dehydration. Equipment generally includes CO_2 separation equipment, compressor, scrubber tank, cooler, dehydration and drying skid, etc. Dehydration and drying skid mainly includes separator, dehydrator, regenerative heater, heat exchanger, KO drum, etc.

7.2.2 CO_2 Separation

7.2.2.1 The separation of CO_2 in oil and gas well stream is based on the oil and gas production system. The separation process design shall meet the requirements of Chapter 5 of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

7.2.3 CO_2 Compression

7.2.3.1 The CO_2 compressor shall be surveyed with reference to the relevant rules/guidelines of China Classification Society.

7.2.3.2 The pressure protection of CO_2 compressor shall meet the requirements of Chapter 6 in the Guidelines.

7.2.4 CO_2 Dehydration

7.2.4.1 Available CO_2 dehydration methods include absorption method (glycol absorption method), adsorption method (molecular sieve adsorption method) and cryogenic method. The of methods shall be selected according to the overall comparison field development plan, general arrangement, CO_2 pressure, composition, CO_2 product requirements and dehydration depth.

7.2.4.2 The pressure vessels or shell-and-tube heat exchangers for CO_2 dehydration shall meet the applicable requirements of global or Chinese codes and standards.

Section 3 Capture of CO_2 from Natural Gas Processing System

7.3.1 General Requirements

7.3.1.1 Capture of CO_2 in natural gas processing system is achieved by natural gas decarbonization. The natural gas decarbonization process generally bases on membrane filtration method or alkylol amine-based chemical absorption method.

7.3.1.2 The natural gas-associated CO_2 capture system installed on offshore mobile units, fixed platforms and floating production, storage and offloading facilities (FPSOs) shall meet the relevant requirements of deacidification in Chapter 7, Section 2 of the *Rules for Offshore Oil and Gas Processing System* issued by China Classification Society.

7.3.1.3 The CO_2 capture system for natural gas processing system installed in the onshore terminal shall meet the relevant requirements of *Code for design of natural gas conditioning plant* （SY/T

0011）*and* the *Guidelines for Certification and Survey of Offshore Oil Onshore Terminals* issued by China Classification Society.

Section 4 Capture of CO_2 From Flue Gas

7.4.1 General Requirements

7.4.1.1 This section is applicable to flue gas capture systems of boilers, diesel engines, gas turbines and other types of internal combustion engine that use natural gas or crude oil as fuel on offshore platforms or installations.

7.4.1.2 Chemical or physical absorption method should be adopted for CO_2 capture.

7.4.1.3 The tower vessels for capture of CO_2 in flue gas shall meet the requirements in applicable global or Chinese codes and standards.

7.4.1.4 Other pressure vessels for capture of CO_2 in flue gas shall meet the requirements in applicable global or Chinese codes and standards.

7.4.1.5 Piping and accessories shall be designed and arranged to prevent flue gas from leaking into enclosed places.

7.4.1.6 After installation of flue gas CO_2 capture system, the exhaust gas back pressure, in various operating conditions, shall always be maintained within the range specified by the manufacturer of the gas or oil burning device.

7.4.1.7 The design and arrangement of the flue gas CO_2 capture system shall ensure the gas or oil burning device continues normal operation when the flue gas CO_2 capture system fails or stops working. If a bypass device is required to achieve the above objectives, the bypass device shall meet the following requirements:

(1) Local and remote control locations are provided with facilities to correctly indicate working status;

(2) The operation is reliable. The gas or oil burning device can run safely in all cases;

(3) A safety interlock device shall be set between the bypass valve and the corresponding inlet valve of the flue gas CO_2 capture system to ensure the exhaust gas of the gas/oil burning device can be discharged smoothly in all cases;

(4) Failure alarm.

7.4.1.8 A block valve shall be set on the flue gas trunk pipe connected to the CO_2 capture system. The block valve shall be provided with an opening/closing state indication device. There shall also be an interlocking or any other effective device between the block valve (on the trunk pipe transporting boiler flue gas to the CO_2 capture system) and the boiler soot blowing device, so as to prevent boiler blowing when the block valve is opened. In addition, there shall be a purging device for the valve.

7.4.2 Flue Gas Pretreatment

7.4.2.1 The flue gas temperature, dust content, SO_2 content and NO_x content after pretreatment shall meet the requirements of CO_2 absorption device.

7.4.2.2 Sampling ports shall be set on the flue gas inlet and outlet line of pretreatment system.

7.4.3 CO_2 Absorption and Desorption

7.4.3.1 The absorbent shall be a solvent with strong CO_2 absorption capability, good regeneration performance, low corrosiveness and non-degradation.

7.4.3.2 CO_2 absorption and desorption system shall be kept with water balance.

7.4.3.3 The design superficial velocity of absorption tower and desorber shall be 50%~70% of the

flooding velocity.

7.4.3.4 The temperature of lean liquid entering the absorption tower shall be 40℃~50℃, and the temperature at the bottom of desorber shall be 100℃~125℃.

7.4.3.5 Desalinated water shall be used as makeup water for scrubbing system of absorption tower.

7.4.3.6 The absorption tower flue gas inlet line shall be fitted with temperature and flow monitoring, flue gas outlet line shall be fitted with sampling port, lean liquid inlet line shall be fitted with bypass filter, and bypass filter should include pre-filter, activated carbon filter and post-filter.

7.4.3.7 The desorber top outlet line shall be fitted with temperature detection and high & low temperature alarms, and should be interlocked with the steam flow of reboiler at the tower bottom.

7.4.3.8 Sampling ports shall be set on the lean and rich liquid piping.

7.4.3.9 When a booster fan is provided, it shall meet the following requirements:

(1) The booster fan should be a centrifugal fan;

(2) The booster fan may be adjusted by inlet throttle or variable speed, but the booster fan driven by direct-coupled motor should be adjusted by inlet throttle;

(3) The minimum flow of booster fan shall not be less than 105% of surge flow;

(4) The outlet pressure of booster fan should be 1.2 times of the pressure drop at the maximum system gas flow.

7.4.4 CO_2 Compression and Dehydration

7.4.4.1 CO_2 compression system shall adapt to the fluctuation of the gas composition, inlet pressure, inlet temperature and inlet flow.

7.4.4.2 The selection of CO_2 compressor should meet the following requirements:

(1) When the gas flow is large, the centrifugal compressor should be selected;

(2) When the pressure is high and the gas flow is small, the reciprocating compressor should be selected;

(3) When the pressure is small and the gas flow is small, the screw compressor should be selected.

7.4.4.3 The reciprocating compressor shall be fitted with vibration reduction measures.

7.4.4.4 The CO_2 dehydration system shall be located at an interstage or after the last stage of the compressor.

7.4.4.5 The dew point after CO_2 dehydration shall meet the following requirements:

(1) If the product is required to be gaseous, the dew point of water shall be 5℃ lower than the minimum ambient temperature under the transport condition;

(2) If the product is required to be liquid, the dew point of water shall be 5℃ lower than the liquefaction temperature.

7.4.4.6 On-line water dew point analyzer shall be set on the outlet pipeline of CO_2 dehydration system.

7.4.5 CO_2 Liquefaction and Storage

7.4.5.1 CO_2 liquefaction process may base on high-pressure liquefaction or low-temperature liquefaction method.

7.4.5.2 When the high-pressure liquefaction method is adopted for CO_2 liquefaction, the CO_2 shall

be directly transported out by piping.

7.4.5.3 When the low-pressure liquefaction method is adopted for CO_2 liquefaction, ammonia should be selected as the refrigerant.

Chapter 8 CO_2 Pipeline Transport

Section 1 General Provisions

8.1.1 General Requirements

8.1.1.1 The requirements of this Chapter are applicable to submarine pipelines transporting offshore CO_2.

8.1.1.2 The submarine pipelines transporting CO_2 shall meet the requirements of 3.1.2.1 in the *Rules for Submarine Pipeline Systems* issued by China Classification Society. Supercritical CO_2 and liquid CO_2 shall be classified as E-category transport medium, and gaseous CO_2 shall be classified as C-category medium.

8.1.1.3 When CO_2 is transported in gas phase, the pressure at any point along the pipeline shall not be higher than the saturated vapor pressure of CO_2 under the transport temperature.

8.1.1.4 When CO_2 is transported in liquid phase, the pressure at any point along the pipeline shall be higher than the saturated vapor pressure of CO_2 under the transport temperature.

8.1.1.5 When CO_2 is transported in supercritical state, the pressure at any point along the pipeline shall not be less than 1.1 times the critical pressure.

8.1.1.6 The water content, water dew point, H_2S content and total sulfur content of CO_2 medium shall meet the requirements of relevant codes and standards.

8.1.1.7 Water hammer analysis shall be required in the design of liquid phase and supercritical CO_2 pipelines.

8.1.1.8 Safety valves or other pressure control facilities shall be set for pipeline may be subjected to overpressure.