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Supervision Regulation on Safety Technology for Stationary Pressure Vessels

1 General Requirement

1.1 Purpose

In order to ensure the safe use of stationary pressure vessels, prevent and reduce accidents, protect the safety of human life and property, and promote the development of national economy, this *Supervision Regulation on Safety Technology for Stationary Pressure Vessels* (abbreviated Regulation, hereinafter) is established in accordance with *Law on Safety of Special Equipment of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment.*

1.2 Stationary pressure vessels

Stationary pressure vessels refer to pressure vessels installed and operated at fixed locations (hereinafter referred to as pressure vessels, see Note 1.1).

Note 1-1: Pressure vessels to be moved and/or used within the certain scope of the facility or plant field for a particular purpose, as well as air tanks in transportable air compressor units are jurisdicted by this Regulation; heat recovery boilers in process devices designed and fabricated as process equipments based on pressure vessels are jurisdicted by this Regulation.

1.3 Applicable scope

This Regulation is applicable to stationary pressure vessels defined in the catalogue of special equipment, and in conformity with all of the following conditions as a whole：

(1) The operating pressure is equal to or greater than 0.1MPa (Note 1-2);

(2) The volume is equal to or greater than 0.03 m^3 and the inside diameter (it refers to the maximum geometric dimension of the inside boundary at the cross-section for non-circular cross sections) is equal to or greater than 150 mm (Note 1-3);

(3) The medium is gas, liquefied gas or liquid which maximum operating temperature is equal to or greater than its standard boiling point (Note 1-4).

Note 1-2: Operating Pressure, refers to the maximum pressure (gauge pressure) possibly occurred on the top of a vessel at normal operating conditions.

Note 1-3: Volume, refers to the geometrical room of the pressure vessel, namely the volume calculated

based on the dimensions of the design drawings and after roundness (tolerance is not considered). In general, the volume of the internals permanently amounted inside the pressure vessel should be deducted.

Note 1-4: This Regulation is also applicable to the vessel when the maximum operating temperature of the containing liquid lower than its standard boiling point, meanwhile, the vapor space volume is equal to or greater than $0.03m^3$.

1.4 Special provisions for applicable scope

Users shall be responsible for the safety management of their pressure vessels subject to this Article according to the service management provisions in Chapter 7 of this Regulation.

1.4.1 Pressure vessels which comply with the General Requirement, Material, Design, and Fabrication only

Under the applicable scope of this Regulation, the following pressure vessels are required to meet the provisions of only Chapter 1to Chapter 4:

(1) Non-independent pressure vessels of cryogenic installations, pressure vessels of direct-fired absorption refrigeration equipments, aluminum plate-fin heat exchangers, and pressure vessels in cold boxes of process equipments;

(2) Jacketed heat exchangers containing the medium group 2 (Note 1-5);

(3) Ultra-high pressure tubular reactor.

Note 1-5: Pressure vessel medium grouping see Annex A of this Regulation.

1.4.2 Pressure vessels conforming to General Requirement, Design and Fabrication only

Under the applicable scope of this Regulation, the following pressure vessels are required to meet the provisions of only Chapter 1, Chapter 3 and Chapter 4.

(1) Air tanks for transportable air compressor units;

(2) Air compressed hydraulic tanks used for hydraulic auto-pneumatic water feeding devices (water feeding without tower), air compressed tanks or water (foam) feeding compressed tanks used for extinguishing devices;

(3) Pressure vessels used for ion exchange or filtration process in water treatment equipments, water expansion tanks used for hot-water boilers;

(4) Pressure shell of accumulator.

1.5 Non-applicable scope

This Regulation is not applicable to pressure vessels as following:

(1) Transportable pressure vessels, gas cylinders and hyperbaric oxygen chambers;

(2) Pressure vessels used for military equipment, nuclear facilities, aerospace vehicles, locomotives, offshore installations and ships, as well as coal mines;

(3) Vessels with normal operating pressure less than 0.1MPa (including vessels connecting to atmosphere with an instantaneous pressure no less than 0.1MPa during feeding or discharging processes);

(4) Pressure containers that are as integral parts or components of rotating or reciprocating mechanical devices, such as shell of pumps, shell of compressors, shell of turbines, hydraulic cylinders, paper roller, etc;

(5) Plate heat exchangers, spiral plate heat exchangers, air-cooling heat exchangers and cooling pipes.

(6) Steam heating coils of atmospheric pressure vessels, tubular heating furnace of process equipments;

(7) Fully enclosed electric apparatus (capacitance pressure vessels) used for power industry only;

(8) Tire vulcanizers and pressed rubber moulds used in rubber industry;

(9) Non-reinforced plastic pressure vessels.

1.6 Definition of pressure vessel scope

The jurisdiction scope of this Regulation covers pressure vessel bodies, safety accessories and instruments.

1.6.1 Body of the pressure vessel

The main body of a pressure vessel is defined as following:

(1) The bevel surface of the first circumferential joint between a pressure vessel and external pipes or devices connected by welding, the first threaded joint with screwed connections, first flanged sealing surface with flanged connections and the first sealing surface with special connectors or pipe connectors;

(2) Pressure covers and their fasteners of the openings of pressure vessels;

(3) Connection welds between non-pressure parts and pressure components.

Main pressure components in a pressure vessel body include forming shell sections (including transition section reducers), petals of a spherical tank, shell plates of a non-circular vessel, formed heads, flat heads, expansion joints, equipment flanges, tubesheets and tubes of a heat exchanger; main bolts greater than M36 (including M36) in specification, nozzle and pipe flanges with diameter no less than 250mm.

1.6.2 Safety accessories and instruments

Safety accessories of pressure vessels include safety valves directly connected with pressure vessels, bursting disc devices, fusible plugs, emergency shut-off devices and safety

interlock devices.

Instruments of pressure vessels include such measuring instruments directly connected with pressure vessels as pressure gages, thermometric instruments, and liquid level gages, etc.

1.7 Categories of Pressure Vessels

Depending on the hazard level, pressure vessels applicable to this Regulation are classified into Category Ⅰ, Ⅱ, Ⅲ (Note 1-6), and the classifications of pressure vessels see Annex A.

Note 1-6: Pressure vessels classified to Category Ⅰ, Ⅱ, Ⅲ in this Regulation are equal to the first, second, third class pressure vessels in the catalogue of special equipment; Ultra-high pressure vessels in this Regulation are classified to Category Ⅲ pressure vessels.

1.8 Inter-relationship with technical standards and management rules

(1) Regulation specifies the essential safety requirements of pressure vessels. Involved technical standards and management rules of pressure vessels, as a minimum, shall meet the requirements of this Regulation;

(2) The design, fabrication, installation, alteration and repair of pressure vessels shall conform to the requirements of this Regulation and corresponding pressure vessel product standards (hereinafter abbreviated as product standards).

1.9 The rule for handling inconformity to this Regulation

For pressure vessels constructed with new material, new technology, new process and/or its special service conditions not meet the requirements of this Regulation, or may cause significant impact on safety performance while not be stipulated in this Regulation, involved enterprises/institutes shall submit the technical documentations involving the foundation, data, results, as well as inspection and testing reports of the design, research, and experiment to General Administration of Quality Supervision, Inspection and Quarantine of P. R. China (abbreviated AQSIQ). Safety technology consulting bodies or relevant professional organizations entrusted by AQSIQ shall carry out technical evaluations and assessments. The pressure vessels cannot be put into construction and service unless the results are approved by AQSIQ.

1.10 Harmonized standards and quoted standards

Harmonized standards of this Regulation refer to standards which comply with the essential safety requirements of this Regulation. Main harmonized standards of this Regulation are as follows:

(1) GB 150 *Pressure Vessels*;

(2) GB 151 *Heat Exchangers*;

(3) GB 12337 *Steel Spherical Tanks*;

(4) NB/T 47011 *Zirconium Pressure Vessels*;

(5) NB/T 47041 *Vertical Vessels Supported by Skirt*;

(6) NB/T 47042 *Horizontal Vessels on Saddle Supports*;

(7) JB 4732 *Steel Pressure Vessels- Design by Analysis*;

(8) JB/T 4734 *Aluminum Welded Vessels*;

(9) JB/T 4745 *Titanium Welded Vessels*;

(10) JB/T 4755 *Copper Pressure Vessels*;

(11) JB/T 4756 *Nickel and Nickel Alloy Pressure Vessels*.

Quoted standards of this Regulation refer to essential standards appointed by this Regulation, such as medium standards, material standards, measures standards, parts standards.

Note 1-7: For harmonized standards or quoted standards in this Regulation with the year note, both their amendment sheets (not including contents of corrections) and revisions do not apply to this Regulation. Ones without the year note, their latest versions apply to this Regulation.

1.11 Supervisory administration

All parties involved in the design, fabrication, installation, alteration, repair, service, inspection, and testing of pressure vessels shall implement the provisions of this Regulation accordingly, subject to the supervisory administration of the departments in charge of special equipment safety supervision and administration of local people’s governments (hereinafter abbreviated as special equipment safety supervisory administration departments), as well as follow the regulations of information management for special equipment, and input required data into the information systems in time.

2 Material

2.1 General requirements for materials

2.1.1 Essential requirements

(1) Mechanical properties, physical properties, process properties and the compatibility with mediums shall be considered when selecting materials for pressure vessels;

(2) The property, quality, specification and identification mark of materials used for pressure vessels shall conform to the requirements of corresponding National Standards or Industrial Standards;

(3) Material manufacturers of pressure vessels shall make clear and solid hard stamp or other traceable identification marks at conspicuous locations of the material;

(4) Material manufacturers of pressure vessels shall provide the material quality certificate to the user of materials. The content of material quality certificate shall have complete and clear content, and printed with traceable information identification marks, stamped with quality inspection by material manufacturers;

(5) When the parties involved in fabrication, alteration and repair of pressure vessels obtain materials not from materials manufacturers, an original material quality certificate provided by the materials manufacturer or a copy of document with an official seal of the material business units and a manager’s signature (stamp) is required;

(6) The parties involved in fabrication, alteration and repair of pressure vessels are responsible for the authenticity and consistency of the materials and its quality certificates;

(7) Nonmetallic pressure vessel manufacturers shall have reliable ways to confirm the raw material or the material after forming can be reliably used in corrosion conditions, and if necessary, a verification test shall be conducted.

2.1.2 The use of foreign designate materials

2.1.2.1 Materials produced by manufacturers outside P. R. China

(1) Foreign designate materials shall be the ones currently being allowed for the pressure vessel based on relevant pressure vessel codes and standards in valid, and also having sound experience in service under similar operating conditions. Its application scope shall conform to specifications of corresponding standards and codes;

(2) Properties of foreign designate materials shall not be less than the essential requirements of this Regulation (such as contents of S and P, sampling position and sampling direction of impact specimen and its impact energy, elongation);

(3) Material quality certificates shall conform to provisions of Article 2.1.1 of this Regulation;

(4) The parties involved in fabrication, alteration and repair of pressure vessels shall review and verify physical materials and material quality certificates, and re-examine the chemical composition and mechanical properties for materials of main pressure components. The material can be put into use only after the re-examination result conforms to the requirements of this Regulation and respective material standards;

(5) While materials used for pressure components of welded pressure vessel structure, parties involved in fabrication, alteration and repair of pressure vessels shall conduct the welding procedure qualification based on the welding performance of the material prior to the first application;

(6) When materials not listed in harmonized standards are to be adopted for main pressure components, like the low alloy steel with specified tensile strength lower limit greater than 540MPa, or the low alloy steel used for design temperature lower than -40℃, material manufacturers shall apply for a technical evaluation and assessment and get approval according to Article 1.9 of this Regulation before the material is allowed to be in use.

2.1.2.2 Steel plates (strips) produced by domestic manufacturers

Foreign designate steel plates (strips) produced by domestic manufacturers shall conform to the requirements in Article 2.1.2.1 of this Regulation, and shall formulate the enterprise standard.

2.1.2.3 Selection of foreign designate materials

If the design unit selects foreign designate materials, it shall explain in the design document that the material conforms to the requirements in Article 2.1.2.1 of this Regulation.

2.1.3 Use of new materials

2.1.3.1 Materials not listed in harmonized standards of this Regulation

When materials not listed in harmonized standards are to be adopted for main pressure components, the material development unit shall carry out systematically experiment and research before the trial production, and get approval according to Article 1.9 of this Regulation.

2.1.3.2 Steel first produced by material manufacturers

When material manufacturers produce such materials for pressure vessels for the first time, as the low alloy steel with specified tensile strength lower limit greater than 540MPa, or the low alloy steel used for pressure vessels with the design temperature lower than -40℃, they shall get approval according to Article 1.9 of this Regulation.

2.1.4 Materials usage and identification mark transfer

(1) The parties involved in fabrication, alteration and repair of pressure vessels shall ensure the materials used for pressure vessels to be in conformity with this Regulation, and verify the material quality certificates and material marks by the material receiving inspection; for the material used for main pressure components of which the authenticity of material quality certificate is uncertain or the mechanical properties and chemical composition are doubtful, re-examination on the material shall be conducted. The material cannot be put into fabrication unless it is verified to conform to the requirements of this Regulation and corresponding material standards;

(2) The purchased grade IV forging for the category III pressure vessel shall be re-examined;

(3) The identification marks on materials for pressure components of pressure vessels shall be transferred prior to cutting to ensure the traceability of materials.

2.1.5 Material substitute

When the parties involved in fabrication, alteration and repair of pressure vessels intend to use substitute materials for main pressure components, the written approval shall be provided from the original design unit in advance, and the corresponding record shall be prescribed on the as-built drawing in detail.

2.2 Technical requirements of metal materials

2.2.1 Technical requirements of steel materials

2.2.1.1 Smelting methods

The steel used for pressure components of pressure vessels shall be killed steel smelted by oxygen converter or electric furnace process. For low alloy steel plates and austenite-ferrite stainless steel plates with the specified tensile strength lower limit greater than 540MPa, and the low temperature steel plates and low temperature steel forgings generally used for design temperature lower than -20℃, an additional out-of-furnace refining process is required.

2.2.1.2 Chemical composition (heat analysis)

2.2.1.2.1 Carbon steels and low alloy steels used for welded structure

The content of Carbon, Phosphor and Sulfur of carbon steels and low alloy steels: C≤0.25％, P≤0.035％, S≤0.035％.

2.2.1.2.2 Carbon steels and low alloy steels specially used for pressure vessels

The content of Phosphor and Sulfur of carbon steels and low alloy steels (steel plates, steel tubes and forgings) specially used for pressure vessels shall meet the requirements as followings:

(1) For steel materials with the specified tensile strength lower limit≤540MPa, P≤0.030%, S≤0.020%;

(2) For steel materials with the specified tensile strength low limit＞540MPa, P≤0.025%, S≤0.015%;

(3) For steel materials, of which design temperature lower than -20℃ and specified tensile strength lower limit≤ 540MPa, P≤0.025%, S≤0.012%;

(4) For steel materials, of which design temperature lower than -20℃ and specified tensile strength low limit＞540MPa, P≤0.020%, S≤0.010%.

2.2.1.3 Mechanical properties

2.2.1.3.1 Impact energy

For steel plates with thickness no less than 6mm, tubes with the diameter and thickness capable to make a 5mm sub-size impact specimen, and forgings with any size, the impact energy (KV_2) of V-notch specimen under the temperature of the designed impact test shall meet the requirements in Table 2-1.

Table 2-1 Impact Energy of Carbon Steel and Low Alloy Steel
(Steel Plate, Steel Tube and Steel Forging) (Note 2-1)

Specified Tensile Strength Lower Limit R_m (MPa)	Mean Impact Energy of Three Standard Specimens KV_2 (J)
≤450	≥20
＞450～510	≥24
＞510～570	≥31
＞570～630	≥34
＞630～690	≥38 （with lateral expansion *LE*≥0.53mm）
＞690	≥47 （with lateral expansion *LE*≥0.53mm）

Note 2-1:

(1) The sampling position and sampling direction of a specimen shall conform to the specifications of the related steel standard.

(2) Three standard specimens (10mm in width) shall be tested for each group of impact test. It is allowed that one of individual specimens' impact energy values is lower than those listed in above table, but shall not be lower than 70% of the value.

(3) When steel material sizes are not sufficient for preparing standard specimens, sub-size impact specimens with width of 7.5mm and 5mm shall be prepared separately, and the impact energy for them shall be 75% and 50% of that for standard specimens respectively.

(4) For the steel material with its impact energy value required in the steel standards higher than that in Table 2-1, the provisions of the relevant steel standards shall be followed either.

2.2.1.3.2 Elongation

(1) For steel plates, steel tubes and steel forgings for pressure components of pressure vessels, their elongation (*A*) shall conform to the applicable requirements of this Regulation and the corresponding steel standards.

(2) For plates of carbon steels, low alloy high-tensile steels and low alloy low temperature steels used for welded structure, the elongation value shall meet the requirements in Table 2-2;

(3) The elongation values of specimens whose dimensions are different from the standard specimens shall be converted according to GB/T 17600.1 *Conversion of steel elongation, part 1: carbon steels and low alloy steels* and GB/T 17600.2: *Conversion of steel elongation, part 2: austenite steels*. The converted values shall meet the requirements of this Article.

Table 2-2 Elongation of Steel Plate (Note 2-2)

Specified Tensile Strength Lower Limit R_m (MPa)	Elongation *A* (%)
≤420	≥23
＞420～550	≥20
＞550～680	≥17
＞680	≥16

Note 2-2: If the elongation value specified in the steel plate standard is greater than that in Table 2-2, the provisions of the relevant steel plate standards shall be followed either.

2.2.1.4 Ultrasonic test (UT) for steel plates

2.2.1.4.1 Test requirement

For plates of carbon steels and low alloy steels with thickness equal to or thicker than

12mm (except layered plates of wrapped layered pressure vessels) used for main pressure components of pressure vessels, the ultrasonic test shall be conducted on each plate when one of the conditions listed below is met:

(1) Pressure vessels for containing extremely or highly toxic mediums;

(2) Pressure vessels used in wet H_2S corrosive environment;

(3) Pressure vessels with design pressure equal to or higher than 10MPa;

(4) Steel plates requiring UT for each plate as specified in product standards or required by the designer.

2.2.1.4.2 Acceptance criteria of UT

The UT of steel plates shall be conducted according to NB/T 47013 *Nondestructive Testing of Pressure Equipment*. For steel plates conforming to the requirements specified in item (1) to (3) of Article 2.2.1.4.1, the acceptance quality criteria shall not be less than Class II. For steel plates conforming to the requirements specified in item (4) of Article 2.2.1.4.1, the acceptance quality criteria shall be in conformity with the provisions of corresponding product standards or design documents.

2.2.1.5 Special requirements of steels used for ultra-high pressure vessels

2.2.1.5.1 Chemical composition (heat analysis)

For steel forgings of ultra-high pressure vessels, out-of-furnace refining process and vacuum treatment are required, the content of Phosphor and Sulfur, P≤0.012%, S≤0.005%, and the content of Hydrogen, Oxygen, and Nitrogen of steels as well as toxic trace elements such as Arsenic, Stanum, Stibium, Plumbum, Bismuth shall be strictly specified.

2.2.1.5.2 Mechanical properties

The manufacture of steel forgings used for pressure components of ultra-high pressure vessels shall provide mechanical properties at room temperature, including yield strength, tensile strength, elongation, shrinkage, Charpy (V-notch) impact energy and lateral expansion, as well as the yield strength, tensile strength, elongation, shrinkage of material at design temperature. In which KV_2≥47J, LE≥0.53mm, and when R_m≤880MPa，A≥16%；when R_m＞880MPA, A≥14%.

When the smelting, forging or heat treatment process is changed, the fracture toughness (K_{IC}) and fracture appearance transition temperature (FATT50) of which K_{IC}≥130MPa·$m^{½}$ shall also be provided.

2.2.1.6 Special requirements of steels used for non-welded cylinder type vessels (Note 2-3)

2.2.1.6.1 Steel material of the body

2.2.1.6.1.1 Smelting and heat treatment

(1) The steel material of the body shall be smelted by electric furnace or oxygen converter, and additional out-of-furnace refining process and vacuum treatment are required;

(2) When the body is processed and formed, quenching and tempering heat treatment shall be conducted and the metallographic structure after heat treatment shall be tempered sorbite.

2.2.1.6.1.2 Chemical composition and mechanical properties

(1) For cylinder type vessels containing compressed gas such as hydrogen, natural gas and methane, the chemical composition of steel material used for its body, C≤0.35%, P≤0.015%, S≤0.008%; the mechanical property after heat treatment is R_m≤880MPa, and the yield ratio (R_{eL} refers to yield strength) is R_{eL}/R_m≤0.86, A≥20%; under impact test temperature required by design, KV_2≥47J, LE≥0.53mm, and the specimen shall be transverse;

(2) For cylinder type vessels containing other compressed gas except that mentioned in Item (1) of this Article, the chemical composition of steel material used for its body, P≤0.020%, S≤0.010%; the mechanical property after heat treatment, R_m≤1060MPa, R_{eL}/R_m≤0.90, A≥16%; under impact test temperature required by design, KV_2≥47J, LE≥0.53mm, and the specimen shall be transverse.

2.2.1.6.1.3 Ultrasonic test

100% UT of steel material used for cylinder bodies shall be conducted according to NB/T 47013, and the acceptance quality criteria shall be Class Ⅰ.

2.2.1.6.2 Steel material of the end plug

The steel material of end plug shall be matched with that of body and use steel forgings which shall conform to the requirements of NB/T 47008 *Carbon and alloy steel forgings for pressure equipments*, NB/T 47009 *Low-alloy steel forgings for low temperature pressure equipments*, NB/T 47010 *Stainless and heat-resisting steel forgings for pressure equipments*. The steel forgings with nominal diameter equal to or greater than 50mm which contacted with the medium shall not be less than Class Ⅲ; and the other forgings shall not be less than Class Ⅱ.

2.2.1.7 Special requirements of steels used for gas storage well

2.2.1.7.1 Steel tubes used for well pipes and couplings

The mechanical properties shall conform to the following requirements:

(1) When 689MPa＜R_m≤750MPa, then R_{eL}/R_m≤0.90, A≥18%; under impact test temperature required by design, KV_2≥41J (transverse specimen, the same below), LE≥0.53mm;

(2) When 750MPa＜R_m≤810MPa, then R_{eL}/R_m≤0.91, A≥17%, KV_2≥47J, LE≥0.53mm;

(3) When 810MPa＜R_m≤870MPa, then R_{eL}/R_m≤0.93, A≥15%, KV_2≥54J, LE≥0.53mm.

2.2.1.7.2 Steel material used for well head equipments and well bottom equipments

For the gas storage well, the material of main pressure components of well head equipments and well bottom equipments shall be Cr-Mo steel forgings with grade more than Class Ⅲ (including Class Ⅲ), and shall meet the requirements of NB/T 47008.

2.2.1.8 Special requirements of steels used for simple pressure vessels

The carbon steel for simple pressure vessels shall conform to the following requirements:

(1) The supplied carbon steel shall be the hot rolling or normalizing killed steel;

(2) The chemical composition: C≤0.25%, S≤0.045%, P≤0.045%;

(3) The specified tensile strength lower limit at room temperature is less than 510MPa.

Note 2-3: See Annex A for the definition of non-welded cylinder type vessels, gas storage well and simple pressure vessel.

2.2.2 Special requirements of clad steel plates

Clad steel plates used for pressure vessels shall be selected according to the specifications of product standards, and shall meet the requirements as followings:

(1) The shear strength of the bonded interface of clad steel plates shall not be less than 210MPa for stainless steel and steel, not be less than 210MPa for nickel and steel, not be less than 140MPa for titanium and steel, not be less than 100MPa for copper and steel, and not be less than 140MPa for zirconium and steel;

(2) The service condition of the base material for the clad steel plate shall conform to the specifications of product standards;

(3) For the base material of the carbon steel and low alloy steel (including steel plate and steel forging), the impact test shall be conducted according to base material standards, and the impact energy value shall conform to base material standards or provisions of the purchase order.

2.2.3 Technical requirements of cast iron vessels

2.2.3.1 Application limitation for cast irons

Cast irons shall not be used for pressure components of pressure vessels containing extremely, highly or moderately toxic mediums, and containing explosive mediums with the design pressure equal to or higher than 0.15MPa. It shall not be used for pressure components of tubular heat recovery boilers, and paneling and welding repair are not allowable.

The following cast iron materials can be used for pressure vessels:

(1) Grey cast irons: HT200, HT250, HT300 and HT350;

(2) Nodular cast irons: QT350-22R, QT350-22L, QT400-18R and QT400-18L.

2.2.3.2 Limitation of design pressure and design temperature of cast iron vessels

(1) For grey cast irons, the design pressure shall not be higher than 0.8MPa and the design temperature range is 10℃~200℃;

(2) For nodular cast irons, the design pressure shall not be higher than 1.6MPa, the design temperature range is 0~300℃ for QT350-22R and QT400-18R, -10℃ ~300℃ for QT400-18 L, and -20℃~300℃ for QT350-22L.

2.2.4 Technical requirements of cast steel vessels

2.2.4.1 Application limitation for cast steels

Cast steels shall not be used for pressure components of pressure vessels containing extremely, highly or moderately toxic mediums, and containing explosive mediums with the design pressure equal to or higher than 0.4MPa, as well as not be used in wet H_2S corrosion environment.

2.2.4.2 Smelting and chemical composition of cast steels

The cast steel shall be killed steel smelted by electric furnace or oxygen converter, its chemical composition (heat analysis), P≤0.035%, S≤0.035%; the chemical composition of weldable cast steel, C≤0.25%, P≤0.025%, S≤0.025%; out-of furnace refining or electroslag remelting shall be conducted for high alloy austenite heat-resisting cast steel and its chemical composition, P≤0.035%, S≤0.020%.

2.2.4.3 Properties of cast steels

The cast steel used for pressure components of pressure vessels shall be selected according to the corresponding national standards or industrial standards, and the material designation shall be indicated on the product quality certificate. Its specified tensile

strength lower limit at room temperature is less than 540MPa, $A \geq 17\%$; impact energy value under design temperature $KV_2 \geq 27J$.

2.2.4.4 Limitation of design pressure and design temperature of cast steel vessels

(1) For carbon steel or low alloy carbon manganese steel vessels, the design pressure shall not be higher than 2.5MPa and the design temperature range is -20℃~400℃;

(2) For low alloy Cr-Mo steel vessels, the design pressure shall not be higher than 4.0MPa and the design temperature range is 0℃~450℃;

(3) For high alloy austenite heat-resisting steel vessels, the design pressure shall not be higher than 4.0MPa, and the design temperature upper limit shall take that of forging steel with same designation for reference.

2.2.5 Technical requirements of nonferrous pressure vessels

2.2.5.1 General requirement

Nonferrous materials for pressure vessels (i.e. aluminum, titanium, copper, nickel, zirconium and their alloys) shall meet the requirements as followings:

(1) Nonferrous materials used for pressure vessels shall be in accordance with the provisions of product standards. The additional requirements, if necessary, shall be prescribed on design drawings or indicated in corresponding technical specifications;

(2) Manufacturers of pressure vessels shall establish the strict storage system, and set specific areas to separate nonferrous materials from carbon and low alloy steels.

2.2.5.2 Aluminum and aluminum alloy vessels

When used for pressure components of pressure vessels, aluminum and aluminum alloys shall meet the requirements as followings:

(1) The design pressure shall not be higher than 16MPa;

(2) The design temperature range shall be -269~65℃ for aluminum alloys with the magnesium content equal to or greater than 3% (e.g., 5083 and 5086), and -269~200℃ for other aluminum and aluminum alloys.

2.2.5.3 Copper and copper alloy vessels

When used for pressure components of pressure vessels, the design temperature of the pure copper and brass shall be lower than 200℃.

2.2.5.4 Titanium and titanium alloy vessels

When used for pressure components of pressure vessels, titanium and titanium alloys shall meet the requirements as followings:

(1) The design temperature shall not be higher than 315℃ for titanium and titanium alloys, and not be higher than 350℃ for titanium-steel clad plates;

(2) Titanium and titanium alloys used for shells of pressure vessels shall be used under the annealed condition.

2.2.5.5 Nickel and nickel alloys

Nickel and nickel alloys used for pressure components of pressure vessels shall be used under the annealed or the solid solution condition.

2.2.5.6 Tantalum, zirconium, niobium and their alloys

When used for pressure components of pressure vessels, tantalum, zirconium, niobium and their alloys shall be used under the annealed condition. The design temperature shall not be higher than 250℃ for tantalum and its alloy, not be higher than 375℃ for zirconium and its alloy, and not be higher than 220℃ for niobium and its alloy.

2.2.6 Welding consumables

(1) For welding materials used for pressure parts of pressure vessels, the tensile property of the filler metal shall conform to the specified tensile stress lower limit for the base metal and the impact energy shall conform to the provision of Table 2-1 of this Regulation; other properties of the filler metal shall not less than corresponding requirements of the base meal when necessary;

(2) Welding consumables shall meet the requirements of standards for corresponding welding consumables and products, and the supplier shall provide the quality certificates of welding consumables with clearly and solidly tagged labels;

(3) The parties involved in fabrication, alteration, and repair of pressure vessels shall set up and strictly implement procedure of receiving, re-examination, preservation, drying, distribution and return for welding consumables.

2.3 Technical requirements of non-metallic materials

2.3.1 Graphite pressure vessels

2.3.1.1 General requirements of graphite materials

(1) The graphite material used for pressure vessels shall be subject to procedure qualification (including impregnation procedure qualification and composite material forming procedure qualification), the certified material qualification report (CMQ) and the certified material specification (CMS) shall be approved by the technical chief and confirmed by supervisory inspectors of the manufacturer; for the qualified procedure and

material, periodical verification shall be conducted (at least once every six months);

(2) The graphite material and adhesive shall be consistent with the material specified in procedure qualification specifications and be traceable;

(3) The source and grade of raw materials used for graphite materials and adhesives shall be recorded on the certified material qualification report.

2.3.1.2 Requirements of graphite material properties

The mechanical properties of graphite material shall conform to the requirements in Table 2-3.

Table 2-3 Mechanical Properties of Graphite Material

Items	Synthetic resin impregnated graphite tube	Synthetic resin impregnated graphite block	Synthetic resin profiling graphite tube
Lowest tensile strength at room temperature	26MPa	14MPa	10MPa
Lowest tensile strength at 205℃	21MPa	11MPa	6MPa
Lowest bending strength	39MPa	_	35MPa
Lowest compressive strength	69MPa	45MPa	31MPa
Highest permeability coefficient	2.9× $10^{-3}mm^2/s$	2.9× $10^{-3}mm^2/s$	2.9× $10^{-3}mm^2/s$

2.3.1.3 Requirements of adhesives

The adhesives shall be subject to property evaluation, and its mechanical properties shall conform to the requirements in Table 2-4.

Table 2-4 Mechanical Properties of Adhesives

Items	Adhesives (Note 2-4)
Lowest tensile strength at room temperature	10MPa
Lowest tensile strength at 205℃	6MPa

Note: Adhesives refer to the mixture of graphite filler, synthetic resin and curing agent.

2.3.2 Fiber reinforced plastic pressure vessels

2.3.2.1 Fiber reinforcement

The material used for fiber reinforced plastic pressure vessels shall be impregnated well with resins and conform to design requirements. The manufacturer shall examine the lowest strength of fiber which shall not less than 90% of fiber nominal property.

2.3.2.2 Resin matrix

The resin used for fiber reinforced plastic pressure vessels shall be consistent with the material selected in design documents, and its heat distortion temperature shall be re-examined before using and shall be 20℃ above higher than the design temperature of pressure vessels.

2.3.2.3 Properties of adhesive materials

The property of material for adhesive shall not be lower than that for component bonded.

2.3.2.4 Thermoplastic lining

The interlaminar shear strength of thermoplastic lining and fiber reinforced plastic structure layer shall be equal to or more than 5MPa.

3 Design

3.1 General Requirements

3.1.1 License and responsibility of design unit

(1) The design unit and the legal representative shall be responsible for the design quality of pressure vessels;

(2) The license of the design unit, as well as the categories of the licenses, variety and scope for pressure vessels shall conform to the provisions of related safety technical regulations;

(3) The design of pressure vessels shall conform to the essential safety requirements of this Regulation. For pressure vessels designed by international standards or codes outside P.R. China, the design unit shall provide Conformity Declaration and Comparison Table to AQSIQ which declare the design has satisfied the essential safety requirements specified in this Regulation;

(4) The design unit shall provide design documents specified in Article 3.1.4.1 of this Regulation to the design entrusting party.

3.1.2 Dedicated stamp for design

(1) A dedicated stamp for design (a copy of stamp is invalid) shall be sealed by the design unit on the assembly drawing of the pressure vessel, and the design drawings sealed the as-built stamp shall not be used for fabrication;

(2) The content of the dedicated stamp for design of pressure vessels shall at least include the name of the design unit, the serial no. of the license, the legal representative and technical responsible personnel, etc.

3.1.3 Design specification

The design entrusting party shall provide the formal design specification of the pressure vessel to the design unit in written. The design specification shall include the following as a minimum:

(1) Operating parameters (including operating pressure, operating temperature range, liquid level height, load on nozzle, etc.);

(2) The location and natural conditions for the pressure vessel service (including ambient temperature, seismic precautionary intensity, loads of wind and snow, etc);

(3) Composition and properties of medium;

(4) Estimated service life;

(5) Geometric parameters, nozzle location and orientation;

(6) Other necessary specifications for the design.

3.1.4 Design documents

3.1.4.1 Content of design documents

(1) The design documents of pressure vessels include risk assessment report (when necessary), strength calculation sheets or stress analysis reports, design drawings, manufacturing technical specification. When necessary, the installation, operation, and maintenance instructions shall also be included;

(2) When pressure vessels are equipped with safety valves or bursting disc devices, the design documents shall also include the calculation sheets of safety relieving capacity of pressure vessels, the discharge capacity of safety valves and the relieving area of bursting disc devices. If simulating computation is adopted or these calculations cannot be completed, the pressure relief devices shall be selected by consultation with the design entrusting party or the user.

3.1.4.2 Review and approval of design documents

For the risk assessment report, strength calculation sheets or stress analysis reports, assembly drawings of design documents, at least three-step signing of design, check, review and approval shall be conducted. For category III pressure vessels, except for the three-step singing, an approval signature of the technical responsible personnel or his / her authorized person of the pressure vessel design unit shall be signed on the assembly drawing (four-step singing) .

3.1.4.3 Retention period

The retention period of design documents shall not be less than the design service life of pressure vessels.

3.1.4.4 Assembly drawing

3.1.4.4.1 Main content of the assembly drawing

The assembly drawing of pressure vessels shall include the following as a minimum:

(1) Name and category of pressure vessels, regulations and standards for the design and manufacture;

(2) Operating condition, including operating pressure, operating temperature, properties of medium (toxicity and explosion damage degree, etc.);

(3) Design specifications, including design temperature, design loads (including pressure and all kinds of loads to be considered), medium (composition), corrosion

allowance, welded joint efficiency, natural condition, etc; the maximum filling ratio for tanks containing liquefied gas; limited content of corrosive medium for storage pressure vessels with material having stress corrosion tendency;

(4) Material designations and corresponding standards for main pressure components;

(5) Main characteristic parameters (such as pressure vessel volume, heat transfer area and passes number of heat exchanger);

(6) Design service life of pressure vessels (indicate the cycle number for vessels designed by fatigue analysis);

(7) Special requirements for fabrication;

(8) Requirements for heat treatment;

(9) Requirements for nondestructive examination;

(10) Requirements for proof pressure test and leak test;

(11) Requirements for corrosion-prevention (corrosion rate and stress corrosion tendency of medium);

(12) Specifications of safety accessories and instruments as well as particular purchase requirements (except considered in the process system);

(13) Location of the pressure vessel nameplate;

(14) Requirements for packing, transportation, field-assembly welding and installation.

3.1.4.4.2 Particular requirements

The particular requirements for assembly drawing are needed for the following situations:

(1) For pressure vessels with multiple chambers, the test pressure of each pressure chamber shall be indicated individually. The allowable pressure difference between two sides of the shared parts, and the test procedure and requirements shall be indicated where special requirements existing;

(2) For pressure vessels filled with catalysts and fillings, the technical requirements for periodic inspection in service shall be indicated;

(3) For pressure vessels incapable of internal inspections due to the structural reason, the calculated thickness and the requirements for periodic inspection in service shall be indicated;

(4) For pressure vessels incapable of proof pressure tests, the calculated thickness and special requirements for fabrication and operation shall be indicated;

(5) For pressure vessels with the thermal-isolation lining, the requirements for technical measures of preventing pressure components from over-heating shall be indicated;

(6) For pressure vessels with the heat or cold insulation, the corresponding measures shall be provided.

3.1.5 Design method

The design-by-rules or the design-by-analysis can be used for the design of pressure vessels. When necessary, the experimental method, the empirical comparable design method based on experience or other design methods can also be used after got approval in accordance with the provisions of Article 1.9 in this Regulation.

Based on the design specification in Article 3.1.3 of this Regulation, the Design unit of pressure vessels shall consider comprehensively all related factors, failure modes and safety margin, to ensure the strength, rigidity, stability and corrosion resistance of pressure vessels are sufficient. At the same time, the design unit shall also consider the strength requirements of the welded joints between the main body of pressure vessels and supports, base rings, lugs as well as other supporting fittings to ensure the safety of pressure vessels in design service life.

3.1.6 Risk evaluation

For category III pressure vessels or other pressure vessels required by the user, the design unit shall provide a risk evaluation report which included main failure modes, risk control, etc.

3.1.7 Requirements for energy-saving

In the design of pressure vessels, the principles of energy-saving and consumption reduction shall be fully considered. The design shall meet the requirements as the following:

(1) The economy of pressure vessels shall be fully considered to select the material and the dimension;

(2) For heat exchangers, the design shall be optimized to increase efficiency of heat exchanging and to meet the requirement of energy efficiency;

3.1.8 Loads

The load required in Item (1), (2) of this Article shall be considered when designing, and that in Item (3) to (10) shall also be considered when necessary.

(1) Internal pressure, external pressure or the maximum pressure difference;

(2) Static head pressure of liquid, which can be ignored when the static head pressure of liquid is less than 5% of design pressure;

(3) Dead weight of the pressure vessel, and gravitational load of the pressure vessel filled with mediums, catalysts and fillings etc. under normal operating conditions or proof pressure test condition;

(4) Gravitational load of accessory equipments and thermal-isolation materials, linings, pipelines, ladders, platforms, etc.

(5) Wind load, seismic load, snow load, etc;

(6) Reacting force of bearings, base rings, support lugs as well as other supporting fittings;

(7) Acting force caused by connecting pipelines and other parts;

(8) Acting force caused by temperature gradient or different thermal expansion;

(9) Impact load, including the impact load caused by abrupt fluctuation of pressure, reacting force caused by impacting of fluid, etc;

(10) Acting force generated in transportation or hoisting.

3.1.9 Pressure

3.1.9.1 Design pressure and calculated pressure

(1) Design pressure is defined as the maximum set pressure at the top of the vessel and shall be applied as the conditions of design load with the corresponding design temperature. The design pressure shall not be less than the operating pressure;

(2) Calculated pressure is defined as the pressure used to determine the thickness of the parts with the coincident design temperature. It shall take consideration of additional loads such as the static head pressure of liquid, etc.

3.1.9.2 Set pressure of pressure relief devices

(1) For pressure vessels equipped with pressure relief devices, the set pressure of pressure relief devices shall not be higher than the design pressure of pressure vessels;

(2) For pressure vessels, of which the maximum allowable operating pressure is indicated on design drawings, the set pressure shall not be higher than the maximum allowable operating pressure.

3.1.9.3 The design pressure for the pressure vessel containing liquefied gas at ambient temperature

The design pressure for the pressure vessel containing liquefied gas at ambient temperature shall be determined as the following based on the operating pressure at

specified temperature:

(1) The operating pressure at specified temperature for the pressure vessel containing liquefied gas at ambient temperature shall be determined according to Table 3-1;

Table 3-1 Operating Pressure at Specified Temperature for Pressure Vessels Containing Liquefied Gas at Ambient Temperature

<table>
<tr><td rowspan="3">Critical temperature of liquefied gas</td><td colspan="3">Operating Pressure at Specified Temperature</td></tr>
<tr><td rowspan="2">Without insulation</td><td colspan="2">With Insulation</td></tr>
<tr><td>Without temperature actually measured by test</td><td>With maximum operating temperature actually measured by test, and ensuring it less than critical temperature</td></tr>
<tr><td>Greater than and equal to 50℃</td><td>Saturated vapor pressure at 50℃</td><td colspan="2">Saturated vapor pressure at probable maximum operating temperature</td></tr>
<tr><td>Less than 50℃</td><td colspan="2">Gas pressure at 50℃ under maximum filling ratio specified by design</td><td>Saturated vapor pressure at actually measured maximum operating temperature by test</td></tr>
</table>

(2) The operating pressure at specified temperature for the pressure vessel containing mixed liquefied petroleum gas at ambient temperature shall be determined by the actual saturated vapor pressure of the mixed composition of liquefied petroleum gas at the temperature not less than 50℃. The design unit shall prescribe the limited composition and the corresponding pressure on the drawings. When the actual composition data is unavailable or the composition analysis is not made, the operating pressure at specified temperature shall be not less than the specified value as indicated in Table 3-2.

Table 3-2 Operating Pressure at Specified Temperature for Pressure Vessels Containing Mixed Liquefied Petroleum Gas at Ambient Temperature

<table>
<tr><td rowspan="2">Saturated Vapor Pressure of Mixed Liquefied Petroleum Gas at 50℃ (MPa)</td><td colspan="2">Operating Pressure at Specified Temperature (MPa)</td></tr>
<tr><td>Without Insulation</td><td>With Insulation</td></tr>
<tr><td>Less than or equal to saturated vapor pressure of isobutene at 50℃</td><td>Saturated vapor pressure of isobutene at 50℃</td><td>Saturated vapor pressure of isobutene at probable maximum operating temperature</td></tr>
<tr><td>Greater then saturated vapor pressure of isobutene at 50℃; less than saturated vapor pressure of propane at 50℃</td><td>Saturated vapor pressure of propane at 50℃</td><td>Saturated vapor pressure of isobutene at probable maximum operating temperature</td></tr>
<tr><td>Greater than saturated vapor pressure of propane at 50℃</td><td>Saturated vapor pressure of propylene at 50℃</td><td>Saturated vapor pressure of isobutene at probable</td></tr>
</table>

		maximum operating temperature

3.1.10 Temperature

(1) Design temperature is defined as the set metal temperature of the pressure part under normal operating conditions of the pressure vessel, i.e. average of metal temperature along the cross section of the pressure part. The design temperature shall be as the conditions of design load with the coincident design pressure;

(2) For designing storage pressure vessels at ambient temperature, when the atmospheric environment temperature has influence on the shell metal temperature of pressure vessels, the lowest design temperature shall not be greater than the minimum value of the lowest monthly average temperature over the years. The lowest monthly average temperature refers to the value calculated by the sum of the lowest temperature for each day of that month divided by total days of that month.

3.1.11 Corrosion allowance

For pressure vessels with uniform corrosion, the corrosion allowance shall be determined by the estimated service life and the material corrosive rate with the involved medium. In the meantime, the impact of abrasion and erosion due to medium flow shall also be taken into consideration for pressure components.

3.1.12 Minimum thickness

The minimum thickness of pressure vessels shall be determined by taking consideration of the impact of manufacture, transportation, installation, etc.

3.1.13 Filling ratio

The design storage capacity of pressure vessels containing liquefied gas shall be specified and the filling ratio shall not be greater than 0.95.

3.1.14 Inspection openings

(1) Inspection openings including manholes and hand holes shall be set on pressure vessels when necessary. The location, amount and size of the inspection openings shall meet the requirements of internal inspection;

(2) For pressure vessels required but incapable of setting inspection openings, the design unit shall provide specific technical measures such as increasing the items or percentage of inspection in manufacture, and shall specify requirements about key inspection items, methods of periodic inspection in service.

3.1.15 Non-detachable thermal isolation

For pressure vessels with thermal isolation which is not allowed to be detached in

design, the requirements for the periodic inspection items and methods in service shall be prescribed in the design documents. When necessary, the particular requirements of full nondestructive examination on all welded joints shall be prescribed on the drawings either.

3.1.16 Nondestructive examination

The method, percentage, technical requirements, etc. of nondestructive examination shall be specified by the designer on design documents.

3.1.17 Proof pressure test

Proof pressure test shall be performed after the pressure vessel is fabricated. Proof pressure tests include three types, i.e. hydrostatic test, pneumatic test and pneumatic-hydrostatic combination test. The types, pressure, medium, temperature, etc. of proof pressure test shall be specified by the designer on design documents.

3.1.18 Leak test

After the proof pressure test completed and accepted, leak test shall be conducted for the pressure vessel containing extremely or highly toxic medium, or permitting no slight leakage as specified in design documents. Depending on the difference of test mediums, leak tests include gas leak test, ammonia leak test, halogen leak test and helium leak test, etc. The types, pressure, technical requirements, etc. of leak test shall be specified by the designer in design documents.

For the pressure vessel requiring pneumatic test as specified on design drawings, whether the leak test is required shall be prescribed on design drawings.

For the cast pressure vessel containing gaseous mediums, gas leak test shall be prescribed on design drawings.

For the pressure vessel equipped with pressure relief devices such as safety valves, bursting disc devices, the designer shall provide the maximum allowable operating pressure if gas leak test is required by design.

3.2 Design requirements for metallic pressure vessels

3.2.1 Safety factor and allowable stress

3.2.1.1 Safety factor

The minimum safety factor for the allowable stress (or the design stress intensity) of metal materials (plate, forging, pipe and bolt) shall be determined in accordance with the provisions specified in Table 3-3 to Table 3-5.

Table 3-3 Safety Factors of Design-by-Rules Method

Material（Plate, Forging and Pipe）	Safety factors			
	Tensile Strength at Room Temperature R_m	Yield Strength at Design Temperature R^t_{eL}（$R^t_{p0.2}$）（Note 3-1）	Average Value of Creep Rupture Strength at Design Temperature R^t_D（Note 3-2）	Creep Limit at Design Temperature (for 0.01% of the creep rate per 1000h) R^t_n
Carbon Steel and Low Alloy Steel	$n_b \geq 2.7$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$
High Alloy Steel	$n_b \geq 2.7$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$
Titanium and Alloys	$n_b \geq 2.7$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$
Nickel and Alloys	$n_b \geq 2.7$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$
Aluminum and Alloys	$n_b \geq 3.0$	$n_s \geq 1.5$	—	—
Copper and Alloys	$n_b \geq 3.0$	$n_s \geq 1.5$	—	—
Zirconium and Alloys	$n_b \geq 3.0$	$n_s \geq 1.5$	—	—

Table 3-4 Safety Factors of Design-by-Analysis Method

Material（Plate, Forging and Pipe）	Safety Factors			
	Tensile Strength at Room Temperature R_m (Note 3-3)	Yield Strength at Design Temperature R^t_{eL}（$R^t_{p0.2}$）（Note 3-1）	Average Value of Creep Rupture Strength at Design Temperature R^t_D（Note 3-2）	Creep Limit at Design Temperature (for 0.01% of the creep rate per 1000h) R^t_n
Carbon Steel and Low Alloy Steel	$n_b \geq 2.4$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$
High Alloy Steel	$n_b \geq 2.4$	$n_s \geq 1.5$	$n_d \geq 1.5$	$n_n \geq 1.0$

Table 3-5 Safety Factors of Stud (Bolt)

Material	Stud (Blot) Diameter (mm)	Heat Treatment Conditions	Safety factors	
			Yield Strength at Design Temperature R^t_{eL}（$R^t_{p0.2}$）	Average Value of Creep Rupture Strength at Design Temperature R^t_D （Note 3-2）
Carbon Steel	≤M22	Hot Rolled, Normalized	2.7	1.5
	M24～M48		2.5	
Low Alloy Steel and Martensitic High Alloy Steel	≤M22	Quenched Plus Tempered	3.5	
	M24～M48		3.0	
	≥M52		2.7	
Austenite High Alloy Steel	≤M22	Solid Solution	1.6	
	M24～M48		1.5	

Note 3-1: For austenite stainless plate, if $R^t_{p1.0}$ is specified in corresponding material standards and allowed in product standards, it can be used for the calculation of the allowable stress.

Note 3-2: This safety factor is the average value of creep rupture strength at design temperature after 1.0×10^5h.

Note 3-3: For design-by-analysis, if R^t_m is specified in corresponding material standards, it can be used for the calculation of the allowable stress.

The safety factor for the tensile strength of grey cast irons at room temperature shall be not less than 10.0. The safety factor for the tensile strength of nodular cast irons at room temperature shall be not less than 8.0.

The safety factor for the tensile strength of cast steels at room temperature shall be not less than 4.0.

When the safety factor selected by design is below the provisions specified in this Regulation, it shall get approval in accordance with the provisions of Article 1.9 in this Regulation.

3.2.1.2 Allowable stress

The allowable stress of plate, forging and pipe shall take the smallest one among the values of tensile strength at room temperature R_m, yield strength at design temperature R^t_{eL} ($R^t_{p0.2}$), average value of creep rupture strength at design temperature R^t_D and creep limit at design temperature (for 0.01% of the creep rate per 1000h) R^t_n after being divided by the corresponding safety factor respectively (Note 3-4).

Note 3-4: For pressure components made of austenite high alloy steel, when the design temperature is lower than creep range and slight permanent deformation is permitted, the allowable stress can be raised to 0.9 $R^t_{p0.2}$ but no more than $\frac{R_{p0.2}}{1.5}$ (this provision is not applicable to flanges or other situations when leak or failure occurs caused by slight permanent deformation); for shells of austenitic stainless steel cryogenic vessels applying pressure strengthening technique, the allowable stress can be determined based on tensile strength at design temperature R^t_m and yield strength at design temperature R^t_{eL} ($R^t_{p0.2}$); for non-welded shells of cylinder type vessels, the allowable stress can be determined based on the strength guarantee value after heat treatment through which the product material properties have been improved.

The allowable stress of bolt shall take the smaller value between yield strength at design temperature R^t_{eL} ($R^t_{p0.2}$) and average value of creep rupture strength at design temperature R^t_D after being divided by the corresponding safety factor respectively.

3.2.2 Welded joint

3.2.2.1 Design for shell joints

For welded pressure vessels, full penetration welded joint shall be used for Categories A and B butt joints (the classification of Categories A and B butt-welded joints of pressure vessels is in accordance with the specification of GB 150).

3.2.2.2. Design of welded joint between nozzle and shell

For pressure vessels, the design for nozzle (flange)-to-shell welded joints and jacketed pressure vessel welded joints, full penetration welded joint shall be used if any of the following cases may occur:

(1) Pressure vessels containing inflammable and extremely or highly toxic mediums;

(2) Pressure vessels requiring the pneumatic test or pneumatic-hydraulic combination test;

(3) Category III pressure vessels;

(4) Low temperature pressure vessels;

(5) Pressure vessels designed by fatigue analysis;

(6) Directly fired pressure vessels;

(7) The designer deemed necessary.

3.2.3 Welded joint efficiency

(1) For welded pressure vessels, the joint efficiency shall be determined according to product standards based on the types of welded joints and percentage of nondestructive examination;

(2) It is not allowed to exempt nondestructive examination of pressure vessels by decreasing welded joint efficiency except for simple pressure vessels.

3.2.4 Test coupon (plate) and specimen

The designer shall indicate the preparation requirements for welded test coupon and corrosion resistance test coupon, and specify the type, quantity, sampling and preparation of specimens, as well as examination and test methods, acceptance criteria and re-test request, etc.

3.2.4.1 Pressure vessels requiring preparation of the product welded test coupon

(1) Carbon steel and low alloy steel pressure vessels under low temperature service;

(2) Low alloy steel pressure vessels with specified tensile strength lower limit greater than 540MPa;

(3) Pressure vessels containing extremely or highly toxic mediums;

(4) Pressure vessels applying pressure strengthening technique (for continuous lot produced pressure vessels with volume equal to or less than $5m^3$, it shall select 1 from 30 pressure vessels for preparation of the product welded test coupon at most under same design and same material batch no.);

(5) The designer deemed necessary or pressure vessels which the product welded test coupon is required on corresponding product standards.

3.2.4.2 Preparation requirements for the corrosion resistance test coupon

(1) For pressure vessels or pressure components requiring the corrosion resistance test, the corrosion resistance test coupon shall be prepared;

(2) For stainless steel and nickel alloy pressure vessels requiring the inter-granular corrosion sensitivity test, their test coupons and specimens shall conform to the specifications of GB/T 21433-2008 *Inter-granular Corrosion Sensitivity Test of Stainless Steel Pressure Vessel* or corresponding product standards.

3.2.5 Nozzle flanges of pressure vessels

(1) For steel pressure vessels, the design for nozzle flange, gasket and fastener shall refer to the specifications of HG/T 20592~HG/T 20635-2009 *Steel Nozzle Flange, Gasket,*

Fastener standards;

(2) For pressure vessels containing liquefied petroleum gas, extremely or highly toxic mediums and moderately toxic mediums with strong penetrability, the design of nozzle flange shall conform to the specifications of HG/T 20592 ~ HG/T 20635 standards, and shall use the combination of long welding neck flanges, spiral-wound gaskets with reinforcing rings and high strength blots at special grade; for pressure vessels incapable of using the nozzle flange seal combination, the designer shall determine the flange connection structure according to medium, pressure and temperature properties.

3.2.6 Leakage telltale hole

For the reinforcement ring of the opening on the pressure vessel and the backing having reinforcing function with continuous weld along periphery, at least one leakage telltale hole shall be set. For each layer of the wrapped layered pressure vessel, each shell ring of the integrally wrapped layered pressure vessel and both ends of each single wall cylinder (except the inner cylinder) of shrink fit pressure vessels , at least one leakage telltale hole shall be set.

3.2.7 Particular requirements of corrosion-resistant

For pressure vessels or pressure parts that have particular requirements of corrosion-resistant, for example those in corrosion medium condition with inter-granular corrosion, stress corrosion, pitting corrosion, crevice corrosion, etc, the corresponding corrosion-resistant measures, testing methods of corrosion resistance and other technical requirements shall be prescribed on design documents.

3.2.8 Design of plastic lining

(1) The structure design of pressure vessels shall take consideration of the deformation compatibility between metal base and plastic lining, and shall meet the requirements of plastic lining process;

(2) A leakage telltale hole shall be set on the body of pressure vessel.

3.2.9 Water quality

For tubular heat recovery boilers, steam generator, etc., the water quality shall conform to the specifications of GB 1576-2008 *Water Quality for Industrial Boiler* or GB/T 12145-2008 *Quality Criterion of Water and Steam for Generating Unit and Steam Power Equipment*.

3.2.10 Nondestructive examination

3.2.10.1 Nondestructive examination methods

(1) The methods of nondestructive examinations for pressure vessels include

radiographic test, ultrasonic test, magnetic particle test, liquid penetration test and eddy current test, etc., which shall be performed according to the provisions of NB/T 47013;

(2) When the nondestructive examination method is not included or exceed the applicable scope of NB/T 47013, it shall get approval in accordance with the provisions of Article 1.9 in this Regulation.

3.2.10.2 Nondestructive examination of welded joints for pressure vessels

3.2.10.2.1 The selection of nondestructive examination methods

(1) For butt-welded joints of pressure vessels, the radiographic test (including Film or digital imaging) or ultrasonic test shall be performed, ultrasonic test includes the Time of Flight Diffraction Technique (TOFD), the recordable and un-recordable Ultrasonic Pulse-echo Method; when using un-recordable Ultrasonic Pulse-echo Method, radiographic test or TOFD shall be used as a spot examination additionally; for butt-welded joints of large pressure vessels, when γ–ray test for panoramic exposure is performed, X-ray test or TOFD shall be used as a 50% spot examination additionally; if unacceptable defect occurs, a 100% X-ray test or TOFD reexamination shall be conducted.

(2) The radiographic test shall be preferably used for the welded joints of nonferrous pressure vessels;

(3) The magnetic particle test or liquid penetration test shall be preferably used for the surface cracks of welded joints;

(4) The magnetic particle test shall be preferably used for welded joints of pressure vessels made of magnetic ferrite material.

3.2.10.2.2 Percentage of nondestructive examination

3.2.10.2.2.1 Essential percentage requirements

The percentage of nondestructive examination for butt welded joints of pressure vessels is generally divided into two kinds: full (100%) and spot (equal to or greater than 20%) examinations. For carbon steel and low alloy steel pressure vessels under low temperature service, the percentage of the spot nondestructive examination shall be equal to or greater than 50%.

3.2.10.2.2.2 The full examination by radiographic test or ultrasonic test

Categories A and B butt-welded joints of pressure vessels shall be performed the full (100%) nondestructive examination with the method specified in the item (1) of Article 3.2.10.2.1 in this Regulation for one of the following conditions:

(1) Pressure vessels containing extremely or highly toxic mediums;

(2) The category Ⅲ pressure vessels with design pressure equal to or greater than 1.6MPa;

(3) Pressure vessels fabricated by standards of design-by-analysis;

(4) Pressure vessels requiring pneumatic test or pneumatic-hydrostatic combination test;

(5) Pressure vessels with welded joint efficiency of 1.0 or pressure vessels required but incapable of internal inspection in service;

(6) Low-alloy steel pressure vessels with specified tensile strength lower limit greater than 540MPa;

(7) Welded joints which the designer deemed it's necessary to conduct the full nondestructive examination.

3.2.10.2.2.3 Spot radiographic test or ultrasonic test

Each Categories A or B butt-welded joints of pressure vessels which are not required full nondestructive examination shall be performed the spot nondestructive examination with the method specified in the item (1) of Article 3.2.10.2.1 in this Regulation.

3.2.10.2.2.4 Surface nondestructive examination

The magnetic particle test or liquid penetration test shall be carried out for the welded joints for one of the following conditions:

(1) Welded joints of the pressure vessels containing extremely or highly toxic mediums;

(2) Welded joints of the pressure vessels requiring pneumatic test or pneumatic-hydrostatic combination test;

(3) Welded joints of the low alloy steel pressure vessels under low temperature service with design temperature lower than -40℃;

(4) Welded joints of low-alloy steel with specified tensile strength lower limit greater than 540MPa, ferritic stainless steel and austenite-ferritic stainless steel pressure vessels; in addition, for low-alloy steel pressure vessels with specified tensile strength lower limit greater than 540MPa, magnetic particle test or liquid penetration test for the welded joints shall be performed after proof pressure test;

(5) Welded joints of austenitic stainless steel pressure vessels with thickness greater than 20mm;

(6) Welded joints of Cr-Mo low alloy steel pressure vessels;

(7) Overlaying surface, cladding welded joints of clad steel plate, welded joints of the

dissimilar steel, and the welded joints with the reheat cracking tendency and the delayed cracking tendency; for the material having reheat cracking tendency, an additional nondestructive examination shall be performed after heat treatment;

(8) All joints of convex heads which are formed after paneling;

(9) Welded joints which the designer deemed it's necessary to conduct the surface nondestructive examination.

3.2.10.2.3 The technical requirements for nondestructive examination

3.2.10.2.3.1 Radiographic test

Radiographic test shall be performed in accordance with the specification of NB/T 47013, the quality requirements and acceptable quality criterion are as follows:

(1) For butt-welded joints requiring full nondestructive examination, the radiographic test technology level shall not be lower than Class AB, the acceptable quality criterion shall not be lower than Class Ⅱ;

(2) For butt-welded joints requiring spot nondestructive examination, the radiographic test technology level shall not be lower than Class AB, the acceptable quality criterion shall not be lower than Class III.

3.2.10.2.3.2 Ultrasonic test

Ultrasonic test shall be performed in accordance with the specification of NB/T 47013, quality requirements and acceptable quality criterion are as follows:

(1) For butt-welded joints requiring full nondestructive examination, the technical level of Ultrasonic Pulse-echo Method shall not be less than Class B, the acceptable quality criterion shall be Class Ⅰ;

(2) For butt-welded joints requiring spot nondestructive examination, the technical level of Ultrasonic Pulse-echo Method shall not be less than Class B, the acceptable quality criterion shall not be less than Class Ⅱ;

(3) For fillet joints and T-shaped joints, the technical level of Ultrasonic Pulse-echo Method shall not be less than Class B, the acceptable quality criterion shall be Class Ⅰ;

(4) For welded joints tested by the Time of Flight Diffraction Technique (TOFD) method, the acceptable quality criterion shall not be less than Class Ⅱ.

3.2.10.2.3.3 Combination examination

When combination of radiographic test and ultrasonic test is used, the quality requirements and acceptable quality criterion shall conform to the specification of standards

for radiographic test and ultrasonic test respectively, and both acceptable quality criteria shall be met.

3.2.10.2.3.4 Surface nondestructive examination

The magnetic particle test or liquid penetration test of all pressure vessel welded joints shall be performed in accordance with the specification of NB/T 47013, and the acceptable quality criterion is as follows:

(1) For steel pressure vessels tested by magnetic particle or liquid penetration, the acceptable quality criterion shall be Class I;

(2) For non-ferrous pressure vessels tested by liquid penetration, the acceptable quality criterion shall be Class I.

3.2.10.2.4 Nondestructive examination requirements for welded joints of nozzles.

(1) For butt welded joints of pressure vessel nozzles with nominal diameter equal to or greater than 250mm, the nondestructive examination methods, percentage and the acceptable quality criterion shall be the same as that for welded joints of the main body;

(2) For butt welded joints of pressure vessel nozzles with nominal diameter less than 250mm, the nondestructive examination methods, percentage and the acceptable quality criterion shall be specified by the designer or product standards.

3.2.10.3 Nondestructive examination requirements of raw materials and parts

Nondestructive examination methods, percentage, and the acceptable quality criteria of raw materials and parts shall be specified by the designer according to this Regulation and corresponding product standards.

3.2.11 Postweld heat treatment

(1) When the stress after welding affects safety service, the postweld heat treatment (stress relief) shall be conducted for pressure vessels and pressure components;

(2) The postweld heat treatment shall be conducted for carbon steel and low alloy steel pressure vessels containing extremely mediums and pressure components.

When the stress relief methods other than the postweld heat treatment are used, it shall get approval in accordance with the provisions of Article 1.9 in this Regulation.

Postweld heat treatment is generally not required for austenitic stainless steel pressure vessels and non-ferrous pressure vessels. If heat treatment is necessary for special requirements, it shall be specified on design drawings.

3.2.12 Proof pressure Test

3.2.12.1 Test pressure

The minimum test pressure shall be calculated by (3-1):

$$p_T = \eta p \frac{[\sigma]}{[\sigma]^t} \tag{3-1}$$

Where:

p_T — Test pressure，MPa；

η — Pressure factor of proof pressure test，obtained from Table 3-6；

P — Design pressure of the pressure vessel or the maximum allowable operating pressure specified on the nameplate of the pressure vessel（for the pressure vessel in service, generally taken as the allowable operation pressure or control operation pressure determined by the inspection），MPa;

$[\sigma]$ — Allowable stress of material at test temperature（or design stress intensity），MPa;

$[\sigma]^t$ — Allowable stress of material at design temperature（or design stress intensity），MPa

When the components of the pressure vessel (such as cylinder, head, nozzle, equipment flange, man-hand hole flange and fastening) are made of different materials, the test pressure shall be calculated with the minimum value of $[\sigma]$ / $[\sigma]^t$ for the materials of each component; $[\sigma]^t$ shall not be less than the minimum allowable stress of material controlled by the tensile strength and yield strength.

Table 3-6 Pressure Factor of Proof Pressure Test

Pressure Vessel Material	Pressure Factor η	
	Hydrostatic Test	Pneumatic Test Pneumatic-Hydrostatic Test
Steel and Nonferrous Metal	1.25	1.10
Cast Iron	2.00	—

3.2.12.2 Test temperature

During proof pressure test, the test temperature (the wall metal temperature of the

pressure vessel) shall be 30℃ higher than the nil ductility transition temperature of the vessel metal, or be in accordance with the specifications of product standards. If the nil ductility transition temperature of the material is raised due to the plate thickness etc, the testing temperature shall be increased correspondingly.

3.2.12.3 Test medium

(1) Any liquid having no risk in test may be used as the hydrostatic test medium at the temperature less than the boiling point of that liquid. When an inflammable liquid is used as the hydrostatic test medium, the test temperature shall be less than the flash point of that liquid;

(2) When the testing liquid cannot be filling into the pressure vessel due to the reason of structure or support, or even a little amount of residual liquid in the pressure vessel is not permitted due to operating requirements, a pneumatic test may be used; the testing gases shall be dry and clean air, nitrogen or other inert gases;

(3) The pressure vessel which cannot be fully filled with liquid due to load-bearing or other reasons may subject to pneumatic-hydrostatic combination test with the routine of filling in part of liquid based on the load-bearing capacity firstly and then filling in gas. The testing liquids and gases shall conform to the related requirements of item (1) and (2) of this Article respectively.

3.2.13 Leak test

3.2.13.1 Gas leak test

The gases used in gas leak test shall conform to the item (2) of Article 3.2.12.3 in this Regulation, and the test pressure is the design pressure of the pressure vessel.

3.2.13.2 Ammonia leak test

The ammonia leak test methods, such as ammonia-air method, ammonia-nitrogen method, 100% ammonia method can be used. The ammonia consistence, the test pressure, and the holding time for pressure are specified by the designer on design documents.

3.2.13.3 Halogen leak test

In halogen leak test, requirements of vacuum level inside the vessel, the type of halogen gas, the test pressure, the holding time for pressure, and the test operation procedure are specified by the designer on design documents.

3.2.13.4 Helium leak test

In helium leak test, requirements of vacuum level inside the vessel, the consistence of

helium, the test pressure, the holding time for pressure, and the test operation procedure are specified by the designer on design documents.

3.2.14 Special requirements for the design of ultra-high pressure vessels

3.2.14.1 Design methods

(1) For ultra-high pressure vessels, burst pressure calculation method or elastic plastic analysis shall be used for the design of static strength; when elastic plastic analysis is used, the load amplification factor shall be equal to or greater than 2.0;

(2) Fatigue analysis shall be conducted for ultra-high pressure vessels.

3.2.14.2 Safety factor

3.2.14.2.1 Safety factor of burst pressure calculation method

For ultra-high pressure vessels, the safety factor shall be equal to or greater than 2.2 when the burst pressure is calculated according to the tensile test data of material, and it shall be equal to or greater than 2.4 for ultra-high pressure crystal autoclave; when the burst pressure is calculated according to the torsion test data of material, the safety factor shall be equal to or greater than 2.2.

3.2.14.2.2 Safety factor of fatigue analysis

In fatigue analysis, the safety factor of alternative stress amplitudes and cycle times shall be 2 and 15 respectively.

3.2.14.2.3 Safety factor of the stud (bolt)

The safety factor of yield strength at design temperature shall be equal to or greater than 1.8.

3.2.14.3 Maximum metal temperature

A permanent-recordable temperature measuring device shall be set on the place expected to show the maximum temperature, and the location and dimensions of temperature measuring hole shall be specified; the maximum metal temperature of ultra-high pressure vessels shall not be higher than the allowable service temperature of steel.

3.2.14.4 Nondestructive examination

The methods of nondestructive examinations for ultra-high pressure vessels include ultrasonic test, magnetic particle test, liquid penetration test and eddy current test, etc. The designer shall specify the methods, percentage, perform timing and technical requirements of nondestructive examination in design documents according to the requirements of this Regulation and corresponding product standards.

3.2.14.5 Autofrettage treatment

Hydraulic boosting shall be used for autofrettage treatment, and appropriate methods shall be used to control the circumferential strain of vessel wall which shall not be greater than 2%.

3.2.14.6 Test pressure

For ultra-high pressure vessels, hydraulic test is generally used for proof pressure test. The minimum test pressure (p_T) shall be calculated by (3-2):

$$p_T = 1.12p\frac{R_{p0.2}}{R^t_{p0.2}} \quad (3\text{-}2)$$

Where:

P ---- Design pressure of ultra-high pressure vessels (operation pressure for ultra-high pressure vessels in service), MPa;

$R_{p0.2}$ ---- Yield strength at material test temperature, MPa;

$R^t_{p0.2}$ ---- Yield strength at material design temperature, MPa;

3.2.15 Special requirements for the design of simple pressure vessels

3.2.15.1 Assembly drawing

For simple pressure vessels, the assembly drawing shall not only meet the requirements of Article 3.1.4.4 of this Regulation, but also include the following:

(1) Welding methods and requirements;

(2) Burst test requirements when design-by-test is used.

3.2.15.2 Design methods

For simple pressure vessels, the wall thickness of main pressure components shall be determined by testing or calculating.

3.2.15.2.1 Testing

For the simple pressure vessels designed by testing, the burst pressure at room temperature shall not be less than 4 times of the design pressure, and the circumferential permanent deformation rate shall not be greater than 1%.

3.2.15.2.2 Calculating

When the wall thickness of main pressure components is determined by calculating, it shall meet the requirements as follows:

(1)The general membrane stress shall be equal to or less than $0.6R_{p0.2}$, or be $0.3R$m;

(2) If the shell of pressure vessel has manually welded longitudinal joints, the calculation thickness of shell shall be increased by 15%.

3.2.15.3 Minimum wall thickness

For austenitic stainless steel simple pressure vessels, the actual wall thickness of shaped shell shall not be less than 1mm; for carbon steel simple pressure vessels, it shall not be less than 2mm.

3.2.15.4 Spot-check of nondestructive examination

For the simple pressure vessels designed by calculating, the butt-welded joints shall be subject to the spot check of radiographic test according to NB/T 47013, and the technology level shall not be lower than Class AB, the acceptable quality criterion shall not be lower than Class Ⅲ. The principle of spot-check are as follows:

(1) For butt-welded joints using automatic welding or machine welding process, it shall conduct radiographic test for the first product after the welding procedure is changed;

(2) In the process of manufacturing, at least one vessel shall be subject to radiographic test for each batch products (note 3-5); one vessel must be chosen for radiographic test when the daily production is not enough for one batch;

(3) For butt-welded joints using manual welding process, at least one vessel shall be subject to radiographic test for the products welded by each welding operation personnel (hereinafter referred to as welder) everyday.

(4) The longitudinal welds including cross welds shall be the preferable location of radiographic test, the length for test of each product shall not be less than 200mm.

Note 3-5: The batch production principle for simple pressure vessels is in Article 4.2.9.2 of this Regulation.

3.2.15.5 Proof pressure test

(1) The minimum test pressure shall be 1.5 times of the design pressure of simple pressure vessels;

(2) In proof pressure test, the metal temperature of simple pressure vessels and the temperature of test medium shall not cause brittle fracture, and the temperature of test medium is generally not lower than 5℃.

3.2.16 Special requirements for the design of quick opening pressure vessels

Pressure vessels with the quick opening closure are ones with quick seal locking devices mutually nested with each other between the main body and the head or end plate of the in-and-out path. Bolts connected vessels (such as swing bolts) do not belong to quick opening pressure vessels. The impact of fatigue load shall be taken into consideration for the design of pressure vessels with the quick opening closure.

When designing quick opening pressure vessels, the designer shall set safety interlock

devices, and specify the technical requirements such as its service environment, calibration periodicity and calibration methods.

The safety interlock devices shall meet the following requirements:

(1) Operation for pressure cannot be started unless the quick opening closure reaching the preset shut position;

(2) The quick opening closure cannot be opened until internal pressure of the pressure vessel completely being released.

3.3 Design requirements of nonmetallic pressure vessels

3.3.1 Graphite pressure vessels

3.3.1.1 Design scope

The design scope of graphite pressure vessels is as follows:

(1) Maximum design external pressure, 2.4MPa;

(2) Maximum design internal pressure, 2.4MPa;

(3) Lowest design temperature, -70℃;

(4) Highest design temperature, 205℃.

3.3.1.2 Safety factor and allowable stress

The allowable stress value used in design shall be the tensile strength at design temperature specified in certified material qualification report (CMQ) of graphite or 80% of average value of compression test divided by the safety factor 6.0 (when the medium is extremely or highly toxic, the safety factor shall be 7.0).

3.3.1.3 Corrosion resistance

The graphite material selected shall keep the corrosion resistance in service conditions.

3.3.1.4 Proof pressure test

The test pressure shall not be lower than 1.5 times of the design pressure; for pressure vessels containing extremely or highly toxic mediums, the test pressure shall not be lower than 1.75 times of the deign pressure.

The medium of proof pressure test generally is clean water.

3.3.1.5 Leak test

For pressure vessels containing extremely or highly toxic medium, the leak test shall be conducted for all joints and junctions with test pressure not lower than design pressure. The test method shall be specified by the designer.

3.3.1.6 Cementing specimen

For pressure vessels containing extremely or highly toxic medium, the designer shall provide the preparation requirements of cementing specimens, and specify the quantity and preparation of specimens, inspection and test methods, acceptance criteria and re-test request etc.

3.3.2 Fiber reinforced plastic pressure vessels

3.3.2.1 General requirements

(1) Fiber reinforced plastic pressure vessels cannot be used to contain extremely or highly toxic medium and liquefied gas;

(2) Except the requirements of Article 3.1.5 of this Regulation, the layer design of fiber reinforced materials shall be conducted along with strength calculation and rigidity calculation simultaneously;

(3) The wall of fiber reinforced plastic pressure vessels is composed of inside liner, structure layer and outside protection layer; only the pressure strength of structure layer shall be consider for strength calculation of internal pressure; the external pressure levels and dead load shall be calculated by the total thickness of the pressure vessel;

(4) The anisotropy of compound materials and the property degradation caused by material aging shall be considered;

(5) The design temperature of fiber reinforced plastic pressure vessels shall be the operating temperature of mediums and not lower than -54℃.

3.3.2.2 Design types

The design for fiber reinforced plastic pressure vessels are classified to the following three types. The designer shall determine the design type according to design parameters, design methods, manufacturing procedures, etc. and indicate in the design documents (assembly drawing):

(1)Type Ⅰ pressure vessel, when hand lay-up molding and spraying forming process are used for manufacturing , the design pressure shall be equal to or less than 1MPa; when filament winding process is used for manufacturing without pore enveloping, the design pressure shall be equal to or less than 10MPa; when filament winding process is used for manufacturing and pore enveloping is performed, the design pressure shall be equal to or less than 20MPa; when the operating temperature is no greater than 65℃, the design temperature shall be 65℃; when the operating temperature is greater than 65℃, the design temperature shall be no greater than 120℃, and the heat distortion temperature of resins

used shall be at least 20℃ above the design temperature;

(2) Type Ⅱ pressure vessel, the filament winding process must be used for cylinders, and the hand lay-up molding, spraying forming process or filament winding process can be used for heads; when design-by-rules is adopted, the product of operating pressure and inside diameter shall be no greater than 2.4MPa·m, the maximum design pressure shall be no greater than 1.6MPa, the maximum design inside diameter shall be no greater than 4.8m; when design-by-analysis or the combination of design-by-rules and design-by-analysis is adopted, the design pressure shall be no greater than 0.6MPa, the inside diameter shall be no greater than 4m; the design temperature shall be no greater than 120℃, and the heat distortion temperature of resins used shall be 20℃ above greater than the design temperature;

(3) Type Ⅲ pressure vessel, the filament winding process and pore enveloping must be used for manufacturing, and the design pressure shall be no greater than 100MPa and no less than 20MPa; the design temperature shall be no greater than 85℃, and the heat distortion temperature of resins used shall be 20℃ above greater than the design temperature.

3.3.2.3 Design methods and safety factor

(1) Type Ⅰ pressure vessel, prototype vessels shall be fabricated and 100 thousand times pressure fatigue test shall be conducted for the prototype vessels with pressure range from normal pressure to design pressure. After the fatigue test, pressure test shall be carried out with test pressure equal to or more than 6 times of the design pressure, and no leakage or rupture happens to the vessel during the test;

(2) Type Ⅱ pressure vessel，when design-by-analysis or the combination of design-by-rules and design-by-analysis is adopted，and acoustic emission testing is used for acceptance, the design safety factor of Type Ⅱ pressure vessels shall consider the load conditions, forming process, service environment, temperature, estimated service life, material discrete, etc; it shall improve the safety factor when acoustic emission testing can’t be used; the design allowable strain shall be no greater than 0.1%, and the external safety factor shall be no less than 5.0; the specific safety factors of Type Ⅱ pressure vessels are specified in appropriate product standards;

(3) Type Ⅲ pressure vessel, prototype vessels shall be fabricated and whether the

fatigue test is performed depends on design conditions. After the fatigue test, pressure test shall be carried out. When carbon fiber reinforced plastic is used for manufacturing, the test pressure shall be no less than 2.25 times of the design pressure; when glass fiber reinforced plastic is used for manufacturing, the test pressure shall be no less than 3.5 times of the design pressure. No leakage, blisters, obvious deformation and rupture happens to the vessel during the test.

3.3.2.4 Lay-up design

The lay-up design for fiber reinforced plastic pressure vessels shall at least include the followings:

(1) Types of fibers and fiber products;

(2) Resin system and composition;

(3) Sequence, direction and layers of lay-up;

(4) Forming process (including curing process);

(5) Resin content (weight ratio).

3.3.2.5 Cementing design

For cementing design, it shall ensure the allowable bearing capacity of cementing joints is no less than the annulus load, axial load and radial load at the joints.

3.3.2.6 Proof pressure test

Hydrostatic test is generally used for proof pressure test, and the test medium shall be clean water or other appropriate liquid; for pressure vessels not fit the hydrostatic test, pneumatic test can be used.

The test internal pressure shall be no less than 1.1 times of the design internal pressure, the test external pressure shall be no less than 1 times of the design external pressure.

For Type Ⅱ pressure vessels, acoustic emission testing shall be carried out for proof pressure test. When acoustic emission testing can’t be performed, the test internal pressure shall be no less than 1.25 times of the design internal pressure, the test external pressure shall be no less than 1.1 times of the design external pressure and no greater than 0.1MPa.

3.3.3 Design for metal pressure components of nonmetallic pressure vessels

The design for metal pressure components of nonmetallic pressure vessels shall conform to the corresponding provisions related to metallic pressure vessels in this Regulation.

4 Fabrication

4.1 General requirement

4.1.1 Manufacturer

(1) The pressure vessel manufacturer (including field fabrication, field-assembly welding, field cementing, see note 4-1) shall obtain the special equipment manufacturing license, and fabricate within the approved scope, establish and implement effectively the quality assurance system in accordance with the requirements of relevant rules of laws, and safety technical regulations. The manufacturer and the legal representative must be responsible for the quality of pressure vessels;

(2) Manufacturers shall strictly enforce the relevant rules of laws, safety technical regulations and technical standards, and fabricate pressure vessels in accordance with the technical requirements of design documents.

Note4-1: The field fabrication, field-assembly welding, field cementing of stationary pressure vessels, respectively refer to the fabrication on service field for large pressure vessels (including spherical tanks) unable to transport, the assembly welding on service field for section-by-section delivery pressure vessels, and the cementing on service field for nonmetallic pressure vessels.

4.1.2 Type test (Prototype test)

Simple pressure vessels and accumulators shall pass through type (prototype) tests taken by the approved type test institute of the AQSIQ, and the test items, requirements and results shall meet the requirements of corresponding product standards.

Prior to manufacturing cylinder type vessels and vacuum insulation cryogen vessels for the first time, the manufacturer shall make a demo product and pass through type (prototype) tests taken by the approved type test institute of the AQSIQ, and the test items, requirements and results shall meet the requirements of corresponding product standards.

4.1.3 Supervisory inspection on manufacturing

For pressure vessels requiring supervisory inspection (including the pressure components and parts of pressure vessels in article 4.1.5.2 of this Regulations), the manufacturers shall invite the special equipment inspection institute to conduct the supervisory inspection during their manufacturing process and obtain the Supervisory Inspection Certificate of Special Equipment, then the pressure vessels can be delivered.

4.1.4 Quality plan

(1) Prior to the manufacturing of pressure vessels, the manufacturer shall make a sound quality plan (inspection plan) according to the requirements of this Regulation,

product standards and design documents, which shall include control points of fabrication procedure and inspection items for pressure vessels, pressure components or parts;

(2) During the manufacture process and after the completion of pressure vessels, the manufacturer shall conduct corresponding inspection and testing for vessels according to the timing specified in the quality plan, and the relevant personnel shall make records or corresponding reports.

4.1.5 Product delivery documentation or as-built documentation

4.1.5.1 General requirement

When pressure vessels are delivered or completed, the manufacturers shall provide users with following technical documentations (Note 4-2) as a minimum, and offer CD or other electronic medium storing the electronic documents of pressure vessel conformity certificates and product quality certification documents:

(1) As-built drawings, the as-built drawing shall have the dedicated stamp for design unit (duplication of the stamp is invalid, excluding the batch produced pressure vessels) and the finish seal (including the manufacturer name, the manufacturing license number, the signature of the review person and the sign of "As-built Drawing"). If anything happened during fabrication, such as material substitution, change of nondestructive examination method or change of final size etc., the manufacturer shall clearly make indications on the as-built drawings in accordance with the written approval document by the design unit, and the signature of the person who makes changes and the date of changes shall be marked at the indication column;

(2) Pressure vessel conformity certificate (including Product Data Sheet, see sample in Annex B) and product quality certification documents; product quality certification documents include material list, material quality certificates of the main pressure components, quality plan, checking report of appearance and geometric dimensions, weld (cementing) map, nondestructive examination report, heat treatment report and automatically recorded curves, proof pressure test report and leak test report and a rubbing or a copy of the product's nameplate etc; for vacuum insulation pressure vessels, it also includes the inspection results of sealing-off vacuum degree, vacuum interlayer leakage rate, static evaporation rate, etc;

(3) Supervisory Inspection Certificate of Special Equipment (applicable to the products for which supervisory inspection are conducted);

(4) Pressure vessel design documents provided by the design unit.

Note 4-2: For simple pressure vessels, the manufacturer shall only provide the copy of as-built drawing, product conformity certificate and Supervisory Inspection Certificate of Special Equipment.

4.1.5.2 Product delivery documentations of pressure components and parts of pressure vessels

For pressure components of pressure vessels (such as shell rings, heads, forgings etc.) and pressure parts (such as tube bundles of heat exchangers, man holes, etc.) delivered individually, the manufacturers shall provide its quality certificate documents to Purchasers.

4.1.5.3 Retention period

The retention period of product delivery documentation or as-built documentation shall not be less than the design service life of pressure vessels.

4.1.6 Product nameplate

Manufacturers shall set the product nameplates in a conspicuous place on pressure vessels. The nameplate shall be clear, solid, durable, and shall be written in Chinese (in both Chinese and English when necessary) and SI unit. The contents of the product nameplate shall at least include the following:

(1) Product name;

(2) Name of manufacturer;

(3) License number and level of manufacture licensing;

(4) Product standards;

(5) Materials of main body;

(6) Medium name;

(7) Design temperature;

(8) Design pressure, maximum allowable operating pressure (when necessary);

(9) Pressure of proof pressure test;

(10) Product serial number or batch number;

(11) Equipment code (numbering method of special equipment code is in Annex D);

(12) Date of manufacture;

(13) Pressure vessel category;

(14) Dead load and volume (heat transfer area).

The format of product nameplate is in Annex C.

4.1.7 Design changes

When the manufacturer intends to change the original design, a written document of

agreement for the change shall be obtained from the original design unit. All the changes shall be recorded in details.

4.1.8 Nondestructive examination

Manufacturers shall formulate and implement the process documents of nondestructive examination according to the design documents. The nondestructive examination personnel shall obtain the certification according to the relevant technical regulations before they can perform the nondestructive examination within the scope of the NDE method and Level of the certification.

4.1.9 Proof pressure test

Manufacturers shall conduct the proof pressure test according to the regulations of design documents after the pressure vessel is fabricated.

4.1.9.1 Preparations of proof pressure test

(1) All the fastenings at various connecting locations of the pressure vessel shall be completely mounted and properly tightened prior to proof pressure test;

(2) The pressure gages used for test shall conform to the corresponding provisions of Chapter 9 of this Regulation. At least two calibrated pressure gages with the same measuring range shall be used and installed at the top of tested vessel for easy observation;

(3) During proof pressure test, the appropriate measures for temporary pressure parts welded on the pressure vessel shall be taken to ensure the strength and safety;

(4) The reliable safety protection facilities shall be provided at the site of proof pressure test, and be identified and accepted by the technical chief and the safety department of the manufacturer.

4.1.9.2 General requirements for proof pressure test

(1) When the test pressure is higher than that specified in design documents, each pressure components shall be subject to strength verification;

(2) During the holding period, any action of continuously raising pressure to keep the pressure constantly is not allowed. During proof pressure test process, the fastenings shall not be tightened and any external force shall not be applied on pressure components;

(3) During the proof pressure test, any unrelated work is not allowed, and any unrelated personnel shall not stay at the testing site;

(4) During the proof pressure test, the supervisory inspector shall be present on site for supervisory inspection;

(5) There shall be no fire source around the testing site, and necessary fire fighting

equipments shall be provided;

(6) After the proof pressure test, if the repairing depth greater than 1/2 the thickness of the vessel, one more proof pressure test shall be conducted.

4.1.9.3 Hydrostatic test

4.1.9.3.1 Procedures of hydrostatic test

(1) The test mediums shall conform to the requirements of product standards and design drawings. When water used as the hydrostatic test medium, it shall be drained after the test is acceptably completed, and the water stains shall be cleaned off when necessary;

(2) The tested pressure vessel shall be fully filled with testing liquid. Any gas in the pressure vessel shall be released completely. And the outer surface of the pressure vessel shall be kept dry;

(3) When the wall metal temperature of the pressure vessel is close to liquid temperature, the pressure in testing may be raised up to the design pressure gradually. After no leakage is identified, the pressure in testing shall be continuously raised up to the specified test pressure, and be held for a sufficient time. Then the pressure is relieved to the design pressure, and is held a sufficient time for inspection. During inspection, the pressure shall be kept constant;

(4) The hydrostatic test procedure for heat exchangers shall conform to the specifications of product standards.

4.1.9.3.2 Acceptance criterion of hydrostatic test

The hydrostatic test of the pressure vessel is acceptable when all the following conditions are met:

(1) No leakage;

(2) No visible deformation;

(3) No unusual noise during testing.

4.1.9.4 Pneumatic test

4.1.9.4.1 Procedures of pneumatic test

(1) During testing, the manufacturer shall make an emergency plan and send someone to supervise on testing site, withdraw the unrelated personnel;

(2) During testing, the pressure shall be gradually raised to 10% of the specified test pressure, and be held for a sufficient time for the preliminary inspection on all welds (cementing) and connecting locations. If no leakage occurs, the pressure in testing may be

continuously raised to 50% of the specified test pressure. If no any unusual phenomenon occurs, the pressure in testing may be raised step by step with a gradient of 10% of the specified test pressure up to the test pressure, and be held for a sufficient time. Then, the pressure is relieved to the design pressure for inspection. During inspection, the pressure shall be kept constant.

4.1.9.4.2 Acceptance criterion of pneumatic test

During the test, the pressure vessel with no unusual noise, no leakage during the test of soap liquid or other liquid, and no visible deformation can be identified as acceptable.

4.1.9.5 Pneumatic-hydrostatic combination test

Requirements for the pressure raising and pressure relieving, safety protection, and the acceptance criteria during pneumatic-hydrostatic combination test shall conform to the provisions of Article 4.1.9.4 in this Regulation.

4.1.10 Leak test

Manufacturers shall conduct the leak test according to the specifications of design documents after the proof pressure test completed and accepted.

4.1.10.1 Gas leak test

(1) During gas leak test, in general the safety accessories shall be completely mounted;

(2) After holding a sufficient time at the test pressure, the pressure vessel with no leakage shall be identified as acceptable.

4.1.10.2 Other types of leak test

The leak tests such as ammonia leak test, halogen leak test, helium leak test etc. shall be conducted by the manufacturer according to the specifications of design documents.

4.2 Requirements for fabrication of mental pressure vessels

4.2.1 Welding

4.2.1.1 Welding Procedure Qualification

The requirements of pressure vessel welding procedure qualifications are as follows:

(1) Before pressure vessel products are welded, welded joints of pressure components, welds to pressure components, tack welds that melt in permanent welds, welding overlay and welding repair on the base metal of pressure components, as well as welding repair of all welds mentioned above shall go through welding procedure qualifications or be supported by qualified welding procedure specifications (WPS);

(2) The pressure vessel welding procedure qualification shall conform to the requirements of NB/T 47014 *Welding procedure qualification for pressure equipment*;

(3) The supervisory inspector shall supervise the process of the welding procedure qualification;

(4) Upon completion of the welding procedure qualification, the welding procedure qualification record (PQR) and the welding procedure specification reviewed by the responsible welding engineer of the manufacturer, approved by the technical chief of the manufacturer, signed and confirmed by the supervisory inspector shall be kept in technical files;

(5) The technical file of the welding procedure qualification shall be kept as long as the expiry date of the welding procedure qualification, the specimens of the welding procedure qualification shall be kept for at least 5 years.

4.2.1.2 Welder

(1) Welders engaged in welding operation of pressure vessels shall be qualified in accordance with the provisions of related safety technical regulations, and hold the personnel certificate of special equipment operator prior to welding within the scope of applicable terms before the expire date;

(2) The welder shall perform welding in accordance with the welding procedure specification or welding operating instructions and make the welding records. The inspector of the manufacturer shall check the actual welding parameters;

(3) The welder identification symbol shall be stamped at the specified place adjacent to the weld of the pressure component or recorded in the weld map (including welds layout drawing). The weld map shall be included in the product quality certification documents;

(4) The manufacturer shall create a welder technical file.

4.2.1.3 Paneling and assembly of pressure vessels

(1) Paneling is not allowed for petals of spherical tanks;

(2) The use of cross weld is not recommended on pressure vessels;

(3) Forced assembly is not allowed during the fabrication of pressure vessels.

4.2.1.4 Welding repair

The requirements of welding repair (including welding repair of base metal defects) are as follows:

(1) The cause of defect shall be analyzed, and the appropriate procedure for welding repair shall be presented;

(2) The welding procedure qualification of welding repair shall be carried out in accordance with the Article 4.2.1.1 of this Regulation, or it shall be supported by qualified

welding procedure specifications. Welding repair shall be recorded in detail;

(3) It's not recommended to carry out welding repair more than twice at the same position, otherwise, the welding repair shall be approved by the technical chief of the manufacturer beforehand, and the times, position and situations of welding repair shall be recorded in the quality certification documents;

(4) For the pressure vessel requiring postweld heat treatment, generally, the welding repair shall be performed prior to heat treatment. In case the welding repair is conducted after heat treatment, the requirement for stress relief heat treatment shall depend on the depth of welding repair;

(5) For pressure vessels or pressure components with particular requirements on corrosion resistance, the corrosion resistance shall be kept not less than original requirements after welding repair;

(6) The position of welding repair shall be re-examined and accepted in accordance with the original requirements.

4.2.2 Test coupon (plate) and specimen

4.2.2.1 The preparation requirements for heat-treatment test coupon of the base metal

The heat-treatment test coupon of the base metal shall be prepared when heat treatment is used for the material mechanical property (see Article 4.2.6.1 of this Regulation) recovery or improvement in the manufacturing process.

When preparing above heat-treatment test coupon of a base metal, if the product welded test coupon is required also, one combination test coupon is allowed.

4.2.2.2 The preparation of welded test coupon (plate)

(1) The product welded test coupon shall be at the extension portion of the shell section longitudinal weld, and shall be welded simultaneously with the shell section longitudinal weld (except for spherical pressure vessels and forged-welded pressure vessels);

(2) The raw material of the test coupon shall be acceptable, and shall be of the same material standard, same designation, same thickness, and same heat treatment condition as those of the vessel;

(3) The test coupon shall be done by the welder who welds the pressure vessel with the same condition and same welding procedures as the pressure vessel; for the pressure vessel with the requirement of heat treatment, the test coupon shall generally be heat-treated together with the pressure vessel. Otherwise, special measures shall be taken to ensure that the test coupon is heat-treated in the same process as pressure vessel;

(4) The pressure vessel test coupon applying pressure strengthening technique shall be subject to the pressure strengthening pre-stretching in accordance with corresponding product standards.

4.2.2.3 Examination requirements of mechanical properties for both product welded test coupon and heat treatment test coupon of the base metal

(1) The type, quantity, sampling and preparation of specimens shall conform to the specifications of design documents and product standards;

(2) The test methods, test temperatures, acceptance criteria and re-test request of mechanical examination shall be in accordance with the specifications of design documents and product standards.

4.2.3 Expanding

The flexible expanding methods or mechanical expanding methods may be used for the expanded joint of tube-to-tubesheet of heat exchangers. Before expanding, an expanding procedure specification shall be formulated, and the operators shall perform the expanding in conformity with the expanding procedure specification.

4.2.4 Appearance requirements

4.2.4.1 The appearance and geometric dimensions of shells

The main examination items on appearance and geometry dimensions of shells are as follows, whereas examination methods and acceptance criteria are in accordance with the specifications of design documents and product standards.

(1) The main geometric dimensions, nozzle location and orientation;

(2)Abrupt rigid-or-valley and alignment offset of longitudinal and girth welds in the single wall cylinder (including the inner shell of the wrapped layered pressure vessel), shell and head, spherical shell;

(3) The loose area of the wrapped layered pressure vessel and the integrally wrapped pressure vessel, the clearance between the shrink surface of the shrink-fit pressure vessel;

(4) The inner dimension tolerance of the convex head, and the knuckle radius of the torispherical head and toriconical head;

(5) Shape and dimensions of the circular shaped top plate and petals of the spherical vessel;

(6) The transition size of the butt joint with unequal thicknesses.

4.2.4.2 Surface quality of welded joints

(1) The surface shall be free of various defects such as surface cracks, incomplete

penetrations, incomplete fusions, surface porosities, arc craters, incomplete filled grooves, and visible slag inclusions;

(2) The weld shall have a smooth transition to the base metal;

(3) The shape of the fillet weld shall be in concave transition smoothly;

(4) For pressure vessels designed by fatigue analysis, the weld reinforcement for longitudinal and girth welds shall be ground flush with the base metal;

(5)The undercut and other surface quality shall conform to the specifications of design documents and product standards.

4.2.5 Nondestructive examination

4.2.5.1 The timing for performing nondestructive examination

(1) For the welded joints of pressure vessels, nondestructive examination shall be performed after they pass visual inspection on shape, dimension and appearance;

(2) The nondestructive examination for welded heads shall be performed after forming. If the nondestructive examination is performed prior to forming, then a nondestructive examination shall also be conducted from the knuckle to the straight section of the formed head;

(3) For the material having delayed cracking tendency, the nondestructive examination shall be performed at least 24 hours after welding.

4.2.5.2 The requirements for performing spot radiographic test or ultrasonic test

(1) The location of the spot nondestructive examination shall be specified by the manufacturer based on the actual situation, but it shall include the intersecting portions of the Categories A and B welds and the welds to be covered by other components (note4-3);

Note 4-3: For glass-lined equipments, the nondestructive examination for assembly welds of up and down attachment ring and the jacket as well as nozzle welded joints with nominal diameter less than 250mm shall be in accordance with the specifications of national standards or industrial standards of glass-lined equipments.

(2) When the unacceptable defect occurs at the welded joint by the spot nondestructive examination, a supplementary spot examination of the length not less than 250mm of the same welded joint shall be performed from both ends of the examined parts. If the result still fails to meet the criteria, a 100% examination shall be conducted on that welded joint;

(3) For pressure vessels with the spot nondestructive examination, the Manufacturer shall still be responsible for the quality of welds which are not performed any nondestructive examination.

4.2.5.3 Records and reports of nondestructive examination

Manufacturers or nondestructive examination institutes shall fill in nondestructive examination records truthfully, issue the nondestructive examination reports correctly, be responsible for the authenticity, accuracy and validity of the nondestructive examination reports, and well preserve the examination records such as radiographic films and ultrasonic test data (including the record before defects repairing) and reports.

4.2.6 Heat treatment

4.2.6.1 The situations required heat treatment

(1) Postweld heat treatment required by design (see Article 3.2.11 in this Regulation);

(2) When large deformation of material or large changes of structure caused by cold forming in the manufacturing process affects the material microstructure and mechanical property, or when the specified heat treatment condition of the base metal in service are the same as that in delivery, if the heat treatment condition is altered in the manufacturing process, the heat treatment for material property recovery shall be conducted for pressure components;

(3) When heat treatment is required to achieve the design strength and toughness index, the heat treatment for material property improvement shall be conducted for pressure components.

4.2.6.2 The requirements for performing heat treatment

(1) Manufacturers of pressure vessels shall formulate the heat treatment procedure and strictly implement. The specific technical requirements of heat treatment shall be proposed for the field heat treatment;

(2) The postweld heat treatment shall be performed after the welding and inspection are fully completed. All kinds of heat treatment shall be conducted before the proof pressure test;

(3) The heat treatment equipment (furnace) is furnished with thermometers of automatic curve records, and the time versus temperature curve shall be plotted.

4.2.7 Special requirements for pressure vessels of steel forgings, cast irons, stainless steels and non-ferrous metals

4.2.7.1 Forged-welded pressure vessels

(1) For steel forgings of pressure vessels, the designation, the chemical composition, mechanical properties, process performance and examination requirements shall be in accordance with design drawings and the specifications of product standards;

(2) When the verification ring of a circumferential weld is required by design drawings, the material and dimensions of the ring, as well as the type, quantity, sampling, testing

methods, and the acceptance criterion of the circumferential weld test coupons shall be in accordance with design drawings;

(3) The cylinder surface shall be machined, and the tolerances on geometric dimensions (abrupt rigid-or-valley, alignment offset, roundness, butt weld of unequal thicknesses, etc.) shall be in accordance with design drawings and the specifications of product standards.

4.2.7.2 Cast iron pressure vessels

(1) The surface of cast iron pressure components must be free of cracks after fabrication. The casting defects such as shrinkage cavities, sand inclusions, blowholes and shrinkage porosities etc. shall not exceed the requirements specified on design drawings. A liberal radius shall be provided at projecting edges and in reentrant corners to avoid abrupt changes on the surface contour and the wall thickness at junctures;

(2) A hydrostatic destructive test shall be conducted on the first trial product to verify the design rationality. If the test result is unacceptable, the batch of the product shall not be carried on. The test shall be properly planned with reliable safety measures.

4.2.7.3 Stainless steel and non-ferrous metallic pressure vessels

(1) When fabricating pressure vessels or pressure components with stainless steels and non-ferrous metals, it shall have the specific workshop or specific equipments and the field to avoid mixing with ferrous metals or other products. The workshop or work field shall keep clean, dry and strictly control dust;

(2) The machining/forming equipment and welding facility shall meet the requirements for the fabrication of stainless steels and nonferrous metals. Any mechanical damage and splash on the surface shall be strictly controlled;

(3) For pressure vessels or pressure components with corrosion resistance and corrosion prevention requirements, the surface treatment must be conducted based on the requirements specified on design drawings, for instance, the austenitic stainless steel surface can be treated by acid pickling and passivation.

(4) Prior to manufacturing vessels by applying pressure strengthening technique for the first time, the manufacturer shall verify the pressure strengthening process according to the requirements of related standards and trial-produce a demo vessel. The manufacturing cannot be carried out unless the demo product is acceptable via supervisory inspection.

4.2.7.4 Non-ferrous metallic pressure vessels

4.2.7.4.1 Groove machining

In general, the groove surface shall be processed mechanically, and other cutting

methods that no damage to material properties and no effect on welding quality can also be used. If thermal cutting methods are adopted for the groove preparation, the oxidation layer and contamination layer shall be removed mechanically.

Requirements on the processed groove are as follows:

(1) For aluminum and titanium pressure vessels, cracks, laminations, inclusions of impurities and other defects affecting welding quality are not permitted at the groove surface;

(2) For copper and nickel pressure vessels, cracks, laminations, wrinkles, and lacerations are not permitted at the groove surface.

4.2.7.4.2 Aluminum pressure vessels

All supports of horizontal pressure vessels made of aluminum shall be fully contact with the shells.

4.2.7.4.3 Titanium pressure vessels

Titanium pressure vessels shall meet the following requirements:

(1) After welding, the surface color shall be inspected for all of the welded joints under as-welded condition, and the acceptance criteria shall be in accordance with product standards. The welded joints with unacceptable surface color shall be treated according to the requirements of product standards;

(2) The titanium head should be processed by hot forming. During the hot forming, necessary protection measures shall be taken to prevent the surface oxidation and contamination according to the requirements of product standards. After cold forming, the shape of the titanium head should be adjusted by heating.

4.2.7.4.4 Copper heads

For copper heads, if the stress corrosion cracking may occur under the specified operating environment, the treatment of annealing or stress relief annealing shall be performed in accordance with the requirements of design drawings and product standards.

4.2.7.4.5 Pressure vessels of nickel and nickel alloy

The electrical furnace should be used for heating or heat treatment of nickel and nickel alloy pressure vessels and pressure components, the fuel gas furnace or the fuel oil furnace is also acceptable, but the coke or coal furnace is not allowed. When the gas furnace or the fuel oil furnace is used, the sulfur content in gas or oil shall be strictly controlled according to the requirements of product standards.

4.2.8 Special requirements for fabrication of super-high pressure vessels

4.2.2.8.1 Material examination

(1) After the property heat treatment for main pressure components forgings of super-high pressure vessels, mechanical property at room temperature testing for the forgings shall be conducted to test the tensile strength, yield strength, elongation, Charpy (V-notch) impact energy and lateral expansion. Meanwhile, the metallographic analysis and hardness test shall be performed, which result shall conform to the design technical conditions;

(2) For the purchased shell forgings of super-high pressure vessels, the manufacturers shall conduct the re-test one by one based on material standards; the re-test items include chemical composition, mechanical property, macrostructure, grain size, nonmetallic inclusion and nondestructive examination; for other purchased forgings of pressure components, the supplier shall provide complete forging material quality certificates and inspection reports.

4.2.8.2 Nondestructive examination

4.2.8.2.1 Nondestructive examination personnel

The nondestructive examination of super-high pressure vessels shall be performed by the nondestructive examination personnel with level Ⅱ certificate or above, and experienced in the examination of pressure vessel forgings. The ultrasonic test report shall be approved by the nondestructive examination personnel with level Ⅲ certificate.

4.2.8.2.2 The timing for performing nondestructive examination

(1) For the shell of super-high pressure, a 100% ultrasonic test shall be conducted before and after the quenching and tempering respectively, and ultrasonic test with straight probe and tilting probe shall be conducted simultaneously after the quenching and tempering. For other pressure components, a 100% ultrasonic test shall be conducted at least once;

(2) A 100% magnetic particle test or liquid penetration test shall be conducted for the internal and external surface of shell after machining (for the shell with inside diameter less than 500mm, at least external surface examination shall be conducted). For the shell with outside diameter less than 250mm, at least eddy current test shall be conducted;

(3) For the shell using autofrettage technique, a 100% ultrasonic test shall be conducted for the shell after autofrettage treatment;

(4) After proof pressure test, at least 20% ultrasonic test and 100% surface examination shall be conducted for the shell (for the shell with inside diameter less than 500mm, at least external surface examination be conducted).

4.2.8.3 Autofrettage treatment

Manufacturers shall formulate and perform the autofrettage treatment procedure according to the specifications of design documents.

4.2.9 Special requirements for the fabrication of simple pressure vessels

4.2.9.1 Types of simple pressure vessels

The simple pressure vessels satisfied the following requirements at the same time can be classified to the same type:

(1) Same design method (refer to calculation method or testing method);

(2) Same design pressure and design temperature;

(3) Similar structure;

(4) Same types of inspection hole;

(5) Same welding procedure specification.

4.2.9.2 Batch production principle for simple pressure vessels

Simple pressure vessels with the same type no. and drawing no. can be batch produced. The requirements for batch production are as follows:

(1)Batch production duration, the continuous production time shall not exceed 15 days;

(2)Batch production quantity, for the vessels with inside diameter $D_i \leqslant 400$mm, one batch shall not exceed 1000 vessels based on production sequence; for that with inside diameter $D_i > 400$mm, one batch shall not exceed 500 vessels based on production sequence.

4.2.9.3 Welded joints

The tensile strength of welded joints shall not be less than the specified tensile strength limit of base metal, and shall not have defects endangering the safety of pressure vessels.

4.2.9.4 Bursting test

For the simple pressure vessels designed by testing, the manufacturers shall conduct bursting test in the manufacturing process.

4.2.9.4.1 Test requirements

(1) For the pressure vessels with automatic welded or mechanical welded butt joints, one pressure vessel shall be selected in one batch for bursting test;

(2) For the pressure vessels with manual welded butt joints, at least one pressure vessel shall be selected in the simple pressure vessels welded by each welder everyday for bursting test;

(3) The bursting test shall be performed at room temperature, and the pressurization rate shall not exceed 0.1MPa/s;

(4) Prior to bursting test, the actual wall thickness of shell and the circumference of middle shall be measured. During testing, the pressure shall be gradually raised to 4 times of the design pressure, and be held for more than or equal to 5min. If no leakage occurs, the pressure shall be relieved to zero. After measuring the circumference of middle, the pressure shall be gradually raised until the pressure vessel is burst.

4.2.9.4.2 Acceptance criterion

The acceptance criterion for bursting test of simple pressure vessels are as follows:

(1) Circumferential permanent deformation rate is not exceed 1%;

(2) Burst pressure is not less than 4 times of design pressure;

(3) No fragment;

(4) The initial cracking point of crevasse is not on the welded joint.

When the bursting test is failed, it's permitted to select other two pressure vessels in that batch for re-test, and this batch can be identified acceptable if the two pressure vessels are acceptable; for the pressure vessels with manual welded butt joints, other two pressure vessels shall be selected in the pressure vessels welded by the welder the same day for re-test, the simple pressure vessels welded by the welder the same day can be identified acceptable if the two pressure vessels are acceptable.

If the burst pressure fails to meet the acceptance criterion, the batch or the simple pressure vessels welded by the welder the same day are unacceptable.

4.2.9.5 Nondestructive examination

The radiographic test for simple pressure vessels shall be conducted according to the following requirements:

(1) The radiographic test shall be conducted according to the spot check principle specified by design;

(2) When the radiographic test is failed, it's permitted to select other two pressure vessels in that batch for re-test, and this batch can be identified acceptable if the two pressure vessels are acceptable; for the pressure vessels with manual welded butt joints, other two pressure vessels shall also be selected from the pressure vessels welded by the welder on the same day for radiographic test, the simple pressure vessels welded by the welder on the same day can be identified acceptable if the two pressure vessels are acceptable;

(3) For the unacceptable simple pressure vessels after re-test, the batch or the pressure vessels welded by the welder the same day shall be conducted radiographic test one by one, and the acceptance criterion remains the same.

4.2.9.6 Type test

Prior to the first batch production of simple pressure vessels with the same type, the manufacturer shall apply for type test to the corresponding qualified type test institute with complete design documents. The type test institute shall select one demo product of simple pressure vessels on the fabrication site, and issue the type test report (including test result, restricted conditions, and necessary explanation with drawing and writing) and type test certificate after proving the demo product meets the requirements of this Regulation an design documents by data check as well as appropriate examination and test for the demo product.

When the main manufacturing procedure is changed, the product type is changed caused by modification of design documents or the manufacturing is restarted with more than 6 months production break, the type test shall be conducted again.

The type test items for simple pressure vessels shall include the following contents as a minimum:

(1) Appearance examination;
(2) Geometric dimensions measuring;

(3) Radiographic test and proof pressure test (applicable to the design-by- calculation simple pressure vessels);

(4) Bursting test (applicable to the design-by-test simple pressure vessels);

(5) Other test items specified on product standards.

4.3 Requirements for fabrication of nonmetallic pressure vessels

4.3.1 Special requirements for fabrication of graphite pressure vessels

4.3.1.1 General requirements

(1) Fabricate graphite components according to the certified material specification (CMS);

(2) Conduct cementing procedure qualification, and fabricate vessels according to the qualified cementing procedure specification (CPS); the qualified cementing procedure shall be verified periodically (at least once every 6 months);

(3) The operation of cementing shall be performed by the qualified operators who have been trained and tested by the manufacturers;

(4) During the operation of cementing, the average temperature of cemented material shall be kept between 10℃ to 52℃.

4.3.1.2 Procedure qualification

4.3.1.2.1 Essential factors for procedure re-qualification

When the following essential factors change, the procedures shall be re-qualified:

(1) Carbon or graphite materials (e.g. material manufacturer, grade or batch no., density range, granularity range);

(2) Synthetic resins (e.g. material manufacturer, resin designation, specific gravity range, viscosity scope at room temperature, important components and range);

(3) Procedure parameters (e.g. the range of pressure, time, temperature and vacuum).

4.3.1.2.2 Certified Material Qualification report (CMQ)

The certified material qualification report of graphite shall include the tensile strength at room temperature and at the maximum allowable service temperature, flexure strength (only for heat exchange tubes), compressive strength, coefficient of permeability (only for materials of pressure vessels containing extremely or highly toxic mediums).

4.3.1.2.3 Test coupon and property test

The size of test coupon shall meet the requirements of making 10 standard specimens for each group. The property test shall be carried out according to appropriate standards of test methods.

4.3.1.3 Cementing procedure qualification

4.3.1.3.1 Essential factors to cementing procedure re-qualification

When the following essential factors change, the cementing procedures shall be re-qualified:

(1) Joint design and clearance;

(2) Surface preparation state;

(3) Cementing material parameters (e.g. filling materials, resins, curing agent, etc.);

(4) Procedure parameters (e.g. curing time, temperature range, etc.).

4.3.1.3.2 Cementing Procedure Qualification report (CPQ)

The cementing procedure qualification report shall include the tensile strength at room temperature and at the maximum allowable service temperature of material.

4.3.1.3.3 Test coupon and property test

The test coupon shall be prepared according to the joint type of design and procedure requirements. The size of test coupon shall meet the requirements of making 10 standard specimens for each group. The property test shall be carried out according to appropriate standards of test methods.

4.3.1.4 Training and examination of cementing operators

The manufacturers shall carry out training and examination for the operators engaged in

cementing operation of graphite pressure vessels and parts.

Operators who do not perform cementing in six months or whose ability is doubted shall be qualified again.

4.3.1.5 Material repair

Materials can be repaired with qualified cementing procedures.

There shall be detailed records for material repair which at least include cementing types, size of cementing part, material designation, material manufacturer, cementing procedure parameters (joint clearance, curing temperature and time, etc), cementing operators and repair time, etc.

The repair of same position at the cementing seam is inadvisable to exceed two times, if it exceeds two times, the condition shall be summarized and approved by the technical chief of the manufacturer before repairing, the times, position of repair and repair situation shall be recorded into quality certificate documents.

4.3.1.6 Cementing test coupon

The cementing test coupon shall be prepared according to the specifications of Article 3.3.1.6 and conform to the following requirements:

(1)The material of test coupon shall be same with the pressure vessel material which is produced by the same material manufacturer;

(2) The cementing of test coupon shall be completed by the operator cementing the pressure vessel with the same conditions and procedures of pressure vessel cementing;

(3) The size of cementing test coupon and specimen as well as its machining, testing, evaluation shall conform to the provisions of GB/T13465.9 *Test Method of the Adhesion Tensile Strength of Graphite Impermeable Adhesion Agent.*

4.3.1.7 Appearance examination

The appearance of graphite parts and as-built pressure vessels shall meet the drawing requirements, which internal and external appearance shall be smooth without bubble, sand hole, concave pit and crack and no defects like abrupt sharp scratch, etc.

4.3.1.8 Hydrostatic test or pneumatic test for graphite tubes

Prior to assembling, the hydrostatic test or pneumatic test shall be conducted for graphite tubes one by one with test pressure no less than two times of the design pressure and no less than 1MPa. No leakage is acceptable.

4.3.1.9 Hydrostatic test or pneumatic test for graphite blocks

Prior to the assembling of rectangular block heat exchangers of graphite, the

hydrostatic test or pneumatic test shall be conducted for each block with test pressure no less than 1.5 times of the design pressure and no less than 1MPa. The pressure shall be held for 10min and no leakage is acceptable.

4.3.1.10 Proof pressure test

The proof pressure test for graphite pressure vessels is performed according to the specifications of Article 3.3.1.4 of this Regulation.

For graphite pressure vessels, the pressure shall be held 2min-3min for each 0.1MPa increased. After it is raised up to the specified test pressure, the pressure in testing shall be held for 30min. Then the pressure is relieved to the design pressure slowly, and is held a sufficient time for inspection. No leakage is acceptable.

4.3.1.11 Leak test

After the proof pressure test, leak test shall be carried out according to the requirements of Article 3.3.1.5 of this Regulation.

4.3.2 Special requirements for fabrication of fiber reinforced plastic pressure vessels

4.3.2.1 Fabrication environment requirements

For fiber reinforced plastic pressure vessels, the fabrication temperature shall be no lower than 10℃ and no greater than 35℃, the relative humidity shall be no greater than 80%, and direct sunlight shall be avoided for manufacturing.

4.3.2.2 Service requirements for raw materials

(1) Resins and additives shall be stored in cool places and keep away from heat, which can’ be used when it expires the storage period;

(2) Accelerating agent and curing agent are prohibited to add resins simultaneously.

4.3.2.3 Requirements for fabrication procedures

(1) When fabrics are used for lay-up, the overlay width of the fabrics at the same layer shall be no less than 10mm;

(2) Winding angles shall conform to design specifications; for winding layers, the line-type must be complete and no gap or overlapping occurs.

4.3.2.4 Prototype vessels

For Type Ⅰ and Type ⅢⅠfiber reinforced plastic pressure vessels, prototype vessels shall be fabricated. After the prototype vessels are qualified in various inspections and tests, the Type Ⅰ and Type ⅢⅠfiber reinforced plastic pressure vessels can be put into fabrication.

4.3.2.5 Fabrication forming procedure

(1) The forming procedure for Type Ⅰ and TypeⅢfiber reinforced plastic pressure vessels shall be formulated in accordance with the procedure of fabricating prototype vessels;

(2) Prior to the fabrication of Type Ⅱ fiber reinforced plastic pressure vessels, forming procedure qualification and cementing procedure qualification shall be carried out. The forming procedure specification and cementing procedure specification shall be formulated in accordance with the qualified procedures.

4.3.2.6 Personnel requirements for procedure qualification

The forming procedure qualification and cementing procedure qualification shall be operated and conducted according to the proposed procedure instruction by the operators of manufacturers (these operators have passed the test through training, loaning personnel form other companies is not permitted).

4.3.2.7 Fabrication inspection

Delivery inspection shall be performed for each fiber reinforced plastic pressure vessel. The inspection items include: appearance examination, geometric dimensions (thickness, diameter, taper, height, etc), curing extent, resin content, total mass and mechanical property.

The thermoplastic lining and structural layer shall not be separated.

4.3.2.8 Proof pressure test

The proof pressure test shall be carried out according to design requirements, and the pressure rate of raising and dropping per minute shall not exceed 2% of the test pressure.

4.3.3 Fabrication for metal pressure components of nonmetallic pressure vessels

The fabrication for metal pressure components of nonmetallic pressure vessels shall conform to the corresponding provisions related to metallic pressure vessels in this Regulation.

5 Installation, Alteration and Repair

5.1 Company of installation, alteration and repair

(1) The company engaged in installation, alteration and significant repair for pressure vessels shall obtain the corresponding qualification; it shall establish and implement a quality assurance system and implement effectively in accordance with the requirements of relevant safety technical regulations. The company engaged in installation, alteration and repair for pressure vessels and the main responsible person shall be responsible for the quality of the installation, alteration and repair of pressure vessels;

(2) The company engaged in installation, alteration and repair for pressure vessels shall strictly implement involved rules of laws, safety technical regulations, and technical standards;

(3) The company engaged in installation, alteration and repair for pressure vessels shall provide the user with technical documentations, including construction scheme, drawings of installation, alteration and repair, and the conformity certificate of construction;

(4) Prior to the installation, alteration and significant repair for pressure vessels, the company engaged in installation, alteration and significant repair for pressure vessels shall inform in writing to the department of special equipment safety supervision and administration at the place of service.

5.2 Alteration and significant repair

5.2.1 The definition and essential requirements of alteration and significant repair

(1) The alteration of pressure vessels refers to the structural change of main pressure components, or the change of operating parameters, the change of containing medium or the change of service, etc; the significant repair of pressure vessels includes replacement, structural adjustment, removal of main pressure components, and welding repair on a butt weld joint as specified in Article 3.2.2.1 of this Regulation, or mending on cementing seams of nonmetallic pressure vessels;

(2) The scheme for alteration or significant repair of pressure vessels shall be approved in writing by the original design unit or a design unit with relevant qualification;

(3) The alteration and significant repair of pressure vessels can use the original product standard; after alteration or significant repair, the structure and strength of pressure vessels shall be ensured to meet the requirements of safety service;

(4) The construction process of alteration or significant repair on pressure vessels

conform to the requirements of Article 6.1.2.2 of this Regulation shall be supervisory inspected by the special equipment inspection institute with corresponding qualification. The above mentioned pressure vessels cannot be put into service unless they pass the required supervisory inspection.

(5) The stationary pressure vessels cannot be altered to transportable pressure vessels.

5.2.2 Preparations before alteration and repair

The user of pressure vessels shall prepare and complete cleaning work following the regulations of safety production and requirements of periodic inspection prior to the alteration or repair personnel entering the pressure vessels. If the requirements are not met, it is prohibited to enter the pressure vessels.

5.2.3 Welding requirements of alteration and repair

(1) The construction plan for the removal and welding repair, replacement of the cylindrical segment, adding (enlarging) open nozzle and postweld heat treatment shall be formulated in accordance with the corresponding product standards, and this shall be approved by the technical chief of the company engaged in alteration or repair.

(2) The welding (the welding procedure qualification shall be conducted in accordance with the Article 4.2.1.1 of this Regulation) can only be performed after the nondestructive examination is conducted to ensure all defects are completely removed. The nondestructive examination shall be performed after the welding repair;

(3) After welding repair on the base metal, it shall be ground to the base metal level;

(4) If the postweld heat treatment of stress relief is required, whether the stress relief heat treatment is necessary shall depend on the depth of welding repair;

5.2.4 Special requirements for the alteration or repair of nonmetallic pressure vessels

(1) For graphite pressure vessels, when altering or repairing graphite pressure components for which cementing or impregnation is required, the corresponding procedure qualification shall be conducted according to Article 4.3.1.2 and 4.3.1.3 of this Regulation before alteration and repair;

(2) During the process of alteration and repair for fiber reinforcement plastic pressure vessels, it shall far away from the thermal source or fire source.

5.2.5 Proof pressure test in alteration and significant repair

The proof pressure test shall be conducted in the construction process of alteration and significant repair for the pressure vessels under one of the following conditions:

(1) A main pressure component is replaced or added by a welding (cementing) method;

(2) The repair welding depth is greater than 1/2 thickness of the pressure vessel;

(3) The service condition is changed; the design parameter exceeds the original one and qualified in strength verification;

(4) The lining is required to replace (the proof pressure test shall be performed prior to replacement of the lining).

6 Supervisory inspection

6.1 General requirements for supervisory inspection

6.1.1 Supervisory inspection

Supervisory inspection of pressure vessels (hereinafter referred to as supervisory inspection) shall be carried out in the process of manufacturing, alteration and significant repair of pressure vessels (supervisory inspection is not carried out for installation). Supervisory inspection is the process supervisory carried out on the basis of acceptable quality inspection, check and test (hereinafter referred to as self-examination) of the company engaged in manufacturing, alteration and repair of pressure vessels (hereinafter referred to as the inspected company), and is the compliance verification meeting the essential safety requirements.

Supervisory inspection work shall not take the place of self-examination of the inspected company.

6.1.2 Applicable scope

6.1.2.1 Products required supervisory inspection on manufacturing

(1) Fully assembled pressure vessels to be delivered;

(2) Field fabricated, field welded and field cemented pressure vessels;

(3) The welded and individually delivered shell sections, heads, petals of spherical tanks, or the heat exchanger bundles.

6.1.2.2 Supervisory inspection on alteration and significant repair

(1) Alteration when the structural of main pressure parts or the service conditions (operation parameter, containing medium and purpose) are changed, and proof pressure test is necessary;

(2) Significant repair when the replacement, structural adjustment, removal of main pressure parts, or repair welding/cementing of butt joints of the shell are carried out, and post-weld heat treatment or proof pressure test is necessary.

6.1.3 Supervisory inspection institute

Supervisory inspection institute refers to the special equipment inspection institute with corresponding qualification approved by the AQSIQ.

6.1.4 Obligations of inspected companies

The inspected company shall perform the following obligations in supervisory inspection work:

(1) Establish the quality assurance system and keep it being implemented effectively, and be responsible for the quality of fabrication and construction of pressure vessels;

(2) Prior to the fabrication and construction of pressure vessels, it shall apply for supervisory inspection to the supervisory inspection institute;

(3) Provide necessary operating conditions to the supervisory inspection institute, and provide authentic and valid quality assurance system documents, technical data, inspection records and test reports etc. which relate to the inspected products;

(4) Appoint a contact person for supervisory inspection; timely inform the supervisory inspection personnel (hereinafter referred to as supervisory inspector) to be present according to the quality plan and manufacturing schedule;

(5) For "Liaison Sheet for Supervisory Inspection of Special Equipment" (hereinafter referred to as "Liaison Sheet for Supervisory Inspection", which is detailed in Annex E) and "Notice on Supervisory Inspection for Special Equipment" (hereinafter referred to as "Supervisory Inspection Notice", which is detailed in Annex F), deal with them within the stipulated period and reply in written form; if the inspected company fails to do this, the supervisory inspection institute shall suspend the supervisory inspection;

(6) Pressure vessels which should have been supervisory inspected shall not be delivered or put into service.

6.1.5 Duties and responsibilities of supervisory inspection institutes

(1) Establish the quality management system and keep it being implemented effectively, and be responsible for the quality of supervisory inspection;

(2) Provide procedures of supervisory inspection work and certification of supervisory inspectors to the inspected company;

(3) Periodically organize the evaluation over the implementation of quality assurance system of the inspected company;

(4) When it discovers that serious problems exist both in the implementation of quality assurance system of the inspected company or in the safety performance of pressure vessels (Note 6-1), it shall send out the "Supervisory Inspection Notice", and simultaneously report to the local department of special equipment safety supervisory and administration as well as the department of special equipment safety supervisory and administration issued the license;

(5) Strengthen management against supervisory inspectors, and periodically carry out training and examination to the inspectors so as to prevent improper supervisory inspection behaviors and correct them timely;

(6) According to the requirements of informatization and annual report, summarize, count, repot and upload relevant supervisory inspection data in time.

Note 1: Serious problem means that the supervisory inspection items are unqualified and cannot be corrected; the implementation of quality assurance system of inspected company is out-of-control seriously; problems proposed in "Liaison Sheet for Supervisory Inspection" are rejected to be corrected; corresponding licensing conditions have been invalid when licensing is required; the licensing system for special equipment has been seriously violated (for example, the special equipment license is obliterated, forged, assigned or sold out, or the product quality certification documents is sold or illegally provided to companies without the special equipment license); or with severe quality accidents etc.

6.1.6 Duties and responsibilities of supervisory inspectors

The personnel undertaking supervisory inspection of pressure vessels shall hold the corresponding certificates, and perform the following duties and responsibilities in supervisory inspection work:

(1) Timely carry out supervisory inspection according to the manufacturing schedule of the inspected company, and be responsible for conclusion of supervisory inspection;

(2) Take good care of and be obligated to keep confidential the technical data provided by the inspected company;

(3) When he/she discovers that general problems exist both in the implementation of quality assurance system of the inspected company or in the safety performance of pressure vessels, he/she shall give out the "Liaison Sheet for Supervisory Inspection" to the inspected company;

(4) When he/she discovers that the implementation of quality assurance system of the inspected company or the safety performance of pressure vessels seriously fail to meet this Regulation, he/she shall stop the supervisory inspection and report to the supervisory inspection institute;

(5) Timely sign (seal) on the work witness for the purpose of confirmation, and fill in the supervisory inspection record;

(6) For qualified pressure vessels in supervisory inspection, he/she shall issue the "Supervisory Inspection Certificate for Special Equipment" (hereinafter referred to as "Supervisory Inspection Certificate", which is detailed in Annex G), and shall be responsible for stamping the supervisory inspection identification (for supervisory inspection on manufacturing).

6.1.7 Supervisory inspection procedures

General procedures for supervisory inspection of pressure vessels are as follows:

(1) The inspected company files an application for supervisory inspection and signs the supervisory inspection agreement with the supervisory inspection institute to specify the right, responsibility and obligation of both parties;

(2) The supervisory inspector shall determine supervisory inspection items;

(3) The supervisory inspector shall carry out supervisory inspection over the fabrication and construction process and fill in such work witness as the supervisory inspection record, etc;

(4) When the supervisory inspection on manufacturing (including field fabrication, field welding and field cementing) is qualified, the supervisory inspector shall stamp the supervisory inspection identification;

(5) The supervisory inspection institute shall issue the "Supervisory Inspection Certificate".

6.1.8 Content of supervisory inspection

(1) To verify if the pressure vessel manufacturing, alteration and significant repair meet the requirements of this Regulation through review, inspection and witness of the related technical data and procedures affecting the essential safety requirements;

(2) To inspect and evaluate on the implementation of quality assurance system of the inspected company.

6.1.9 Supervisory inspection items

6.1.9.1 Determination principles of supervisory inspection items

According to this Regulation, product standards and technical requirements for manufacturing which are specified in design documents and the procedure document, the supervisory inspector shall determine supervisory inspection items on the basis of the product quality plan by taking comprehensive consideration of the influence of the fabrication and construction process of pressure vessels over safety performance, and by combining the implementation of the quality assurance system of the inspected company.

Supervisory inspection items determined by the supervisory inspector shall not be inferior to the requirements of Article 6.2 to 6.5 of this Regulation.

6.1.9.2 Classification of supervisory inspection items

Supervisory inspection items are classified into Category A, B and C, and their requirements are as follows:

(1) Item of Category A refers to key one which has significant influence over the safety performance of pressure vessels, and shall be supervised by the supervisory inspector on site while fabricating, altering and repairing pressure vessels. The fabrication, alteration and repair shall not continue until the result has been confirmed as qualified by the inspector;

(2) Item of Category B refers to key one which has large influence over the safety performance of pressure vessels, and generally should be supervised by the inspector on site. When the supervisory inspector fails to arrive at the site timely, the fabrication, alteration and repair may continue after the self-examination of the inspected company is qualified, and then the supervisory inspector shall carry out on-site inspection to confirm whether the item meets the requirements or not;

(3) Item of Category C refers to the one which has influence on the safety performance of pressure vessels. The supervisory inspector confirms whether the item meets the requirements through review relevant self-examination reports and records of the inspected company;

(4) For supervisory inspection items set as Category C/B by this Regulation, the supervisory inspector may treat it as Category C, but when on-site inspection is required according to relevant articles of this Regulation, product standards or design documents, the inspector shall treat it as Category B.

(5) The classification of supervisory inspection items is set forth in corresponding chapters and sections of this Regulation.

6.1.10 Witness and record of supervisory inspection

Supervisory inspection institutes formulate the requirements on relevant witness and records of supervisory inspection according to the needs of supervisory inspection.

(1) Supervisory inspection witness includes the quality plan after the supervisory inspection and corresponding inspection report, test report and supervisory inspection record which are provided by the inspected company and signed (sealed) by the supervisory inspector;

(2) Supervisory inspection record shall be able to indicate the implementation of the supervisory inspection process, and shall be traceable. Except supervisory inspection records explicitly required by this Regulation, the supervisory inspector shall also record the spot-check conditions as well as items and contents of problems found in the supervisory inspection process.

6.1.11 Filing data of supervisory institutes

After finishing the supervisory inspection, the supervisory inspection institute shall timely issue the "Supervisory Inspection Certificate" and shall file the relevant supervisory inspection data. The supervisory inspection data at least shall include the following contents:

(1) “Supervisory Inspection Certificate”;

(2) Relevant supervisory inspection witness such as copies of finished quality plan after the supervisory inspection, supervisory inspection records, etc;

(3) “Product Data Sheet of pressure Vessels”;

(4) "Liaison Sheet for Supervisory Inspection" and "Supervisory Inspection Notice";

(5) Other documents required to be filed as specified in quality management system document of supervisory inspection institute.

6.2 Supervisory inspection on manufacturing

6.2.1 General requirements for supervisory inspection on manufacturing

6.2.1.1 Review on technical documents

Prior to fabrication, the inspected company shall submit the design document, quality plan and relevant process documents such as welding procedure specification (or cementing procedure specification, the same below) and heat treatment process of pressure vessels to the supervisory inspector for review.

The supervisory inspector shall review the design document, quality plan and relevant process documents of pressure vessels one by one, and signs on the assembly drawing. If the pressure vessel inspected is an approved product (see Note 6-2), then the inspector may review its design documents by product model.

Note 2: Approved products refer to the pressure vessels with identical design documents, procedure documents and quality plan.

6.2.1.1.1 Review on design documents

The contents of review shall include the following at least:

(1) Qualification of the design unit, assembly drawing and approval procedures for the design modification (including material substitution);

(2) Witness data of technology review on external drawing of the inspected company;

(3) Completeness of design documents required by Article 3.1.4.1 of this Regulation;

(4) Whether the regulation, product standards, and the standard for materials of main pressure parts adopted for design are valid; whether there is any declaration for the conformance of the design document with Chinese essential safety requirements when the international standard or foreign standard is adopted for design;

(5) Review the technical evaluation and assessment required in Article 3.15 of this Regulation and corresponding approval procedures; confirm the supervisory inspection data of test process when design-by-test is adopted;

(6) Type test report (certificate) of products required to conduct the type test;

(7) Whether the requirements for nondestructive examination, heat treatment, proof pressure test and leakage test noted on the assembly drawing meet the provisions of this Regulation.

6.2.1.1.2 Review on process documents

(1) Review the approval procedures of related process documents;

(2) Verify whether the welding procedure specification conforms to the applied welding procedure qualification;

(3) Review the technical evaluation and corresponding approval procedures as required by this Regulation when new processes are adopted such as nondestructive examination method, welding residual stress relief method, material properties improvement method and leakage test method which is not specified in this Regulation and product standards.

6.2.1.1.3 Review on quality plan

Review the approval procedures of quality plan, and check whether the following contents conform to the specifications of this Regulation, product standards and design documents:

(1) Material acceptance of main pressure components;

(2) Welding, impregnation, cementing, etc. procedure qualification;

(3) Inspection and test on product test coupons;

(4) Nondestructive examination;

(5) Special processes as post-weld heat treatment. etc.;

(6) Appearance and geometric dimensions examination;

(7) Proof pressure test and leak test;

(8) Special technical requirements specified in assembly drawing;

(9)Quality control requirements of the new material and new procedure which are not specified in this Regulation and product standards.

After reviewing the quality plan, the supervisory inspector shall outline the supervisory inspection items on quality plan according to the specifications of Article 6.1.9 of this Regulation.

6.2.1.2 Material supervisory inspection

6.2.1.2.1 Supervisory inspection on material acceptance (Category C/B)

The supervisory inspection shall include the following content as a minimum:

(1)Review the witness data of material acceptance of main pressure components;

(2) Review the original material quality certificate of main pressure components or the copy stamped by material supply company and the responsible person; check whether the chemical composition and mechanical properties of materials meet the requirements of this Regulation;

(3) If the main pressure components are subcontracted or purchased and have not been performed supervisory inspection, the supervisory inspector shall carry out the supervisory inspection according to (1) and (2) of this Article; if they have been performed the supervisory inspection, then review the acceptance witness data and supervisory inspection certificate of subcontracted or purchased components;

(4) If material re-examination and nondestructive examination are required for main pressure components, the supervisory inspector shall review whether approval procedures for material re-examination report and nondestructive examination report as well as the test items and acceptance requirements conform to the provisions of this Regulation, product standards and design documents;

(5) If the inspected company uses the material with foreign designation to fabricate domestically used pressure vessels, the supervisory inspector shall review whether the adopted material with foreign designation conforms to specifications of this Regulation and product standards;

(6) If the new materials required the technical evaluation and assessment according to the requirements of this Regulation are adopted to fabricate pressure vessels, the supervisory inspector shall review the technical evaluation and assessment of material and corresponding approval procedures.

6.2.1.2.2 Supervisory inspection on material mark transplantation (Category C/B)

(1) For the supervisory inspection on material mark transplantation of main pressure components, the supervisory inspector shall determine the number for spot inspection according to the implementation of quality assurance system of inspected company and the material category of pressure vessels;

(2) If the main pressure components are made of special materials (Note 6-3), the supervisory inspector shall spot check the transfer of material identification on site.

Note 6-3：Special materials refer to the low alloy steel plate with specified tensile strength lower limit

greater than 540MPa, austenitic-ferritic stainless steel plate, steel plate for low temperature pressure vessels, nonferrous metal and the material used for welding by the inspected company for the first time (including cladding steel plate satisfied the above mentioned requirements, the same below).

6.2.1.2.3 Supervisory inspection on material substitution (Category C)

During the manufacturing, if the material used for pressure components is substituted, the supervisory inspector shall review the written approval document of the original design unit.

6.2.1.3 Supervisory inspection on proof pressure test and leak test

6.2.1.3.1 Essential requirements

(1) The inspected company shall ensure the procedures and inspections for pressure vessels prior to the proof pressure test are all completed, and the preparation for proof pressure test and leak test meet the fabrication technical requirements specified in this Regulation, product standard and assembly drawing;

(2) The inspected company shall inform the supervisory inspector of proof pressure test time in advance. The inspector shall arrive at the site for proof pressure test on time.

6.2.1.3.2 Supervisory inspection on proof pressure test (Category A)

The contents of supervisory inspection shall include the following at least:

(1) Check and confirm whether the medium, temperature, pressure and holding time for the proof pressure test meet the fabrication technical requirements specified in this Regulation, product standards and assembly drawings;

(2) Confirm whether there is any leakage, visible deformation and abnormal noise during the proof pressure test.

6.2.1.3.3 Supervisory inspection on leak test (Category C/B)

Check whether the test method and test report of leak test conform to the specifications of this Regulation, product standards and assembly drawing.

6.2.1.4 Review on delivery documents (Category C)

6.2.1.4.1 Product delivery documents

If the products to be supervisory inspected are fully assembled, field welded or field fabricated pressure vessels, the content of review for delivery documents shall include the following at least:

(1)Review whether the approval procedures of product delivery documents (as-built drawings, product conformity certificates and product quality certification documents) are complete according to the requirements of this Regulation and product standards;

(2) Review the approval procedures of design modification and design change as well as the marking on as-built drawings;

(3) Review the quality certificate and verification report of the pressure relief device, and check whether its manufacturer holds the manufacture license of special equipment, whether the verification report and the action pressure conform to the requirements of safety technical regulation.

6.2.1.4.2 Delivery documents of pressure components and parts of pressure vessels

When the products to be supervisory inspected are shell sections, heads and petals of spherical tanks or the heat exchanger bundles in Item (3) of Article 6.1.2.1 of this Regulation, the inspector shall review the approval procedures of product quality certification documents and check whether it conforms to the requirements of this Regulation and product standards.

6.2.1.5 Supervisory inspection on product nameplate (Category B)

The supervisory inspector shall check whether the content of product nameplate conform to the requirements of this Regulation and product standards.

6.2.1.6 Steel stamp and certificate of supervisory inspection

The steel stamp and certificate of supervisory inspection shall conform to the following requirements:

(1) If the products to be supervisory inspected are fully assembled, field fabricated, field welded or field cemented pressure vessels, the inspector shall stamp the supervisory inspection identification on the product nameplate;

(2) If the products to be supervisory inspected are heads, petals of spherical tanks or the heat exchanger bundles in Item (3) of Article 6.1.2.1 of this Regulation, the inspector shall stamp the supervisory inspection identification on the product quality certificate.

(3) For the products qualified in the supervisory inspection, the inspector shall issue the Supervisory Inspection Certificate after summarizing the supervisory inspection record and witness data.

6.2.2 Supervisory inspection requirements for metallic pressure vessels

6.2.2.1 Supervisory inspection on welding procedure qualification

If the inspected company is required to carry out the welding procedure qualification, the inspector shall perform the supervisory inspection on qualification process of the welding procedure. The contents of supervisory inspection shall include the following at least:

(1) Review the procedure of welding procedure qualification (Category C);

(2) When examining the test coupon of welding procedure qualification (Category A),

the inspector shall conduct the on-site inspection on test coupon of welding procedure qualification and mark the supervisory inspection identification prior to the preparation of tensile specimen, bending specimen and impact specimen;

(3) When confirming the test report for welding procedure qualification (Category C/B), the inspector shall review the test report on specimen of welding procedure qualification. If the inspector deems necessary, on-site inspection for tested specimen shall be conducted;

(4) When reviewing welding procedure qualification report (Category C), the inspector shall review the welding procedure qualification report (PQR) and welding procedure specification (WPS).

6.2.2.2 Supervisory inspection on welding (Category C/B)

The contents of supervisory inspection shall include the following at least:

(1) Prior to heat treatment or proof pressure test, the inspected company submits the weld map and welding record to the supervisory inspector for review and the inspector randomly checks whether the qualification of welders and the process parameters during actual welding conform to the WPS;

(2) For pressure vessels constructed of special material, the supervisory inspector shall also carry out spot inspection on welding operation to check whether the qualification of welders, welding materials and welding process parameters conform to the WPS;

(3) Review the approval procedures of repairs over specified times and check whether the repair process conforms to the qualified WPS.

6.2.2.3 Supervisory inspection on product welding test coupon

The contents of supervisory inspection are as following:

(1) When reviewing the preparation of product welding test coupon (Category C/B), the inspector shall review whether the preparation method and number of welding test coupon conform to the provisions of this Regulation, product standards and design documents; if post-weld heat treatment is required, the consistency of heat treatment processes between welding test coupon and the actual product shall also be inspected;

(2) When inspecting the product welding test coupon (Category A), prior to the preparation of tensile specimen, bending specimen and impact specimen, the inspector shall inspect the welding process of product welding test coupon on site and mark the supervisory inspection identification;

(3) When confirming the specimen of product welding test coupon and test result (Category C/B), the inspector shall review the test report of product welding test coupon; if

the inspector deems necessary, the tested specimen shall be inspected on site.

6.2.2.4 Supervisory inspection on fitting-up quality for field fabricated and field welded pressure vessels (Category B)

When the fitting-up is completed, the inspected company shall submit the fitting-up quality examination record or report to the supervisory inspectors before welding.

The supervisory inspectors shall review whether the items for fitting-up quality examination conform to the specifications of this Regulation, product standards and design documents, and carry out spot inspection on fitting-up accuracy, groove surface quality and groove gap, etc. The number of spot inspection depends on the difficulty of fitting-up.

6.2.2.5 Supervisory inspection on appearance and geometric dimensions

Prior to the proof pressure test, the inspected company shall submit the examination report on appearance and geometric dimensions of pressure vessels to the supervisory inspector. The supervisory inspector shall carry out inspection on appearance and geometric dimensions prior to the proof pressure test.

6.2.2.5.1 Review on records and reports (Category C)

Supervisory inspectors shall review approval procedures of the examination report on appearance and geometric dimensions of pressure vessels, and check whether the examination items in the report conform to the specifications of this Regulation, product standards and design documents.

6.2.2.5.2 Visual inspection (Category B)

The contents of visual inspection shall include the following at least:

(1) Inspect the layout of welds;

(2) Spot check the damage from mechanical contact on the surface of base material and the surface quality of welded joints;

(3) Focus on inspecting the reinforcement of longitudinal weld and circumferential weld as well as the welds appearance for the pressure vessels designed by fatigue analysis;

(4) Spot check the expansion appearance quality of tube to tube sheet of heat exchangers.

6.2.2.6 Supervisory inspection on nondestructive examination

Prior to heat treatment or proof pressure test of pressure vessels, the inspected company shall submit the nondestructive examination records and reports of welded joints, and radiographic testing films to the supervisory inspector for review.

6.2.2.6.1 Review on records and reports of nondestructive examination (Category C)

The contents of review shall include the following at least:

(1) Qualification certificates of nondestructive examination personnel and approval procedures of nondestructive examination process and reports;

(2) Whether the timing, percentage, location, applied technical standard and evaluation level of nondestructive examination conform to the provisions of this Regulation, product standards and design documents.

6.2.2.6.2 Review of radiographic films (Category C)

The supervisory inspector shall determine the selection of radiographic film including the number and the location to be reviewed according to the implementation of quality assurance system of the inspected company, complexity of pressure vessel welding structure and weldability of material and review whether the quality of radiographic films and defect evaluation conform to the provisions of this Regulation, product standards and design documents.

The number of radiographic films and their covered locations shall meet the following requirements at least:

(1)Review the films of the cross weld, repair part, extended part and additional partial radiographic testing due to the application of non-recordable pulse reflection ultrasonic testing;

(2) For pressure vessels made of special material or chromium molybdenum steel, the number of radiographic films to be reviewed shall be not less than that specified in Table 6-1.

Table 6-1 Requirements for the Number of Radiographic Films to be Reviewed

Total number of radiographic films of a pressure vessel (*N*)	The number of radiographic films to be reviewed for different radiographic films to be reviewed	
	All (100%)	Partial ((≥20%)
N≤l0	*N*	*N*
10<*N*≤100	30% of *N* and no less than 10	50% of *N* and no less than 10
100<*N*≤500	20% of *N* and no less than 30	25% of *N* and no less than 50
N>500	15% of *N* and no less than 100	20% of *N* and no less than 125

6.2.2.7 Supervisory inspection on heat treatment

6.2.2.7.1 Review on records and reports of heat treatment (Category C)

Prior to the proof pressure test, the inspected company shall submit heat treatment records and reports as well as relevant examination and test reports to the supervisory

inspector for review. The contents of supervisory inspection shall include the following at least:

(1) Review the approval procedures of heat treatment reports;

(2) Review whether the heat treatment record curve and report conform to the heat treatment procedure.

6.2.2.7.2 Heat treatment after welding repair (Category C)

Review whether the heat treatment after welding repair conforms to the specifications of this Regulation and product standards.

6.2.2.7.3 Supervisory inspection on heat treatment test coupon

The contents of supervisory inspection shall include the following at least:

(1) When reviewing the preparation of heat treatment test coupon (Category C/B), the inspector shall review whether the preparation method and number of heat treatment test coupon conform to the provisions of this Regulation, product standards and design documents;

(2) When inspecting the heat treatment test coupon (Category A), prior to specimen preparation, the inspector shall inspect the heat treatment test coupon on site and mark the supervisory inspection identification.

(3) When confirming the specimen of heat treatment test coupon and test result (Category C/B), the inspector shall review the specimen of heat treatment test coupon and test result; if the inspector deems necessary, the tested specimen shall be inspected on site.

6.2.2.7.4 Supervisory inspection on field heat treatment (Category A)

If post-weld heat treatment is performed for the field welded or field fabricated pressure vessels, the supervisory inspector shall review the field heat treatment scheme and inspect the arrangement of thermocouples and data collection of heat treatment temperature.

6.2.2.8 Special requirements for supervisory inspection on manufacturing of ultra-high pressure vessels

(1) Review whether the items of material examination of ultra-high pressure vessels and mechanical property test of shell after the heat treatment conform to Article 4.2.8.1 of this Regulation (Category C);

(2) Inspect on site whether the autofrettage treatment process of ultra-high pressure vessels conforms to Article 4.2.8.3 of this Regulation (Category B).

6.2.2.9 Special requirements for supervisory inspection on underground gas storage well

(1) Except for reviewing the acceptance for raw material of main pressure components

such as well tube, etc., the supervisory inspector shall also review the acceptance for raw material of sealing grease, cement or other anticorrosive materials (Category C);

(2) Spot check the well tube assembly on site, such as the assembling torque of steel tube, the usage of special thread sealing grease and the arrangement of centralizer(Category C/B);

(3) Review whether the examination and evaluation on well cementation quality conform to the specifications of design documents (Category C).

6.2.3 Supervisory inspection requirements for the manufacturing of nonmetallic and nonmetallic-lined pressure vessels

6.2.3.1 Supervisory inspection on manufacturing of metal pressure parts or devices of nonmetallic pressure vessels

Supervisory inspection on manufacturing of metal pressure parts or devices combined or connected with nonmetallic pressure vessels shall conform to the corresponding specifications related to metallic pressure vessels in this Regulation.

6.2.3.2 Special requirements on manufacturing of graphite and graphite-lined pressure vessels

(1) Review whether the procedure of the certified material qualification for graphite (including impregnation procedure qualification and composite material forming procedure qualification) and the cementing procedure qualification, the proposed procedure specification, the preparation of test coupon and specimen, the property test etc., conform to the requirements of this Regulation (Category B); review the test reports of the procedure qualifications mentioned above (Category C);

(2) Confirm on-site the preparation and performance of test on certified material qualification for graphite and cementing procedure qualification (Category A);

(3) Spot check whether the temperature of cemented material during cementing conforms to the requirements of this Regulation (Category B);

(4) Review whether the preparation method, the number and property test report of cementing test coupon conform to design documents (Category C/B);

(5) Review the training and qualification of cementing operators (Category C).

6.2.3.3 Special requirements for supervisory inspection on the manufacturing of fiber reinforced plastic and fiber reinforced plastic-lined pressure vessels

(1) Review whether the forming and bonding procedure qualification, proposed procedure specification, preparation of test coupon and specimen, property test etc., conforms to the requirements of this Regulation (Category C);

(2) Confirm on site whether the pressure test of prototype vessels conforms to Article

3.3.2.3 of this Regulation (Category A);

(3) Spot check whether the manufacturing environment conforms to Article 4.3.2.1 of this Regulation (Category C);

(4) Review the training and qualification of forming and bonding operators (Category C).

6.2.3.4 Special requirements for supervisory inspection on the manufacturing of glass lined pressure vessels

(1) Review the quality certificates, acceptance check records and re-inspection records of metal materials and glass lined enamel; review the physical and chemical property of glass lined enamel (Category C);

(2) Review records of the thickness measurement of glass-lined layer and DC high voltage test (Category C/B).

6.3 Supervisory inspection on alteration and significant repair

6.3.1 Review of construction scheme and quality plan

Prior to alteration and significant repair of pressure vessels, the inspected company shall submit the construction scheme to the supervisory inspector for review. The contents of review shall include the following at least:

(1) Review the approval procedures of alteration and significant repair construction scheme, and the approval document provided by the original design unit or the company with corresponding qualification for the construction scheme of the alteration and significant repair;

(2) Review whether the technical requirements for materials, welding (cementing), heat treatment, nondestructive examination, proof pressure test and leak test meet the provisions of this Regulation and product standards.

After the review of construction scheme on alteration and significant repair is qualified, the supervisory inspector shall outline the supervisory inspection items on the quality plan in accordance with the requirements of Article 6.1.9 in this Regulation.

6.3.2 Inspection of construction conditions on site and the implementation of quality assurance system of the inspected company (Category B)

The contents of inspection shall include the following at least:

(1) Inspect whether the inspected company effectively implements the quality assurance system at the construction site and review whether the appointment of related responsible personnel meets the specified requirements;

(2) Review whether the welder and nondestructive examination personnel hold corresponding qualifications;

(3) Check whether the necessary tooling and equipment is provided;

(4) Check whether the necessary storage place for welding consumables, parts etc. is provided.

6.3.3 Supervisory inspection on construction process

The contents of supervisory inspection include the following at least:

(1) Prior to welding repair of main pressure parts, inspect whether defects are completely removed (Category B);

(2) During the alteration and significant repair of pressure vessels, the supervisory inspection on materials, fitting-up and welding (cementing), nondestructive examination, heat treatment, appearance and geometric dimensions, proof pressure test and leak test shall be conducted according to the applicable provisions of Article 6.2 in this Regulation.

6.3.4 Review of as-built information of construction and supervisory inspection certificate (Category C)

Once the alteration and significant repair of pressure vessels is completed, the inspector shall issue Supervisory Inspection Certificate provided that the review of quality certificate documents and the as-built drawing on alteration and significant repair are reviewed and accepted.

6.4 Supervisory inspection on imported pressure vessels

6.4.1 Basis of supervisory inspection

The basis of supervisory inspection is this Regulation as well as construction codes and standards stipulated in the trade contract.

6.4.2 Supervisory inspection methods

For imported pressure vessels, the supervisory inspection may be conducted during manufacturing process. If the manufacturing supervisory inspection couldn’t be implemented aboard, the supervisory inspection for product safety performance shall be carried out by the supervisory inspection institute approved by AQSIQ after the products arriving at the port or the service place (hereinafter referred to as arrival inspection, see Note 6-4).

For the pressure vessels which are part of the imported complete set of equipment and fabricated by domestic manufacturer, if they have been inspected by supervisory inspection institute where the manufacturer is located in accordance with the requirements of Article 6.2 in this Regulation, it’s not necessary to conduct the arrival inspection again after they arriving

at the port or service place.

Note 6-4: Arrival inspection refers to the supervisory inspection for product safety performance after imported pressure vessels arrive at the port or the service place in order to verify whether they meet the essential safety requirements of this Regulation.

6.4.3 Supervisory inspection procedure

Supervisory inspection procedures of imported pressure vessels are as follows:

(1) A written application for supervisory inspection by the inspected company;

(2) Determination and implementation of oversea inspection items and arrival inspection items;

(3) Review of relevant technical documents and inspection information;

(4) Stamp supervisory inspection identification and issue Supervisory Inspection Certificate for Safety Performance of Imported Special Equipments (see the format in Appendix G).

6.4.4 Requirements for supervisory inspection application

Domestic companies importing pressure vessels or foreign pressure vessel manufacturers shall apply for supervisory inspection to the supervisory inspection institute located in service place or port of entry (if the service place is uncertain).

For pressure vessels designed by international standards or foreign standards, a conformance declaration required in Item (3) of Article 3.1.1 of this Regulation and a comparison table for its products and the essential safety requirements in this Regulation shall also be provided.

6.4.5 Determination of supervisory inspection items

The items for supervisory inspection aboard or arrival inspection shall be determined according to the requirements of Article 6.1.9 and 6.2 in this Regulation.

6.4.6 Oversea supervisory inspection

Based on the determined oversea supervisory inspection items, the supervisory inspection institute dispatches inspectors for oversea supervisory inspection according to the requirements of Article 6.2 of this Regulation.

6.4.7 Arrival inspection

Based on the determined arrival inspection items, the supervisory inspection institute shall carry out the inspection focusing on the following items:

(1) Thickness of main pressure components;

(2) Examination of appearance and geometric dimensions;

(3) Spot check of the nondestructive examination of butt-welded joints, no less than 10% of the butt welded joints and no less than one weld shall be spot checked (except the welds cannot be spot checked for nondestructive examination);

(4) Product nameplates;

(5) Suspicious inspection items during review of relevant inspection information.

For imported pressure vessels which have been supervisory inspected by China inspection institute aboard, arrival inspection is not required.

6.4.8 Review of relevant technical documents and inspection information

Determine technical documents and inspection information which need to be reviewed by reference to the requirements of Article 6.1.9 and 6.2 in this regulation. While the following technical information and inspection information shall be reviewed:

(1) Review design documents of pressure vessels; when pressure vessels are designed according to international standards or foreign standards, check whether the design method, safety factor, risk assessment report, safety interlock device of quick opening pressure vessels meet the essential safety requirements of this Regulation;

(2) Review the material list and quality certificate documents of main pressure components of pressure vessels, and check whether the chemical composition of materials, mechanical properties of materials and ultrasonic testing of steel plates meet the essential safety requirements of this Regulation;

(3) During oversea supervisory inspection, the inspector shall also review whether the welding procedure specifications of pressure vessels conform to the welding procedure qualification reports; whether the welding map of pressure vessels conforms to the welding procedure specifications;

(4) Review the test report on welding test coupon of pressure vessels; when pressure vessels are designed according to international standards or foreign standards, check whether the preparation of welding test coupon meets the essential safety requirements of this Regulation;

(5) Review the nondestructive examination report of pressure vessels; when pressure vessels are designed according to international standards or foreign standards, check whether the nondestructive examination method and percentage meet the essential safety requirements of this Regulation;

(6) During oversea supervisory inspection, the radiographic testing films of welds of pressure vessels shall also be inspected;

(7) Review the heat treatment report of pressure vessels;

(8) Review the inspection report on appearance and geometric dimensions of pressure vessels;

(9) Review the proof pressure test report and leak testing report of pressure vessels; when pressure vessels are designed according to international standards or foreign standards, check whether test methods and pressure coefficient meet the essential safety requirements of this Regulation;

(10) Review delivery (as-built) information of pressure vessels.

6.4.9 Stamp and certificate of supervisory inspection

After supervisory inspection is qualified, the inspector shall, in accordance with the requirements of Item (6) of Article 6.1.6 in this Regulation, stamp supervisory inspection identification and issue the Supervisory Inspection Certificate for Safety Performance of Imported Special Equipments.

6.5 Supervisory inspection methods of batch-manufactured products

6.5.1 Applicable scope

It is applicable to batch-manufactured accumulators, simple pressure vessels and heads with welds as well as Category I and Category II pressure vessels with volume less than $5m^3$. For Category I and Category II pressure vessels with volume less than $5m^3$, they shall meet the followings simultaneously:

(1) Adopt the same design document, process document, quality plan, materials with the same designation, same production plan No., the production quantity is no less than 30 and the delivery number is continuous;

(2) Product welding test coupon or post-weld heat treatment is not needed.

The inspected company applies for supervisory inspection of batch-manufactured products to the supervisory inspection institute, and the supervisory inspection institute carries out the inspection after confirmed the products satisfy the batch-manufacturing requirements.

6.5.2 Requirements for supervisory inspection number

Supervisory inspectors determine the number of pressure vessels for spot check according to the quality assurance system implementation of the inspected company. For simple pressure vessels, the number of pressure vessels for spot check shall not be less than 5% of the batch and shall be at least 3; for other batch-manufactured products, the number of pressure vessels for spot check shall not be less than 10% of the planned quantity and shall be at least 4. The first fabricated pressure vessel of the batch must be supervisory inspected.

6.5.3 Supervisory inspection of spot-checked products

The supervisory inspection of spot-checked products on design documents, procedure documents, materials, assembling, welding, nondestructive examination, appearance and geometric dimensions and proof pressure test shall be performed in accordance with the relevant requirements of Article 6.2 in this regulation. For simple pressure vessels, the supervisory inspectors shall witness the bursting test.

6.5.4 Supervisory inspection record

Except the supervisory inspection witness required in Article 6.1.10 of this regulation, the serial number of spot checked products shall also be recorded.

6.5.5 Delivery (as-built) information, supervisory inspection stamp and supervisory inspection certificate (Category C/B))

(1) Review the delivery (as-built) information of spot-checked products in accordance with the requirements of Article 6.2.1.4 of this regulation; review product nameplates of pressure vessels according to the requirements of Article 6.2.1.5 of this regulation; after the review is qualified, stamp the supervisory inspection identification on all the planned manufactured pressure vessels in accordance with the requirements of Article 6.2.1.6 of this regulation;

(2) Issue the Supervisory Inspection Certificate in batches, its copies shall be determined through negotiation with the inspected company;

(3) Supervisory Inspection Certificate shall also be noted with the serial No. of all products of the batch, and with the serial No. of spot checked products.

6.5.6 Treatment of the unqualified

During the supervisory inspection on materials, assembling, welding, nondestructive examination, appearance and geometric dimensions and proof pressure test, if general problems are found, the supervisory inspectors shall increase the product number for spot check which shall be twice of the problematic products at least, and send out Liaison Sheet for Supervisory Inspection to the inspected company.

The supervisory inspectors shall timely report to the supervisory inspection institute and suspend supervisory inspection method for batch-manufactured products under one of the following conditions:

(1) Serious problems exist in the spot checked products;

(2) General problems exist in the spot-checked products, and unconformities with this Regulation still exist after additional supervisory inspection is carried out.

6.6 Evaluation on quality assurance system implementation of pressure vessel manufacturer

6.6.1 Essential requirements

Supervisory inspection institutes shall perform the evaluation on quality assurance system implementation of the inspected company according to the following requirements:

(1) During the manufacturing supervisory inspection (except field fabrication, field welding and field cementing) of pressure vessels, the evaluation on quality assurance system implementation of the inspected company shall be conducted at least once a year, and the evaluation content and requirements see Article 6.6.2 to 6.6.5 of this Regulation;

(2) During the supervisory inspection on field fabrication, field welding and field cementing of pressure vessels, the evaluation on quality assurance system implementation of the inspected company shall be conducted by reference to Article 6.6.2 to 6.6.5 of this Regulation based on the characteristics of pressure vessel manufacturing;

(3) The evaluation report shall be issued timely after the evaluation and sent to the inspected company, reported to the local department in charge of safety supervisory administration of special equipments; when serious problems are found in the quality assurance system of inspected company, the evaluation report shall also be reported to the department in charge of safety supervisory administration of special equipments which issues the license; the non-conformities with Article 6.6.2 and 6.6.4 in evaluation report shall be explained in details and suggestions shall be provided.

6.6.2 Changes of resource of the inspected company

Inspect the technical capacity of inspected company such as technical personnel, personnel responsible for quality assurance system, operating personnel of special equipment or inspection and testing personnel as well as the resource such as plant, site and fabrication facility, and check whether they conform to the manufacturing license requirements.

6.6.3 Maintenance and improvement of quality assurance system

6.6.3.1 Quality system document

Review whether the modification of quality assurance system document conforms to the changes of regulations, standards and actual manufacturing situation.

6.6.3.2 Control of document and record

Check whether external documents such as regulations or standards and the control on acquisition, filing, preservation or retention period of inspection and testing records conform to the quality assurance system.

6.6.3.3 Control of subcontractor (supplier)

Review whether the evaluation and management for subcontractors of physical and chemical inspection, heat treatment, nondestructive examination and material sub-suppliers of main pressure components conform to the quality assurance system.

6.6.3.4 Control of equipment and inspection & test device

Check whether the control of main equipments for manufacturing pressure vessels and inspection & test devices conform to the quality assurance system.

6.6.3.5 Control of non-conformity products (items)

Review whether the treatment of non-conformity products (items) conforms to the quality assurance system.

6.6.3.6 Personnel training, assessment and management

Inspect further education of the personnel significant to product quality such as personnel responsible for quality assurance system, inspectors and testing personnel, etc. Inspect the certificate replacement of certificate holding personnel due to expiration.

6.6.3.7 Quality improvement and customer service control

Review whether the quality information feedback, treatment of customer complaint, internal audit and management review, etc. conform to the quality assurance system.

6.6.4 Implementation of licensing system of special equipment (when licensing is required)

Review whether the implementation of special equipment licensing system and service management of manufacturing license meet the requirements of regulations.

6.6.5 Problems found during supervisory inspection and treatment

Check whether the treatment of Liaison Sheet for Supervisory Inspection and Supervisory Inspection Notice conforms to the quality assurance system, and whether the treatment results conform to the requirements of this Regulation, product standards and design documents.

7 Service Management

7.1 Safety service management

7.1.1 Responsibility of the user

The user of the pressure vessel shall conduct safety service management for pressure vessels according to the related requirements of *Regulation on Service Management of Special Equipment*. The user shall set safety management departments, appoint safety management responsible person, safety management personnel and operating personnel, apply for service registration, establish the safety management system, formulate operation instructions and carry out the inspection.

7.1.2 Service registration

Prior to putting into service of any pressure vessel or within 30 days after the initial service, the user shall apply to the local department in charge of special equipment service registration (hereinafter referred to as the registration authority) for *Service Registration Certificate of Special Equipment* (hereinafter referred to as *Registration Certificate*) in accordance with the relevant provisions. When registering the pressure vessels, the safety situation rating and first inspection date shall be determined according to the following requirements:

(1) For new pressure vessels with complete fabrication data confirmed by the Registration authority, its safety situation rating is Class 1; the rating of safety situation for imported pressure vessels is evaluated by the special equipment inspection institute conducting supervisory inspection for imported pressure vessels;

(2) The first inspection date of pressure vessels shall be determined in accordance with the provisions of Article 8.1.6 and 8.1.7 of this Regulation, exclusive of the situation which the product standard or the user deems it’s necessary to shorten the inspection period; when the first periodic inspection is required to prolong, the user shall explain the special situation with written application. After approved by the safety management responsible person of the user, the first periodic inspection can be prolonged but the prolong period shall not exceed to 1 year.

7.1.3 Operation instruction of pressure vessels

The pressure vessel user shall clearly document the requirements for safety operation of pressure vessels in the process operation instructions and the operating post instructions. It shall at least include the following contents:

(1) Process operation parameters (include operating pressure, maximum or minimum

operating temperature);

(2) Operating post instructions (including operating procedures to start-up/shutdown and attentions);

(3) Key points and locations of on-stream inspection, the potential malfunction in operating and corresponding preventive measures, as well as handling and reporting procedures for emergency.

7.1.4 Routine maintenance

The user shall establish the routine inspection rules for pressure vessels, and conduct the routine maintenance on main body of pressure vessels and safety accessories, the attachment of filling and discharging, the safety protective devices, the measurement and control devices, and the affiliated apparatus and instruments. The unusual situations shall be treated and recorded timely, ensure the pressure vessel in service is always in normal operation.

7.1.5 Periodic self-examination

The self-examination for pressure vessels includes monthly inspection and annual inspection.

7.1.5.1 Monthly inspection

The user shall conduct the monthly inspection for the pressure vessels in service at least once a month, and record the inspection situation; when the time of annual inspection and monthly inspection is coincided, the monthly inspection can be exempted. The monthly inspection includes check whether the main body of pressure vessels and safety accessories, the attachment of filling and discharging, the safety protective devices, the measurement and control devices, and the affiliated apparatus and instruments are in good condition, whether there is any leakage of sealing surface, and other unusual situations, etc.

7.1.5.2 Annual inspection

The user shall perform the annual inspection for the pressure vessels in service at least once a year. The annual inspection shall be performed according to the requirements of Article 7.2 of this Regulation. After the annual inspection, the analysis of safety service situation for pressure vessels shall be carried out and the hidden hazard shall be resolved immediately.

The annual inspection shall be performed by the operating personnel with professional training provided by the safety management personnel of the user, and also can be performed by the qualified special equipment inspection institute.

7.1.6 Periodic inspection

The user shall submit the inspection application to the special equipment inspection

institute for the periodic inspection one month prior to the expiration date of the last periodic inspection of the pressure vessel, and prepare well for the periodic inspection.

After the periodic inspection, the user shall conduct such works as pipes connection, sealing, installation of accessories (including safety accessories and instruments) and internals, and be responsible for the safety of pressure vessels.

7.1.7 In service pressure vessels exceeding the design service life

For pressure vessels that have already reached the design service life (or have been in service for more than 20 years without any specification of design service life), if the user intends to use the pressure vessels continually, the user shall apply for the inspection by a qualified special equipment inspection institute in accordance to the related provisions of periodic inspection. If necessary, safety evaluation shall be performed in accordance with Article 8.9 of this Regulation. Upon the approval of the responsible personnel of the user and change of registration certificate, the pressure vessels can be put into continuous service.

7.1.8 Handling of unusual cases

When any of the following unusual case of pressure vessels occurs, the pressure vessel operator shall immediately take specific emergency action and report it immediately to the corresponding department and personnel of the company in accordance with the specified procedure:

(1) Operating pressure, operating temperature of the pressure vessel exceeds the specified value, and cannot be effectively controlled by taking measures or adjustments;

(2) Damages affecting the safety of the pressure vessel such as cracks, unusual deformations, leakage, and the lining layer failure etc are detected on the main pressure components;

(3) Safety accessories are unable to provide any protection due to failure, damage, etc;

(4) Safe operation cannot be ensured due to damage of gaskets or fasteners;

(5) Fire occurs that threaten the safe operation of pressure vessels;

(6)Unusual liquid level in the pressure vessel occurs that cannot be effectively controlled even with the proper operating procedure;

(7) Serious vibration occurs between the pressure vessel and piping that may impact the safe operation;

(8) The piping connected with the pressure vessel leaks that may impact the safe operation;

(9) Parts of the external wall of the vacuum insulation pressure vessel are seriously

frozen, or the operating pressure is significantly increased;

(10) Any other unusual situations occur.

7.1.9 Requirements for connecting devices at filling and discharging

When filling and discharging operations between transportable and stationary pressure vessels are required, the connecting devices shall meet the following requirements:

(1) Pressure vessels shall be equipped with reliable connecting devices between the pipes or the flexible tubes of filling and discharging;

(2) Protective interlocking devices shall be installed to prevent disconnection of pipes or flexible tubes of filling and discharging;

(3) The materials for pipes or flexible tubes of filling and discharging shall be suitable with mediums and low temperature conditions, and the nominal pressure of the flexible tubes filling or discharging high (low) pressure liquefied gas, frozen liquefied gas and liquid shall be not less than 2 times of the operating pressure of the filling and discharging system, the nominal pressure of the flexible tubes filling or discharging compressed gas shall be not less than 1.3 times of the operating pressure of the filling and discharging system, and the minimum bursting pressure shall be greater than 4 times of the nominal pressure;

(4) The filling company or the user must conduct the proof pressure test for the pipes or the flexible tubes of filling and discharging once a year, and the test pressure shall be 1.5 times of the nominal pressure. No leakage and no unusual deformation are acceptable. The test results shall be recorded and signed by the personnel who perform the test.

7.1.10 Safety requirements for repair and under pressure leak sealing

Any repair with pressure in the vessel shall be prohibited. If the under pressure leak sealing is required for an emergent leakage, the user shall provide the effective operating requirements and protective measures based on the design specification. All above shall be approved by the safety management responsible person of the user.

The operating personnel shall take the professional training and hold the certificate for special equipment operation of under pressure leak sealing. The operation shall be supervised on-site by the safety management department personnel of the user.

7.1.11 Special requirements for service management of simple pressure vessels and the pressure vessels within the scope of Article 1.4 of this Regulation

For simple pressure vessels and the pressure vessels within the scope of Article 1.4 of this Regulation, service registration is not required and periodic inspection is not required during the design service life. The user shall be responsible for the safety management of service and

do the following works:

(1) Establish safety management files for equipments, conduct the routine maintenance, carry out the periodic self-examination and file the records; when unusual case occurs, it shall apply for inspection to special equipment inspection institutes timely;

(2) The pressure vessels that have already reached the design service life shall be scrapped, if the user intends to use the pressure vessels continually, the user shall apply for the inspection to the special equipment inspection institute in accordance to the related requirements of Chapter 8 of this Regulation;

(3) When an accident occurs, the entity with the accident shall take effective measures immediately for rescue to prevent expansion of the accident, report and handle it according to the requirements of *Regulation on Accident Reporting and Handling for Special Equipment*; late reporting, misrepresentation or concealment of accidents are not permitted.

7.2 Annual examination

The annual examination shall at least include the examinations of safety management, the main body of pressure vessels and operating performance, and the safety accessories of pressure vessels.

7.2.1 Examination on safety management

The examinations on safety management of pressure vessels shall at least include the following contents:

(1)Whether the safety management system of pressure vessel is complete and effective;

(2)Whether the design documents, as-built drawings, product conformity certificates, product quality certification documents, instructions on installation & service and maintenance, supervisory inspection certificates as well as the data of installation, alteration and repair specified in this Regulation are complete;

(3) Whether the *Registration Certificate, Service Registration Table of Special Equipment* (hereinafter referred to as *Registration Table*) conform to the actual situation;

(4) Whether the routine maintenance, operation records and periodic safety examination records of pressure vessels meet the requirements;

(5) Whether the reports on annual examination and periodic examination of pressure vessels are complete, and whether the problems referred in the examination and examination report have been solved;

(6) For safety accessories and instruments, whether the records of calibration (verification), repair and replacement are complete and authentic;

(7) Whether there are specific emergency plans of pressure vessel and drilling records;

(8) Whether the accidents and failures of pressure vessels are recorded.

7.2.2 Examination on the main body of pressure vessels and operating performance

7.2.2.1 Essential requirements

The examination on the main body of pressure vessels and operating performance shall at least include the following contents:

(1) Whether the nameplates and other related marks of pressure vessels meet the corresponding provisions;

(2) Whether cracks, overheat, deformation, leakage, damage from mechanical contact occur on the main body of pressure vessels, nozzle locations (valves, pipelines) and welded (cemented) joints;

(3) Whether corrosions, unusual frosting and dewing etc. exist on the external surface; whether there are unusual frosting and dewing, etc;

(4) Whether the insulation are damaged, come off, damp and heat-losing;

(5) Whether the liquid or gas is leaked from the leak detection holes and telltale holes; whether the leak detection holes are clear;

(6) Whether unusual vibration, noise or friction happens to the pressure vessels and adjacent pipelines or components;

(7) Whether the bearing or supporting is damaged; whether the foundation is sinking, inclined or cracking; whether the fasteners are complete and in good condition;

(8) Whether the discharge (drain, blow-down) devices are in good condition;

(9) Any phenomenon such as over-pressure, over-temperature, over-quantity, etc. happens during the operation;

(10) For tanks with grounding devices, check whether the grounding devices meet the requirements;

(11) For pressure vessels under control, check whether the control measures have been effectively implemented.

7.2.2.2 Special requirements for annual examination of nonmetallic and nonmetallic lining pressure vessels

7.2.2.2.1 Examination of glass-lined pressure vessels

(1) Whether the anti-corrosion paint used in the external surface of pressure vessels is intact; any case like rusting or corrosion happens;

(2) Any leakage occurs on the sealing surface;

(3) Whether the opening and closing of discharge (drain) port at the bottom of the jacket is flexible;

(4) Whether the opening and closing of the blow-off port at the top of the jacket is flexible.

7.2.2.2.2 Examination of graphite and graphite-lined pressure vessels

(1) Whether the anti-corrosion paint used in the external surface of pressure vessels is intact; any phenomenon like rusting or corrosion happens;

(2) Any case such as corrosion, damage or crack happens to the external surface of graphite parts;

(3) Any leakage occurs on the sealing surface.

7.2.2.2.3 Examination of fiber reinforced plastic and fiber reinforced plastic-lined pressure vessels

(1) Whether the anti-corrosion paint used in the external surface of pressure vessels is intact; any case such as corrosion, damage, fiber exposure, cracks/crevices, delamination, concave pits, scratches, blisters or deformation happens;

(2) Whether the connections such as nozzles and supporters are cracked or disconnected;

(3) For the supporting, ladder or platform, etc., whether there is any factor affecting the safety such as loosening, break;

(4) Whether the parts such as fasteners or valves are damaged due to corrosion;

(5) Whether any leakage occurs on the sealing surface.

7.2.2.2.4 Examination of thermoplastic lined pressure vessels

(1) Whether the anti-corrosion paint of the external surface of pressure vessels is intact and any case like rusting or corrosion happens;

(2) Any leakage occurs on the sealing surface.

7.2.3 Examination of safety accessories and instruments

The safety accessories to be examined include safety valves, bursting disc devices, safety interlock devices, etc; the instruments to be examined include pressure gages, liquid level gages, and thermometry apparatuses, etc.

7.2.3.1 Safety valve

7.2.3.1.1 Contents and requirements of the examination

The examination of safety valves shall at least include the following contents and requirements:

(1) Whether the selection of safety valves is right;

(2) Whether it's used in the valid period of calibration;

(3) For lever type safety valves, whether the anti-deviation device to prevent the weight from freely shifting and guide frame to limit the leverage deviation are intact; for spring-loaded safety valves, whether the lead seal device to prevent the adjusting of screws is intact; for dead weight safety valves, whether the protection device to prevent the weight from moving away is intact;

(4) If a globe valve is mounted between the safety valve and the discharge port, whether the globe valve is kept at a full-open position and whether the lead seal is in good condition;

(5) Whether the safety valve leaks;

(6) Whether the blow-down pipe is clear and whether the rain-hat is intact.

7.2.3.1.2 Handing of examination results

During the examination of safety valves, when one of the following cases occurs, the user shall make corrections within a time limit and take effective measures to ensure the safety during the correcting, or suspend the service of the pressure vessel:

(1) The selection of safety valves is wrong;

(2) Exceed the valid period of calibration;

(3) The lead seal is damaged;

(4) The safety valve leaks.

7.2.3.1.3 Calibration period of safety valves

7.2.3.1.3.1 Essential requirements

Generally, the safety valve is calibrated at least once a year; when it conforms to the special requirements for prolonging the calibration period in Article 7.2.3.1.3.2 and 7.2.3.1.3.3 of this Regulation, the calibration period can be properly prolonged by the safety management responsible person of the user.

7.2.3.1.3.2 The calibration period is prolonged to 3 years

For spring-loaded safety valves, when it satisfies the following requirements, the calibration period can be prolonged to a maximum of 3 years:

(1) The safety valve manufacturer can provide documents to prove that the spring in service is strengthened or hot pre-stressed in accordance with GB/T 12243 *Spring Loaded Safety Valve*; and for springs with the same heat treatment furnace and same specifications, 10% of which (but no less than 2) is taken for the measurement of deformation or stiffness under the specified load and the deviation of measured values is not more than 15%;

(2) The materials of internal parts of safety valves resist to the medium corrosion;

(3) No opening happens during the normal operation of safety valves;

(4) No obvious rusting occurs during the service of pressure vessels and the body of safety valve;

(5) The pressure vessel contains non-sticky and moderately or below toxic mediums;

(6) The user has established and implemented sound rule of equipment service, management and maintenance of equipment, and reliable pressure control and adjusting devices or overpressure alarm devices are provided;

(7) The user has established a calibration station as required and is able to calibrate the safety valves.

7.2.3.1.3.3 The calibration period is prolonged to 5 years

For spring loaded safety valves, when it satisfies the requirements of Item (2), (3), (4), (6), (7) of Article 7.2.3.1.3.2 of this Regulation, and also meet the following requirements, the calibration period can be prolonged to a maximum of 5 years:

(1) The safety valve manufacturer can provide documents to prove that the spring in service is strengthened or hot pre-stressed in accordance with GB/T 12243 *Spring Loaded Safety Valve*; and for springs with the same heat treatment furnace and same specifications, 20% of which (but no less than 4) is taken for the measurement of deformation or stiffness under the specified load and the deviation of measured values is not more than 10%;

(2) The pressure vessel contains low (no) toxic gas mediums, and the operating temperature is not greater than 200℃.

7.2.3.1.4 Field calibration and adjusting

For safety valves, when the field calibration (on-line check) and pressure adjustment is required, the pressure vessel safety management personnel and safety valve examination (calibration) personnel of the user shall be present for confirmation. The calibrated valve shall be sealed. The precision of pressure gages used in calibration and adjustment shall not be lower than Class 1. During the calibration and adjustment, reliable protective measures shall be provided.

7.2.3.2 Bursting disc devices

7.2.3.2.1 Contents and requirements of the examination

The examination of bursting disc devices shall at least include the followings:

(1) Whether the specified service life of the bursting disc device is expired;

(2) Whether the installation direction of the bursting disc device is correct; whether the

burst pressure and temperature on the product nameplate meet the operation requirements;

(3) Whether the bursting disc device leaks;

(4) Whether bursting without overpressure or no bursting with overpressure happens during the operation of bursting disc devices;

(5) Whether the blow-down pipe connected with the bursting disc device gripper is clear; any water or ice stored in the blow-down pipe; whether the waterproof endcap or rainproof strip is intact;

(6) Whether the globe valve mounted between the bursting disc device and the pressure vessel is kept at a full-open position and whether the lead seal is in good condition;

(7) When the bursting disc device and the safety valve are used in series, if the bursting disc device is mounted at the inlet side of the safety valve, it shall check whether the pressure gage mounted between the bursting disc device and the safety valve shows the pressure; and check whether any gas is exhausted by opening the globe valve;

(8) When the bursting disc device and the safety valve are used in series, if the bursting disc device is mounted at the outlet side of the safety valve, it shall check whether the pressure gage mounted between the bursting disc device and the safety valve shows the pressure; if it shows the pressure, then open the globe valve and check whether the draining and exhausting goes well.

7.2.3.2.2 Handling of examination results

During the examination of bursting disc devices, when one of the following cases occurs, the user shall replace the bursting disk device immediately and take effective measures to ensure the safety during replacement, or suspend the service of the pressure vessel:

(1) The specified service life of the bursting disc device is expired;

(2) The installation direction of bursting disc devices is wrong;

(3) The calibrated bursting pressure and temperature of the bursting disc device is not accordance with the operation requirements;

(4) No bursting happens when it exceeds the calibrated bursting pressure in the operation of rapture disks;

(5) When the bursting disc device and the safety valve are used in series, the pressure gage mounted between the bursting disc device and the safety valve shows the pressure or the gas leaks when the globe valve is opened;

(6) When the bursting disc device is acted as a pressure relief device separately or the bursting disc device and the safety valve are used in parallel, the globe valve mounted

between the rapture disk and the pressure vessel is not at a full-open position or the lead seal is damaged;

(7) The bursting disc device leaks.

7.2.3.3 Safety interlock devices

Check whether the safety interlock device of the quick opening pressure vessel is in good condition; whether the functions meet the requirements.

7.2.3.4 Pressure gage

7.2.3.4.1 Contents and requirements of the examination

The examination of pressure gages shall at least include the following contents:

(1) Whether the selection of the pressure vessel meets the requirements;

(2)Whether the periodic maintenance, calibration expiration and seal conform to the specifications;

(3) Whether the appearance, precision class and measuring range meets the requirements;

(4) When a three-way cock or a needle valve is mounted between the pressure gage and the pressure vessel, whether its position, the on-off label and the lock device conforms to the specifications;

(5) Whether the reading on each pressure gage of the same system are consistent.

7.2.3.4.2 Handling of the examination results

During the examination of pressure gages, when one of the following cases occurs, the user shall make corrections within a time limit and take effective measures to ensure the safety operation during the correcting, or stop the service of the pressure vessel:

(1) The selection of pressure vessels is wrong;

(2) The glass on the dial is cracked or the scale on the dial is blur;

(3) The seal is damaged or the valid period is expired;

(4) The spring tube of the gage leaks or the gage pointer got loose;

(5) The gage pointer is twisted and broke or the shell is in serious corrosion;

(6)The on-off label of the three-way cock or needle valve is unclear or the lock device is damaged.

7.2.3.5 Liquid level gages

7.2.3.5.1 Contents and requirements of the examination

The examination of liquid level gages shall at least include the following contents:

(1)Whether the periodic examination and maintenance of the liquid level gage conforms

to the specifications;

(2)Whether the appearance and appurtenance of the liquid level gage conforms to the provisions;

(3) For the liquid level gage used outdoor in the cold climate region or containing low-temperature (less than 0℃) mediums, whether the selection of liquid level gages conforms to the provisions;

(4) For the pressure vessel containing the explosively or extremely, highly toxic liquefied gas, whether the protection device against leakage of the liquid level gage is mounted in accordance with the specifications.

7.2.3.5.2 Handling of examination results

During the examination of liquid levels gages, when one of the following cases occurs, the user shall make corrections within a time limit and take effective measures to ensure the safety during the correcting, or stop the service of the pressure vessel:

(1) The selection of liquid level gages is wrong;

(2) The specified examination period is expired;

(3) The glass plate(tube) is cracked or broken;

(4) The valves are solid;

(5) The indication of liquid level is wrong;

(6) The indication of liquid level gage is blur;

(7) The protection device against leakage is damaged.

7.2.3.6 Thermometry apparatuses

7.2.3.6.1 Contents and requirements of the examination

The examination of thermometry apparatuses shall at least include the following contents:

(1)Whether the periodic calibration and examination of the thermometry apparatus conforms the specifications;

(2)Whether the measuring range of the thermometry apparatus is matched with the measured temperature range;

(3) Whether the appearance of the thermometry apparatus and the secondary instrument conforms to the specifications.

7.2.3.6.2 Handling of examination results

During the examination of thermometry apparatuses, when one of the following cases occurs, the user shall make corrections within a time limit and take effective measures to

ensure the safety during the correcting, or stop the service of the pressure vessel:

(1) The selection of measuring range of the apparatus is wrong;

(2) The specified calibration and maintenance period is expired;

(3) The apparatus and its protection device are damaged.

7.2.4 Examination reports and conclusions

After the annual examination, the examiners shall issue the examination report (see Annex H of the report format) according to the actual examination situation and make the following conclusions:

(1) Conform to the requirements --- no defects or only slight defects are found which will not affect the safety operating of pressure vessel, and the pressure vessel can continue to be used within the permitted parameter scope;

(2) Basically conform to the requirements --- general defects are found but the safety operating can be ensured by taking measures, the pressure vessel can be used under control; the problems to be solved and the complete date shall be indicated in the conclusion;

(3) Non-conformity with the requirements --- serious defects are found and the safety operating of pressure vessels cannot be ensured; the pressure vessel is not permitted to continue to use, and the operation shall be stopped or further inspection shall be carried out by the inspection institute.

When the annual examination is carried out by the user itself, it shall make records according to the examination items and requirements of this section and issue the annual examination report which shall be approved by the safety management responsible person or the authorized safety management personnel of the user.

8 Periodic Inspection

8.1 General requirements

8.1.1 Periodic inspection

The periodic inspection of pressure vessels refers to a compliance verification on the safety condition of in-service pressure vessels within periodic intervals conducted by the special equipment inspection institute (herein after abbreviated as inspection institute) during the shutdown of pressure vessels according to the requirements of this Regulation.

8.1.2 Periodic inspection procedures

The procedure of periodic inspection generally includes the developing of inspection plans, preparation for the inspection, implementation of inspection, treatment of defects and problems, summary of inspection results and issuance of inspection reports, etc.

8.1.3 Inspection institute and inspector

The inspection institute can only conduct the periodic inspection in accordance with the approved inspection scope. The inspector and examiner (herein after abbreviated as inspector) shall hold the corresponding certificate of special equipment inspection and examination. The inspection institute shall be responsible for the authenticity, accuracy and validity of the periodic inspection reports of pressure vessels (Note 8-1).

Note 8-1: Authenticity means the reports shall be based on objective reality and false reports are forbidden; accuracy means the precision of the inspection data involved in the reports shall be in accordance with applicable requirements; validity means the qualification of the inspection institute and inspector, the inspection standards used and the approval procedures of the inspection report shall be valid and meet applicable requirements.

8.1.4 Inspection Application

The user shall submit the inspection application for inspection to the inspection institute at least one month prior to the periodic inspection expiry date of the periodic inspection of pressure vessels. Once receiving the application, the inspection institute shall implement carry out the inspection prior to the deadline of periodic inspection.

8.1.5 Safety situation rating

The safety status of an in-service pressure vessel is classified as Class 1 to Class 5. The safety situation, one of which the pressure vessel shall be rated as according to applicable requirements of Article 8.5 and Article 8.6 of this Regulation and the inspection results.

8.1.6 Inspection interval

8.1.6.1 Inspection interval of metallic pressure vessels

In general, the first periodic inspection of metal pressure vessels shall be performed within three years since the initial service. The subsequent inspection intervals shall be determined by the inspection institute based on the safety situation rating of pressure vessels as the following:

(1) For Class 1 or Class 2, the inspection interval generally shall be 6 years;

(2) For Class 3, the inspection interval generally shall be 3 to 6 years;

(3) For Class 4, the pressure vessel could operate only under control with specific and effective measures by the user for no more than 3 years cumulatively and the inspection interval shall be determined by the inspection institute.

(4) For Class 5, all the defects shall be treated, otherwise the pressure vessels are not permitted to operate.

8.1.6.2 Inspection interval of nonmetallic pressure vessels

In general, the first periodic inspection of nonmetallic pressure vessels shall be performed within 1 year since the initial service. The subsequent inspection intervals shall be determined by the inspection institute based on the safety situation rating of pressure vessels as the following:

(1) For Class 1, the inspection interval generally shall be 3 years;

(2) For Class 2, the inspection interval generally shall be 2 years;

(3) For Class 3, the pressure vessel could operate only under control for no more than 1 year cumulatively;

(4) For Class 4, the pressure vessel is not allowed to contain the current medium; if another properly corrosive medium is chosen, the pressure vessel shall operate under control for no more than 1 year cumulatively. The subsequent inspection intervals shall be determined by the inspection institute;

(5) For Class 5, all the defects shall be treated, otherwise the pressure vessels are not permitted to operate.

8.1.7 Special provisions for inspection intervals

8.1.7.1 Shortening of inspection intervals

The inspection intervals of pressure vessels shall be shortened appropriately if any of the following conditions is satisfied:

(1) The corrosion on the material of pressure vessel caused by the medium or

circumstance is unclear or abnormal;

(2) There is an environment-assisted cracking tendency or mechanical damage, and corresponding cracking has been found (Note 8-2);

(3) Working medium has been changed and it likely causes corrosion deterioration;

(4) The material deterioration is rather obvious;

(5) The ultra-high pressure crystal autoclave has been used for more than 15 years or operating temperature once exceeded the required limit;

(6) The user did not conduct the annual examination as specified in this Regulation;

(7) Other doubtful situation affecting the safety of the pressure vessel is found during the inspection.

For rotary spherical digester without effective anti-corrosion measures used in the ammonium sulfite process for paper-making, the periodic inspection shall be carried out at least once a year.

If the spherical tank is made of low alloy steel with specific tensile strength lower limit greater than 540MPa, an intrusive inspection is necessary within 1 year since the initial service.

Note 8-2: Environment-assisted cracking mainly includes stress-corrosion, hydrogen induced cracking, intergranular corrosion and so on; mechanical damaging mainly includes various fatigues, high-temperature creep and so on. The GB/T 30579 *Damage Models Identification for Pressure Equipments* is recommended as the reference.

8.1.7.2 Prolonging of inspection interval

For metal pressure vessels rated as Class 1 or Class 2, the inspection interval can be appropriately prolonged if any of the following conditions is satisfied:

(1) For pressure vessels with annual corrosion rate lower than 0.1mm and applied with reliable anti-corrosion metal lining or thermal spaying metal coating, the inspection interval is permitted to be prolonged up to 12 years if the corrosion is confirmed to be slight or the lining intact by one or two periodic inspections.

(2) For pressure vessels containing catalyst or fillers, the inspection interval shall be determined through consultation by the user and the inspection institute (if necessary, the opinions of the design unit should be asked) based on the design drawing and actual operating conditions.

8.1.7.3 Impracticable or overdue periodic inspection

For pressure vessels a periodic inspection is unable to be performed or cannot be

performed in the prescribed period, the requirements below shall be followed:

(1) If the design document indicates that a periodic inspection is unable to be performed for this pressure vessel, a written explanation shall be provided by the user when applying for the Service Registration Certificate.

(2) For pressure vessels a periodic inspection cannot be performed in the prescribed period due to special reasons, the user shall submit a written application approved by the legal representative to make an explanation. The inspection can be postponed only after the application is permitted by the inspection institute who carried out the last periodic inspection or Risk Based Inspection (RBI) (except the extension for the first inspection), and filed to the Service Registration Authority. Alternatively, the user shall submit an application and follow the procedures in accordance with article 8.10 of this Regulation.

For pressure vessels a periodic inspection is unable to be performed or cannot be performed in the prescribed period, the user shall take effective control and emergency handling measures.

8.2 Preparation for inspection

8.2.1 Inspection plan

The inspection institute shall develop the inspection plan according to the service situation, damage modes, failure mechanisms of the pressure vessel as well as the applicable requirements of this Regulation before the inspection. The inspection plan shall be reviewed and approved by the technical chief of the inspection institute. For some special conditions, the inspection institute shall solicit the opinion of the user on inspection plan.

The inspector shall strictly carry out the inspection in accordance with the approved inspection plan.

8.2.2 Document review

In general, the inspector shall review the following documents before the inspection:

(1) Design documents include qualification certificates for the design unit, specifications for design, installation and operation, design drawing, strength calculation sheet, etc;

(2) Fabrication (including field welding) documents include qualification certificates for manufacturers, product conformity certificate, quality certificate documents, as-built drawing and so on, as well as the supervisory inspection certificate, supervisory inspection report on safety performance of import pressure vessel;

(3)Completion data for installation of pressure vessels;

(4)Alteration or significant repairs documents include scheme and completion data, as well as supervisory inspection certificates of alteration and significant repairs;

(5)Service management documents include Service Registration Certificate, Registration Table, as well as operating records, operational shutdown and start-up records, records for the changes of operation conditions and abnormal circumstances occurred during the operation, etc;

(6)Inspection and examination documents include annual examination reports within the current periodic inspection and the last periodic inspection report;

The document concerned in Item (1) to (4) of this Article must be reviewed for the first periodic inspection since the initial service. The review for the subsequent periodic inspections is required if necessary (such as the re-installation, alteration and significant repairs).

During the document review, if it is found that the user didn't carry out annual examination, or the user/its name is changed without registration as required resulting in a difference from the content of the Service Registration Form, the inspection institute shall report the corresponding situation to the service registration authority.

During the document review, if it is found that the manufacture supervisory inspection for the pressure vessels (safety performance supervisory inspection for imported pressure vessels) was not performed, or the pressure vessel has no Service Registration Certificate, the inspection institute shall suspend the inspection immediately and report to the service register authority.

8.2.3 Field condition

8.2.3.1 General requirements

The user, as well as involved support unit, shall make necessary technical preparation after the pressure vessel is shut down and conduct safety check to confirm the field condition is adequate for the inspection. Prior to the inspection the field condition shall meet the following at least:

(1) Accessories or others hindering the inspection shall be disassembled or removed in accordance with applicable inspection requirements;

(2) Facilities, such as scaffoldings (protective fence shall be set if the height of scaffoldings is over 2m above ground), portable ladders, etc. for inspection shall be safe and firm;

(3) Surfaces subjected to the inspection shall be thoroughly cleaned to uncover the base metal, especially on the place that corrosion and crack tend to develop; The surface subjected to nondestructive examination shall meet the applicable requirements of NB/T 47013;

(4) When an internal inspection is adopted, the containing medium shall be discharged and the internal surface of the vessel shall be cleaned up. Blind plates are required to cut off all the sources of fluids, gases and steams, and a significant sign for isolation is necessary; Shutting-down of the valves as a substitute of isolation with blind plates is absolutely forbidden;

(5) When an internal inspection is adopted for a pressure vessel containing flammable, explosive, combustible, toxic or suffocating mediums, the inside of the vessel shall be properly treated, such as replacement, neutralization, disinfection, washing and sampling analysis. The analysis results shall satisfy the applicable provisions of regulations and standards. Frequency of sampling analysis shall meet the applicable requirements of the user. Pressure vessels containing flammable, explosive and combustible mediums are strictly prohibited to use air as replaced medium.

(6) Once manholes and inspection holes are opened, all the remaining medium shall be cleaned up if they are flammable, explosive, toxic and harmful gases or fluids. The oxygen content of the gas inside the pressure vessel shall be kept above 0.195. The ventilation equipments and safety rescue equipments shall be provided if necessary.

(7) For pressure vessels operating at elevated temperature or low temperature, the pressure vessels shall be slowly attempered to proper range for inspection;

(8) Rotatory or movable components inside the pressure vessels shall be switched off and fixed firmly;

(9) Electric source connected to pressure vessels shall be switched off and a significant safety sign shall be set. The lighting voltage shall be not more than 24V, and the cables entering into the pressure vessels must have good insulation and reliable groundings.

(10) When radiographic inspection is performed, the isolation for irradiation areas and warning marks are required in accordance with applicable safety regulations.

8.2.3.2 Specific requirements for field conditions of nonmetallic and nonmetallic lining pressure vessels

(1) Soft-soled shoes are required while inspectors entering into the vessel, and their

clothes shall be free of metal or other hard objects;

(2) Before inspector and instruments entering into the vessel, the internal surface of the vessel shall be effectively protected by soft materials, and no instrument is allowed to be placed on the surface of the pressure vessels directly;

(3)Hot work inside the pressure vessel and strongly hitting (hammering) the nonmetallic parts are strictly forbidden.

(4) The internal surface of the pressure vessel shall be dry, clean and without any deposit.

8.2.4 Insulation removal

Part or all insulation shall be removed from the pressure vessels if one of the following conditions occurs:

(1) There are damages or failure of the insulation.

(2) It is suspected that there might be corrosion or cracking on the pressure vessel shell under insulation;

(3) If the internal inspection is impracticable, an external inspection or the inner testing from the outside of the pressure vessel is needed.

(4) Those are required by the inspector.

8.2.5 Verification and calibration for equipments

Equipments, instruments, measuring tools for inspection shall be used within their valid period of verification or calibration.

8.2.6 Safety requirements for inspection

(1) The periodical safety training to inspectors are required and the training records shall be kept by inspection institute.

(2) The inspection shall be not allowed till that the field conditions have been confirmed to be adequate by the inspector. Some special activities, such as hot work, power utilization, working at height, confined space operation, safety protection, safety supervision, shall be executed in accordance with applicable requirements of the user.

(3) During the inspection, pressure vessel safety manager, operating and maintenance personnel are required to assist the inspection work on site, provide required documents timely, as well as to be responsible for safety supervision and reliable communication.

8.3 Periodic inspection content and method for metal pressure vessels

8.3.1 Inspection content

The inspection content of metal pressure vessels mainly includes visual examination, thickness measurement, surface defect detection and safety accessory inspection. If necessary, additional inspection is required, such as hidden defect detection, material analysis, seal fasteners inspection, strength verification, proof pressure test, leakage test, etc.

In addition, the specific requirements for the inspection content, method and requirements in design document shall be met.

8.3.2 Macro inspection

Macro inspection mainly depends on the visual method (endoscope, magnifying lens, or other auxiliary equipment, measuring tool shall be employed if necessary) to inspect the principal structure, dimension, surface imperfections (such as cracking, corrosion, leakage, deformation) of the pressure vessel, as well as welds, insulation, lining, etc. Except special requirements described in Article 8.3.3 and Article 8.3.4(Note 8-3), general requirements for macro inspection are as following:

(1) Structure inspection covers head type, the connection between head and shell, location and reinforcement of opening, layout and type of the longitudinal (circumferential) weld, layout and type of bracket or support, drainage (water drainage, contamination drainage) devices, etc;

(2) Dimensions inspection includes the out-of-roundness (difference between the maximum and minimum diameters on the same cross-section of the shell), the alignment offset, abrupt rigid-or-valley, undercut, reinforcement, etc. of longitudinal (circumferential) weld;

(3) Appearance inspection covers nameplate and marking, the corrosion of internal and external surface of the pressure vessel, main pressure components and their cracking, leakage, blistering, deformation, damage from mechanical contact, overheating, welding points of fixture tools, damage from arc burn, and the setting, tilting and spalling of the bracket, support or foundation, bracing gradient of the vertical vessel or the spherical tanks, the expansion hole of the support on the multi-supporting horizontal vessel, the blockage, corrosion, deposites of the drainage (water drainage, contamination drainage) devices or the hole for leakage indicating, the integrity of the seal fasteners and foundation bolt, etc;

The structure examination, the dimension measurement and other inspection are required for the first comprehensive inspection, and are required for the subsequent

periodic inspection to pressure vessels with fatigue loads only. The emphasis for the subsequent periodic inspection focuses on the area where new defects develop.

Not 8-3: the inspection and examination for pressure vessels in this Regulation is generally the macro inspection if no specific explanation is made.

8.3.3 Inspection of insulation, lining and overlaying

The inspection of insulation, lining and overlaying generally includes the following:

(1) The insulation shall be checked for damage, missing and damp and if the shell under the insulation has tendency for corrosion or cracks, the insulation shall be removed for further inspection;

(2) The lining shall be checked for damage, corrosion, cracking or missing, and the telltale hole shall be checked for leakage trace. If through-wall defects of lining or defects likely causing corrosion to the base material are found, partial or the whole lining shall be removed for inspection of the corrosion situation and other defects;

(3) Overlaying shall be checked for corrosion, cracking, stripping and missing.

8.3.4 Inspection of vacuum insulated pressure vessels

Besides external macro inspection, the followings are required for vacuum insulated pressure vessels:

(1) If the interlayer is equipped with a vacuum test device, the interlayer's vacuum degree shall be measured;

(2) If the interlayer is not equipped with a vacuum test device, the daily evaporation rate of the pressure vessel shall be measured if necessary.

8.3.5 Thickness measurement

Ultrasonic technique is used usually for thickness measurement. The measuring location shall be representative, and the inspection amount shall be adequate. If any abnormal value is read, a detailed plotting and recording are required.

Generally the following locations are recommended for thickness measurement:

(1) Area where the liquid level fluctuates;

(2) Area vulnerable to corrosion and erosion, such as medium inlet, streamwise direction turning, sudden change of cross-section, etc;

(3) Area where thickness is reduced during the manufacturing, and where deformation or abrasion is likely to occur;

(4) Nozzle conjunction joints;

(5) Suspected locations found during the macro inspection;

If lamination is found in the material during the thickness measuring, the measuring amounts shall be increased or the ultrasonic testing shall be employed to determine the distribution of lamination and the angularity between the lamination and the surface of base metal. A plotting and recording is required.

8.3.6 NDT for surface defects

Surface shall be tested by MT and/or PT referring to NB/T 47013. The MT is preferred if the pressure vessels are made of ferromagnetic materials.

Following are required for surface defects detecting:

(1) The detected length shall be not less than 20% of the length of butt-welded joints for low-temperature pressure vessel made of carbon steel and low alloy steel, pressure vessels with tendency of environment-assisted cracking and mechanic damage, pressure vessels with tendency of reheating cracking, pressure vessels made of Cr-Mo steel, pressure vessels made of low alloy steel with the specific tensile strength lower limit greater than 540MPa, pressure vessels designed by the fatigue analysis method, pressure vessels of Category III with design pressure equal to or greater than 1.6MPa during the first periodic inspection;

(2) The inspection shall be focused on locations with stress concentration, deformation area, locations with cracking found during the macro inspection, overlaying made of austenite steel, welded joints of different steels, T-joint, fillet joint for nozzles, other suspected welded joints, welding repair area, welded points of fixture tools, arc generating area and the locations most likely to crack. For materials sensitive to welded cracks, more attention shall be paid to the inspection of potential delayed cracking;

(3) If cracks are found during the inspection, the percentage of NDT shall be increased to detect more potential defects;

(4) If the pressure vessel is incapable of internal inspection, the inner surface can be detected from the outside.

8.3.7 Hidden defects detecting

Hidden defects shall be detected by RT, UT or other testing method set forth in NB/T 47013.

The method and proportion of the non-destructive examination shall be determined by the inspectors based on the given circumstance if any of the following is met, and acoustic emission testing in NB/T 47013 can be used to analyze the activity of the defects if necessary:,

(1) Welding repaired components in service;

(2) Locations where the weld cracks on the surface are found and detection for hidden defects is deemed necessary;

(3) Welds joints with excessive alignment offset and/or abrupt ridge-or-valley according to the applicable requirements of products standard;

(4) The leaking place on the welded joints in service and its extendings;

(5) Welded joints bearing the alternate loading, and other locations with concentrated stress;

(6) Locations required by the user or inspectors.

Re-detecting for hidden defects is not necessary if hidden defects detecting has been completed ever before and no abnormal situation has been found in service.

8.3.8 Materials Analysis

Chemical analysis, spectral analysis, hardness measurement, metallographic analysis can be employed for Material analysis depending on the conditions.

Materials analysis shall meet the following requirements:

(1) If the material is unknown, in general, the material category of main pressure part shall be identified. For category III pressure vessels and pressure vessels with specific requirements (note 8-4), the material must be identified definitely;

(2) Hardness measurements are required if the pressure vessels have a tendency of material deterioration. Metallographic analysis can be applied if necessary.

(3) Hardness measurements are necessary if the welds hardness of the pressure vessel is required.

Re-inspection is not necessary if the inspection described in item (1) has been completed and proper disposition has been finished.

Note 8-4: The pressure vessels with specific requirements mainly refer to the following: pressure vessels with fatigue loads, pressure vessels designed with analysis method, pressure vessels containing extremely or highly toxic levels mediums, as well as explosive mediums, pressure vessels made of low alloy steel with specific tensile strength lower limit greater than 540MPa;

8.3.9 Pressure vessels incapable of internal inspection

For pressure vessels incapable of internal inspection, reliable examination methods (such as endoscope, acoustic emission, ultrasonic testing, etc) are required to detect from the outside (Note 8-5).

Note 8-5: For instance, the shell of ultra-high pressure crystal autoclaves can be inspected by

detecting from the outside and its blocking bolts on the bottom can be inspected by detecting from the outside without opening generally.

8.3.10 Bolt inspection

Bolts with size equal to or greater than M36 shall be inspected for damage and cracking separately after cleaning. The inspection shall focus on whether circumferential cracks exist on the threads and the transition area, and the NDT is required if necessary.

8.3.11 Strength Verification

Strength verification is required for pressure vessels with corrosion depth exceeding the corrosion allowance, whose nominal thickness is unknown, whose structure is unreasonable with severe defects found, or whose strength is suspected by the inspector. The strength verification shall be carried out by the inspection institute or a capable design unit of pressure vessels.

The principals of strength verification are as follows:

(1) If the strength design standard is known in the original design, the same standard can be adopted;

(2) If the strength design standard is unknown or no stress calculation is found in the original design, the applicable standards at that time can be adopted for the strength verification according to usage (such as petroleum, chemical industry, metallurgy, light industry, refrigeration, etc) or structural type (such as spherical tanks, waste heat boilers, glass lining equipment, heat exchanger, high-pressure vessel, etc);

(3) The standard for strength verification shall be in accordance with the original design standard for imported pressure vessels or those designed by foreign standard. If the design standard is unknown, similar Chinese standards can be referred;

(4) For pressure vessels whose material is unknown and with no special requirements, the minimum strength value of the same category material shall be taken for the strength verification;

(5) Welded joint coefficient shall be determined in accordance with the actual structural type and inspection results as well as specifications of original design;

(6) The wall thickness for strength verification is determined by the minimum of actually-measured value of the wall thickness minus the estimated corrosion loss before the date of the next inspection;

(7) Pressure used for strength verification shall be equal to or greater than the allowable (controlled) operating pressure;

(8) Metal temperature used for strength verification shall be the design temperature or operation temperature. Ambient temperature shall be taken for pressure vessels operating at low temperature;

(9) Shell diameter shall be the maximum of the actually-measured value;

(10) Wind loads, seismic loads as well as other additional loads shall be considered if strength verification is conducted for towers, spherical tanks and similar equipments;

If regular methods are not applicable to strength verification, stress analysis or experimental stress testing can be adopted.

8.3.12 Inspection of Safety Accessories

Inspection of safety accessories mainly includes the following:

(1) Whether the calibration of safety valves is valid;

(2) Whether the rupture disks are replaced as scheduled;

(3)Whether the safety interlocks of quick opening pressure vessels meet the technical requirements for service by the design documentation.

8.3.13 Proof pressure test

During the periodic inspection, a proof pressure test is required if the user or the inspection institute suspect the safety conditions of the pressure vessels. Test parameters for proof pressure test [test pressure, test temperature as well as other test parameters shall be calculated with the allowable service parameters determined by this periodic inspection], preparation, safety protection, test medium, test process, criterions shall meet the applicable requirements of this Regulation.

The proof pressure test shall be arranged by the user and inspected by the inspection institutes.

8.3.14 Leak testing

A leak testing is required if the mediums contained are extremely or highly hazardous, or if any slight leakage is not allowed by the design. Leak testing includes air tightness test and leak test with ammonia, halogen or helium. Test methods shall be selected in accordance with the applicable requirements of the design drawing.

The leak testing shall be arranged by the user and inspected by the inspection institutes.

The leak testing shall meet the following requirements:

(1) Test pressure of air tightness test shall be the allowable (controlled) operating pressure determined by this periodic inspection. Preparation, safety protection, test

temperature, test medium, test process, criterion of the test shall meet the applicable requirements of this Regulation; if a pneumatic test is required, air tightness test can be arranged simultaneously; for pressure vessels used in enormous process plant, the air tightness test can be substituted by the systematic leak test.

(2) Leak test with ammonia, halogen or helium shall be in accordance with the design drawing or applicable requirements.

8.4 Content and method of periodic inspection for nonmetallic pressure vessels or pressure vessels with nonmetallic lining

8.4.1 Inspection content

The inspection content of nonmetallic and nonmetallic lining pressure vessels mainly includes visual examination, the safety accessories and instruments inspection. If necessary seal fasteners inspection, proof pressure test are also required; the periodic inspection of metallic pressure components in the nonmetallic pressure vessels shall be in accordance with the applicable requirements of metal pressure vessels in this Regulation. Special specifications listed in the design documentation shall be satisfied for inspection contents, inspection methods and inspection requirements.

8.4.2 Inspection of glass-lining pressure vessels

8.4.2.1 Inspection of nameplates and marks

Inspect whether the nameplate and mark is clear and firmly attached.

8.4.2.2 Inspection of glass-lining

The following content shall be inspected:

(1) Whether there is corrosion trace, whether there are abrasion and damage from mechanical contact, whether the glass lining is exploded and drops off, whether the glass lining near the flange periphery drops off.

(2) A direct current high voltage test shall be applied to glass lining according to GB/T 7991.6 *Test method of vitreous and porcelain enamels-Part 6: High voltage test*, and the test voltage shall be 10Kv; if a proof pressure test is required, the direct current high voltage test shall be conducted after the pressure test is complete;

(3) The thickness of glass lining shall be measured according to GB/T 7991.5 *Test method of vitreous and porcelain enamels-Part 5: Determination of thickness by electromagnetic method*.

8.4.2.3 Inspection of accessories, instruments and components

The following content shall be inspected:

(1) Whether there is corrosion trace in clips or lap joint flanges;

(2) Whether the sealing surfaces have leakage, whether the Teflon layers of the sealing gaskets are intact, whether the structure layers are intact and have good flexibility;

(3) Whether any leakage occurs when the dump valve is closed, whether the anticorrosive coating of the orifice plate is intact.

8.4.2.4 Inspection of medium inlet impingement plate of the jackets

Inspect whether the medium inlet impingement plate of the jackets and the locations nearby are intact, and their functions meet the applicable requirements.

8.4.2.5 Inspection of repaired locations of glass lining

Inspect whether there are corrosion, cracking and disbonding in the repaired locations of the glass lining.

8.4.3 Inspection of graphite and graphite lining pressure vessels

8.4.3.1 Graphite pressure

8.4.3.1.1 Inspection of nameplates and marks

Inspect whether the nameplates and the marks are clear and solid.

8.4.3.1.2 Macro inspection

The following shall be inspected:

(1) Whether there are deformations or corrosions in shells, side cover plates, upper cover plates and lower cover plates of the pressure vessels;

(2) Any defect such as corrosion, friability, abrasion, delamination, chipping, or cracking occurs in the surface of the graphite components;

(3) Whether the stick parts between graphite components are intact and there is corrosion, cracking or leakage.

8.4.3.1.3 Inspection of the seal surface of the flanges

Inspect whether there is leakage in the surface of the flanges and the seal gaskets are intact.

8.4.3.1.4 Inspection of the anticorrosive coatings of accessories and instruments

The integrity of the anticorrosive coating of accessories and instruments shall be verified.

8.4.3.2 Graphite lining pressure vessels

Besides the surface inspection of lining described in Article 8.4.3.1.2 of this Regulation, it is also required to inspect whether the graphite linings have blistering or fall off the base mental.

8.4.4 Inspection of fiber reinforced plastic and fiber reinforced plastic lining pressure vessels

8.4.4.1 Fiber reinforced plastic pressure vessels

8.4.4.1.1 Inspection of name plates and marks

Inspect whether the nameplates or the marks are clear, solid and reliable.

8.4.4.1.2 Macro inspection of external surface

Inspect whether there are chalkiness due to corrosion, cracking, abrasion, damage from mechanical contact, blistering, deformation, exposed fibers or other defects in external surface of the fiber reinforced plastic pressure vessels.

8.4.4.1.3 Macro inspection of internal surface

The following shall be inspected:

(1) Whether the surface is smooth, whether there are impurities, exposed fibers, cracking, whether there are obvious scratches;

(2) Whether there are chemical corrosion defects, such as chalkiness, color change, crazing, resin pulverization, strength-loosing of fiber, etc;

(3) Whether there are defects from mechanical damaging, such as breakage, cracking, crazing, etc;

(4) Whether there are infiltration and corrosion defects, such as swelling, delamination, bubbling, etc;

(5) Whether the resin of the angle joint, overlap joint as well as the internal adhesive seam between the shell and the head are filled, whether there are delaminating, peeling in the resin mentioned above, whether the bonding seam are exposed, whether there are corner cracking, peeling, delamination, damage as well as other defects in adhesive foundation flanges;

(6) Whether there are damage, peeling, delamination, edge delamination as well as other defects in manholes, inspection holes, pipe flanges as well as its internal reinforcement structural regions;

(7) Whether the main body of pressure vessel, internal support frames and the connections between the internal components are solid, whether there are cracking, damage as well as other defects in the stress area of the connections.

8.4.4.1.4 Inspection of connection locations

Inspect whether the phenomenon like cracking and disconnection happens in connection locations such as nozzles, supporters, etc.

8.4.4.1.5 Inspection of anticorrosive coatings of accessories and instruments

The integrity of anticorrosive coatings of accessories and instruments shall be verified.

8.4.4.2 Inspection of fiber reinforced plastic lining pressure vessels

Besides the visual examination on the surface of the coatings described in Article 8.4.4.1.3 of this Regulation, the following shall be also required to be inspected:

(1) Whether there are blistering in lining, whether the lining are separated from the base metal, etc;

(2) The nonmetal layer thickness gauge shall be employed to measure the thickness of the fiber reinforced coating, and a direct current high voltage test of 5 kV is also required.

8.4.5 Inspection of thermoplastic plastic lining

(1) Inspect whether there are defects in the lining, such as corrosion chalkiness, season cracking, abrasion, damage from mechanical contact, blistering, separation from the base materials, etc;

(2) Thickness measurement and direct current high voltage test with 5kV shall be applied to plastic linings. If a proof pressure test is required, the direct current high voltage test shall be conducted after the proof pressure test is completed.

8.4.6 Proof pressure test

A proof pressure test shall be performed for nonmetallic or nonmetallic lining pressure vessels during the periodic inspection if any of the following conditions is satisfied:

(1) The user or the inspection institute suspects the safety condition of the pressure vessels;

(2) Main pressure components or linings have been replaced;

(3) A local repair has been made to nonmetallic parts.

8.5 Rating of the safety situation of metal pressure vessels

8.5.1 Assessment principal

(1) The safety situation of a pressure vessel shall be rated as a result of a comprehensive evaluation based on the inspection results, and the lowest rating of all the items rated shall be the rating of the safety situation of a pressure vessel;

(2) When a pressure vessel needs alteration or repairs, the rating of its safety situation shall be rated based on the results of the alteration or repairs;

(3) Pressure vessels with safety accessories which failed to pass the inspection are not allowed to be put in service

8.5.2 Material issues

If the materials of main pressure components are not consistent with the original design, or the materials are unknown, or the materials have been deteriorated, the class of safety condition shall be rated in accordance with the following requirements:

(1) Used Materials inconsistent with the original design

If the material is known, the strength verification is qualified, no new-growth defects (except the normal uniform corrosion) are found after the inspection, and the inspector believe it is safe to operate, the rating will not be affected; if defects occur during operation, and it is confirmed that these defects are caused by the improper use of the materials, the safety situation can be rated as Class 4 or Class 5.

(2) Materials being unknown

For pressure vessels operating at ambient temperature, if no new-growth defects (except the normal uniform corrosion) are found by the inspection, and the strength verification (taking the minimum strength of the same category material) is qualified, the safety situation can be rated as Class 4 or Class 5; for liquefied petroleum gas storage tank, the safety situation shall be rated as Class 5;

(3) If material deterioration phenomenon such as surface decarburization, carburization, graphitization, temper brittleness and the phenomenon of creep deformation and high temperature hydrogen corrosion are found, and irreparable defect or damage has been developed, the safety situation can be rated as Class 4 or 5 based on the severity of the damage; if the damage is slight and a safe operation can be ensured under specified operation conditions and over the planned inspection internal, the safety situation can be rated as Class 3.

8.5.3 Structure problems

The safety situation shall be rated in accordance with the following requirements if the pressure vessel has inappropriate structures:

(1)The primary parameters of heads inconsistent with applicable product standards

If no new-growth defects (except the normal uniform corrosion) are found by the inspection, the safety situation can be rated as Class 2 or Class 3; if new-growth defects are found, the safety situation shall be rated in accordance with applicable articles;

(2) The connection between head and shell

If a butt joint structure with one side welding is adopted and the incomplete penetrations exist, the safety situation shall be rated according to the applicable specifications of Article 8.5.10 in this Regulation; if the overlapping structure is adopted, it can be rated as Class 4 or Class 5; if butt joints with un-uniformed thicknesses (forge pieces) are adopted, skiving process (or overlaid cladding)is not performed as specified, and no new-growth defects are found by the inspection (except the normal uniform corrosion), the safety situation can be rated as Class 3, otherwise rated as Class 4 or Class 5.

(3) When the layout of the welding seams is inappropriate, cross welding seams are found or the welding seam spacing doesn't satisfy the applicable requirements of product standards, the safety situation can be rated as Class 3 if no new-growth defects are found after the inspection (except the normal uniform corrosion), or rated as Class 4 or Class 5 if new-growth defects are found and it is confirmed that it is caused by the inappropriate layout of welding seams,;

(4) When corner welds or pipe angle seams should have adopted the full penetration structure according to applicable regulations, the safety situation can be rated as Class 3 if no new-growth defects(except the normal uniform corrosion) are found by the inspection, otherwise rated as Class 4 or Class 5;

(5) If the location of the opening is inappropriate and no new-growth defects (except normal uniform corrosion) is found by the inspection, the safety situation can be rated as Class 2 or Class 3 for general pressure vessels, or rated as Class 3 or Class4 for pressure vessels with special requirements. When the geometrical parameters of the opening don't satisfy the requirements of product standards, the rating of safety situation will not be affected if the calculation and reinforcement have been made with special consideration, or the safety situation can be rated as Class 4 or Class 5 with no special consideration.

8.5.4 Surface cracking and concave pit

No cracks are allowed in internal and external surface. If a cracking is found, a grinding shall be made to eliminate the cracking. If the pit formed by grinding is in the permissible range, the rating will not be affected; otherwise a repair welding or stress analysis shall be performed. If the repair welding is qualified or the stress analysis indicates that the pit will not affect the safe service, the safety situation can be rated as Class 2 or Class 3;

If the depth of the pit formed by grinding is lower than wall thickness allowance

(wall thickness allowance = actually-measured wall thickness - nominal thickness + corrosion allowance), then the pit is allowed to exist; otherwise, the pit shall be standardized into a semi ellipsoid with a long axis of length 2A (mm), a short axis of length 2B (mm) and a depth of C (mm) according to its circumscribed rectangular, then the non-dimensional G_o shall be calculated, if $G_o < 0.10$, the pit is in the permissible range.

The pit that will be subject to the non-dimensional parameter calculation shall satisfy all the conditions as following:

(1) The surface of the pit shall be smooth and transits smoothly, the half-width of the pit B shall be no less than three times of the depth of the pit C, and there are no other surface defects or hidden defects in the region nearby;

(2) The pit shall not be closed to the discontinuities or the zones with sharp corners;

(3) Vessels do not bear external pressure or fatigue loads;

(4) Thin wall cylinder with T/R lower than 0.18 or thin wall spherical shell with T/R lower than 0.10;

(5) Materials used meet the applicable specifications of the design code of pressure vessels, and no material deterioration is found;

(6) Pit depth C is less than 1/3 of wall thickness T and less than 12 mm. Minimum thickness under the pit (T-C) shall be no less than 3 mm;

(7) Half length of the pit $A \leqslant 1.4\sqrt{RT}$;

The no-dimensional parameter of the pit's defects shall be calculated according to formula (8-1).

$$G_0 = \frac{C}{T} \times \frac{A}{\sqrt{RT}} \tag{8-1}$$

In the formula:

T——the thickness of the pressure vessel where the pit is located (the actually-measured wall thickness minus the estimated corrosion loss before the date of the next inspection next), mm;

R——the average radius of the pressure vessel, mm.

8.5.5 Deformation, damage from mechanical contact, welding zoon of fixture tools and damage from arc burn

For deformation, damage from mechanical contact, welding zoon of fixture tools,

damage from arc burn as well as others, the safety situation shall be rated in accordance with the following requirements:

(1) If the safety use will not be affected without handling the deformation, the rating will not be affected; if the requirements for strength and safety cannot be satisfied based on the analysis of the causes of deformation, the safety situation can be rated as Class 4 or Class 5;

(2) For damage from mechanical contact, welding zoon of fixture tools, damage from arc burn and other defects, the safety situation shall be rated after the grinding is complete according to the applicable specifications of Article 8.5.4 of this Regulation.

8.5.6 Undercut of welds

If the depth of undercuts of welds in the internal surface is not greater than 0.5 mm, the continuous length of the undercut is not greater than 100 mm, and the total length of undercuts at both sides of the welds is not greater than 10% of the welds' length, and if the depth of undercuts of welds in external surface is not greater than 1.0 mm, the continuous length of the undercut is not greater than 100 mm, and the total length of the undercuts at both sides of the welding seam is not greater than 15% of the welds' length, the safety situation shall be rated according to the following requirements:

(1) For general pressure vessels, its rating will not be affected by undercuts, but the undercuts shall be repaired if the geometric dimensioning of the undercuts are beyond the allowed range;

(2) For pressure vessels with special requirements, the safety situation can be rated as Class 2 or Class 3 if no new-growth defects (such as cracking in weld foots) are found by the inspection, or the undercuts shall be repaired if new-growth defects are found or the geometric dimensioning of the undercuts are beyond the allowed range of this Article;

Undercuts are not allowed for pressure vessels with low temperature.

8.5.7 Corrosion

For pressure vessels with corrosion, the safety situation shall be rated in accordance with the following requirements:

(1) Scattered pits. The rating will not be affected if the corrosion depth is not greater than 1/3 of the value after deducting the corrosion allowance from the nominal thickness; the rating will not be affected if the total area of the pitting does is not greater than 4500 mm^2 within any 200-mm diameter circle, or the total length of the pitting along any straight lines is not greater than 50 mm;

(2) Uniform corrosion. The rating will not be affected if the strength verification is qualified based on the residual wall thickness (the minimum of actually-measured value of the wall thickness minus the estimated corrosion loss before the date of the next inspection); if the repair welding is qualified, the safety situation can be rated as Class 2 or Class 3;

(3) Local corrosion. If the corrosion depth exceeds the residual wall thickness, the shape and the dimension of the corrosion pit shall be confirmed and a full consideration shall been given to the dimensional change of the corrosion pit over the inspection interval, the safety situation can be rated according to the applicable specifications of Article 8.5.4 of this Regulation.

(4) For pressure vessels with lining or made of composite plates, if the corrosion depth is not greater than 1/2 of the thickness of lining or 1/2 of the thickness of clad material, the rating will not be affected; otherwise, the safety situation shall be rated as Class 3 or Class 4.

8.5.8 Environment-assisted cracking and mechanical damage

For pressure vessels with tendency of environment-assisted cracking or mechanical damage, if cracks are found, a grinding shall be applied to eliminate the cracks as well as a treatment according to applicable specifications of Article 8.5.4 in this Regulation shall be given. The safety situation shall be rated as Class 3 if the requirements of safe service can be satisfied under specified operation conditions and over planned inspection interval; otherwise, the safety situation shall be rated as Class 4 or Class 5.

8.5.9 Misalignment and angularity of weld

If the misalignment or the angularity of weld exceeds the applicable specifications of product standard, a compressive assessment shall be applied to the rating of safety situation based on the specific conditions as following:

(1) If the misalignment and the angularity of weld are in the allowed range of table 8-1, the pressure vessels do not bear fatigue loads, and no cracks, infusion, un-penetration as well as other defects are found in those areas, the safety situation can be rated as Class 2 or Class 3;

Table 8-1 Allowed range of Misalignment and Angularity of Weld Unit：mm

Actually-measured thickness of steel at joints	Misalignment	Angularity(note 8-6)

$t \leq 20$	≤1/3t, and ≤	≤ (1/10t + 3), and ≤ 8
$20 < t \leq 50$	≤1/4t, and ≤8	
$t > 50$	≤1/6t, and ≤20	
For forged welded vessels of different thickness		≤1/6t, and ≤8

Note 8-6: Sample plate to measure the degree of angularity shall be selected in accordance with applicable product standards.

(2) If the misalignment and the angularity are out of the allowed range of table 8-1, or pressure vessels are within the scope of table 8-1 bearing fatigue loads or having infusion, un-penetration as well as other defects in those areas, a strength analysis shall be applied to confirm whether the pressure vessels can continually operate; if the pressure vessel can be operated safely under specified operation conditions and over planned inspection interval, the safety situation can be rated as Class 3 or Class 4.

8.5.10 Hidden defects of welds

The rating of safety situation will not be affected if the hidden defects are in the allowed range of applicable product standards of pressure vessels; if hidden defects exceed the allowed range, the safety situation shall be rated in accordance with the following requirements:

(1) If the length of the major axis of a single circular defect is greater than 1/2 of the wall thickness or greater than 9 mm, the safety situation shall be rated as Class 4 or Class 5; if the length of the major axis of a single circular defect is less than 1/2 of the wall thickness and less than 9 mm, its accordingly rating of safety situation shall refer to Table 8-2 and Table 8-3.

Table 8-2 Pressure vessels with requirement of local NDE (low temperature pressure vessels are excluded)

Circular defects and its corresponding rated-class of safety situation (note 8-7)

Class of Safety Situation	The number of defect points under different dimensions of evaluation area and actually-measured thickness		
	Evaluation Area (mm)		
	10×10	10×20	10×30
	Actually-measured Thickness t (mm)		

	$t \leq 10$	$10 < t \leq 15$	$15 < t \leq 25$	$25 < t \leq 50$	$50 < t \leq 100$	$t > 100$
Class 2 or Class 3	6 ~ 15	12 ~ 21	18 ~ 27	24 ~ 33	30 ~ 39	36 ~ 45
Class 4 or Class 5	> 15	> 21	> 27	> 33	> 39	> 45

Table 8-23 Pressure vessels with requirement of 100% NDE (including low temperature pressure vessels)

Circular defects and its corresponding rated-class of safety situation (note 8-7)

Rating of Safety Situation	Number of defect points under different dimensions of evaluation area and different actual thickness					
	Evaluation Area (mm)					
	10×10			10×20		10×30
	Actually-measured Thickness t (mm)					
	$t \leq 10$	$10 < t \leq 15$	$15 < t \leq 25$	$25 < t \leq 50$	$50 < t \leq 100$	$t > 100$
Class 2 or Class 3	3 ~ 12	6 ~ 15	9 ~ 18	12 ~ 21	15 ~ 24	18 ~ 27
Class 4 or Class 5	> 12	> 15	> 18	> 21	> 24	> 27

Note 8-7: For conversion from the dimension of a circular defect to the number of defect points as well as the requirements on dimension of the defect which has no number limitation, see applicable provisions of NB/T 47013.

(2) For non-circular defects and its corresponding rated class of safety situation, see Table 8-4 and Table 8-5.

Table 8-4 No-circular Defects and its corresponding rated-class of safety situation of general pressure Vessels (note 8-8)

Location of defect	Dimension of defect (mm)			Class of safety situation
	Infusion	Un-penetration	Slag inclusion of strip shape	
Spherical shell butt welds; Longitudinal welds in shell as well its circumferential welds connected to heads	H ⩽ 0.1t, and H⩽2; L⩽ 2t	H ⩽ 0.15t, and H⩽3mm, L ⩽3t *t*	H ⩽ 0.2t, and H⩽4; L⩽ 6t	Class 3
Circumferential welds in shell	H ⩽ 0.15t, and H⩽3; L⩽ 4t	H ⩽ 0.2t, and H⩽4, L⩽ 6t	H ⩽ 0.25t, and H ⩽ 5,L ⩽ 12t	

Table 8-5 No-circular Defects and its Corresponding class of Safety Situation of Pressure Vessels with Special Requirements (note 8-8)

Position of defect	Size of defect (mm)			Class of safety situation
	Infusion	Un-penetration	Slag inclusion of strip shape	
Spherical shell butt welds; Longitudinal welds in shell as well its circumferential welds connected to heads	H ⩽ 0.1t, and H⩽2; L⩽t	H ⩽ 0.15t, and H⩽3; L⩽ 2t	H ⩽ 0.2t, and H⩽4; L⩽3t	Class 3 or Class 4
Circumferential welds in shell	H ⩽ 0.15t, and H⩽3mm, L ⩽2t	H ⩽ 0.2t, and H⩽4mm, L ⩽4t	H ⩽ 0.25t, and H⩽5mm, L ⩽6t	

Notes: 8-8: H in Table 5 and Table 6 refers to the dimension of defect in the thickness direction, also known as height of defect; L refers to the length of defect; t refers to the actually-measured

thickness. The length and the height of the unacceptable non-circular defects shall be measured during the periodic inspection and shall be re-checked in next scheduled inspection.

(3) If effective methods can be employed to confirm that the defect is inactive, the allowable value of the length of the defect regulated in Table 5 and Table 6 can be extended by 50%.

8.5.11 Delamination of base material

If the base materials have delamination, the safety situation shall be rated in accordance with the following requirements:

(1) If the lamination is parallel to the free surface, the rating will not be affected;

(2) If the angle between the lamination and the free surface is lower than 10°, the safety situation can be rated as Class 2 or Class 3;

(3)If the angle between the lamination and the free surface is greater than or equal to 10°, the inspector can adopt other examination or analysis method to conduct a comprehensive judgment, if it is confirmed that the delamination will not affect the safe service of the pressure vessel, the safety situation can be rated as Class3, otherwise rated as Class 4 or Class 5.

8.5.12 Blistering

If the blisters are formed during the operation, the reason shall be determined and its steady-state condition shall be judged, if the cause of the blistering can be determined and it can be confirmed that the blisters will not propagate in the future and will not affect the safe service of the pressure vessels, the safety situation can be rated as Class 3; if the cause cannot be determined or the cause determined indicates that the bulisters will continually propagate in the future, the safety situation shall be rated as Class 4 or Class 5.

8.5.13 Thermal insulation performance

For stationary vacuum insulated pressure vessels, if the measurement results of vacuum degree and daily evaporation rate are in the allowed range of Table 8-6, the rating will not be affected; if the measuring results are beyond the allowed range of Table 8-6 but not more than double, the safety situation can be rated as Class 3 or Class 4; otherwise, rated as Class 4 or Class 5.

Table 8-6 Measurement of vacuum degree and daily evaporation rate

Insulation	Vacuum degree	Daily evaporation rate

approach	Measurement conditions	Value	
Power insulation	without medium	≤65	The actually-measured value of daily evaporation is lower than 2 times of the rated indications
	with medium	≤10	
Multilayer insulation	without medium	≤20	
	with medium	≤0.2	

8.5.14 Proof pressure test

If the disqualification of the proof pressure test is resulted from the pressure vessel itself, the safety situation can be rated as Class 5;

8.5.15 Specific requirements for the rating of ultra-high pressure vessels

The safety situation shall be rated as Class 5 if any of the following conditions is met:

(1) The materials of main pressure components are unknown;

(2) Cracks are found in internal or external surface of the main pressure components, if no repair-grinding is conducted or the strength verification is not qualified after the repair-grinding;

(3) Through-wall cracks are found in main pressure components;

(4) Material deterioration happens in main pressure components, and the safe operation cannot be ensured;

(5) Safe operation cannot be ensured due to other serious defects, such as serious deformation in local or overall shell, propagating hidden defects are existed, etc.

8.6 Rating of nonmetallic and nonmetallic-lining pressure vessels' safety situation

8.6.1 Assessment principal

(1) The safety situation of a pressure vessel shall be rated as a result of a comprehensive evaluation based on the situation of nonmetallic parts and metallic pressure components, and the lowest class of all the items rated shall be the class of the safety situation of this pressure vessel;

(2) If a pressure vessel needs alteration or repairs, the class of its safety situation shall be rated based on the results of the alteration or repairs;

(3) Pressure vessels with safety accessories failed to pass the inspection are not allowed to be put in service.

8.6.2 Glass lining pressure vessels

The class of the safety situation of glass-lining shall be rated in accordance with the following requirements:

(1) If the surface of the glass lining is bright as new and is without corrosion chalkiness, damage, abrasion or damage from mechanical contact, the safety situation shall be rated as Class 1;

(2) For glass linings whose surface have slight corrosion chalkiness, slight abrasion, or damage from mechanical contact, if it passes the test of direct current high voltage of 10 KV, the safety situation shall be rated as Class 2; if not, the safety situation shall be rated as Class 5;

(3) The safety situation shall be rated as Class 3 if the glass lining has been subject to local repairs, but the repaired locations of tantalum intensify tetrafluoroethylene will not affect the rating;

(4) For glass linings whose surface have obvious corrosion chalkiness, or significant corrosion, cracking, disbonding, abrasion, damage from mechanical contact, if it passes the test of direct current high voltage of 10 kV, the safety situation shall be rated as Class 4; if not, the safety situation shall be rated as Class 5;

(5) For detachable and replaceable glass-lining components, such as impeller, sleeve of thermometer dump valve, where corrosion, abrasion, or damage of glass-lining is found during the inspection, the rating will not be affected if these components are replaced by new ones.

8.6.3 Graphite pressure vessels and graphite linings

The safety situation of graphite components and graphite lining shall be rated in accordance with the following requirements:

(1) If the surface of graphite components are normalized, the bonding area are intact, and there are no corrosion, crisp, layer-stripping, chipping, cracking, abrasion, damage from mechanical contact or other defects, the safety situation shall be rated as Class 1; if the surface of graphite lining is smooth and is without corrosion, crisp, abrasion, damage from mechanical contact, cracking, or other defects, and there are no separation between the lining and the metal base materials, the safety situation shall be rated as Class 1;

(2) If the surface of graphite components have slight corrosion, the bonding areas are intact, there are no layer-stripping, chipping, cracking, but there are slight abrasion and damage from mechanical contact, the safety situation shall be rated as Class 2; if the

surface of the graphite lining has slight corrosion, slight abrasion, slight damage from mechanical contact, and there are no cracking or separation between the lining and the metal base materials, the safety situation shall be rated as Class 2;

(3) The safety situation shall be rated as Class 3 if the graphite pressure vessels have been subject to local repairs;

(4) If the surface of graphite pressure components have obvious corrosion, abrasion, or damage from mechanical contact but are without leakage, the safety situation shall be rated as Class 4; if the surface of graphite-lining have obvious corrosion, abrasion, cracking and damage from mechanical contact, the safety situation shall be rated as Class 4;

(5) If the surface of graphite pressure components has significant corrosion, chipping, cracking, abrasion as well as other defects, or there are cracking in the bonding area, or leakage are found in the graphite pressures, the safety situation shall be rated as Class 5; if the surface of graphite-lining has significant corrosion, abrasion, cracking, damage from mechanical contact as well as other defects, or the graphite-lining is damaged, the safety situation shall be rated as Class 5.

(6) For detachable and replaceable graphite lining components where corrosion, abrasion, damage is found during the inspection, if these components are replaced by new ones, the rating will not be affected.

8.6.4 Rating of fiber reinforced plastic pressure vessels and fiber reinforced plastic-lining

The safety situation of fiber reinforced plastic pressure vessels and fiber reinforced plastic-lining shall be rated in accordance with the following requirements:

(1) If the internal surface is bright as new and there are no corrosion chalkiness, crazing, color change, resin pulverization, fiber strengthen loosing, swelling, abrasion, damage from mechanical contact, cracking, exposed glass fibers and delamination, or the pressure vessels have no blistering and deformation, and its lining has no bugling and disbonding, the safety situation shall be rated as Class 1;

(2) If the internal surface has slight corrosion chalkiness, damage, color change, or has slight abrasion, damage from mechanical contact, and there are no cracking, crazing, resin pulverization, fiber strength loosing, swelling, exposed glass fibers and delamination, while the lining has no disbonding and the pressure vessels have slight blistering and deformation, the safety situation shall be rated as Class 2;

(3) The safety situation shall be rated as Class 3 if the fiber reinforced plastic

pressure vessels or the fiber reinforced plastic-lining pressure vessels have been subject to a local repair;

(4) If there are obvious corrosion or obvious abrasion, cracking and damage from mechanical contact occurred in the internal surface, and the pressure vessels have obvious blistering and deformation but are without leakage or significant deformation, the safety situation shall be rated as Class 4;

(5) If there are significant corrosion chalkiness, or cracking, crazing, resin pulverization, fiber strengthen loosing, swelling, abrasion, damage from mechanical contact as well as other defects occurred in internal surface, while the lining has been penetrated and leakage and significant deformation have been occurred, the safety situation shall be rated as Class 5;

(6) For detachable and replaceable fiber reinforced plastic components where corrosion, abrasion, damaging is found during the inspection, if these components are replaced by new ones, the rating will not be affected.

8.6.5 Thermoplastic plastic lining of pressure vessels

The safety situation of thermoplastic plastic lining of pressure vessels shall be rated in accordance with the following requirements:

(1) If the internal surface is bright as new and without any corrosion chalkiness, color change, season cracking, leakage, abrasion, damage from mechanical contact, cracking or blistering, the connection area has no cracking or pulling-off, the accessories are intact, and there is no separation between lining and base metal material, then the safety situation shall be rated as Class 1;

(2) If the internal surface has slight corrosion chalkiness, color change or abrasion, damage from mechanical contact, and is without of cracking, season cracking, leakage and blistering, the connection area has no cracking or pulling-off phenomenon, the accessories are intact, and there is no separation between lining and metal based materials, then the safety situation shall be rated as Class 2;

(3) The safety situation shall be rated as Class 3 if the plastic lining has been subject to local repairs;

(4) For internal surface with significant corrosion, abrasion, cracking, season cracking, damage from mechanical contact as well as other defects, if the plastic lining passes the test of direct current high voltage of 5 kV, the safety situation shall be rated as Class 4; if not, the safety situation shall be rated as Class 5.

8.6.6 Proof pressure test

If the disqualification of the proof pressure test is resulted from the pressure vessel itself, the safety situation can be rated as Class 5;

8.7 Conclusions and reports of periodic inspection

8.7.1 Inspection conclusions

8.7.1.1 Inspection conclusions of metal pressure vessels

For metal pressure vessels with composite rating of safety situation varied from Class 1 to Class 3, the inspection conclusion is conform to the requirements and can operate continually; for pressure vessels with Class 4 of safety situation rated, the inspection conclusion is basically conform to the requirements and can operate under specific control; for pressure vessels with Class 5 of safety situation rated, the inspection conclusion is nonconformity with the requirements and the continued use is forbidden.

8.7.1.1 Inspection conclusions of nonmetal pressure vessels

For nonmetal pressure vessels with composite rating of safety situation varied from Class 1 to Class 2, the inspection conclusion is conform to the requirements and can operate continually; for pressure vessels with Class 3 or Class 4 of safety situation rated, the inspection conclusion is basically conform to the requirements and can operate under specific control; for pressure vessels with Class 4 of safety situation rated, if its rating is a result of corrosion, the inspection conclusion is cannot continually operate under current medium; for pressure vessels with Class 5 of safety situation rated, the inspection conclusion is nonconformity with the requirements and cannot operate continually.

8.7.2 Inspection reports

The inspection institutes shall ensure the quality of the inspection, and inspection records are required during the inspection. The inspection institute shall issue reports after the inspection, the format of the reports shall be in accordance with the applicable requirements of attachment J in this Regulation (the format of single item inspection report shall be regulated by the inspection institute in its Quality Management System Documentation). The inspection records shall be in detail, true, and accurate, the amount of information recorded by the inspection records shall be no less than the amount of information recorded by inspection reports. The inspection records and the inspection reports shall be maintained appropriately by the inspection institute, the storage period shall be no less than 6 years and no less than the next inspection interval of the pressure vessel.

The issuance of the inspection reports shall be in accordance with the following requirements:

(1) Generally, the inspection institute shall issue the reports within 30 days after the completion of inspection and deliver them to the User to be stored in technical archives of pressure vessels;

(2) The conclusions and reports of periodic inspection of pressure vessels shall be signed by three level persons who respectively are drafter, auditor and approver, the approver shall be the technical director or the authorized signatory of the inspection institute;

(3) If required by the operation of equipment, the inspector can issue a *Notice for the Advice of the Periodic Inspection (1)* (see attachment K) to notify the User of the preliminary inspection conclusions in writing before issuing the formal inspection reports, the inspector shall be responsible for the accuracy of the inspection advice;

(4) If there are defects which need treatment been found in devices during the inspection, the User shall be responsible for the treatment of the defects, the inspection institute can notify the User of the property of the defects through the *Notice for the Advice of the Periodic Inspection (2)* (see attachment K), and the inspection reports shall be issued only after the defects have been treated and the results have been confirmed by the inspection institute; if the User cannot complete the treatment of defects within the appointed period, the inspection institute can issue the inspection report ahead of time based on the actual inspection condition, when the defects have been treated and the results have been confirmed by the inspection institute, then the inspection institute will issue an inspection report again (substitute the original one); if a serious hidden danger is found during the inspection, the inspection institute shall timely notice the service registration authority of this situation using the *Notice for the Advice of the Inspection* (2).

8.7.3 Management of inspection information

(1) The User and the inspection institute shall strictly conform to the applicable requirements of this Regulation to carry out the periodic inspection, and timely upload the required inspection renewal data to the service registration and inspection information system of special equipment in accordance with the applicable work regulation on informatization of special equipment.

(2) The inspection institute shall summarize the inspection results and report them to service registration authority in accordance with applicable regulation.

8.7.4 Inspection cases

During the inspection process, whenever if a defect or a damage which will affect the safety is found to be existed in pressure vessels and the pressure vessels require a significant repair or is not allowed to operate continually, the inspection institute shall fill out the inspection cases one by one according to applicable regulation and timely report and archive the inspection cases.

8.7.5 Inspection mark

When the inspection inclusion opinion conform to the requirements or basically conform to the requirements, the inspection institute shall issue the inspection mark in accordance with applicable regulation.

8.8 Special requirements on periodic inspection of pressure vessels for miniature refrigerating equipment

8.8.1 Applicable scope

These special requirements are applied to the periodic inspection of pressure vessels for miniature refrigerating equipment which use the ammonia as refrigerant and whose single ammonia storage tanks' volume is no more than 5 m^3 and the total ammonia storage tanks' volume is no more than 10 m^3. For the periodic inspection of pressure vessels for miniature refrigerating equipment which adopts other refrigerant, the property of the refrigerant shall be taken into consideration, and the periodic inspection shall be executed referring to the requirements of this section.

Pressure vessels for miniature refrigerating equipment mainly include condenser, ammonia storage tank, ammonia storage tank of low pressure cycle, ammonia liquid separator, intercooler, oil collector, oil separator, etc.

8.8.2 Preparation for inspection

Besides the preparation work described in Article 8.2 of this Regulation, the User shall also presesnt the records of the filling time of liquid ammonia and the inspection records of liquid ammonia's composition, an environmental ammonia concentration inspection is required to verify that the environmental ammonia concentration are not exceed the allowable range of applicable national standards.

8.8.3 Inspection items and inspection methods

The periodic inspection of pressure vessels for miniature refrigerating equipment can be carried out without power off of the system. The inspection items include documentation review, visual examination, inspection of liquid ammonia's composition, thickness

measurement and the NDE of the external surface of the pressure vessels in high-pressure side. If necessary additional methods are required, such as the NDE of the external surface of the pressure vessels in low-pressure side, acoustic emission testing, inner defects detection, material analysis, strengthen verification, inspection of safety accessories, proof pressure test, etc.

8.8.3.1 Documentation review

Besides reviewing the documents required by Article 8.2.2 of this Regulation, it is also required to review the records of liquid ammonia's filling time and the inspection records of ammonia's composition.

8.8.3.2 Visual examination

(1) During the first overall inspection, check whether the pressure vessels' structure (such as the connection between the shell and the heads, location and reinforcement of opening, the layout of the welding seam) are in accordance with applicable requirements, the subsequent inspection shall only focus on the contents which may change during the operation;

(2) Check whether the nameplates, marks are in accordance with applicable regulation;

(3) Check whether there are damages, disbonding, cold air releasing or other phenomenon in insulation, whether the surface paint is intact;

(4) Check whether there are cracking, corrosion, deformation, damage from mechanical contact as well as other defects in the external surface of the pressure vessel in high-pressure side;

(5) Using the phenolphthalein test paper to check whether there is leakage in welding seams, openings as well as other connection areas of the pressure vessel in the working condition;

(6) If necessary, the fillet joints between the tube-sheets of condenser and the heat exchange tubes shall be inspected for the corrosion and leakage without water in the state;

(7) Integrity, fitness and the corrosion degree of the surface of fasteners shall be verified;

(8) The brackets or supports shall be inspected for setting, tilting and foundation spalling.

8.8.3.3 Inspection of ammonia composition

Check whether ammonia composition inspection records of the User are in accordance with the applicable requirements of N/B T 47012 *Pressure Vessels in Refrigerating Equipment*,

if the composition doesn't meet the requirements, an inspection shall be carried out according to the applicable requirements of Article 8.8.3.5.2 and Article 8.8.3.5.3 of this Regulation.

8.8.3.4 Thickness Measurement

According to the applicable specifications of Article 8.3.5 of this Regulation, representative locations shall be selected to conduct the thickness measurement, and adequate inspection locations shall be ensured.

8.8.3.5 Nondestructive examination

8.8.3.5.1 Surface nondestructive examination of the pressure vessel in the high-pressure side

For pressure vessels in the high-pressure side, spot check of the external surface nondestructive examination shall be conducted, and the key inspection locations are stress concentration locations, deformation locations, doubtful welded joints, repair welding locations, welding zone of fixture tools, electric arc damaged locations and the parts easy to appear cracks.

8.8.3.5.2 Acoustic emission testing or surface nondestructive examination of the pressure vessel in the low-pressure side

For the pressure vessel in the low-pressure side, when one of the following cases occurs, spot check of the acoustic emission testing or surface nondestructive examination shall be carried out:

(1) The design service life is expired;

(2) The composition analysis of liquid ammonia is unconformity with the applicable requirements of NB/T 47012;

(3) Abnormal cases occur during the visual examination, and the inspection personnel deem it's necessary.

8.8.3.5.3 Ultrasonic testing

When one of the following cases occurs, the ultrasonic testing shall be employed for the inner defects, an intrusive inspection is required if necessary:

(1)For pressure vessels with defects found in visual examination or surface nondestructive testing, he/she thinks it's necessary to conduct the inspection on the inner defects of welds;

(2) The composition analysis of liquid ammonia for pressure vessels in the high-pressure side is unconformity with the applicable requirements of NB/T 47012;

(3) Retest for the acoustic emission source is required;

(4) The inspector deems it’s necessary.

8.8.3.6 Material analysis

When the materials of main pressure components are unknown, the material category shall be determined; for pressure vessels in the low-pressure side, the strength verification can be conducted according to Q235A.

8.8.3.7 Strength verification

When one of the following cases occurs, the strength verification shall be carried out:

(1) The uniform corrosion depth exceeds the corrosion allowance;

(2) The inspectors are doubtful about the strength.

8.8.3.8 Inspection of safety accessories

The inspection of safety accessories shall be performed according to the applicable provisions of Article 8.3.12 of this Regulation.

8.8.3.9 Proof pressure test

When the proof pressure test is required, it shall be carried out according to the applicable provisions of Article 8.3.13 of this Regulation.

8.8.4 The evaluation of safety situation rating and inspection interval

8.4.1 The evaluation of safety situation rating

The safety situation rating shall be evaluated according to the applicable provisions of Article 8.5 in this Regulation based on the inspection result. For pressure vessels required to be altered or repaired, the safety situation rating shall be evaluated according to the retest results after alteration or repairs.

The pressure vessels with non-conforming safety accessories are not permitted to put into service.

8.8.4.2 Inspection interval

(1) For Class 1 to Class 3 of the safety situation rated, the inspection conclusion conforms to the requirements and can continually operate, the inspection interval generally shall be 3 years;

(2) For Class 4 of the safety situation rated, the inspection conclusion is basically conform to the requirements and shall operate only under specific control. The inspection interval shall be determined by the inspection institute, and the accumulated intervals under specific control shall be no more than 3 years; before the expiration of the time of control, the pressure vessels cannot continually operate but all the defects have been treated;

(3) For Class 5 of the safety situation Class 5 rated, the inspection conclusion is

nonconformity with the requirements and cannot continually operate but all the defects have been treated.

8.9 Fitness-for-purpose

For pressure vessels with expiration of under specific control period, or those in which serious defects found on the vessels during periodic inspections that may eventually lead to pressure vessels out-of-service, all defects shall be treated. Methods for the treatment of defects include eliminating defects by repairs or subjecting to fitness-for-purpose.

The fitness-for-purpose shall meet the following:

(1) The inspection institute that undertakes fitness-for-purpose of the pressure vessel shall be approved, has corresponding inspection certificate, corresponding professional evaluation personnel and inspection ability, has evaluation experiences, has participated in establishing and revising of related standards and has test ability of material breaking performance, numerical analysis ability of structure stress and test ability of corresponding damage modes;

(2) The User shall submit an application in writing for fitness-for-purpose to the inspection institute which has the capacity of evaluation. Meanwhile, the User shall notify the service registration authority in wiring of the basic situation of the pressure vessel which requires evaluation;

(3) The fitness-for-purpose of the pressure vessel shall be performed in accordance with GB/T 19624 *"safety assessment for in-service pressure vessels containing defects"* and other applicable standards. The inspection institute undertaking the fitness-for-purpose shall provide explicit evaluation conclusions in evaluation report determining the effects of defects on the safe use of pressure vessel based on the property, the source and the developing prediction of existing defects;

(4)The reports of the fitness-for-purpose of the pressure vessels shall be issued by the experienced reviewers. The reports shall be approved by the legal representative of the inspection institute or the technical director of the inspection institute. The inspection institute undertaking the fitness-for-purpose shall be responsible for the correctness of the evaluation conclusions;

(5) Based on the fitness-for-purpose conclusion and the results of other inspection items, the inspection institute shall issue the inspection reports and determine the rating of safety situation, allowable operation parameters and the next inspection date;

(6) The User shall report the fitness-for-purpose conclusions to the service registration authority. The User shall control the operation parameters of the pressure vessel in strict compliance with the requirements of the inspection reports, implement monitoring and precautionary measures and reinforce the annual inspection.

8.10 Risk-based inspection (RBI)

8.10.1 Application condition

The User applying for RBI shall get safety management assessment from the superior administrative unit or the third party (who should be a national social-organization with characteristics of being professional, non-profitable and uninterested with the applicant and inspection unit) and shall prove their compliance with the following:

(1) Have a well-established management system and a high level management;

(2) Establish a special emergency preplan to deal with different emergencies and exercise it regularly;

(3) The equipments like pressure vessels and pressure pipings operate well, and are inspected and maintained in accordance with applicable provisions;

(4) Materials regarding production facilities and key equipments are complete and intact;

(5) Operating processes are stable;

(6) Digital distribution control systems are integrated into production facilities with reliable safety protective interlocking systems.

8.10.2 The implementation of RBI

(1) The inspection institutes who undertakes RBI shall be approved by AQSIQ, get the certificate of RBI; the person occupied in RBI shall be adequately trained and be familiar with related national standards and specialized analysis software;

(2) The User shall submit an application in writing to a RBI inspection institute along with materials which have passed the safety management assessment, and notify to the service registration authority. The RBI inspection institute shall audit the r materials;

(3) The RBI inspection institute shall evaluate risk levels of the plant and pressure vessels based on the status of equipments, failure modes, consequences of failure and management conditions as well as other factors, and put forward an inspection strategy (includes inspection time, inspection contents and inspection methods) according to the acceptability of risk as well as applicable national standards of RBI;

(4) For pressure vessels to which the RBI is applied, the User shall schedule a specific

inspection plan based on the proposed inspection strategy, and the inspection institute undertaking the RBI shall formulate specific inspection plan based on the inspection strategy, execute the inspection and issue the RBI report;

(5) For pressure vessels with risk level above the acceptable level during the operation, the on-stream inspection or other methods shall be adopted to minimize the risk;

(6) The User of pressure vessels which adopts RBI shall report the RBI conclusions to the service registration authority for reference, and implement various measures to ensure the safe operation of pressure vessels, and undertake the entity responsibility of the safe use.

8.10.3 Determination of the inspection intervals

The inspection interval of pressure vessels based on RBI can be determined by the following:

(1) The inspection interval of pressure vessels can be determined referring to the applicable provisions described in Article 8.1.6.1 of this Regulation, and the inspection interval can be shortened or prolonged based on the risk level, but no longer than 9 years;

(2) Based on the remaining service life of pressure vessels, the longest inspection interval can’t be longer than half of the remaining service life, and can’t be longer than 9 years.

9 Safety Accessory and instrument

9.1 Safety accessory

9.1.1 General requirements

(1) The manufacturer of safety valves, bursting disc devices shall hold the appropriate manufacturing license of special equipment;

(2) For safety accessories requiring type (prototype) tests, such as safety valves, bursting disc devices and emergency shut-off devices etc, type(prototype) tests shall be conducted by the approved type test institute of AQSIQ, and proof documents of type tests shall be obtained;

(3) The design and fabrication of safety accessories shall conform to provisions of corresponding safety technical regulations;

(4) The safety accessory shall be delivered together with the quality certificate documents, and a metallic nameplate shall be tightly mounted on the product;

(5) The periodic inspection of safety accessories shall be carried out regularly, and it shall be conducted according to the provisions of this Regulation and corresponding safety technical regulations.

9.1.2 Mount requirements of safety relief devices

(1) Pressure vessels within the jurisdiction scope of this Regulation shall be equipped with safety relief devices based on the design requirement. When the external pressure source can be reliably controlled, the safety relief device shall not be mounted directly on the pressure vessel;

(2) When the combination of bursting disc device and safety valve is used, it shall conform to corresponding specifications of pressure vessel product standards. Bursting disc devices in series of the combination structure shall not be allowed to break into fragments during bursting;

(3)For pressure vessels containing explosive or extremely, highly or moderately toxic medium, a relief tube shall be mounted at the outlet of the safety valve or the bursting disc device. The discharged substance shall be guided to a safe place and properly disposed. It is prohibited to directly the discharge into air atmosphere;

(4) When the operating pressure of the pressure vessel is less than the source pressure, a pressure reducing valve shall be mounded on the piping connected to the inlet of the pressure vessel. If the pressure reducing valve may not operate reliably due to the medium, a pressure

regulating valve may be used instead of the pressure reducing valve. Then, the safety valve and the pressure gage shall be mounted at the lower pressure side of the pressure reducing valve or the regulating valve.

(5) The users shall ensure that safety relief devices have been mounted according to design requirements prior to the service of pressure vessels.

9.1.3 Installation requirements for safety relief devices

(1) Safety relief devices shall be mounted at the gas phase space over the liquid level of the pressure vessel, or be mounted on the pipe that connected to the gas phase space of the pressure vessel; safety valves shall be plumb mounted;

(2) The cross-sectional area of the connecting pipe and the fitting between the pressure vessel and the safety relief device shall be not less than the inlet part of the safety relief device. The connecting pipe shall be as short and straight as possible;

(3) When two or more safety relief devices are mounted on one inlet pipe of the pressure vessel, the cross-sectional area of the inlet pipe shall be at least equal to the sum of the cross-sectional areas of inlets of those safety relief devices;

(4) In general, the globe valve should not be mounted between the safety relief device and the pressure vessel. For the purpose of the on-line check of the safety valve, a bursting disc device may be mounded between the safety valve and the pressure vessel. In the case of the pressure vessel containing extremely/ highly or moderately toxic medium, explosive medium, corrosive or sticky medium or valuable medium, a globe valve may be mounted between the safety relief device and the pressure vessel in order to facilitate cleaning and replacement of the safety valve with the approval of the user's safety chief and the reliable protection measures. The globe valve shall be kept at a full-open position (by lead seal or lock device) under the normal operating condition of the pressure vessel. The structure and the nominal diameter of the globe valve shall not block the relief of the safety relief device;

(5) A new safety valve shall be calibrated prior to installation.

9.1.4 Safety valves and bursting disc devices

9.1.4.1 The discharge capacity of safety valves and bursting disc devices

The discharge capacity of the safety valve and the bursting disc device shall be equal to or greater than the safety relief capacity of the pressure vessel. The calculations for the discharge capacity and the safety relief capacity are based on the specification of appropriate standards, and test verification shall be conducted when necessary. For the pressure vessel

containing the mixed gas/liquid medium under saturated or overheated condition, the relief area of the outlet for the bursting disc device shall be calculated in design to prevent from explosion.

9.1.4.2 The set pressure of safety valves

In general, the set pressure of safety valves shall not be greater than the design pressure of the pressure vessel. The maximum allowable operating pressure may be used as the set pressure of safety valves when the value of the maximum allowable operating pressure is indicated on design drawings or on the nameplate.

9.1.4.3The bursting pressure of bursting disc devices

If the pressure vessel equipped with bursting disc devices, the design bursting pressure of the bursting disc device shall not be greater than the design pressure of the pressure vessel, and the minimum design bursting pressure of the bursting disc device shall not be less than the operating pressure of the pressure vessel. If the maximum allowable operating pressure is indicated on design drawings or the nameplate, the design bursting pressure of the bursting disc device shall not be greater than the maximum allowable operating pressure of the pressure vessel.

9.1.4.4 The action system of safety valves

Deadweight safety valves shall have the anti-deviation device to prevent the weight from freely shifting and guide frame to limit the leverage deviation; spring-loaded safety valves shall have the seal device to prevent the adjusting screw from casual pinch; and direct-loaded safety valves shall have the protection device to prevent the weight from moving away.

9.1.4.5 The calibration institute of safety valves

The calibration institute of safety valves shall possess qualified calibration technicians, calibration equipment/apparatus and workplace, as well as the corresponding procedure and system. The calibration technician shall hold the personnel certificate of the safety valve calibration. After the calibration, the calibration institute shall present a calibration report and seal the calibrated safety valve.

9.2 Instrument

9.2.1 Pressure gage

9.2.1.1 The selection of the pressure gages

(1) Pressure gages shall be compatible with the medium contained in the pressure vessel;

(2) For pressure vessels with design pressure less than 1.6MPa, the precision of pressure

gages shall not be lower than Class 2.5. For pressure vessels with the design pressure equal to or greater than 1.6MPa, the precision of pressure gages shall be not lower than Class 1.6;

(3) The maximum scale on the pressure gage shall be 1.5-3.0 times of the operating pressure.

9.2.1.2 The calibration for pressure gages

The calibration and maintenance for pressure gages shall conform to corresponding provisions regulated by the Metrology Authority of China. Pressure gages shall be calibrated prior to installation. A red line shall be marked on the dial to indicate the operating pressure, and the next calibrating date shall be indicated. A lead seal shall be put on the pressure gage after calibrating.

9.2.1.3 Installation of pressure gages

(1) Pressure gages shall be located at the position for easy observation and cleaning. Any adverse effects such as direct radiation, freezing or vibration shall be avoided；

(2) A three-way cock or a needle valve (with the on-off label and the lock device) shall be mounted between the pressure gage and the pressure vessel, and any fitting or nozzle used for other service shall not be connected between the pressure gage and the pressure vessel；

(3) For pressure gages used for steam as the medium, a bent pipe for collecting condensed water shall be mounted between the pressure gage and the pressure vessel;

(4) For pressure gages used for the corrosive or highly sticky medium as the medium, a buffer device for isolating the medium shall be mounted between the pressure gage and the pressure vessel.

9.2.2 Liquid level gages

9.2.2.1 General requirements of liquid level gages

Liquid level gages used for pressure vessel shall conform to the following:

(1) The selection of liquid level gages of the pressure vessel is based on the medium contained, the design pressure (or maximum allowable operating pressure) and design temperature of the pressure vessel;

(2) Prior to installation and usage, the liquid level gage used for the pressure vessel with the design pressure less than 10MPa shall be hydrostatically tested with a pressure of 1.5 times of the nominal pressure of the liquid level gage. For the pressure vessel with the design pressure equal to or greater than 10MPa, the liquid level gage shall be tested hydrostatically with a pressure of 1.25 times of the nominal pressure of the liquid level gage;

(3) For the pressure vessel containing low-temperature (less than 0℃) medium, a frost-proof liquid level gage shall be used;

(4) For the liquid level gage used outdoor in the cold climate region, a jacket or a thermal insulation type liquid level gage shall be used;

(5) For the pressure vessel containing the explosively or extremely, highly toxic liquefied gas, the liquid level gage shall be equipped with the protection device against leakage;

(6) When a stable indication of the liquid level is required, the float-type (buoy-type) liquid level gage shall not be used.

9.2.2.2 Installation of liquid level gages

A Liquid level gage shall be located at the position for easy observation. Otherwise other auxiliary devices shall be provided. For the large scale pressure vessel, a central-control system with an alert/alarm device shall be provided. The highest and lowest safe liquid level positions on liquid level gage shall be marked clearly.

9.2.3Test apparatus for metal temperature

For pressure vessels requiring the metal temperature control, a thermometry apparatus (or thermometer) shall be equipped. The thermometry apparatus shall be calibrated periodically.

10 Supplement

10.1 Interpretation authorization

AQSIQ has the authority to provide official interpretations of this Regulation.

10.2 Enforcement date

This Regulation is enforced on Oct 1st, 2016. Accordingly, *"Supervision Regulation on Safety Technology for Nonmetallic Pressure Vessel"* (TSG R0001-2004) (AQSIQ [2004] No. 79) issued by AQSIQ June 28th, 2004, *"Supervision Regulation on Safety Technology for Super-high Pressure Vessel"* (TSG R0002-2005) (AQSIQ [2005] No. 160) issued by AQSIQ November 8th, 2005, *"Supervision Regulation on Safety Technology for Simple Pressure Vessel"* (TSG R0003-2007) (AQSIQ [2007] No. 18) issued by AQSIQ January 24th, 2007, *"Supervision Regulation on Safety Technology for Stationary Pressure Vessel"* (TSG R0004-2009) (AQSIQ [2009] No. 83) issued by AQSIQ August 31st, 2009 and Addenda No.1 of TSG R0004-2009 issued in 2010 are repealed. For periodical inspection and supervisory inspection of stationary pressure vessels, "*Regulation on Periodical Inspection for Pressure Vessel*" (TSG R7001-2013) (AQSIQ [2013] No. 10) issued by AQSIQ January 16th, 2013, "*Regulation on Supervision Inspection for Pressure Vessel*" (TSG R7004-2013) (AQSIQ [2013] No. 191) issued by AQSIQ December 31st, 2013 are not implemented.

ANNEX A

CLASSIFICATION FOR CATEGORIES OF STATIONARY PRESSURE VESSELS

A1 Classification for Categories of Pressure Vessels

A1.1 Medium grouping

Mediums of pressure vessels are classified into two groups:

(1) The medium group 1: chemicals with toxicity of extremely hazard or highly hazard, explosive mediums, liquefied gases;

(2) The medium group 2: mediums except for those in the first group.

A1.2 Hazard of the medium

Hazards of the medium refer to the severity of hazards resulted from mass contact of human body with medium due to accidents, explosions, or occupational chronic harmfulness resulted from frequent leak of medium during production. It is indicated by the toxicity degree and the explosiveness of the medium.

A1.2.1 Toxic mediums

Regarding hazardous factors of the acute toxicity, the maximum permissible concentration and the occupational chronic hazard comprehensively, the maximum permissible concentration of the extreme toxic medium is less than 0.1mg/m^3; the maximum permissible concentration of the highly toxic is 0.1mg/m^3~1.0mg/m^3; the maximum permissible concentration of the moderate toxic is 1.0mg/m^3~10.0mg/m^3; The maximum permissible concentration of the light toxic is equal to or greater than 10.0mg/m^3.

A1.2.2 Explosive mediums

Explosive mediums refer to the explosive mixture formed when the vapor and the mist of gases or liquids mix with the air, of which the lower explosion limit is less than 10% or the difference between upper and lower explosion limits is equal to or greater than 20%.

A1.2.3 Determination of the hazardous degree of the toxic medium and explosive medium

The medium group shall be determined according to HG 20660-2000 *Classification for Toxicity and Explosiveness of Chemical Medium in Pressure Vessels.* For the medium group which is not provided in HG 20660, it shall be determined by the design unit of the

pressure vessel based on GBZ 230-2010 *Classification for Harmfulness of Occupational Contact with Toxic Medium.*

A1.3 Classification for Categories of Pressure Vessels

A1.3.1 Basic classification

Based on characteristics of the medium, the classification for categories of pressure vessels is determined by the design pressure p (Unit:MPa) and the volume V (Unit:m^3), and the categorization figures for different medium groups are as the following:

1) The medium group 1, the classification for categories of pressure vessels, see Fig.A-1;

(2) The medium group 2, the classification for categories of pressure vessels, see Fig.A-2.

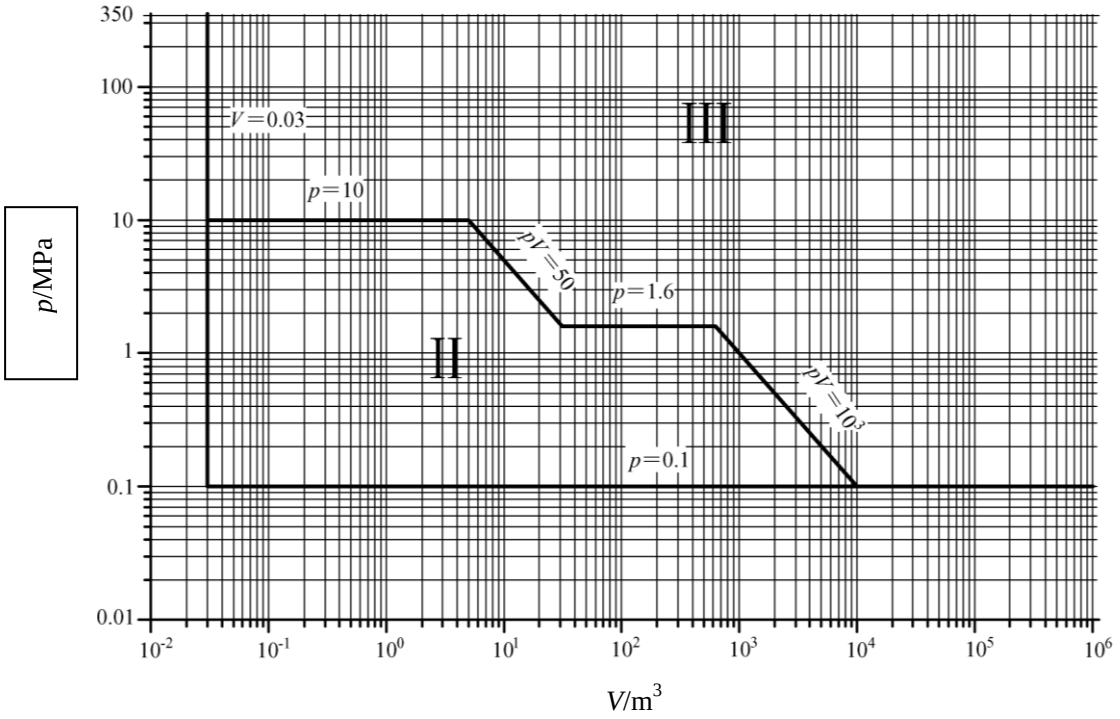
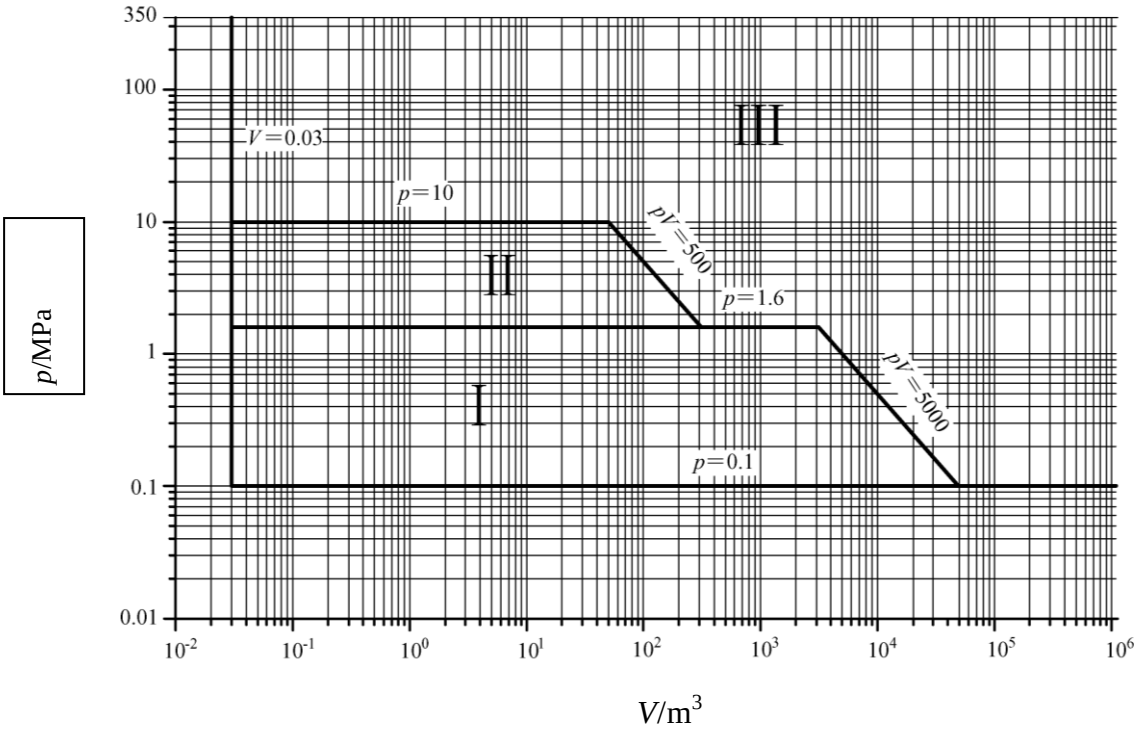


Fig.A-1 Classification for categories of pressure vessels - the medium group 1



FigA-2 Classification for categories of pressure vessels - the medium group 2

A1.3.2 Classification for categories of pressure vessels with multiple chambers

For pressure vessels with multiple chambers (such as tube-side and shell-side of heat-exchangers, and jacket pressure vessels), the classification shall be determined in accordance with the corresponding category of that pressure chamber respectively. And the design pressure shall be taken as the corresponding design pressure of that chamber and volume taken as the geometric volume of that chamber. The vessel category and corresponding service management are based on the relatively higher category among these pressure chambers. But the technical requirements for design and fabrication of each pressure chamber shall be determined in accordance with the corresponding category of that pressure chamber respectively.

A1.3.3 Classification for categories of pressure vessels with multiple mediums in the same chamber

When multiple mediums are contained in the same pressure chamber, the vessel category is based on the highest category among these mediums.

A1.3.4 Classification for categories of pressure vessels with extremely small amount of medium

When the quantity of a hazardous substance is extremely low in the medium, considering the hazard and quantity comprehensively, the vessel category shall be

determined based on the medium category provided by the design unit of the pressure vessel.

A1.3.5 Classification for categories under special conditions

(1) When the (*p*, *V*) is located at the category line in Fig.A-1 or Fig.A-2, the vessel category shall be determined based on the relatively higher category;

(2) Simple pressure vessels are all classified to be category I.

A2 Special Type Pressure Vessel

A2.1 Non-welded cylinder type vessels

The definition is the pressure vessel made of high strength seamless steel tube (nominal diameter>500mm) by spinning technology.

A2.2 Gas storage wells

It refers to the well type tubular equipment standing under ground for storing compressed gases.

A2.3 Simple pressure vessels (Note A)

Simple pressure vessels shall meet following conditions in the same time:

(1) The pressure vessel composes of cylinder, flat head and convex head (exclude spherically dished head), or composes of two convex heads;

(2) The material of main pressure parts (such as the cylinder, head and connecting pipe) are carbon steel, Austenitic stainless steel or Q345R;

(3) Design pressure is less than or equal to 1.6Mpa;

(4) Volume is less than or equal to $1m^3$;

(5) The product of work pressure and volume is less than or equal to $1Mpa \cdot m^3$;

(6) The mediums of pressure vessels are air, nitrogen, carbon dioxide, inert gases, the steam evaporated from medical distilled water, or the mixture of above gases; it allows the medium contains some composition such as oil which is not enough to change the medium characteristics, and not affect the compatibility of medium and material;

(7) Design temperature is greater than or equal to -20℃, the maximum work temperature is less than or equal to 150℃;

(8) Indirect flame heating welding pressure vessels (it allows to connect by flat cover bolts if the diameter is less than or equal to 550mm).

Dangerous chemicals packing, fire extinguisher, quick opening pressure vessels are beyond the scope of simple pressure vessels.

Note A: In general, the production mode of simple pressure vessel is batch production. If it cannot be produced by batch due to the low quantity, then it shall be designed and manufactured in accordance with GB150 (do not need a type test), and the service management shall be conducted according to article 7.1.11 of this Regulation.

A3 Classification of Pressure Classes

Based on the design pressure (p), the classification for pressure classes is specified as following four classes: low pressure, medium pressure, high pressure and ultrahigh pressure:

(1) Low pressure (symbol L), 0.1MPa ≤ p < 1.6MPa;

(2) Medium pressure (symbol M), 1.6MPa≤ p < 10.0MPa;

(3) High pressure (symbol H), 10MPa ≤p < 100MPa;

(4) Ultrahigh pressure (symbol U), p≥100MPa.

A4 Classification of the Pressure Vessel Sorts

Based on the function in the production process, the classification for the pressure vessel sorts is divided to reaction vessels, heat-exchange vessels, separation vessels and storage vessels. It is specified as following:

(1) Reaction vessels (symbol R): pressure vessels mainly used for physical or/and chemical reactions of mediums, such as various types of reactors, reaction kettles, polymerization kettles, synthesis converters, transformation furnaces, gas generators;

(2) Heat-exchange vessels (symbol E): pressure vessels mainly used for heat exchange of mediums, such as various types of heat exchangers, coolers, condensers, evaporators;

(3) Separation vessels (symbol S): pressure vessels mainly used for fluid pressure balance/damping of mediums, and gas cleaning/separating, such as various types of separators, filters, oil collectors, washers, absorption towers, cuprammonium washing towers, drying towers, stripping towers, steam distributors and deaerators;

(4) Storage vessels (symbol C, for spherical tanks, symbol B): pressure vessels mainly used for storing and containing substance of gases, liquids, or liquefied gases etc, such as various types of storage tanks.

When two or more functions exist in the same pressure vessel, the sort classification shall be based on the main function in the process.

ANNEX B

Product Conformity Certificate of Pressure Vessel

Serial Number:

Name of Manufacturer			
Unified Social Credit Code of Manufacturer		Manufacture License Number	
Product Name		Manufacture Licensing Level	
Product Serial Number		Equipment Code	
Drawing Number		Category of Pressure Vessels	
Design Unit			
Unified Social Credit Code of Manufacturer		Design License Number	
Design Date		Manufacture Date	

This pressure vessel conforms to the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel（TSG 21-2016）*, the design drawings, relevant technical standards, and the purchase order via quality inspection in fabrication process.

Responsible Inspection Engineer (Signature / Stamp): Date:

Quality Control Engineer(Signature / Stamp): Date:

Seal for product quality inspection

DD MM YY

Note: This certificate includes Product Data Sheet of the pressure vessel.

ANNEX b

Product Date Sheet of Stationary Pressure Vessel

Serial Number:

<table>
<tr><td colspan="3">Product Name</td><td colspan="3"></td><td colspan="2">Equipment Type</td><td colspan="2"></td></tr>
<tr><td colspan="3">Product Standard</td><td colspan="3"></td><td colspan="2">Product Serial Number</td><td colspan="2"></td></tr>
<tr><td colspan="3">Equipment Code</td><td colspan="3"></td><td colspan="2">Design Service Life</td><td colspan="2"></td></tr>
<tr><td rowspan="8">Main Parameters</td><td colspan="2">Volume</td><td>m^3</td><td colspan="2">Inner Diameter</td><td>mm</td><td colspan="2">Vessel Height(Length)</td><td>mm</td></tr>
<tr><td rowspan="4">Materials</td><td>Cylinder(spherical shell)</td><td></td><td rowspan="4">Thickness</td><td>Cylinder(spherical shell)</td><td>mm</td><td colspan="2">Dead Load</td><td>kg</td></tr>
<tr><td>Head</td><td></td><td>Head</td><td>mm</td><td colspan="2" rowspan="2">Contained Medium Weight</td><td rowspan="2">kg</td></tr>
<tr><td>Lining</td><td></td><td>Inner Lining</td><td>mm</td></tr>
<tr><td>Jacket</td><td></td><td>Jacket</td><td>mm</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Design Pressure</td><td>Shell-side</td><td>MPa</td><td rowspan="3">Design Temperature</td><td>Shell-side</td><td>℃</td><td rowspan="3">Maximum Allowable Operating Pressure</td><td>Shell-side</td><td>MPa</td></tr>
<tr><td>Tube-side</td><td>MPa</td><td>Tube-side</td><td>℃</td><td>Tube-side</td><td>MPa</td></tr>
<tr><td>Jacket</td><td>MPa</td><td>Jacket</td><td>℃</td><td>Jacket</td><td>MPa</td></tr>
<tr><td colspan="2">Shell-side Medium</td><td></td><td colspan="2">Tube-side Medium</td><td></td><td colspan="2">Jacket Medium</td><td></td></tr>
<tr><td rowspan="2">Structure Types</td><td colspan="2">Structure Type of Main Body</td><td colspan="3"></td><td colspan="2">Installation Type</td><td colspan="2">(Vertical or Horizontal)</td></tr>
<tr><td colspan="2">Support Type</td><td colspan="3"></td><td colspan="2">Thermal Isolation / Insulation Methods</td><td colspan="2">(Fill in methods, or mark “—” if not applicable)</td></tr>
<tr><td rowspan="3">Examination and Test</td><td colspan="2">Nondestructive Examination Methods</td><td colspan="3"></td><td colspan="2">Percentage of Nondestructive Examination</td><td colspan="2">%</td></tr>
<tr><td colspan="2">Types of Proof Pressure Test</td><td colspan="3"></td><td colspan="2">Pressure of Proof Pressure Test</td><td colspan="2">MPa</td></tr>
<tr><td colspan="2">Types of Leak Test</td><td colspan="3"></td><td colspan="2">Pressure of Leak Test</td><td colspan="2">MPa</td></tr>
<tr><td colspan="3">Heat Treatment Type</td><td colspan="3"></td><td colspan="2">Heat Treatment Temperature</td><td colspan="2">℃</td></tr>
<tr><td colspan="10">Safety Accessories and relevant devices</td></tr>
<tr><td colspan="3">Name</td><td colspan="2">Model</td><td colspan="2">Specification</td><td>Quantity</td><td colspan="2">Manufacturer</td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Manufacturing Supervisory Inspection</td><td colspan="2">Supervisory Inspection Organization</td><td colspan="7"></td></tr>
<tr><td colspan="2">Unified Social Credit Code of Supervisory Inspection Institute</td><td colspan="3"></td><td>Approved Certificate Number</td><td colspan="2"></td></tr>
</table>

ANNEX C

Product Nameplate of Pressure Vessel

(1) Product nameplate of pressure vessel/压力容器产品铭牌

监检标记
Supervisory Inspection Mark

产品名称 Product Name					
产品编号 Product Serial Number		压力容器类别 Pressure Vessel Category		制造日期 Manufacture Date	年 月 日 (Year) (Month) (Day)
设计压力 Design Pressure	MPa	耐压试验压力 Pressure of Proof Pressure Test	MPa	最高允许工作压力 Maximum Allowable Working Pressure	MPa
设计温度 Design Temperature	℃	容器自重 Dead Load	kg	主体材料 Main Body Material	
容积 Volume	m^3	工作介质 Working Medium		产品标准 Product Standard	
制造许可级别 Manufacture Licensing Level		制造许可证编号 Manufacture License Number			
制造单位 Manufacturer Name					
设备代码 Equipment Code					

铭牌的拓印件或者复印件存于压力容器产品质量证明文件中
The rubbing or copy of the nameplate shall be put into product quality certification documents of the pressure vessel.

(2) Product nameplate of heat exchanger/换热容器产品铭牌

监检标记
Supervisory Inspection Mark

产品名称 Product Name				
			管程(夹套) Tube-Side(Jacket)	壳程(壳体) Shell-Side(Shell)
产品编号 Product Serial Number		设计压力 Design Pressure	MPa	MPa
压力容器类别 Pressure Vessel Category		耐压试验压力 Pressure of Proof Pressure Test	MPa	MPa
制造日期 Manufacture Date	年 月 日 (Year)(Month)(Day)	最高允许工作压力 Maximum Allowable Working Pressure	MPa	MPa
容器自重 Dead Load	kg	设计温度 Design Temperature	℃	℃
换热面积 Heat Exchange Area	m^2	工作介质 Working Medium		
折流板间距 Baffle Plate Spacing	mm	主体材料 Main Body Material		
产品标准 Product Standard		制造许可级别 Manufacture Licensing Level		制造许可证编号 Manufacture License Number
制造单位 Manufacturer Name				
设备代码 Equipment Code				

铭牌的拓印件或者复印件存于压力容器产品质量证明文件中

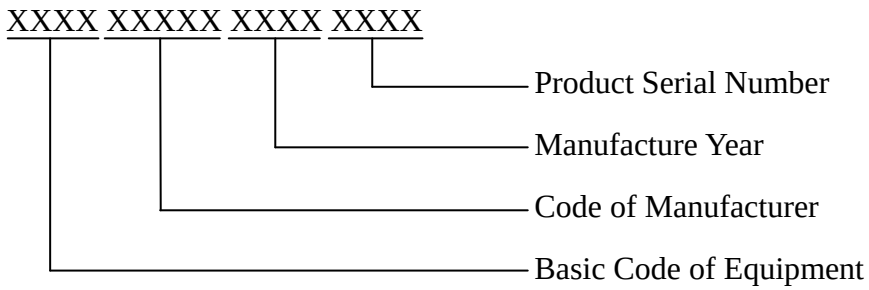
The rubbing or copy of the nameplate shall be put into product quality certification documents of the pressure vessel.

ANNEX D

Code Numbering Methods of Special Equipments

D1 Basic numbering methods

The equipment code is the identification of the equipment, which must be unique, and consists of the basic code of the equipment, the code of the manufacturer, the manufacture year, and the product serial number, between which there are no spaces.



D2 Meaning of the code

D2.1 Basic code of the equipment

It is compiled according to the equipment code (4 Arabic numerals) of the variety listed in the Special Equipment Catalogue. For example, for the second class pressure vessels, the code is “2150”.

D2.2 Code of Manufacturer

The code of the manufacturer is consisted of the code of the administrative region (2 Arabic numerals) where the approval authority of manufacture license is located and the manufacturer serial number (3 Arabic numerals) included in the manufacture license number of the manufacturer. For instance, for a manufacturer of pressure vessels located in Heilongjiang Province, if it is reviewed and approved by AQSIQ, its manufacturer license number is “TS2210890-2015”, in which the code of the administrative region for AQSIQ is indicated by 10, the serial number of the license is 890, and then the code of the manufacturer is “10890”. If it is reviewed and approved by the Quality & Technology Supervision Bureau of Heilongjiang Province, then its manufacture license number code is “TS2223010-2015”, in which the code of the administrative region for Heilongjiang Province is indicated by 23, the serial number of the license is 10, and then the code of the manufacturer is “23010”.

D2.3 Manufacture year

The year when the product is manufactured (4 Arabic numerals). For example, for a product fabricated in 2015, the manufacture year is “2015”.

D2.4 Product serial number

The product serial number is numbered by the manufacturer itself (4 Arabic numerals). For example, for a type of the pressure vessel fabricated in 2015, if the fabrication serial number is 98, then it is numbered as “0098”.

If the product serial number exceeds 9999, then it can be replaced by phonetic alphabet. For example, if the fabrication serial number for a certain variety pressure vessel is 10000 or 11000, then the product serial number is A000 or B000, and the rest can be deduced by analogy.

ANNEX E

Liaison Sheet for Supervisory Inspection of Special Equipment

(Inspected company): No.:

Through supervisory inspection, we found the following problems which may affect safety performance during (manufacture, installation, alteration and important repair) of (name, batch No., Serial No. or location No. of pressure vessels), please submit the treatment result to the supervisory inspection institute before Date: DD MM YY.

Problems and opinions: Supervisory inspector: Date: Receiver of the inspected company: Date:
Treatment result: Person in charge of the inspected company: Date: (Official seal of the inspected company) DD MM YY

Note: This liaison sheet is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the inspected company, one of which shall be returned to the supervisory inspection institute within the required date.

ANNEX F

Notice on Supervisory Inspection of Special Equipment

(Inspected company): No.:

Through supervisory inspection, we found the following problems which may affect safety performance during manufacture, installation, alteration and important repair of (name, batch No., Serial No. or location No. of pressure vessels), please submit the treatment result to the supervisory inspection institute before Date: DD MM YY.

Problems and opinions:		
Supervisory inspector:	Date:	
Technical chief of the supervisory inspection institute:	Date:	(Dedicated seal of the supervisory inspection institute) DD MM YY
Receiver of the inspected company:	Date:	
Treatment result:		
Person in charge of the inspected company:	Date:	(Official seal of the inspected company) DD MM YY

Note: This notice is in quadruplicate, one is for municipal or provincial quality and technical supervisory department of the Special Equipment, one is filed by supervisory inspection institute, and the other two is delivered to the inspected company, one of which shall be returned to the supervisory inspection institute within required date.

ANNEX G

Supervisory Inspection Certificate of Special Equipment (Pattern)

Supervisory Inspection Certificate for Special Equipment Manufacturing

(Pressure Vessel)

No.:

Name of manufacturer			
Manufacture licensing level		Manufacturing license No.	
Equipment category	Stationary pressure vessel	Product name	
Product Serial No.		Equipment code	
Design unit			
Design unit license No.		Product drawing No.	
Design date	DD MM YY	Manufacture date	DD MM YY

In accordance with the requirements of *Special Equipment Safety Law of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment*, the safety performance of this pressure vessel, through supervisory inspection of our institute, meets the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel*(TSG 21-2016). The certificate is hereby issued, and the following supervisory inspection mark is stamped on the product nameplate of the pressure vessel.

TS

Supervisory Inspector: Date:

Checked by: Date:

Approved by: Date:

Supervisory inspection institute: (Dedicated seal of the supervisory inspection institute)

DD MM YY

Approved No.of the Supervisory Inspection Institute:

Note: This certificate is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the manufacturer, one of which shall be delivered to the user with the product delivery documentations of the pressure vessel.

Supervisory Inspection Certificate for Special Equipment Manufacturing

(Batch-manufactured pressure vessels)

No.:

Name of manufacturer			
Manufacture licensing level		Manufacture license No.	
Equipment category	Stationary pressure vessel	Product name	
Product batch No.		Equipment code	
Design unit			
Design license No.		Product drawing No.	
Design date	DD MM YY	Manufacture date	DD MM YY

In accordance with the requirements of *Special Equipment Safety Law of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment*, the safety performance of this bath-manufactured pressure vessel, through supervisory inspection of our institute, meets the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel* (TSG 21-2016). The certificate is hereby issued, and the following supervisory inspection mark is stamped on the product nameplate of the bath-manufactured pressure vessel.

TS

Serial No. of spot-checked products for supervisory inspection: (fill in product serial No.)

Serial No. of products applicable to this certificate: (fill in product serial No.)

Supervisory Inspector: Date:

Checked by: Date:

Approved by: Date:

Supervisory inspection institute: (Dedicated seal of the supervisory inspection institute)

DD MM YY

Approved No. of the Supervisory Inspection Institute:

Note: This certificate is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the manufacturer, one of which shall be delivered to the user with the product delivery documentation of the pressure vessel.

Supervisory Inspection Certificate for Alteration and Important Repair of Special Equipment

(pressure vessel)

No.:

Construction unit			
License No. for		Construction type	(alteration or important repair)
User			
Equipment service location			
Equipment category	Stationary pressure vessel	Service registration No.	
Equipment code		Equipment name	
Completion date	DD MM YY	Product drawing No.	
Items of alteration and important repair:			

In accordance with the requirements of *Special Equipment Safety Law of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment*, the safety performance for alteration and important repair of the pressure vessel, through supervisory inspection of our organization, meets the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel* (TSG 21-2016).The certificate is hereby issued.

Supervisory Inspector: Date:

Checked by: Date:

Approved by: Date:

Supervisory inspection institute: (Dedicated seal of the supervisory inspection institute)

DD MM YY

Approved No. of the Supervisory Inspection Institute:

Note: This certificate is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the construction unit, one of which shall be delivered to the user with the as-built documentation of the pressure vessel by the construction unit.

Supervisory Inspection Certificate for Special Equipment Manufacturing

(Pressure Components and Parts of pressure vessels)

No.:

Name of manufacturer			
Product name		Serial No. (Batch No.) of product	
Type and specification		Material	
Quantity		Processing with customer's material	☐Yes ☐No
Manufacture date	DD MM YY		

In accordance with the requirements of *Special Equipment Safety Law of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment*, the safety performance of this (batch of) pressure components (parts), through supervisory inspection of our institute, meets the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel* (TSG 21-2016).The certificate is hereby issued, and the following supervisory inspection mark is stamped on the product conformity certificate for components (parts) of the (batch of) pressure vessels.

TS

Supervisory Inspector: Date:

Checked by: Date:

Approved by: Date:

Supervisory inspection institute: (Dedicated seal of the supervisory inspection institute)

DD MM YY

Approved No. of the supervisory Inspection Institute:

Note: This certificate is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the manufacturer, one of which shall be delivered to the user with the product delivery documentation of the pressure component or part of the pressure vessel.

Supervisory Inspection Certificate for Safety Performance of Imported Pressure Vessels

No.:

Name of manufacturer			
Manufacture licensing level		Manufacture license No.	
Equipment type	Stationary Pressure Vessel	Product name	
Serial No. (Batch No.) of product		Product drawing No.	
User			
Equipment service location			
Equipment code		Manufacture date	DD MM YY

In accordance with the requirements of *Special Equipment Safety Law of the People's Republic of China* and *Regulations on Safety Supervision of Special Equipment*, the safety performance for this (batch) pressure vessel, through supervisory inspection of our institute, meets the requirements of *Supervision Regulation on Safety Technology for Stationary Pressure Vessel* (TSG 21-2016).The certificate is hereby issued, and the following supervisory inspection mark is stamped on the product nameplate of the pressure vessel or the batch of pressure vessels.

TS

Supervisory Inspector: Date:

Checked by: Date:

Approved by: Date:

Supervisory inspection institute: (Dedicated seal of the supervisory inspection institute)

DD MM YY

Approved No. of the Supervisory Inspection Institute:

Note 1: For supervisory inspection certificate issued in batches, "serial No. (batch No.) of product" may be changed to "batch No. of product"; "equipment code" changed to "product serial No. ", and product serial No. allowed to be delivered is detailed.

Note 2: This certificate is in triplicate, one is filed by supervisory inspection institute, the other two delivered to the manufacturer, one of which shall be delivered to the user with the product delivery documentation of the pressure vessel.

ANNEX H

Annual Inspection Report of Pressure Vessel

Report No.:

<table>
<tr><td>Equipment name</td><td></td><td>Type of pressure vessel</td><td></td></tr>
<tr><td>Service registration certificate No.</td><td></td><td>Company internal No.</td><td></td></tr>
<tr><td>User</td><td colspan="3"></td></tr>
<tr><td>Equipment service location</td><td colspan="3"></td></tr>
<tr><td>Safety management personnel</td><td></td><td>Contact telephone number</td><td></td></tr>
<tr><td>Rating of safety situation</td><td></td><td>Next periodic inspection date</td><td>MM YY</td></tr>
<tr><td>Basis of inspection</td><td colspan="3">Supervision Regulation on Safety Technology for Stationary Pressure Vessel (TSG 21-2016)</td></tr>
<tr><td>Problems and treatments</td><td colspan="3">The position, type and degree of defects found through the inspection, and suggestion of treatment (attach the drawing and appendix if necessary)</td></tr>
<tr><td rowspan="3">Conclusion</td><td rowspan="3">(Conform to the requirements, Basically conform to the requirements, Non-conformity with the requirements)</td><td colspan="3">Allowable (Control) Operation Parameters</td></tr>
<tr><td>Pressure MPa</td><td>Temperature ℃</td></tr>
<tr><td>Medium</td></tr>
<tr><td colspan="4">Next annual inspection date: MM YY</td></tr>
<tr><td>Note</td><td colspan="3">(Problems need to be solved during the control operation and completion date)</td></tr>
<tr><td colspan="2">Inspector : Date:</td><td colspan="2" rowspan="3">(Dedicated seal or official seal of the inspection institute)
DD MM YY</td></tr>
<tr><td colspan="2">Checked by: Date:</td></tr>
<tr><td colspan="2">Approved by: Date:</td></tr>
</table>

ANNEX J

Periodic Inspection Report of Pressure Vessel

Report No.:

<table>
<tr><td colspan="2">Equipment name</td><td></td><td>Inspection category</td><td colspan="2">(first inspection or periodic inspection)</td></tr>
<tr><td colspan="2">Type of pressure vessel</td><td></td><td>Equipment code</td><td colspan="2"></td></tr>
<tr><td colspan="2">Company internal No.</td><td></td><td>Service registration certificate No.</td><td colspan="2"></td></tr>
<tr><td colspan="2">Manufacturer</td><td colspan="4"></td></tr>
<tr><td colspan="2">Installer</td><td colspan="4"></td></tr>
<tr><td colspan="2">User</td><td colspan="4"></td></tr>
<tr><td colspan="2">Equipment service location</td><td colspan="4"></td></tr>
<tr><td colspan="2">Unified Social Credit Code of User</td><td></td><td colspan="2">Postcode</td><td></td></tr>
<tr><td colspan="2">Safety management personnel</td><td></td><td colspan="2">Contact telephone number</td><td></td></tr>
<tr><td colspan="2">Design Service Life</td><td>Years</td><td>Date of putting into use</td><td colspan="2">MM YY</td></tr>
<tr><td colspan="2">Structure type of main body</td><td></td><td colspan="2">Operation status</td><td></td></tr>
<tr><td rowspan="4">Parameters</td><td>Volume</td><td>m^3</td><td>Inside diameter</td><td colspan="2">mm</td></tr>
<tr><td>Design pressure</td><td>MPa</td><td>Design temperature</td><td colspan="2">℃</td></tr>
<tr><td>Operation pressure</td><td>MPa</td><td>Operation temperature</td><td colspan="2">℃</td></tr>
<tr><td>Work medium</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Basis of Inspection</td><td colspan="4">Supervision Regulation on Safety Technology for Stationary Pressure Vessel (TSG 21-2016)</td></tr>
<tr><td colspan="2">Problems and treatments</td><td colspan="4">[The position, type and degree of defects found during the inspection, and suggestion of treatment (attach the drawing and appendix if necessary, or remark in individual item inspection report)]</td></tr>
<tr><td rowspan="4">Conclusion</td><td colspan="5">The rating of safety situation of the pressure vessel is</td></tr>
<tr><td rowspan="2">(Conform to the requirements,
Basically conform to the requirements,
Non-conformity with the requirements)</td><td colspan="4">Allowable (Control) Operation Parameters</td></tr>
<tr><td>Pressure</td><td>MPa</td><td>Temperature</td><td>℃</td></tr>
<tr><td>Medium</td><td></td><td>other</td><td></td></tr>
<tr><td colspan="5">Next periodic inspection date: MM YY</td></tr>
<tr><td>Note</td><td colspan="5">(Including the situation of change)</td></tr>
<tr><td>Inspector</td><td colspan="5"></td></tr>
<tr><td colspan="3">Date of establishment: Date:</td><td colspan="3" rowspan="3">Approved certificate No. of inspection organization:
(Dedicated seal or official seal of the inspection institute)
DD MM YY</td></tr>
<tr><td colspan="3">Checked by: Date:</td></tr>
<tr><td colspan="3">Approved by: Date:</td></tr>
</table>

Page ___of ___

Attached Sheet of Periodic Inspection Report of Pressure Vessel

Report No.:

No.	Inspection Items	Inspection Results	Note
1	☐ Documents review of pressure vessels		
2	☐ Macro inspection		
3	☐ Wall thickness measurement		
4	☐ Strength verification		
5	☐ Radiographic testing		
6	☐ Ultrasonic testing		
7	☐ TOFD testing		
8	☐ Magnetic particle testing		
9	☐ Penetrate testing		
10	☐ Acoustic emission testing		
11	☐ Material composition analysis		
12	☐ Hardness test		
13	☐ Metallographic analysis		
14	☐ Safety accessory inspection		
15	☐ Proof pressure test		
16	☐ Gas leak test		
17	☐ Ammonia leak test		
18	☐ Helium & Halogens leak test		

ANNEX K

Notice on Periodic Inspection of Special Equipment (1)

No.:

User			
Equipment type (name)	Equipment code or company internal No.	Service registration certificate No.	Inspection result
Description of situation:			
Validity of this note until: DD MM YY Inspector: Date: (Dedicated seal of the inspection institute) DD MM YY Representative of the user: Date:			

Note: This notice is only used when no problems found from the inspection report, or may exist problem but does not require the user to response, it is an effective conclusion of the inspection report issued before the inspection results. This notice is in two copies for inspection institute and user. This notice is valid within the validity period.

Notice on Periodic Inspection of Special Equipment (2)

No.:

(User's name):

Through the inspection, we found the following problems in your company (equipment category) (equipment name:_____, equipment type: _____, equipment code:_____, company internal No.:_____, Service registration certificate No.:_____), please submit the treatment result to the inspection organization before Date: DD MM YY.

Problems and opinions: Inspector: Date: Technical principal of the inspection institute: Date: (Dedicated seal of the inspection institute) DD MM YY Receiver of the user: Date:	
Treatment result: Person in charge of safety management of the user: Date: (Dedicated seal or official seal of the user) DD MM YY	

Note: This notice is for the problems exist in the inspection, and need the user to deal with. This notice is in triplicate, one is filed by inspection organization, the other two delivered to the user, one of which shall be return to inspection institute by the user within required date. If any serious hidden accidents are found, one copy shall be reported to the service registration institute of pressure vessels.