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NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA

ICS 71. 100. 20

G 86

GB 4962-2008

Replacing GB 4962-1985

Technical Safety Regulation for Gaseous Hydrogen Use

氢气使用安全技术规程

Issued on: December 11, 2008

Implemented on: October 1, 2009

**Issued by: General Administration of Quality Supervision, Inspection and
Quarantine;
Standardization Administration of the People's Republic of China.**

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Technical Safety Regulation for Gaseous Hydrogen Use

1 Scope

This Standard specifies the safety specifications of gaseous hydrogen on such aspects as application, replacement, storage, compression and filling, discharging process, firefighting and emergency treatment, as well as safety protection.

This Standard is applicable to the various workplaces on the ground where gaseous hydrogen is produced, and it is not applicable to the locations for liquid hydrogen, overwater gaseous hydrogen and hydrogen used in aviation as well as on-board hydrogen supply system. Corresponding procedures during hydrogen production may be implemented by reference.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. For dated reference, subsequent amendments to (excluding correction to), or revisions of, any of these publications do not apply. However, the parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards. For undated references, the latest edition of the normative document referred to applies.

GB 2893 Safety Colors

GB 2894 Safety Signs and Guideline for the Use

GB 3836.1 Electrical Apparatus for Explosive Gas Atmospheres - Part 1: General Requirements

GB 4385 Technical Requirements for Antistatic Footwear and Conductive Footwear

GB 7144 Colored Cylinder Mark for Gases

GB 7231 Basic Identification Colors and Code Indications and Safety Sign for Industrial Pipelines

GB 12014 Working Clothing of Anti-electrostatic

GB 16804 Precautionary Labels for Gas Cylinders

GB 50016 Code of Design on Building Fire Protection and Prevention

GB 50057 Design Code for Protection of Structures against Lightning

GB 50058 Electrical Installations Design Code for Explosive Atmospheres and Fire Hazard

GB 50177-2005 Design Code for Hydrogen Station

SH 3059 General Rule of Piping Design Materials Selection for Petrochemical Industry

SY/T 0019 Design Specification of Sacrificial Anode for Buried Steel Pipeline

Safety Inspection Regulations for Gas Cylinders (State Bureau of Quality and Technical Supervision; implemented on July 1, 2001)

Supervision Regulation on Safety Technology for Pressure Vessel (Former Ministry of Labor; implemented on January 1, 1991)

Operating Regulations for Turbine Generator (1999 edition) (State Grid Corporation; implemented on November 9, 1999)

3 Terms and Definitions

For the purposes of this Standard, the following terms and definitions apply.

3.1

Hydrogen filling station

General term of such sites as buildings and structures for supplying hydrogen through bottles and/or pipelines, excluding hydrogen generation equipment

3.2

Gaseous hydrogen receiver

General term of vessels with constant pressure and variable volume (dish gas holder) and with variable pressure and constant volume for storing hydrogen, excluding gas cylinder

3.3

Gaseous hydrogen filling station

General term of such sites as buildings and structures equipped with hydrogen compression

- c) The fire separation between horizontal, vertical, spherical and dish receivers (holders) shall not be less than the diameter of the adjacent larger receiver;
- d) The total volume of a group of horizontal, vertical or spherical receivers shall not exceed 30000m³. The fire separation between groups shall not be less than one half of the height of the adjacent larger receiver for horizontal gaseous hydrogen receivers; it shall not be less than the diameter of the adjacent larger receiver for vertical and spherical receivers, and shall not be less than 10m.

4.1.3 Hydrogen filling station and gaseous hydrogen receiver shall be independent, which should be equipped with noncombustible solid wall and arranged at the leeward of the perennial minimum frequency wind direction of the factory, away from open fire or sparking sites, and shall not be arranged in the crowded areas or close to the main traffic lines.

4.1.4 Gaseous hydrogen filling station, hydrogen filling station, full cylinder room and empty cylinder room should be arranged at the edge of the workshop building.

4.1.5 Hydrogen use area shall be well ventilated. It shall be ensured that the maximum hydrogen content in the air shall not exceed 1% (volume). As for the buildings using mechanical ventilation, the air inlet shall be arranged on the lower part of the building, with the air outlet on the upper part.

4.1.6 Top plane of the building shall be even, so as to prevent hydrogen from accumulating in the dents. Transom window or gas vent shall be arranged on the top of building or on the upper part of outer wall. Gas vent shall be arranged uppermost toward the safety zone.

4.1.7 Where the hydrogen may accumulate or hydrogen concentration may increase, stationary flammable gas detecting alarm should be arranged above the monitoring point (source of release) or on the top of the workshop building, of which the installation height should be 0.5m~2m higher than the source of release and the surrounding should be reserved with clearance not less than 0.3m for the convenience of monitoring the hydrogen concentration. Effective covering level plane radius of flammable gas detecting alarm should be 7.5m indoor and 15m outdoor.

4.1.8 There shall be no open fire at least 10m around the gaseous hydrogen filling station, hydrogen filling station, full cylinder room and empty cylinder room.

4.1.9 Hydrogen in the hydrogen system must not be released inside the building.

4.1.10 Hydrogen reservoir vessels shall be separated with oxygen, compressed air, halogen, oxidant and other combustion-supporting gas cylinders.

4.1.11 Hydrogen filling station shall be independent single-layer building, not lower than Grade II fire resistance, which shall not be arranged in the basement or semi-basement of the

building. Besides, pressure relief facilities shall be arranged for the explosive hazard zone in the station according to the requirements of GB 50016. When the full cylinders do not exceed 60 or the floor area does not exceed 500m², it may be adjacent to the hydrogen-consuming workshop building not lower than Grade II fire resistance or non-open-fire-working Class D or Class E workshop building not lower than Grade II fire resistance, but the adjacent wall shall be the fire-proof one without door, window or opening.

4.1.12 Hydrogen filling station, gaseous hydrogen receiver, filling station and manifolds room shall be equipped with lightning earthing facilities according to the requirements of GB 50057 and GB 50058. Lightning protection devices shall be detected once every year. All the lightning and electrostatic earthing devices shall be periodically detected for the earthing resistance at least once every year; lightning protection devices in the explosive hazard zone should be detected once every half year.

4.1.13 As for the hydrogen filling station, gaseous hydrogen receiver, filling station, manifolds room and loading platform, their grounds shall be flat and smooth, sparkless and wear-resistant.

4.1.14 As equipment hoisting or hydrogen filling shall be conducted in the hydrogen filling station and filling station, bundle of seamless steel cylinders shall be adopted and hoisting facilities should be arranged, and the hoisting weight of hoisting facilities shall be determined according to the maximum load of the hoisting pieces; explosion-proof hoisting facilities shall be adopted in the explosive hazard zone.

4.1.15 Filling station, manifolds room, empty cylinder and full cylinder shall be arranged according to the following requirements:

- a)** Manifolds room, empty cylinder and full cylinder shall be separated. Where the empty cylinder and full cylinder are stored in the closed or semi-open building, manifolds room shall be connected with the empty cylinder room or full cylinder room through door opening, but each room shall be provided with independent entrance/exit.
- b)** Where the full cylinders are not greater than 60, the empty cylinders, full cylinders and manifolds may be arranged in the same room, but the full cylinders and empty cylinders shall be separated; the spacing between the full cylinders and empty cylinders shall not be less than 0.3m. The spacing between the empty (full) cylinders and manifolds should not be less than 2m.
- c)** Manifolds room, empty cylinder room and full cylinder room shall not be directly connected with the instrument room, distribution room and welfare quarter, which shall be separated by the fire wall without door, window or opening. Otherwise, double-foyer room shall be arranged, self-closing door (e.g. swing door) shall be adopted, and fire endurance shall not be less than 0.9h.

medicines that may affect their operation or judgment.

4.3 Hydrogen system

4.3.1 Hydrogen mass in the hydrogen system shall meet its safety requirements.

4.3.2 After stopping, the hydrogen system shall be separated with operating equipment with blind plate or other active isolating measures, and replaced and purged with the inert gas (its oxygen volume fraction shall not exceed 3%) in conformity with the safety requirements. Hot work shall conform to the written examination and approval system by the director of the security department. Hydrogen system hot work overhaul shall ensure that the maximum hydrogen volume fraction content shall not exceed 0.4 % in the system and hot work zone. Overhaul or inspection facilities shall be intact and reliable, and personal protective articles shall meet the requirements. Open fire and other excitation energy must be forbidden in the fire-forbidden zone; never use all tools and hot objects that may generate open fire and high temperature such as electric furnace, electric drill, stove and blow lamp. Sparkless tools shall be adopted during hot work overhaul. Replacement and purging shall be implemented in accordance with Chapter 5.

4.3.3 Withstand voltage, washing (purging) and airtight test shall be carried out for the hydrogen system used for the first time or after overhaul, which may be put into service after it meets the requirements. Air-tight test shall be carried out for the just assembled bundle of seamless steel cylinders; the test pressure is nominal operating pressure of the cylinder; the bundle without leakage point shall be regarded as qualified; the test medium shall be nitrogen or oil-free air.

4.3.4 Oxygen volume fraction of hydrogen in the hydrogen system shall not exceed 0.5%, and the hydrogen system shall be equipped with replacement and purging facilities with inert gas of oxygen content less than 3%.

4.3.5 Hydrogen system equipment must not be knocked, maintained under pressure, fastened, or overpressure during operation. Hydrogen system equipment must not be under a negative pressure state.

4.3.6 Hydrogen system overhaul or inspection operation shall be formulated with operating scheme, provided with such safety protection measures as isolation, replacement and ventilation, and examined and approved by the equipment, safety and other relevant departments. Without written examination and approval of the director of security department, the operating personnel shall not arbitrarily maintain or disassemble the safety protection devices on the hydrogen equipment and pipeline system.

4.3.7 Gaseous hydrogen filling system shall be equipped with overpressure-relief safety valve, hydrogen return valve, grouping stop valve, purging vent valve, pressure display alarm instrument, test instrument for residual gas and oxygen content in the cylinder, and vacuum

extractor, etc.

4.3.8 Hydrogen system may be equipped with gas filtration device, on-line hydrogen leakage alarm instrument, on-line hydrogen purity instrument and on-line hydrogen hygograph as required by the process.

4.4 Equipment and pipeline

4.4.1 Hydrogen equipment shall be strictly prevented from leakage; the sealing of such spare parts as meters and valves shall be in good condition and inspected periodically; leak source shall be handled timely when found.

4.4.2 Air leakage inspection for the connecting points of hydrogen equipment, pipeline and valve shall be carried out with neutral soap water or portable flammable gas detecting alarm, for which open fire must not be used. Portable flammable gas detective alarm shall be calibrated periodically.

4.4.3 Electrical equipment in the explosive hazard zone shall meet the requirements of GB 3836.1, with Class II, Grade C and Group T₁ explosion-proof grade; explosion-proof measures shall be taken for the non-explosion-proof equipment, if necessary, used in the explosive hazard zone.

4.4.4 Hydrogen pipeline shall be seamless metallic one and must adopt cast iron pipeline; pipeline shall adopt welding connection or other connection modes that can prevent hydrogen leakage effectively. Pipeline shall adopt valves and accessories with good sealing performance; ball valves and globe valves should be adopted on the pipeline. Selection of valve materials shall meet the requirements of Table 12.0.3 in GB 50177-2005; selection of flanges and gaskets on the pipeline shall meet the requirements of Table 12.0.4 in GB 50177-2005. Threaded tight coupling should not be adopted between pipelines; sealing gasket connecting hydrogen pipeline and accessory shall adopt stainless steel, non-ferrous metal, polytetrafluoroethylene or fluoroelastomer materials; PTFE tape or other insulating materials must not be used as the connection sealing measures.

4.4.5 Hydrogen pipeline shall be arranged with analysis and sampling opening as well as purging opening in the positions that can meet the requirements for the gas sampling, purging and replacement in the hydrogen pipeline; vent pipe shall be arranged at the highest point and fire arrestor shall be arranged at the pipe orifice; drainage installation shall be arranged at the lowest point of the humid hydrogen pipeline.

4.4.6 Overhead laying mode should be adopted for the hydrogen pipeline, and its bracket shall be non-combustible component. Overhead pipeline shall not be laid on the same bracket with cable, conducting circuit and high-temperature pipeline. Where hydrogen pipeline is laid on the same bracket with oxygen pipeline, other flammable gas pipeline or flammable liquid pipeline, hydrogen pipeline should be separated with the above pipelines with utility pipeline

- c) Strict measures shall be taken to prevent welding slag, iron rust and combustible from entering into or remaining in the pipeline during and after the installation of hydrogen pipeline, valve and pipe fittings;
- d) Test medium and test pressure of hydrogen pipeline shall meet those specified in Table 12.0.14 of GB 50177-2005;
- e) After qualified strength test, hydrogen pipeline shall be purged with oil free air or inert gas at the flow rate not less than 20 m/s until the outlet is free from iron rust, dust and other dirt that is regarded as the qualified point.
- f) Long-distance buried running piping should be subject to electrochemical protection during design and installation and ball-passing treatment before purging. Electrochemical protection should be detected once every year and the detection results shall be archived and put on records.

4.4.14 Gaseous hydrogen filling platform should be arranged with two groups of or more bundles of seamless steel cylinders, one group for supplying gas and the other for reversing cylinders.

4.4.15 Hydrogenation reactor and its pipeline material shall meet the requirements of SH 3059 due to application of hydrogen under high pressure and high temperature. During the operation period of hydrogenation reactor, the operating personnel shall strictly enforce the process operation regulations, ensure stable reaction temperature and pressure, and avoid temperature runaway and overpressure. Safety inspection shall be carried out at regular intervals, including appearance inspection, wall thickness measurement at fixed point, as well as wall temperature and corrosive medium composition analysis measurement at fixed time. Reasonable commencement and shutdown schemes shall be formulated before commencement and downtime; proper dehydrogenation process shall be added during the downtime, so as to avoid emergency pressure relief and cooling. Inspection focuses on weld zone, clad layer, bolt and nut, washer and supporting structures inside and outside of vessels by such methods as nitrogen gas seal, non-destructive testing for internal wall of reactor, and macrographic inspection for internal wall, and air-tight test or hydraulic test shall be taken if necessary to ensure the use safety of hydrogenation reactor.

4.4.16 In the annealing furnace in the metallurgy industry, programmable logic controller (PLC) and intelligent adjuster shall be adopted not only to conduct full automatic control operation for the overall annealing process but also to monitor overtemperature of heating mantle and furnace hood, over-current, overload and overheating of severe convection fan of furnace base, over-current and overload of cooling fan of cooling hood, as well as protective atmosphere in the furnace during gas replacement and annealing process. Under the premise that the protective gas supplied meets the safe service conditions, leak tightness of annealing furnace as well as continuity and pressure of protective gas supply shall be ensured. During the annealing process, the normal operating pressure of gas in the annealing furnace shall be

kept at micro-positive pressure (absolute pressure is 105 kPa, slightly higher than one standard atmospheric pressure), and pressure alarm system shall be arranged. Operation specifications shall be strictly enforced during the operation, commencement and downtime period; relevant plan or scheme shall be formulated during the commencement, downtime and overhaul process, so as to ensure the use safety of annealing furnace. Annealing furnace shall be equipped with protective hydrogen purification equipment.

4.4.17 Technical specifications for the hydrogen-cooled generator in the power plant (station) may be implemented with reference to "Operating Regulations for Turbine Generator". Other technical requirements shall be in accordance with the relevant requirements in the electric power industry.

4.4.18 Safety colors shall be painted according to the requirements of GB 7231, GB 2893 and GB 2894, and safety marks and signs shall be arranged.

5 Replacement

5.1 The equipment and piping to be replaced in the hydrogen system shall be isolated reliably from the system.

5.2 The replacement method with inert gas shall meet the following requirements:

- a)** The volume fraction of oxygen in inert gas shall not exceed 3%.
- b)** The replacement shall be made completely, preventing hydrogen residual at blind angle or end point.
- c)** The contents of oxygen or hydrogen in the hydrogen system shall be eligible in at least two continuous analyses; the replacement may end where the volume fraction of oxygen in the hydrogen system is less than or equal to 0.5% and the hydrogen volume fraction less than or equal to 0.4%.

5.3 The evacuating by water injection shall meet the following requirements:

- a)** It shall be ensured that equipment and pipe are full of water completely, and all hydrogen is exhausted completely.
- b)** Water shall overflow from the overflow vent on the equipment top after injecting water, and overflow shall last a period of time.

5.4 The bundle of seamless steel cylinders may be replaced by the methods below:

- a)** Pressure replacement method: the equipment or system is filled with inert gas at a

6.3 Hydrogen Cylinder (Cylinder Bundle)

6.3.1 Full and empty cylinders for gaseous hydrogen shall be respectively stored in the warehouses at the fringe of the equipment, and they shall be far away from naked flame or the equipment whose operating temperature shall be equal to or higher than the self-ignition point.

6.3.2 Design, manufacturing and inspection of hydrogen cylinders shall meet the "Safety Inspection Regulations for Gas Cylinders".

6.3.3 According to the requirements in GB 7144, gaseous hydrogen cylinder body shall be light green, air cylinder with pressure 20MPa shall be marked with yellow circle, and letters "hydrogen" and filling organization name in red paint. Paint color and letters shall be kept bright at all times.

6.3.4 Except in special needs of manufacturing, the hydrogen cylinders used in multi-storey building should be arranged on the external wall on the top storey.

6.3.5 As for the hydrogen cylinders used indoors (onsite) due to production demand, the quantity hereof shall not exceed 5, the ventilation conditions indoors (onsite) shall conform the requirements in 4.1.5, and the arrangement of the ventilation shall meet the following requirements:

- a) The clearance from hydrogen cylinder to vessel/air cylinder containing flammable, explosive, combustible substance or oxidizing gas shall not be less than 8m;
- b) The clearance to open fire or common electrical equipment shall not be less than 10m;
- c) The clearance to induced draft inlet of air conditioner, air compression pump and ventilating equipment (non-explosion-proof) shall not be less than 20m;
- d) The clearance to other flammable gas storage places shall not be less than 20m.

6.3.6 During the transportation, cylinder opening of hydrogen cylinder body shall be arranged with anti-collision measures like cap (except gas cylinder with protective hood), shock proof ring (except bundled cylinder) to avoid damage to valve.

6.3.7 Hydrogen cylinders shall be handled carefully free of throwing or rolling, and they must not be subject to impact or sharp shock. Hydrogen cylinders shall not be rolled downwards from the vehicle, and they shall be fixed strictly during transportation.

6.3.8 The place in which hydrogen cylinders are stored and used shall be kept well-ventilated. The hydrogen cylinders shall be kept clear of fire source, heat source and sun insolation. They shall not be stored with chemical products like strong acid, strong base and

oxidant in same storehouse. Hydrogen cylinders shall be stored by being isolated from oxygen cylinder, chlorine cylinder and fluorine cylinder.

6.3.9 Hydrogen cylinder, when in use, shall be arranged with air reducer, and the threads of the air reducer joint and pipe joint shall be screwed in not less than 5 circles.

6.3.10 Hydrogen cylinders, when in use, shall be fixed in the way specified in 4.1.15 d), to prevent tip over. The cylinder, pipe, valve and joint shall be fixed and kept from looseness or moving, and anti-collision devices shall be arranged for pipe and valve.

6.3.11 If the mouth of a gas cylinder is frozen, the valve shall be closed down first and then unfrozen with warm water.

6.3.12 The gas in the cylinder shall not be used out, and the gas cylinder shall be preserved with pressure of at least 0.05MPa, to prevent air accessing the gas cylinder inside.

6.3.13 Gas cylinder valve, if damaged, shall be repaired by the organization with relevant qualification.

6.3.14 For opening the gas cylinder valve, the operating staff shall stand at back of the valve port, and open the valve slowly.

6.3.15 According to the requirements of "Safety Inspection Regulations for Gas Cylinders", hydrogen cylinders shall be inspected regularly (every three years), and they shall be marked with inspection stamp and color code.

6.3.16 Cylinder bundle shall have anti-collision devices to prevent pipe and valve from collision; gas cylinder, pipe, valve and joint shall be repaired and maintained frequently, and kept from looseness, moving or leakage.

6.3.17 Manifold main and branch of hydrogen cylinder bundle shall be good-quality copper pipe or stainless steel pipe. Copper pipe and pipe fittings shall be welded by silver brazing to ensure the tightness of weld; after welding, the piping, pipe fittings and weld shall be applied with stress relieving and annealing. Manifold main and branch of cylinder bundle shall subject to hydraulic test before use.

6.3.18 Each steel cylinder on the tube trailer shall be arranged with safe pressure relief device, and the valve and safe pressure relief device or its protection unit for the steel cylinder shall be able to subject to the inertia force as doubled as the weight of itself. Where the steel cylinder length exceeds 1.65m and its diameter exceeds 244mm, safe pressure relief device with low melting alloy plus bursting disk or independent bursting disc shall be arranged at both ends of the steel cylinder; safe pressure relief device with independent bursting disc should be arranged the steel cylinders 559mm or more in diameter; the valve (beside the filling port) on the head end of each shall be kept open normally. The discharge outlet of the

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