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Safety requirements for flammable materials, explosive devices, toxic gas and radiational sources in spacecraft

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Safety requirements for flammable materials, explosive devices, toxic gas and radiational sources in spacecraft

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FOREWORD

The standard is translated from the Chinese version of Standard on GB/T 29083-2012 released by Standardization Administration of China (SAC) under the management of State General Administration of Quality Supervision and Inspection and Quarantine. TC 425 is responsible for the translation. In case of any doubt about the contents of English version, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with rules given in GB/T 1.1-2009.

This standard is proposed by China Aerospace Science and Technology Corporation.

This standard is under the jurisdiction of National Technical Committee on Space Technology and Operation of Standardization Administration of China (SAC/TC 425).

INTRODUCTION

This standard belongs to the National Standard System of China Space. The National Standard System of China Space is applicable to the formulation, revision, and management of national standards in the field of space, covering three sectors of space management, space technology, and space application and services and serving as the basis for guiding spacecraft and launch vehicle project management, engineering, space launch services, and in-orbit satellite applications.

Based on task requirements, the spacecraft inevitably adopts flammable materials, explosive devices, toxic gas, radiational sources and other products, which bring safety risks to spacecraft and safety threats to astronauts. In order to avoid the potential safety hazards, China set up design and utilization requirements for flammable materials, explosive devices, toxic gas, radiational sources of spacecraft, which have been successfully tested and applied on manned spacecraft and Beidou satellites. This standard will play an effective role in guiding and effectively controlling the utilization of flammable materials, explosive devices, toxic gas, radiational sources in spacecraft.

Safety requirements for flammable materials, explosive devices, toxic gas and radiational sources in spacecraft

1 Scope

This standard specifies the safety design and application requirements for propellant storage and feed system, pyrotechnics devices, high-pressure vessel, gas and liquid pipelines, electric devices, battery, radiational sources, propellant ground operation and flammable materials selection in the identification of dangerous sources of spacecraft.

This standard is applicable to the whole process of spacecraft ground and flight tests.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB 3836.1 Explosive atmospheres Part 1: Equipment General requirements

GB 14347 Discharge standard of water pollutants for space propellant

GB 19517 National safety technical code for electric equipment

GB/Z 114 Radiological protection standards for using sealed radioactive sources and container of γ sealed radiation sources

3 Terms and definitions

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

3.1

sealed module

module that can prevent the gas leakage or keep gas leakage rate lower than a certain limit.

3.2

flammable material

materials with ignition point close to or lower than normal temperature.

3.3

explosive device

pyrotechnics device, high-pressure vessel, battery, etc. which are easily explosive when burned.

3.4

toxic gas

gas that propellant and materials emit and that imposes potential harm to people, other creatures, and the environment.

4 General requirements

4.1 In spacecraft design, attention shall be focused on safety. For the equipment and system using flammable materials, explosive devices, toxic gas and radiational sources, strict safety control and protective measures shall be formulated and executed.

4.2 Specific procedures shall be prepared, suitable safety protection equipment provided and effective safety protective measures taken for the installation, experiments, tests, loading and unloading, transportation and maintenance of spacecraft equipment and system that adopt the flammable materials, explosive devices, toxic gas and radiational sources.

4.3 Spacecraft equipment and system using flammable materials, explosive devices, toxic gas and radiational sources shall be operated by qualified professionals. Operators shall use required protective devices, conduct the operation in strict accordance with safety operation procedures, implement the double-post system and keep records for future reference.

4.4 Spacecraft equipment and system using flammable materials, explosive devices, toxic gas and radiational sources shall be subject to the specified ground test and confirm that these hazardous items have met safety index requirements before being used in the spacecraft.

5 Safety requirements for equipment and system

5.1 Equipment and system installed in the sealed module with sources of danger shall meet such design safety requirements as sealing, pressure tolerance, fire prevention, etc.

5.2 Gas and liquid pipelines using toxic medium shall have sufficient bearing capability to ensure that they will not be damaged under various loads and that no pollution or fire accidents will be caused by leakage of toxic materials as a result of pipeline system damage.

6 Safety requirements for the propellant storage and feed system

6.1 The propellant storage and feed system shall adopt the structural design for effective prevention of propellant leakage. Under the maximum design operation pressure, the leakage rate of propellant storage and feed system shall meet specified requirements. Propellant shall be loaded after the leakage detection test is passed for installed system.

6.2 Generally, the burst pressure of propellant tank and gas cylinder shall not be lower than twice of maximum work pressure, while the burst pressure of other pressurized parts shall not be lower than four times of maximum work pressure. Inspection pressure of pressurized parts is often 1.5 times of maximum work pressure.

6.3 A pressure transducer shall be installed in the output section of gas cylinder, storage tank, and pressure reducing valve or pressure stabilizing valve.

6.4 The propellant storage and feed system shall have sufficient strength and rigidity to bear the stress of test, operation, transportation, launching, in-orbit operation, return environment, and shall not be so deformed that leakage faults occur under specified conditions.

6.5 Propellant tank shall have obvious marks or labels to indicate the name and capacity.

6.6 The welding line and joints of propellant tank and pipelines shall be subject to leakage detection and the leakage rate value shall be recorded.

6.7 The propellant storage and feed system shall be under the controllable safe thermal environment.

6.8 Combustion and oxidizing agents shall be completely isolated to prevent the explosion.

6.9 Filling and drain ports of combustion and oxidizing agents shall be kept at a safe distance, and shall be strictly distinguished and marked clearly.

6.10 Before the start-up of propulsion system, propellant is only stored inside the tank. Isolation valve at the outlet of propellant tank shall be close to the tank. Before the system operation, isolation valve shall be closed.

6.11 At least two serial and independent valves shall be installed along the pipeline from propellant tank to engine.

6.12 Propellant shall not directly contact with heating components. Parts that may generate sparks and electrostatic discharge (ESD) shall be sealed and grounded properly.

6.13 Differential design shall be adopted for the connecting parts interface of storage and feed system pipeline with different kinds of propellants.

6.14 Emergency isolation measures and treatment procedures shall be in place for the leakage when engine or system fails.

7 Requirements for application safety of pyrotechnics device

7.1 Failure of pyrotechnics device shall not damage the integrity of spacecraft body and the leakproofness of sealed module.

7.2 Pyrotechnics and electric explosive device shall be capable of preventing the accidental ignition caused by the following reasons: static accumulation, thunder and electromagnetic interference inside the launching area.

7.3 Non-electric conductive detonation device inside the module shall have protective device to prevent from misoperation.

7.4 After the installation of pyrotechnics device, striking, cutting or punching operation is strictly prohibited.

7.5 Electrically initiated device or igniting components of pyrotechnics device shall be installed at the end of assembly procedure.

7.6 Except special provisions, dummy of pyrotechnics devices are generally used in the integration,, electrical test and mechanical envirionmental test of spacecraft.

7.7 Safety design of pyrotechnics device shall ensure that harmful gas shall not be exhausted to the sealed module during the operation.

8 Requirements for application safety of high-pressure vessel

8.1 High-pressure vessel shall have obvious marks or labels to indicate the volume, operating pressure

and flow direction.

8.2 High-pressure vessel shall be subject to the specified pressure test and seal leakage detection before being used in spacecraft.

8.3 Safety requirements for filling high-pressure vessel shall be subject to the specified documents.

8.4 High-pressure vessel shall have the capability to discharge medium out of the vessel. Discharging technology shall prevent the medium having mutual chemical reaction from mixing and leading to the fire or explosion.

8.5 All high-pressure gas cylinders inside the re-entry module of returnable spacecraft shall be discharged to the safety limit prior to the landing.

8.6 Effective isolation measures shall be applied to the high-pressure fluid container to prevent the overflowing working fluids from damaging the adjacent equipment.

8.7 When heating equipment, such as heater, is used to monitor and control the heating in the sealed module, measures shall be taken to ensure that toxic gas will not be released to the sealed module. Heater shall be equipped with thermal control circuit to monitor and control the overheating, and automatic shutdown device shall also be placed.

8.8 Operators of system comprising high-pressure vessel and pipeline shall pass the assessment, operate and test the high-pressure gas system based on the detailed operating steps and safety measures.

8.9 The welding line of high-pressure vessel shall be subject to leakage detection and the leakage rate value shall be recorded.

8.10 Refer to Chapter 6 for relevant contents of propellant tank.

9 Requirements for application safety of gas and liquid pipelines

9.1 The minimum burst pressure of pipeline system shall be at least 4 times of maximum working pressure. Or the pipeline system shall be designed with the safety coefficient determined after approval level by level.

9.2 Pipeline, valve and joints shall be fastened firmly and protected properly to avoid the danger of leakage and shall not be used as hand rail.

9.3 Isolation valve shall be used as the first component at the downstream area of high-pressure vessel and come close to the high-pressure vessel as much as possible.

9.4 Fluid inside the pipeline shall not freeze or boil under the static or normal flowing state; if the fluid is frozen or boiled, the pipeline shall be capable of preventing the system from suffering irreparable damage.

9.5 Fluids in the fluid loop of sealed module shall select the nontoxic, non-corrosive and non-flammable working fluids.

9.6 The potential liquid leakage shall be eliminated or removed from heat exchanger.

9.7 The welding line of pipeline shall be subject to leakage detection and leakage rate value shall be

recorded.

9.8 Refer to Chapter 6 for pipelines of propellant.

9.9 See 8.8 for operator requirements.

10 Requirements for application safety of electrical devices

10.1 Electrical system or equipment shall not result in dangers of electric sparks, fire, explosion and over-temperature.

10.2 Electrical system shall be well grounded and common grounded.

10.3 Equipment with electromagnetic radiation and dangerous equipment shall prevent dangers caused by short circuit/open circuit or static accumulation.

10.4 Electrostatic discharging path shall be designed to prevent spacecraft from generating ESD during the space flight.

10.5 Grounding design shall be standardized and shall ensure that metal enclosure is equipotential body.

10.6 Electric devices of electric connectors with power output, especially for equipment with output voltage of 100V, shall be connected by means of base hole to prevent the accidental short circuit.

10.7 The solvents that may easily release harmful gas shall not be used for electric devices in the operation process. If it is necessary to carry out such technological operation as the acid pickling, it shall be ensured that relevant measures, including ventilation, will be taken and gas will be volatilized completely without any residue within a certain period of time.

10.8 Application safety of electric devices shall meet GB 19517 requirements.

11 Requirements for application safety of battery

11.1 Battery shall have obvious marks and special safety precautions.

11.2 Battery shall be sealed inside the container. Shell design of battery shall ensure that the electrolyte can be fully accommodated under the conditions of overpressure, overload or short circuit. If battery shell is damaged, electrolyte shall not leak.

11.3 During the storage, transportation, installation and readjustment of battery set that has already passed though acceptance, influence on its performance before the launching shall be minimized.

11.4 Lithium battery shall be stored in environment free of chemical pollution and shall not be close to heat source; the battery shall be stored in the temperature range of -10℃~10℃, with relative humidity no higher than 80%. State of charge in storage shall be no more than 50% or follow related detailed specifications. The storage period is two years and the battery shall be activated once half a year.

11.5 Cadmium-nickel battery shall be stored in form of battery cell under the discharge condition. The positive and negative electrodes of the battery cell shall be short circuited; the storage temperature is -10℃~5℃ and the storage period is three years.

11.6 Zinc-silver battery shall be stored in warehouse under the temperature of 5℃~35℃ with relative

humidity no higher than 80%. No acid, alkali and other corrosive gas and radiational material shall be stored in the warehouse. The storage period is five years in dry state.

11.7 In-orbit use shall meet the following requirements:

a) Control methods and parameters for the normal and emergency charging of battery set shall be based on the data of spacecraft and battery set measured during the development. Charge control is mainly performed by automatic control and supplemented by command control. Under any circumstance, overcharge at high rate shall be avoided. Measures shall be available to adjust the recharging rate.

b) In general, recharging ratio shall be kept at 1.00~1.20.

c) Charging current shall be adjusted based on the operating temperature and recharging time of battery and charging voltage capacity.

d) When the recharging volume of battery set meets the requirements, it shall be converted to trickle charging and such trickle charging will be maintained until the next discharging permitted in orbit. Trickle charging current shall ensure that capacity of battery set is always the capacity reached by normal charging.

e) When it is permitted in operation orbit, battery set shall be subject to the periodic in-orbit readjustment.

f) At the resting period, trickle charging shall be provided to the battery set as much as possible and trickle charging rate shall be sufficient to maintain the battery capacity. Resting period without trickle charging shall not exceed 96 hours.

g) During in–orbit operation, depth of discharge and cycle times of battery set shall be no more than design value of battery set.

h) When the temperature of battery set reaches to the safe temperature, protective device shall be capable of reducing or disconnecting the charging automatically.

i) Voltage and current parameters of battery set or battery cell shall be monitored regularly.

j) In the charging or discharging circuit of battery set, on-off switch that can be controlled by remote control command shall be configured.

12 Requirements for application safety of radiational sources

Safety application of radiational sources shall meet the requirements specified in GB/Z 114.

13 Safety requirements for propellant ground operation

13.1 Propellant professionals shall be qualified and familiar with the following requirements:

a) Physicochemical properties of propellant;

b) Physiological effect of propellant toxicity on the human body;

c) Maximum allowable concentration of propellant toxicity;

d) Flammability limit of propellant in the air;

e) Compatibility of propellant with contacting materials;

f) On-site purification methods and steps;

g) Prevention and control methods for the fire and leakage;

h) Operation and use methods of safety equipment.

13.2 Detailed safety measures and operation procedures shall be formulated and executed for the operation involving propellant.

13.3 Operation position for the filling, discharging, blowdown or draindown system of propellant shall be set outside the module, or at the place that can be easily accessed and operated from outside.

13.4 Safety requirements for propellant filling are as follows:

a) During and after the filling, monitoring points shall be set at the internal and external environment of manned spacecraft for the safety monitoring. Monitored value shall be reported to the site commander in time. When monitored value exceeds the safety value, the filling shall be suspended to implement troubleshooting;

b) Prior to the operation, operators shall firstly contact ground rod or use the static eliminator to eliminate the static electricity on human body;

c) Filling operators shall use the protective articles that are inspected to be qualified. Such protective articles shall include fully enclosed rubber overall (or overall for upper or lower body) resistant to static electricity and corrosion, anti-static and corrosion-resistant rubber shoes, gas mask or oxygen mask. Other operators shall wear the cotton overall and anti-static cloth, shoes and socks;

d) During the filling, ventilation equipment shall operate normally and good ventilation shall be maintained.

13.5 After filling, the spacecraft shall be placed in a still enclosed space for 24 hours before the internal and external detecting points are detected.

13.6 Special safety requirements for nitro oxidizer: When the ambient temperature is close to boiling point of nitro oxidizer under relevant environment, the container cap shall not be opened.

13.7 Special safety requirements for hydrazine fuel: During operation, electric devices, ventilation and lightning devices, power switch and other equipment to be selected for use shall meet the requirements of GB 3836.1; dimethyl hydrazine, anhydrous hydrazine, DT-3 shall select Group T3, Grade A, Class II; methyl hydrazine shall select Group T4, Grade A, Class II. When filling propellant and pressurizing for methyl hydrazine, pressurized gas shall use helium.

13.8 Special safety requirements for mixed amine fuel: during operation, the selection of electric devices, ventilation and lightning devices, power switch and other equipment shall meet the requirements of Group T2, Grade A, Class II of GB 3836.1.

13.9 Waste-water discharge management of propellant ground operation shall meet the requirements of GB 14374.

14 Safety requirements for selection of materials

14.1 Within the human reaching area, metallic materials that will damage human health or pollute the environment shall not be used, such as Sb, As, Ba, Cd, Cr, Pb, Hg and Se. When these materials must be used to complete specific function and performance inside the equipment, the quantity of these materials shall be strictly limited. It is strictly forbidden to use toxic metals like beryllium, beryllium oxide, beryllium alloy and mercury inside the sealed module.

14.2 Materials coming into contact with propellant shall have good compatibility with propellant during its life time to prevent the damage caused by corrosion. Absorptive thermal insulation materials shall not be used for propellant storage and feed system. Thermal insulation materials shall not produce the chemical reaction with propellant.

14.3 Non-metallic materials shall pass performance test, and the non-metallic materials used inside the sealed module of spacecraft shall pass the fire retardant test and test of harmful gas released. Other non-metallic materials shall subject to the material mass loss test in the vacuum condition and volatile condensable matter test.

14.4 Spacecraft equipment shall be made from materials with good thermal stability and the materials shall not release flammable, explosive and toxic substances under the operation temperature.

14.5 Generally, composite materials shall be subject to vacuum degassing before they are applied in spacecraft.

14.6 Non-metallic materials selected for application in spacecraft shall meet the following requirements:

a) Non-metallic materials used inside the sealed module of spacecraft shall be fire-resistant, anti-static and flame retardant;
b) Pollutants released from the materials shall not produce chemical reaction with atmospheric composition inside the module and generate the toxic matters beyond the specified range;
c) There shall not be interactions that may produce the flammable, explosive and harmful secondary dangerous compounds;
d) Level of stimulating or special odors released shall not be higher than 1.5;
e) The quantity of carbon monoxide released from it shall not be larger than 25μg/g (under normal atmospheric environment, 101.325kPa, 50℃, 72 hours); the quantity of total organic matter released from it shall not be larger than 100μg/g (pentane) (under normal atmospheric environment, 101.325kPa, 50℃, 72 hours);
f) Total mass loss shall not be greater than 1%;
g) The percentage of volatile condensable matter shall not be larger than 0.1%;
h) Flashing and ignition point shall not be lower than 204℃.

14.7 It is forbidden to use the following materials in the sealed module:

a) Rubber: chloroprene rubber;
b) Tape: 8711 double-sided aluminized polyester film pressure-sensitive tape, adhesives releasing deadly toxic compounds and stimulating odor;
c) Plastics: 5564 PVC foam plastics, high pressure vinyl chloride and polyvinyl chloride products must not be used as food packages;
d) Coating: FR-A fire-proof paint, noise reduction and damping coating and oil paints;
e) Composite materials: 9713 orange-yellow polyester pongee;
f) Oils: petroleum products (gasoline, kerosene and diesel);
g) Non-metallic materials having or releasing stimulating odor: such as acid, halogen, halide, ammonia, amine, dimethyl sulphate, formaldehyde, phenol and other compounds;
h) Plywood, compressed panel, shaving board and their products: such as poly plate and paper overlaid plywood;
i) Insecticides and cigarette materials.