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Space systems — Oxygen safety —

Part 5: Operational and emergency procedures

Systèmes spatiaux — Sécurité des systèmes d'oxygène —

Partie 5: Procédures de fonctionnement et d'urgence

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22538-5 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

ISO 22538 consists of the following parts, under the general title *Space systems — Oxygen safety*:

— *Part 1: Design of oxygen systems and components*

— *Part 2: Selection of metallic materials for oxygen systems and components*

— *Part 3: Selection of non-metallic materials for oxygen systems and components*

— *Part 4: Hazards analyses for oxygen systems and components*

— *Part 5: Operational and emergency procedures*

— *Part 6: Facility planning and implementation*

Space systems — Oxygen safety —

Part 5:
Operational and emergency procedures

1 Scope

This part of ISO 22538 specifies a set of operational and emergency procedures for the safe storage, handling and transfer of liquid and gaseous oxygen.

2 Terms, definitions and abbreviated terms

2.1 Terms and definitions

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

2.1.1
oxygen-enriched atmosphere
gas mixture or liquid mixture that contains more than 25 volume percent oxygen

2.1.2
qualified technical personnel
person who, by virtue of education, training or experience, knows how to apply physical and chemical principles involved in the reactions between oxygen and other materials

EXAMPLE Engineers, chemists.

2.2 Abbreviated terms

GOX gaseous oxygen

LOX liquid oxygen

PPE personal protective equipment

SOP standard operational procedure

3 Operational procedures

3.1 General guidelines

Standard operational procedures (SOPs) shall be developed, with checklists as required. The SOPs shall be prepared by qualified technical personnel familiar with the work being done and be reviewed by personnel experienced the use of oxygen. SOPs for all hazardous operations shall be reviewed by the designated safety authority. Occupational health personnel shall be involved in the review cycle when operational procedures involve potential health hazards. The SOPs shall be implemented by line management. SOPs shall provide for the control of hazards to an acceptable risk and shall be reviewed annually for observance and improvement. The procedures shall include the following:

a) notification of the designated safety authority during hazardous operations;

b) protection of personnel;

c) prevention and detection of oxygen leaks;

d) elimination of ignition sources;

e) identification of proper safety control and hazard identification equipment;

f) priming gaseous oxygen (GOX) or liquid oxygen (LOX) containing equipment during installation and start-up.

The design of safe facilities and equipment shall consider human capabilities and the limitations of personnel responsible for operations.

3.2 Personnel

3.2.1 General

3.2.1.1 Consideration for the safety of personnel at and near oxygen storage and use facilities shall start in the earliest planning and design stages. Safety documentation shall describe the safety organization and comment specifically on the following:

— inspections;

— training;

— safety communications and meetings;

— operations safety and instruction manuals;

— accident investigations;

— safety instruction records.

Training shall familiarize personnel with the physical, chemical and hazardous properties of LOX and GOX, with personal protective equipment (PPE), with the correct operation of oxygen systems and with hazard recognition and control prevention.

3.2.1.2 The responsible user organization of the facility shall be notified of oxygen transport, loading and use operations. The user organization shall ensure that the safety equipment required at the operational site is present, operational and that all necessary support organizations, such as security, have been notified. Transportation of oxygen-loaded systems shall not be scheduled during peak traffic periods if possible.

3.2.1.3 Equipment failures caused by operator errors can result in fires, explosions, injury and extensive damage. Operators shall be trained for proper operations and kept informed of any changes in operating or safety procedures. The operators shall be qualified and certified for working with LOX and GOX. They shall also be trained in the corrective actions required in an accident. Personnel engaged in operations shall be advised of the hazards that may be encountered.

3.2.2 Confined space

3.2.2.1 Instruments used for determining oxygen enrichment or oxygen depletion shall be calibrated in accordance with the manufacturer's requirements specific for the instrument. Given that oxygen itself is silent, odourless and invisible, undetectable by the human senses, the oxygen content of a workspace environment is a critical safety concern and shall not be underestimated for the following reasons:

— a slight reduction in the oxygen content of ambient air has physiological effects on exposed personnel: at low concentrations, it can incapacitate or even kill within minutes;

— a few percent increase in oxygen content increases flammability: without an effective detection/warning system, personnel are extremely vulnerable.

3.2.2.2 Personnel shall not be permitted to enter a confined space that may be subject to oxygen enrichment or oxygen depletion, or a confined space that contains a toxic material, until an assessment of that space is made and specific authorization is obtained. All personnel shall be aware of instrument limitations and cross-sensitivities to other contaminants. Entry shall be permitted in accordance with facility requirements and only trained personnel shall be allowed to use monitoring equipment, evaluate the possibility of access and actually enter the area. Free entrance is permissible only if the oxygen concentration is between 19,5 and 25,0 volume percent.

3.2.3 Operator certification

Before being certified to work with LOX or GOX, the operator shall demonstrate the following:

a) knowledge of the properties of LOX and GOX;

b) general knowledge of approved materials that are compatible with LOX and GOX under operating conditions;

c) familiarity with manufacturers' manuals detailing equipment operations;

d) proficiency in the use and care of protective equipment, clothing and safety equipment;

e) proficiency in maintaining a clean system and clean equipment in oxygen service;

f) recognition of normal operations and symptoms that indicate deviations from such operations;

g) conscientious following of instructions and checklist requirements.

3.2.4 Personal protective measures

3.2.4.1 General

Protective clothing and equipment, including respiratory protection, shall be included in personal protective measures. All operations that involve handling LOX shall be performed with a minimum of two members of staff (under the so-called “buddy system”) at the level required for the hazard and complexity of the task.

3.2.4.2 Safety clothing

3.2.4.2.1 Gloves for use around LOX systems shall not be made of leather and shall have a good insulating quality. They shall be designed for quick removal in case of infiltration by LOX. Because LOX may also infiltrate footwear, shoes shall have high tops, and trouser legs shall be worn outside and over the tops of shoes. The trousers shall have no external pocket openings and no cuffs. The shoes shall be of leather.

3.2.4.2.2 Personnel handling LOX shall wear head and face protection appropriate for the task. A face shield or a hood with a face shield shall be worn. If LOX is being handled in an open system, an apron of impermeable material shall be worn.

3.2.4.2.3 Oxygen will saturate normal clothing, rendering it extremely flammable. Clothing described as flame-resistant or flame-retardant under normal atmospheric conditions may be flammable in an oxygen-enriched atmosphere. Impermeable clothing components with good insulating properties may help protect the wearer from thermal injuries.

3.2.4.2.4 Any clothing that has been splashed or soaked with oxygen vapours shall not be removed until completely free of the gas. Personnel exposed to high-oxygen atmospheres shall leave the area and avoid all sources of ignition until the oxygen in their clothing dissipates. Oxygen can also saturate the skin, therefore personnel shall avoid ignition sources for 30 min after exposure.

3.2.4.3 Respiratory protection

If respiratory protection is required, as in cleaning, venting or purging operations, the breathing air used shall be periodically tested to ensure it meets required specifications. Cleaning, venting and purging operations may introduce chemical hazards, as well as oxygen deficiency or oxygen enrichment hazards. The breathing air shall be adequately characterized to ensure that the ambient air is safe to breathe. Respiratory protection shall be based upon this characterization.

3.2.4.4 Auxiliary equipment

3.2.4.4.1 Portable oxygen detectors of approved design are useful where oxygen leakage may increase fire and explosion hazards.

3.2.4.4.2 Safety showers and eye-wash fountains are provided only to deal with fire and corrosive chemicals or to flush cryogenic liquids from clothing and skin.

3.2.4.4.3 Water hoses shall be available to thaw valves and fittings on cryogenic storage containers. Atmospheric moisture may freeze on valve stems and similar components, making them impossible to open or close. Running water onto the frozen part may thaw the ice and enable component operation. Running water is also useful to thaw ice if a person's gloved hand freezes to a valve handle.

3.2.4.4.4 Appropriate warning systems shall be used to monitor oxygen systems that are a potential danger to operating personnel. The warning systems shall be shielded and designed in such a way that the operation of a single detection device serves to alarm, but not necessarily to initiate, basic fire and emergency protection. System and equipment safety components shall be installed for control of automatic equipment in order to reduce the hazards indicated by the warning systems. Manual controls within the system shall include automatic limiting devices to prevent overranging.

3.3 Cool-down and loading procedures

3.3.1 General

Appropriate cool-down and loading procedures shall be followed to limit liquid geysering and large circumferential and radial temperature gradients in the piping. Liquid flow cools a pipe faster than comparable gas flow and non-uniform cooling may occur with two-phase flow. System failures can result from operational pressure surges. The procedures and checklists shall ensure operation sequencing to prevent pressure spikes.

3.3.2 Cryogenic cold-shock

Subjecting a newly assembled LOX system to cold shock by loading it with clean liquid nitrogen following final assembly is highly recommended. After the cryogenic cold-shock, the system shall be emptied of liquid nitrogen and warmed to ambient temperature. Bolts and threaded connections shall then be retorqued to prescribed values and gas-leak-checking procedures shall follow.

Following cold-shock, the entire system shall be inspected for evidence of cracking, distortion or any other anomaly, with special attention directed to welds. System cleanliness shall then be checked and verified.

3.3.3 Hydrostatic testing

Where cleaning requirements preclude post-hydrostatic testing of a cold-shocked system, a thorough review of system integrity shall be conducted. This includes cases where a previously tested system is to be modified.

3.4 Examinations

A visual safety examination of the oxygen systems shall include verification of dimensions, joint preparations, alignment, welding or joining, supports, assembly and erection, and checking for conditions such as the following:

- corrosion (especially under insulation);
- mechanical damage;
- cracking (especially at welds and areas of known stress concentration);
- bulges or blisters;
- leakage;
- loose nuts, bolts, or other parts;
- excessive vibration;
- abnormal noise;
- excess temperature;
- discrepancies in gauge readings;
- pipe hanger condition;
- flexible hose anti-whip devices;
- frost on vacuum-jacketed lines and on containers;
- obstruction in relief-valve vents;
- evidence of contamination in system.

4 Emergency procedures

4.1 Types of emergencies

4.1.1 Leaks and spills

4.1.1.1 Primary danger

The primary danger from oxygen leaks and spills is a fire or explosion caused by combustible materials in the presence of a high concentration of oxygen. Oxygen-enriched environments greatly increase the rate of combustion of flammable materials. Just a few percent increase in oxygen content can increase flammability. This can happen rapidly in the event of a significant leak or spill, especially in a confined space. Without an effective detection/warning system, personnel are extremely vulnerable.

4.1.1.2 Gaseous oxygen

GOX leaks can result in oxygen-enriched environments, especially in confined spaces. Impingement of GOX onto an organic material such as grease can cause a fire. When leaks are detected, the source of the oxygen shall be halted or disconnected. Any equipment inherently heat-producing or spark-producing shall be turned off or disconnected. Disassembly and repair of leaking lines shall begin only after the area has been properly ventilated.