CHAPTER 10.2 SAFETY AND HEALTH REQUIREMENTS FOR TEST, VACUUM, OR OXYGEN-ENRICHED FACILITIES

10.2.1. Applicability of this chapter

You are required to follow this chapter if you design, operate, oversee, or modify facilities used for testing or involve vacuum or oxygen-enriched environments.

10.2.2. Test facility

A test facility is a building, an area in a building, or outside area where hazardous tests and training activities are conducted as described in Chapter 6.8, “Space Systems and Test Safety.” Test facility requirements don’t apply to laboratories conducting analysis, research, or experimentation unless they involve human subjects or Humans in the Loop (HITL).

10.2.3. Requirements for all test facilities

10.2.3.1 Designers of test facilities shall:

a. Ensure hazardous test and training facilities meet the requirements in Chapter 10.1, “Safety and Health Requirements for Designing, Constructing, and Operating JSC Facilities.”

b. Ensure facility support systems meet applicable requirements found in other chapters of this JPR.

c. Provide an environment where a credible single-point failure, loss of or change in utilities, or loss of software command won’t injure test personnel or damage property.

d. Include warning systems that test personnel can see and hear in test and support areas. Warning systems shall:

   (1) Provide adequate warning to the affected area.

   (2) Include an effective maintenance program to keep the systems ready to safely and effectively support hazardous tests.

e. Include safety or medical monitoring stations if a real-time test safety officer or medical representative will be present for tests in the facility. Make sure monitoring capabilities are acceptable to the Safety and Test Operations Division or Occupational Health and include the following:

   (1) Visual coverage of the test.

   (2) Access to necessary data.

   (3) Direct communication with the test director.

   (4) Access to test team communications.

f. Include redundant life support systems if the facility provides life support functions to test team members, such as breathing air, oxygen, or cooling. Redundancy isn’t necessary if there is time to detect a life-threatening condition and rescue the affected team member.

g. Provide in-chamber emergency alarms and egress capability for test chambers and chamber locks large enough to trap personnel.

h. Include oxygen flow limiters, venting, or monitoring devices to prevent an oxygen-enriched environment in test areas where test personnel use oxygen and that don't meet the requirements of paragraphs 10.2.7through 10.2.10.

i. Provide emergency power and other necessary utilities for systems that, if lost, would endanger test personnel or property.

j. Meet the requirements of paragraphs 10.2.7 through 10.2.11 if they are vacuum or oxygen-enriched test facilities.

10.2.4. Requirements for test facilities using Human in the Loop (HITL) test subjects

10.2.4.1 Designers of facilities using Human in the Loop (HITL) test subjects:

a. Make sure rescue personnel can rescue incapacitated test subjects quickly under all test and anticipated emergency conditions.

b. Have a material control program to prevent flammability and toxic off-gassing hazards where people work in enclosed environments. The following are the minimum requirements for material control:

(1) Make sure such hardware meets the flammability and toxic offgassing requirements of NASA-STD-6001, "Flammability, Off-gassing and Compatibility Requirements and Test Procedures."

(2) Get written approval from the JSC Materials and Process Branch (ES4) for any material applications.

c. Include provisions to safely end a test and remove the test subjects if a power failure, fire, or other emergency happens.

d. Include a non-electric lifting device as the primary means to place and remove test subjects from the water in underwater test facilities.

e. Submit an engineering evaluation or research protocol for facilities using human test subjects either for approval by the Institutional Review Board (IRB, https://eirb.jsc.nasa.gov/) for use of the facilities with human subjects in research or obtain an exemption from IRB review. This assessment shall comply with NPD 7100.8 and NPR 7100.1, "Protection of Human Research Subjects". An IRB exemption can be obtained via one of the two processes as described in Section 6.8.10.1.c.

10.2.5. Safety and quality assurance provisions for test facilities

10.2.5.1 For safe operations that meet quality requirements, facility management shall:

a. Have a safety plan addressing how to make sure test and facility operations are safe. Have the plan approved by the Safety and Test Operations Division.

b. Prepare and maintain facility failure and hazard analyses as described in Chapter 2.3, "Hazard Analysis." The hazard analysis shall address all hazards of the facility hardware, support equipment, facility software, and operations and how the hazards are controlled.

c. Document quality assurance tasks for the facility in either the facility operating procedures or a quality assurance plan. Develop and maintain a quality assurance plan if the facility handles flight hardware or if required by the S&MA Flight Equipment Division. Quality assurance tasks may include:

(1) Calibrating instruments.

(2) Making sure consumables in life support systems, such as breathing air or water, meet any applicable standards.

(3) Inspecting hardware and making sure operations meet requirements.

(4) Certifying pressure systems.

10.2.6. Operating procedures

10.2.6.1 Test facilities shall have documented facility operating procedures at the operating level as described in Chapter 10.4, “Facility Baseline Documentation Requirements for Critical, Complex, or Hazardous Facilities.” The following requirements apply:

a. Signature concurrence is required from the Safety and Test Operations Division on the operating procedures .

b. Operating procedures may contain more stringent requirements than those of this JPR if necessary.

c. Operating procedures shall:

(1) Carry out the safety requirements of this chapter and of Chapter 6.8.

(2) Outline the processes, ground rules, and personnel for facility and test operation.

(3) Outline the process to work with the Safety and Test Operations Division.

10.2.7. Vacuum or oxygen-enriched facilities

A vacuum or an oxygen-enriched facility is a building or an area in a building with either a vacuum or an oxygen-enriched environment, as defined in the Glossary.
The requirements for vacuum or oxygen-enriched facilities don’t apply to the underwater neutral buoyancy facilities where the breathing air is less than 23% oxygen by volume.

10.2.8. Requirements for vacuum or oxygen-enriched facilities

10.2.8.1 All vacuum and oxygen-enriched facilities shall meet these requirements:

a. Follow applicable safety codes and standards , such as National Fire Protection Association (NFPA), National Electric Codes (NEC), and American Society for Testing and Materials (ASTM) standards.

b. Provide relief devices certified under JPR 1710.13, “Design, Inspection, and Certification of Ground-Based Pressure Vessels and Pressurized Systems,” for chambers with oxygen-enriched environments.

c. Have a material control program to control hazards with increased flammability or vacuum instability. The following are the minimum requirements for material control:

(1) Make sure hardware used in oxygen-enriched environments meets the requirements of NASA-STD-6001, “Flammability, Off-gassing and Compatibility Requirements and Test Procedures.”

(2) Make sure materials used in vacuum environments meet the requirements of JSC-SP-R-0022A, “Vacuum Stability Requirements of Polymeric Materials for Spacecraft Application.”

(3) Get written approval from the JSC Materials and Process Branch (ES4) for any material applications.

d. Provide a means to automatically de-energize electrical equipment and systems when the fire suppression system is activated.

e. Ensure electrical circuits are properly controlled as follows:

(1) Use adequate fuses or current limiters to electric circuits.

(2) De-energize all circuits before making or breaking connections. Use an environmental electrical connector such as the “zero-G connector,” Marshall Space Flight Center specification 40M39580B, and interrupt the load before making or breaking connections, if necessary.

NOTE: Normal values for current limiter settings may not be enough in a vacuum or an oxygen-enriched environment.

10.2.9. Requirements for facilities with people in oxygen-enriched environments

10.2.9.1 Designers of facilities with people in oxygen-enriched environments shall:

a. Use materials meeting the flammability requirements of NASA-STD-6001 in the atmosphere for all wire insulation and accessories.

b. Design, make, and install wire runs and bundles to:

(1) Avoid damage to insulation or connectors from crimping, scraping, pressure, or other sources of damage.

(2) Make them easy to inspect.

c. Keep all systems free of hydrocarbon contamination.

d. Never use pyrotechnic or ordnance devices where the device or heat from the device could contact an oxygen-enriched environment.

e. Provide a means to immediately detect an incipient fire or other hazardous condition in each crewed compartment of any test area. Automatically monitor any compartments that you can’t watch.

f. Include firefighting provisions and suppression systems to allow for safe rescue of test subjects under pretest and test conditions. Ensure the system can be activated and controled from both outside and inside a test compartment.

10.2.10. Requirements for facilities with people in vacuum environments

10.2.10.1 Designers of facilities with people in vacuum environments shall:

a. Provide a means to repressurize locks and chambers in an emergency. Develop procedures for emergency repressurization and conduct periodic training and drills.

b. Make sure any failure in a facility environmental control system affecting one test subject doesn't affect any other test subjects.

10.2.11. Training for working in test, vacuum, or oxygen-enriched facilities

10.2.11.1 Test, vacuum, or oxygen-enriched facilities shall have written training and certification requirements for each position. Facility employees shall:

a. Be trained in:

(1) Duties for normal operations and emergencies.

(2) The hazards faced and the safety precautions to take.

b. Be certified under Chapter 5.8, "Hazardous Operations: Safe Practices and Certification," if functioning as a chamber operator or rescue technician.

10.2.12. Emergency planning for test, vacuum, or oxygen-enriched facilities

10.2.12.1 Test, vacuum, or oxygen-enriched facilities shall:

a. Have an emergency action plan as described in Chapter 3.8, "Emergency Management."

b. Conduct emergency drills at least twice a year under the facility's or JSC's emergency procedures to make sure the test team can react to emergencies effectively. Ensure a representative of the Safety and Test Operations Division monitors and evaluates emergency drills. Regular emergency drills aren't required for inactive facilities.

c. If the facility has been inactive, ensure all test team members have participated in an emergency drill within 3 months before a test.

10.2.13. Other requirements for test, vacuum, or oxygen-enriched facilities

In addition to the requirements in this chapter, test, vacuum, or oxygen-enriched facilities shall meet the requirements in this table as they apply.

For . . .	*Follow this standard . . .*
Test facilities that use human subjects	• NPD 7100.8, "Protection of Human Research Subjects"
Vacuum or oxygen-enriched facilities	• JPR 5322.1, "JSC Contamination Control Requirements Manual" • JPD 8080.4, "Exposure to Reduced Atmospheric Pressures" • National Fire Protection Association Standard 99B, "Standard for Hypobaric Facilities" • ASTM Committee G4.05, "Fire Hazards in Oxygen Systems"

	• Compressed Gas Association, “Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres”
Determining what materials are acceptable in vacuum or oxygen-enriched environments	• NASA-STD-6001 • JSC-SP-R-0022A