Department of the Air Force
HQ AEDC (AFMC)
Arnold AFB, TN 37389

Safety, Health, and Environmental Standard

Title: **CRYOGENIC FLUIDS**

Standard No.: E13

Effective Date: 06/12/2015

Releasability: There are no releasability restrictions on this publication.

The provisions and requirements of this standard are mandatory for use by all AEDC personnel engaged in work tasks necessary to fulfill the AEDC mission. Please contact your safety, industrial health and/or environmental representative for clarification or questions regarding this standard.

Approved:

Contractor /ATA Director
Safety, Health, and Environmental

Air Force Functional Chief

Record of Review/Revision

(Current revisions are highlighted in yellow and marked with a vertical line in the right margin.)

Date/POC	Description
05/11/2015 S. Nikodym	Three-year review. No change in process. Minor administrative edits included: Expanding Paragraph 1.3 Applicability; removing parenthetical standard references, removing the OSHA Process Safety Standard reference (1910.119) since AEDC doesn't have quantities of applicable cryogens that meet or exceed the specified Threshold Quantities, adding a reference to NFPA 55 Compressed Gases and Cryogenic Fluid Code to supplement the requirements of AEDC SHE Std. D2, revising the definition of cryogenic fluid for consistency with 2014 revisions to AFI91-203 and NFPA 55, correcting the standard numbers for the referenced Compressed Gas Association standards, deleting a referenced book since it wasn't a regulatory, Air Force, or consensus standard.
03/11/13	Added NFAC supplement; no other change.
05/17/12 G. Sterling	Two-year review; revised/rearranged to improve clarity/consistency. Split requirements and responsibilities into two separate sections. Removed material covered by other standards or portions of this standard. Added reference citations; adjusted numbering throughout the document. Rearranged text is not highlighted. No change in process.
06/10/10 W. Jennings	Two-year review; minor administrative changes. Added format changes. Clarified the requirement for explosives training if using cryogenics as a rocket propellant. Clarified requirement for use of an apron in paragraph 4.1.7.4. No change in process.
02/09/08 W. Jennings	Annual review; minor administrative changes: Added Paragraph 4.1.1.6 to reiterate a requirement by higher level standards; deleted reference to AFI 32-1065 Grounding Systems which was rescinded 09/22/08
02/25/08	Annual review; no change required
04/11/07 Roosa	Annual review; minor formatting changes; updated organizational names and references; deleted duplications; removed responsibilities for Security Police and renumbered subsequent paragraphs; changed interval for refresher training from annual to three-year; corrected frequency for electrical protection systems inspections and testing from "as-required" to "annually." Changes are highlighted in yellow.
01/31/06 W. Jennings	Annual review; minor formatting updates; no other changes required.
07/20/04 W. Jennings	1.0 Reworded Introduction 2.0 Reworded the Basic Hazards and Human Factors section. 4.0 Moved the 'Procedures' section up to para. 4.10. 4.1.2.1 Required posting of emergency procedures, etc. 4.1.3.5, 4.1.3.6 and 4.1.3.7 Added 4.1.5.3 to 4.1.5.10 Added 4.1.7.3 Added boot requirements 4.1.7.4 Added 4.2.1 to 4.2.7 Added 4.1.9 Changed the paragraph to address requirements for SSHA and procedure for adverse weather. Inserted requirement to evacuate in event of lightning. 4.7.2 Changed the paragraph to require the use of cryogenic rated insulated gloves. 4.7.3 Changed the paragraph to require the use of cryogenic rated aprons. 4.3.3 AEDC/SE 03/02/05:Added "document" [site-specific training] to paragraph .
06/28/04	Eliminated first aid section.
06/28/02	Revised format of entire standard to the COI format.

Safety, Health, and Environmental Standard

CRYOGENIC FLUIDS

1.0 INTRODUCTION/SCOPE/APPLICABILITY

1.1 Introduction – This standard outlines general safety criteria applicable to activities involving cryogenic operations at AEDC.

1.2 Scope – This standard covers the process for cryogenic activities. The intent of this standard is to limit personnel exposure when conducting cryogenic operations by establishing consistent, safe, and efficient procedures. Base operating contractor shall notify the government of any conflicts noted between this standard and industry or national codes, standards, or regulatory requirements.

1.3 Applicability – This standard applies to all AEDC personnel and operations, including Air Force, Navy, Army Corps of Engineers and Contractors (including Subcontractors) at the Tennessee location and operations conducted by AEDC personnel outside the confines of Arnold AFB. Training requirements (to include use and inspection) for Subcontractor personnel training requirements are established and provided by their management.

2.0 BASIC HAZARDS/HUMAN FACTORS

2.1 Cryogenic operations produce numerous hazards. Primary hazards include burns, frostbite, asphyxiation, high pressures, flammability, and burst piping (from trapped liquid).

3.0 DEFINITIONS

3.1 Cryogenic Fluids – Extremely cold liquids having boiling points below -130 °F (-90 °C) at 14.7 psia. (See Annex A.)

3.2 Dewars – Insulated storage tanks designed specifically to store cryogenic fluids.

3.3 Base Operating Contractor – A long-term contractor directly accountable to the Air Force for the AEDC mission; term used to identify the AEDC Operation, Maintenance, Information Management and Support Contractor.

3.4 Outside Contractor/Subcontractor – An organization employed by a contractor or the Air Force to do construction, maintenance, repair or other work at AEDC; also referred to as the construction contractor.

3.5 Pressure Relief Devices – Used to vent pressure buildup in a system if it exceeds a pre-determined amount.

4.0 REQUIREMENTS/RESPONSIBILITIES

4.1 Requirements

4.1.1 Pressure Buildup and Relief

4.1.1.1 Heat flux into the cryogen is unavoidable, regardless of the quality of the insulation provided. Pressure relief must be provided to permit routine off-gassing of the vapors generated by this heat input. Typically spring-loaded relief devices or an open passage to the atmosphere is used to provide relief.

4.1.1.2 Each portion of the cryogenic system must have uninterruptible pressure relief. Any part of the system that can be isolated by valves from the remainder must have separate and adequate provisions for pressure relief. Examples of parts that usually require separate relief systems include: pressurized supply dewars; tubing and hoses used to transfer cryogen unless an air gap is provided; bath space surrounding experimental volume; experiment volume, even if cryogen is not present; and vacuum spaces in contact with cryogen. Pressure-relief devices must be provided in the last two cases since cracks may develop at cryogenic temperatures. Cryogen or air may leak into sealed spaces through such cracks. Air condenses at least partly under such conditions and exists as a cryogen in the sealed space as well. Upon warming, these cracks may close, and the contained vaporizing fluid then can rupture the vessel.

4.1.1.3 Additional backup relief devices should be provided when the capacity of operational relief devices are not adequate to take care of unusual or accidental conditions. This may be the case if the insulation is dependent on maintaining vacuum in any part of the system (e.g., permanently sealed dewars), if the system may be subject to an external fire, or if rapid exothermic reactions are possible in the cryogen or a container cooled by the cryogen. In each case, relief devices capable of handling the maximum volume of gas that could be produced under the most adverse conditions must be provided. Frangible disks, or burst disks, are recommended for this service.

4.1.1.4 All system parts that come in contact with the cryogenic fluid must be rated for cryogenic service.

4.1.1.5 System parts that are thermally isolated from the cryogenic fluid may consist of ordinary pressure system parts (not rated for cryogenic service) but only at the direction of an engineer experienced in the design of cryogenic systems.

4.1.1.6 If dry ice or a dewar containing cryogenic fluid must be transported by elevator, it should not be accompanied by personnel. In case of a power failure, an excessive amount of cryogen could vaporize and escape into the cab, leaving personnel with no means to escape or ventilate the cab. In these cases, the load should be sent by itself and measures taken to ensure that no passengers are loaded on intermediate floors.

4.1.1.7 Containers and other devices used for cryogenic storage or use must be rated for cryogenic service.

4.1.2 Labeling and Posting

Storage dewars, process vessels, piping, and similar cryogenic equipment shall be labeled with the common name of the contents. Where a flammable cryogenic or liquid oxygen is used, "DANGER, NO SMOKING" signs shall also be posted.

4.1.3 Liquid Oxygen

4.1.3.1 Liquid oxygen shall only be handled by personnel who are properly trained of its hazards.

4.1.3.2 Liquid oxygen contains 4,000 times more oxygen per unit volume than the atmosphere.

4.1.3.3 Materials that are normally considered to be noncombustible burn rapidly in the presence of liquid oxygen and organic materials react explosively. Hydrocarbon surface contamination levels must be kept to less than 100 milligrams per square foot (1.06 mg/cm^2) to avoid detonation within the system.

4.1.3.4 Liquid oxygen has a high heat capacity, and spills can penetrate deeply and persist for extended periods of time, causing fires and explosions long after the visible spill has completely disappeared.

4.1.3.5 Liquid oxygen should only be handled over surfaces known to be suitable for such purposes, such as concrete or clean gravel. Accidental spills onto asphalt, plastic, wood or other organic substances can result in detonation of the surface. Repeated spills multiply the hazard. Immediate flushing with water is advised to increase the evaporation rate after a spill.

4.1.3.6 During and after any operations that involve handling liquid oxygen, avoid exposure to ignition sources such as smoking and electrostatic discharge, which may result in severe clothing fires. Exposure to concentrated oxygen gas may persist in clothing and hair for long periods of time.

4.1.3.7 Precautions in this section should also be employed when cryogens containing liquid oxygen as a component are encountered. Even a slight change in oxygen concentration from the atmospheric proportions alters burning characteristics of materials substantially.

4.1.3.8 Liquefied oxygen storage systems and operating locations will be placarded to indicate: “OXYGEN - NO SMOKING - NO OPEN FLAMES.”

4.1.3.9 When used as propellant, liquefied oxygen must meet the criteria for liquid propellants.

4.1.4 Air-Freezing Cryogens

4.1.4.1 Certain cryogens, such as helium and hydrogen, are cold enough to solidify atmospheric air. Entry of air into such cryostats must be prevented by pressurizing the system. If openings to the atmosphere exist, they are likely to become plugged by solidified air, leading to over pressure and vessel failure if they are relied on for pressure relief. Such a condition also results in hazardous contamination of the fluid. Again, adequate pressure-relief devices must be provided to vent gas produced in case of maximum possible heat flux into the system.

4.1.4.2 Unless these fluids are handled in vacuum-jacketed vessels and piping, air also condenses on the exterior of the system. Due to the different evaporation temperatures, condensate is rich in oxygen content. The hazards created by this include frostbite from touching the cold surfaces, dripping liquid air (oxygen enriched), and exploding insulation. The latter can happen when air condenses between the metal surface and the insulating layer. On warming, the air vaporizes and can rip off the insulation with explosive force. Such insulation systems must be specifically engineered to prevent air penetration.

4.1.5 Liquid Hydrogen

4.1.5.1 Liquid hydrogen poses extreme hazards if not handled correctly. Its use shall be limited to specially trained personnel. The hazards arise not only from the air-freezing properties, but also from the hydrogen gas that is generated in large volume if the fluid leaks or spills.

4.1.5.2 Hydrogen expands more than 850 times in volume upon vaporization. Flammable mixtures with air are formed over a wide range of concentrations, approximately 4 to 75% by volume. It can be ignited by a spark containing only 0.02 millijoules of energy; the minimum energy requirement to ignite methane in air is 15 times larger. Furthermore, explosion-proof electrical equipment for hydrogen service is often not available; custom-designed electrical systems based on thorough understanding of the properties of hydrogen are required. Finally, hydrogen causes embrittlement of materials otherwise suitable for cryogenic service.

4.1.5.3 As a minimum, liquefied hydrogen systems will comply with the following requirements:

4.1.5.3.1 Each container shall be legibly marked to indicate “LIQUEFIED HYDROGEN – FLAMMABLE GAS”.

4.1.5.3.2 Liquefied hydrogen containers shall be equipped with safety relief devices.

4.1.5.3.3 Liquefied hydrogen storage containers shall not be exposed near electric power lines, flammable liquid lines, flammable gas lines, or lines carrying oxidizing materials.

4.1.5.3.4 Liquefied hydrogen storage containers and associated piping shall be electrically bonded and grounded.

4.1.5.3.5 Storage sites shall be fenced and posted to prevent entrance by unauthorized personnel. Sites shall be placarded as follows: “LIQUEFIED HYDROGEN –FLAMMABLE GAS-NO SMOKING-NO OPEN FLAMES”.

4.1.5.3.6 When used as propellant, liquefied hydrogen must meet the criteria for liquid explosive propellants.

4.1.6 Oxygen Enrichment

4.1.6.1 Cryogenic fluids with a boiling point below that of liquid oxygen have the ability to condense oxygen out of the air if exposed to the atmosphere. This is particularly troublesome if a stable system is replenished repeatedly to make up for evaporation losses; oxygen accumulates as an unwanted contaminant. Violent reactions may occur if the system or process is not compatible with liquid oxygen.

4.1.6.2 Oxygen enrichment also occurs if liquid air is permitted to evaporate. Oxygen evaporates less rapidly than nitrogen. Oxygen concentrations of 50 percent may be reached. Condensed air dripping from the exterior of cryogenic piping is enriched in oxygen.

4.1.7 Personal Protective Equipment

4.1.7.1 The use of safety glasses is required at all times when cryogenic fluids are present. If a cryogen is poured or if the fluid is in an open container and the cryogen may bubble, the use of safety goggles and a full-face shield is required. Safety glasses and face shield are required when valves are actuated on piping systems unless the operator is shielded from leaks at potential failure points.

4.1.7.2 Hand protection is primarily required to guard against the hazard of touching cold surfaces. Loose insulating gloves, rated for cryogenic use, that can be tossed off readily in case they become soaked with cryogen are required.

4.1.7.3 Cryogen handlers shall wear proper foot protection in compliance with SHE Standard F2, PPE. Cuff-less trousers shall be worn outside foot protection to shed spilled liquid. Foot protection shall have no mesh sides or air holes and will be tightly laced to prevent spilled cryogen seeping inside.

4.1.7.4 Industrial clothing made of non-absorbent material is usually satisfactory. An apron rated for cryogenic use is required when handling or exposed to cryogenic fluids. Where exposure to drenching is possible, a full protective suit with supplied air should be considered.

4.1.8 Mechanical/Chemical

4.1.8.1 Since cryogenic fluids exist as liquids only at temperatures considerably below ambient, normal storage and fluid containment must allow for the unavoidable heat input from the environment. For ordinary operations, this means good insulation, adequate pressure-relief devices, and proper disposal or recycling of the gases that are continually produced. Full containment of the fluid as a liquid at room temperature is usually not feasible. For example, the pressure required to maintain helium at liquid density at room temperature is 18,000 psi; likewise for hydrogen (28,000 psi) and nitrogen (43,000 psi).

4.1.8.2 The chemical properties of substances are severely exaggerated under cryogenic conditions. Liquid oxygen, for example, reacts explosively with materials that are usually considered to be noncombustible. Nitric oxide is detonable under cryogenic conditions; a detonation can be set off by "bumping" or by organic impurities. It must be remembered that condensing a cryogen from a pure gas at room temperature concentrates the material typically 700 to 800 fold; in the case of neon, the concentration is over 1,400 fold.

4.1.8.3 Material properties are drastically affected by cryogenic temperatures; ductile materials become brittle, material shrinkage exceeds anticipated values; leaks can develop that are not detectable at room temperature even under considerable pressure, etc. Hence, the suitability of materials must be carefully investigated before they are employed in cryogenic service.

4.1.9 Adverse Weather Conditions

4.1.9.1 The AEDC Operations Center is responsible for making initial notification of severe weather conditions such as lightning.

4.1.9.2 Operations involving explosive, flammable cryogenics shall be discontinued if lightning is detected within ten miles.

4.1.9.3 Cryogenic operations should have adverse weather conditions analyzed and documented in a system safety hazard analysis for countermeasures and procedures that cover adverse weather conditions.

4.1.10 Procedures

4.1.10.1 Cryogenic fluids shall be handled only by personnel fully trained and aware of the properties of the materials and equipment, and responsibly cognizant of the consequences of a mishap. Operators should be selected on the basis of capability to understand the hazards and the equipment, mature judgment, and ability to follow established procedures.

4.1.10.2 Cryogenic work must be performed according to standard operating procedures developed by competent operating personnel and reviewed by the contractor safety office. Checklists, valve sequences, etc., should be included. Deviations from established procedures should be allowed only after evaluation of the consequences and with the consent of higher authority. Procedures should be reviewed periodically and updated whenever changes in procedures or equipment are made.

4.1.10.3 An emergency plan to guide personnel actions during malfunction or mishap is required and shall be reviewed prior to operations. The plan should cover shutdown, alarm, and evacuation procedures for the most likely mishaps. For larger installations, and operations involving liquid hydrogen or liquid oxygen, emergency procedures should include periodic emergency drills.

4.2 Responsibilities

4.2.1 Base Operating Contractor Responsibilities

4.2.1.1 Ensure that all personnel whose duties involve contact with cryogenics are trained and qualified to perform their designated tasks.

4.2.2 Base Operating Contractor Safety Office Responsibilities

4.2.2.1 Develop, administer, and document initial and three-year refresher cryogenic safety training for all affected Base Operating Contractor employees.

NOTE: DoD employees may be trained as necessary.

4.2.2.2 Assist operations in the development and implementation of required cryogenic safety procedures. Advise contractor personnel on safety matters involving cryogenics.

4.2.2.3 Conduct annual inspections for each cryogenic operation or location to ensure compliance with safety criteria. Special emphasis should be placed on operations involving liquid hydrogen and liquid oxygen. Conduct periodic spot inspections, as necessary.

4.2.2.4 Document all inspection findings, assign Risk Assessment codes, and ensure that satisfactory corrective actions are implemented. Forward a copy of each inspection report and subsequent corrective actions to AEDC/SE.

4.2.3 Base Operating Contractor Functional Manager and/or Project Engineer Responsibilities

4.2.3.1 Ensure that system safety hazard analyses are performed for all projects involving cryogenics. These analyses should identify hazards, associated risks, and specific controls to be implemented to eliminate or reduce those risks.

4.2.3.2 Support the development, administration, and documentation of operational training that is area/site-specific for operators of each system using Process Safety Management (PSM) principles for systems that are affected by the PSM standard for highly hazardous chemicals.

4.2.3.3 Ensure that approved operating instructions/procedures are posted or readily available for each cryogenic operation.

4.2.3.4 Ensure that personnel handling and/or working with cryogenics have received all required cryogenics safety training.

4.2.4 Base Operating Contractor Supervisor Responsibilities

4.2.4.1 Maintain knowledge of all hazards involved in cryogenic operations and associated emergency procedures. Communicate cryogenic hazards and emergency procedures to area/site workers and visitors.

4.2.4.2 Brief all personnel on the standards they are expected to follow.

4.2.4.3 Ensure that approved operating instructions/procedures are posted or readily available for each cryogenic operation. Ensure that tasks involving cryogenics are performed by qualified personnel in a manner consistent with this standard and other applicable safety directives.

4.2.4.4 Support the development, administration, and documentation of operational training that is area/site-specific for operators of each system using Process Safety Management (PSM) principles for systems that are affected by the PSM standard for highly hazardous chemicals.

4.2.4.5 Ensure and verify that personnel handling and/or working with cryogenics have received all required cryogenics safety training.

4.2.4.6 Ensure that smoking locations are designated as needed in operating areas and are approved by the appropriate authorities.

4.2.4.7 Ensure that all electrical protection systems in cryogenic/explosives areas are inspected and tested as scheduled. Maintain copies of all electrical protection system test reports.

4.2.4.8 Maintain good housekeeping practices within cryogenic storage and operating areas.

4.2.5 AEDC Fire Department Responsibilities

4.2.5.1 Maintain a ready fire-fighting capability for fires involving flammable/explosive cryogenics.

4.2.5.2 Provide information on the fire characteristics of flammable/explosive cryogenics, as requested.

4.2.5.3 Exercise approval authority for all requests for smoking locations in and around flammable/explosives cryogenic areas.

4.2.6 Base Operating Contractor Utilities Systems Engineering, Responsibilities

Inspect and test electrical protection systems in cryogenic/explosives areas annually. This includes all permanently installed grounding, bonding, conductive surfaces, and lightning protection systems.

5.0 TRAINING

5.1 Base Operating Contractor personnel must receive cryogenic safety training before participating in cryogenic operations. This training includes (a) initial training, (b) three-year refresher training, and (c) operational training that is area/site-specific. Personnel who work with cryogenics must understand all safety standards, requirements and precautions that apply to their operations.

5.2 If cryogenics are to be used as a rocket propellant, then the affected Operating Contractor personnel must also receive explosives safety training.

6.0 INSPECTIONS/AUDITS

6.1 Cryogenics equipment, transfer piping, and associated items are to receive an annual inspection, as well as a five-year in depth inspection (performed by a qualified Nondestructive Examination Level II inspector).

6.2 Operational personnel shall conduct daily inspections of charged cryogenic systems.

6.3 Inspections should pay particular attention to relief valves.

7.0 REFERENCES

AEDC Safety, Health and Environmental Standards
A4, System Safety
D2, Pressure Vessels and Systems
D3, Identification of Piping Systems
E15, Explosives Safety
F2, Personal Protective Equipment

Air Force Manual (AFMAN)
AFMAN 91-201, Explosives Safety Standards

Air Force Instruction (AFI)
AFI 91-203, Air Force Consolidated Occupational Safety Instructions

National Fire Protection Association
NFPA 55, Compressed Gases and Cryogenic Fluid Code

Compressed Gas Association (CGA)
CGA S-1.1 Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases
CGA S-1.2 Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases
CGA S-1.3 Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases

Occupational Safety and Health Administration (OSHA) Code of Federal Regulations (CFR)
CFR 1910.103, Hydrogen
CFR 1910.104, Oxygen

8.0 ANNEX

Properties of Cryogenic Fluids

9.0 SUPPLEMENT

NFAC A321-0801-XSP E13 Cryogenic Fluids

Annex A
Properties of Cryogenic Fluids

Gas	Boiling Point, deg[a]				Volume Expansion to Gas	Flam-mable	Toxic	Specific Gravity of Gas (Air = 1)	Odor
	C	F	R	K					
1.1-Difluoroethylene	-83.0	-117.4	342.3	190.2	---	Yes	No[c]	---	Faint Ether
Acetylene	-84.0	-119.2	340.5	189.2	---	Yes	Yes	0.9073	Garlic
Argon	-185.7	-302.3	157.4	87.5	847 to 1	No	No[c]	1.38	No
Boron Trifluoride	-100.3	-148.5	311.2	172.9	---	No	Yes	2.37	Pungent
Carbon Dioxide	-78.5	-109.3	350.4	194.7	553 to 1	No	Yes	1.5289	Slight Pungent
Carbon Monoxide	-192.0	-313.6	146.1	81.2	---	Yes	Yes	0.9678	No
Chlorotrifluoromethane	-81.4	-114.6	345.1	191.8	---	No	Yes	Mild	
Deuterium	-249.5	-417.1	42.6	23.7	---	Yes	Radioactive		
Ethane	-88.3	-126.9	332.8	184.9	---	Yes	No[c]	1.047	No
Ethylene	-103.8	-154.8	304.9	169.4	---	Yes	No[c]	0.978	Sweet
Fluorine	-187.0	-304.6	155.1	86.2	888 to 1	No	Yes	1.312	Sharp
Fluoroform	-84.0	-119.2	340.5	189.2	---	No	No[c]	1.047	No
Helium-3	-269.9	-453.8	5.9	3.3	757 to 1	No	No[c]	0.137	No
Helium-4	-268.9	-452.0	7.7	4.3	757 to 1	No	No[c]	0.137	No
Hydrogen	-252.7	-422.9	36.8	20.5	861 to 1	Yes	No[c]	0.06952	No
HydrogenChloride	-85.0	-121.0	338.7	188.2	---	No	Yes	1.268	Pungent
Krypton	-151.8	-241.1	218.6	121.4	700 to 1	No	No[c]	2.818	No
Methane	-161.4	-258.5	201.2	111.8	578 to 1	Yes	No[c]	0.5544	No
Neon	-245.9	-410.6	49.1	27.3	1438 to 1	No	No[c]	0.6964	No
Nitrogen	-195.8	-320.4	139.3	77.4	696 to 1	No	No[c]	0.967	No
Nitrous Oxide	-89.5	-129.1	330.6	183.7	666 to 1	No	No[c]	1.63	Sweet
Oxygen	-183.0	-297.4	162.3	90.2	860 to 1	No	No[c]	1.1063	No
Ozone	-111.9	-169.6	290.1	161.3	---	Yes	Yes	1.658	Yes
Tetrafluoromethane	-128.0	-198.4	261.3	145.2	---	No	Yes	1.62	No
Tritium	-248.0	-414.4	45.3	25.2	---	Yes	Radioactive		
Xenon	-109.1	164.4	624.1	164.1	573 to 1	No	No[c]	4.53	No

[a] 0 deg. K = -273.16C; - 459.69F.
[b]Sublimes.
[c]Nontoxic, but can act as an asphyxiate by displacing air needed to support life. As with most chemicals, even harmless materials can be toxic or poisonous if taken in sufficient quantities under the right conditions.

A321-0801-XSP E13 Cryogenic Fluids

As there are no Cryogenic Fluids at the NFAC site this supplement is being reserved in the event that if Cryogenic Fluids are introduced at NFAC, this supplement will need to be revised.

Review: Non-Applicable at this time.

References:

Scope:

NFAC Worksite Application: