

Capt. Bob Corbin
644 SW Winterspring Lane
Port Orchard, WA 98367

12463-E
37433
Capt. Bob Corbin

May 17, 2000

RSFA-00-7423-5

83785

Mr. Ryan Posten
Exemptions and Approvals
U.S. DOT Office of Hazardous Materials Exemptions and Approval
400 Seventh Street, SW
Washington, D.C 20590

Dear Mr. Posten:

I am a Captain with Washington State Ferries. I have worked here for over 23 years and have been a Captain for 14 years. I am writing on behalf of many very concerned Captains. We recently received a copy of an exemption from your department to Washington State Ferries, for Cryogenic Oxygen. After reading your document, we found ourselves very concerned for the safety of our passengers, crew and vessels. As represented in their request for an exemption by the WSF, there are many people within the Greater Puget Sound area that need Cryogenic Oxygen to maintain their quality of life. Their quality of life can be maintained by delivering the much needed Cryogenic Oxygen via our Interstate, State and County road systems. We believe there is other relevant information that was not provided to you in the application.

I would like to take this opportunity to point out that on six of the eight ferry routes we operate, a delivery truck can drive County, State and Interstate highways to get to their destination. Please refer to the enclosed Washington State map, I have highlighted the ferry routes in orange, the state and interstate highways in green and the islands not accessible by highway in yellow. As you can see a delivery truck can easily drive to any destination served by the following ferry routes, Port Townsend, Mukilteo, Edmonds, Bainbridge Island, and Bremerton. Bainbridge Island and Whidbey Island are connected to the mainland by bridges. That brings us to Vashon Island which must rely on ferries. I am enclosing a copy of the summer 2000 sailing schedule for Vashon Island. As you can see, a hazardous material trip departs Seattle for Vashon at 7:25a.m. and returns to Seattle at 3:55 p.m. with no passengers on board. Clearly we have made reasonable accommodations. As for the San Juan Islands, specifically San Juan Island, Shaw Island, Orcas Island and Lopez Island there is a hazardous materials trip available to them also. There is also a private ferry, actually a landing craft that serves all the San Juan Islands.

The hazardous materials training my crew and I have received, occurred about a week ago for about one hour. During our training last week, Cryogenic Oxygen was brought up because prior to the exemption a truck tried to board our ferry with the full knowledge it was unlawful. During our discussion, the instructor was very clear on the extreme danger of Cryogenic Oxygen. We received no formal training for its transport. Without question my crew and the terminal personnel have not been properly trained to handle such a dangerous material. Also, we have not (as you require) been trained on the requirements and conditions of this exemption.

On the application you received, please refer to page 3, item 3. The last sentence indicates the car deck of our ferries are well ventilated both underway and at the dock. I am enclosing a Fleet Advisory #FA003198 that clearly shows there is not adequate ventilation on the car deck when the ferries are docked.

If a container were to rupture and go through the car deck, as our small amount of training has informed us can happen, the hydraulic pumps, hoses and oil reservoir for the steering of the vessel are located directly below where we have been instructed to park the truck. In addition, our designated smoking area for each vessel is located directly above the proposed stowage area for this vehicle.

In conclusion, as stated in the application, “WSF is aware that the transportation of Oxygen, **refrigerated liquid** does offer a significant risk to the safety of the passengers, the crew, and the vessel itself? WE completely agree. If you refer to the NASA Glenn Safety Manual, Chapter 5-OXYGEN PROPELLANT <http://osat.grc.nasa.gov/lsm/lsm5.htm> and read the first ten pages, I think you will agree that Cryogenic Oxygen has no place on a **passenger ferry**. We believe the scheduled **hazmat** trips and our highway system can adequately provide for safe transport of this product to those who need it, without endangering the safe passage of 28,000,000 passengers a year. For these reasons, we respectfully request the exemption be immediately rescinded.

If I can answer any questions you may have, please feel free to call me at (360) 981-0592 between 5am and 1pm PST and (360) 895-8656 after 2pm PST. I look forward to hearing from you. Thank you for your time and cooperation in advance.

Sincerely,

A handwritten signature in black ink, appearing to read "Bob Corbin". The signature is fluid and cursive, with a prominent "B" and "C".

Capt. Bob Corbin

cc: Mr. Robert A. McGuire

SUMMER 2000 SCHEDULE

Effective: June 18, 2000 through September 23, 2000

FAUNTLEROY/VASHON/SOUTHWORTH

WEEKDAY SCHEDULE

Lv. Fauntleroy for Vashon & Southworth		Lv. Vashon for Fauntleroy		Lv. Vashon for Southworth		Lv. Southworth for Vashon & Fauntleroy	
* 3	0435	* 3	0415	• VF 3	0415		
2	0530	2	0505	% 3	0450	2	0445
SO 3	0555	3	0530	2	0550	3	0510
VO 7	0620	1	0600	3	0620	VX 2	0610
VO 2	0655	2	0625				
1	0715	1	0650			3	0640
VO 3	(0725) Hazardous	3	0700				
VO 2	0755	2	0720	1	0735		
VO 3	0820	3	0755			1	0755
so 1	0840	1	0815				
2	0900	2	0830				
a 3	0925	3	0845				
6 1	1015	1	0940	2	0925	1	0915
VO 2	1035	2	1005	3	0950	2	0945
3	1110	3	1040	1	1040	3	1020
2	1130	2	1100	3	1135	1	1100
						FD 3	1155
1	1150	1	1120	2	1155	2	1215
3	1230						
2	1305						
VO 1	1325	2	1235	1	1215	1	1235
		1	1255	3	1255	VO 3	1315
VO 1	1420	1	1350	2	1340		
so 2	1445	2	1420			VF 2	1400
1	1515	1	1445				
VO 2	1605	2	1535	1	1540	2	1515
		3	(1555) Hazardous				
so 3	1620	2	1630			FD/VF 1	1600
VO 1	1635						
2	1655	1	1700			3	1700
1	1730	3	1720	2	1725	FD/NV 2	1745
VO 3	1745	3	1810				
2	1815			1	1755		
VO 3	1835	1	1830	2	1835	1	1815
1	1855	3	1905			2	1855
SO 3	1930	2	1915	1	1915		
@VO 2	1955	1	1950			1	1935
VO 1	2025	1	2055	3	2105	FD/VF 3	2005
3	2040			1	2155		
1	2130	3	2145	VS 3	2235	3	2125
3	2210						
1	2250	1	2155			FD/VF 1	2215
VO 3	2325	VS 3	2235	1	2315	FL 3	2255
1	0030	1	2355	1	0055	1	2335
1	0200	1	0130	1	0220	1	0115

VO - VashonOnly

SO - SouthworthOnly

FD - Directly to Fauntleroy from Southworth

NV - No Vashon Traffic

VF - Vashon VIA Fauntleroy

VX - Does NOT load traffic for Vashon

VS - via Southworth (35-40 min. crossing
Fauntleroy/Vashon)

VF - Via Fauntleroy

() Off Schedule

* - Monday through Thursday Only. Will carry both
Fauntleroy & Southworth traffic from Vashon.

- Monday through Thursday ONLY.

% - Friday ONLY.

@ Pump Sewage/Draw Fresh Water

NOTE: RUNNING SCHEDULE IS SUBJECT TO CHANGE DUE TO CHANGES IN SERVICE REQUIREMENTS SUCH AS, BUT NOT LIMITED TO, HOLIDAYS AND SPECIAL EVENTS.



Fleet Advisory

Subject: Carbon Monoxide Issues

Control#

FA003198

Effective Date:

January 22, 1998

To:

Masters, Mates and deck personnel;
Terminal Agents and Terminal staff
Fleetwide

From:

Jim Malde *J.L.M.*
Acting Port Captain, North and South Regions

Posting Requirements:

Current Locations for All Employees

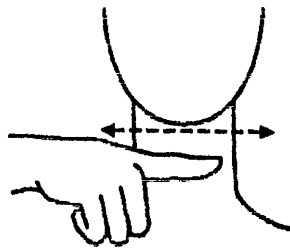
Recent testing on our vessels has revealed that, at times, the carbon monoxide level may momentarily exceed the limit set by Labor & Industries. This happens when vehicles parked in the tunnel start their engines too far in advance of off loading. This condition only occurs within the tunnels on four classes of vessels: Jumbo Mk I, Super, Issaquah and Evergreen State. It is assumed that this finding applies to the Jumbo Mk II class as well.

In the interest of protecting our crews and passengers, we will now require that all vehicles in the tunnel need to refrain from starting their engines until the wings are off-loaded. Although this is not a change of a long-standing policy as stenciled on the cardecks, its implementation and enforcement will present a change of practice for many crews and passengers alike.

Until a better or permanent solution is developed, the following actions/procedures will be put in place to assist you in minimizing levels of exhaust emissions:

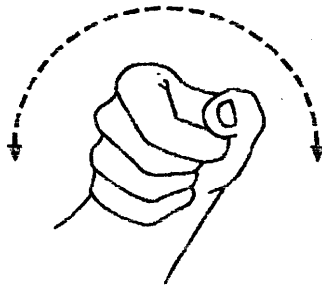
1) Informational handbills will be distributed to all commercial trucks, pick-ups and over-height vehicles at the auto booth, (sample attached).

- 2) When you make your ARRIVAL/NO SMOKING announcement, add a request that, **“Drivers in the ship's tunnel area, especially those parked in the center cardeck area between the stairwells, please do not start your engine until Deck Crew hand signals indicate that you do so.”**
- 3) The tunnel deckhand or Mate's designee will indicate “Motors Off” by sign language at the head of tunnel or to individual drivers who start their engines early.



TURN OFF YOUR ENGINE

- 4) Just prior to off loading the tunnel, the **tunnel** deckhand or Mate's designee **will signal** “Motors On” by hand signals and then the tunnel will off load.



START YOUR ENGINE

As with all significant changes to the way we do business, your best expertise, communication efforts, and skills will be called upon to facilitate cooperation of the traveling public, to the benefit of all. If you have suggestions to improve this process, please forward them to the Port Captain's Office in the South Region.

Expiration date: 1/31/99



US DEPARTMENT OF TRANSPORTATION
4007th STREET S.W.
WASHINGTON, D.C. 20590

FACSIMILE COVER SHEET

FAX NUMBER 202-366-~~4733~~ 3309

DATE: 5/19/00 TIME: _____

NUMBER OF PAGES 6 total

TO: Manny Pfersich

ORGANIZATION: GMSO-3

TELEPHONE NUMBER: _____

FAX NUMBER: 7- 4570

FROM: Ryan Posten

DEPARTMENT: RSPA HAZ-MAT

TELEPHONE NUMBER: 6-6873

E-MAIL: _____

SUBJECT: Re: Emergency Exemption E-12463

Expires 8-31-00
(Ferry Captain's response to exemption)

NASA Glenn Safety Manual

Chapter 5 - OXYGEN PROPELLANT

Revision Date: 7/97

5.0 Overview

Though oxygen itself is not flammable, most engineering materials, including many gases and liquids, will burn fiercely in oxygen under at least some conditions. Current knowledge, however, does not allow the establishment of an absolute set of rules covering all aspects of oxygen system design, material selection, and operating practices. The oxygen hazard is subtle. Some oxygen systems give apparently normal service for decades before circumstances combine to yield an incident or fire.

Much analytical and experimental work has been done in recent years to broaden the understanding of the ignition-triggering mechanisms and the physical combustion processes of metallic and nonmetallic materials in pure oxygen environments. However, because of the immense complexity of this problem, little headway has been made in developing analytic models for the design of oxygen systems (Bond et al. 1983).

Oxygen can be handled and used safely. In fact, experience shows the incidence of oxygen system fires to be low, with a probability of about one in a million (ASTM Committee G4.05).

Major progress in producing oxygen systems that can meet the demands for higher performance, pressures, temperatures, and flows has come through empirical testing of materials in configurations representing their intended uses and by using design techniques that protect or shield the more susceptible materials from direct impingement by or interface with the oxygen (Bond et al. 1983).

This chapter is written to serve as a practical guideline for the safe design and fabrication of systems for, and the safe use of, gaseous and liquid oxygen at Glenn. The chapter is primarily directed at ground based propellant and similar systems. Material is presented to provide the user with a basis for judgement to extend beyond the ground rules and guidelines established for the safe use of propellant oxygen. A summary of operational hazards, along with oxygen safety and emergency procedures, is provided. Appendixes A to C, respectively, give first aid procedures for contact with cryogenic material, cleanliness specifications for gaseous and liquid oxygen systems, and procedures for filling gaseous oxygen tube trailers.

The intent is to provide safe, practical guidance that permits the accomplishment of experimental test operations at Glenn, while being restrictive enough to prevent personnel endangerment and to provide reasonable facility protection. This chapter is also intended to serve as a tutorial for those needing operational information from the viewpoint of oxygen safety.

5.1 SCOPE

These guidelines shall govern all aspects of oxygen handling and usage at the Glenn Research Center, both at the Cleveland Center and Plum Brook Station. The intent here is to present acceptable oxygen standards and practices for minimum safety requirements only. More extensive safety precautions should be employed where possible.

Whenever there is a conflict between information presented herein and information contained in an appendix or reference, these guidelines shall govern. In turn, the appendix shall govern over a reference. These guidelines shall in no way be considered as relaxing any occupational safety or health standard imposed by regulation.

Where precisely quantifiable direction is not possible, oxygen system design, material selection, and operating practice guidelines are based on proven experience and technical judgement.

The references listed in Section 5.13 are an essential part of this chapter. Knowledge of and adherence to these references is mandatory.

For definitions, see the Glossary in appendix D of Chapter 6; it applies to oxygen also.

5.2 POLICY

Liquid and gaseous oxygen shall be stored, handled, and used so that life and health are not jeopardized and the risk of property damage is minimized. Oxygen system design shall be done by experienced engineers with line management oversight.

5.2.1 Hazard Elimination: A NASA Directive

The primary consideration for resolving oxygen hazards shall be to eliminate them by proper design (see NHB-1700.1, "NASA Basic Safety Manual"). Hazards that cannot be eliminated by design shall be controlled by taking the following corrective actions in this order of precedence and by using the principles in Section 5.2.2.

- (a) Designing for minimum hazard
- (b) Installing safety devices
- (c) Installing caution and warning devices
- (d) Developing administrative controls, including special procedures and training
- (e) Providing protective clothing and equipment

5.2.2 Approach to Oxygen Safety

The following design principles shall be adopted to achieve maximum oxygen safety at Glenn. It is assumed that the designer will employ standard analytical methods in the process of design.

Inherent safety. Oxygen systems and operations shall have a high degree of built-in safety. The selection of materials that are ignition- and combustion-resistant at the maximum expected operating conditions and the suitable design of components and systems are essential. Safe oxygen systems must include special designs for preventing leaks, eliminating ignition sources, maintaining a clean system, avoiding cavitation, and preventing resonant vibration.

- “ Two lines of defense. In addition to the inherent safety features, at least two failure-resistant, independent barriers shall be provided to prevent a given failure from mushrooming into a disaster. . Thus, at least two undesirable, independent events would have to occur simultaneously under either normal or emergency conditions before there would be a potential danger to personnel or major damage to equipment and property.

Fail-safe design. The equipment, power, and other system services shall be designed and verified for safe performance in the normal and maximum designed operational regimes. Any failures shall cause the system to revert to conditions that are safest for personnel and that will cause the least property damage. Redundant components shall be incorporated into the design to prevent shutdowns.

Automatic safety devices. System safety valves, flow regulators, and equipment safety features shall be installed to automatically control hazards.

Caution and warning systems. Warning systems to monitor those parameters of the storage, handling, and use of oxygen that may endanger personnel and cause property damage shall be incorporated into oxygen system design. Warning systems shall consist of sensors to detect abnormal conditions, to measure malfunctions, and to indicate incipient failures. Data transmission systems for caution and warning systems shall have **sufficient** redundancy to prevent any single-point failure **from** disabling an entire system.

Formal procedures. All oxygen operations shall be conducted by knowledgeable, trained, and certified personnel following formal procedures. Personnel involved in design and operations will carefully adhere to the safety standards of this chapter and must comply with regulatory codes.

Personnel training. Personnel assigned to handle/use liquid and gaseous oxygen or to design equipment for oxygen systems must become thoroughly familiar with the physical, chemical, and hazardous properties of oxygen.

Operator certification. Operators shall be certified as “qualified” to handle liquid and gaseous oxygen and as “qualified” in the emergency procedures for handling leaks and spills according to Section 5.12.2 of this chapter.

Safety review. At a minimum, all oxygen design, handling, and test operation activities shall be subject to an independent, third-party safety committee review and subject to a permit issued by that Area Safety Committee.

5.3 BASIC CONCEPTS AND GUIDELINES

Safe use of oxygen requires the control of potential ignition energy mechanisms within oxygen systems by judiciously selecting ignition-resistant materials (Sec. 5.9) and system designs (Sec. 5.10), maintaining scrupulously clean systems (Sec. 5.11), and using appropriate operational procedures (Sec. 5.12).

Safe operation with oxygen can be enhanced by understanding the following basic concepts:

- (a) Oxygen can react with nearly all materials that are not already fully oxidized.

(b) The major hazards of liquid and gaseous oxygen are the possibilities of intense fires or explosions.

(c) A facility-wide **fire** hazard always exists when a major oxygen leak occurs. Nearby personnel, equipment, and buildings may readily ignite and burn in an oxygen-enriched atmosphere.

5.3.1 Managing the Oxygen Hazard

The oxygen hazard can be managed by

(a) Minimizing the severity of the environment (i.e., the system's operating parameters and practices)

(b) Using materials and designs best able to withstand the environment

Generally, using as many as possible of the following steps in concert minimizes the overall probability of a significant incident (ASTM Committee G4.05).

Minimizing the severity of the environment. The environmental severity can be controlled by reducing the mechanisms that cause **fires** or add to their consequences, for example, by

(a) Cleaning scrupulously and maintaining this cleanliness

(b) Adopting certain practices, such as opening valves slowly

(c) Using valves with flow capacity to limit downstream pressurization rates

(d) Using automated hardware (or isolating or shielding the hardware) to reduce personnel exposure

(e) Minimizing flow velocities

Fire resistant materials. Using fire-resistant materials improves the system's ability to withstand its environment. Materials used in oxygen service should be selected based on the following criteria:

(a) Resistance to ignition (i.e., materials with high ignition temperatures, high ignition impact thresholds, etc., as measured by specific tests)

(b) Resistance to propagation (i.e., materials that are either inherently or situationally nonflammable)

(c) Limitation of heat release and, therefore, limitation of destructive potential

Because so many variables are involved, there is no unique oxygen-service material. Numerous alternatives exist; therefore it is **difficult** to choose among vendors and/or companies with widely differing approaches and with results that may not meet expectations. 5.3.2 Waiver Provisions

In some instances the importance and urgency of a research program warrants some risk to property. These cases shall be referred, with recommendations and qualifications, to the Executive Safety Board for approval.

5.4 PROPERTIES OF OXYGEN

Liquid oxygen used as an oxidizer in propellant systems shall conform to MIL-P-25508E, Type II. Propellant grade liquid oxygen contains a minimum of 99.5 percent oxygen; the major impurity is argon. Gaseous oxygen used to purge and pressurize propellant systems shall conform to MIL-P-25508E, Type I or Fed. Spec. BB O-925A. Properties for breathing oxygen are specified in MIL-O-27210F.

5.4.1 Physical Properties

Oxygen is an element which, at atmospheric temperatures and pressures, exists as a colorless, odorless, and tasteless gas. High purity liquid oxygen is a light blue, transparent liquid. It is an extremely cold cryogenic fluid, which makes handling it potentially hazardous. It boils at -297 F (90 K) at atmospheric pressure. It boils vigorously at ambient conditions. See table 5.1 for more information on the physical properties of oxygen.

5.4.2 Chemical Properties

Solubility. Most common solvents are solid at liquid oxygen temperatures. Liquid oxygen is completely miscible with liquid nitrogen and liquid methane. Light hydrocarbons are usually soluble in liquid oxygen and such mixtures are very hazardous.

Reactivity. In either gaseous or liquid form, oxygen is a strong oxidizer that vigorously supports combustion.

A material's rate of reaction with oxygen depends on the conditions of its exposure to oxygen and its physical and chemical properties. A particular material may react with oxygen at a rate ranging from very slow to explosive or **detonatable**.

5.5 OPERATIONAL HAZARDS OF OXYGEN

The oxygen hazard is subtle. Materials considered **fireproof** in air will burn violently in a pure oxygen environment. Oxygen-supported combustion of most engineering materials is a potential hazard. Some oxygen systems have given apparently normal service for decades before circumstances combine to yield an incident or fire.

One of oxygen's greatest hazards is its nonevident passive mixing with hydrocarbons. Once such a mixture is ignited, the reaction may proceed violently, even explosively.

The use of cryogenic oxygen can cause design and exposure problems.

5.5.1 General Hazards

The major hazards associated with operational use of liquid and gaseous oxygen are fire and explosion.

Ignition. The ignition temperature of a material in oxygen systems is not an absolute physical property. It depends on many factors. To date, no single test has been developed that can be applied to all materials to produce absolute ignition temperature values. However, relative ranking and estimated ignition temperatures for many materials have been established through experimentation. Representative values are found in Chapter 3.4 of "Oxygen Systems Engineering Review" (Schmidt and Forney 1975).

Materials will ignite at considerably lower temperatures in oxygen environments than in air, and combustion rates are greater in oxygen than in air. Ignition occurs when a combustible material is heated to ignition temperature. The temperature rise could be from within the oxygen system, without any added energy from outside sources. Fluid friction, chemical reactions, adiabatic compression, or impact on container walls can produce sufficient energy for ignition to occur in oxygen systems.

Fire and explosion. Oxygen supports vigorous or even explosive burning. Materials that burn only sluggishly or not at all in air burn quickly in oxygen. Almost any material will burn. For example, stainless steel, Teflon, and silicones, which are generally regarded as fire-proof or fire resistant, can burn easily in oxygen under the right conditions.

Some materials that can react violently with oxygen are oil, grease, asphalt, kerosene, cloth, wood, paint, tar, and dirt. Even many metals burn vigorously in gaseous oxygen. Violent fires in high-pressure oxygen systems have resulted from component failures, entrained metal particles in the flowing gas system, and rapid metal-to-metal contact within components.

Leaking or spilled liquid oxygen can form potentially dangerous, high concentrations of oxygen gas. In an oxygen-rich environment, clothing may become saturated with oxygen, ignite readily, and burn violently.

5.5.2 Cryogenic and Mixing Hazards

The very low temperature of liquid oxygen aids in condensing foreign matter and freezing out many impurities that may react with oxygen at a later time. Oxygen is easily contaminated because many gases and liquids are soluble in it and some are completely miscible. If an odorless and colorless gas is dissolved in oxygen, problems can result. In fact, inadvertent mixing of oxygen and a flammable gas can cause an explosion, and allowing argon or nitrogen to mix with and enter oxygen breathing systems can cause death.

There are other health hazards associated with the very low temperature of liquid oxygen. Frostbite results when such liquid or a noninsulated pipe containing it contacts the skin.

Breathing pure oxygen for limited periods of time (an hour or two) will not have any toxic effects; however, the upper respiratory tract may become irritated if the gas is very dry.

When liquid oxygen is trapped in a closed system and refrigeration is not maintained, pressure rupture may occur. Oxygen cannot be kept liquid if its temperature rises above the critical temperature of - 181.4 F (154.6 K).

5.6 OPERATIONAL SAFETY AND PROTECTIVE

MEASURES

5.6.1 Safety Measures, Buddy System, and Written Procedures

All operations involving the handling of oxygen shall be performed under the buddy system (LMI 1704.1). The level of the buddy system required will vary with the hazard and complexity of the task, but shall never be lower than level "d" as defined in LMI 1704.1. At least two people are required at this level (see Ch. 13 of the Glenn Safety Manual). Other safety measures are as follows:

- (a) Operators shall be certified as "qualified" according to Section 5.12.2 of this chapter.
- (b) All operations involving oxygen **shall** be conducted by knowledgeable and trained personnel following formal written procedures.
- (c) Consideration for the safety of personnel at and near oxygen storage and use facilities must start in the earliest planning and design stages.

Safety documentation made available to personnel should describe the safety organization and comment specifically on inspections, training, safety communications, operations safety, and accident investigations.

Training shall familiarize personnel with the nature of the facility's major process systems. Major systems include loading and storage systems; purge gas piping systems; control, sampling, and analyzing systems; alarm and warning signal systems; ventilation systems; and fire and personnel protection systems.

5.6.2 Personnel Training

Personnel who handle/use liquid and gaseous oxygen or who design equipment for oxygen systems must become familiar with its physical, chemical, and hazardous properties. In addition, the following requirements apply:

- (a) Personnel must know which materials are most compatible with oxygen, what the cleanliness requirements of oxygen systems are, how to recognize system limitations, and how to respond to failures. Designated operators shall be familiar with procedures for handling spills and with the actions to be taken in case of fire.
- (b) Training should include detailed safety programs for recognizing human capabilities and limitations. Instruction on the use/care of protective equipment and clothing shall be provided. Regularly scheduled fire drills and safety meetings shall be instituted.
- (c) Personnel must constantly reexamine procedures and equipment to be sure safety has not been compromised by changes in test methods, overfamiliarity with the work, equipment deterioration, or stresses due to abnormal conditions.
- (d) Trained supervision of all potentially hazardous activities involving liquid oxygen is essential. Everyone working with these materials must be taught both first aid and self aid. Personnel shall be instructed to call **911** (at Cleveland and at Plum Brook) for all emergency aid.

5.6.3 Protective Equipment

Protective clothing and equipment shall be included in personnel protective measures.

Hand and foot protection. Gloves for work near cryogenic systems must be of good insulating quality. They should be designed for quick removal in case liquid oxygen gets inside. Because of the danger of a cryogenic splash, shoes should have high tops, and pant legs should be worn outside and over the shoe tops. Leather shoes are recommended.

Head, face, and body protection. Personnel handling liquid oxygen shall wear splash protection. A face shield or a hood with a face shield shall be worn. If liquid oxygen is being handled in an open system, an apron of impermeable material should also be worn.

Impermeable clothing. Oxygen will saturate clothing, rendering it extremely flammable. Clothing described as flame resistant or flame retardant in air may be flammable in an oxygen-enriched atmosphere. Impermeable clothing with good insulating properties is effective in protecting the wearer from burns due to cryogenic splashes or spills, but even these components can absorb oxygen.

Oxygen vapors on clothing: Any clothing that has been splashed or soaked with oxygen vapors shall be removed and shall not be used until it is completely free of the gas.

Exposure to oxygen-rich atmospheres: Personnel exposed to high-oxygen atmospheres should leave the area and avoid all sources of ignition for at least 20 minutes, until the oxygen in their clothing dissipates. Removal of clothing should be considered.

Respiratory protection. Respiratory protection is not usually required in oxygen operations.

Storage of protective equipment. Facilities should be available near the oxygen use or storage area for the proper storage, repair, and decontamination of protective clothing and equipment. Safety equipment shall be checked frequently to make sure it is operational.

5.6.4 Smoking Regulations

- (a) Smoking and open flames are prohibited within a minimum of 50 feet of an oxygen system.
- (b) Persons who have been in an oxygen-enriched environment shall not smoke until they have been in a safe area for at least 20 minutes. Clothing saturated with oxygen vapor is an extreme fire hazard.

5.6.5 Vapor Detection

High-oxygen-concentration detectors are not normally required.

5.7 EMERGENCY PROCEDURES

5.7.1 Emergency Action

The following priority actions shall be followed in case of an accident or emergency:

- (a) Direct all personnel to evacuate the suspected hazardous area. Activate building evacuation alarms.
- (b) Call the Fire Department by dialing 911 at Cleveland or Plum Brook.
- (c) Isolate or shut off all oxygen supply sources.
- (d) Attempt to control the emergency with the installed facility system safety equipment and preplanned procedures.

5.7.2 Spills and Leaks

A general, facility-area fire hazard always exists when a major oxygen leak occurs. Nearby personnel, equipment, and buildings may ignite and burn in the oxygen-enriched atmosphere; however, proper system design, material selection, operating procedures, and adequate ventilation will minimize the danger.

Note that an oxygen vapor cloud may persist for a considerable distance downwind of a large liquid oxygen spill, because of lack of buoyancy of the cold gas.

5.7.3 Rescue

Only personnel trained in specific rescue techniques shall engage in rescue activities. All other personnel shall stay clear of an emergency area.

Rescue personnel must not try to pull a burning victim out of an oxygen-rich atmosphere since the rescuer risks catching fire also. Instead, deluge the victim with water and move him/her to fresh air as soon as possible.

Fire blankets must not be used to cover personnel whose clothing is saturated with oxygen. A blanket will prevent oxygen from dissipating from the clothing. Blankets also can become oxygen saturated, thus becoming a fire hazard.

5.7.4 Firefighting/Fire Control

Oxygen-enriched environments make all materials more ignitable, increase burning rates, and in general, decrease the time available for suppression. Experiments have shown that manual efforts to prevent ignition of adjacent materials, once burning has started, is very difficult.

Only personnel trained in specific firefighting techniques should be engaged in the fire fighting. All other personnel should stay clear of the area.

Procedures for controlling fires involving oxygen vary with the type and circumstances of the fire. The following general recommendations are to be used as a guide.

Electrical equipment. Do not use carbon dioxide or dry chemicals on electrical fires. De-energize the electric power; then use water sprays for controlling the fire.

Liquid oxygen and fuel. When the fire involves liquid oxygen and liquid fuels, control it as follows:

(a) If fuel and liquid oxygen are mixed but not burning, quickly evacuate personnel, isolate the area from sources of ignition, and allow the oxygen to evaporate. Mixtures of fuel and liquid oxygen present an extreme explosion hazard.

(b) Should a fuel-liquid oxygen fire occur, shut off fuel and oxygen supplies. Only water sprays or fog should be used to cool the fire. Foams should not be applied. The foam will retard oxygen evaporation and will not extinguish the fire.

5.7.5 Transportation Emergencies

Hazards caused by damage to oxygen transportation systems (road, rail, air, and water) include spills and leaks. Such spills may result in fires and explosions.

The first concern should be to prevent injury or death. In an accident or emergency, efforts should be made to move the oxygen transportation system to an open, safe location. All possible ignition sources should be removed and access restricted. If there has been major damage to the vacuum shell or vent system, pressure may build up, causing the liquid oxygen container to rupture explosively. Use water to extinguish secondary fires.

See Section 5.12.7 and appendix C for operational procedures.

5.7.6 Decontamination of Oxygen and Fuel Mixtures

Liquid oxygen will eventually evaporate from contaminated surfaces, given time and adequate ventilation.

When liquid oxygen has been contaminated by fuel, isolate the area from sources of ignition and quickly evacuate personnel. Allow the oxygen to evaporate and the residual fuel to reach ambient temperatures. Purge the oxygen system with gaseous nitrogen prior to any other cleanup step.

5.7.7 First Aid

Call the Fire Department for emergency first aid by dialing 911 at Cleveland or Plum Brook.

Contact with liquid oxygen or its cold boiloff vapors can produce cryogenic burns (frostbite). Unprotected parts of the body should not be allowed to contact noninsulated pipes or vessels containing cryogenic fluids. The cold metal will cause the flesh to stick and tear.

Treatment of truly frozen tissue requires professional medical supervision since incorrect first aid practices almost always aggravate the injury. For reference, recommended emergency treatments for a cryogenic burn are outlined in appendix A; they shall be posted in oxygen handling areas.