Oxygen Deficiency Hazard Information Book

- CAUTION

OXYGEN DEFICIENCY HAZARD ODH-0 & ODH-1 areas inside

REQUIREMENTS PRIOR TO ENTRY INTO ODH-0 AREAS:
- ALL PERSONNEL MUST HAVE OXYGEN DEFICIENCY HAZARD TRAINING

REQUIREMENTS PRIOR TO ENTRY INTO ODH-1 AREAS:
- ALL PERSONNEL MUST HAVE OXYGEN DEFICIENCY HAZARD TRAINING
- THERE MUST BE MULTIPLE PERSONNEL IN CONTINUOUS COMMUNICATION

February 2014 Edition
Many work areas at Jefferson Lab (JLab) store or use compressed gasses, liquefied gasses, and volatile liquids. Some areas may, on occasion, also use subliming solids (i.e., dry ice). The uncontrolled release of these gasses and liquids could lead to a reduction in the concentration of available oxygen in the work area, creating an Oxygen Deficiency Hazard (ODH). There are serious health effects associated with exposure to decreased oxygen concentrations. If oxygen concentrations drop significantly, unconsciousness or even death may occur.

This booklet provides information on how to recognize and protect yourself from cryogenic hazards. It also explains control measures used at Jefferson Lab to reduce these hazards. After reading this booklet, you should be able to work safely in ODH 0 and ODH 1 areas. In order to qualify as an ODH 0/1 worker, you must also pass the ODH proficiency test.

**Visitor Requirements**

Visitors who have not had ODH training may enter an ODH 0 or ODH 1 area ONLY after the ODH hazard has been explained to them. An ODH qualified escort is required for visitor entry into ODH 0 and ODH 1 areas. [Visitor Information](#) is provided on page 24.

The test is accessed on-line as SAF 103 within the [Training and Performance Office website](#) and must be satisfactorily completed to be considered trained.

The Jefferson Lab ES&H Manual Chapters 6540 Oxygen Deficiency Hazard (ODH) Control Program and 6550 Cryogenic Safety Program serve as companions to this booklet and should be consulted for more detailed information. You may also contact your supervisor and [ES&H staff](#) with any questions you may have after reading this booklet.

**Worker Requirements for Entry into ODH 0 and 1 Areas**

Any personnel who need to enter ODH 0 and 1 areas without a qualified escort must complete ODH training once every two years.

**Requirements for Tours**

[ES&H Manual Chapter 1400 Communicating Safety to Visitors](#) provides links regarding tour and requirements. The tour leader must be ODH trained and inform the visitors of the requirements, etc. This booklet has a summary guide for [Visitor Information](#) on page 24.

For larger events, such as open houses, Jefferson Lab follows the Conduct of Operations - Operating Safety Procedures administered through the [Public Affairs](#) office.
Keep this booklet in a convenient location for on-the-job reference.

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Questions or Comments?
Call the Industrial Hygiene Group at x6381
Cryogen Hazards & Mitigation

The principle hazards of cryogens at Jefferson Lab are (in increasing order):

1. Risk of explosion: exposure to effects of flying debris and shrapnel caused by over-pressurization of a cryogenic device or associated equipment or systems. Hydrogen is a significant hazard from fire/explosion in addition to the cryogenic hazard.

2. Risk of cryogenic burns to skin and eyes while dispensing cryogens or from releases.


Mitigation of Cryogenic Hazards

1. Risk of Explosion
   In order to mitigate the risk of explosion, careful engineering design is required. Critical considerations include the selection of suitable materials for cryogenic fabrications, and the installation of appropriate pressure relief devices in any volume that could become isolated in the system (for example, by valve closures).

   The design of experimental apparatus may include cryogenic devices. Examples include, but are not limited to, connection to dewars or feeds of cryogenic fluids to vacuum vessels. Any such design requires the review and approval of a cryogenic expert. When planning the use of such apparatus, contact the Cryogenic Group Leader, who then documents the approval of design drawings, the fabrication materials, and any associated safety equipment, such as pressure relief devices. See also ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program.

2. Personal Protective Equipment (PPE) required when dispensing cryogens:
   - Eye protection – safety glasses and face shield. For amounts under 1 liter, goggles may be substituted for the face shield.
   - Hand protection – loose-fitting insulating gloves for cryogenic materials.
   - Body protection – long pants, no open toed shoes.

3. Oxygen Deficiency Hazards (ODH)
   The appropriate mitigation of the oxygen deficiency hazard associated with cryogen transport and use is achieved by a combination of engineering, administrative, and personal protective equipment controls. The discussion of the use of cryogens and ODH Controls constitutes the remainder of this booklet. Also see ES&H Manual Chapters 6540 Oxygen Deficiency Hazard (ODH) Control Program and 6550 Cryogenic Safety Program for supplemental information.

NOTE: While not technically a cryogenic system, large volumes of compressed inert gases used in various applications can also present ODH environments and installation of such systems are also included in this hazard education and control program. Additional information on a particular installation is found in the ODH Safety Review Form (see ES&H Manual Chapter 6540 Appendix T1 Oxygen Deficiency Hazard (ODH) Safety Review) which is filed in Docushare.
Jefferson Lab Policy and Criteria for Oxygen Deficiency

NORMAL vs. OXYGEN DEFICIENT ATMOSPHERE

<table>
<thead>
<tr>
<th>GAS</th>
<th>VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>78 %</td>
</tr>
<tr>
<td>oxygen</td>
<td>20.9 %</td>
</tr>
<tr>
<td>argon/other</td>
<td>~1 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100 %</td>
</tr>
</tbody>
</table>

JEFFERSON LAB POLICY
A work area with less than 19.5% Oxygen is considered to have an Oxygen Deficient Hazard atmosphere.

Personnel WILL NOT enter or occupy an area in which the oxygen concentration is known to be or suspected to be less than 19.5% without proper training and wearing Self-Contained Breathing Apparatus (SCBA) and accompanied by a similarly equipped worker(s).

See page 15 for more details.

Do not enter the following without permission from the Cryogenic Group Leader (or designee) OR unless accompanied by an authorized JLab person. JLab personnel trained and assigned to the area(s) are permitted access.

- Central Helium Liquefier (CHL) – CHL 1 and CHL 2 (both in Bldg. 8)
- End Station Refrigerator (ESR) – ESR 1 (Bldg. 102) and ESR 2 (Bldg. 104)
- Cryogenic Test Facility (CTF) – CTF (Bldg. 57)
- Hall D Cryo (Bldg. 201)

Continuous Communication Requirement – Certain areas that may have ODH conditions require multiple personnel to be able to effectively communicate changing conditions or to take action. This is achieved by voice, which can be raised to a normal shout or lower. Cell phones, two way radios, two way voice pagers or other paging systems, or video camera/PA systems are NOT considered acceptable means for continuous communications.
Health Effects of Reduced Oxygen

Normal air is approximately 20.9% oxygen and 78% nitrogen. The remaining 1% is mostly argon. Health effects begin at an oxygen concentration of 17%. Oxygen monitors at Jefferson Lab are set to alarm at 19.5%. This advance warning should give ample time to escape the hazard area. The early health effects are difficult to detect and are an unreliable method to determine reduced oxygen concentrations. Therefore, oxygen monitors are relied upon to give early warning.

<table>
<thead>
<tr>
<th>Percent Oxygen</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Night vision reduced; Increased breathing volume; Accelerated heartbeat</td>
</tr>
<tr>
<td>16</td>
<td>Dizziness Reaction time for new tasks is doubled</td>
</tr>
<tr>
<td>15</td>
<td>Poor judgment; Poor coordination; Abnormal fatigue upon exertion; Loss of muscle control</td>
</tr>
<tr>
<td>10-12</td>
<td>Very faulty judgment; Very poor muscular coordination; Loss of consciousness</td>
</tr>
<tr>
<td>8-10</td>
<td>Nausea; Vomiting; Coma</td>
</tr>
<tr>
<td>&lt; 8</td>
<td>Permanent brain damage</td>
</tr>
<tr>
<td>&lt; 6</td>
<td>Spasmodic breathing; Convulsive movements; Death in 5-8 minutes</td>
</tr>
</tbody>
</table>

**NOTE:** Individuals with lung disorders or other health problems may experience health effects sooner than healthy individuals.

**CAUTION:** Oxygen levels of less than 12% can suddenly cause unconsciousness without warning. In such a low oxygen concentration, the blood via the lungs, will actually give up oxygen due to the partial pressures of atmospheric gases. Do not assume that if you are in an oxygen deficient atmosphere that you will be unaffected if you take a deep breath and hold it.
Oxygen Deficiency Hazards at Jefferson Lab: The Cryogen Connection

Oxygen deficiency hazards at Jefferson Lab are associated with standard industrial work, including the use of inert gases and refrigerants. However, the most significant oxygen deficiency hazard is associated with the use of the cryogens helium and nitrogen. Even temporary enclosures (i.e., temporary cleanroom) that have inert gas connections can become an ODH area. A hazard assessment must be conducted for such areas see ES&H Manual Chapter 6540 Appendix T1 Oxygen Deficiency Hazard (ODH) Safety Review).

Employees or other people shall not ride an elevator with a cryogenic container or other compressed gases due to the limited car volume and volume of gas released. Cold temperatures from the released gas or liquid or the surface of cryogenic solids (e.g., dry ice) also present a hazard.

Properties of Cryogens
The term cryogenic is applied to very cold temperatures. Cryogenic fluids are extremely cold when in a liquid state. At room temperatures, they are gases. Gases used at Jefferson Lab that can exist as cryogens are: helium, nitrogen, argon, hydrogen and occasionally “dry ice” (solid carbon dioxide). The temperature of the liquid helium used to cool accelerator cavities is 2^0 Kelvin. This equates to approximately -456^0 F.

NOTE: The cryogens used at Jefferson Lab are colorless. The white/grey cloud observed when a liquid cryogen evaporates to gas is water condensing from the atmosphere and is called the plume. The plume serves as a visual indicator that a cryogenic gas is present.

WARNING: Plumes will not be visible when the gas warms but the hazard may still exist.

Cryogens expand greatly. In the event of a release, they can displace air. Over time, even leaks in small spaces can also reduce oxygen concentrations.

All cryogens expand when evaporating from liquid to gas. The expansion ratio can be estimated at 1000:1. This means that when a gallon of liquid cryogen evaporates, 1,000 gallons of gas will form. When there is a release of liquid, the liquid will evaporate rapidly and the percentage of other gases, most notably oxygen, will decrease in the area of the release. The volume of gas from this large expansion results in the Oxygen Deficiency Hazard.

NOTE: The cryogens used at Jefferson Lab are odorless and tasteless. Because we cannot sense the cryogens, their presence is monitored by a decrease in the oxygen concentration. When a cryogen is released, it will displace air as it rapidly evaporates and expands. The oxygen monitors will alarm when the oxygen concentration drops to 19.5%
**WARNING:** Loose fitting, non-absorbent, insulated gloves are required when handling cryogenic valves, joints or filling dewars. In the event the gloves are “wetted” with a cryogenic liquid, they can be easily removed by a snapping motion of the hands.

Whether cryogen gases are lighter or heavier than air derives from that gas’s density. This is important in determining where a released cryogen will accumulate. For example, oxygen monitors are located at floor level to detect cryogenic plumes heavier than air and located near the ceiling to detect cryogenic plumes lighter than air.

<table>
<thead>
<tr>
<th>GAS</th>
<th>TEMPERATURE</th>
<th>LIGHTER OR HEAVIER THAN AIR</th>
<th>MONITOR PLACEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>helium</td>
<td>any</td>
<td>lighter</td>
<td>ceiling</td>
</tr>
<tr>
<td>nitrogen</td>
<td>cold</td>
<td>heavier</td>
<td>floor</td>
</tr>
<tr>
<td></td>
<td>warm</td>
<td>lighter</td>
<td>ceiling</td>
</tr>
<tr>
<td>argon</td>
<td>any</td>
<td>heavier</td>
<td>floor</td>
</tr>
<tr>
<td>hydrogen</td>
<td>any</td>
<td>lighter</td>
<td>***</td>
</tr>
</tbody>
</table>

**Note blue and black oxygen sensor to right of outlet.**

***Hydrogen is also a flammable cryogen. The flammability hazard is more important than the oxygen deficiency hazard** and becomes significant at low concentrations, so flammable gas detectors would be installed at ceiling level instead of oxygen monitors.

**Cryogenic Support for the Accelerator**

The cryogenic systems at Jefferson Lab use nitrogen and helium. Argon and hydrogen are also on-site but are not used in the cryogenic refrigeration system for the accelerator.

**Accelerator**

Helium is used as the cryogen in the Accelerator Tunnel to cool the superconducting cavities. Fixed oxygen monitors are located at ceiling height because helium is lighter than air.
Lintels and helium removal systems are engineering controls installed in the tunnel. The lintels are located to control helium from entering the exit stairwells which allows sufficient time for staff to evacuate safely.

When cryogens are present in the Accelerator Tunnel, the areas behind and above the Cryomodules and near the ceiling in the walkway are ODH 1. The walkway is ODH 0.

**Service Buildings**

Service Buildings (North and South Linac) are located above the Accelerator and have ceiling to floor penetrations connecting the Accelerator Tunnel to the Service Buildings. Penetrations are plugged to keep helium out of these buildings. Temporary changes in the ODH classification created by maintenance or shutdown work that displaces these plugs requires the reposting of the Service Buildings from an ODH 0 to ODH 1.

![Diagram of Lintel](image)

**NOTE:** Most if not all penetrations have been plugged in the LINAC service buildings associated with the Accelerator. This has reduced the Service Buildings hazard from ODH 1 to ODH 0. Be aware that opening a plugged penetration will significantly increase the oxygen deficiency hazard in that localized area. Opening penetrations always requires RADCON notification and may require Systems Safety notification and posting of the affected area as ODH 1. An appropriate and approved Work Control document (such as an ATLis entry) is required before removing any penetration plugs.

**End Stations**

Significant quantities of both helium and nitrogen are used in the end stations. Lesser amounts of hydrogen are also used. Fixed oxygen monitors are located near both the ceiling and the floor because helium is lighter than air and will rise while cold nitrogen is heavier than air and will sink. Very small amounts of liquid hydrogen may be used as cryogenic targets in the end stations. Hydrogen is not only a cryogen in its liquid state, but it is also a very flammable liquid and gas.
Free Electron Laser (FEL) Building
Helium is used as the cryogen in the FEL, lower level. Floor penetrations exist where electrical relay racks connect the lower level to the upper level. Helium can rise through these penetrations, so the hazard level is significant in electrical relay racks located above open penetrations in the FEL upper level.

**NOTE:** The presence of ambient temperature gas supplies, such as nitrogen helium and sulfur hexafluoride, also contribute to the oxygen deficiency hazard in the FEL. Oxygen monitors are installed near the lower level floor for sulfur hexafluoride releases.

**Other ODH Cryogens (across Jefferson Lab)**
Liquid argon may be used by experimenters and welders and supplied in dewars. Occasionally, solid carbon dioxide (a.k.a., “dry ice”) or gaseous carbon dioxide may be used and therefore those work environments must be assessed according to ES&H Manual Chapter 6540 Appendix T1 Oxygen Deficiency Hazard (ODH) Safety Review. Dewars may be in Experimental Halls and those applications should be assessed BEFORE the dewars are brought into the Halls.

![Typical relay rack](image)

![Silver Carbon Dioxide dewars](image)

**Oxygen Deficiency Hazard Risk Assessment - Jefferson Lab Work Area Classification**

The goal of ODH risk assessment is to estimate the increase in the rate at which fatalities will occur in a given area if no precautions or mitigation are instituted. Controls are then designed and installed to prevent those fatalities.

The level of risk is based on the type of work that will be done in a given area. The level of risk is also based on expected component failure rates for the cryogenic or other equipment that presents an oxygen deficiency hazard.

At Jefferson Lab there are five ODH hazard levels. They are noted ODH 0 through 4. The hazard increases as the number increases. Work areas are classified assuming that there are NO
CONTROLS, not even training. Dividing lines are based on the statistical probability of one worker fatality occurring in a specified number of worker-hours:

<table>
<thead>
<tr>
<th>ODH Class</th>
<th># of worker-hours before a fatality is expected due to ODH events</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Greater than 10 million *</td>
</tr>
<tr>
<td>1</td>
<td>from 100,000 hours to 10 million hours</td>
</tr>
<tr>
<td>2</td>
<td>from 1,000 to 100,000 hours</td>
</tr>
<tr>
<td>3</td>
<td>from 10 to 1,000 hours</td>
</tr>
<tr>
<td>4</td>
<td>less than 10 hours</td>
</tr>
</tbody>
</table>

*10 million hours equates to over 5,000 worker years.

NOTE: At the date of this booklet revision, there are no permanent ODH 3 or ODH 4 areas at JLab. No permanent ODH 3 or ODH 4 areas are anticipated to be approved due to the required engineering or design controls for hazard mitigation.

ODH classification is necessary in work areas where compressed gases, liquefied gases, cryogenic solids, and volatile liquids are stored or used. Areas where cryogenic materials are used will have one of the following placards posted at the entrance to the hazard area.

An ODH 4 area is considered an Immediately Dangerous to Life or Health environment that requires special consideration and precautions.

**LOOK FOR AND OBEY REQUIREMENTS ON SIGNS POSTED AT ODH WORK AREAS!**

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**NOTICE**

**OXYGEN DEFICIENCY HAZARD**

Prior to entry all personnel must have the following:

- Oxygen deficiency hazard training
CAUTION

OXYGEN DEFICIENCY HAZARD 1

PRIOR TO ENTRY ALL PERSONNEL MUST HAVE THE FOLLOWING:
• OXYGEN DEFICIENCY HAZARD TRAINING

MULTIPLE PERSONNEL IN CONTINUOUS COMMUNICATION REQUIRED

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CAUTION

OXYGEN DEFICIENCY HAZARD 2

PRIOR TO ENTRY ALL PERSONNEL MUST HAVE THE FOLLOWING:
• PERSONAL OXYGEN MONITOR
• A SELF RESCUE SUPPLIED ATMOSPHERE RESPIRATOR
• OXYGEN DEFICIENCY HAZARD TRAINING
• MEDICAL APPROVAL FOR OXYGEN DEFICIENCY HAZARD WORK

MULTIPLE PERSONNEL IN CONTINUOUS COMMUNICATION REQUIRED
DANGER

OXYGEN DEFICIENCY HAZARD

Prior to entry all personnel must have the following:
• Personal Oxygen Monitor
• A Self Rescue Supplied Atmosphere Respirator
• Oxygen Deficiency Hazard Training
• Medical Approval for Oxygen Deficiency Hazard Work

Multiple personnel in continuous communication required
Unexposed observer required

DANGER

OXYGEN DEFICIENCY HAZARD

Prior to entry all personnel must have the following:
• Personal Oxygen Monitor
• 30-Minute Self-Contained Breathing Apparatus
• Oxygen Deficiency Hazard Training
• Medical Approval for Oxygen Deficiency Hazard Work

Multiple personnel in continuous communication required
Unexposed observer required
ODH Avoidance
Follow all instructions on posted ODH signs:

ODH 0/1 workers: Stay out of ODH 2, 3, 4 work areas. NO EXCEPTIONS!

Observe the buddy rule for ODH 1 or greater.

Do not enter the Central Helium Liquefier (CHL), the End Station Refrigerator (ESR) Bldg 102, ESR 2 (Bldg 104), Bldg 57 – Cryogenic Building or the Cryogenic Test Facility (CTF) without permission from the Cryogenics Group Leader or unless accompanied by a JLab person authorized or assigned to that area.

INDICATIONS OF AN ODH INCIDENT

Blue flashing light and/or buzzer are ODH alarms. When you hear/see an ODH alarm, EVACUATE the work areas immediately.

Pay attention to local indications such as the sound of rushing gas or plumes, which indicates a leak.
In case of an uncontrolled release of cryogens, NEVER walk into a vapor cloud. Why? Extremely cold vapors, if inhaled, will damage lung tissue. Additionally, the inhalation introduces reduced oxygenated air into the lungs that would most likely result in the person passing out. Visibility in the cloud will also be limited, increasing the chance of fall. Take an alternate exit.

**ODH Safety Review and Risk Assessment**

An ODH Safety Review must be conducted whenever an ODH area is first established or whenever modified, and where ever cryogens are used, stored or dispensed. Contact the ODH Safety Reviewer for assistance and see [ES&H Manual Chapter 6540 Appendix T1 Oxygen Deficiency Hazard (ODH) Safety Review](#) for required information. A Risk Assessment may also be required.

**ODH Control Measures**

Once an ODH area has been identified, specific control measures must be followed to enter that area. These controls are designed to make the risks of ODH 2, 3, and 4 areas comparable to the risk of an ODH 0 area.

These are three types of controls:

1. **Engineering controls consist of:**
   - Fixed oxygen monitors in designated ODH 1-4 areas. Both fixed and portable oxygen monitors will alarm at 19.5% oxygen.
   - The ODH alarm indicator is a flashing blue light (right) and/or a low-pitched buzzer.
   - Complete filling and sealing of all penetrations leading from the Linac Service Buildings on the surface to the Accelerator tunnel below. This prevents helium from entering the Linac Service Building in the event of a helium release in the tunnel.
   - Helium removal systems in the Accelerator tunnel. A lintel/helium removal vent keeps helium out of the exit stairwells in the Accelerator tunnel long enough for staff to exit safely. In the FEL, there are passive vent ducts and a 24/7 ventilation system.

2. **Personal protective equipment and personal oxygen monitors are required for work in areas classified ODH 2 or greater. These are:**
   - personal oxygen monitors;
   - 5-minute escape packs (contains air not oxygen); or
   - self-contained breathing apparatus (SCBA).

If an ODH 3 or ODH 4 area is temporarily created, suitable monitoring, PPE, and work control documents will be established following the Temporary Operating Safety Procedure ([ES&H Manual Chapter 3310 Operational Safety Procedure (OSP) Program](#)).
Personal Oxygen Monitors

Personal oxygen monitors are maintained by the Industrial Hygiene (IH) Group. If there are problems with the monitor do not use it and notify IH at extension 7882, 7863, 6254 or 6381.

Personal Oxygen Monitor locations:
- Machine Control Center (MCC)
- Central Helium Liquefier (CHL)
- End Station Refrigerator (ESR)
- Cryogenic Test Facility (CTF)
- Cryomodule Test Cave (CTMF)
- Industrial Hygiene

MSA Altair Pro Personal Oxygen Monitor Refresher Information

To turn on unit:
- TURN ON IN FRESH AIR.
- Press the power button and hold until lights flash twice.
- Unit will go through test mode of alarms
- Display will read “FAS?“ (fresh air sample)
  - Press power button to initiate this fresh air
  - Unit will display ok if FAS is good**
** If unit does not pass FAS, a calibration is required
  call IH group x7863, 6254, 7882
- YOU MUST PERFORM A DAILY BUMP TEST

To Perform a Bump Test, with the unit operating:
- Hold power button down for 2 seconds.
- Unit will display Test
- Release power button
- The unit will display “GAS?”
- Press power button again
- Hourglass will appear above the word GAS
- Hold the unit up to mouth and breathe on the white sensor until the display reads OK and you hear audible beep
- A check mark √ will appear above the O2 reading: this indicates that the bump test is current and WILL DISPLAY THE CHECK FOR 24 HOURS
- The display indicates 20.8% as the “normal” air concentration of oxygen.
- To turn off unit: hold down power button until long tone is heard.

Use of the Monitor
- Wear the monitor on the outside of the clothing on shoulder/collar area.
- Do not cover the monitor with a coat or keep it in a pocket.
- The personal monitors will alarm at less than or equal to 19.5% oxygen only. Altairs are to be used for monitoring only oxygen and are inadequate for indication of other gases.
that may decrease oxygen. Hazardous concentration of other gases, such as carbon monoxide, will not sufficiently decrease the oxygen concentration for instrument detection.

**Emergency Escape Packs**

*Those entering ODH 2 and 3 areas must take SAF 210 – Escape Pack Training.*

**Reminder: Information for Emergency Escape Packs (does NOT replace SAF 210)**

For ODH 2 and 3 areas, each person is required to carry their own five-minute escape pack. This section outlines the proper procedures for checking, activating, and donning the pack. After activating an Escape Pack for an evacuation requires: 1) Returning the unit to Industrial Hygiene and obtaining a replacement unit and 2) Notifying your Supervisor who will initiate an incident investigation.

**General Information**

An Escape Pack is limited for evacuating an area; it is NEVER for entry into a known hazard or an unknown situation.

The cylinder contains a five minute supply of compressed air.

*Escape packs can only be taken into an area only when the gauge indicates FULL.*

If less than full, return it to the Industrial Hygiene Group for refilling.

Escape pack use requires annual training (SAF 210) and triennial medical approval (MED 113).

**IMPORTANT:** The Escape Pack is to be used for ESCAPE ONLY.

To respond to an ODH event with unknown oxygen concentrations, the properly trained and designated responder must only use a Self-Contained Breathing Apparatus (SCBA) for initial entry and until the affected environment has been evaluated.
Instructions for Donning the Five Minute Escape Pack.

1. Check gauge.
2. Turn Valve ON at top of cylinder.
3. Remove plastic hood.
4. Place hood over head. Immediately leave the area.

Return empty or partially used packs to Industrial Hygiene (IH) for refill.
Self-Contained Breathing Apparatus (SCBA)

Special Qualifications are required to use SCBAs.

Only the SCBA is used for planned work in hazardous atmospheres and for emergency response. The SCBA provides an air supply lasting approximately 30 minutes depending on wearer’s exertion. SCBA use requires an annual training class (SAF 109) in the use of the unit, an annual fit test, and medical approval (MED 13).

*There are no ODH 4 areas at JLab and none should be created that require the routine use of SCBAs; however, ODH4 areas are still possible due to releases from planned work or emergencies.*

**Planned work** – If, in the non-emergency event that an ODH 4 area is created (i.e., due to release), all remotely active controls and efforts are required before any personnel entry. Only the SCBA is to be used for entry into ODH 4 areas. Permission for entry must be received from the Cryogenic Group Leader AND a JLab Certified Industrial Hygienist. Most personnel at Jefferson Lab will not receive permission to enter such an area. Two similarly equipped workers are required for entry with two additional backup workers on stand-by.

**Emergency Response** - SCBA’s are used for rescue conducted ONLY by the Newport News Fired Department as JLab personnel are not trained to conduct a rescue.
3. Administrative Controls:
Examples of administrative controls that may be required for ODH areas include Notice, Caution, and Danger signs, training, use of unexposed observers, and medical approval. Important administrative controls include the Buddy Rule: Multiple personnel in continuous communication is required for entry into any area classified ODH 1 or greater.

Medical Approval Requirements
Medical approval is required only for ODH 2, 3, and 4 work. Most Jefferson Lab personnel and scientific users work in ODH 0 or 1 areas, so medical approval is not a prerequisite. **ODH 0/1 workers do not need and will not have medical approval.**

For ODH 2, 3, and 4 work there are four categories of Medical Classification:

<table>
<thead>
<tr>
<th>MEDICAL CLASSIFICATION</th>
<th>MEANING</th>
<th>DURATION OF MEDICAL CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODH Excluded</td>
<td>No entry into ODH 2, 3, or 4</td>
<td>3 years</td>
</tr>
<tr>
<td>ODH Restricted</td>
<td>Must have escort for ODH 2 and 3. No entry to ODH 4</td>
<td>3 years</td>
</tr>
<tr>
<td>ODH Qualified</td>
<td>Approval for ODH 2 and 3. No entry to ODH 4</td>
<td>To be determined by Occupational Medicine</td>
</tr>
<tr>
<td>SCBA Qualified</td>
<td>Approval for ODH 4</td>
<td>3 years</td>
</tr>
</tbody>
</table>

Medical Approval is based on a general physical exam that includes tests of hearing, vision, blood pressure, and lung capacity. Medical Approval for ODH 2, 3, and 4 is given by Jefferson Lab Occupational Medicine.
MITIGATION FOR ENTRY INTO ODH 0 THROUGH ODH 4 AREAS

The REQUIRED mitigations are outlined in the following table. If at any time you are unsure of the classification of your work area, contact your supervisor and make sure you understand the classification BEFORE you enter the area and begin work. An “x” indicates requirement.

<table>
<thead>
<tr>
<th>ODH Control Measures</th>
<th>ODH Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering Controls</strong></td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>Ventilation - One air change per hour (Minimum)</td>
<td>X X X X</td>
</tr>
<tr>
<td>Fixed oxygen monitor</td>
<td>X X X X</td>
</tr>
<tr>
<td>North &amp; South Linac Service Buildings, Injector Service Building: penetrations filled with stone and sealed with gas-tight gasketed aluminum plate. (Normal operating conditions)</td>
<td>X</td>
</tr>
<tr>
<td>North &amp; South Linac Service Buildings with open penetration(s)</td>
<td>X</td>
</tr>
<tr>
<td>Tunnel only: helium removal system, lintel/helium vent</td>
<td>X X X X</td>
</tr>
<tr>
<td>Test Lab</td>
<td>X X</td>
</tr>
<tr>
<td><strong>Administrative Controls</strong></td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>ODH Signs</td>
<td>X X X X X</td>
</tr>
<tr>
<td>ODH Training</td>
<td>X X X X X</td>
</tr>
<tr>
<td>Buddy Rule: In order to enter a work area there must be at least two workers who stay in close proximity to each other. This is referred to as multiple personnel in continuous communication.</td>
<td>X X X</td>
</tr>
<tr>
<td>Three-man rule/Unexposed Observer</td>
<td>X</td>
</tr>
<tr>
<td>Medical Approval</td>
<td>X X X</td>
</tr>
<tr>
<td><strong>Personal Protective Equipment</strong></td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>Personal oxygen meter</td>
<td>X X X</td>
</tr>
<tr>
<td>5 minute escape pack, one for each person entering</td>
<td>X X</td>
</tr>
<tr>
<td>Self-contained breathing apparatus (minimum 30 minutes)</td>
<td>X</td>
</tr>
</tbody>
</table>

- **NOTE:** Certain work or temporary conditions may render a work area temporarily ODH 2 or greater.

**NOTE:** At the date of this booklet revision, there are NO permanent ODH 3 or ODH 4 areas at JLab. Any work that may create ODH 3 or 4 conditions must be preplanned and coordinated with the Cryogenic Group Leader and in consultation with Industrial Hygiene. A cryogenic expert will then be assigned for planning ODH 3 or ODH 4 work and protocols will be established following the Temporary Operating Safety Procedure (see ES&H Manual Chapter 3310 Operational Safety Procedure (OSP) Program).

The Three-Man Rule/Unexposed Observer: An unexposed observer is required for ODH 3 work. An unexposed observer is an ODH-qualified worker who is physically removed from an ODH 3 area and can monitor work activities. In case of an ODH incident the unexposed observer can summon help.
# EMERGENCY PROCEDURES

<table>
<thead>
<tr>
<th>PROBLEM / SITUATION</th>
<th>RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed oxygen monitor alarms</td>
<td>• EVACUATE</td>
</tr>
<tr>
<td></td>
<td>• notify Crew Chief*/Supervisor</td>
</tr>
<tr>
<td></td>
<td>• do not enter work area until problem has been solved</td>
</tr>
<tr>
<td>Any indication of possible gas leak, such as: vapor cloud or sound of rushing gas</td>
<td>• EVACUATE the work area</td>
</tr>
<tr>
<td></td>
<td>• notify Crew Chief*/Supervisor</td>
</tr>
<tr>
<td>Any indication of an ODH situation and a worker is DOWN</td>
<td>• EVACUATE</td>
</tr>
<tr>
<td></td>
<td>• Call 911</td>
</tr>
<tr>
<td></td>
<td>• notify Crew Chief*/Supervisor</td>
</tr>
<tr>
<td>Personal oxygen monitor alarms</td>
<td>• Don escape pack and EVACUATE the area (ODH 2)</td>
</tr>
<tr>
<td></td>
<td>• Troubleshoot monitor to verify monitor is responding properly</td>
</tr>
<tr>
<td></td>
<td>• Notify Crew Chief of potential ODH problem if monitor has not malfunctioned*</td>
</tr>
<tr>
<td>Not enough oxygen monitors for all members of work group to enter an ODH 2 or greater area</td>
<td>• DO NOT ENTER area until each member has a personal oxygen monitor</td>
</tr>
<tr>
<td>Work group enters an ODH 2 area with personal monitors. One monitor is dropped and malfunctions.</td>
<td>• Due to the buddy rule, two workers will have to exit together</td>
</tr>
<tr>
<td>Workers experience initial health effects associated with ODH.</td>
<td>• EVACUATE the work area</td>
</tr>
<tr>
<td></td>
<td>• Call 911</td>
</tr>
<tr>
<td></td>
<td>• Notify Crew Chief*/Supervisor</td>
</tr>
<tr>
<td>Worker(s) collapse or lose conscience</td>
<td>• EVACUATE the work area</td>
</tr>
<tr>
<td></td>
<td>• Call 911</td>
</tr>
<tr>
<td></td>
<td>• Notify Crew Chief*/Supervisor</td>
</tr>
</tbody>
</table>

*If incident occurs on the Accelerator site, notify Crew Chief and Supervisor. If incident occurs elsewhere, notify Supervisor.
# Permanent ODH Areas at Jefferson Lab

As of March 5, 2014:

<table>
<thead>
<tr>
<th>ODH Classification</th>
<th>Location</th>
</tr>
</thead>
</table>
| ODH 0              | - North and South Access Building Electronic Rack rooms  
|                    | - North and South Linac Service Buildings  
|                    | - Injector Service Building  
|                    | - Experimental Halls (Except above crane rails)  
|                    | - Test Lab multiple areas including selected  
|                    | - HDIce area  
|                    | - Certain Labs in the Test Lab Annex (TLA)  
|                    | - Process Support Building (PSB)  
| ODH 0 and 1        | - Accelerator Tunnel: behind cryomodules is ODH 1; near ceiling is ODH 1; rest of tunnel is ODH 0  
|                    | - FEL Vault: ODH 0 and 1, depending on area  
|                    | - FEL Upper Level: Inside designated electronic racks is ODH 1, rest of building is ODH 0  
|                    | - Hall D Tagger tunnel, depending on conditions & location  
|                    | - Test Lab Cryomodule subassembly areas  
|                    | - Test Cave:  
|                       |   o ODH 0 when u-tube not connected to cryomodule with large cave door open  
|                       |   o ODH 1 when u-tube connected with large cave door open  
|                    | - Cooling Tower Support Building by TED  
| ODH 1              | - Central Helium Liquefier Building (CHL) Bldg. 8  
|                    | - End Station Refrigerator Building (ESR) Bldg. 102  
|                    | - End Station Refrigeration Building 2 & ESR 2 (Bldg. 104) once it is operational  
|                    | - Cryogenic Test Facility (CTF) Bldg. 57  
| ODH 2              | - Experimental Halls: Area above the crane rail  
|                    | - Test Lab: Cryomodule Test Cave Mezzanine  
|                    | - Test Lab: Cryomodule Test Cave when cryomodule u-tube connected with large cave door closed  
|                    | - Certain areas of HDIce (Bldg 58)  
| ODH 3              | no permanent area  
| ODH 4              | no permanent area  

For updated locations, consult Industrial Hygiene staff.

The following ODH areas require Cryogenics Department permission or accompaniment:
- Central Helium Liquefier (CHL) – CHL1 and CHL2 (both in Bldg. 8)
- End Station Refrigerator (ESR) – ESR 1 (Bldg. 102) and ESR 2 (Bldg. 104)
- Cryomodule Test Cave
- Cryogenic Test Facility (CTF) – CTF (Bldg. 57)
- Hall D Cryo (Bldg. 201)
Estimating Oxygen Concentration
(See ES&H Manual Chapter 6540 Appendix T1 Oxygen Deficiency Hazard (ODH) Safety Review.)

The equation for estimating oxygen concentration in the work area, if the contents of a compressed gas cylinder are released, is:

Resulting % oxygen = \( \frac{21(V_r - V_g)}{V_r} \)

Where: \( V_r \) = volume of the room
\( V_g \) = volume of the gas

Resulting oxygen concentration percentage must be greater than 19.5%.

*For compressed gas bottles \( V_g \) can range from 200 to 300 cubic feet, depending on the gas and the type of cylinder. Check with the gas supplier. Use room volume in cubic feet.

**For a cryogenic container, \( V_g \) is number of liquid liters x expansion ratio (700 to 1000)/1000 liters per cubic meter. Use the room volume in cubic meters. 1 cubic meter = 35.3 cubic feet.

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Visitor Information
The following may be used as the briefing or a handout for VISITORS:

Certain areas in JLab are classified according to their Oxygen Deficient Hazard (ODH) potential. Many areas contain cryogens or liquefied gases that expand greatly when released or may have other compressed gases. Cryogens can displace air, which contains oxygen with non-oxygenated gases, from the area resulting in varying degrees of adverse health effects to exposed persons. The probability of death is extremely unlikely; however you need to know the following warning methods:

ODH event is indicated by a blue strobe light, a loud buzzing alarm and/or a white plume. Visitors to ODH 0 and ODH 1 posted areas require an escort. Visitors are NOT permitted in ODH 2 or higher areas regardless of an escort.

If any of the low oxygen alarms occur during the visit, promptly leave the building with your escort/host making sure to avoid any plumes. Follow the directions of your host on where to go. If you see any unconscious person, call 911 from a safe area but NEVER attempt a rescue yourself.

March 2014 Edition