



**THE UNIVERSITY OF MAINE**  
**COMPRESSED GAS CYLINDERS**  
**FOR SCUBA DIVING**

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## 1.0 Purpose and Background

Compressed gas cylinders are used at UMAINE in laboratories, scientific diving operations, and maintenance areas. Personnel using compressed gas cylinders must be trained in the safe use, storage, and transportation of high-pressure cylinders. Compressed gas cylinders can be potentially hazardous due to the pressures of the contents, the contents themselves, and/or a sudden and uncontrolled release of contents resulting in a missile/projectile hazard.

### 1.1 Regulatory Guidance

- University of Maine Scientific Diving Standards
- 29 CFR 1910.101, 102 103, 104
- 49 CRY 173.34
- Compressed Gas Association, Inc. CGA P-1, Safe Handling of Compressed Gas in Containers

### 1.2 Requirements

- 12.2.1 Compressed gas cylinder construction standards are regulated by the Department of Transportation. All cylinders shall be tested and inspected within their required periodicity, 49 CFR 173(3). All cylinders will have the required labeling and proper fittings for their use. Cylinders must be labeled as to their contents; cylinder color is not a reliable indication of contents. Scuba cylinders shall be inspected as outlined herein and in the University of Maine Standards for Scientific Diving Certification and Operation of Scientific Diving Programs.
- 1.2.2 Personnel using the cylinders shall understand the hazards of the gas being used. The MSDS should be used to obtain this information. The system with which the gas cylinder is to be used must be compatible with the gas. Incorrect matching can result in leaks, explosion, or fire.
- 1.2.3 Gas cylinders shall be secured to a solid structure or rigid support when in service or storage by a substantial chain, rope, or strap across the front or around the cylinder. At scuba charging stations cylinders may be nested/secured using the three-point method established by the Compressed Gas Association.
- 1.2.4 When not in use cylinder valves will be shut. Cylinders with valve caps will be stored and transported with caps in place. Cylinders should not be lifted by the screw-on valve cap.
- 1.2.5 The gas supplier or UMAINE staff will normally perform cylinder transportation. When transporting cylinders in a vehicle, two requirements must be met:
- Adequate ventilation must be present. Leaking cylinders could potentially asphyxiate the passengers of the vehicle or cause an explosion. Cylinders should not be carried in the passenger compartment.
  - Cylinders must be adequately secured to prevent shifting which could result in damage to the cylinder and create a potential missile/projectile hazard.

### **1.3 Responsibilities**

- Supervisors shall ensure that their employees obtain the required training.
- Employees shall abide by the requirements outlined in this policy.
- The University of Maine Diving Safety Officer (DSO) will conduct training on use of scuba cylinders and the scuba charging system.

### **1.5 Additional Information**

References: NOAA Diving Manual, 4<sup>th</sup> ed. (2001), Sec. 5.7-5.8  
PADI Encyclopedia of Recreational Diving (2005), pp. 3.46-3.56

Contact the UMAINE Diving Safety Officer at 207-563-3146 ext. 232.

## **2.0 Compressed Gas Cylinders for Scuba Diving**

### **2.1 Cylinder Types and Markings**

Cylinders used for scuba diving at UMAINE shall be designed and approved for use in scuba diving activities.

Individuals working with cylinders shall be able to recognize and identify different cylinder types (i.e. aluminum, steel, other) and locate and understand cylinder markings including but not limited to: DOT material codes, working pressure limits, manufacturer serial numbers, and hydrostatic test dates.

### **2.2 Valve Types**

Individuals shall be able to recognize and identify different valve types and their uses including but not limited to: K-valves, J-valves, and Y-valves. Individuals will also be trained to distinguish between yoke valves and DIN valves.

### **2.3 Potential Hazards**

Individuals shall understand the potential hazards of working with high pressure scuba cylinders and the compressed gases they contain. Potential hazards include but may not be limited to: impact/crush injuries from falling or rolling cylinders, injection injuries from escaping contents, traumatic injuries from catastrophic failure of cylinders/valves, and asphyxiation hazards from contents.

### **2.4 Use, Transport, and Storage**

Individuals shall understand proper techniques for use, transport, and storage of scuba cylinders. Such measures include:

#### **2.4.1 Use**

Scuba tanks are only to be used for scuba diving and/or related underwater activities (i.e. suction sampling) and should not be used for other purposes.

#### **2.4.2 Transport**

When transporting/moving by hand, scuba cylinders shall be held by the valve in a manner which prevents both accidental activation of the valve and potential injection injury to the hand. If carried on the shoulder, manual contact with the valve shall be maintained. Cylinders shall not be carried without maintaining positive contact with the valve (i.e. cradling, 'stirruping').

When transporting by vehicle, scuba cylinders shall be blocked or otherwise secured to prevent shifting. Scuba cylinders containing a non-breathable gas (i.e. Argon) should not be transported in the passenger compartment.

#### **2.4.3 Storage**

When stored, scuba cylinders shall be secured from falling. Cylinders may be secured by lashing or chaining the cylinder to a fixed surface, or placing the cylinder in an approved free standing rack designed for this purpose (i.e. "Pelican" rack). Cylinders in a gas manufacturing/compressor area may be secured using the CGA 3-point nesting method. When temporarily staging cylinders for use, as on a dock, cylinders shall be either secured from falling, as above, or placed in a horizontal position and blocked to prevent rolling. At no time shall individual cylinders be left free-standing.

When storing for long periods of time, cylinders shall be secured from falling as all others. Cylinders should be stored away from extreme temperatures and contain a moderate amount of pressurized gas (~1000psi) to minimize stress on cylinder components and prevent internal contamination and/or corrosion.

### 3.0 Compressor System and Breathing Gases

#### 3.1 Description

The Darling Marine Center is currently the only UMAINE facility that maintains an on-site air station comprised of a high pressure air compressor and cascade storage system for use in filling gas cylinders used in scuba diving operations.

Requirements for gas compressor systems are specified in the University of Maine Standards for Scientific Diving Certification and Operation of Scientific Diving Programs (Sec 3.43, 3.44, 3.52) and reflect the minimum standards set forth by the American Academy of Underwater Sciences (AAUS).

[Note: The following sections are copied directly from University of Maine Standards for Scientific Diving Certification and Operation of Scientific Diving Programs (Sec. 3.43, 3.44, 3.52), April 2001]

#### 3.2 Compressor Systems

The following will be considered in design and location of compressor systems:

- Low pressure compressors used to supply air to the diver if equipped with a volume tank shall have a check valve on the inlet side, a relief valve, and a drain valve.
- Compressed air systems over 500 psig shall have slow-opening shut-off valves.
- All air compressor intakes shall be located away from areas containing exhaust or other contaminants.

#### 3.3 Oxygen Systems

- Equipment used with oxygen or mixtures containing over forty percent (40%) by volume oxygen shall be designed and maintained for oxygen service.
- Components exposed to oxygen or mixtures containing over forty percent (40%) by volume oxygen shall be cleaned of flammable materials before being placed into service.
- Oxygen systems over 125 psig shall have slow-opening shut-off valves.

#### 3.4 Compressor Operation and Air Test Records

- Gas analyses and air tests shall be performed on each University of Maine-controlled breathing air compressor at regular intervals of no more than 100 hours of operation or six months, whichever occurs first. The results of these tests shall be entered in a formal log and be maintained.
- A log shall be maintained showing operation, repair, overhaul, filter maintenance, and temperature adjustment for each compressor.

Note: Air compressor maintenance at the UMAINE Darling Marine Center is conducted by an outside contractor (Angel Associates/ Northern Industrial Sales).

### 3.5 Requirements for Breathing Gases

Requirements for breathing gases are specified in the University of Maine Standards for Scientific Diving Certification and Operation of Scientific Diving Programs (Sec. 3.60) and reflect the minimum standards set forth by the American Academy of Underwater Sciences (AAUS).

#### 3.5.1 Air Quality

Breathing air for scuba shall meet the following specifications as set forth by the Compressed Gas Association (CGA Pamphlet G-7.1) and referenced in OSHA 29 CFR 1910.134

CGA Grade E		
Component		Maximum
Oxygen		20 - 22%/v
Carbon Monoxide		10 PPM/v
Carbon Dioxide		500 PPM/v
Condensed Hydrocarbons		5 mg/m <sup>3</sup>
Water Vapor		NS
Objectionable Odors		None

#### 3.5.2 Air Testing

Air quality testing at the UMAINE Darling Marine Center is performed by an outside contractor (Angel Associates/ Northern Industrial Sales).

#### 3.5.3 Other Facilities

Compressed breathing gases obtained from non-UMAINE facilities must meet or exceed UMAINE standards.

### 3.6 Charging/Filling

#### 4.6.1 Inspection Requirements

Individuals shall understand the inspection requirements for scuba cylinders and ensure all requirements are met prior to charging/filling and/or use. Compressed gas cylinders used in scuba diving shall comply with the following inspection requirements:

- Shall be designed, constructed, and maintained in accordance with the applicable provisions of the Unfired Pressure Vessel Safety Orders.
- Shall be free from dings, dents, gouges, external corrosion or other visible damage.
- Shall be hydrostatically tested in accordance with DOT standards.
- Shall have a visual internal inspection at intervals not to exceed twelve months.
- Valves shall be functionally tested at intervals not to exceed twelve months.

#### 3.6.2 Cascade Storage System

Individuals charging/filling scuba cylinders with the cascade storage system shall be properly trained. Charging/filling equipment may be used only with cylinders approved for use in scuba diving related



activities and only with gases approved by the University Diving Control Board. Individuals using the cascade storage system shall comply with the following:

- Be present at all times when cylinders are being charged/filled.
- Not exceed a charging/filling rate of 200-400 psi/minute.
- Maintain accurate and appropriate system records (i.e. Cascade Log).
- Report any problems or concerns to the Diving Safety Officer.

Detailed procedures for use of the cascade storage system are printed in Appendix A.

### 3.6.3 Compressor System

Individuals using the compressor system to charge either the cascade storage system or individual scuba cylinders shall be properly trained. Compressor equipment may be used only with the installed cascade storage system or cylinders approved for use in scuba diving related activities, and only with gases approved by the University Diving Control Board. Individuals using the compressor system shall comply with the following:

- Follow proper procedures for compressor system inspection.
- Understand additional hazards posed by compressor system equipment.
- Insure intake air quality is not compromised by any automotive or other exhaust producing machinery located adjacent to Dive and Field Staging Building.
- Wear designated hearing protection equipment while compressor is in operation and limit time in the vicinity to less than 15 minute intervals.
- Maintain accurate and appropriate system records (i.e. Compressor Log, Cascade Log)
- Report any problems or concerns to the Diving Safety Officer.

Detailed procedures for use of the compressor system are printed in Appendix B.

## Revision Page

<b>DATE</b>	<b>TYPE</b>	<b>PAGE NUMBERS</b>
July 14, 2005	Original Issue	Entire document
November 30, 2007	Reviewed	Entire document
March 16, 2009	Reviewed ISO format	Entire document. Entire document.

## **Appendix A**

### **DARLING MARINE CENTER SCUBA CYLINDER FILLING PROCEDURE (MP07428)**

## **Appendix B**

### **DARLING MARINE CENTER COMPRESSOR OPERATING PROCEDURE (MP07426)**

## **APPENDIX C**

### **DARLING MARINE CENTER AIR COMPRESSOR OPERATING LOG (MF07426)**

## **APPENDIX D**

### **DARLING MARINE CENTER CASCADE STATION/ CYLINDER FILL LOG (MF07428)**

## **APPENDIX E**

### **UMAINE DARLING MARINE CENTER COMPRESSOR MAINTENANCE RECORD (MF07429)**

## **APPENDIX F**

### **UMAINE DARLING MARINE CENTER AIR STATION TRAINING ROSTER (MF07427)**



## **Appendix G**

### **UMAINE DARLING MARINE CENTER Air Quality Tests and Air Licenses (on file with DSO)**

## **Appendix H**

### **UMAINE DARLING MARINE CENTER Compressor Manual (on file with DSO)**