Title: **Compressed Gas and Cryogenic Fluid Handling, Storage and Disposal**			
Number 1-5	Revision 9/05	Effective Date 1993	Pages 12

PURPOSE: To provide guidelines concerning the safe handling and use of portable compressed gas cylinders. Compressed gases are unique in that they represent both a physical and potential chemical hazard (depending on the particular gas). The gases contained in these cylinders vary in chemical properties, ranging from inert and harmless to toxic and explosive. The high pressures of the gases constitutes a serious hazard in the event that the cylinders sustain physical damage and/or are exposed to high temperatures. This procedure does not apply to large stationary compressed gas or cryogenic fluid cylinders.

SCOPE: University wide: Laboratories (research and academic) and non laboratory areas (Maintenance, Physical Plant, Shops, etc)

DEFINITIONS:

Asphyxiant gas: A gas, usually inert, that may cause suffocation by displacing the oxygen in the air necessary to sustain life, or is labeled by the DOT as Division 2.2.

Compressed gas: A gas or mixture of gases having an absolute pressure exceeding 40 psi at 70 degrees F (21.1 degrees C); or, a gas or mixture of gases having an absolute pressure exceeding 104 psi at 130 degrees F (54.4 degrees C) regardless of the pressure at 70 degrees F; or, a liquid having a vapor pressure exceeding 40 psi at 100 degrees F (37.8 degrees C) as determined by ASTM D-323-72.

Corrosive gas: A gas that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact or is labeled by the DOT as Division 2.3 and Division 8 (Corrosive).

Cryogenic fluid: A refrigerated liquefied gas having a boiling point colder than -90 °C (130 °F) at 14.7 psia absolute, or which the DOT requires the Division 2.2 label for non-flammable, nonpoisonous compressed gas-including compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas and oxidizing gas.

Fire Control Area: A Fire Area is an area enclosed and bounded by fire walls, fire barriers, exterior walls or fire-resistance rate horizontal assemblies of a building (NYS Fire Code Sect 902). Control Areas are spaces within a building and outdoor areas where quantities of hazardous materials not exceeding the maximum quantities allowed are stored, dispensed, used or handled (NYS Fire Code Sect. 2703.8.3). Control areas must be separated from each other by not less than a 1 hour fire barrier.

Flammable gas: A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or, a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit; or, one for which the United States Department of Transportation (DOT) requires their red flammable gas label or is labeled as Division 2.1.

Oxidizer gas: A gas that is nonflammable but can support and vigorously accelerate combustion in the presence of an ignition source and a fuel or is labeled by the DOT as Division 2.2 and Division 5.1 (Oxidizer).

Toxic gas: A gas that has a median lethal concentration (LC_{50}) in air of 2,000 parts per million or less by volume of gas (Highly Toxic has an LC_{50} of 200 ppm or less); or, a gas which the DOT requires the white

poison label or is labeled as Division 2.3 "Gas poisonous by inhalation" because it is known to be so toxic to humans as to pose a hazard to health during transportation; or a gas that has an NFPA Health Hazard Rating of 3 (Toxic) or 4 (Highly Toxic).

PROCEDURE:

I. Responsibility

1. Compressed gas cylinders must be handled only by experienced and properly instructed personnel. This includes Right to Know information on the chemical nature of the materials and the appropriate response necessary in the event of fire, leak or spill. Contact EH&S for training.
2. The user responsible for the cylinder and for its installation should check the identity of the gas before use. If the cylinder content is not identified, if hydrostatic test date is past due, or if the cylinder is in any way damaged, the cylinder should be returned to the supplier.
3. The user shall not modify, tamper with, paint, deface, obstruct, remove or repair any part of the cylinder, including the pressure relief device and the container valve or the valve protection device.
4. The user is responsible for the proper disposal of the cylinder when it is empty or no longer needed (see Section VII for procedures).
5. The user is responsible to maintain an inventory of all gas used and stored in their area (see Appendix C for inventory form). This inventory must be provided to the Department of Environmental Health and Safety annually.

II. Identification

1. All compressed gases received, used or stored must be labeled according to the United States Department of Transportation (DOT) and the Occupational Safety and Health Agency (OSHA) regulations. Each cylinder must be marked by label or tag with the name of its contents. It is the manufacturer's and shipper's responsibility to label the cylinders. Do not accept cylinders without the appropriate labels. The primary identifier of cylinder contents is the label. Color should not be used to identify contents.
2. Material Safety Data Sheets (MSDS) must be obtained and maintained for all compressed gases. MSDSs can be found online at the Stony Brook University web site: http://www.stonybrook.edu/facilities/ehs/msds/index.shtml, or for gas delivered through the SBU Tank Gas Program that is not on that web site: http://www.praxair.com/msds.
3. Empty cylinders must be marked EMPTY or MT and stored apart from full cylinders while waiting to be removed.
4. Rooms or cabinets containing compressed gases must be conspicuously labeled COMPRESSED GAS. Container Storage Areas must be prominently posted with the hazard class and the name of the gases stored.
5. Piping systems require additional labeling and markings. Contact EH&S for specific requirements.

III. General Handling Procedures

1. Cylinders must be transported, stored and used upright (with the valve up), and must be securely fastened to prevent them from falling or being knocked over. Suitable racks, straps, chains or stands are required to support cylinders.
2. Cylinder valves are to be protected with the standard cap when not in use (empty or full). Regulators are to

be protected with covers where there is likelihood of damage.

3. Never force a cap or regulator. The cap should be only be hand tight.
4. Cylinders should not be exposed to excessive dampness, or to corrosive chemicals or fumes.
5. Cylinders are not to be exposed to temperature extremes nor stored in the vicinity of combustibles.
6. Gases are not to be transferred from one vessel to another (except dry ice and cryogenic material). Do not try to refill compressed gas cylinders.
7. Before using a cylinder, slowly "crack" the valve to clear dust or dirt, being sure the opening is not pointed toward anyone. Additional precautions must be taken when toxic or flammable gases are involved (see Section IV.) Do not stand in front of the regulator gauge glass when opening the valve.
8. Never use a cylinder without a regulator. Always use the correct pressure regulator.
9. After attaching the regulator, and before the cylinder is opened, check the adjusting screw of the regulator to see that it is released. Never permit the gas to enter the regulator suddenly.
10. Never try to stop a leak between a cylinder and regulator by tightening the union nut unless the valve has been closed first.
11. Never strike an electric arc on a cylinder.
12. Never use a leaking, corroded or damaged cylinder. Remove the cylinder from service and contact the supplier for return.

IV. Specific Handling Procedures

A. Flammable Gases[1]

1. Not more than 100 cubic feet of flammable gas can be used and stored (combined quantity) in a fire control area.[2] In a laboratory 500 square feet or less, not more than 6 cubic feet, and larger laboratories, not more than 0.012 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).
2. Flammable gases must be stored in well-ventilated areas away from flammable liquids, combustible materials, oxidizers, open flames, sparks and other sources of heat or ignition. A distance of 20 feet or a noncombustible barrier at least 18 inches above the tallest container, but not less than 5 feet and laterally not less than 18 inches beyond the sides of the containers and having a fire rating of at least ½ hour is the minimum separation requirement.
3. Portable fire extinguishers (carbon dioxide or dry chemical type) must be available for fire emergencies where flammable gas is stored.
4. Spark-proof tools should be used when working with flammable gas cylinders.
5. "Flow" experiments with flammable gases are not to be left unattended; an explosimeter or combustible gas alarm must be used.
6. In the event of an emergency involving a flammable gas, such as a gas leak, fire or explosion, personnel must immediately evacuate the area. Do not attempt to extinguish burning gas if the flow of product cannot be shut off immediately and without risk.
7. All lines and equipment associated with flammable gas systems must be grounded and bonded.
8. Acetylene should not be utilized in lines or hoses at a pressure exceeding 15 psi.
9. Contact Environmental Health and Safety Fire Safety group for additional information or concerns about flammable gas storage.

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[1] See Appendix A "Hazards of Common Compressed Gases" for examples.

[2] See Appendix B "How to Determine Volume of Gas", or Scott Specialty Gas "Gas Cylinder Size Specifications" (http://www.scottecatalog.com/ScottTec.nsf/74923c9ec562a6fb85256825006eb87d/ef6a526eb60a3c8785256a2c0040b17e?OpenDocument#Standard%20Cylinder%20Sizes%3A) to determine cylinder size and quantity of gas.

B. Asphyxiant Gases

1. Do not store asphyxiant gases in areas without ventilation. This includes environmental chambers (e.g. cold boxes) that do not have a fresh air supply or exhaust system.
2. Any gas that has the potential to displace oxygen in sufficient quantities can cause asphyxiation. Only persons trained, qualified and using a self contained breathing apparatus (SCBA) with adequate back-up should respond to an inert gas leak or enter an area where an asphyxiant gas could be present. Shut off the source of the gas leak if there is no risk to personnel and ventilate the area. If a person has symptoms of asphyxiation, move the victim to fresh air and obtain proper medical attention.

C. Oxidizer Gas

1. Not more than 1500 cubic feet of oxidizing gas can be used and stored (combined quantity) in a fire control area. In a laboratory 500 square feet or less, not more than 6 cubic feet, and larger laboratories, not more than 0.012 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).
2. All equipment used for oxidizing gases must be cleaned with oxygen-compatible materials free from oils, greases, and other contaminants (hydrocarbons and neoprene are not oxygen-compatible; PTFE Teflon is compatible. The equipment will state that it is oxygen compatible). Do not handle cylinders with oily hands or gloves.
3. Oxidizers shall be stored separately from flammable gas containers or combustible materials. A distance of 20 feet or a noncombustible barrier at least 5 feet high having a fire rating of at least ½ hour is the minimum separation requirement.

D. Corrosive Gas

1. Not more than 810 cubic feet of corrosive gas can be used and stored (combined quantity) in a fire control area.
2. Keep exposure to gas as low as possible. Use in fume hood or other vented enclosure when possible. Avoid contact with skin and eyes.
3. Wear safety goggles when handling compressed gases which are corrosive (see EH&S Policy 7-1 *Personal Protective Equipment* for additional information).
4. An emergency shower and eyewash must be installed within 50 feet where corrosive materials, including corrosive gases, are used (see EH&S Policy 1-8 *Emergency Shower and Eyewash Installation, Use, Testing and Maintenance* for additional information).
5. An emergency response procedure must be in place and everyone working in the area must be trained on the procedures.
6. Safety plugs in the valves of chlorine cylinders fuse at 157 degrees F. Care must be exercised to see that they are not exposed to steam, hot water, etc. which could produce this temperature. Chlorine leaks may be located using a cloth wet with aqua-ammonia which will produce white fumes (ammonia chloride) in the presence of chlorine. NOTE: This procedure may only be performed with appropriate respiratory protection. In order for any individual to wear a respirator, he/she must have written physician's approval, attend a respiratory protection training session, and pass a respirator fit test. Training and fit testing are provided by the Department of Environmental Health and Safety.

E. Toxic and Highly Toxic Gas

1. Not more than 1,620 cubic feet of toxic gas can be in storage and 810 cubic feet in use in a fire control area. Not more than 40 cubic feet of highly toxic gas can be in storage and 20 cubic feet in use in a fire control area. In a laboratory 500 square feet or less, not more than 0.3 cubic feet, and larger laboratories, not more than 0.0006 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).

2. Lecture bottle-sized cylinders for all gases that have a health hazard rating[3] of 3 or 4 or a health hazard rating of 2 without physiological warning properties, must be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure. Larger cylinders of toxic or highly toxic gas must be stored in gas cabinets, exhausted enclosures or gas rooms.
3. Toxic and highly toxic gases shall not be stored or used outside of academic or research laboratories.
4. Keep exposure to gas as low as possible. Use in fume hood or other vented enclosure when possible. Avoid contact with skin and eyes.
5. Wear safety goggles when handling compressed gases which are toxic or highly toxic (see EH&S Policy 7-1 *Personal Protective Equipment* for additional information).
6. A gas detection system with visible and audible alarms to detect the presence of leaks, etc. must be installed for all toxic and highly toxic gases when the physiological warning properties for the gas are at a level below the accepted permissible exposure limit or ceiling limit for the gas. Contact EH&S for specifics on installing the gas monitoring system.
7. An emergency response procedure must be in place and everyone working in the area must be trained on the procedures.

F. Cryogenic

1. Wear face shield and chemical safety goggles when dispensing from cylinder or dewar toxic (see EH&S Policy 7-1 *Personal Protective Equipment* for additional information).
2. Wear appropriate insulated gloves to protect from the extreme cold when handling cryogenic containers. Gloves need to be loose fitting so that they can be readily removed in the event liquid is splashed into them. Never allow an unprotected part of the body to touch uninsulated pipes or containers of cryogenic material.
3. Keep liquid oxygen containers, piping, and equipment clean and free of grease, oil, and organic materials (see Section IV. C. 2.)
4. Do not store cylinders or dewars in environmental chambers that do not have fresh air ventilation. A leak or venting from the container could cause an oxygen deficient atmosphere (see Section IV.B.)
5. Large stationary cryogenic systems and piping have additional requirements. Contact EH&S for guidance.
6. First aid treatment for cold-contact burns:
   a. Remove any clothing not frozen to the skin that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. Obtain medical assistance as soon as possible.
   b. Place the affected part of the body in a warm water bath (not to exceed 40^{o} C). Never use dry heat.

G. Pyrophoric Gas

1. Not more than 250 cubic feet of pyrophoric gas can be in a storage area.
2. Lecture bottle-sized cylinders for Pyrophoric (e.g. Silane) gases must be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure.
3. Silane gas with a concentration of 2% or more by volume silane has additional safety requirements for flow control, exhausted enclosures or gas cabinets and emergency power. Contact EH&S for information.

V. Transporting Cylinders

1. The protective cap must be in place.
2. Avoid dropping and striking cylinders together. The cylinder should not be lifted by the cap.
3. Use a cradle for hoisting, never a lifting magnet or sling.
4. Use a suitable hand truck with the cylinder firmly secured. Avoid dragging, sliding or rolling cylinders.
5. Cylinders must be secured in a positive fashion with straps or chains while being transported and when in

[3] The Material Safety Data Sheet (MSDS) will have the NFPA "diamond" hazard rating and physiological warning properties for the gas.

motor vehicles.

6. Use the Freight Elevator when possible. If there is no Freight Elevator, do not use an elevator with people in it and do not allow other people to enter the elevator when transporting cylinders. When transporting Asphyxiant gas in elevators, send the cylinder up by itself and then follow in another elevator or stairs. This can only be done if the elevator can be made to not stop at any other floors before the cylinder is removed.

VI. Storage

1. Cylinder storage areas must be prominently posted with the names and hazard class of the gases to be stored.
2. Cylinders not "in use" ("in use" means connected through a regulator to deliver gas to a laboratory operation, connected to a manifold used to deliver gas to a laboratory operation or a single cylinder secured alongside the cylinder as the reserve cylinder) must not be stored in the laboratory.
3. When gases of different types are to be stored at the same location, cylinders should be grouped by type of gas and the groups arranged taking into account the type of gas contained (e.g., flammable gases may not be stored next to oxidizing gases). Empty cylinders should be stored separately from full cylinders.
4. Storage rooms should be dry, cool, and well ventilated. Cylinders should not be stored at temperatures above 51 degrees C. (125 degrees F.) or near radiators or other sources of heat. Cylinders must be stored a minimum of 20 feet from incompatible materials and a minimum of 10 feet from combustible material, including vegetation.
5. Cylinders stored outside must be protected against extremes of weather and combustible waste and vegetation must be kept a minimum off 10 feet from the cylinders..
6. Cylinders must be protected from any object that will produce a cut or other abrasion in the surface of the metal. Do not store near elevators or gangways, or in locations where heavy moving objects may strike or fall on them.
7. All gas cylinders must be capped and secured when stored. Cylinders must be stored in the upright position, unless designed for use in the horizontal position. Each cylinder must be individually secured. Nesting of cylinders is not permitted.
8. Do not store gas cylinders with pressure on the regulator.
9. Storage, use and handling areas shall be secured against unauthorized entry or access to unauthorized personnel.

VII. Disposal of Cylinders

1. Close and tighten valves and replace safety caps on cylinders.
2. Contact supplier/vendor to obtain guidelines for the shipment of cylinders to be returned.
3. Identify the gas that was in the container. Valves will be removed from empty nontoxic gas cylinders before disposal as metal scrap.
4. Contact the Department of Environmental Health and Safety for removal of cylinders that cannot be returned to the supplier/vendor or for disposal of orphaned cylinders.
5. Cylinders of hydrogen fluoride and hydrogen bromide should be returned to the supplier within two (2) years of the shipping date. Cylinders of corrosive or unstable gases should be returned to the supplier when the expiration date of the maximum recommended retention period has been reached. If no maximum recommended retention time is provided by the supplier, a 36 month (3 year) time limit should be used.

VIII. Emergencies

1. In the event of a leak or suspected leak of gas, evacuate the building or area. Activate the fire alarm by pulling the nearest fire alarm box.
2. Use soapy water to detect leaks. Connections employing flammable or toxic gases are to be leak tested with Leaktec or equivalent.
3. An emergency plan must be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored or used[4]. The plan must include the following information:
   a. The type of emergency equipment available and its location (e.g. emergency eyewash & shower, fire extinguisher).
   b. An indication that hazard identification labeling is provided for each storage area (see Section II.3.)
   c. The location of posted emergency procedures.
   d. A material safety data sheet (MSDS) for each compressed gas or cryogenic fluid or list with name of gas, hazard class, and quantity, stored or used in the area.
   e. A list of personnel who are designated and trained to be liaison personnel for the fire department/emergency responders and who are responsible for the following:
      i. Aiding the emergency responders in pre-emergency planning
      ii. Identifying the location of the compressed gases and cryogenic fluids stored or used
      iii. Accessing material safety data sheets
      iv. Knowing the site emergency procedures.

[4] See Appendix C for Compressed Gas and Cryogenic Fluid Emergency Plan template.

INQUIRIES/REQUESTS:

Environmental Health and Safety
110 Suffolk Hall
Zip 6200
Main Office: 632-6410
FAX: 632-9683

RELATED FORMS:

Compressed Gas and Cryogenic Fluid Emergency Plan template (Appendix C)

RELATED DOCUMENTS:

Compressed Gas Association: (http://cganet.com)
CGA P-1, 2000. *Safe Handling of Compressed Gases in Containers*
CGA P-12, 1993. *Safe handling of Cryogenic Liquids*
CGA P-32. *Safe Storage and Handling of Silane and Silane Mixtures*

Fire Code of New York:
Chapter 27 *Hazardous Materials – General Provisions*
Chapter 30 *Compressed Gas*es
Chapter 31 *Corrosive Materials*
Chapter 32 *Cryogenic Fluids*
Chapter 35 *Flammable Gases*
Chapter 37 *Highly Toxic and Toxic Materials*
Chapter 40 *Oxidizer*s
Chapter 42 *Pyrophoric Materials*

National Fire Protection Association (http://www.nfpa.org)
NFPA 45 *Standard on Fire Protection for Laboratories Using Chemicals*, 2004 Edition
NFPA 55 *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 Edition

OSHA 29 CFR 1910.101 *Compressed Gases – General Requirements* (http://www.osha.gov)

DOT 49 CFR 173 *Hazardous Materials Transportation* (http://hazmat.dot.gov/)

EH&S "Gas Cylinder Safety" and "Cryogenic Safety" Handouts (http://www.stonybrook.edu/ehs/lab/cgs.shtml)
EH&S Policies and Procedures
http://www.stonybrook.edu/facilities/ehs/policy/campus.shtml

Appendix A Hazards of Common Compressed Gases[5]

Many gases exhibit more than one hazard. To provide the best protection to the user, a gas's most severe hazard has been designated with a "P" for primary. Any additional hazards for which added precautions are recommended have been designated with an "S" for secondary.

Gas	Flammable	Asphyxiant	Oxidizer	Toxic	Corrosive	Cryogenic	Other	DOT Class[6]
Acetylene	P	S						2.1
Air, Compressed			S					2.2
Ammonia	S				P	S		2.3 and 8
Argon		P						2.2
Arsine	S			P				2.3 and 2.1
Carbon Dioxide		P						2.3
Carbon Monoxide	S			P				2.3 and 2.1
Chlorine			S	P	S			2.3 and 8
Ethane	P	S				S		2.1
Germane	S			P			*	2.3 and 2.1
Helium		P						2.2
Hydrogen	P	S						2.1
Liquid Nitrogen		P				S		2.2
Methane	P	S						2.1
Nitric Oxide			S	P				2.3, 5.1 and 8
Nitrous Oxide		P	S					2.2 and 5.1
Oxygen			P					2.2 and 5.1
Propane	P	S				S		2.1
Silane	P						Pyrophoric	2.1
Sulfur Hexafluoride		P						2.2

*May undergo explosive decomposition at elevated pressures when heated or ignited

Toxic: In all cases, if a gas is toxic, this is the primary hazard. A toxic gas is any gas that has an LC_{50} between 200 ppm and 2000 ppm. A highly toxic gas is any gas that has an LC_{50} less than or equal to 200 ppm.
Flammable: Any gas for which flammable limits in air are reported is considered flammable. However, if the gas were also toxic, then toxic would be the primary hazard with flammable notes as secondary.
Asphyxiant: This category generally covers all the inert gases. A gas that is listed flammable as primary would usually be listed with asphyxiant as secondary, especially if any reported toxicity approached oxygen-deficient levels.
Oxidizer: This covers those gases that, in the presence of an ignition source and a fuel, support any may vigorously accelerate combustion. If the gas were also toxic, this would be listed as primary hazard with oxidizer as the secondary hazard. Some gases, such as fluorine, are as aggressive an oxidizer as they are toxic, so moth hazards are listed as primary.
Corrosive: Primarily, most gases in the absence of water are not corrosive. However, since most sources refer to the gas properties in moist air, corrosive is listed as a mostly secondary hazard where appropriate.
Cryogenic: If a gas is shipped as a liquefied gas under pressure, extreme cold would generally be listed as a secondary hazard, assuming there are more significant (primary) hazards. However, an inert cryogenic liquid is listed as the primary hazard.

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[5] From: CGA P-1 2000. See Appendix D for a complete list.
[6] From: Department of Transportation Hazardous Materials Table 49 CFR 173. Class 2.1=Flammable Gas; Class 2.2=Non-flammable, nonpoisonous compressed gas - including compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas and oxidizing gas; Class 2.3=Gas poisonous by inhalation; Class 5.1=Oxidizer; Class 8=Corrosive Liquid.

Appendix B How to Determine the Volume of Compressed Gas

Stony Brook University Tank Gas on Contract:

GAS TYPE	SIZE	CUBIC FT
5% CO2 IN O2 (CERT)	K/H	249
	T/J	335
10% CO2 IN AIR	T/J	314
10% METHANE IN ARGON (P10)	T/J	331
ACETYLENE	B	40
	WS	130
	WTL	390
AA ACETYLENE	WTL	390
AIR DRY	T/J	314
ARGON COMM	T/J	331
ARGON PREPURE	T/J	331
ARGON UHP	T/J	331
CO2 BONE DRY	K/H	50LB
HELIUM HP	T/J	278
HELIUM INDUSTRIAL	K/H	210
HELIUM UHP	T/J	278
HYDRO PREPURE, UHP	T/J	256
LIQUID NITROGEN	LS160	3936
NITROGEN COMM	K/H	232
NITROGEN ED, PP, UHP	T/J	307
NITROUS OXIDE USP	E	6.4LB
	K/H	50LB
OXYGEN COMM	K/H	249
	S	147
OXYGEN ED	T/J	335
OXYGEN USP	E	20CF
PROPANE MOTOR FUEL	33LB	33LB

Cyl. Size	Nominal Size* Dia X Height (inches)	Nominal * Tare Weight (lbs.)	Water Capacity (lbs.)	Internal Volume @ 70° F (21° C), 1 ATM (liters/cubic feet)		US DOT Specs
K	9.25 X 60	135	110	49.9	1.76	3AA2400
A	9 X 56	115	96	43.8	1.55	3AA2015
B	8.5 X 31	60	37.9	17.2	0.61	3AA2015
C	6 X 24	27	15.2	6.88	0.24	3AA2015
D	4 X 18	12	4.9	2.24	0.08	3AA2015

QT	3 X 14**	2.5**	2.0	0.900	0.0318	
LP5		18.5	47.7	21.68	0.76	4BW240
	18.25					

Volume of Gas in Cylinder

To find the volume of gas available from a compressed gas cylinder, we apply the Ideal Gas Law (PV = nRT). In a high-pressure cylinder, the volume will be affected by the content's compressibility factor Z (PV = ZnRT). For example, an AL cylinder of pure helium may contain 134 cu. ft. of gas while the same cylinder of pure air may contain 144 cu. ft. under the same conditions. For these practical calculations, however, we assume ideal gas behavior for simplicity.

The Ideal Gas Law PV = nRT
Where:
P is pressure
V is volume
n is the number of moles
R is the gas constant
T is the absolute temperature
When the temperature is kept constant, we can derive the equation:
P (1) x V (1) = P (2) x V (2)
Where:
P (1) is the pressure of the compressed gas in the cylinder (psi)
V (1) is the internal volume of the cylinder, often referred to as water volume (liter)*
P (2) is the atmospheric pressure (1 atm - 14.7 psi)
V (2) is the volume of gas at pressure P (2) (liter).

For example, an AL sized cylinder is filled with nitrogen at 2000 psi. What is the gas volume of nitrogen from the cylinder?
P (1) is 2000 psi
V (1) is the internal volume of AL cylinder 29.5 liter*
P (2) is 14.7 psi
V (2) is the unknown volume of gas

Solving the equation above for V (2) gives:
V (2) = [p (1) x V (1)]/P (2) = (2000 psi x 29.5 liters)/14.7 psi = 4013 liters (approximately 140 cu. ft.)

Appendix C **Compressed Gas and Cryogenic Fluid Emergency Plan Template**

Building:			**Room:**	**Date Completed:**
Department:			**Responsible Person:**	
Emergency Contact Person:			**Work Phone:**	**After Hours Phone:**
Emergency Equipment Available:	☐ **Emergency Shower**	☐ **Emergency Eyewash**	☐ **Fire Extinguisher Type:**	☐ **Other:**
	☐ **Fume Hood**	☐ **Ventilated Enclosure**	☐ **Room labeled "COMPRESSED GAS"**	☐ **Storage Area labeled with name of gas & hazard class**
	☐ **Emergency Procedures Posted – Location:**			

Compressed Gas and Cryogenic Fluid Inventory

Name	Hazard Class[7]	Cylinder Size[8]	Number of Cylinders

Post Emergency Plan near phone and send a copy to the Department of Environmental Health & Safety

[7] Hazard Class: Flammable, Asphyxiant, Oxidizer, Corrosive, Toxic/Highly Toxic, Pyrophoric, Cryogenic, Other

[8] See Appendix B: How to Determine the Volume of Gas