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SAFETY INFORMATION PROFILE

Compressed Gas Cylinders Charging and Handling

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## PREFACE

The information in this profile was prepared in accordance with the provisions of NIOSH Contract #210-78-0130-0000 and is only one of twenty-seven Industry Profiles prepared under the contract. The reader should understand that this study is not intended to be an in-depth analysis, but rather, a limited overview of the industry. Each individual profile was prepared by a Profile Manager utilizing approximately 45 hours of professional time. Each profile is a reflection of the available literature, and other information obtained from industry, government, and labor contacts. Information Profiles are primarily intended for use in determining future study needs, priorities and directions. From this preliminary study may come various in-depth studies such as criteria documents, technology assessments, epidemiological studies, etc.

Radian gratefully acknowledges the guidance and direction of Mr. Ted Pettit, Project Officer, and Ms. Pat Gussey, Assistant Project Officer. Radian also thanks the many industry labor and government officials who provided information and assistance on short notice.

## Table of Contents

	<u>Page</u>
Title Page	
Preface	
Table of Contents	
Executive Summary	1
A. Standard Industrial Classifications Included	3
B. Process Descriptions	5
C. Potential Hazards	9
D. Existing Hazard Controls	14
E. Accident and Illness Statistics	15
F. Exposure Levels	27
G. Related Studies	28
H. Industry Trends	29
I. Existing Standards	30
J. Names of Industry Associations and Other Interested Parties	43
K. Names and Addresses of Companies	44
L. Summary Analysis of Data	48
M. Other Data	49
References and Sources	52
Appendices	56



## EXECUTIVE SUMMARY

Cylinder charging and handling is similar for all compressed gas products, independent of manufacturing process or end use. Each gas product must be considered individually due to differing physical and chemical characteristics. This profile deals primarily with four common gas products considered to represent a cross section of the gas cylinder industry.

- (1) Nitrogen ( $N_2$ ) - non-flammable, non-toxic, non-liquefied, high pressure compressed gas
- (2) Oxygen ( $O_2$ ) - supports combustion, non-toxic, non-liquefied, high pressure compressed gas
- (3) Acetylene ( $C_2H_2$ ) - flammable, non-toxic, dissolved media container, low pressure compressed gas
- (4) Chlorine ( $Cl_2$ ) - non-flammable, irritant-toxic, liquefied, low pressure compressed gas

Most other gases handled in cylinders will have similar characteristics to the above four, with only technical details being different, for example, valve material, composition, etc.

This review considers: the steps in the process of cylinder filling at (1) the point of manufacture or (2) at a distributor location; loading and unloading of transport vehicles; user hook up and disconnection; emergency procedures; and temporary storage of cylinders.

The U.S. Department of Transportation defines a cylinder as:

"...a pressure vessel designed for pressures higher than 40 psia and having a circular cross section. It does not include a portable tank, multi-unit tank car tank, cargo tank, or tank car."(10)

This profile has been limited to generally exclude the following aspects:

- (1) Transportation in commerce
- (2) Cylinder retesting, valve reconditioning
- (3) Gas packaged in containers other than DOT cylinders
- (4) Major consumers of compressed gases from other than cylinder containers
- (5) Long term warehousing - storage of gas in cylinders
- (6) Consumption or use, beyond the cylinder primary pressure reducer
- (7) Fire extinguishers, SCUBA, SCBA and liquefied petroleum gas cylinders

Statistics for accidents involving only cylinders were not available for this profile. The industries involved with compressed gas cylinder filling have experienced better than average injury and illness frequency and severity rates. No meaningful statistics related to cylinder accidents occurring at cylinder gas consuming facilities are available.

An adequate body of knowledge is available concerning cylinder filling, storage and utilization. Current regulations are cumbersome, but cover most important situations. Some gaps in existing regulations do exist but are not considered worthy of separate regulatory action. These gaps could be closed by amending existing regulations.

## COMPRESSED GAS CYLINDERS CHARGING AND HANDLING

### A. Standard Industrial Classifications Included

#### (1) Supply of Compressed Gases in Cylinders (25)

The filling of cylinders in association with the manufacture of the four subject gases involves the general Standard Industrial Classification (SIC) Code 28 - Chemicals and Allied Products. Specifically involved are industrial establishments with the following SIC codes:

- (a) 2812 - Alkalies and Chlorine
- (b) 2813 - Industrial Gases

Where the cylinder filling operation is conducted by the distribution trade, utilizing tank cars, tank trucks or bulk storage containers, the general SIC Code 51 - Wholesale Trade (non-durable) is involved. Specifically, the following SIC code is important:

- (c) 516 - Chemical and Allied Products

Of the basic chlorine producers (SIC 2812) only one company ships the products in ton containers and cylinders. All others ship to distributors in tanks. Therefore, the majority of the chlorine cylinder filling is at distribution plants (SIC 516).(24)

## (2) Utilization of Gas from Cylinders(25)

Compressed gases contained in cylinders are used by a broad range of establishments. The following outline delineates some of the more common uses of the four subject gases. Again, large volume consumers of compressed gases do not utilize cylinders.

- (a) Oxygen and acetylene
  - o Small welding users, maintenance operations, found in most two-digit SIC codes
- (b) Oxygen medical and laboratory use, SIC 80, Health Services
- (c) Chlorine utilized for municipal and industrial small sanitation requirements
  - o Water treatment - SIC 4941
  - o Sewerage - SIC 4952
- (d) Chlorine, recreational
  - o Swimming pools - SIC 7999
  - o Hotels and other lodging places - SIC 70--
- (e) Nitrogen
  - o Laboratories - SIC 7391, 8071
  - o Small quantity industrial users - Various SIC codes

## B. Process Descriptions

### (1) Operation Description - Filling

The four subject gases are manufactured to proper grade or specification and delivered to the cylinder filling station(s) via pipeline or bulk transport containers. The gas charger (filler operator) attaches the cylinder valve to the supply system. As cylinders are filled, transfer quantities are monitored by weight (liquefied compressed gas) or pounds pressure (non-liquefied gases). The supply pressure is sufficient to effect the transfer.(8) Chlorine, a liquefied compressed gas, may require periodic venting, to reduce cylinder pressure to less than the liquid supply pressure. This is accomplished by a "blow down" process wherein gaseous chlorine is vented from the cylinder via a valved manifold and gas pipeline to a caustic solution. Reaction of the chlorine with the caustic produces a by-product solution of sodium hypochlorite (household bleach). In some instances, the chlorine gas is returned to the low pressure circuit and recompressed. Occasionally, it is vented to the atmosphere.(24) The amount of blow down required is dependent on supply pressure and the temperature and pressure parameters associated with the receiving cylinder.

Cylinder filling can be the full time work of the filler operator. However, it is often only part of an individual's work regime. Other duties may include cylinder retesting, reconditioning, valve reconditioning and product preparation (including sodium hypochlorite control). Pre-filling inspection (visual) to establish ownership, cylinder condition and need for required retesting is usually a normal part of the fillers job as are painting, labeling,

tagging and leak testing.(24) Obviously, the filler is involved with cylinder handling which may be strictly manual or mechanically assisted.

## (2) Operation Description - Utilization

Cylinder utilization involves manual and/or mechanical handling of cylinders to and from their point of use. Proper cylinder stock rotation and avoidance of incompatible storage are important considerations associated with compressed gas utilization.

Cylinder utilization usually involves: (1) pressure regulation devices mounted on the cylinder valve, (2) remote regulators connected by piping systems, (3) no pressure regulator where back pressure and contamination may present a hazard and (4) unknowledgeable personnel.

Errors made by the cylinder filler such as (1) improper cylinder contents resulting from contamination or deficient cylinder labeling, and (2) deficient cylinder valves may result in hazardous exposure to the user.(6)

Cylinder users may create hazards because of infrequent review and incomplete understanding of procedures (routine/emergency). Infrequent emergency releases and transient operating personnel contribute to this type of hazard.

### (3) Exposure Mode

Individuals are exposed to a variety of hazards associated with the filling of compressed gas cylinders and the consumption of compressed gas from cylinders. The following outline delineates common opportunities for exposure to the listed hazards. The hazards are discussed in more detail in Section C of this profile.

- (a) Escaping gas - toxic, flammable, suffocating, reactive, high pressure release
  - o Proximal hose, piping, compressing and tank system failures
  - o Cylinder valve leakage
  - o Cylinder to system connection failures
  - o Over temperature relief device (function/malfunction)
  
- (b) Fire, Explosion
  - o Resulting from above
  - o Reaction of contents within cylinder
  - o External fires transmitted into cylinders
  - o Simultaneous dual product filling operation failures
  - o Normal pressure but undetected cylinder defects
  - o Cylinder jetting
  
- (c) Associated chemical exposures
  - o Chlorine - blow down - caustic materials
  - o Acetylene - acetone absorbant

- o Associated equipment failures
- o Paint and solvents
- o Valve reconditioning chemicals - acids, caustics, solvents

(d) Cylinder Handling

- o Mechanical cylinder handling equipment and techniques
- o Manual cylinder handling techniques (lifting, rolling, twisting or turning cylinders)

(e) Electrical Exposures

- o Control and power circuits - exhaust fans, pumps,
- o Static generation
- o Lightning discharge

## C. Potential Hazards

### (1) Safety (Hazards expected at both cylinder filling and cylinder utilization locations)

Manual cylinder handling throughout the system exposes the personnel to typical material handling hazards of pinched or smashed fingers and toes and strained backs.

Certain gases have flammable or explosive characteristics alone or as a mixture with other gases (e.g., air).(7,13)

Leakage of cylinders and/or piping, or rupture of pressure systems are ever present sources of hazard, creating the potential for explosion, the production of shrapnell, and occasionally the jetting of cylinders. "The case of the errant cylinder" has had wide long-term publicity. See Appendix A-1.

Excessive filling (charging) of cylinders with liquefied compressed gas results in reduced ullage (gas space) which can, if cylinder temperature rises sufficiently, result in hydraulic pressures. Typically this pressure results in cylinder deformation, leakage at threaded joints, fuse plugs, and malfunctions of metering or pressure reducers.(7)

Cylinders returned by customers may have been intentionally or accidentally contaminated with other products. The filling of contaminated cylinders may

precipitate rapid energy release, or chemical decomposition of the container. Consumer utilization of contaminated gas may result in hazardous chemical reactions or other problems.(6)

Oxygen - with the exception of the inert gases, all elements combine directly with oxygen, usually forming oxides. Oxidation occurs at a wide range of temperatures. Spontaneous ignition in air may occur with elements such as phosphorus and magnesium. The noble metals oxidize only at high temperature. All materials that are flammable in air burn much more vigorously in oxygen. Pure oxygen is non-flammable.(7)

The affinity of chlorine for moisture and the resulting corrosive effects on exposed metals create a major hazard. Ultra low volume chlorine leaks or open piping connections result in metal deterioration.(7) This phenomenon is responsible for eventual deterioration of valve and mating thread connections as well as many other types of leakage. Any leakage of chlorine will progressively worsen and may result in pressured separation of piping connections, etc.

Chlorine is non-flammable and non-explosive. As a gas, it is 2.5 times heavier than air; as a liquid, it is 1.5 times as heavy as water. Like oxygen, it is capable of supporting the combustion of certain substances. Many organic chemicals react readily with chlorine. Common reactants with chlorine include: Hydrogen and hydrogen compounds, hydroxides, ammonia and ammonium compounds, hydrocarbons, alcohols, and esters.(7)

Liquid chlorine has one of the greatest coefficients of temperature expansion of all liquefied compressed gases. Overfilling (reduced ullage) and subsequent increased temperature results in hydraulic expansion when there is no longer any gas space.(7) This can result in cylinder deformation, threaded connection leakage, fuse plug leakage and cylinder rupture.

Mixtures of gaseous acetylene and air or oxygen (2.5 - 80% volume acetylene to air) will explode if ignited.(7, 9)

Solid, liquid and gaseous acetylene will decompose violently in the presence of an ignition source. Ignition may also result under certain conditions of pressure and container size and shape.(7, 9)

Acetylene cylinders are designed to avoid the decomposition characteristics of the gas by incorporating a porous mass packing material having minute cellular spaces. No pockets of appreciable size remain where "free" acetylene in gaseous form can collect. The porous mass is saturated with acetone in which the acetylene dissolves. The maximum authorized cylinder pressure is 250<sup>0</sup> psig at 70<sup>0</sup>F. This pressure is considered safe when the special packing is utilized.(7)

Special safe design considerations must be employed for the handling or utilization of acetylene at pressures above 15 psig. Deviations from accepted techniques of packaging, or utilization of pressure above 15 psig are responsible for internal explosive type accidents.(7)

Leakage of fittings, hoses, valves or utilization equipment can result in explosions and/or fire originating outside the system with the potential of propagating into the acetylene system.(8)

Under certain conditions, acetylene forms readily explosive compounds with copper, silver and mercury or their salts, compounds and high concentration of alloys.(7)

A discussion of the general explosive behavior of acetylene deflagrations and detonations can be found in "Acetylene Transmission for Chemical Synthesis".(27)

## (2) Health

Practically all gases can act as simple asphyxiants by displacing the natural oxygen in the air. Some gases exert toxic effects, either through inhalation or high vapor concentration or by liquefied gas contacting the skin or eyes resulting in tissue damage (frostbite).(7)

Oxygen - no special health hazards - at normal temperature and pressure (NTP).(7)

Nitrogen - asphyxiant - no other special health hazard at NTP. Nitrogen is a colorless, odorless, flavorless, non-toxic and almost totally inert gas. It does not burn and supports neither combustion nor respiration. Nitrogen is slightly soluble in water and most other liquids and is a poor conductor of heat and electricity.(7)

Chlorine is a respiratory and skin irritant and a primary and secondary asphyxiant. High concentrations of chlorine gas result in eye irritation, coughing and labored breathing. Prolonged exposure may cause breathing difficulties resulting in death from suffocation. Chlorine produces no known cumulative effects or chronic systemic effects.(7,23)

Acetylene cylinder fillers may be exposed to ketone solvents (acetone) which can produce dry scaly and fissured dermatitis and irritation of conjunctiva and mucous membranes of nose and throat. Systemically ketones in high concentrations produce narcosis.(23)

Acetylene in low concentrations exerts a narcotic effect. In higher concentrations, it displaces oxygen and results in anoxia. Impurities in commercial acetylene, such as arsine, hydrogen sulfide, phosphine, carbon disulfide and carbon monoxide may also produce symptoms.(23)

#### D. Existing Hazard Controls

Control of the known hazards of compressed gas in cylinders is accomplished by compliance with existing regulations and other referenced guidelines, standards and publications. The Compressed Gas Association Pamphlet P-1, Safe Handling of Compressed Gases in Containers and its 20 references generally covers the spectrum of guidance.(13) See Appendix B.

All of the hazards listed in Section C of this profile can be mitigated by utilizing known cylinder filling and handling rules and/or techniques. Injuries typically result from deviations from these rules or techniques.(3,6) In his article "Potential Hazards of Compressed Gas Cylinders" Feeley states, "the difficulties we have encountered with medical gas cylinders developed because of a lack of compliance by suppliers and hospitals with existing NFPA, CGA and DOT guidelines."(6)

## E. Accident and Illness Statistics

Feeley reports that in a survey of 14,000 medical compressed gas cylinders, 120 or 1.2% had irregularities. However, there were no reported injuries resulting from these irregularities.(6)

Two NASA accident/incident summaries(21) indicate that pressure systems were involved in 19% of all reported incidents in an 8 year review. Of the 139 incidents involving pressure systems, only four contained references to cylinders. The other 135 incidents involved pressure systems other than cylinders. Of the four cylinder incidents, one involved liquid oxygen improperly stored, in liquid form, in a "K" bottle (not included in this profile). This unit exploded with material damage and no injuries to personnel.

A NASA technical memorandum(22) reviewed oxygen incidents of which eight were identified as related to cylinder supplied gaseous oxygen. These included: two regulator incidents (an improper regulator and an improper pressure setting); two cylinder valve failures (one fatigued material problem and one improper valve material); one improperly labeled gas; one contamination of piping connection; and one cylinder pressure relief valve function during exposure to fire. Numerous non-NASA aircraft oxygen incidents, some of which may have been cylinder related, were included. However, insufficient information was provided to determine if cylinders were involved.

## UNITED STATES - ESTABLISHMENTS, EMPLOYEES, AND PAYROLL BY INDUSTRY BY EMPLOYMENT - SIZE CLASS: 1976

TABLE 1

(Excludes government employees, railroad employees, self-employed persons, etc. - see "General Explanation" for definitions and statement on reliability of data. Size class 1 to 4 includes establishments having payroll but no employees during mid-March pay period. "D" denotes figures withheld to avoid disclosure of operations of individual establishments, the other alphabetic indicate employment-size class - see footnote.)

SIC code	Industry, establishments, employees, and payroll	Employment-size class									
		Total	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000 or more
2813	Industrial gases										
	Number of establishments	512	194	120	91	75	22	9	1	-	-
	Number of employees	7,948	(D)	816	1,254	2,449	1,665	1,117	(D)	-	-
	Payroll, first quarter (\$1,000)	28,265	(D)	2,664	4,407	9,110	5,670	3,873	(D)	-	-
	Payroll, annual (\$1,000)	118,375	(D)	11,306	19,592	37,638	22,963	16,171	(D)	-	-
2812	Alkalies and chlorine										
	Number of establishments	56	5	1	3	10	8	15	5	6	3
	Number of employees	13,784	(D)	(D)	53	317	567	2,310	(D)	4,443	4,442
	Payroll, first quarter (\$1,000)	51,455	(D)	(D)	164	829	2,085	7,917	(D)	16,649	17,892
	Payroll, annual (\$1,000)	210,779	(D)	(D)	759	3,458	9,188	31,684	(D)	64,092	76,461
516	Chemicals and allied products										
	Number of establishments	6,760	3,194	1,497	1,108	688	165	94	11	1	2
	Number of employees	85,030	(D)	10,371	15,460	20,531	11,514	13,390	3,997	(D)	(D)
	Payroll, first quarter (\$1,000)	312,631	(D)	36,650	54,976	72,867	42,104	54,110	13,394	(D)	(D)
	Payroll, annual (\$1,000)	1,292,474	(D)	153,385	229,059	304,423	173,487	210,355	53,682	(D)	(D)

A: 0-19; B: 20-99; C: 100-249; E: 250-499; F: 500-999; G: 1,000-2,499; H: 2,500-4,999; I: 5,000-9,999; J: 10,000-24,999; K: 25,000-49,999; L: 50,000-99,999; M: 100,000 or more.

UNITED STATES - ESTABLISHMENTS, EMPLOYEES, AND PAYROLL BY INDUSTRY BY EMPLOYMENT - SIZE CLASS: 1976

TABLE 1 (CONT.)

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SIC code	Industry, establishments, employees, and payroll	Employment-size class									
		Total	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000 or more
28	Select SIC Codes for Comparison										
	Chemicals and allied products										
	Number of establishments	11,032	2,966	1,776	1,784	2,013	1,042	779	333	206	133
	Number of employees	856,468	6,522	12,581	25,736	65,034	74,377	122,932	116,695	145,176	287,515
	Payroll, first quarter (\$1,000)	2,983,347	18,772	34,268	74,421	196,759	229,387	396,250	402,111	519,569	1,111,818
	Payroll, annual (\$1,000)	12,469,059	95,923	147,002	315,844	826,081	957,556	1,659,476	1,716,107	2,214,619	4,536,448
281	Industrial inorganic chems.										
	Number of establishments	1,179	308	191	172	212	113	93	48	29	13
	Number of employees	103,498	586	1,350	2,416	7,004	7,984	13,833	16,335	21,846	32,144
	Payroll, first quarter (\$1,000)	371,791	1,794	4,296	8,332	23,645	26,412	47,174	59,761	81,676	118,705
	Payroll, annual (\$1,000)	1,600,524	9,299	18,641	36,364	99,242	112,842	199,975	247,513	351,701	524,944

A: 0-19; B: 20-99; C: 100-249; E: 250-499; F: 500-999; G: 1,000-2,499; H: 2,500-4,999; I: 5,000-9,999; J: 10,000-24,999; K: 25,000-49,999; L: 50,000-99,999; M: 100,000 or more.

UNITED STATES - ESTABLISHMENTS, EMPLOYEES, AND PAYROLL BY INDUSTRY BY EMPLOYMENT - SIZE CLASS: 1976

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SIC code	Industry, establishments, employees, and payroll	Employment-size class										
		Total	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000 or more	
...	Select SIC Codes for Comparison											
	Wholesale trade											
	Number of establishments	357,653	164,150	81,893	61,128	37,146	9,164	3,320	628	182	42	
	Number of employees	4,455,130	353,561	575,250	857,019	1,132,247	631,758	497,635	218,713	124,854	64,093	
	Payroll, first quarter (\$1,000)	13,605,403	999,578	1,605,132	2,508,779	3,424,067	1,949,107	1,618,290	771,502	463,921	265,032	
	Payroll, annual (\$1,000)	57,296,143	4,834,694	6,760,538	10,458,832	14,237,519	8,075,611	6,715,404	3,188,669	1,932,594	1,092,280	
50	Wholesale trade - durable goods											
	Number of establishments	208,096	94,024	49,400	36,736	21,248	4,753	1,560	289	73	13	
	Number of employees	2,435,645	202,745	347,089	513,963	643,574	324,455	232,580	99,880	52,415	18,944	
	Payroll, first quarter (\$1,000)	7,616,839	579,816	993,388	1,543,960	2,022,161	1,034,772	783,690	379,316	211,799	67,929	
	Payroll, annual (\$1,000)	32,158,820	2,829,714	4,186,102	6,440,353	8,407,897	4,308,048	3,265,216	1,555,867	881,939	283,694	
A: 0-19; B: 20-99; C: 100-249; E: 250-499; F: 500-999; G: 1,000-2,499; H: 2,500-4,999; I: 5,000-9,999; J: 10,000-24,999; K: 25,000-49,999; L: 50,000-99,999; M: 100,000 or more.												

UNITED STATES - ESTABLISHMENTS, EMPLOYEES, AND PAYROLL BY INDUSTRY BY EMPLOYMENT - SIZE CLASS: 1976

TABLE 1 (CONT.)

(Excludes government employees, railroad employees, self-employed persons, etc. - see "General Explanation" for definitions and statement on reliability of data. Size class 1 to 4 includes establishments having payroll but no employees during mid-March pay period. "D" denotes figures withheld to avoid disclosure of operations of individual establishments, the other alphabetic indicate employment-size class - see footnote.)

SIC code	Industry, establishments, employees, and payroll	Employment-size class									
		Total	1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000 or more
51	Select SIC Codes for Comparison Wholesale trade - nondurable goods										
	Number of establishments	145,046	68,980	31,744	23,605	14,966	3,959	1,473	238	67	14
	Number of employees	1,807,023	148,139	222,955	331,949	459,203	276,223	221,975	83,176	44,745	18,658
	Payroll, first quarter (\$1,000)	5,149,023	408,207	592,465	921,203	1,291,545	799,451	675,931	257,134	142,667	60,422
	Payroll, annual (\$1,000)	21,665,662	1,928,943	2,494,126	3,839,702	5,373,081	3,302,013	2,785,350	1,076,263	605,043	261,131

A: 0-19; B: 20-99; C: 100-249; E: 250-499; F: 500-999; G: 1,000-2,499; H: 2,500-4,999; I: 5,000-9,999; J: 10,000-24,999; K: 25,000-49,999; L: 50,000-99,999; M: 100,000 or more.

Table 1 indicates that in 1976 there were 21,732 employees in SIC 2812 and 2813. Of this number, no information was developed as to number of employees engaged in compressed gas cylinder filling. Production from these plants is typically utilized in processes on location. It may also be transferred to distributors in bulk by barge, rail car or tank trailer.(2)

The distribution system which receives bulk gas shipments performs the majority of the cylinder filling operations.(2) SIC 516 (Chemicals and Allied Products) employs 85,030.(26) The number of employees engaged in cylinder filling could not be determined.(2)

Acetylene, because of its hazardous characteristics is shipped in cylinders rather than in large containers. Most acetylene cylinder filling is accomplished at the manufacturing establishment covered in SIC 2813.

The three industries (SIC codes 2812, 2813, 516) have experienced an injury incidence rate (Table 2) approximately equal to or better than: Wholesale and Retail Trade, and total Chemical and Allied Products. Their incidence rates are significantly better than the Private Sector and total Manufacturing.

Table 3 reflects the injury and illness rate for various sizes of establishments. Detail is not provided for SIC codes 2812, 2813, 516, but information for 2812, 2813 is included in the major heading 281. The smallest and the largest have the best rates. Establishments of 50-99 employees have the least desirable rates. The employment size-frequency curves roughly parallel other industry segments reflecting similar characteristics.

OCCUPATIONAL INJURY INCIDENCE RATES, PRIVATE SECTOR, BY INDUSTRY  
UNITED STATES, 1975 AND 1976

TABLE 2

Industry 1/	SIC code 2/	Incidence rates per 100 full-time workers 3/							
		Total cases 4/		Lost workday cases		Nonfatal cases without lost workdays		Lost workdays	
		1975	1976	1975	1976	1975	1976	1975	1976
Private Sector		8.8	8.9	3.2	3.4	5.6	5.5	54.6	57.8
Manufacturing (Total)		12.5	12.6	4.3	4.6	8.2	8.0	72.9	76.7
Durable Goods		13.6	13.5	4.6	4.9	9.0	8.6	77.8	81.1
Nondurable Goods		10.9	11.3	3.9	4.2	7.0	7.1	65.7	70.4
Chemicals & Allied Products	28	7.5	7.5	2.6	2.9	4.9	4.6	46.1	48.0
Industrial Inorg. Chemicals	281	6.9	6.4	2.2	2.5	4.7	4.0	53.4	50.1
*Alkalies and Chlorine	2812	7.0	5.4	1.9	2.1	5.0	3.3	50.9	46.8
*Industrial Gases (Acetylene, Nitrogen, Oxygen)	2813	-	7.1	-	2.6	-	4.4	-	42.8
Wholesale & Retail Trade		7.2	7.3	2.6	2.8	4.6	4.6	38.8	42.4
Wholesale Trade		8.0	8.0	3.2	3.3	4.8	4.7	48.8	50.9
Durable Goods	50	7.8	7.9	2.9	3.0	5.0	4.9	43.8	45.7
Nondurable Goods	51	8.3	8.1	3.6	3.7	4.7	4.4	55.7	57.9
*Chemical & Allied Prods.	516	7.4	6.8	2.8	2.6	4.5	4.2	39.8	43.5

\*Profile Subjects

1/ Totals for divisions and 2- and 3-digit SIC codes include data for industries not shown separately.

2/ Standard Industrial Classification Manual SIC, 1972 Edition.

3/ The incidence rates represent the number of injuries or lost workdays per 100 full-time workers and were calculated as:  $(N/EH) \times 200,000$ , where  
 N = number of injuries or lost workdays  
 EH = total hours worked by all employees during calendar year  
 200,000 = base for 100 full-time equivalent workers (working 40 hours per week, 50 weeks per year).

4/ Includes fatalities. Because of rounding, the difference between the total and the sum of the rates for lost workday cases and nonfatal cases without lost workdays do not reflect the fatality rate.

5/ Excludes farms with fewer than 11 employees.

6/ Data conforming to the OSHA definitions for coal and lignite mining (SIC 11 and 12) and metal and nonmetal mining (SIC 10 and 14), and for railroad transportation (SIC 40) were provided by the Mining Enforcement and Safety Administration, U.S. Department of the Interior, and by the Federal Railroad Administration, U.S. Department of Transportation.

NOTE: Dashes indicate no data reported, or data that do not meet publication guidelines.

n.e.c. = not elsewhere classified.

SOURCE: Bureau of Labor Statistics, U.S. Department of Labor.

Chartbook on Occupational Injuries and Illnesses in 1976, U.S. Department of Labor, Bureau of Labor Statistics, 1978, Report 535, Table 5.

Table 3

Occupational Injury and Illness Incidence rates, private sector, by industry and employment size,  
United States, 1975

Industry and employment size 1/	SIC code 2/	Incidence rates per 100 full-time workers 3/			
		Mean 4/	Median 4/	Middle range 4/	
				First quartile	Third quartile
<b>Manufacturing</b>					
All Sizes		13.0	2.9	0.0	17.6
1 to 19		9.3	0.0	0.0	8.4
20 to 49		14.3	8.6	0.0	21.5
50 to 99		16.6	12.4	3.8	23.9
100 to 249		17.3	13.7	6.5	24.1
250 to 499		14.9	11.9	6.2	20.2
500 to 999		12.3	9.6	5.4	16.9
1,000 to 2,499		10.0	8.0	3.7	14.0
2,500 and over		8.2	6.5	3.0	11.9
<b>Industrial Chemicals</b>					
	281				
All Sizes		7.6	7.0	0.0	17.3
1 to 19		11.9	0.0	0.0	17.4
20 to 49		11.2	7.1	0.0	19.1
50 to 99		17.1	12.7	4.8	28.0
100 to 249		11.5	9.2	3.8	15.7
250 to 499		8.4	6.6	2.9	12.7
500 to 999		6.2	4.8	2.4	8.9
1,000 to 2,499		5.6	3.7	1.9	7.8
2,500 and over		3.9	(*)	(*)	(*)
<b>Wholesale Trade</b>					
Nondurable Goods	51	Information Not Provided			

1/ Totals for divisions and 2- and 3-digit SIC codes include data for industries not shown separately.

2/ Standard Industrial Classification Manual, 1967 Edition.

3/ The incidence rates represent the number of injuries and illnesses per 100 full-time workers.

4/ The mean incidence rate is calculated as  $(N/EH) \times 200,000$ , where:

N = number of injuries and illnesses

EH = total hours worked by all employees during calendar year

200,000 = base for 100 full-time equivalent workers (working 40 hours per week, 50 weeks per year).

The median incidence rate is the middle measure in the distribution; half of the establishments have an incidence rate lower than or equal to the median and half have a rate higher than or equal to the median rate.

The middle range (interquartile) is defined by 2 measures; one-fourth of the establishments have a rate higher than or equal to the first quartile rate and one-fourth of the establishments have a rate lower than or equal to the third quartile.

5/ Data conforming to the OSHA definitions for coal and lignite mining (SIC 11 and 12) and metal and nonmetal mining (SIC 10 and 14), and for railroad transportation (SIC 40) were provided by the Mining Enforcement and Safety Administration, U.S. Department of the Interior, and by the Federal Railroad Administration, U.S. Department of Transportation.

NOTE: Asterisk (\*) indicates incidence rate of less than 0.05 per 100 full-time workers.

n.e.c. = not elsewhere classified.

SOURCE: Bureau of Labor Statistics, U.S. Department of Labor.

Occupational Injuries and Illnesses in the United States by Industry, 1975.  
U.S. Department of Labor, Bureau of Labor Statistics, 1978, Bulletin 1981,  
Table 2.

Combined injury and illness incidence rates for the years 1975 and 1976 (Table 4) for the three SIC codes 2812, 2813 and 516 again compare favorably with the private sector and total manufacturing rates. They are equal to or slightly better than Wholesale Trade in total. Table 5 compiled by the National Safety Council for the years, 1975, 1976 and 1977 indicates that accident rates in the three SIC categories are equal to or better than All Industries, Manufacturing, Wholesale and Retail Trade.

No statistical information was found to indicate that cylinder filling and handling was more hazardous or had a higher accident frequency than other operations in the three SIC code industries. The Compressed Gas Association reports that studies to obtain more detailed information were attempted previously but that it was impossible to develop reliable information.(2) The Compressed Gas Association operating procedures that have been developed are directed primarily at the distributors and/or users of the gas. The major health and safety problems are thought to be in that area.(2)

Information from the Chlorine Institute(24) (Table 6) summarizing chlorine incidents which were reported in the news media, indicate that there were 31 and 41 incidents recorded in 1973 and 1974, respectively. Cylinders were identified as the chlorine container. Seventy-five percent of these incidents occurred at a facility, either filling or utilizing; 25% occurred in transit. Information was not developed to indicate injuries or frequencies at filling vs. utilization facilities in this summary.

OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES, PRIVATE SECTOR,

BY INDUSTRY, UNITED STATES, 1975 AND 1976

Industry 1/	SIC code 2/	1976 annual average employment (in thousands) 3/	Incidence rates per 100 full-time workers 4/							
			Total cases 5/		Lost workday cases		Nonfatal cases without lost workdays		Lost workdays	
			1975	1976	1975	1976	1975	1976	1975	1976
Private Sector		64,689.8	9.1	9.2	3.3	3.5	5.8	5.7	56.2	60.5
Manufacturing (Total)		18,883.1	13.0	13.2	4.5	4.8	8.5	8.3	75.8	79.5
Durable Goods		11,015.6	14.2	14.1	4.8	5.1	9.4	9.0	81.1	84.1
Nondurable Goods		7,867.5	11.4	11.8	4.1	4.4	7.3	7.4	66.7	72.8
Chemicals & Allied Prods.	28	1,043.7	8.4	8.2	2.9	3.1	5.5	5.1	48.9	50.6
Industrial Inorganic Chemicals	281	159.4	7.4	7.1	2.4	2.7	5.2	4.4	56.6	54.0
*Alkalies and Chlorine	2812	22.3	7.7	5.7	2.2	2.3	5.5	3.4	54.2	50.1
*Industrial Gases (Acetylene, Nitrogen, Oxygen)	2813	18.6	-	7.4	-	2.7	-	4.7	-	44.8
Wholesale Trade		4,517.3	8.2	8.1	3.2	3.3	5.0	4.8	49.5	51.8
Durable Goods	50	2,590.1	8.0	8.0	2.9	3.0	5.1	5.0	44.4	46.6
Nondurable Goods	51	1,927.1	8.5	8.2	3.6	3.8	4.8	4.4	56.5	59.0
*Chemicals & Allied Products	516	111.0	7.7	7.2	2.9	2.7	4.8	4.4	40.3	47.2
* Profile Subjects										

1/ Totals for divisions and 2- and 3-digit SIC codes include data for industries not shown separately.

2/ Standard Industrial Classification Manual SIC, 1972 Edition.

3/ Annual average employment for nonagricultural industries is based primarily on employment covered by State unemployment insurance program. For those industries in which the unemployment insurance program does not have complete coverage and there is no change in the content of the industry classification between the 1967 and 1972 SIC manuals, estimates from the U.S. Department of Labor's Employment and Earnings Survey, which are based on the 1967 manual, are used. Annual average employment for the agriculture, forestry and fishing division in a composite of data from the unemployment insurance program, and estimates of hired-farm workers engaged in agricultural production (SIC 01 and 02) provided by the Statistical Reporting Service, U.S. Department of Agriculture. The agricultural production estimates are adjusted to exclude employment on farms with fewer than 11 employees.

4/ The incidence rates represent the number of injuries and illnesses or lost workdays per 100 full-time workers and were calculated as:  $(N/EH) \times 200,000$  where

N = number of injuries and illnesses or lost workdays

EH = total hours worked by all employees during calendar year

200,000 = base for 100 full-time equivalent workers (working 40 hours per week, 50 weeks per year).

5/ Includes fatalities. Because of rounding, the difference between the total and the sum of the rates for lost workday cases and nonfatal cases without lost workdays does not reflect the fatality rate.

6/ Excludes farms with fewer than 11 employees.

7/ Data conforming to the OSHA definitions for coal and lignite mining (SIC 11 and 12) and metal and non-metal mining (SIC 10 and 14), and for railroad transportation (SIC 40) were provided by the Mining Enforcement and Safety Administration, U.S. Department of the Interior, and by the Federal Railroad Administration, U. S. Department of Transportation.

NOTE: Dashes indicate no data reported, or data that do not meet publication guidelines.

n.e.c. = not elsewhere classified.

SOURCE: Bureau of Labor Statistics, U.S. Department of Labor.

Recordable Occupational Injury and Illness Incidence Rates\*, 1975-1977, by Industry, Reporters to the National Safety Council

A more complete list of SIC Code industry rates is included in the separate publication Work Injury and Illness Rates, 1978 Edition

Table 5

Industry†	SIC Code‡	Incidence Rates per 100 Full-Time Employees*					
		Total Recordable Cases	Total Lost Workday Cases	Cases Involving Days Away From Work & Deaths	Nonfatal Cases Without Lost Workdays	Total Lost Workdays	Days Away From Work
All Industries		8.47	3.14	2.28	5.31	57	43
Agriculture, Forestry, & Fishing		17.66	5.06	4.80	12.58	86	80
Agricultural production—crops	01	23.85	5.90	6.66	16.93	81	73
Agricultural production—livestock	02	5.72	2.34	2.34	3.37	40	40
Forestry	08	9.85	2.36	2.19	7.48	100	96
Mining		10.80	2.53	2.27	8.24	80	75
Metal mining	10	14.93	3.23	2.47	11.68	102	93
Bituminous coal & lignite mining	12	12.31	4.91	4.99	7.28	183	183
Oil & gas extraction	13	6.21	1.53	1.46	4.66	44	42
Nonmetallic minerals, except fuels	14	18.00	4.15	4.13	13.81	140	133
Construction		14.20	3.69	3.47	10.48	72	65
General building contractors	15	12.85	2.39	2.28	10.45	62	56
Heavy construction contractors	16	13.14	3.78	3.53	9.33	72	65
Highway & street construction	161	12.50	4.38	4.33	8.09	73	69
Heavy construction, except highway	162	14.46	3.40	2.89	11.03	77	65
Special trade contractors	17	30.03	5.01	4.87	24.93	90	85
Manufacturing		9.23	3.15	2.10	6.07	57	43
Non-durable Goods		8.42	2.65	2.00	5.76	55	45
Food & kindred products	20	14.50	4.85	4.50	9.64	91	83
Meat products	201	21.82	8.68	7.06	13.15	118	99
Dairy products	202	12.28	4.49	4.44	7.79	83	81
Preserved fruits & vegetables	203	13.02	3.84	3.31	9.18	73	61
Grain mill products	204	13.47	4.41	4.18	9.05	103	95
Bakery products	205	12.68	4.78	4.71	7.89	86	83
Sugar & confectionery products	206	15.02	5.61	5.23	9.40	114	106
Cane sugar refining	2062	11.46	4.31	4.16	7.13	81	74
Beet sugar	2063	19.19	11.45	11.14	7.74	264	257
Fats & oils	207	19.13	4.56	4.41	14.52	84	81
Beverages	208	18.25	4.97	4.69	13.28	102	91
Malt beverages	2082	19.00	4.95	4.87	14.04	99	90
Distilled liquor, except brandy	2085	14.49	3.92	3.64	10.57	97	87
Misc. foods & kindred products	209	10.29	3.75	3.71	6.54	73	69
Tobacco manufactures	21	9.13	5.52	1.95	3.61	72	36
Textile mill products	22	7.12	1.00	0.82	6.12	34	28
Weaving mills, cotton	221	6.54	0.98	0.76	5.57	33	28
Weaving mills, synthetics	222	7.15	0.69	0.56	6.46	45	41
Weaving, & finishing mills, wool	223	10.50	0.73	0.60	9.77	23	21
Narrow fabric mills	224	7.43	0.71	0.57	6.72	16	13
Knitting mills	225	7.94	1.09	1.07	6.85	27	26
Textile finishing, except wool	226	8.00	1.14	0.95	6.86	37	32
Floor covering mills	227	9.41	1.30	1.10	8.11	43	37
Yarn & thread mills	228	5.96	0.82	0.68	5.14	24	21
Miscellaneous textile goods	229	8.21	1.60	1.39	6.60	51	39
Apparel & other textile products	23	7.74	1.61	1.42	6.14	25	22
Paper & allied products	26	10.68	3.03	2.51	7.64	79	70
Pulp mills	261	12.66	2.59	2.56	10.04	82	77
Paper mills, except building paper	262	8.52	2.68	2.00	5.93	75	65
Paperboard mills	263	12.31	2.57	2.35	9.72	81	74
Misc converted paper products	264	9.96	2.69	2.27	7.27	64	56
Paperboard containers & boxes	265	13.91	4.23	3.62	9.68	97	86
Folding paperboard boxes	2651	11.02	3.29	2.80	7.73	78	69
Corrugated & solid fiber boxes	2653	16.37	4.87	4.31	11.50	100	97
Building paper & board mills	266	11.00	2.91	2.74	8.08	81	77
Printing & publishing	27	7.39	3.03	2.66	4.36	54	49
Chemicals & allied products	28	5.57	1.83	1.11	3.73	37	25
Industrial inorganic chemicals	281	7.90	2.41	1.31	5.48	59	40
Plastics materials & synthetics	282	3.65	1.10	0.58	2.54	25	16
Plastics materials & resins	2821	5.23	1.84	1.08	3.38	39	25
Synthetic rubber	2822	5.07	1.69	0.77	3.38	32	23
Cellulosic man-made fibers	2823	3.70	0.90	0.39	2.78	22	12
Organic fibers, noncellulosic	2824	2.16	0.46	0.20	1.70	12	8
Drugs	283	5.45	2.29	1.47	3.16	39	25
Soap, cleaners, & toilet goods	284	8.04	2.99	2.05	5.04	49	35
Paints & allied products	285	8.23	3.63	1.96	4.60	63	37
Industrial organic chemicals	286	5.44	1.88	1.05	3.56	39	25
Cyclic crudes & intermediates	2865	9.50	3.49	2.48	6.02	54	42
Agricultural chemicals	287	9.25	2.25	1.55	6.98	43	31
Miscellaneous chemical products	289	7.74	2.64	2.10	5.10	54	44
Explosives	2892	5.05	1.33	0.70	3.71	35	23
Petroleum & coal products	29	6.36	2.16	1.35	4.19	45	33
Petroleum refining	291	5.97	2.15	1.23	3.81	45	30
Paving & roofing materials	295	19.18	4.41	4.10	14.72	103	98

See footnotes on page 33.

Industry†	SIC Code‡	Incidence Rates per 100 Full-Time Employees*					
		Total Recordable Cases	Total Lost Workday Cases	Cases Involving Days Away From Work & Deaths	Nonfatal Cases Without Lost Workdays	Total Lost Workdays	Days Away From Work
Wholesale & Retail Trade		7.53	2.56	2.31	4.96	38	35
Wholesale Trade		6.89	2.47	2.19	4.51	39	35
Wholesale trade—durable goods	50	9.90	2.90	2.56	6.99	46	41
Wholesale trade—nondurable goods	51	4.32	2.01	1.85	2.23	33	30
Retail Trade		9.96	2.96	2.83	6.99	34	33
Services		7.05	3.03	2.88	4.02	40	37
Hospitals	806	5.76	2.83	2.82	2.93	38	37
Educational services	82	6.77	3.25	3.24	3.52	34	34
Public Administration (Government)		15.58	7.13	7.06	8.43	114	111
Executive, legislative, & general	91	16.37	7.52	7.47	8.84	119	117
General government, n.e.c.	9190	17.06	7.84	7.78	9.21	125	122
Police protection	9221	12.81	5.39	5.28	7.39	102	89
Fire protection	9224	17.24	7.82	7.81	9.40	127	124
State department of transportation	9991	8.34	4.78	4.58	3.53	82	77
Offices		2.48	0.77	0.54	1.71	14	10
Research & development or laboratory		3.75	1.12	0.65	2.63	18	11

\*Based on OSHA definitions. 200,000 employee hours is used as the equivalent of 100 full-time employees

See page 30.

†Totals for division and 2 and 3 digit SIC codes include data for 4 digit codes not shown separately

‡Standard Industrial Classification Manual, 1972 Edition

OSHA Definitions (See OSHA form No. 100 and Recordkeeping Requirements, Revised 1975):

**Occupational injury** is any injury such as a cut, fracture, sprain, amputation, etc., which results from a work accident or from an exposure involving a single incident in the work environment.

**Occupational illness** of an employee is any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases which may be caused by inhalation, absorption, ingestion, or direct contact.

**Lost workdays** are those days which the employee would have worked but could not because of occupational injury or illness. The number of lost workdays should not include the day of injury or onset of illness. The number of days includes all days (consecutive or not) on which, because of injury or illness: (1) the employee would have worked but could not, or (2) the employee was assigned to a temporary job, or (3) the employee worked at a permanent job less than full time, or (4) the employee worked at a permanently assigned job but could not perform all duties normally connected with it.

**Recordable cases** are those involving an occupational injury or occupational illness, including deaths. Not recordable are first aid cases which involve one-time treatment and subsequent observation of minor scratches, cuts, burns, splinters, etc., which do not ordinarily require medical care, even though such treatment is provided by a physician or registered professional personnel.

**Nonfatal cases without lost workdays** are cases of occupational injury or illness which did not involve fatalities or lost workdays but did result in: (1) transfer to another job or termination of employment, or (2) medical treatment, other than first aid, or (3) diagnosis of occupational illness, or (4) loss of consciousness, or (5) restriction of work or motion.

22

Table 6

## Chlorine Incident Reports (from newspapers)

	<u>1973</u>	<u>1974</u>	<u>1975</u>
<u>Total Reports</u>	172	198	Compilation
Non Chlorine Chlorine Reports	<u>-26</u> 146	<u>-24</u> 174	Incomplete

Location Classification

At facility (producing packaging, utilizing)	110	130
In transit	35	43
Undetermined	<u>1</u> 146	<u>1</u> 174

Container Classification

Container		
Cylinder	31	41
Other	60	65
Plant Equipment	36	41
Unresolved	<u>19</u> 146	<u>27</u> 174

The number of tons of chlorine estimated to be shipped in cylinders and ton containers is 250,000 to 300,000 net tons per year.(24)

The above incident reports reflect public interest (news worthy incidents) with numerous people exposed, hospitalization, etc. and are not indicative of individual exposures or in-plant, non-publicized incidents.

F. Exposure Levels

No information applicable.

## G. Related Studies

Feeley has reported that the following deficiencies were found in a survey of medical gas cylinders.(6)

- (1) Cylinder contents (contamination, partially full, overly full)
- (2) Cylinder identification (missing label, markings painted over, color coded improperly)
- (3) Cylinder valves (non-standard valve threads/connections, loose valve threading, inoperable valves)
- (4) Cylinder testing (out of date retesting, obscured or painted over test dates)
- (5) Cylinder storage (mixed storage - flammable gas stored with oxygen, flammable gas racks of wooden construction. unsecured cylinders)

The Compressed Gas Association has attempted to develop statistically sound information regarding accidents or incidents, but has found information developed to be unreliable.(2)

## H. Industry Trends

It is anticipated that the number of cylinders of compressed gas being handled will remain the same. The trend for medium to small oxygen users to convert to liquefied oxygen (LOX) will continue. However, total cylinders of oxygen will remain relatively the same. Acetylene shipments are anticipated to remain about the same principally to small welding operations. Additional inhouse acetylene generation with reduction in corresponding cylinder use may be anticipated for medium volume users because of the recent cost increase resulting from the distribution industry's cylinder demurrage policies. The number of chlorine cylinders is anticipated to remain relatively constant. No meaningful information concerning trends in nitrogen in cylinders was discovered.(2,3,1,24)

## I. Existing Standards

Items (3) through (7) below have been identified and are referenced as an adopted standard or guideline by one or more of the Federal Regulatory bodies included in (1) and (2). Items (8) and beyond are standards, regulations or guidelines which may be of value to people handling compressed gas cylinders ( $O_2$ ,  $H_2$ ,  $C_2H_2$ ,  $Cl_2$ ).

Dates of applicable standards/guidelines have been omitted because most have had periodic updating. Federal regulations may or may not recognize updated materials.

### (1) 29 CFR U.S. Department of Labor

#### (a) 1910 - General Industry Standards

##### o Subpart H - Hazardous Materials

##### - 1910.101 Compressed Gases (General Requirements)

-- Inspection of compressed gas cylinders incorporates visual and other inspections referencing:

49 CFR 171-179 DOT

14 CFR Part 103 DOT

-- Where DOT regulations are not applicable, then visual and other inspections must be performed according to:

CGA C-6-1968 Standards For Visual Inspection of Compressed Gas Cylinders

CGA C-8-1962 Standards for Requalification of DOT-3HT Cylinders

- 1910.101(b) (Compressed Gases) incorporates  
CGA P-1-1965 Safe Handling of Compressed Gases in Containers
- 1910.101(c) (Safety Relief Devices for Compressed Gas  
Containers) incorporates  
CGA S-1.1-1963 and 1965 addenda (Safety Relief Device Stds. -  
Cylinders)  
CGA S-1.2-1963 (Safety Relief Devices - Cargo, Portable Tanks)
- 1910.102 Acetylene
  - Cylinders, handling, storage, utilization in accordance with:  
CGA G-1-1966
  - Piped systems in accordance with:  
CGA G-1.3-1959 Acetylene Transmission for Chemical Synthesis
  - Generators and filling cylinders in accordance with:  
CGA G-1.4-1966 (no longer issued by CGA) information now  
located in NFPA 51 B.(2)
- 1910.104 Oxygen
  - Applies to containers (bulk liquid or gas) not normally  
applicable to cylinders
- o Subpart M - Compressed Gas and Compressed Air Equipment
  - 1910.166 Inspection of Compressed Gas Cylinders
    - Definitions
    - General requirements
    - Inspection of low pressure cylinders exempt from hydrostatic  
test including acetylene cylinders
    - Low pressure cylinders subject to hydrostatic testing

- High pressure cylinders

- Internal inspection

- 1910.167 Safety Relief Devices for Compressed Gas Cylinders

- Definitions

- General requirements

- Incorporates CGA S-1.1-1963 (Safety Relief Device Standards - Cylinders for Compressed Gases)

- o Subpart Q - Welding, Cutting and Brazing

- 1910.252(a)(2) requires that all portable cylinders used for the storage and shipment of compressed gases should

- be constructed and maintained in accordance with the

- United States Department of Transportation 49 CFR 171-179.

- (b) 1926 - Construction Standards

- o Subpart J - Welding and Cutting

- 1926.350 (Gas Welding and Cutting) requires that cylinders used shall meet the requirements published in 49 CFR, Part

- 178, Subpart C, Specification for Cylinders.

- (c) Maritime standards

- o Standards with references to cylinders

- 1915 Safety and Health Regulation - Ship Repairing

- 1916 Safety and Health Regulation - Ship Building

- 1917 Safety and Health Regulation - Ship Breaking

-- Subpart D (Welding, Cutting and Heating) requires that "only cylinders bearing Interstate Commerce Commission identification and inspection markings shall be used."

o Standards with no references to cylinders

- 1918 (Safety and Health Standards for Longshoring) does not reference welding or other cylinder requirements

(2) 49 CFR Subtitle B - Other Regulations Relating to Transportation, Parts 100-199, Chapter I - Materials Transportation Bureau, Department of Transportation

(a) The following are excerpts from the regulations which are considered relevant to shipment of compressed gas in cylinders.

o 171.7 Matter Incorporated by Reference

(171.7(a)) There is incorporated by reference in Parts 170-189 of this chapter all matter referred to that is not specifically set forth. These materials are hereby made a part of the regulations in Parts 170-189 of this chapter. Unless the reference provides otherwise, matter subject to change is incorporated only as it is in effect on the date of issuance of the regulation referring to that matter.

(171.7(d)) The full title and application of the matter incorporated by reference in Parts 170-189 of this chapter are as follows:

(171.7(a)(1)) ASME Code means sections VIII (Division I) and IX of the "American Society of Mechanical Engineers Boiler and Pressure Vessel Code", and addenda thereto through June 30, 1976.

(171.7(a)(3)) (Compressed Gas Association)

- (i) CGA Pamphlet C-3 is titled, "Standards for Welding and Brazing on Thin Walled Containers", 1968 edition;
- (ii) CGA Pamphlet C-6 is titled, "Standards for Visual Inspection of Compressed Gas Cylinders", 1968 editions;
- (iii) CGA Pamphlet C-7, Appendix A is titled, "A Guide for the Precautionary Markings for Compressed Gas Containers", dated May 15, 1971, Addenda issued January 1976.
- (iv) CGA Pamphlet C-8 is titled, "Standard for Requalification of DOT-3HT Cylinders", 1972 edition.
- (v) CGA Pamphlet S-1.2 is titled, "Safety Relief Device Standards Part 2 - Cargo and Portable Tanks for Compressed Gases", 1966 edition.

(171.7(a)(4)) (American National Standards)

- (ii) American National Standard B16.5 is titled, "Steel Pipe Flanges and Fittings", 1968 edition.

(171.7(a)(7)) (Bureau of Explosives, Association of American Railroads)

- (iv) Bureau of Explosives Pamphlets 1 and 2 titled, "Emergency Handling of Hazardous Materials in Surface Transportation", June 1973.

(171.7(a)(12)) U.S. Department of Commerce, National Bureau of

- Standards Handbook H28 (1957) - Part II is titled, "Screw Thread Standards for Federal Services 1957", December 1966 edition.

(171.7(a)(14)) American Water Works Association (AWWA) Standard C207-55

- is titled, "AWWA Standard for Steel Pipe Flanges", 1955 edition.

(171.7(a)(15) (American Welding Society (AWS)))

(i) AWS Code B-3.0 is titled, "Standard Qualification Procedure", 1972 edition

(ii) AWS Code D-1.0 is titled, "Code for Welding in Building Construction", 1966 edition

(e) Matters referenced by footnote are included as part of the regulations of this subchapter.

(b) Selected numbered headings relevant to compressed gas cylinders.

o 172 - Hazardous Materials Table and Hazardous Materials

Communication Regulations (Regulations for descriptions, proper shipping names, class, label, packaging and other requirements.)

o 173 - Shippers General Requirements for Shipments and Packagings

- Subpart A - General

- Subpart B - Preparation of Hazardous Materials for Transportation

- Subparts C, D, E, F - not applicable

- Subpart G - Compressed Gas - Definitions and Preparation

-- These regulations address cylinder selection, filling limits, pressure limits, charging of cylinders, relief devices and special provisions.

-- 173.300 various

-- 173.301 - General Requirements for shipment of compressed gases in cylinders

- 173.302 - Charging of cylinders with non-liquefied compressed gases
- 173.303 - Charging of cylinders with compressed gas in solution (acetylene)
- 173.304 - Charging of cylinders with liquefied compressed gas

(3) National Fire Protection Association

(a) Standard No. 51A For Acetylene Cylinder Charging Plants  
(Current Standard Equivalent for CGA G-1.4).(2)

o Origin and Development of No. 51A

Although acetylene cylinder charging plants have been built and operated for several decades, a limited number of concerns were involved and these possessed a high degree of design and operating capability. As a result, fire experience was good and there was no need for national standard guidance.

In recent years, a number of other firms have entered this industry and the need for a national standard became evident. Work on this standard was initiated by, and its subsequent promulgation materially assisted by, a Committee of the Compressed Gas Association, Inc., which submitted a text to the NFPA Committee on Industrial and Medical Gases.

This standard was adopted as a tentative standard in 1970.

o Contents

- Introduction 51A-4
- Plant Location, Arrangement,  
Construction and Utilities 51A-5
- Calcium Carbide 51A-7
- Acetylene Generators and Calcium  
Carbide Residue 51A-8
- Acetylene Gasholders, Purifiers,  
and Low Pressure Driers 51A-9
- Acetylene Compressors and High  
Pressure Driers 51A-10
- Acetylene Piping 51A-11
- Acetylene Cylinder Charging  
Manifolds and Acetoning Equipment 51A-12
- Fire Prevention and Protection 51A-13
- General Provisions 51A-15

o 1.1 Purpose

This standard is intended to provide safety requirements for the design, construction and installation of acetylene cylinder charging plants in order to provide safeguards for the protection of the plant, its employees and the public.

o 1.2 Scope

1.2.1 This standard applies to plants which are engaged in the generation and compression of acetylene, and in the charging of acetylene cylinders, either as their sole operation or in

conjunction with facilities for charging other compressed gas cylinders.

1.2.2 The authority having jurisdiction may authorize the continued use of an existing plant which is not in strict compliance with the provisions of this Standard where such continued use will not constitute a distinct hazard to life or nearby property.

1.2.3 This standard does not apply to plants which only produce and compress acetylene for chemical operations, or to plants which only produce and compress acetylene below 15 psig. (Refer to NFPA No. 51 for acetylene generating plants where the acetylene is used with oxygen for welding, cutting, heating, and heat-treating operations.)

o 8. Acetylene Cylinder Charging Manifolds and Acetoning Equipment

8.1 General

8.1.1 Each cylinder charging manifold shall be provided with a shutoff valve and a blow down valve vented to the outdoors or to the low pressure system.

8.1.2 A check valve shall be installed in the pipe line at each cylinder charging manifold or in each cylinder charging lead.

8.1.3 Each cylinder charging manifold shall be provided with a pressure gage located downstream of the shutoff valve.

8.1.4 Each cylinder charging manifold outlet shall be provided with a shutoff valve.

8.1.5 Cylinder charging manifolds shall be arranged so that excessive stress in the cylinder charging leads is prevented.

8.1.6 The storage areas for charged cylinders shall be as far as practicable from the charging manifolds.

## 8.2 Acetoning Equipment

8.2.1 Acetone storage containers shall be constructed and installed in accordance with NFPA No. 30, Flammable and Combustible Liquids Code. Aboveground acetone storage containers in excess of one 55-gallon drum shall be located at least 25 feet from the storage of acetylene cylinders and other flammable gas cylinders.

## 8.3 Cylinder Cooling Systems

8.3.1 Acetylene cylinders connected to charging manifolds shall be cooled by water spray applied from a manually activated spray nozzle system, when needed for removing heat of solution of acetylene, as determined by ambient temperature and cylinder charging rate.

- (b) Standard No. 51 -- Oxygene Fuel Gas Systems for Welding and Cutting
  - o Source of information for existing Federal Standards

### (4) Compressed Gas Association (CGA)

- (a) G-1 Acetylene
- (b) G-1.3 Acetylene Transmission for Chemical Synthesis
- (c) G-1.4 Obsolete reference. Refer to NFPA Standard 51A for Acetylene Cylinder Charging Plants(2)

- (d) C-6 Standard for Visual Inspection of Compressed Gas Cylinders
  - (e) C-8 Standard for Requalification of DOT-3HT Cylinder
  - (f) P-1 Safe Handling of Compressed Gas in Containers
  - (g) S-1.1 Standard Safety Relief Device for Cylinders
  - (h) S-1.2 Standard for Safety Relief Devices for Cargo, Portable Tanks
- (5) American Society of Mechanical Engineers (ASME)
- (a) ASME Boiler and Pressure Vessel Code
    - o Section VIII (Division I) and
    - o Section IX
- (6) American National Standards Institute (ANSI)
- (a) Z48.1 Standard Method for Marking Portable Compressed Gas Containers to Identify the Material Contained
  - (b) Z57.1 Compressed Gas Cylinder Valve Outlet and Inlet Connection
  - (c) B31.1 Standard Code for Pressure Piping
  - (d) 49.1 Safety in Welding and Cutting (Some of Standards not incorporated)
- (7) American Society of Testing Materials (ASTM)
- (a) B-88-66a Specification for Seamless Copper Water Tube
- (8) Compressed Gas Association
- (a) C-2 Recommendations for the Disposition of Unserviceable Compressed Gas Cylinders
  - (b) C-7 Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers

- (c) C-9 Standard Color-Marking of Compressed Gas Cylinders Intended for Medical Use in the United States
  - (d) C-10 Recommendations for Changes of Service for Compressed Gas Cylinders Including Procedures for Inspection and Contaminant Removal
  - (e) E-1 Standard Connections for Regulators, Torches Fitted Hose for Welding and Cutting Equipment
  - (f) E-2 Hose Line Check Valve Standards for Welding and Cutting
  - (g) G-4 Oxygen
  - (h) G-4.1 Equipment Cleaned for Oxygen Service
  - (i) G-10.1 Commodity Specification for Nitrogen
  - (j) P-2 Characteristics and Safety Handling of Medical Gases
  - (k) P-4 Safety Handling of Cylinders by Emergency Rescue Squads
  - (l) P-7 Tentative standard for requalification of cargo tank hose used in the transfer of compressed gas
  - (m) SB-3 Compressed Gas Cylinder Filling Procedures
  - (n) SB-4 Handling Acetylene Cylinders in Fire Situations
- (9) National Fire Protection Association (NFPA)
- (a) Number 50 - Standards for Bulk Oxygen Systems at Consumer Sites
  - (b) Number 51B - Standard for Fire Prevention in Use of Cutting and Welding Processes
- (10) Compressed Gas Association Standards
- (a) C-9 Standard Color-Marking of Compressed Gas Cylinders Intended for Medical Use in the United States

- (b) C-10 Recommendations for Change of Service for Compressed Gas Cylinders Including Procedures for Inspection and Contaminant Removal
- (c) V-1 Pamphlet V-1 American National, Canadian Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections

(11) The following were identified as referring to State or Foreign Standards, compressed gases and cylinders from a search of NIOSHTIC.

- (a) NIOSH -00015096 Welding Safety (German)
- (b) NIOSH -00020210 Valves for Cylinders Containing Compressed, Liquefied or Dissolved gases under Pressure (Polish)
- (c) NIOSH -00035307 Grothe, I (German)
- (d) NIOSH -00036091 Colours - Cylinders for Gas Intended for Medical Purposes - The use of Colour Conventions to Identify Gases (French)
- (e) NIOSH -00036092 Colours - Industrial Gas Cylinders - The Use of Colours for Identification of Gases (French)
- (f) NIOSH -00071841 Code of Safe Practice for Oxy-Acetylene Equipment
- (g) NIOSH -00035332 Technical Rules Concerning Compressed Gases
- (h) NIOSH -00052480 North Carolina Occupational Safety and Health Standards Applicable to Welding - Cutting - Brazing

J. Names of Industry Associations and Other Interested Parties (28)

(1) Industry Associations

Compressed Air and Gas Institute

1230 Keith Building

1621 Euclid Avenue

Cleveland, Ohio 44115

Compressed Gas Association, Inc.

500 Fifth Avenue

New York, NY 10036

American Welding Society Inc.

2501 N.W. 7th Street

Miami, Florida 33125

National Welding Supply Association

1900 Arch Street

Philadelphia, PA 19103

Chlorine Institute Inc.

342 Madison Avenue

New York, New York 10017

American Water Works Association Inc.

6666 W. Quincy Avenue

Denver, Colorado

K. Names and Addresses of Companies (20)

(1) Large Chlorine Producing Companies

Hooker Chemicals and Plastics Corp.

1515 Summer

Stamford, Connecticut

Pennwalt Corp., Inorganic Chemicals Division

Pennwalt Building

Three Parkway

Philadelphia, PA

(2) Large Acetylene Producing Companies

Liquid Carbonic Corp, Sub. of Houston

Natural Gas Dept. TR

135 So. LaSalle Street

Chicago, IL

Union Carbide Corp., Linde Division

270 Park Avenue

New York, NY

(3) Large Oxygen Producing Companies

Air Products and Chemicals, Inc.

P. O. Box 538T

Allentown, PA

(4) Large Nitrogen Producing Companies

Alabama Oxygen Co., Inc.

2610 18th Avenue

Bessemer, Alabama

Industrial Air Products Co.

3210 N.W. Yeon Ave.

Portland, Oregon

(5) Small Chlorine Producing Companies

Diamond Shamrock Corp.

1100 Superior Ave.

Cleveland, Ohio

Ashland Chemical Co. Div. of Ashland Oil Inc.

Industrial Chemicals and Solvents Div.

P. O. Box 2219

Columbus, Ohio

(6) Small Acetylene Producing Companies

Acetylene Products Co.

1760 S. Harding

Indianapolis, Indiana

Acetylene Gas Co.

P. O. Box 14858

St. Louis, MO

(7) Small Oxygen Producing Companies

Industrial Oxygen Co., Inc.

1377 S. 7th

Louisville, KY

Whitmore Oxygen Co.

1884 So. 300 West

P. O. Box 2099

Salt Lake City, Utah

(8) Small Nitrogen Producing Companies

Scientific Gas Products, Inc.

2330-T.Hamilton Blvd.

South Plainfield, NJ

Wayne Nitrogen Inc.

Royal Ave. Ext.

Goldsboro, NC

(9) Identified High Volume Cylinder Fillers(1)

Jones Chemicals Inc.

Dept. ATR

Caledonia, NY

Thompson-Hayward Chemical Co.

5200 Speaker Rd.

Kansas City, KA

McKesson Co.

Santee Circle

Moncks Corner, SC

## L. Summary Analysis of Data

There is adequate knowledge and sufficient rules and regulations to safely fill, handle, store, transport, and utilize oxygen, acetylene, nitrogen, and chlorine gases in cylinders.

The frequency/severity of injuries related to cylinder-sized quantities of these gases appears to be low. Injuries reportedly result from violations of existing known good practice. A simplification of existing regulations, and the elimination of confusing, merry-go-round cross-referencing are areas that NIOSH may wish to investigate.

One potential existing deficiency appears to be the lack of regulations, rules, or guidelines regarding cylinder valve maintenance, reconditioning, and testing. No injuries were identified in the literature where a valve failure was responsible; however, injuries are thought to have occurred (see Appendix A). The gas consumer is more likely to be injured than the cylinder filler. This subject may be worthy of NIOSH investigation.

The existing OSHA regulations do not define "cylinder" in regulations associated with non-DOT regulated cylinder applications. They also do not adequately address cylinder hydrostatic retesting.

## M. Other Data

The Bureau of Explosives indicated that stolen cylinders are a problem. So-called stolen cylinders are cylinders whose ownership is unknown or confused. Original cylinder markings can identify manufacturer, purchaser or user and do not necessarily identify ownership. Usually, the larger companies fill only their own cylinders. However, smaller companies and distributors frequently fill other cylinders. Cylinder incidents resulting from filling of unowned cylinders can lead to legal complications regarding liabilities.(1)

The enforcement of DOT regulations is quite limited. Typically, filling operations are not checked by the DOT enforcement people. OSHA inspectors (typically not well versed in DOT regulations) are not inspecting for DOT (OSHA adopted) regulations. Therefore, there is an overlapping of regulation and a lack of inspection.(1)

Reports of incidents involving cylinders are almost nonexistent. Compared to other hazardous materials and packaging, the cylinder regulations must be doing what they are intended to do. The number of incidents and/or releases will increase because of two factors: (1) good past performance, and (2) no age limit on cylinder use.(1)

Defective cylinders are a problem because: (1) cylinder rebuilding is being accomplished in unapproved shops (illegally), (2) cylinders are being repaired improperly; or (3) cylinders are not being repaired because of an insufficient number of approved shops.(1)

Currently there are no regulations addressing valve maintenance.(19)  
The lack of regulation may contribute to incidents and occasionally to injury, directly or indirectly. Failure of a valve at the filling location is less hazardous than at the utilizing location because adequate facilities and knowledgeable personnel typically found at filling locations allow handling of valve problems with minimal exposure. Valve problems at the utilization location create the potential for subsequent incidence. Valve failures include: Stem failure closed and open, packing gland leakage, connecting thread deterioration, valve contained fuse plug failures, valve-to-cylinder thread connection failure and, for chlorine, multiple failures resulting from low-level, long-term leakage.

Information received from the Department of Transportation, Materials Transportation Bureau tabulating Hazardous Materials Incidence Reports for the four representative gas products is summarized in Table 7. This information is included, although the transportation of cylinders was excluded from the profile perimeters. Twenty-four cylinder incidence are reported for the 91 month period, which indicates the relative effectiveness of cylinder handling of compressed gases.(5-29)

TABLE 7

## DOT Computer Search (5-29)

First Entry 1/26/7 Last Entry 8/15/78 = 91 Months

Summary for four products identified - 82 reports

Cylinder as identified container	-28
(Bulk and other container)	<u>54</u>

	<u>Reports</u>	<u>Percent</u>	<u>91 Month Average</u>
Reports	28	100	0.31
Nitrogen	6	21	0.23
Oxygen	4	14	0.15
Acetylene	5	17	0.19
Chlorine	13	46	0.51
Carrier			
Highway (Private Carrier)	17	61	0.19
Highway (For Hire)	6	21	0.07
Air	2	7	0.02
Water	2	7	0.02
Railway	<u>1</u>	<u>4</u>	<u>0.01</u>
	28	100	0.31
Deaths Reported	-0-		
Injuries Reported Total	63	100	0.69
Nitrogen	0		
Oxygen	0		
Acetylene	0		
Chlorine	63	100	0.69
Dollar Damage	\$16,478	99	181
Nitrogen	8,595	52	94
Oxygen	211	1	2
Acetylene	207	1	2
Chlorine	7,465	45	82

## REFERENCES AND SOURCES

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- (2) Personal communication with Edwin A. Olsen, Managing Director, Compressed Gas Association, New York, New York, November 7 and 10, 1978.
- (3) Personal communication with Richard C. White, Sales Engineer, Matheson, Newark, California.
- (4) Personal communication with Stella Ruggiano, National Welding Supply Association, Philadelphia, PA, November 7, 1978.
- (5) Personal communication with Ms. Cureton, Accident Analysis Branch, DOT RSPA, Washington, D.C., November 7, 1978.
- (6) Feeley, Thomas, W., M.D., et. al., "Potential Hazards of Compressed Gas Cylinders" - Anesthesiology 48, 72-74, 1978.
- (7) Cusack, G.C., (Chairman Handbook Committee)(1966), Handbook of Compressed Gases, Van Nostrand Reinhold Publishers, New York, New York.
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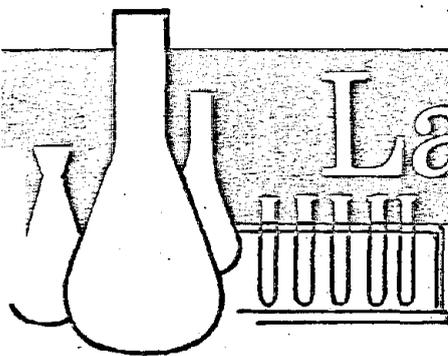
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- \*(12) Anon., 1959, Chlorine Manual, Third Edition, Chlorine Institute Inc., New York, New York.
- (13) Anon., 1974, Safe Handling of Compressed Gases In Containers, CGA Pamphlet P-1, (Sixth Edition), Compressed Gas Association Inc., Publishers, New York, New York.
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- \*(15) Anon., "Oxygen - Fuel Gas Systems for Welding and Cutting" 1973 Edition, NFPA No. 51, National Fire Protection Association, Boston, MA.
- \*(16) Anon., "Cutting and Welding Processes", NFPA No. 51B, 1971 Edition, National Fire Protection Association, Boston, MA.

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- (20) Anon., Thomas Register, 1977 Edition, Thomas Publishing Company, New York, New York.
- (21) "Manned Space Programs Accident/Incident Summaries, 1963-1969 and 1970-1971", NASA CR-120998 and CR-120999
- (22) --, "Mishaps with Oxygen in NASA Operations", NASA TM x 67953, NASA Technical Memorandum, November 9-11, 1971, Cleveland, Ohio.
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- (26) --, County Business Patterns, U.S. Bureau of Census, 1976, Table IB.
- (27) "Acetylene Transmission for Chemical Syntheses", CGA Pamphlet G1.3, Compressed Gas Association Inc., Publishers, New York, New York.
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- (29) Department of Transportation, Materials Transportation Bureau, Computer Printout of Selected Hazardous Materials Incidents Reports.

\*General reference background information.

APPENDIX A



# Laboratory Safety

Published by the Department of Environmental Health and Safety  
The University of Michigan Health Service

Vol. 5, No. 5

May, 1969

## On Securing Compressed Gas Cylinders.

Editors Note: It isn't too often that we come across a vivid description of the actions of a damaged compressed gas cylinder; however recently an article concerning this was published in the National Safety Council Chemical Section Newsletter (May, 1969). The article was submitted by Eli Lilly and Co., and is reprinted with the permission of that company.

### The Case of the Errant Cylinder

The anchoring of compressed gas cylinders, to keep them from being knocked over with the accompanying possibility of breaking off the valve, is an accepted safe practice. However, there has been some skepticism as to what would happen if a cylinder valve was knocked off.

While it wasn't asked for, we now have first-hand knowledge as to what happened in one case, thanks to a compressed gas cylinder ( $\text{CO}_2$ ) that caused a few moments of frenzied activity in a building under construction.

Six 220-cubic-foot cylinders, part of a fire extinguishment system, had been moved away from their wall supports to allow painters to complete the painting of the area. While moving them back into position, it was noticed that one cylinder was leaking. The painter had the cylinder leaning against his shoulder, and was attempting to scoot it across the floor. At this time, the valve separated from the cylinder and was projected backward hitting the side of a stainless steel cabinet.

The man suddenly found himself with a jet-propelled 215-pound piece of steel. He wrestled it to the floor, but was unable to hold it. The cylinder scooted across the floor hitting another cylinder, knocking it over and bending its valve. The cylinder then turned 90 degrees to the right and traveled 20 feet where it struck a painter's scaffold causing a painter to fall 7 feet to the floor. After spinning around several

times, it traveled back to its approximate starting point, where it struck a wall.

At this point, the cylinder turned 90 degrees to the left and took off lengthwise of the room chasing an electrician in front of it. It crashed into the end wall 40 feet away breaking loose four concrete blocks. It turned again 90 degrees to the right, scooted through a door opening, still chasing the electrician. The electrician ducked into the next door opening, but the cylinder continued its travel in a straight line for another 60 feet, where it fell into a truck well striking the truck well door. The balance of the cylinder pressure was released as the cylinder spun harmlessly around in the truck well area. The painter who fell from the scaffold received multiple fractures of his leg.

It is summarized that the cylinder valve had obtained previous damage, and it was a matter of chance that it separated from the cylinder at this particular time.

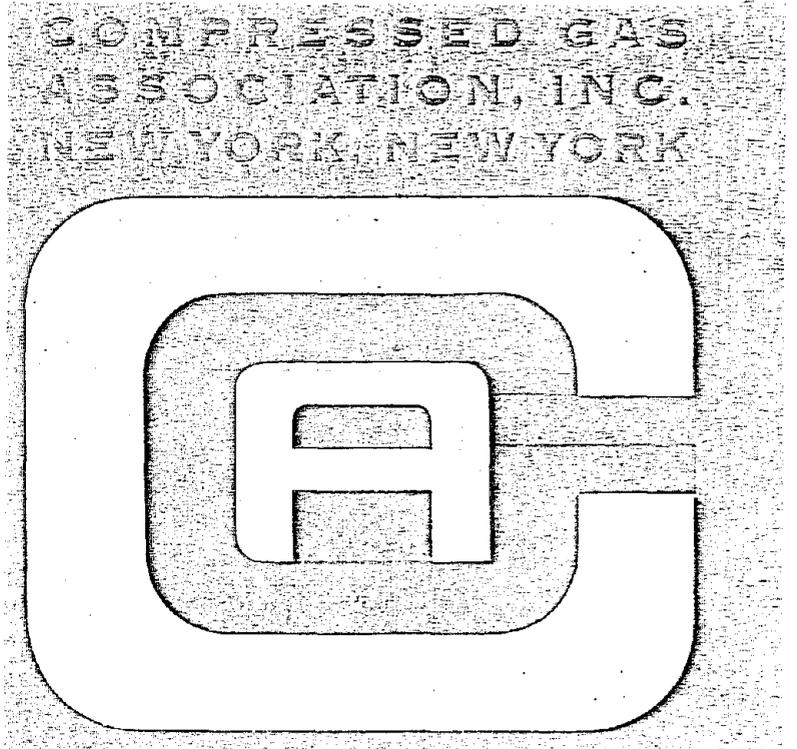
This incident illustrates what can happen when a valve is separated from a compressed gas cylinder. This one contained pressure of about 900 pounds per square inch, but many cylinders are pressurized to 2200 pounds per square inch. If you have any doubts about the need for anchoring compressed gas cylinders you might think about the 2200 pounds per square inch and ask yourself "What if...?"

### Minimizing Fire Damage

By this time, it is generally known that a fire occurred in the Chemistry Building. The fire resulted in a considerable amount of damage and required a great deal of time to remove the debris.

Fires in laboratory situations are extremely troublesome and all precautions should be taken to make certain that if a fire does break out, damage can be held to a minimum.

**SAFE HANDLING  
OF  
COMPRESSED GASES  
IN CONTAINERS**





**PLEASE NOTE:**

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review and users are cautioned to obtain the latest edition. Comments and suggestions are invited from all users for consideration by the Association in connection with such review; any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard.

This document should not be confused with federal, state or municipal specifications or regulations, insurance requirements or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding.

CONTENTS		Page
1. INTRODUCTION .....		5
1.1 General .....		5
1.2 Scope .....		5
1.3 Definitions .....		5
1.3.1 Compressed Gas .....		5
1.3.2 User .....		5
1.3.3 Charging .....		5
1.3.4 Acid and Alkaline Gases .....		5
2. REGULATIONS APPLICABLE TO COMPRESSED GASES IN CONTAINERS .....		5
2.1 Transportation Regulating Authorities .....		5
2.2 Publications Covering Transportation Regulations .....		5
2.3 Container Shipping Regulations .....		5
2.4 Fillers' Responsibilities .....		5
2.5 OSHA and Other Regulating Authorities .....		6
2.6 American National Standards Institute Standards .....		6
3. SAFE HANDLING RULES FOR COMPRESSED GAS CONTAINERS (in general usage) .....		6
3.1 Filling .....		6
3.1.1 Approval to Fill .....		6
3.1.2 DOT Regulations .....		6
3.1.3 Content Identification .....		6
3.1.4 Transfilling .....		6
3.1.5 Gas Mixtures .....		6
3.1.6 Changing Gas Service .....		6
3.1.7 Spheres and Drums .....		6
3.1.8 Check List .....		6
3.2 Maintenance .....		6
3.2.1 Authorization .....		6
3.2.2 Changing Prescribed Markings .....		6
3.2.3 Changing Content Markings .....		6
3.2.4 Pressure-Relief Devices .....		6
3.2.5 Containers or Appurtenances .....		6
3.2.6 Painting .....		6

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CONTENTS (Continued)		Page
3.2.7	Contamination .....	6
3.2.8	Leaking or Defective Containers .....	6
3.2.9	Fire-Burned Containers .....	7
3.2.10	Corroded Containers and Valves .....	7
3.2.11	Other Container Damage .....	7
3.3	Container Usage .....	7
3.3.1	Content Identification .....	7
3.3.2	Cylinder Caps .....	7
3.3.3	Misuse .....	7
3.3.4	Containers Not in Use .....	7
3.3.5	Electrical Circuits .....	7
3.3.6	High Temperature .....	7
3.3.7	Low Temperature .....	7
3.3.8	Leaking Containers .....	7
3.3.9	Inadequate Information .....	7
3.3.10	Returning Empty Containers .....	7
3.3.11	Non-Refillable Containers .....	7
3.3.12	American National Standards Institute Standard Z 49.1 .....	7
3.4	Moving Containers .....	8
3.4.1	Trucks .....	8
3.4.2	Rough Handling .....	8
3.4.3	Lifting .....	8
3.5	Storing Containers .....	8
3.5.1	Regulations .....	8
3.5.2	Posting .....	8
3.5.3	Grouping .....	8
3.5.4	Storage Rooms .....	8
3.5.5	Separation from Combustibles .....	8
3.5.6	External Corrosion .....	8
3.5.7	Mechanical Damage .....	8
3.5.8	Containers Standing Upright .....	8
3.5.9	Outdoor Storage .....	8
3.5.10	Public Areas .....	8
3.5.11	Interference with Egress .....	8
3.6	Connecting Container and Withdrawing Content .....	8
3.6.1	Trained Personnel .....	8
3.6.2	Content Identification .....	9
3.6.3	Caps .....	9
3.6.4	Secure Containers .....	9
3.6.5	Pressure Regulator .....	9
3.6.6	System Pressure-Relief Device .....	9
3.6.7	Connections .....	9
3.6.8	Manifold .....	9
3.6.9	Changing Service .....	9
3.6.10	Container Valve .....	9
3.6.11	Dusting Clothing .....	9
3.6.12	Check Valves .....	9
3.6.13	Gas Tightness .....	9
3.6.14	Removing Pressure Regulator .....	9
4.	SAFE HANDLING RULES FOR COMPRESSED GAS CONTAINERS (by service classification) .....	9
4.1	Flammable Gases .....	9
4.1.1	Storage Outdoors or in Separate Building (without other occupancy) .....	9
4.1.2	Storage in Separate Rooms (without other occupancy) .....	9
4.1.3	Storage in Buildings and Rooms (with other occupancy) .....	10
4.1.4	Fire Protection .....	10
4.1.5	NFPA No. 50A .....	10
4.1.6	NFPA No. 51B .....	10
4.1.7	NFPA No. 58 .....	10
4.1.8	NFPA No. 59A .....	10

CONTENTS (Continued)		Page
4.2	Oxygen (including Oxidizing Gases) .....	10
4.2.1	Cleanliness .....	10
4.2.2	Separation of Oxygen from Combustibles .....	10
4.2.3	Capacity Limitation .....	10
4.2.4	Oxygen-Enriched Atmospheres .....	10
4.3	Acid and Alkaline Gases .....	10
4.3.1	Personal Protective Equipment .....	10
4.3.2	Respiratory Equipment .....	10
4.3.3	Emergency Showers and Eyewash Fountains .....	11
4.3.4	Quantity on Site .....	11
4.3.5	Ventilation .....	11
4.3.6	Common Acid and Alkaline Gases .....	11
4.4	Highly Toxic Gases .....	11
4.4.1	Respiratory Equipment .....	11
4.4.2	Storage Locations .....	11
4.4.3	Ventilation .....	11
4.4.4	Toxicity .....	11
4.4.5	Quantity on Site .....	11
4.4.6	Common Highly Toxic Gases .....	11
4.4.7	Information Sources .....	11
4.5	Cryogenic Liquefied Gases .....	11
4.5.1	General .....	11
4.5.2	Personal Protective Equipment .....	12
4.5.3	Ventilation .....	12
4.5.4	Container Handling .....	12
4.5.5	Containers and Cryogenic Equipment .....	12
4.5.6	Pressure-Relief Devices .....	12
4.5.7	Transfer of Cryogenic Liquids .....	12
4.5.8	Liquid Oxygen .....	12
4.5.9	Liquid Hydrogen .....	12
4.5.10	Liquid Helium and Liquid Neon .....	12
4.5.11	Liquefied Natural Gas .....	12
4.6	Inert Gases .....	12
5.	GENERAL PRECAUTIONS FOR TANK CARS .....	12
5.1	Shipment of Compressed Gases in Tank Cars .....	12
5.2	Qualification, Maintenance and Use of Tank Cars .....	12
5.3	Placarding and Handling of Tank Cars .....	12
5.4	Tank Car Specifications .....	12
5.5	Gas Service .....	12
5.6	Shippers' Instructions .....	13
5.7	Unloading Supervision and Protection .....	13
5.8	DOT 106A and 110A Tanks .....	13
5.9	Leaks .....	13
5.10	Sidings .....	13
5.11	Derails .....	13
5.12	Electric Grounding .....	13
5.13	Information .....	13
6.	CARGO TANKS AND PORTABLE TANKS .....	13
6.1	Shipment of Compressed Gases in Cargo Tanks and Portable Tanks .....	13
6.2	Qualification, Maintenance and Use of Cargo Tanks .....	13
6.3	Qualification, Testing, Maintenance and Use of Portable Tanks .....	13
6.4	Placarding and Handling of Cargo Tanks and Portable Tanks .....	13
6.5	Specifications for Cargo Tanks .....	13
6.6	Specifications for Portable Tanks .....	13
6.7	Handling Instructions .....	13
7.	REFERENCES .....	13
8.	APPENDIX A .....	15

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