FIRETRACE
AUTOMATIC FIRE SUPPRESSION SYSTEMS

DESIGN, INSTALLATION, OPERATION AND MAINTENANCE MANUAL

FOR

PRE-ENGINEERED AUTOMATIC INDIRECT CARBON DIOXIDE EXTINGUISHER UNITS

Models:
950504 - IHP-500
951004 - IHP-1000
952004 - IHP-2000
953504 - IHP-3500
955004 - IHP-5000

DIOM Part Number: 800058

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1.0 FORWARD

1.1 General

This manual is written for the fire protection professional that designs, installs, and maintains Firetrace Pre-engineered Automatic High-Pressure Carbon Dioxide (CO_2) Extinguisher Units.

Firetrace CO_2 automatic high-pressure extinguisher units are to be designed, installed, inspected, tested, maintained, and recharged by qualified trained personnel in accordance with the following:

All instructions, limitations, etc. contained in this manual P/N 800058
All information contained on the agent cylinder nameplate(s).
NFPA-12, *Standard on Carbon Dioxide Extinguishing Systems 2018 Edition.*
Local Authority having jurisdiction.

1.2 Safety Precautions

Safety precautions are essential when any electrical or mechanical equipment is involved. These precautions should be followed when handling, servicing, and recharging Firetrace CO_2 automatic high-pressure extinguisher unit cylinders and equipment. If safety precautions are overlooked or ignored, personal injury or property damage may occur.

The following symbols are used throughout this manual. Always heed these precautions. They are essential to the safe use of the equipment described in this manual.

⚠ DANGER:

This danger symbol identifies immediate hazards and provides specific instructions or procedures, which if not correctly followed WILL result in severe personal injury or death.

⚠ WARNING:

This warning symbol identifies specific instructions or procedures, which, if not correctly followed, COULD result in severe personal injury of death.

⚠ CAUTION:

This caution symbol identifies specific instructions or procedures, which, if not correctly followed, COULD result in minor personal injury or equipment or property damage.

The following safety precautions should always be followed:

⚠ WARNING

Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of causing bodily injury, death or property damage.

1. Read and understand this manual and the other documents referenced herein.
2. The valve discharge outlet safety cap and filling port cap **MUST** be installed on the the cylinder valve at all times and only removed when connected into the discharge tubing, or when performing testing, or salvaging operations in accordance with the procedures contained in this manual.
3. Wear safety glasses when working with pressurized cylinders and charging equipment. It is recommended to wear leather gloves to avoid any cryogenic burns if CO_2 is accidentally discharged on or near the skin.
4. Make sure that the ball valve (attached to the cylinder valve) is closed (lever is in "OFF" position), the detection tubing has been removed from the cylinder valve; and the safety caps installed, before removing the cylinder from the installation, and before performing any charging, leak tests or salvage operations.
5. Follow all of the safety procedures included on the cylinder nameplate and in this manual.
6. Never assume that a cylinder is empty. Treat all cylinders as if they are fully charged.

Any questions concerning the information contained in this manual should be addressed to:

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The following web site should be visited for frequent technical announcements

www.firetrace.com

2.0 INTRODUCTION

The following Firetrace High Pressure CO_2 Automatic Fire Extinguisher Units are covered in this manual:

950504 - IHP-500
951004 - IHP-1000
952004 - IHP-2000
953504 - IHP-3500
955004 - IHP-5000

These units are designed for total flooding using CO_2, in accordance with NFPA-12, *Standard on Carbon Dioxide Extinguishing Systems: 2018 Edition*

Each installed pre-engineered unit is equipped with its' own detection and its own discharge tubing and nozzles. The pre-engineered concept minimizes the amount of engineering involved in the unit's design. When the discharge tubing and nozzles are installed within the limitations stated in this manual, no hydraulic calculations are required to determine pressure drop, agent flow or discharge time.

The hazard being protected can be any size, shape or volume, provided that the hazard being protected is within the limitations described in this Manual. Each extinguisher unit, when installed, is a self-contained unit, meaning that it is equipped with its own automatic (non-electric) detection system, which when actuated, automatically releases the suppression agent into the hazard area.

Local authorities having jurisdiction should be consulted as to the acceptability for particular hazards and requirements covering installation.

2.1 Carbon Dioxide Extinguishing Agent

The extinguishing agent used in Firetrace pre-engineered automatic high-pressure extinguisher units is Carbon Dioxide, more commonly known as CO_2. CO_2 is a colorless, odorless, electrically nonconductive inert gas that is an extremely effective fire suppression agent.

2.1.1 Cleanliness

CO_2 is clean and leaves no residue, thereby minimizing any after fire clean up, along with keeping expensive downtime to a minimum. Most materials such as steel, aluminum, stainless steel, brass, as well as plastics, rubber and electronic components are not affected by exposure to CO_2. This agent is also environmentally friendly, having an ozone depletion potential (ODP) of 0.00.

2.1.2 Physical Properties of Carbon Dioxide

Chemical Name: Carbon Dioxide

Molecular Weight	44.01
Boiling Point (°F) @ 14.7psia	-109.3
Freezing Point (°F)	-69.9
Critical Temperature (°F)	87.9
Critical Pressure (psia)	1071
Critical Density (lbm/ft3)	29.2
Specific Heat, Liquid (BTU/Lb-°F) @ 2°F	0.489
Specific Heat, Vapor (BTU/Lb-°F) @ Constant Pressure (1 ATM) @ 77°F	
Heat of Vaporization (BTU/lb) @ Boiling Point	
Thermal Conductivity (BTU/hr ft oF) of Liquid @ 77°F	
Viscosity, Liquid (lb/ft hr) @ 77°F	
Vapor Pressure (psig) @ 70°F	838
Ozone Depletion Potential	0.00

2.1.3 Fill Density

Each Firetrace CO_2 storage cylinder has been designed for a maximum fill density as shown in Table 3.1. It is important that these values not be exceeded.

Fill density and temperature significantly affect the pressure in the storage cylinder. At elevated temperatures the rate of increase in pressure is very sensitive to fill density (see Figure 2.1). If the maximum fill density is exceeded; the pressure will increase rapidly with temperature increase so as to present a hazard to personnel and property. Adherence to the limits on fill density and pressurization levels will prevent excessively high pressures from occurring if the storage cylinder is exposed to elevated temperature. This will also minimize the possibility of an inadvertent discharge of agent through the cylinder pressure relief device, where provided. It is recommended to not mount the cylinder in direct sunlight as this would create elevated cylinder temperatures.

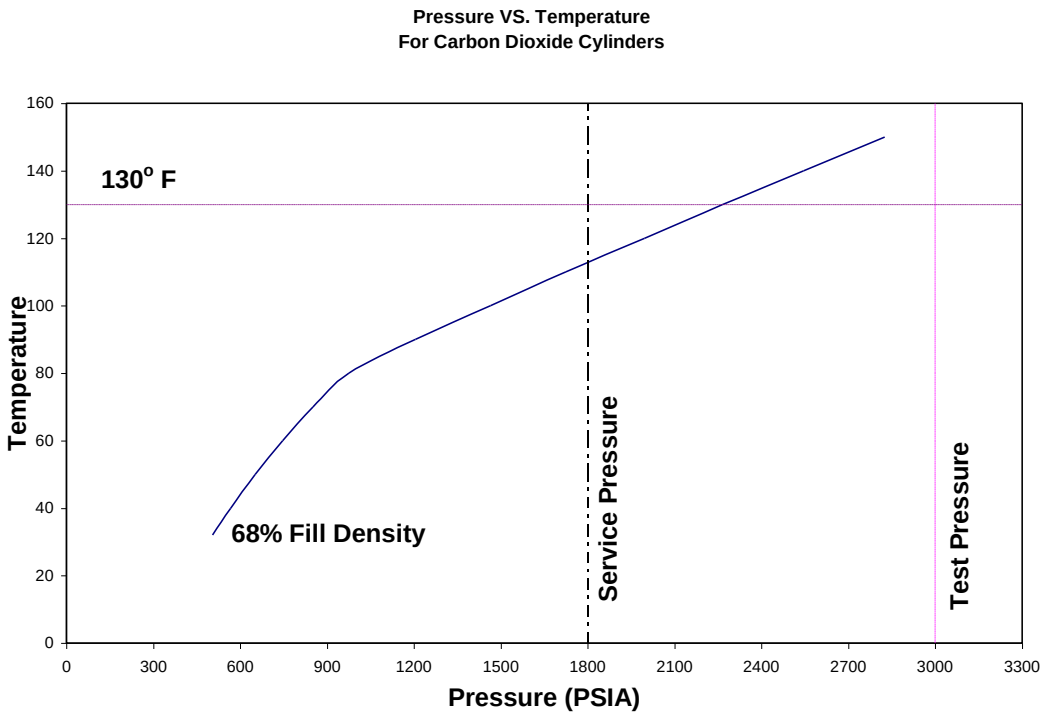


Figure 2.1: Pressure vs. Temperature of CO_2

3.0 SYSTEM DESCRIPTION

3.1 General

The Firetrace CO_2 Automatic High-Pressure units are available in 5 sizes, namely:

950504 - IHP-500 - Charged with 5.0 Lbs. of CO_2
951004 - IHP-1000 - Charged with 10.0 Lbs. of CO_2
952004 - IHP-2000 - Charged with 20.0 Lbs. of CO_2
953504 - IHP-3500 - Charged with 35.0 Lbs. of CO_2
955004 - IHP-5000 - Charged with 50.0 Lbs. of CO_2

These units are designed for use in Total Flooding applications where the hazard is not occupiable by a human being. A lock-out valve shall be provided on all systems except where dimensional constraints prevent personnel from entering the protected space.

The Firetrace CO2 units can be used, but are not limited, to protect the following:

- Electrical and electronic cabinets.
- Telecommunication areas.
- Data Processing areas and cabinets.
- Other high value assets.
- Laboratory fume /exhaust cabinets
- Pump enclosures
- UPS units
- Flammable Chemicals storage cabinets
- Generator Enclosures
- Transformer Cabinets
- Computer/Data Storage Cabinets
- CNC & VMC Machining centers
- Many other applications

CO_2 is a gaseous fire-extinguishing agent that is effective for use on:

- Class A -
    - Surface type fires
    - Deep seated fires
- Class B - Flammable liquid fires
- Class C - Electrical equipment fires

CO_2 should not be used where the following materials may be present.
Pyrotechnic chemicals containing their own oxygen supply.
Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium.
Metal hydrides.

Chemicals capable of undergoing auto thermal decomposition, such as certain organic peroxides and hydrazine.

For hazards beyond the scope described above, it is recommended that the designer consult with Firetrace, NFPA-12, and the local authority having jurisdiction, as to the suitability on the use of CO_2 for a particular hazard, for personnel exposure effects from the design concentration, and for installation requirements.
Firetrace CO_2 Automatic High-Pressure Extinguisher Units consist of the following major components:

- CO_2 Cylinder/Valve assembly.
- Cylinder Mounting Bracket.
- Firetrace detector/actuation tubing and fittings (no substitute).
- Discharge nozzles.
- Discharge Port Adapter
- Pressure switch
- Discharge tubing and fittings (furnished by others).

Once installed, the Firetrace Automatic High-Pressure Unit becomes a self-contained, self-actuating unit that does not require an external source of power or electricity.

The unit utilizes unique Firetrace flexible tubing that is attached to the cylinder valve. This tubing is pressurized with dry nitrogen to maintain the cylinder valve in the closed position. The tubing is temperature sensitive, and acts as a continuous linear thermal detector that ruptures upon direct flame impingement. Once the detector tubing is ruptured, the cylinder valve automatically opens, allowing the CO_2 agent to flow through the discharge tubing, distributing the extinguishing agent through the nozzle(s) onto the protected area. Upon actuation, the pressure switch can be used to indicate discharge, shutdown ventilation, close all openings, shut-off electrical power, etc. as may be required.

3.1.1 Operating Pressure

The CO_2 cylinder is stored as a liquefied gas under its own pressure; 838psig @ 70^{o}F.

3.1.2 Operating Temperature Range Limitations:

The ambient operating temperature range for all unit components is:

0^{o}F to +130^{o}F (-17.8^{o}C to +54.4^{o}C).

3.2 Component Descriptions

3.2.1 CO2 Cylinder Valve Assemblies

CO_2 is stored in DOT/TC aluminum cylinders as a liquefied compressed gas, under its own pressure; 838psig @ 70°F (5,778 KPa @ 21°C). The cylinder/valve assemblies are available in 5 sizes, namely:

5 LB size filled with 5.0 LBS (2.27 Kg) of CO_2
10 LB size; filled with 10.0 LBS (4.54 Kg) of CO_2
20 LB size; filled with 20.0 LBS (9.07 Kg) of CO_2
35 LB size; filled with 35.0 LBS (15.88 Kg) of CO_2
50 LB size; filled with 50.0 LBS (22.68 Kg) of CO_2

Each cylinder is equipped with a brass valve and a quarter turn ball valve that interfaces with the Firetrace detector tubing. The ball valve must be kept closed at all times when the cylinder is not in service.

In addition, the CO_2 Cylinder valves are equipped with a pressure relief (rupture disc) device in compliance with DOT/TC requirements.

Each valve is also equipped with (1) discharge outlet port and (1) filling port. Each port is provided with a safety cap that must be installed whenever a cylinder is not in service. These caps are safety devices designed to prevent uncontrolled discharge of the cylinder in the event that the valve is accidentally actuated.

⚠ WARNING

The safety caps must be installed on the valve discharge port and filling port at all times, except when connected into the units discharge tubing or when filling. Failure to follow these instructions could result in personal injury, death or property damage.

Table 3.1 describes the cylinder assemblies. Each cylinder is equipped with a straight siphon tube and can only be mounted in a vertical (upright) position.

Table 3.1: CO_2 Cylinder / Valve Assemblies

Nom Size	Assy Part No.	Outside Dia.		Overall Height		Internal Volume		CO_2 Agent		Fill Density
		in.	cm	in.	Cm	in^3	cm^3	lb.	kg	%
5	110050	5.25	12.70	20.0	50.67	205	3359	5.0	2.27	68
10	110100	6.89	17.50	22.4	55.32	408	6717	10.0	4.54	68
20	110200	8.00	20.32	29.0	72.14	816	13340	20.0	9.07	68
35	113500	8.00	20.32	42.3	107.44	1429	23417	35.0	15.88	68
50	115000	8.66	22.00	52.0	132.08	2040	33430	50.0	22.68	68

Table 3.2 describes the DOT/TC Specifications used for the manufacture of the CO_2 cylinders.

Table 3.2: DOT/TC Cylinder Specifications

Nominal Size	DOT Spec	TC Spec	Cylinder Service Pressure psig	Test Pressure	
				DOT psig	TC psig
5	3AL1800	3ALM124	1800	3000	2700
10	3AL1800	3ALM124	1800	3000	2700
20	3AL1800	3ALM124	1800	3000	2700
35	3AL1800	3ALM124	1800	3000	2700
50	3AL1800	3ALM124	1800	3000	2700

The Firetrace CO_2 Units are designed for an operating temperature range of 0°F to +130°F. Table 3.3 shows the cylinder, pressure-temperature relationship based on a maximum fill density of 68%; and a charged pressure of 838 psig at 70°F

Table 3.3: Cylinder Pressure-Temperature Relationship

Cylinder Pressure			
Temperature		Pressure	
°F	°C	psig	kPa
32	0.00	505	3,481
40	4.44	567	3,909
50	10.00	652	4,495
60	15.56	747	5,150
70	21.11	852	5,874
80	26.67	975	6,722
90	32.22	1205	8,308
100	37.78	1465	10,100
110	43.33	1725	11,893
120	48.89	1995	13,755
130	54.44	2265	15,616
140	60.00	2545	17,547
150	65.56	2825	19,477

3.2.2 Cylinder Mounting Bracket

A wall mounted painted steel bracket is used to mount the 5, 10, and 20lb cylinder/valve assemblies in a vertical (upright) position. Each bracket is equipped with an interlocking steel strap that is secured with a metallic pin.

A wall mounted steel and nylon strap bracket is used to mount the 35 and 50 lb cylinder/valve assemblies in place.

3.2.3 Firetrace Flexible Detector/Actuation Tubing

The Firetrace tubing is used as a combination linear heat detector and unit activation device to cause actuation of the CO_2 agent cylinder. The tubing is installed throughout the hazard volume, with one end connected to the CO_2 cylinder valve. The tubing is pressurized with nitrogen to 195 psig while maintaining the ball valve in the "OFF" position. An optional pressure gauge or pressure switch can be connected to the other end of the detector tube to monitor tubing pressure and/or signal unit actuation etc. The detector tubing is heat sensitive and in a fire situation is designed to rupture at any point along the tube. The rupture of the tube releases the nitrogen pressure causing the CO_2 cylinder valve to actuate, resulting in complete discharge of the CO_2 agent through the nozzles.

3.2.4 Discharge Nozzle

Discharge nozzles are used to distribute CO_2 agent uniformly throughout the hazard area. One size nozzle is available for use with all IHP models used for total flood applications and must be used within the limitations described in this Manual

3.2.5 Pressure Switch

A pressure switch is available as an optional item. This switch can be connected at the end of the line of the Firetrace detector tubing to monitor unit pressure, unit actuation and or to energize or de-energize electrically operated equipment. Firetrace recommends that all units use a pressure switch coupled with some device to alert personnel in the event of discharge.

3.2.6 Recharge Adapters, CO_2 Cylinder

The recharge adapter is connected to the filling port located on the cylinder valve during the cylinder recharging procedure. The adapter is used for refilling the cylinder with CO_2.

3.2.7 Cylinder N2 Recharge Adapter

The recharge adapter is connected to the Firetrace tubing, and the other end of the tubing is attached to the ball valve, located on the cylinder valve, during the charging procedure. The adapter is used to apply nitrogen pressure to the detection tubing, and to keep the valve piston seated.

3.2.8 CO2 Warning Nameplate

The Warning Plate is required to warn personnel not to enter the hazard area during or after discharge. Warning signs shall be provided in a conspicuous location, at the entrance to the protected areas, or in the case of cabinet protection on the front face of the cabinet. Signs must be in accordance with NFPA 12, Section 4.3.

4.0 SYSTEM DESIGN AND LIMITATIONS FOR TOTAL FLOODING

4.1 General

The Firetrace series of CO_2 Pre-Engineered Automatic High-Pressure Extinguisher units were tested and limits established by Firetrace and Factory Mutual. These units were subjected to numerous performance tests, in order to verify their suitability and to establish design limitations for:

- Hazard volume
- Nozzle placement
- Discharge time and flow rates
- Design concentrations & design factors
- Detector tubing placement

The pre-engineered automatic unit concept minimizes the amount of engineering required when evaluating a design for a specific application. So long as the discharge piping, tubing, and nozzles are installed within the limits prescribed in this manual, no calculations are required for pressure drop, flow rates or discharge time. When the additional limitations of hazard volume, design concentration, agent quantity, detector arrangement, etc., are also met, the unit installation can be understood to comply with the design requirements and NFPA-12.

4.2 Design Procedure

The following procedures should be used to design a Firetrace CO_2 pre-engineered IHP automatic extinguisher unit. In addition, the applicable requirements specified in NFPA-12 should be followed.

a) Conduct a survey and analysis of the hazard to be protected
b) Determine the height, length, and width of the enclosure. Calculate the volume. All of these parameters must be within the dimensional limits specified in this manual. (See Section 4.3, Table 4.1).
c) Determine the anticipated minimum and maximum ambient temperatures expected within the enclosure to be protected.
d) Determine the minimum design concentration required for the hazard. (See Section 4.5 and Table 4.3).
e) Determine the integrity of the enclosure. Are there any openings that must be closed at the time of agent discharge? (See Section 4.6).
f) Calculate the quantity of CO_2 agent required, with the proper design concentration, to protect the enclosed space. (Refer to Section 4.7 and Example 4.8.1).
g) Determine the cylinder size required, based on the hazard volume limitations, enclosure size, and quantity of CO_2 agent required.
h) Determine the location of the CO_2 cylinder.

i) Determine the location and quantity of nozzles required, based on the size and configuration of the enclosure. (See Section 4.9 and Table 4.6).
j) Determine the routing and quantity of discharge pipe (tubing) required. The discharge pipe (tubing) and fitting limitations must not be exceeded. (See Section 4.9 and Table 4.6).
k) Determine the arrangement and placement of the Firetrace detector tubing. (See Section 4.10).
l) Determine any auxiliary equipment requirements, such as pressure switch(s) to sound alarms, shut-down ventilation, shut-off electrical power, etc..
m) Prepare system drawings, bill of materials list, etc; following Section 4.4 of NFPA-12 2005 Edition.

4.3 Hazard Enclosure Volume Limitations

The maximum volume for each size unit is shown in Table 4.1. The protected enclosure can be any size or shape provided that the volume does not exceed the limitations shown in Table 4.1 with the exception of the IHP-2000, IHP-3500 and IHP-5000 as noted below.

Table 4.1: Enclosure Size Limitations

Model	CO_2 (Lbs)	Volume (Ft^3)
IHP-500	5.0	**70**
IHP-1000	10.0	**140**
IHP-2000	20.0	**300***
IHP-3500	35.0	**525***
IHP-5000	50.0	**750***
* At least one dimension (l, w, h) must not exceed 2 feet Volumes are based on 34% Design Concentration		

4.4 General Specifications

4.4.1 Discharge Time:

Surface fires: The design concentration must be achieved within 1 minute from start of discharge.

4.4.2 Storage and Operating Temperature Range:

The Firetrace CO_2 units and equipment are designed to be stored and operated at an ambient temperature range of 0^oF to $+130^oF$. (-17.8^oC to $+54.4^oC$).

4.4.3 System Operating Pressure:

The normal operating pressure for the unit is 838 psig at 70°F.

4.5 Minimum Design Concentrations

The minimum design concentrations to be used with Firetrace CO_2 units shall not be less than 34%. For class B hazards, proper consideration must be given to the material involved in the hazard, the design concentration should then be given a safety factor (SF) of 20%, as specified in NFPA-12, Year 2005 edition.

Table 4.2: Minimum Safety Factor

Hazard Type	Minimum Safety Factor
Class B Flammable Liquids	20%

Table 4.3 lists CO_2 minimum design concentrations that must be used with Firetrace CO_2 units for Class A hazards and the various Class B fuels shown.

Consult Firetrace website, or contact Firetrace if the hazard you desire to protect is not listed.

Table 4.3: Minimum Carbon Dioxide Concentrations for Extinguishment

Material	Theoretical Minimum CO_2 Concentration %	Minimum Design CO_2 Concentration %
Class A (surface fires) [(a)] Including plastic materials typically found in electrical/electronic equip.	34	**34**
Class B fuels [(b)]		
Acetylene	55	**66**
Acetone	27	**34**
Aviation Gas Grades 115/145	30	**36**
Benzol, Benzene	31	**37**
Butadiene	34	**41**
Butane	28	**34**
Butane-I	31	**37**
Carbon Disulfide	60	**72**
Carbon Monoxide	53	**64**
Coal or Natural Gas	31	**37**
Cyclopropane	31	**37**
Diethyl Ether	33	**40**

Dimethyl Ether	33	**40**
Dowtherm	38	**46**
Ethane	33	**40**
Ethyl Alcohol	36	**43**
Ethyl Ether	38	**46**
Ethylene	41	**49**
Ethylene Dichloride	21	**34**
Ethylene Oxide	44	**53**
Gasoline	28	**34**
Hexane	29	**35**
Higher Paraffin Hydrocarbons C_nH_{2m} + 2m - 5	28	**34**
Hydrogen	62	**75**
Hydrogen Sulfide	30	**36**
Isobutane	30	**36**
Isobutylene	26	**34**
Isobutyl Formate	26	**34**
JP-4	30	**36**
Kerosene	28	**34**
Methane	25	**34**
Methyl Acetate	29	**35**
Methyl Alcohol	33	**40**
Methyl Butene - I	30	**36**
Methyl Ethyl Ketone	33	**40**
Methyl Formate	32	**39**
Pentane	29	**35**
Propane	30	**36**
Propylene	30	**36**
Quench, Lube Oils	28	**34**

Note: The theoretical minimum extinguishing concentrations in air for the materials in the table were obtained from a compilation of Bureau of Mines, *Limits of Flammability of Gases and Vapors* (Bulletins 503 and 627)

For all materials not given in Table 4.3, the minimum theoretical carbon dioxide concentration shall be obtained from some recognized source or determined by test.

4.6 Openings and Ventilation Shutdown

Provisions must be made to provide means to close all openings in the hazard enclosure and shut-off ventilation at the time of discharge.

4.7 CO2 Design Concentration Flooding Factors

The total flooding quantity of CO_2 agent needed to protect an enclosure containing a material requiring a 34% design concentration can be found in Table 4.4.

To find the total quantity of CO_2 required, multiply the hazard volume by the Volume Factor found in Table 4.4

If the design concentration is greater than 34%, the basic quantity calculated from Table 4.4 shall be multiplied by the corresponding conversion factor found in Figure 4.1.

⚠ CAUTION

This table should only be used for materials requiring a 34% CO_2 Design Concentration. And for environments where the temperature range is between 0-130 ° F

Table 4.4: Flooding Factors for 34% Concentration.

(A) Volume of Space	(B) Volume Factor		(C) Calculated Quantity (LB)
(Ft^3)	Ft^3/lb CO_2	lb CO_2/Ft^3	(Not Less Than)
Up to 140	14	0.072	---
141-500	15	0.067	10
501-1600	16	0.063	35
1601-4500	18	0.056	100
4501-50,000	20	0.050	250
Over 50,000	22	0.046	2500

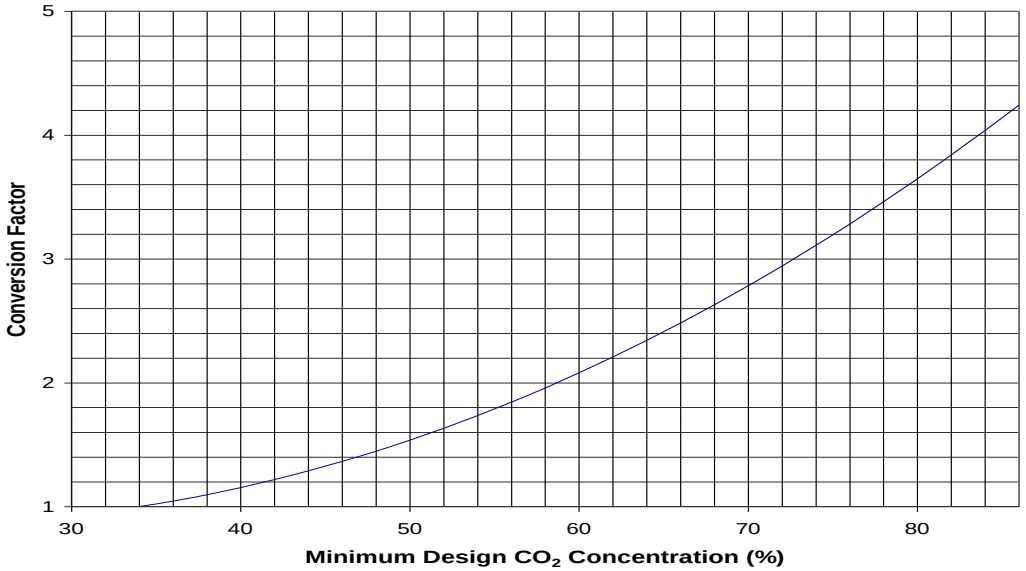


Figure 4.1: Conversion Factor for Design Concentrations Greater than 34%.

4.8 Maximum Protected Volume

The maximum volume that can be protected by the Firetrace CO_2 units is dependent on the minimum design concentration. The maximum volumes calculated from Table 4.4 for concentrations of 34% for Firetrace CO2 systems are listed below.

Table 4.5: Maximum Protected Volume for IHP Systems

Model	Volume (ft^3)
IHP 0500	Up to 70
IHP 1000	71 to 140
IHP 2000	141-300
IHP 3500	301-525
IHP 5000	526-700

4.8.1 Example Calculations

The requirements given in Sections 4.1 through 4.8 describe the procedures to be used to design and size a Firetrace IHP CO_2 unit.

The following example provides guidelines, following procedures 4.2.a, through 4.2.e., in order to determine the quantity of CO_2 agent required and cylinder size for a total flooding application.

Example:

Given:

- Hazard – Small cabinet storing Ethyl Alcohol.
- Class B hazard
- Enclosure size: 4′ wide x 4′ long x 6′ high. One (1) access door equipped with self closing apparatus
- Minimum anticipated ambient temperature: 50°F
- Maximum anticipated ambient temperature: 90°F

Procedure:

a. Determine min. design concentration required (Refer to Table 4.2)
Use 43% min. design concentration for Ethyl Alcohol.

b. Calculate hazard volume (V).
V = 4′ x 4′ x 6′ =96 Ft^3

c. Calculate quantity (Q) of CO_2 required first using volume factor for 34% concentration (Refer to Table 4.4)
volume of 96 Ft^3 shows that a Volume Factor 0.072 Lb CO_2/Ft^3

Q = 96 Ft^3 x 0.072 Lb CO_2/Ft^3 = 6.912 Lbs. of CO_2 is required. Because this is based on a 34% concentration, it must be multiplied by the conversion factor, which can be found in Figure 4.1. For a design concentration of 43%, the conversion factor is 1.25.
Qtotal = 6.912 x 1.25= 8.64 Lbs (This then requires the use of a IHP-1000 with 10 Lbs of CO2)

4.9 Nozzle and Discharge Tubing Requirements

4.9.1 Discharge Nozzle Limitations

One size nozzle P/N 510010 is to be used with all Firetrace IHP CO_2 extinguisher units in total flooding applications.

Placement of nozzles shall be such that discharge of CO_2 will not splash flammable liquids or create dust clouds that could extend the fire.

More than one nozzle can be used to protect a particular hazard, as long as the "Equivalent Length of Pipe" for Firetrace IHP CO_2 systems is not exceeded. Refer to section 4.9.3 for information regarding the "Equivalent Length of Pipe".

4.9.2 Discharge Piping & Fitting Specifications

All Firetrace IHP Units shall use steel piping for the distribution system. The following piping and fittings shall be used.

Piping Specifications:

Material:	**Black or Galvanized steel pipe**
Type:	**ASTM A 53 seamless or electric welded, Grade A or B**
Size:	**½ Pipe**

Note: For other options consult NFPA 12 2005 Edition Section 4.7

Pipe Fitting Specifications:

Material:	**Malleable or ductile iron fittings**
Type:	**Class 300**

4.9.3 Maximum Piping and Fitting Limitations

The maximum "Equivalent Length of Piping" shall not exceed 24ft. The "Equivalent Length of Piping" includes individual lengths of pipe and all pipe fittings. Table 4.6 includes the equivalent lengths of ½ inch threaded pipe fittings that need to be considered when determining the total "Equivalent Length of Piping".

Table 4.6: Equivalent length in feet of threaded pipe fittings.

Pipe Size	Elbow Std. 45°	Elbow Std. 90°	Elbow 90° Long Radius & Tee Thru Flow	Tee Side	Union Coupling
1/2	0.8	1.7	1.0	3.4	0.4

4.10 Firetrace Detector Tubing

For the Indirect CO_2 units, the Firetrace tube is used as a combination heat detector and unit activation device to cause actuation of the CO_2 agent cylinder.

The detector tubing is heat sensitive and in a fire situation is designed to rupture at any point along the tube upon direct flame impingement.

Location and spacing of the tubing is critical to the response time in the event of a fire. The tubing should be placed above the hazard areas being protected. The drawing in Appendix A provides general guidelines for placement of the detector tubing along with the maximum spacing and height limitations. Depending on the configuration of specific hazards, the guidelines may, or may not, be applicable. The maximum length of tubing that can be used for any IHP unit is 120 feet. The maximum height that is allowed between layers is 3.28 feet. The maximum distance between passes is 21.12 inches.

NOTE: It is recommended that the tubing **not** be placed horizontally adjacent to potential fire sources as this may significantly delay response time.

5.0 INSTALLATION INSTRUCTIONS

This section provides installation instructions covering components and limitations described in Sections 3 and 4 of this manual.

All components should be installed to facilitate proper inspection, testing, recharging, and any other required service or maintenance as may be necessary. Equipment must not be subjected to severe weather conditions or mechanical, chemical, or other damage, which could render the equipment inoperative. The equipment must be installed in accordance with instructions in this manual and NFPA 12.

⚠ WARNING

CO_2 cylinder/valve assemblies must be handled, installed, and serviced in accordance with the instruction contained in this manual and on the cylinder nameplate. Failure to follow these instructions could result in severe injury, property damage or death.

5.1 CO_2 Cylinder/Valve and Bracket Assemblies

The CO_2 cylinders should be located as close as possible to the protected enclosure. In some cases the cylinder can be mounted inside the protected enclosure. The assemblies shall be located in a readily accessible location to allow for ease of inspection service and maintenance. The cylinders shall be located in an environment protected from the weather and where the temperature range is between 0°F and + 130°F.

Cylinder and bracket must be mounted in the vertical plane with the cylinder valve facing up.

Mount the cylinder where it will not be subject to accidental damage or movement. Suitable protection must be installed where necessary to prevent damage or movement.

⚠ CAUTION

Make sure that the ball valve, located on the cylinder valve, is maintained in the "OFF" position, and the discharge port safety caps are in place. Failure to follow these instructions will result in actuation and discharge of the cylinder contents.

1. Securely mount the cylinder bracket to structural support using 2 or more mounting holes.

2. Secure cylinder in place using the bracket strap.

5.2 Discharge Piping and Nozzles

1. Locate the nozzle(s) following the guidelines and limitations described in Section 4.9.

2. Determine the routing of the discharge piping following the guidelines and limitations described in Section 4.9

3. Remove the safety cap from the valve discharge port as required. Attach female connection fittings (Firetrace P/N 200201) onto discharge port.

4. Install the necessary piping and fittings between the cylinder and nozzle(s). Secure piping with appropriate size piping clamps as required.

5.3 Firetrace Detection Tubing

⚠ CAUTION

1. **Do not kink, bend, or crush Firetrace tubing in order to prevent leakage, which could result in accidental unit discharge.**
2. **Do not install tubing in a hazardous environment where the maximum**

ambient temperature exceeds 176°F (80°C)

3. **Do not place the tubing on a surface where the temperature of the surface exceeds 140°F (60°C)**
4. **Maximum length of detector tubing shall not exceed 120 Feet.**

1. Follow guidelines as outlined in section 4.10 and the drawing in Appendix A for the tubing placement.

2. Secure detection tubing using Mounting Tabs at 1.5 ft. intervals.

3. Use appropriate rubber/plastic grommets when detection tubing is routed through sharp holes in order to prevent damage to the tubing.

4. Connect the end of line adapter and spring top unit to the detection tubing as shown in Appendix A.

5. When installing tubing to the cylinder valve make sure that the detection tubing is pushed through the top of the ball valve inlet all the way through to the shoulder and then tighten the spring top unit to a torque of 4-6 Nm.

6. Ensure the detection tubing is pushed through the end of line adapter all the way through to the shoulder. Then tighten the spring top unit to the end of line adapter to a torque of 4-6 Nm.

7. The detector tubing is now ready to be pressurized with nitrogen. (See section 5.4 for pressurization procedure)

5.4 Pressurization of Firetrace Detection Tubing

1. Attach the filling adapter (P/N 600023) to the detector-tubing end of line adapter.

2. Using a regulated dry nitrogen supply, pressurize the detection tubing with dry nitrogen through the filling adapter to 195 psig. It is recommended to have a portable dry nitrogen cylinder for on site use.

3. Remove the filling adapter and attach calibrated test pressure gauge & 0-ring to verify that the tubing is pressurized to at least 195 psig at 70°F.

4. With gauge still attached to the end of line adapter, test for leakage.
    a. Apply soapy water solution to the cylinder valve connection, end of line adapter connection, and the pressure gauge connection. Observe for bubble leaks.
    b. Wait 30 minutes, then observe pressure gauge. Any decrease in pressure is an indication of a leak.
    c. In the event of a leak go back to Section 5.3 and repeat steps 4, 5, & 6.
    d. If no leaks are observed proceed to step 5 of Section 5.4

5. If an optional pressure switch is to be installed in the EOL adapter, remove pressure gauge and install the washer and pressure switch using wiring instructions located on the device. Check pressure switch connection for bubble leaks using soapy water solution.

6. After confirming that there is no leakage within the detector tubing, **SLOWLY** rotate the ball valve lever counter clockwise to the "ON" position.

⚠ CAUTION

If the ball valve lever is opened abruptly this may result in activation of the cylinder valve and unit discharge.

1. Tamper proof the unit by choosing one of the options below
   a. Option #1 Remove the ball valve lever completely. Follow directions for removal of lever listed in Appendix A.
   b. Option #2 Attach tamper seal around the ball valve lever to secure it in the "ON" position, which is the set/ready position also shown in Appendix A.

2. Ensure appropriate electrical connections to the optional EOL pressure switch, which can be used to annunciate unit discharge, shut down ventilation, etc., as may be required by the end user or the AHJ. (All electrical connections are to be in accordance to NFPA 70 National Electric Code)

3. Attach the warning nameplate(s) (Firetrace P/N 800031) to the appropriate locations.

4. Unit is now fully armed and ready for use.

6.0 SERVICE, MAINTENANCE, & FILLING INSTRUCTIONS

⚠ WARNING

1. **CO_2 cylinder/valve assemblies must be handled, installed, inspected and serviced only by qualified and trained personnel in accordance with the instructions contained in this manual, the cylinder nameplate, NFPA-12, and any other regulations and codes that may apply.**
2. **Before performing maintenance or refilling procedures refer to the material safety data sheets in the appendix at the back of this manual.**

6.1 General

A regular program of systematic maintenance must be established for continuous, proper operation of all CO_2 units, and to avoid violating the warranty. A periodic maintenance schedule must be followed and an inspection log maintained for ready reference. As a minimum, the log must record: (1) inspection interval, (2) inspection procedure

performed, (3) maintenance performed, if any, as a result of inspection, and (4) name of inspector performing task.

6.2 Periodic Service and Maintenance

Perform service and maintenance of the CO_2 unit in accordance with the schedule shown in Table 6.2

Table 6.2: Periodic service and maintenance schedule.

Schedule	Requirement	Reference Paragraph
Weekly	Visually inspect unit components	6.3.1
Monthly	Visually inspect unit components.	6.3.1
Semi-Anually	Check CO_2 cylinder weight. Check nozzles for obstruction.	6.3.2
Every 5 Years	Perform external visual inspection of CO_2 Cylinders.	6.3.3

6.3 Periodic Service and Maintenance Procedures

6.3.1 Weekly/Monthly: Performed by Owner or End User

1. Make a general visual inspection of the CO_2 cylinder and equipment for damaged or missing parts.
2. Ensure access to hazard areas, discharge nozzles, and cylinders are unobstructed and that there are not obstructions to the operation of the equipment or distribution of CO_2 agent.
3. Inspect detection tubing in hazard area for abrasion, distortion, cuts, or dirt accumulation, and that there are no obstructions preventing tubing from sensing a fire should one occur.
4. Verify that there have been no changes in the size of the enclosure and that no new ventilation has been added.

6.3.2 Semi-Annual Inspection

1. Check CO_2 cylinder for weight.
2. Remove cylinder from the installation as follows:

a. Close ball valve, by turning ball valve lever clockwise to the "OFF" position.
b. Disconnect detector tubing at the ball valve. Note: There will be a loss of nitrogen pressure out of the tubing.
c. Disconnect piping and fittings from the cylinder valve discharge port.
d. Immediately install safety cap onto the valve discharge port.
e. Remove cylinder from bracket

3. Weigh cylinder. Compare measured weight with weight found on the cylinder nameplate. If the container shows a loss in agent quantity of more than 10 percent, the cylinder shall be refilled or replaced.
4. Remove nozzle(s) and inspect for obstructions. Reinstall nozzles.
5. Reinstall cylinder and re-pressurize detector tubing with nitrogen following the applicable procedures outlined in Section 5.0.

6.3.3 Five Year Inspection

CO_2 cylinders continuously in service without discharging shall be given a complete external visual inspection in place, every 5 years or more frequently if required.

6.4 Post Fire Maintenance

In the event of a unit discharge the following procedures shall be performed.

6.4.1 CO2 Cylinder Valve

Remove the cylinder assembly from the installation following procedures detailed in Section 6.3.2, Step 2. Inspect and service the CO_2 cylinder valve as follows:

⚠ WARNING

Prior to removal of the valve from the cylinder, verify that all pressure has been released. To relieve any remaining pressure loosen but do not remove the valve safety caps. Then open the ball valve to the "ON" position and allow any residual pressure to leak out past the plugs.

1. Only after verifying that the cylinder has been depressurized, remove valve from cylinder.
2. Perform a visual inspection of the valve to verify that no damage occurred due to the fire. If integrity of the valve looks compromised, contact Firetrace. The valve should not be serviced by anyone other than a Firetrace Technician.
3. Change the cylinder/valve o-ring. Discharge of CO_2 causes the o-ring to undergo vacuum decompression; failure to change the o-ring will result in leaks around the cylinder/valve connection.
4. Re-seat the piston in the valve by following the procedure in Section 6.6, Step 2.

6.5 CO2 Cylinder Retest

Firetrace CO_2 cylinders are built to DOT-3AL specifications and therefore fall under DOT regulations for retest prior to refill.

DOT-3AL cylinders used exclusively in CO_2 service are required to be retested and re-stamped prior to recharge and shipment if the last retest date has expired.

Firetrace CO_2 (DOT-3AL) containers requiring retest must be hydrostatically tested in accordance with DOT CFR Title 49, Section 173.34(e). This periodic retest must be performed by an authorized retester having a current identification number issued by the Associated Administrator for Hazardous Material Safety of DOT, and must include an internal and external examination in accordance with CGA pamphlet C-6, C-6.1, C-6.2, or C-6.3, as applicable. The test procedures are described in CGA pamphlet C-1. Because volumetric expansion of the container must be measured, only the water jacket volumetric expansion method or the direct expansion methods are acceptable.

As an alternate option, CO_2 agent containers may be given a complete external visual inspection, as detailed in Section 173.34(e)(13), in lieu of hydrostatic test. The visual inspection shall only be made by competent persons. A person who performs the visual examination specified in 173.34(e)(13) is not required to have a re-tester's identification number.

Retest can be performed by either of the following methods:

Retest Method	First Retest Due (Yrs)	Subsequent Retest Due (Yrs)	Special Marking
Full hydrostatic test including determination of cylinder expansion.	5	5	Retest Date Month/Year
External visual inspection per paragraph 173.34(e)(13) and CGA pamphlet C-6, Section 3.	5	5	Retest Date followed by "E"

6.6 Filling Procedures

1. Weigh and record cylinder empty weight with valve and the 2 safety caps installed.
2. Remove the safety cap from the discharge port and visually check that the piston is seated inside of the valve. Replace safety cap. (If piston is not seated, apply 195 psi of Nitrogen pressure through the ball valve. You will be able to hear the piston

change positions. Return ball valve to “OFF” position and remove hose connection).

3. Remove safety cap from filling port and attach Firetrace CO_2 filling adapter (P/N 60024) to filling port
4. Attach CO_2 supply line to filling adapter. (CO_2 is to be pumped)
5. Place the cylinder, with supply line hooked up, on scale and zero the scale. Open the supply of CO_2 from bulk tank to fill the cylinder to the required weight.
6. Close supply of CO_2 while maintaining all connections.
7. Disconnect CO_2 recharge adapter and immediately attach discharge port cap to valve.

⚠ CAUTION

Any hissing or discharge coming from vent valve indicates that the piston is not seating properly or has opened. If this occurs, repeat Step 10 and verify that the cylinder valve piston remains closed.

1. Verify weight by checking it against what is printed on the label.
2. Leak test the cylinder.
3. Cylinder is now ready to be transported to the installation site.

Note: All reasonable efforts must be made to prevent emitting any CO_2 to the environment during filling or servicing of Firetrace units.

APPENDIX A

COMPONENT DESCRIPTION DRAWINGS

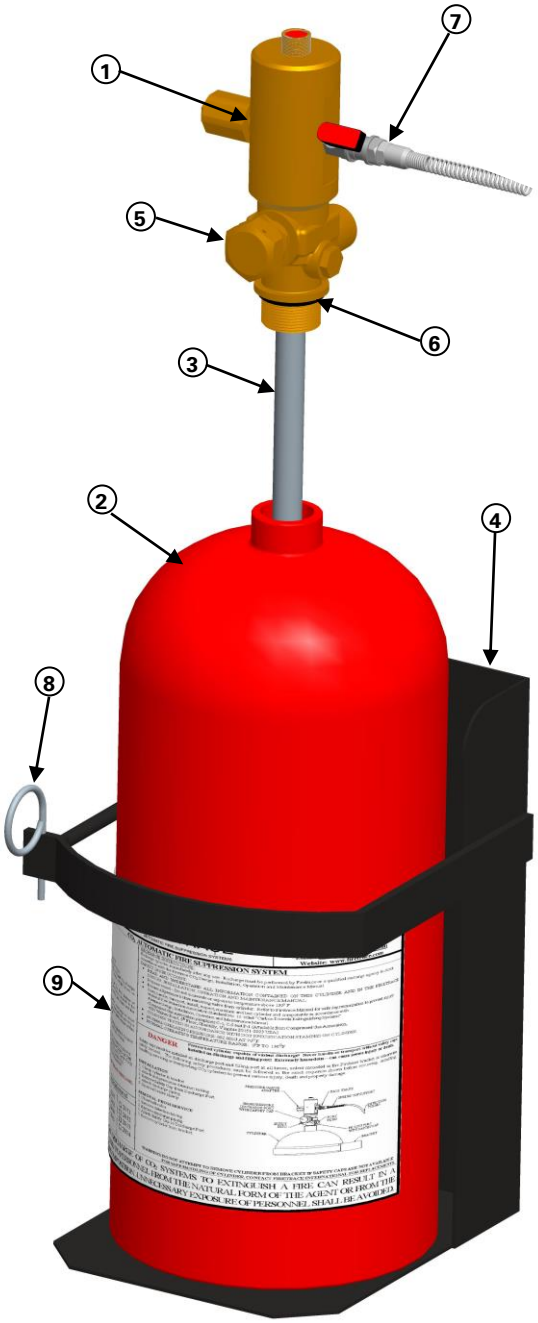
INSTALLATION DRAWINGS

Parts List

5, 10, & 20 LB.
PRE-ENGINEERED
AUTOMATIC INDIRECT
CO_2 EXTINGUISHER UNIT

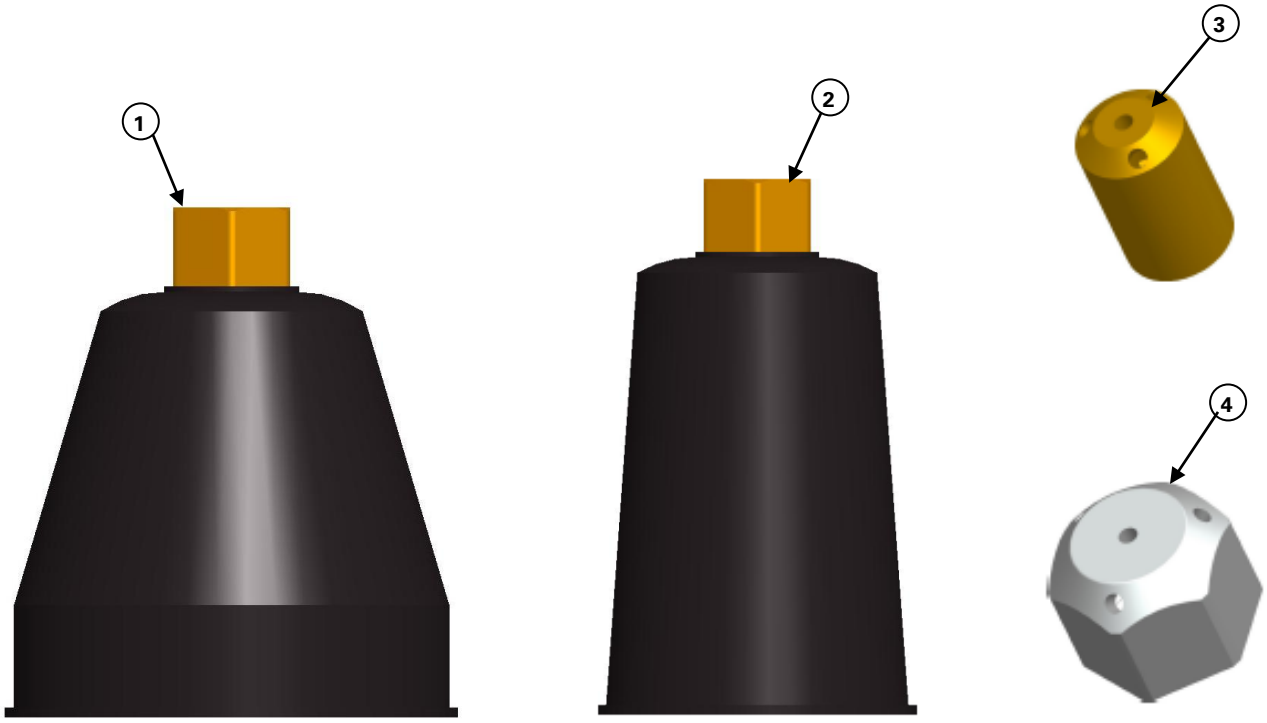
950504 5 LB. CO_2 IHP
951004 10 LB. CO_2 IHP
952004 20 LB. CO_2 IHP
953504 35 LB. CO_2 IHP
955004 50 LB. CO_2 IHP

ITEM	PART NO.	DESCRIPTION	SYSTEM
1	310201	IHP Valve	All Systems
2	110050	5 Lb. Cylinder	5 LB
2	110100	10 Lb. Cylinder	10 LB
2	110200	20 Lb. Cylinder	20 LB
2	110350	35 Lb. Cylinder	35 LB
2	110500	50 Lb. Cylinder	50 LB
3	600008	Siphon Tube $^5/_8$"x13$^1/_4$"	5 LB
3	600005	Siphon Tube $^5/_8$"x15$^1/_4$"	10 LB
3	600006	Siphon Tube $^5/_8$"x21$^1/_2$"	20 LB
3	600035	Siphon Tube $^5/_8$"x36"	35 LB
3	600036	Siphon Tube $^5/_8$"x45"	50 LB
4	111201	5 Lb. Heavy Duty Bracket	5 LB
4	111010	10 Lb. Heavy Duty Bracket	10 LB
4	111020	20 Lb. Heavy Duty Bracket	20 LB
4	111035	Strap Bracket	35, 50 LB
5	310310	Discharge Port Safety Cap	All Systems
6	310305	Collar O-Ring	All Systems
7	200179	Slip-On Union	All Systems
8	600053	Pull Pin	All Systems
9	600007	Nameplate: CO_2	All Systems
*	600125	Label: IHP CO2 FM Approval	All Systems
*	800100	Warranty/Registration Card	All Systems
*	200201	Discharge Port Adapter	All Systems
* PART NOT PICTURED			



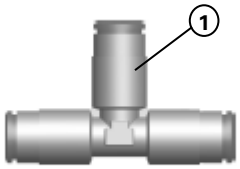
Discharge Line Parts List

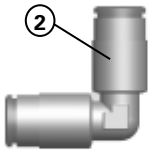
ITEM NUMBER	PART NUMBER	DESCRIPTION
*	200201	IHP Discharge Port Adapter
3	510010	Small Total Flood Nozzle
4	500024	Total Flooding Nozzle
1	510015	IHP Wide Dispersion Nozzle
2	510016	IHP Narrow Dispersion Nozzle
*	850028	Fitting - Hose to Hose 1/2" HP (FxF)
*	850029	Fitting - Hose to Hose Elbow 1/2" HP (FxF)
*	850030	Fitting - Hose to Hose Tee 1/2" HP (FxFxF)
*	850031	Fitting - Fitting to Nozzle Bulkhead 1/2" HP (MxM)
*	201825	2 ft High Pressure Flexible Hose 1/2" (MxM)
*	201826	4 ft High Pressure Flexible Hose 1/2" (MxM)
*	201827	6 ft High Pressure Flexible Hose 1/2" (MxM)
*	201828	8 ft High Pressure Flexible Hose 1/2" (MxM)
*	201829	10 ft High Pressure Flexible Hose 1/2" (MxM)
* PART NOT PICTURED		

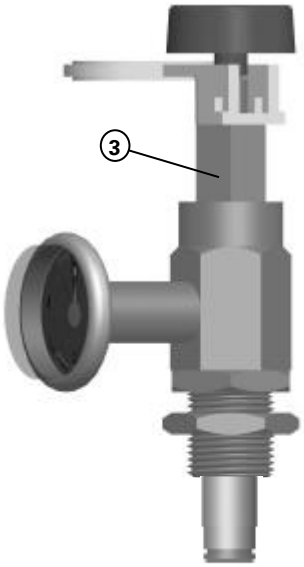


Detection Line Parts List

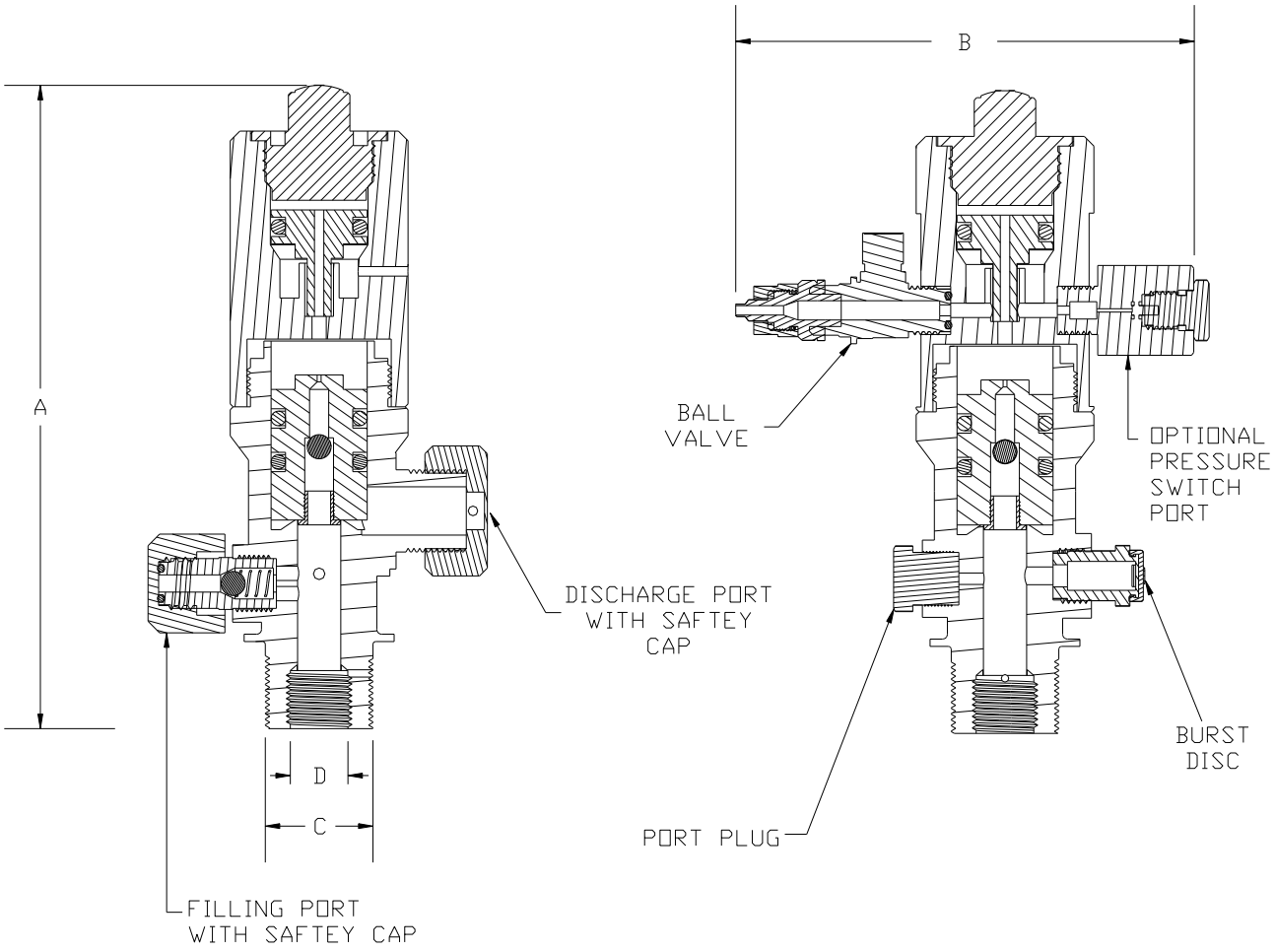
ITEM NUMBER	PART NUMBER	DESCRIPTION
*	200005	Firetrace Detection/Actuation Tubing (by the foot)
*	200158	Tube Union Slip On Fitting
1	200157	Tube Tee Slip On Fitting
2	200178	Tube Elbow Slip On Fitting
*	200179	Tube to Threads Union Slip On Fitting
*	200177	Tube to Threads Tee Slip On Fitting
*	200159	Tube to Threads Elbow Slip On Fitting
*	200133	Tube Plug
3	600064	Manual Release With CO_2 Gauge and Slip On Fitting
*	200168	End Of Line Adapter With Slip On Fitting
*	200169	In Line Adapter With Slip On Fitting
*	310303	Plug With O-Ring For End Of Line Adapter
*	400029	CO_2 195 psi Pressure Gauge
*	400004	Pressure Switch With Washer for End Of Line Adapter
*	600090	Audible Alarm (Battery Operated)
*	200171	Mounting Tabs (Qty. 12)
*	200150	Rubber Grommets (Qty. 2)
*	200151	Plastic Grommets (Qty. 2)
* PART NOT PICTURED		





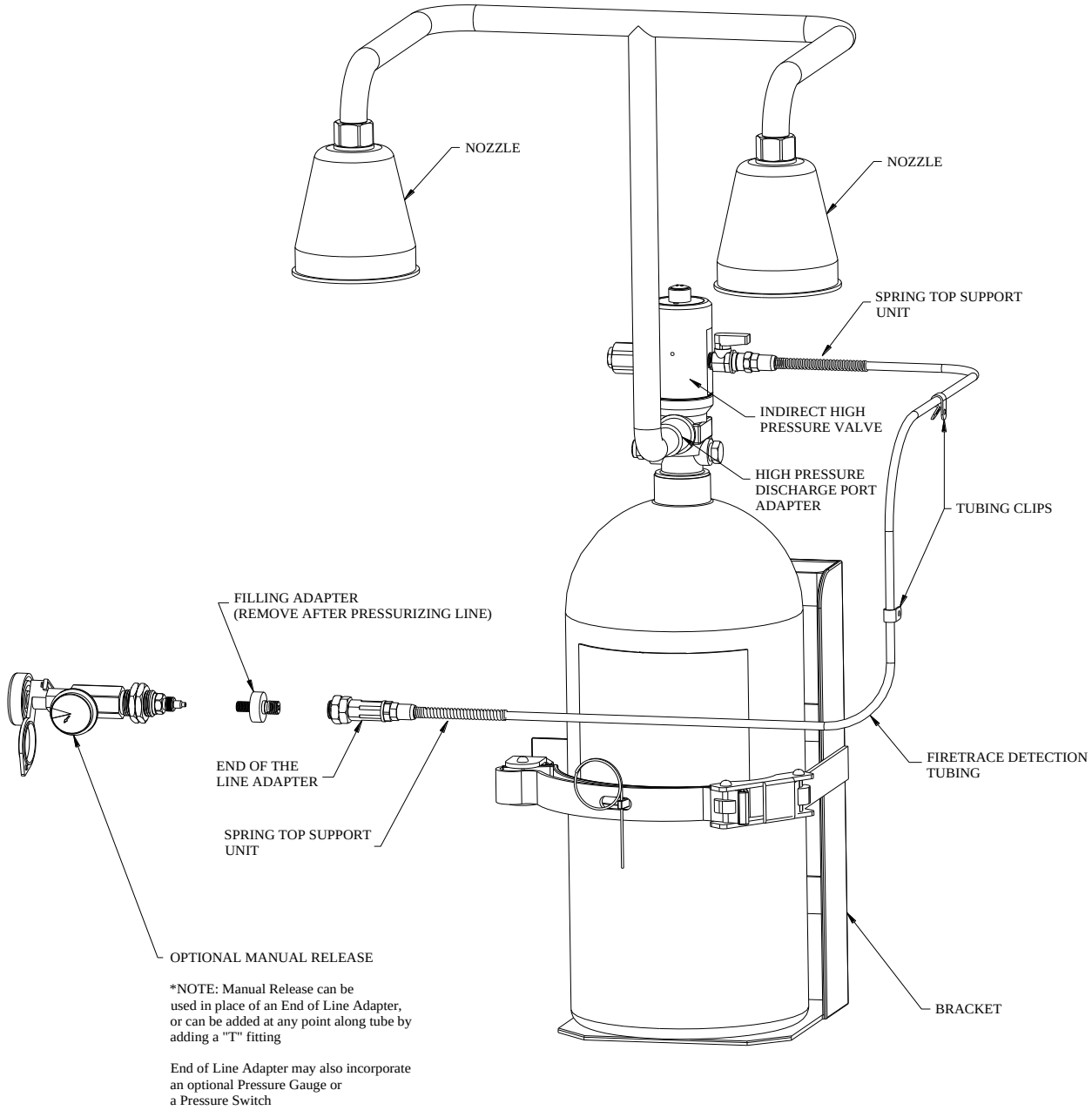


Firetrace Indirect High Pressure (IHP) Valve
P/N 310201

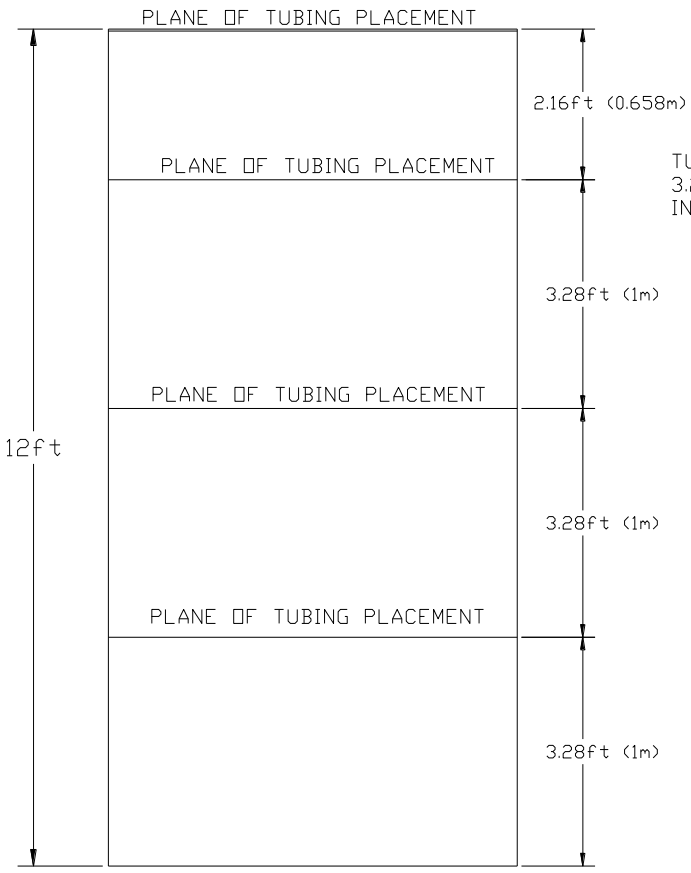


VALVE	DIMENSIONS (INCHES)				DIMENSIONS (METERS)			
	A	B	C	D	A	B	C	D
CO2	6.625	5	1.125-12 UNF-2A	G 3/8	0.168	0.127	1.125-12 UNF-2A	G 3/8

Firetrace IHP System Overview

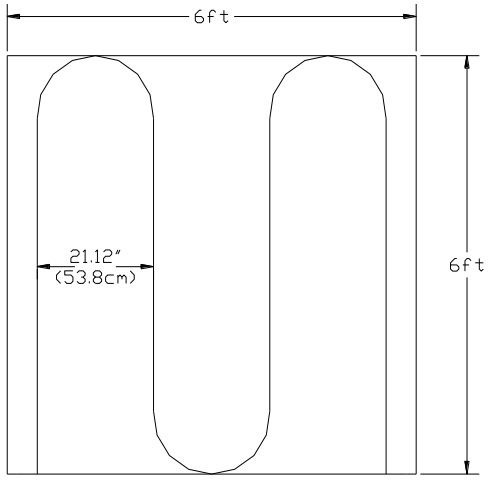


Firetrace Tubing Placement Diagram



MAXIMUM HEIGHT TUBING LAYOUT

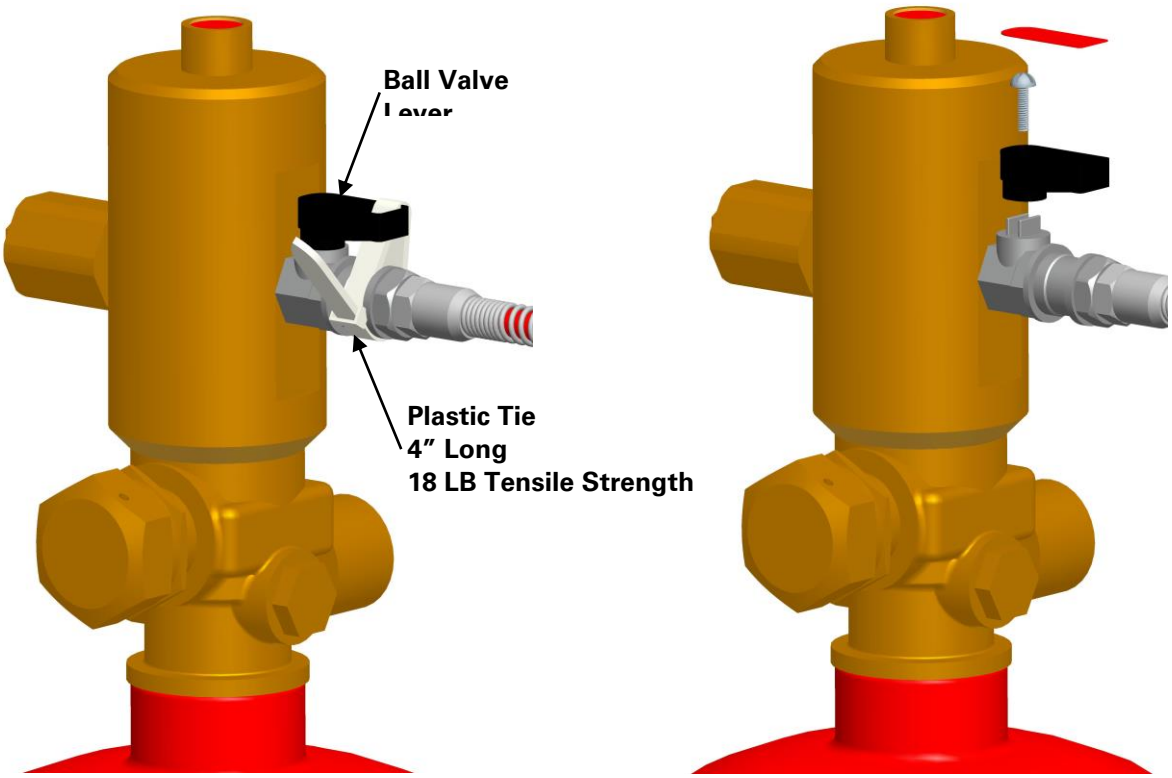
Side View



MAXIMUM AREA TUBING LAYOUT

Overhead View

Maximum Length: 120ft
Maximum Height Between Layers: 3.28ft
Maximum Distance Between Passes: 21.12in



Option #1

1. Check to see that the ball valve lever is set to the “ON” position.
2. Remove the ON/OFF faceplate.
3. Pull the tie through the hole in the ball valve lever.
4. Wrap the tie around the ball valve assembly.
5. Firmly pull on the tie to tighten and secure the lever.
6. If desired, cut off the excess tie.

Option #2

1. Remove the ON/OFF faceplate.
2. Unscrew the ball valve lever from the assembly.
3. Pull the lever off of the ball valve assembly.
4. Keep the items in a bag and secure them to the unit.

APPENDIX B

Material Safety Data Sheet

Carbon dioxide

Safety Data Sheet P-4574

This SDS conforms to U.S. Code of Federal Regulations 29 CFR 1910.1200, Hazard Communication.

Date of issue: 01/01/1980 Revision date: 10/17/2016 Supersedes: 07/19/2016

SECTION: 1. Product and company identification

1.1. Product identifier

Product form	:	Substance
Name	:	Carbon dioxide
CAS No	:	124-38-9
Formula	:	CO2
Other means of identification	:	Medipure® Carbon Dioxide, Extendapak® EX-2, Refrigerant gas R744, carbonic anhydride, carbonic acid gas

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture	:	Industrial use. Use as directed.

1.3. Details of the supplier of the safety data sheet

Praxair, Inc.
10 Riverview Drive
Danbury, CT 06810-6268 - USA
T 1-800-772-9247 (1-800-PRAXAIR) - F 1-716-879-2146
www.praxair.com

1.4. Emergency telephone number

Emergency number	:	Onsite Emergency: 1-800-645-4633
		CHEMTREC, 24hr/day 7days/week — Within USA: 1-800-424-9300, Outside USA: 001-703-527-3887 (collect calls accepted, Contract 17729)

SECTION 2: Hazard identification

2.1. Classification of the substance or mixture

GHS-US classification

Liquefied gas H280

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :

GHS04

Signal word (GHS-US) : WARNING

Hazard statements (GHS-US) : H280 - CONTAINS GAS UNDER PRESSURE; MAY EXPLODE IF HEATED
OSHA-H01 - MAY DISPLACE OXYGEN AND CAUSE RAPID SUFFOCATION
CGA-HG01 - MAY CAUSE FROSTBITE
CGA-HG03 - MAY INCREASE RESPIRATION AND HEART RATE

Precautionary statements (GHS-US) : P202 - Do not handle until all safety precautions have been read and understood
P261 - Avoid breathing gas
P262 - Do not get in eyes, on skin, or on clothing
P271+P403 - Use and store only outdoors or in a well-ventilated place
CGA-PG05 - Use a back flow preventive device in the piping
CGA-PG10 - Use only with equipment rated for cylinder pressure
CGA-PG06 - Close valve after each use and when empty
CGA-PG02 - Protect from sunlight when ambient temperature exceeds 52°C (125°F)

2.3. Other hazards

Other hazards not contributing to the classification : Asphyxiant in high concentrations

Contact with liquid may cause cold burns/frostbite

WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous. Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level.

2.4. Unknown acute toxicity (GHS US)

No data available

SECTION 3: Composition/Information on ingredients

3.1. Substance

Name : Carbon dioxide

CAS No : 124-38-9

Name	Product identifier	%
Carbon dioxide	(CAS No) 124-38-9	99.5 - 100

3.2. Mixture

Not applicable

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures after inhalation : Remove to fresh air and keep at rest in a position comfortable for breathing. . If not breathing, give artificial respiration, with supplemental oxygen given by qualified personnel. If breathing is difficult, qualified personnel should give oxygen. Call a physician.

First-aid measures after skin contact : MAY CAUSE FROSTBITE. For exposure to liquid, cold vapor, or solid carbon dioxide (dry ice), immediately warm frostbite area with warm water not to exceed 41°C (105°F). Water temperature should be tolerable to normal skin. Maintain skin warming for at least 15 minutes or until normal coloring and sensation have returned to the affected area. In case of massive exposure, remove clothing while showering with warm water. Seek medical evaluation and treatment as soon as possible.

First-aid measures after eye contact : Immediately flush eyes thoroughly with water for at least 15 minutes. Hold the eyelids open and away from the eyeballs to ensure that all surfaces are flushed thoroughly. Contact an ophthalmologist immediately.

First-aid measures after ingestion : Ingestion is not considered a potential route of exposure.

4.2. Most important symptoms and effects, both acute and delayed

No additional information available

4.3. Indication of any immediate medical attention and special treatment needed

None.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Use extinguishing media appropriate for surrounding fire.

5.2. Special hazards arising from the substance or mixture

Explosion hazard : Heat of fire can build pressure in container and cause it to rupture. Containers are equipped with a pressure relief device. (Exceptions may exist where authorized by DOT.) No part of the container should be subjected to a temperature higher than 125°F (52°C).

Reactivity : No reactivity hazard other than the effects described in sub-sections below.

5.3. Advice for firefighters

Firefighting instructions : **WARNING! Liquid and gas under pressure.**

Evacuate all personnel from the danger area. Use self-contained breathing apparatus (SCBA) and protective clothing. Immediately cool containers with water from maximum distance. Stop flow of gas if safe to do so, while continuing cooling water spray. Remove ignition sources if safe to do so. Remove containers from area of fire if safe to do so. On-site fire brigades must comply with OSHA 29 CFR 1910.156 and applicable standards under 29 CFR 1910 Subpart L—Fire Protection.

Other information : Containers are equipped with a pressure relief device. (Exceptions may exist where authorized by DOT [U.S.] or TC [Canada].).

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : **WARNING! Liquid and gas under pressure.. Rapid release of gaseous carbon dioxide through a pressure relief device (PRD) or valve can result in the formation of dry ice, which is very cold and can cause frostbite..**

6.1.1. For non-emergency personnel

No additional information available

6.1.2. For emergency responders

No additional information available

6.2. Environmental precautions

Try to stop release.

6.3. Methods and material for containment and cleaning up

For containment : Prevent waste from contaminating the surrounding environment. Discard any product, residue, disposable container, or liner in an environmentally acceptable manner, in full compliance with federal, provincial, and local regulations. If necessary, call your local supplier for assistance.

6.4. Reference to other sections

See also sections 8 and 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Avoid breathing gas

Do not get in eyes, on skin, or on clothing

This gas is heavier than air and in an enclosed space tends to accumulate near the floor, displacing air and pushing it upward. This creates an oxygen-deficient atmosphere near the floor. Ventilate space before entry. Verify sufficient oxygen concentration

WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous. Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level

Wear leather safety gloves and safety shoes when handling cylinders. Protect cylinders from physical damage; do not drag, roll, slide or drop. While moving cylinder, always keep in place removable valve cover. Never attempt to lift a cylinder by its cap; the cap is intended solely to protect the valve. When moving cylinders, even for short distances, use a cart (trolley, hand truck, etc.) designed to transport cylinders. Never insert an object (e.g, wrench, screwdriver, pry bar) into cap openings; doing so may damage the valve and cause a leak. Use an adjustable strap wrench to remove over-tight or rusted caps. Slowly open the valve. If the valve is hard to open, discontinue use and contact your supplier. Close the container valve after each use; keep closed even when empty. Never apply flame or localized heat directly to any part of the container. High temperatures may damage the container and could cause the pressure relief device to fail prematurely, venting the container contents. For other precautions in using this product, see section 16.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions : Store in a cool, well-ventilated place. Store and use with adequate ventilation. Store only where temperature will not exceed 125°F (52°C). Firmly secure containers upright to keep them from falling or being knocked over. Install valve protection cap, if provided, firmly in place by hand. Store full and empty containers separately. Use a first-in, first-out inventory system to prevent storing full containers for long periods

This gas is heavier than air and in an enclosed space tends to accumulate near the floor, displacing air and pushing it upward. This creates an oxygen-deficient atmosphere near the floor. Ventilate space before entry. Verify sufficient oxygen concentration.

7.3. Specific end use(s)

None.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Carbon dioxide (124-38-9)		
ACGIH	ACGIH TLV-TWA (ppm)	5000 ppm
ACGIH	ACGIH TLV-STEL (ppm)	30000 ppm
USA OSHA	OSHA PEL (TWA) (mg/m³)	9000 mg/m³
USA OSHA	OSHA PEL (TWA) (ppm)	5000 ppm
USA IDLH	US IDLH (ppm)	40000 ppm
ACGIH	Not established	
USA OSHA	Not established	

Carbon dioxide (124-38-9)		
ACGIH	ACGIH TLV-TWA (ppm)	5000 ppm
ACGIH	ACGIH TLV-STEL (ppm)	30000 ppm
USA OSHA	OSHA PEL (TWA) (mg/m³)	9000 mg/m³
USA OSHA	OSHA PEL (TWA) (ppm)	5000 ppm

8.2. Exposure controls

Appropriate engineering controls : Use a local exhaust system with sufficient flow velocity to maintain an adequate supply of air in the worker's breathing zone. Mechanical (general): General exhaust ventilation may be acceptable if it can maintain an adequate supply of air. **WARNING: Concentration levels of carbon dioxide above about 1 percent are dangerous.** Praxair recommends continuous monitoring with alarms to indicate unsafe conditions before and during potential personnel exposure. Use appropriate monitoring devices to ensure a safe oxygen level (minimum of 19.5 percent) and a safe carbon dioxide level.

Materials for protective clothing : Wear work gloves and metatarsal shoes for cylinder handling. Protective equipment where needed. Select in accordance with OSHA 29 CFR 1910.132, 1910.136, and 1910.138.

Eye protection : Wear safety glasses when handling cylinders; vapor-proof goggles and a face shield during cylinder changeout or whenever contact with product is possible. Select eye protection in accordance with OSHA 29 CFR 1910.133.

Skin and body protection : As needed for welding, wear hand, head, and body protection to help prevent injury from radiation and sparks. (See ANSI Z49.1.) At a minimum, this includes welder's gloves and protective goggles, and may include arm protectors, aprons, hats, and shoulder protection as well as substantial clothing.

Respiratory protection : When workplace conditions warrant respirator use, follow a respiratory protection program that meets OSHA 29 CFR 1910.134, ANSI Z88.2, or MSHA 30 CFR 72.710 (where applicable). Use an air-supplied or air-purifying cartridge if the action level is exceeded. Ensure that the respirator has the appropriate protection factor for the exposure level. If cartridge type respirators are used, the cartridge must be appropriate for the chemical exposure. For emergencies or instances with unknown exposure levels, use a self-contained breathing apparatus (SCBA).

Thermal hazard protection : Wear cold insulating gloves when transfilling or breaking transfer connections.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	: Gas
Appearance	: Colorless gas.
Molecular mass	: 44 g/mol
Color	: Colorless.
Odor	: Odorless.
Odor threshold	: No data available
pH	: 3.7 (carbonic acid)
Relative evaporation rate (butyl acetate=1)	: No data available
Relative evaporation rate (ether=1)	: Not applicable.
Melting point	: No data available
Freezing point	: No data available
Boiling point	: -78.5 °C (-109.3°F)
Flash point	: No data available
Critical temperature	: 31 °C (87.7°F)
Auto-ignition temperature	: No data available
Decomposition temperature	: No data available
Flammability (solid, gas)	: No data available
Vapor pressure	: 57.3 bar (831 psig)
Critical pressure	: 73.7 bar (1069 psig)
Relative vapor density at 20 °C	: 762
Relative density	: 1.22
Relative gas density	: 1.52
Solubility	: Water: 2000 mg/l Completely soluble.
Log Pow	: 0.83
Log Kow	: Not applicable.
Viscosity, kinematic	: Not applicable.
Viscosity, dynamic	: Not applicable.
Explosive properties	: Not applicable.
Oxidizing properties	: None.
Explosion limits	: No data available

9.2. Other information

Gas group	: Liquefied gas
Additional information	: Gas/vapor heavier than air. May accumulate in confined spaces, particularly at or below ground level

SECTION 10: Stability and reactivity

10.1. Reactivity

No reactivity hazard other than the effects described in sub-sections below.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

None.

10.4. Conditions to avoid

None under recommended storage and handling conditions (see section 7).

10.5. Incompatible materials

Alkali metals, Alkaline earth metals, Acetylide forming metals, Chromium, Titanium > 1022°F (550°C), Uranium (U) > 1382°F (750°C), Magnesium > 1427°F (775°C).

10.6. Hazardous decomposition products

Electrical discharges and high temperatures decompose carbon dioxide into carbon monoxide and oxygen. The welding process may generate hazardous fumes and gases.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

Skin corrosion/irritation : Not classified
pH: 3.7 (carbonic acid)

Serious eye damage/irritation : Not classified
pH: 3.7 (carbonic acid)

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

Reproductive toxicity : Not classified

Specific target organ toxicity (single exposure) : Not classified

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general : No ecological damage caused by this product.

12.2. Persistence and degradability

Carbon dioxide (124-38-9)	
Persistence and degradability	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
Persistence and degradability	No ecological damage caused by this product.

12.3. Bioaccumulative potential

Carbon dioxide (124-38-9)	
BCF fish 1	(no bioaccumulation)
Log Pow	0.83
Log Kow	Not applicable.
Bioaccumulative potential	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
BCF fish 1	(no bioaccumulation)
Log Pow	0.83
Log Kow	Not applicable.
Bioaccumulative potential	No ecological damage caused by this product.

12.4. Mobility in soil

Carbon dioxide (124-38-9)	
Mobility in soil	No data available.
Ecology - soil	No ecological damage caused by this product.

Carbon dioxide (124-38-9)	
Mobility in soil	No data available.
Ecology - soil	No ecological damage caused by this product.

12.5. Other adverse effects

Effect on ozone layer : None
Global warming potential [CO2=1] : 1

Effect on the global warming : When discharged in large quantities may contribute to the greenhouse effect

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste treatment methods : May be vented to atmosphere in a well ventilated place. Discharge to atmosphere in large quantities should be avoided. Do not discharge into any place where its accumulation could be dangerous. Contact supplier if guidance is required.

Waste disposal recommendations : Do not attempt to dispose of residual or unused quantities. Return container to supplier.

SECTION 14: Transport information

In accordance with DOT

Transport document description : UN1013 Carbon dioxide, 2.2
UN-No.(DOT) : UN1013
Proper Shipping Name (DOT) : Carbon dioxide
Class (DOT) : 2.2 - Class 2.2 - Non-flammable compressed gas 49 CFR 173.115
Hazard labels (DOT) : 2.2 - Non-flammable gas

Additional information

Emergency Response Guide (ERG) Number : 120

Other information : No supplementary information available.

Special transport precautions : Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers: - Ensure there is adequate ventilation. - Ensure that containers are firmly secured. - Ensure cylinder valve is closed and not leaking. - Ensure valve outlet cap nut or plug (where provided) is correctly fitted. - Ensure valve protection device (where provided) is correctly fitted.

Transport by sea

UN-No. (IMDG) : 1013
Proper Shipping Name (IMDG) : CARBON DIOXIDE
Class (IMDG) : 2 - Gases
MFAG-No : 120

Air transport

UN-No. (IATA) : 1013
Proper Shipping Name (IATA) : Carbon dioxide
Class (IATA) : 2
Civil Aeronautics Law : Gases under pressure/Gases nonflammable nontoxic under pressure

SECTION 15: Regulatory information

15.1. US Federal regulations

Carbon dioxide (124-38-9)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	
SARA Section 311/312 Hazard Classes	Immediate (acute) health hazard Sudden release of pressure hazard

15.2. International regulations

CANADA

Carbon dioxide (124-38-9)
Listed on the Canadian DSL (Domestic Substances List)

Carbon dioxide (124-38-9)
Listed on the Canadian DSL (Domestic Substances List)

EU-Regulations

Carbon dioxide (124-38-9)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

15.2.2. National regulations

Carbon dioxide (124-38-9)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Listed on the Canadian IDL (Ingredient Disclosure List) Listed on INSQ (Mexican National Inventory of Chemical Substances) Listed on CICR (Turkish Inventory and Control of Chemicals)

15.3. US State regulations

Carbon dioxide(124-38-9)	
U.S. - California - Proposition 65 - Carcinogens List	No
U.S. - California - Proposition 65 - Developmental Toxicity	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Female	No
U.S. - California - Proposition 65 - Reproductive Toxicity - Male	No
State or local regulations	U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List U.S. - Pennsylvania - RTK (Right to Know) List

Carbon dioxide (124-38-9)				
U.S. - California - Proposition 65 - Carcinogens List	U.S. - California - Proposition 65 - Developmental Toxicity	U.S. - California - Proposition 65 - Reproductive Toxicity - Female	U.S. - California - Proposition 65 - Reproductive Toxicity - Male	Non-significant risk level (NSRL)
No	No	No	No	

Carbon dioxide (124-38-9)
U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List U.S. - Pennsylvania - RTK (Right to Know) List

SECTION 16: Other information

Other information : When you mix two or more chemicals, you can create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an industrial hygienist or other trained person when you evaluate the end product. Before using any plastics, confirm their compatibility with this product

Fumes and gases produced during welding and cutting processes can be dangerous to your health and may cause serious lung disease. KEEP YOUR HEAD OUT OF FUMES. DO NOT BREATHE FUMES AND GASES. Use enough ventilation, local exhaust, or both to keep fumes and gases from your breathing zone and the general area. Short-term overexposure to fumes may cause dizziness, nausea, and dryness or irritation of the nose, throat, and eyes; or may cause other similar discomfort. Contaminants in the air may add to the hazard of fumes and gases. One such contaminant, chlorinated hydrocarbon vapors from cleaning and degreasing activities, poses a special risk. DO NOT USE ELECTRIC ARCS IN THE PRESENCE OF CHLORINATED HYDROCARBON VAPORS—HIGHLY TOXIC PHOSGENE MAY BE PRODUCED. Metal coatings such as paint, plating, or galvanizing may generate harmful fumes when heated. Residues from cleaning materials may also be harmful. AVOID ARC OPERATIONS ON PARTS WITH PHOSPHATE RESIDUES (ANTI-RUST, CLEANING PREPARATIONS)—HIGHLY TOXIC PHOSPHINE MAY BE PRODUCED

The opinions expressed herein are those of qualified experts within Praxair, Inc. We believe that the information contained herein is current as of the date of this Safety Data Sheet. Since the use of this information and the conditions of use are not within the control of Praxair, Inc, it is the user's obligation to determine the conditions of safe use of the product

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Praxair asks users of this product to study this SDS and become aware of the product hazards and safety information. To promote safe use of this product, a user should (1) notify employees, agents, and contractors of the information in this SDS and of any other known product hazards and safety information, (2) furnish this information to each purchaser of the product, and (3) ask each purchaser to notify its employees and customers of the product hazards and safety information

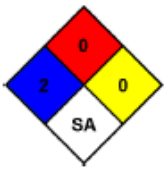
PRAXAIR, the Flowing Airstream design, Medipure, and the Medipure design are trademarks or registered trademarks of Praxair Technology, Inc. in the United States and/or other countries.

NFPA health hazard : 2 - Intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical attention is given.

NFPA fire hazard : 0 - Materials that will not burn.

NFPA reactivity : 0 - Normally stable, even under fire exposure conditions, and are not reactive with water.

NFPA specific hazard : SA - This denotes gases which are simple asphyxiants.



HMIS III Rating

Health : 1 Slight Hazard - Irritation or minor reversible injury possible

Flammability : 0 Minimal Hazard

Physical : 3 Serious Hazard

SDS US (GHS HazCom 2012) - Praxair

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.