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Standard on Carbon Dioxide Extinguishing Systems

2018

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Δ Table 5.3.2.2 Minimum Carbon Dioxide Concentrations for Extinguishment

Material	Theoretical Minimum CO_2 Concentration (%)	Minimum Design CO_2 Concentration (%)
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
Higher paraffin hydrocarbons $C_n H_{2n+2}, n \geq 5$	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, Bulletins 503 and 627.

*Calculated from accepted residual oxygen values.

5.3.3.2.2 If one volume requires greater than normal concentration *(see 5.3.4)*, the higher concentration shall be used in all interconnected volumes.

5.3.4 Material Conversion Factor. For materials requiring a design concentration over 34 percent, the basic quantity of carbon dioxide calculated from the volume factor given in Table 5.3.3(a) and Table 5.3.3(b) shall be increased by multiplying this quantity by the appropriate conversion factor given in Figure 5.3.4.

Table 5.3.3(a) Volume Factors and Flooding Factors

(A)	(B)		(C)
Volume of Space (ft^3)	Volume Factor (ft^3/lb CO_2)	Flooding Factor (lb CO_2/ft^3)	Calculated Quantity (lb) (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

Δ Table 5.3.3(b) Volume Factors and Flooding Factors (SI Units)

(A)	(B)		(C)
Volume of Space (m^3)	Volume Factor (m^3/kg CO_2)	Flooding Factor (kg CO_2/m^3)	Calculated Quantity (kg) (Not Less Than)
Up to 3.96	0.86	1.15	—
3.97–14.15	0.93	1.07	4.5
14.16–45.28	0.99	1.01	15.1
45.29–127.35	1.11	0.90	45.4
127.36–1415.0	1.25	0.80	113.5
Over 1415.0	1.37	0.74	1135.0

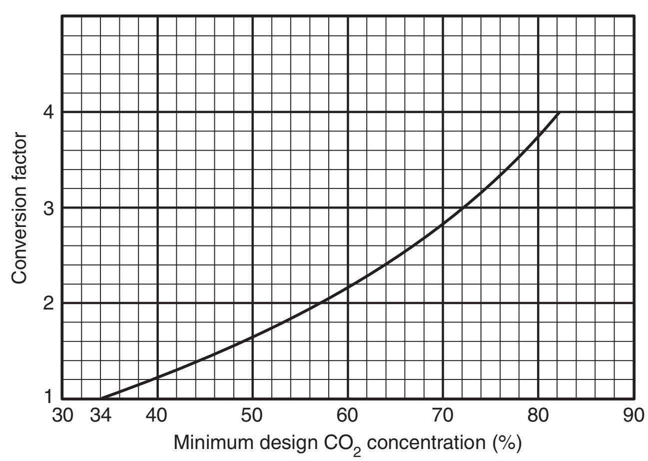


FIGURE 5.3.4 Material Conversion Factors.

5.3.5 Special Conditions. Additional quantities of carbon dioxide shall be provided to compensate for any special condition that could adversely affect the extinguishing efficiency.

5.3.5.1* Openings That Cannot Be Closed.

5.3.5.1.1 Any openings that cannot be closed at the time of extinguishment shall be compensated for by the addition of a quantity of carbon dioxide equal to the anticipated loss at the design concentration during a 1-minute period.

5.3.5.1.2 This amount of carbon dioxide shall be applied through the regular distribution system. *(See 5.2.1.1 and A.5.5.2.)*

5.3.5.2 Ventilating Systems.

5.3.5.2.1 For ventilating systems that cannot be shut down, additional carbon dioxide shall be added to the space through the regular distribution system in an amount computed by dividing the volume moved during the liquid discharge period by the flooding factor.

5.3.5.2.2 This additional amount of carbon dioxide shall be multiplied by the material conversion factor (determined from Figure 5.3.4) when the design concentration is greater than 34 percent.

5.3.5.3* For applications where the normal temperature of the enclosure is above 200°F (93°C), a 1 percent increase in the calculated total quantity of carbon dioxide shall be provided for each additional 5°F (2.8°C) above 200°F (93°C).

5.3.5.4 For applications where the normal temperature of the enclosure is below 0°F (−18°C), a 1 percent increase in the calculated total quantity of carbon dioxide shall be provided for each degree Fahrenheit below 0°F (−18°C).

5.3.5.5* Except for unusual conditions, it shall not be required to provide extra carbon dioxide to maintain the design concentration.

5.3.5.6 If a hazard contains a liquid having an auto-ignition temperature below its boiling point, the carbon dioxide concentration shall be maintained for a sufficient period to allow the liquid temperature to cool below its auto-ignition temperature. *(See 6.3.3.5.)*

5.3.5.7* Flooding Factor.

5.3.5.7.1 A flooding factor of 8 ft^3/lb (0.50 m^3/kg) shall be used in ducts and covered trenches.

5.3.5.7.2 If the combustibles represent a deep-seated fire, the fire shall be treated as described in Section 5.4.

5.4 Carbon Dioxide Requirements for Deep-Seated Fires.

5.4.1* General.

5.4.1.1 After the design concentration is reached, the concentration shall be maintained for a substantial period of time, but not less than 20 minutes.

5.4.1.2 Any possible leakage shall be given special consideration because no allowance is included in the basic flooding factors.

5.4.2* Combustible Materials.

Δ **5.4.2.1*** The design concentrations listed in Table 5.4.2.1 shall be achieved for the hazards listed.

5.4.2.2 Other Deep-Seated Fires.

5.4.2.2.1 Flooding factors for other deep-seated fires shall be justified to the satisfaction of the authority having jurisdiction before use.

5.4.2.2.2 Consideration shall be given to the mass of material to be protected because the thermal insulating effects reduce the rate of cooling.

5.4.3 Volume Consideration.

5.4.3.1 The volume of the space shall be determined in accordance with 5.3.3.1.

5.4.3.2 The basic quantity of carbon dioxide required to protect an enclosure shall be obtained by treating the volume of the enclosure by the flooding factor given in 5.4.2.

5.4.4 Special Conditions. Additional quantities of carbon dioxide shall be provided to compensate for any special condition that could adversely affect the extinguishing efficiency. *(See 5.3.5.2, 5.3.5.3, and 5.3.5.4.)*

5.4.4.1 Any openings that cannot be closed at the time of extinguishment shall be compensated for by the addition of carbon dioxide equal in volume to the expected leakage volume during the extinguishing period.

5.4.4.2 If leakage is appreciable, consideration shall be given to an extended discharge system as covered in 5.5.3. *(See also 5.2.1.3.)*

5.5 Distribution System.

5.5.1 General. The distribution system for applying carbon dioxide to enclosed hazards shall be designed with due consideration for the materials involved and the nature of the enclosure, because these items can require various discharge times and rates of application.

Δ **Table 5.4.2.1 Volume Factors and Flooding Factors for Specific Hazards**

Design Concentration (%)	Volume Factors		Flooding Factors		Specific Hazards
	ft^3/lb CO_2	m^3/kg CO_2	lb CO_2/ft^3	kg CO_2/m^3	
50	10	0.62	0.100	1.60	Dry electrical hazards in general [spaces less than 2000 ft^3 (56.6 m^3)]
50	12	0.75	0.083 (200 lb minimum)	1.33 (91 kg minimum)	Dry electrical hazards in general [spaces greater than 2000 ft^3 (56.6 m^3)]
65	8	0.50	0.125	2.00	Record (bulk paper) storage, ducts, covered trenches
75	6	0.38	0.166	2.66	Fur storage vaults, dust collectors

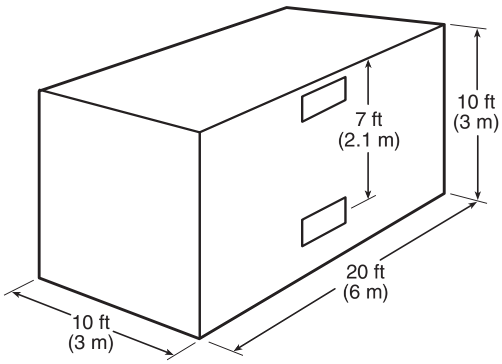
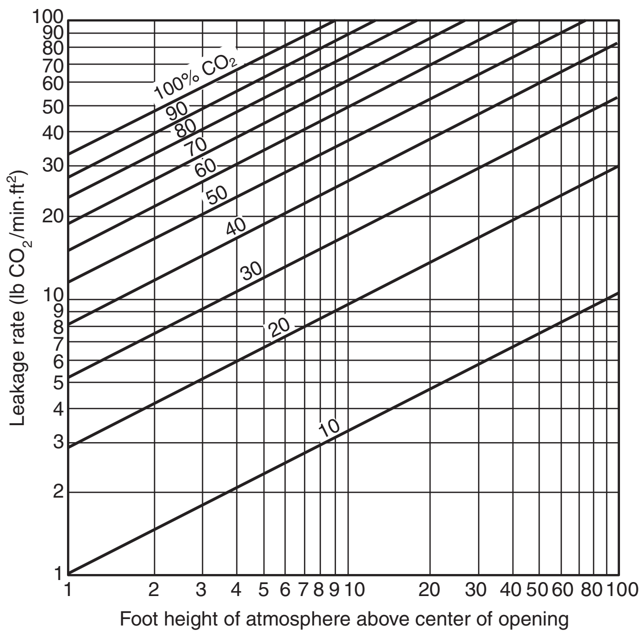


FIGURE E.1(a) Diagram of Enclosure for Example 1 and Example 2.



For SI units, 1 ft = 0.305 m; 1 lb/min·ft^2 = 4.89 kg/min·m^2.

FIGURE E.1(b) Calculated CO_2 Loss Rate Based on an Assumed 70°F (21°C) Temperature Within the Enclosure and 70°F (21°C) Ambient Outside.

Annex F Local Application Carbon Dioxide Systems

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 A local application carbon dioxide system is designed to apply carbon dioxide directly to a fire that could occur in an area or space that essentially has no enclosure surrounding it. Such systems should be designed to deliver carbon dioxide to the hazard being protected in a manner that will cover or surround all burning or flaming surfaces with carbon dioxide during operation of the system.

The flow rate and time of application required depend on the type of combustible material involved, the nature of the hazard (whether it is a liquid surface, such as a dip tank or quench tank, or a complicated piece of machinery, such as a printing press), and the location and spacing of the carbon dioxide nozzles with respect to the hazard.

The important factors to be considered in the design of a local application system are the rate of flow, the height and area limitations of the nozzles used, the amount of carbon dioxide needed, and the piping system. The following steps are necessary to lay out a system:

(1) Determine the area of the hazard to be protected. In determining this area, it is important to lay out to scale the actual hazard, showing all dimensions and limitations as to placement of nozzles. The limits of the hazard should be carefully defined to include all combustibles that could be included in the hazard, and the possibility of stock or other obstructions that might be in or near the hazard should be carefully considered.
(2) For overhead-type nozzles, based on the height limitations of the hazard to be protected, lay out the nozzles to cover the hazard by using various nozzles within the height and area limitations that are expressed in the listings or approvals of these nozzles. The limits on area coverage of a nozzle for a particular height are determined from listing information, which is presented in a form similar to that shown in Figure F.1(a). In considering the area covered by a particular nozzle, it is important to remember that all nozzle coverage is laid out on the basis of approximate squares. Omit this step for tankside or linear-type nozzles.
(3) Based on the height above the hazard of each nozzle, determine the optimum flow rate at which each nozzle should discharge to extinguish the hazard being protected. This is determined from a curve such as the one shown in Figure F.1(b), given in the individual listings or approvals of nozzles. For tankside or linear nozzles, based on the configuration of the hazard, lay out the nozzles to cover the hazard within the spacing limitations expressed in approvals or listings. Based on the spacing or area coverage, select an appropriate flow rate from an approval or listing curve such as the ones shown by Figure F.1(c) and Figure F.1(d). Omit this step for overhead-type nozzles.
(4) Determine the discharge time for the hazard. This time will always be a minimum of 30 seconds, but it can be longer, depending on such factors as the nature of the material in the hazard and the possibility that some hot spots can require longer cooling.
(5) Add the flow rates of the individual nozzles to determine the total flow rate, and multiply this sum by the duration of discharge to determine the total quantity of carbon dioxide needed to protect the hazard. Then multiply that number by 1.4 (for high-pressure systems) to obtain total capacity of storage cylinders.
(6) Locate the storage tank or cylinders, and lay out the piping connecting the nozzles and storage containers.
(7) Starting from the storage cylinders, compute the pressure drop through the system piping to each nozzle to obtain the terminal pressure at each nozzle. *(See Section C.1.)* Be sure to allow for equivalent lengths of pipe for various fittings and system components. Equivalent lengths of system components are found in individual listings or approvals of these components. Assume 750 psi