Fike CORPORATION

CO_2 DESIGN GUIDE

SUBFLOOR PROTECTION

The ***Subfloor Application Profile*** (AP 006) provides guidance on fire protection requirements for spaces beneath raised floors. In the event of a fire, the Fike Carbon Dioxide Extinguishing System will provide protection for costly hardware in high asset environments, and will also provide a safe working environment.

This Design Guide provides a step by step design process of a Fike Carbon Dioxide Extinguishing System protecting subfloor spaces. It is intended to be a sample and is not applicable to all applications. Fike's Carbon Dioxide Design, Installation, and Maintenance Manual and NFPA 12 should be referenced when designing systems.

This carbon dioxide design guide will be a total flooding / deep seated design for a dry electrical space with a volume that exceeds 2,000 ft^3 as specified by NFPA 12, Table 2-4.2.1. This sample is a computer room subfloor with no leakage or ventilation compensation. The following design parameters have been taken into consideration to determine the amount of agent, flow rate, quantity of nozzles, and ultimately a Fike CO_2 parts list.

Example:
1) Computer room subfloor with electrical equipment and cable runs.
2) Ventilation system to shutdown upon discharge
3) All leakage areas sealed
4) 60 air changes per hour
5) Hazard Size: 40 ft. (12.2 m) long x 40 ft. (12.2 m) wide x 2.5 ft. (.76 m) high

STEP #1 - DETERMINE THE HAZARD VOLUME.

The first step is to calculate the total volume of the hazard being protected.

- The volume is determined by multiplying: length x width x height.
- Volume = 40 ft. x 40 ft. x 2.5 ft. = 4,000 ft^3 (12.2 m x 12.2 m x .76 m = 113.12 m^3)

STEP #2 – DETERMINE THE FLOODING FACTOR.

The flooding factor used for a system design is based on the specific hazard being protected. To determine the base quantity of Carbon Dioxide agent required, multiply the hazard volume by a flooding factor selected from the following table found in NFPA 12.

FLOODING FACTORS FOR SPECIFIC HAZARDS					
Design Conc.	**ft^3 / lb. CO_2**	**lb. CO_2 / ft^3**	**m^3 / kg. CO_2**	**kg. CO_2 / m^3**	**Specific Hazard**
50%	10	0.100	0.62	1.60	Dry electrical hazards in general. (Spaces 0 - 2,000 ft^3./ 56.6 m^3)
50%	**12**	**0.083 (200 lb/min)**	**0.75**	**1.33 (91 kg/min)**	**Dry electrical hazards (Spaces over 2,000 ft^3 / 56.6 m^3)**
65%	8	0.125	0.50	2.00	Record or bulk paper storage, ducts & covered trenches
75%	6	0.166	0.38	2.66	Fur storage vaults, dust collectors, etc.

Minimum Carbon Dioxide Concentration and Flooding Factor

Both the minimum Carbon Dioxide concentration and flooding factor are based on the specific hazard being protected. For this example, a miscellaneous dry electrical hazard requires:

- Minimum Carbon Dioxide concentration = 50%.
- Flooding factor = 0.083 lb. CO_2/ft^3 (1.33 kg CO_2/m^3)

STEP #3 – CALCULATE THE MINIMUM AMOUNT OF CO_2 REQUIRED.

The minimum quantity of Carbon Dioxide required is based on the volume of the hazard being protected and the Flooding Factor. Multiply the volume of the hazard times the correct flooding factor.

MINIMUM QUANTITY OF CARBON DIOXIDE – UNADJUSTED SYSTEM	
English Units	**Metric Units**
4,000 ft^3 x .083 = 332 lbs. Carbon Dioxide	113.12 m^3 x 1.33 = 150.5 kg. Carbon Dioxide

STEP #4 – DETERMINE THE DISCHARGE DURATION AND FLOW RATE.

Deep-Seated hazard systems are discharged at a slower flow rate and for a longer duration to counter-act the characteristics of a smoldering fire. For Deep-Seated fires, the design concentration shall be achieved within **seven (7) minutes,** but at a flow rate that will provide a concentration of 30% within **two (2) minutes**.

To calculate the minimum flow rate for a 30% concentration, multiply the hazard volume by **0.043 (0.688** for metric calculations). This will determine the amount of Carbon Dioxide to be discharged within **two (2) minutes**.

QUANTITY OF CO_2 FOR 30% CONCENTRATION	
English Units	**Metric Units**
4,000 ft^3 x .043 (30% concentration) = 172 lbs./ 2 min.	113.12 m^3 kg. x .688 (30% concentration) = 77.83 kg/ 2 min.

Dividing the resultant quantity of Carbon Dioxide by **two (2)** provides the required flow rate in pounds (kg) of Carbon Dioxide per minute. (Reference: NFPA 12, Section 2-5.2.3)

MINIMUM FLOW RATE REQUIREMENTS	
English Units	**Metric Units**
172 ÷ 2 minutes = 86 lbs./min. (flow rate)	77.83 kg. ÷ 2 minutes = 38.92 kg/min. (flow rate)

The total system discharge must be completed in 7 minutes or less. Divide the total supplied quantity of Carbon Dioxide by the minimum flow rate, which is 86 lbs./min. (38.92 kg/min.).

DISCHARGE DURATION	
English Units	**Metric Units**
400 lbs. ÷ 86 lbs./minute = 4.7 minutes	181.45 kg. ÷ 38.92 kg/minutes = 4.7 kg/min. (flow rate)

STEP #5 - DETERMINE THE NOZZLE TYPE AND QUANTITY

All Fike CO_2 nozzles are acceptable for Total Flood applications, but the Radial and "S" type nozzles are best suited when protected spaces beneath raised floors. For this system, Radial nozzles will be utilized due to the minimal amount of leakage from the protected area.

NOTE: Nozzle selection is based on the system flow rate, ***not*** on the system supply quantity.

The first criteria will involve the system flow rate. The recommended flow rate for a 1/2" NPT Radial Nozzle is 100 lbs./min. (45.4 kg/min.), and the recommended flow rate for a 3/4" NPT Radial Nozzle is 150 lbs./min. (68 kg/min.). Choosing between the two sizes is largely a matter of preference and consideration should be given to the cost of larger pipe and fittings vs. additional smaller nozzles. Additional consideration shall be given to turbulence caused by the discharge from larger nozzles and its possible impact. For this application, the ½" Radial nozzle will be utilized.

½" RADIAL NOZZLE	
English Units	**Metric Units**
86 lbs. ÷ 100 lbs./minute = .86 = 1 Nozzle	38.92 kg. ÷ 45.4 kg/minutes = .86 = 1 Nozzle

The second criteria will involve the area coverage limitations for the nozzles:

- The 1/2" Radial Nozzle can cover an area 20 ft. x 20 ft. (6.1 m x 6.1 m). Therefore, two nozzles will be required to cover the 40 ft. (12.2m) width, and two nozzles to cover the 40 ft. (12.2 m) length.

In summary, four (4) ½" Radial nozzles are required to protect this application due to the recommended spacing of 20 ft. on center, and to keep the flow rate at a minimum, decreasing any potential for leakage from the subfloor during the system discharge and hold times.

STEP #6 – DETECTION

Photoelectric smoke detectors are the recommended detection methodology for spaces beneath raised floors. When the space beneath the raised floor is served by air-handling systems, it is important not to install the smoke detectors where airflow prevents operation of the detectors.

Detector spacing in spaces beneath raised floors is also a key design parameter, especially when air movement is present. Lower air changes per hour will decrease the detector spacing. For our sample application, the air change per hour is 60, which results in a minimum detector spacing of 125 ft^2. Smoke detector spacing requirements associated with air movement are provided in Table 2-3.6.6.3 of NFPA 72 and shown below.

Minimum per Air Change	**Air Changes per Hour**	**Spacing per Detector ft2**	**m2**
1	**60**	**125**	**11.61**
2	**30**	**250**	**23.23**
3	**20**	**375**	**34.84**
4	**15**	**500**	**46.45**
5	**12**	**625**	**58.06**
6	**10**	**750**	**69.68**
7	**8.6**	**875**	**81.29**
8	**7.5**	**900**	**83.61**
9	**6.7**	**900**	**83.61**
10	**6**	**900**	**83.61**

STEP #7 – DESIGN CONSIDERATIONS

Ventilation: It is recommended to shutdown and /or damper the ventilation system for the Carbon Dioxide System discharge in accordance with NFPA 12, Section 2-2.2.2. If total air shutdown is not possible and dampers are installed, air pressure from the fans will allow leakage through the ductwork, assuming the dampers will not be entirely effective. Additional carbon dioxide gas will be required to compensate for a non-static flooding condition. When this particular condition appears with your application, Fike Protection Systems should be consulted to provide assistance in designing the Carbon Dioxide system.

Unclosable Openings: All unclosable openings in a protected hazard must be compensated for by providing additional Carbon Dioxide in accordance with NFPA 12, Section 2-3.5.1. The additional quantity of Carbon Dioxide must equal the total anticipated quantity of Carbon Dioxide agent that will be lost through the openings during the required agent hold time. When protecting spaces beneath raised floors, majority of agent loss will result through wall penetrations made for running cables. These areas are to be properly sealed to prevent loss of agent. Agent loss through perforated floor tiles will be at a minimum due to carbon dioxide gas being 1.5 times heavier than air.

Determining the leakage compensation in spaces beneath raised floors can be a difficult task. When unique leakage conditions arise, Fike Protection Systems should be consulted to provide assistance in designing the Carbon Dioxide System.

STEP #8 – DEVELOP A FIKE CO2 PARTS LIST.

Fike CO_2 *Sample* Parts List – Subfloor Application

Quantity	Description	Part Number
4	100 lb. (45.4 kg) Cylinder w/Brass Valve	C70-100
4	Flexible Discharge Bend w/Check Valve	C70-226
2	12V DC Master Cylinder Package	C85-113
1	Connecting Link Assembly	C70-228
4	½” Radial Nozzle / 360 Degree	C80-041
1	½” Stop Maintenance Valve	C02-1232
1	½” Header Vent Plug / Low Pressure	C02-1363
1	½” Header Safety Release / High Pressure	C70-231
1	4 Cylinder Rack Assembly w/weigh track	C70-040-40
1	SHP Control System, 110 VAC	10-051-R-1
1	SRM4, Relay Module	10-2176
1	Battery Assembly, 7AH	10-2190-1
16	Detector, Photoelectric	63-1024
16	6” Detector Base, 430 ohm	67-1034
1	Manual Release Station	10-1638
2	Horn/Strobe Device, 15/75 Candela	20-098
1	Strobe, 15/75 Candela	20-091A
1	Warning Sign / Vacate Area Immediately..	C70-1034
1	Warning Sign / Do Not Enter…	C70-1081
1	Warning Sign / Manual Actuation…	C70-1032

CARBON DIOXIDE SAFETY CONCERNS:

Extinguishing concentrations of Carbon Dioxide create a health hazard to area personnel. High concentrations of Carbon Dioxide will cause suffocation. In addition, fogging during and after discharge can limit visibility in protected areas. Carbon Dioxide does **NOT** contain Oxygen in any form or quantity and **WILL NOT** sustain life.

The following human reactions to Carbon Dioxide have been documented:

- At concentrations of 3 to 4% by volume in the atmosphere, the breathing rate increases and headaches may occur.
- At concentrations exceeding 9% by volume, personnel can lose consciousness within minutes. This is generally preceded by disorientation, visual disturbance, ringing in the ears, tremors, etc.
- At concentrations greater than 20% by volume, death is likely.

The above effects are important to note as inexperienced personnel may fail to think clearly and take proper action if suddenly exposed to relatively low concentrations of Carbon Dioxide.

Any person overcome by Carbon Dioxide should be moved immediately to a location where plenty of fresh air is available and artificial respiration applied, as in a case of drowning. **DO NOT use Carbon Dioxide as a stimulant**. Call a physician or take the patient to a hospital for examination. Persons rendered unconscious by exposure to Carbon Dioxide can usually be revived without any permanent ill effects when promptly removed from a Carbon Dioxide atmosphere.

Direct contact with Carbon Dioxide liquid or dry ice particles will cause severe frostbite burns to the skin. Carbon Dioxide vaporizes quite rapidly. Therefore, this hazard is generally limited to the immediate vicinity of the discharge nozzle(s).

Carbon Dioxide can drift into, and settle in, adjacent spaces unless specific precautions are taken to prevent leakage from the protected space, and/or leakage into nearby areas. Such leakage can accumulate into dangerous concentration levels if left unattended. Consideration must be given to warning all personnel in the area of possible agent migration. A means of ventilating the Carbon Dioxide from enclosed areas, pits, etc., shall be considered when designing a Carbon Dioxide suppression system. NFPA 12, Sections 1-5 and A-1-5 provide additional guidelines for safety considerations.

Typically, flooded hazards and low-lying areas must be well ventilated before personnel are allowed to re-enter the protected space(s). Under some circumstances, it may be necessary to provide self-contained breathing apparatus (SCBA) to all persons responsible for investigating the event. When all traces of the fire have been extinguished and the possibility of re-ignition eliminated, thoroughly ventilate the hazard to ensure that only fresh air is remaining in the protected space. When there is a question as to the presence of Carbon Dioxide after a discharge, **DO NOT ENTER**. Rely on the fire department or other responsible authorities to determine when it is safe to re-enter.

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