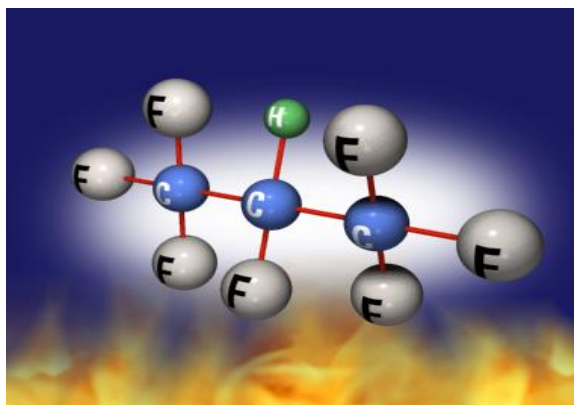




Total Flooding Systems

- Guideline -



HFC-227 ea
CF₃-CHF-CF₃
Heptafluoropropane

Note: This guideline has been prepared with the best information available at the time of publication. Changes in standards mentioned or technical changes may apply without further notice.

Guideline For TSP FM-200[®] Extinguishing Systems

1) General Information

FM-200[®] has been developed as an alternative to Halon 1301, production of which ceased at the end of 1993, under the agreed adjustments made to the Montreal Protocol in November 1992.

FM-200[®] contains no Bromine or Chlorine and has therefore an Ozone depleting potential of zero.

FM-200[®] systems utilize one or more storage containers arranged to provide the protected area with a pre-determined quantity of gas.

FM-200[®] storage containers are designed to hold FM-200[®] in liquid form and Nitrogen, which is used to super-pressurize the container to 24.8 bar (360 psi) at 20°C.

Handling and Installation of FM-200[®] equipment should only be carried out by persons experienced in dealing with this type of equipment.

2) Properties of FM-200[®]

FM-200[®] is stored as a liquefied compressed gas and is discharged into the protected area as a vapour.

FM-200[®] (HFC-227ea) is a clean, gaseous agent containing no particles or oily residues. It is produced under ISO 9002 guidelines to strict manufacturing specifications ensuring product purity. FM-200[®] leaves no residue or oily deposits on delicate electronic equipment, and can be removed from the protected space by ventilation.

The present understanding of the functioning of FM-200[®] is that 80% of its fire fighting effectiveness is achieved through heat absorption and 20% through direct chemical means (action of the fluorine radical on the chain reaction of a flame).

FM-200[®] decomposes at temperatures in excess of 500°C and it is therefore important to avoid applications involving hazards where continuously hot surfaces are involved. Upon exposure to the flame FM-200[®] will decompose to form halogen acids. Their presence will be readily detected by a sharp, pungent odour before maximum hazardous exposure levels are reached. It has been concluded from fire toxicity studies that decomposition products from the fire itself specially carbon monoxide, smoke, oxygen depletion and heat may create a greater hazard.

Chemical Formula:	CF ₃ CHFCF ₃
Boiling Point @ 1 atm:	-16.4 °C
Vapour Pressure @ 20°C:	3.91 bar (56.7 psi)
Vapour Density @ 20°C:	31.18 kg/m ³ (1.95 lb/ft ³)
Liquid Density @ 20°C:	1407 kg/m ³

3) Approvals

The FM-200[®] system and components used in the TSP extinguishing system have been tested and approved by LPCB (European System) and UL/FM (non-European System).

Only approved components may be used in the FM-200[®] system.

Guideline For TSP FM-200[®] Extinguishing Systems

4) Safety Margins

	Use Conc.	NOAEL*	Safety Margin
Novec 1230™	4% - 6%	10%	67% - 150%
Halon 1301	5%	5%	Nil
FM-200[®]	6,4% - 8,7%	9%	3% - 29%

* No Observable Adverse Effect Level
Low Observable Adverse Effect Level (**LOAEL**) for FM-200[®] is **>10.5%** !

5) Environmental Comparison

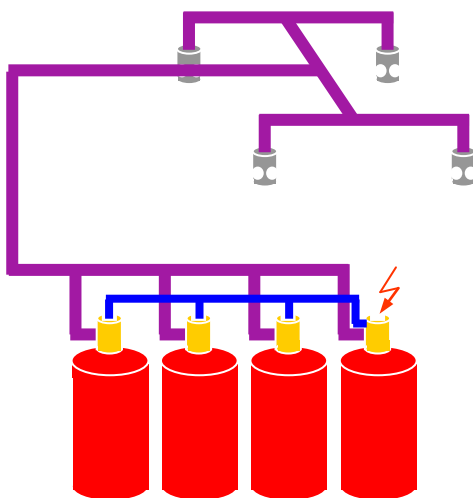
	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)	Atmospheric Lifetime (years)
Novec 1230™	0	1	0,014
Halon 1301	12	6900	65
HFC-227ea	0	3500	33

* IPCC 2001

6) General System Design

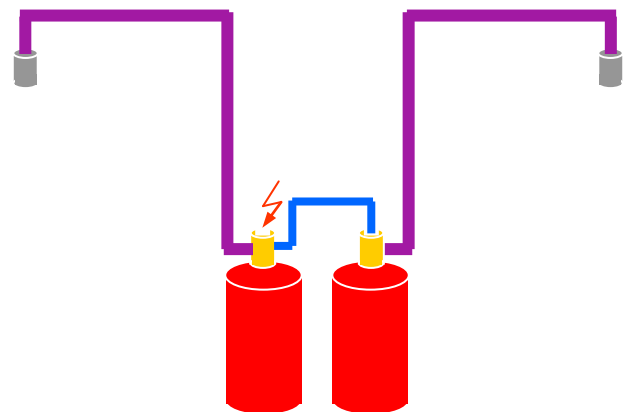
Total Flooding is the only approved application method for FM-200[®] systems!

Manifolded System



All cylinders the same size and the same filling!

Modularized System



Guideline For TSP FM-200[®] Extinguishing Systems

7) Hazard Analysis

Note: A thorough hazard analysis is important for a qualified quotation.

The following questions should be answered:

PROJECT: (enter name if applicable; country must be indicated)

Name	Country

SUPPRESSION SYSTEM:

<input type="checkbox"/> CO ₂ HP <input type="checkbox"/> FM-200 <input type="checkbox"/> Novec™ <input type="checkbox"/> i2/i3 <input type="checkbox"/> Inergen <input type="checkbox"/> Other (specify) _____
Type

<input type="checkbox"/> NFPA/FM <input type="checkbox"/> NFPA/UL <input type="checkbox"/> ISO <input type="checkbox"/> VdS <input type="checkbox"/> Other (specify) _____
Design Standard / Approval

<input type="checkbox"/> DOT <input type="checkbox"/> TPED <input type="checkbox"/> None <input type="checkbox"/> Other (specify) _____
Agent Container Approval

<input type="checkbox"/> Electric <input type="checkbox"/> Manual <input type="checkbox"/> Pneumatic
System Release

<input type="checkbox"/> Inside Hazard <input type="checkbox"/> Outside Hazard: _____ [m] horizontal distance _____ [m] vertical distance
Agent Container Location

HAZARD:

No.	Name	Hazardous Material
-----	------	--------------------

[°C] Minimum Temperature	[°C] Maximum Temperature	[m] Altitude above/below sea level
-----------------------------	-----------------------------	---------------------------------------

Hazard Dimensions:

[m] Length	[m] Width	[m ²] Floor Area (alternative)
---------------	--------------	---

[m] Height of Ceiling Void (if applicable)	[m] Height of Room (excl. ceiling/floor void)	[m] Height of Floor Void (if applicable)
---	--	---

Impermeable Building Structures: _____ [m ³] <small>Only permanent impermeable building structures within the area may be deducted from the gross volume</small>
--

- Note** In the following cases please supply additional sketches/drawings with dimensions and any relevant details:
- irregular room shapes
 - ceiling obstructions such as beams greater than 300 mm (12 in.) height
 - other unusual conditions.

Further Information / Comments:

Guideline For TSP FM-200[®] Extinguishing Systems

8) System Design

The system design requires the following steps:

1. Check on design standard / hazardous material involved to get the design concentration
2. Determination of net* hazard volume.
*Only permanent impermeable building structures within the hazard may be deducted from the overall hazard volume.
3. Determination of the extinguishing agent quantity
4. Check the max. reached concentration
5. Determination of number and size of agent containers.
6. Determination of nozzle size and quantity.
7. Determination of pipe sizes and pipe run.
Note: Pipes and fittings are generally not supplied by TSP.

8.1) FM-200[®] Design Concentrations

	ISO 14520	CEA 4045	NFPA 2001	EN 15004
Surface Class A	7,9 %	8,4 %	6,25-7 % ³⁾	7,9 %
Higher Hazard Class A ¹⁾	8,5 %	---	---	8,5 %
Class B (Heptane) ²⁾	9,0 %	8,8 %	8,7 % ³⁾	9,0 %

¹⁾ ISO 14520-1 § 7.5.1.3 | EN 15004-1 § 7.5.1.3
It is recognized that the wood crib and polymeric sheet class A fire tests may not adequately indicate extinguishing concentrations suitable for the protection of certain plastic fuel hazards (e.g. electrical and electronic type hazards involving grouped power or data cables such as computer and control room under-floor voids, telecommunication facilities, etc.). An extinguishing concentration not less than that determined according to clause 7.5.1.3, or not less than 95% of that determined from the heptane fire test in Annex C, Clause C.6.2, whichever is the greater, should be used under certain conditions.

These conditions may include:

- (1) Cable bundles greater than 100 mm in diameter
- (2) Cable trays with a fill density greater than 20 percent of the tray cross-section
- (3) Horizontal or vertical stacks of cable trays (closer than 250 mm)
- (4) Equipment energized during the extinguishment period where the collective power consumption exceeds 5 kW

NFPA 2001 - 2008 Edition A.5.4.2.2 (7)(g)

Where any of the following conditions exist, higher extinguishing concentrations might be required:

- (1) Cable bundles greater than 100 mm in diameter
- (2) Cable trays with a fill density greater than 20 percent of the tray cross-section
- (3) Horizontal or vertical stacks of cable trays (closer than 250 mm)
- (4) Equipment energized during the extinguishment period where the collective power consumption exceeds 5 kW

²⁾ For design concentrations for any other class B fuel see design standards or contact Tyco Technical Service.

³⁾ Values are from NFPA 2001 - 2008 Edition Table A.5.4.2.2(b)
The Pyrochem FM-200[®] design manual lists 7,17% for class A and 90,% for class B (Heptane).
Acc. to Pyrochem Bulletin 2168, UL accepts 6,4% minimum design concentration for class A and C.

Important!

These design concentrations are **not applicable** (and are not to be used) **for Marine applications.**

Guideline For TSP FM-200[®] Extinguishing Systems

8.2) FM-200[®] Flooding Factor Table

Table 1: FM-200[®] weight requirements per volume of protected space:

		Flooding Factors FM-200															
Design Temperature of Hazard	Specific Vapor Volume	Design concentrations															
		6.00 %	6.20 %	6.25 %	6.40 %	6.60 %	6.80 %	7.00 %	7.17 %	7.20 %	7.30 %	7.50 %	7.90 %	8.00 %	8.40 %	8.50 %	9.00 %
Agent Quantity Requirements per Volume of Protected Hazard (kg/m ³)																	
-20 °C	0.11664	0.5472	0.5667	0.5716	0.5862	0.6058	0.6255	0.6453	0.6622	0.6652	0.6752	0.6952	0.7354	0.7455	0.7862	0.7964	0.8479
-15 °C	0.11920	0.5355	0.5545	0.5593	0.5736	0.5928	0.6121	0.6314	0.6480	0.6509	0.6606	0.6802	0.7196	0.7295	0.7693	0.7793	0.8297
-10 °C	0.12177	0.5242	0.5428	0.5475	0.5615	0.5803	0.5992	0.6181	0.6343	0.6372	0.6467	0.6659	0.7044	0.7141	0.7531	0.7629	0.8122
-5 °C	0.12433	0.5134	0.5316	0.5362	0.5499	0.5683	0.5868	0.6054	0.6212	0.6240	0.6334	0.6521	0.6899	0.6994	0.7376	0.7471	0.7954
0 °C	0.12690	0.5030	0.5209	0.5253	0.5388	0.5568	0.5750	0.5931	0.6087	0.6114	0.6206	0.6389	0.6759	0.6852	0.7226	0.7320	0.7794
5 °C	0.12947	0.4930	0.5105	0.5149	0.5281	0.5458	0.5636	0.5814	0.5966	0.5993	0.6083	0.6263	0.6625	0.6717	0.7083	0.7175	0.7639
10 °C	0.13203	0.4834	0.5006	0.5049	0.5179	0.5352	0.5526	0.5701	0.5850	0.5876	0.5964	0.6141	0.6497	0.6586	0.6946	0.7036	0.7491
15 °C	0.13460	0.4742	0.4911	0.4953	0.5080	0.5250	0.5421	0.5592	0.5738	0.5764	0.5851	0.6024	0.6373	0.6461	0.6813	0.6902	0.7348
20 °C	0.13716	0.4654	0.4819	0.4860	0.4985	0.5152	0.5319	0.5488	0.5631	0.5657	0.5741	0.5911	0.6254	0.6340	0.6686	0.6773	0.7211
25 °C	0.13973	0.4568	0.4730	0.4771	0.4894	0.5057	0.5222	0.5387	0.5528	0.5553	0.5636	0.5803	0.6139	0.6223	0.6563	0.6648	0.7078
30 °C	0.14229	0.4486	0.4645	0.4685	0.4805	0.4966	0.5128	0.5290	0.5428	0.5453	0.5534	0.5698	0.6026	0.6111	0.6445	0.6529	0.6951
35 °C	0.14486	0.4406	0.4563	0.4602	0.4720	0.4878	0.5037	0.5196	0.5332	0.5356	0.5436	0.5597	0.5921	0.6003	0.6331	0.6413	0.6827
40 °C	0.14742	0.4330	0.4484	0.4522	0.4638	0.4793	0.4949	0.5106	0.5239	0.5263	0.5342	0.5500	0.5818	0.5898	0.6220	0.6301	0.6709
45 °C	0.14999	0.4256	0.4407	0.4445	0.4559	0.4711	0.4864	0.5018	0.5150	0.5173	0.5250	0.5406	0.5719	0.5798	0.6114	0.6194	0.6594
50 °C	0.15256	0.4184	0.4333	0.4370	0.4482	0.4632	0.4783	0.4934	0.5063	0.5086	0.5162	0.5315	0.5623	0.5700	0.6011	0.6089	0.6483
55 °C	0.15512	0.4115	0.4261	0.4298	0.4408	0.4555	0.4704	0.4852	0.4979	0.5002	0.5077	0.5227	0.5530	0.5606	0.5912	0.5989	0.6376
60 °C	0.15769	0.4048	0.4192	0.4228	0.4336	0.4481	0.4627	0.4773	0.4898	0.4920	0.4994	0.5142	0.5440	0.5515	0.5816	0.5891	0.6272
65 °C	0.16025	0.3983	0.4125	0.4160	0.4267	0.4410	0.4553	0.4697	0.4820	0.4842	0.4914	0.5060	0.5353	0.5426	0.5722	0.5797	0.6172
70 °C	0.16282	0.3920	0.4060	0.4095	0.4200	0.4340	0.4481	0.4623	0.4744	0.4765	0.4837	0.4980	0.5268	0.5341	0.5632	0.5706	0.6074
75 °C	0.16538	0.3860	0.3997	0.4031	0.4134	0.4273	0.4412	0.4551	0.4670	0.4691	0.4762	0.4903	0.5187	0.5258	0.5545	0.5617	0.5980
80 °C	0.16795	0.3801	0.3936	0.3969	0.4071	0.4207	0.4344	0.4482	0.4599	0.4620	0.4689	0.4828	0.5107	0.5178	0.5460	0.5531	0.5889
85 °C	0.17051	0.3743	0.3876	0.3910	0.4010	0.4144	0.4279	0.4414	0.4530	0.4550	0.4618	0.4755	0.5030	0.5100	0.5376	0.5448	0.5800
90 °C	0.17308	0.3688	0.3819	0.3852	0.3951	0.4083	0.4215	0.4349	0.4463	0.4483	0.4550	0.4685	0.4956	0.5024	0.5296	0.5367	0.5714

8.3) Altitude Correction Factors

At elevations above sea-level, FM-200[®] has a greater specific volume because of the reduced atmospheric pressure. A system designed for sea-level conditions will therefore develop an actual higher concentration at levels above sea-level and an actual lower concentration at levels below sea-level.

Table 2:

Altitude (m)	-1000	Sea Level	1000	1500	2000	2500	3000	3500	4000	4500
Correction Factor	1.130	1.000	0.885	0.830	0.785	0.735	0.690	0.650	0.610	0.565

8.4) Determination of FM-200[®] Quantity

$$Q = V \times C_F \times C_{Alt}$$

- Where
- Q = Agent quantity required [kg]
 - V = Hazard volume [m³]
 - C_F = Flooding factor [kg/m³] (see Table 1)
 - C_{Alt} = Altitude correction factor (see Table 2)

Guideline For TSP FM-200[®] Extinguishing Systems

Example:

Type of hazard: Computer room (surface class A)
 Design Standard: ISO 14520
 Volume: 8,0 m x 4,25 m x 2,5 m = 85 m³
 Minimum hazard temperature: 20°C
 Maximum hazard temperature: 30°C
 Altitude: 1500 m

$$Q = 85 \times 0.6254 \times 0.83 = 44.13 [\text{kg}]$$

Round up to the next full kg → **Required agent quantity = 45 kg FM-200[®]** .

8.5) Check the max. reached concentration

To check the concentration C reached in a hazard the following formula can be used:

$$C = \frac{Q \times s \times 100}{V + (Q \times s)}$$

Where Q = agent quantity supplied from the system [kg]
 V = hazard volume [m³]
 s = specific vapor volume [m³/kg] = 0.1269 + 0.0005131 * T → **at sea level !**
 T = max. hazard temperature [°C]

Example:

Type of hazard: Computer room (surface class A)
 Design Standard: ISO 14520
 Gros volume: 8,0 m x 4,25 m x 2,5 m = 85 m³
 Minimum hazard temperature: 20°C
Maximum hazard temperature: 30°C
 Altitude: 1500 m

A quantity of 45 kg FM-200[®] has been calculated at an altitude of 1500 m.

At sea level this would result in 45 kg / 0,83 = **54.22 kg FM-200[®]**

What concentration is reached at the max. hazard temperature of 30°C ?

$$S = 0.1269 + 0.0005131 * 30 = 0.1423$$

$$C = \frac{54.22 \times 0.1423 \times 100}{85 + (54.22 \times 0.1423)} = \frac{771.55}{92,72} = 8,32\%$$

Concentration @ 30°C is less than NOAEL (9%) – okay for occupied space !

Guideline For TSP FM-200[®] Extinguishing Systems

8.6) Determination of number and size of containers

Each container assembly consists of

- FM-200[®] container
- FM-200[®] valve with pressure gauge
- Siphon tube

Containers are painted red as standard.

Containers are fitted with a label which provides handling, maintenance and recharge instructions.

All containers are designed for vertical mounting only.

Each assembly may be provided with a range of FM-200[®] fills to suit the design requirements.

After filling, the containers are super-pressurised with dry nitrogen to 24.8 bar +5% (at a temperature of 20°C).

Table 3a:

FM-200 Container						
Container manufactured to meet 84/527/EEC (TPED)						
Container Size	Container Diameter	Ht. to Valve Outlet	Tare Weight*	Min. FM 200 Filling	Max. FM 200 Filling	Max. Gross Weight
(litre)	(mm)	(mm)	(kg)	(kg)	(kg)	(kg)
---	---	---	---	---	---	---
8	254	300	14.8	4.0	8.0	22.8
16	254	499	18.4	8.0	16.0	34.4
32	254	831	26.1	16.0	32.0	58.1
52	406	593	49.1	26.0	52.0	101.1
106	406	1018	71.8	53.0	106.0	177.8
147	406	1352	89.9	73.5	147.0	236.9
180	406	1631	105.8	90.0	180.0	285.8
---	---	---	---	---	---	---

Table 3b:

FM-200 Container						
Container manufactured to DOT						
Container Size	Container Diameter	Ht. to Valve Outlet	Tare Weight*	Min. FM 200 Filling	Max. FM 200 Filling	Max. Gross Weight
(litre)	(mm)	(mm)	(kg)	(kg)	(kg)	(kg)
4.5	178	280	7.7	2.3	4.5	12.2
8	254	300	14.8	4.0	8.0	22.8
16	254	499	18.4	8.0	16.0	34.4
32	254	831	26.1	16.0	32.0	58.1
52	406	593	49.1	26.0	52.0	101.1
106	406	1018	71.8	53.0	106.0	177.8
147	406	1352	89.9	73.5	147.0	236.9
180	406	1631	105.8	90.0	180.0	285.8
343	610	1466	207.0	171.5	343.0	550.0

Note: 1) In EU countries only TPED compliant containers can be used.

2) Unless a hydraulic flow calculation is done, approximate 80% of the max. filling should be used to determine a container size (this is a recommendation from experience, not a fixed technical value).

Example: using TPED container

Required agent quantity = 41 kg FM-200[®]

Container size	Min. Filling	Max. Filling	80% Max. Filling*	Actual Fill%	
32 l	16,0 kg	32,0 kg	25,6 kg	128%	➔ > 100%
52 l	26,0 kg	52,0 kg	41,6 kg	79%	➔ o.k
106 l	53,0 kg	106,0 kg	84,8 kg	39%	➔ min. filling not reached

* experience value

1 x 52 liter container required – filled with 41 kg FM-200[®].

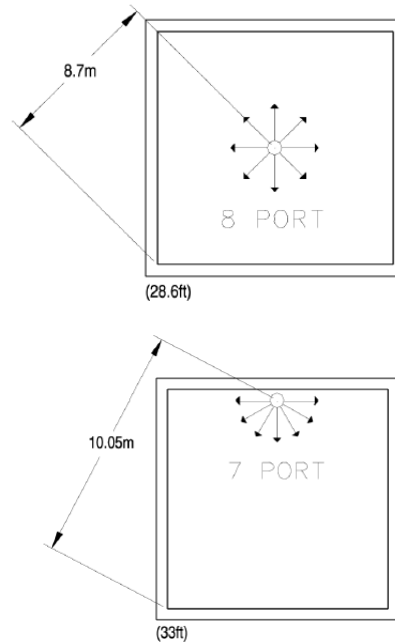
Guideline For TSP FM-200[®] Extinguishing Systems

8.7) Determination of number and size of nozzles

FM-200[®] Discharge Nozzles:

	180° Pattern	360° Pattern
Number of ports	7	8
Available size	15/20/25/32/40/50 mm	
Max. area of coverage	see figure	
Max. coverage height	4.87 m	

Nozzle Coverage:



Example:

Hazard = 8,0 m x 4,25 m x 2,5 m

45 kg FM-200[®]

Note:

Discharge time for a FM-200[®] system is **max. 10 seconds.**

A) Number of nozzles:

- check nozzle coverage vs. hazard area
- check max. coverage height (4.87 m) vs. height of hazard

1 nozzle 180° or 1 nozzle 360° possible.

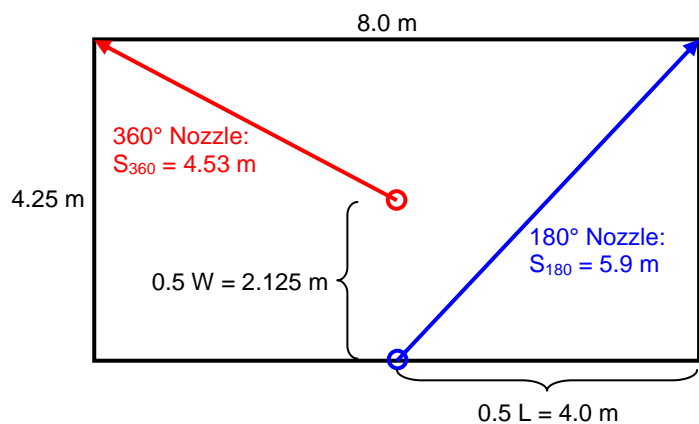
B) Nozzle size:

- check agent flow [kg/s] per nozzle and determine nozzle size from table 4 (see § 8.8)

Agent flow = 4.5 kg/s

Nozzle size = 32 mm (1 1/4")

Check of nozzle coverage

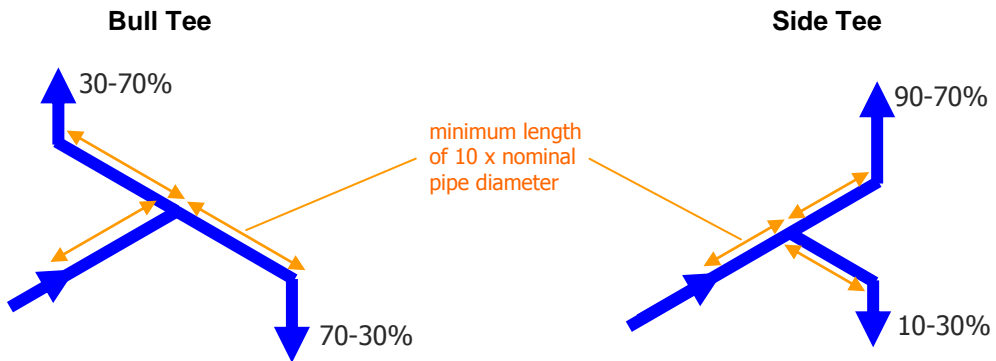


Guideline For TSP FM-200[®] Extinguishing Systems

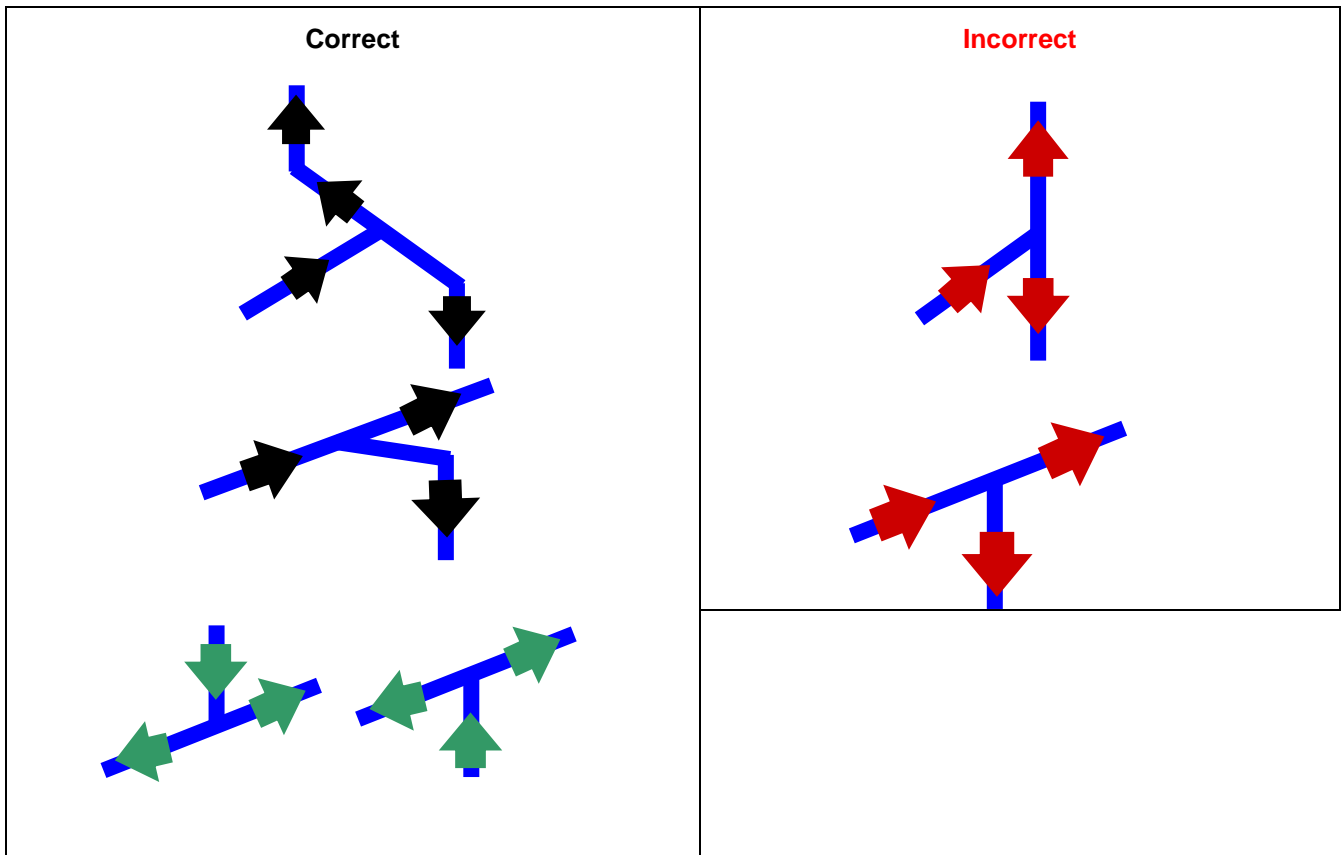
8.8) Determination of pipe sizes and pipe run

System Limitations

Flow limitations at T-splits



Pipe arrangements at T-splits



Guideline For TSP FM-200[®] Extinguishing Systems

Pipe Size Estimation

Use table 4 to determine the pipe size according to the agent flow.

Note: Table 4 is for estimation purpose only. The final pipe size will be determined by the hydraulic flow calculation software.

Example:

- Total quantity = 45 kg FM-200[®] (in 10 s)
- ➔ 4.5 kg/s
- find the next higher value in "Max. Flow" column
- ➔ **estimated pipe size = 32 mm (1¼")**

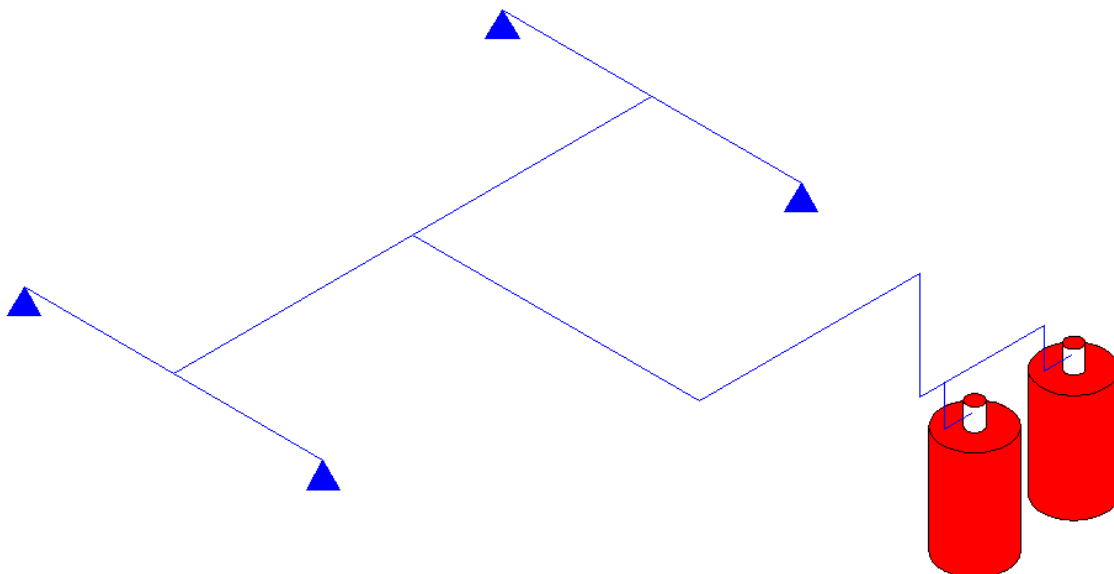
Table 4: FM-200[®] Flow in Schedule 40 Pipe

Pipe Size mm (in)	Minimum flow rate kg/s (lb/s)	Maximum flow rate kg/sec.(lb/s)
10 (3/8)	0.272 (0.60)	0.907 (2.00)
15(1/2)	0.454 (1.00)	1.361 (3.00)
20 (3/4)	0.907 (2.00)	2.495 (5.50)
25 (1)	1.588 (3.50)	3.855 (8.50)
32 (1 1/4)	2.722 (6.00)	5.67 (12.50)
40 (1 1/2)	4.082 (9.00)	9.072 (20.00)
50 (2)	6.35 (14.00)	13.61 (30.00)
65 (2 1/2)	9.072 (20.00)	24.95 (55.00)
80 (3)	13.61 (30.00)	44.92 (99.00)
100 (4)	24.95 (55.00)	56.7 (125.00)
125 (5)	40.82 (90.00)	90.72 (200.00)
150 (6)	54.43 (120.00)	136.1 (300.00)

General Piping Practices and Rules

- Piping material must comply with the local regulations.
- Always try to design a symmetric pipe run.

Example for balanced pipe run



Guideline For TSP FM-200[®] Extinguishing Systems

9) Pressure Venting

The designer of a fire suppression system should be aware, that the discharge of any gaseous extinguishing agent into an enclosure will raise the pressure within that enclosure, which could affect the structural integrity of the enclosure.

NFPA 2001 § 5.3.6

The protected enclosure shall have the structural strength and integrity necessary to contain the agent discharge. If the developed pressures present a threat to the structural strength of the enclosure, venting shall be provided to prevent excessive pressures.

For pressure relief vent area or equivalent leakage area, see 5.1.2.2(28)

To calculate the free venting area, use the following formular:

$$A = \frac{Q_{\text{Agent}} \times V_{\text{Agent}}}{\sqrt{\Delta p \times V_{\text{HOM}}}} \times C_2$$

- A required free venting area (m²)
- Q FM-200[®] flow (kg/s)
- v specific volume of agent (m³/kg)*
- Δp max. allowable pressure increase (Pa)**
- V_{HOM} specific volume of the homogeneous air / FM-200[®] mixture***
- C₂ resistance coefficient for the opening****

- * Use 0,137 m³/kg for FM-200[®].
- ** A value between 100 and 300 Pascal's should be used if there is no other value offered by the client or clients representative.
- *** 0.6 is a good average value for 7,9% FM-200[®] concentration.
- **** 0,5 < c₂ < 1; to simplify the formular, use c₂=1

Example: 45 kg FM-200[®] to be discharged (within 10 seconds).
 Maximum overpressure allowed = 300 Pa.

$$A = \frac{4,5 * 0,137}{\sqrt{300 \times 0,6}} \times 1 = \frac{0,617}{13,42} = 0.046 \text{ [m}^2\text{]}$$

0.05 m² free venting area is required.