SYSTEM DESIGN MANUAL

SIEX-NC™ 1230
360 & 610 psi
(25 & 42 bar)

SIEX-NC™ 1230 S-FLOW
465, 490, 725, 800 psi
(32, 34, 50 & 55 bar)

FK-5-1-12

HALOCARBON GAS at
360, 465, 490, 610, 725 and 800 psi
(25, 32, 34, 42, 50 and 55 bar)

LISTED EX15547

APPROVED 3062401

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References to other manuals of the system

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1. Design

The design criteria explained in this design manual are based on the requirements of the NFPA 2001, ISO 14520, EN-UNE 15004.

The design of the pipework **MUST** be verified by means of hydraulic flow calculations before installing the SIEX-NC™ 1230 system. If the specific limitations are not adhered to, it is possible that the system will not deliver the necessary quantity of extinguishant.

1.1 Desing criteria

The complexity of two-phase flow formulas does not allow the use of a simple manual calculation method in the case of FK-5-1-12 extinguishant. For this reason, the flow calculations and design criteria described in this manual have been included in the software for clean agent flow calculations.

➢***ATTENTION***: *The FK-5-1-12 extinguishing agent flow calculation program (software) is the only calculation method applicable with SIEX equipment. No other calculation method is accepted for systems supplied by* ***SIEX***.

System designers must fully familiarise themselves with this manual. For the use of the software for the calculation, it is necessary to take into account a series of limitations for these input parameters in the software to obtain accurate results. The majority of these limitations are to be found in the program. However, before inputing the data, the system designer needs to take a series of restrictions into account. This manual describes the main design parameters and limitations which need to be considered.

To design a **SIEX-NC™ 1230** system the following steps must be followed:

- Carrying out of a risk analysis and inspection in the protected area,
- Establishing the necessary design concentration,
- Determining if there are risks to people in the enclosure (*safety measures*),
- Calculating the quantity of extinguishant needed for the risk,
- Determining if there are leaks or openings from the protected area.
- General system design concepts.

1.2 Properties of FK-5-1-12 extinguishant

FK-5-1-12 is a transparent, colourless; with low-odor gas which is electrically non-conducting and has a density approximately eleven times that of air. It is stored as a liquid and extinguishes fires mainly through a combination of physical and chemical mechanisms.

PROPERTY	REQUIREMENT
Purity	*99.6% min.*
Acidity	*3 x 10^{-6} (3 ppm) max.*
Water content	*1 x 10^{-3} % (10 ppm) max.*
Non-volatile residues	*0.03 % (m/m) max.*
Substances in suspension or sediment	*None visible*

Table 1 – FK-5-1-12 specifications.

PROPERTY	UNIT
Molecular weight	*316.04*
Boiling point at 14.7 psi (1.013 bar) (absolute)	*120.2 ºF (49 °C)*
Freezing point	*-162.4 °F (-108.0 °C)*
Critical temperature	*335.6 ºF (168.66 °C)*
Critical pressure	*270.44 psi (18.65 bar)*
Critical volume	*0.0251 ft^3/lbm (494.5 cc/mole)*
Critical density	*39.91 lb/ft^3 (639.1 kg/m^3)*
Vapour pressure at 68ºF (20 °C)	*4.728 psi (0.326 bar) abs*
Liquid density at 68ºF (20 °C)	*100.88 lb/ft^3 (1.616 kg/m^3)*
Saturated vapour density at 68ºF (20 °C)	*0.2703 lb/ft^3 (4.3305 kg/m^3)*
Specific volume of superheated vapour at 14.7 psi at 68ºF (1.013 bar at 20 °C)	*1.1517 ft^3/lb (0.0719 m^3/kg)*
Chemical formula	*$CF_3CF_2C(O)CF(CF_3)_2$*
Chemical name	*Dodecafluoro-2-methylpentan-3-one*

Table 2 – Physical properties of FK-5-1-12.

1.3 Uses and limitations

FK-5-1-12 Extinguishant is suitable for the following Classes of Fire:

- Class A: Fires involving solid materials of an organic nature which normally produce embers from their combustion (deep-seated fires).
- Class B: Fires involving flammable liquids or liquefiable solids.
- Electrical risks (Class C): These are considered as Class A fires for calculation purposes.

However, precautions must be taken with some materials since FK-5-1-12 extinguishant **is not effective for:**

- Chemical products with their own oxygen supply, such as cellulose nitrate.
- Class D fires (*combustion of metals*); reactive metals such as lithium, sodium, potassium, titanium, etc, some of which can react violently,
- Radioactive elements such as uranium and plutonium.

1.4 Exposure time

SIEX-NC™ 1230 is a suitable system for use in areas occupied by people and can be designed for concentrations above the NOAEL (10%).

✓ ***NOAEL (No Observed Adverse Effect Level):*** highest concentration which has not been observed any adverse physiological or toxic effect.

✓ ***LOAEL (Lowest Observed Adverse Effect Level):*** lowest concentration which has been observed an adverse physiological or toxic effect.

PROPERTIES	VALUE
NOAEL	*10 %*
LOAEL	*>10%*

Table 3- Security percentage for FK-5-1-12.

1.4.1 Risk analysis and inspection of the protected area

The first and most important step in designing an extinguishing system using SIEX-NC™ 1230 clean agent is to carefully analyse the risk to be protected. Use the instructions in the NFPA 2001 *(US standard)*, ISO 14.520 and UNE-EN 15.004 standards as a design guide.

BASIC CONCEPTS WHICH MUST BE KNOWN:

1) CLASS OR TYPE OF RISK

2) TYPE OF FIRE PRODUCED (CLASS A, B or C)

3) ENVIRONMENTAL CONDITIONS (TEMPERATURE, HUMIDITY, CORROSION, ETC)

4) PRESENCE OF PEOPLE IN THE ROOM DURING THE DISCHARGE (OCCUPIED AREA)

5) OPENINGS WHICH REMAIN OPEN DURING DISCHARGE

6) SYSTEM OF OPERATION UNDER NORMAL CONDITIONS AND AFTER THE DISCHARGE OF THE FK-5-1-12 EXTINGUISHANT,

7) PROTECTED AREA ACCESS (EVACUATION ROUTES, EVACUATION TIME, ETC)

8) TYPE OF CONSTRUCTION OF THE PROTECTED AREA (DOORS, FIRE RESISTANT WALLS, ETC)

9) VOLUME OF THE COMPARTMENT TO BE PROTECTED

10) MAXIMUM HEIGHT OF THE ENCLOSED AREA TO BE PROTECTED

11) FALSE FLOORS AND CEILINGS IN THE ENCLOSED AREA

12) LOCATION OF THE EXTINGUISHING SYSTEM (CYLINDERS OR BANKS)

13) ANY OTHER SPECIAL CONSIDERATION TO BE TAKEN INTO ACCOUNT WHICH MAY AFFECT THE RISK

1.4.2 Determining the design concentration needed for the hazard to be protected

The design concentration is based on the extinguishing concentration plus a safety factor which varies according to the Class of Fire and the standard to be applied.

For Class A fires a safety factor of 30% is added for *ISO-14520* or *UNE-EN 23570* and 20% for *NFPA 2001*. On the other hand, for Class B fires, 30% is added for *ISO-14520, UNE-EN 23570* and *NFPA 2001. For class C fires, a safety factor of 35% is added according to NFPA 2001.* The extinguishing concentrations are based on laboratory tests using standardised methods in accordance with the standard.

Difficult environments or those which require intrinsically safe or Ex-proof equipment will be considered as special cases and would need to be studied in detail before completing the system design.

Table 4 shows the minimum extinguishing and design concentrations recommended for various flammable liquids.

Fuel	Minimum Extinguish Concentration Cup Burner (% v/v)	Design Concentration, 30% Safety Factor (% v/v)
1-Butane	4.90	6.59
1-Propanol	5.40	7.26
2,2,4-Trimethylpentane	4.70	6.32
2-Butoxyethanol	5.20	6.99
Acetone	4.30	5.78
Acetonitrile	3.23	4.34
Commercial Heptane	4.40	5.92
Commercial Hexanes	4.30	5.78
Cyclohexane	4.50	6.05
Cyclopentanone	4.60	6.19
Denatured Alcohol (92.2% EtOH, 4.6% IPA, 3.1% MeOH)	5.30	7.13
Diesel Fuel	3.40	4.57
Diethyl Ether	4.90	6.59
Ethanol	5.50	7.40
Ethyl Acetate	4.70	6.32
Gasoline-87 oct. unleaded	4.50	6.05
Hexene	4.60	6.18
Isooctane	4.70	6.32
Isopropanol Alcohol	4.90	6.59
Methane	5.60	7.53
Methanol	6.50	8.75
Methyl Ethyl Ketone	4.50	6.05
Methyl Isobutyl Ketone	4.40	5.92
Methyl Tert Butyl Ether	4.58	6.15
n-Heptane	4.50	6.05
n-Pentane	4.70	6.32
Octane	4.40	5.92
Propane	5.80	7.80
Pyrrolidine	4.70	6.32
Technical Heptane	4.30	5.78
Tetrahydrofuran	5.00	6.72
Toluene	3.50	4.71
Transformer Oil	4.50	6.05

Table 4 – Design concentrations for FK-5-1-12 systems (Source: 3M).

The values in ***Table 5*** were verified by means of real fires in “pan and crib” tests on flammable liquids and represent concentrations 30% higher than the test values from the NFPA 2001 standard. Typical Class A dangers include surface fires in wood or in cellulose materials. ***For other fire risks consult SIEX.***

1.4.3 Calculation of the percentage concentration

As explained above, the majority of fires are normally included in one of the two categories (*Classes A and B*), although at times they may be a combination of the two. The designer needs to take into account the type of fire to establish the correct design concentration and so determine the quantity of extinguishant needed. The three types of fires which will be considered in this manual are:

- ✓ ***Class A***: Wood, paper, clothing or anything which leaves an ash residue after combustion
- ✓ ***Class B***: For flammable liquids
- ✓ ***Class C:*** For electrical risks

A guide is given below to determine the appropriate percentage extinguishant concentration according to the hazard.

1.4.4 Class A fires or Electrical Risks and n-heptane risks

a) According to NFPA 2001:

The design concentrations given in table 6 are for 69.8ºF (21ºC). The values for Class B are for heptane. The values for the design for class A have a safety factor of 1.2, the values for the design of class B have a safety factor of 1.3. The class C fires correspond to the minimum concentration for Class A fire plus a safety factor of 1.35.

FUELS	EXTINGUISHING %	MINIMUM DESIGN %
Class A surface fires 1)	3.34	4.50
Class B	4.50	5.85
Class C	3.34	4.51

1) NFPA 2001, 5.4.2.4* The minimum design concentration for a Class A surface-fire hazard shall be determined by the greater of the following:
(1) The extinguishing concentration, as determined in 5.4.2.2, times a safety factor of 1.2. (3.34*1.2= 4.0)
(2) Values base on the Standard **NFPA 2001 table A.5.4.2 (b**) minimum burner extinguishment concentration. (4.5).

Table 5 – FK-5-1-12 nominal design and extinguishing concentrations NFPA 2001.

b) According to ISO 14520 and UNE-EN 15004:

The design concentration for Class A fires and electrical hazards is 5.3% according to ISO 14520 – UNE-EN 15004, and it is different for Class B fires.

The systems protecting hazards which contain Class B flammable hazards and for n-heptane, can be designed with a concentration of 5.9%. (According to ISO 14520 and UNE-EN 15004).

FUEL	EXTINGUISHING %	MINIMUM DESIGN %
Class A surface fires [2)]	4.1	5.3
Class B [1)]	4.5	5.9
Higher Hazard Class A	a	5.6
➢ *NOTES:* *1) See 7.5.1.3 of the Standard ISO 14520-1* *2) Values based on the Standard UNE-EN 15004, Annex B, according to the cup burner method.*		
[a]) The minimum design concentration for Higher Hazard Class A fuels shall be the higher of the Surface Class A or of the Class B minimum design concentration.		

Table 6 - Design and extintion concentrations for FK-5-1-12 taken from the Standards ISO 14520 and UNE-EN 15004.

1.4.5 Safety guidelines

The safety guidelines in this section are as specified in *NFPA 2001,* ISO 14520 and UNE-EN 15004*.* During the evaluation of the project, Designers must take into account the occupation of the protected areas and must bear in mind any hazard to people who might be in the enclosure due to the discharge of the extinguishant. They must make the necessary adjustments and to state any appropriate recommendations.

The terms "NOAEL" and "LOAEL" which appear in ***Table 7*** are defined below:

- ✓ ***NOAEL (No Observed Adverse Effect Level):*** the highest concentration at which no adverse physiological or toxic effect has been observed.

- ✓ ***LOAEL (Lowest Observed Adverse Effect Level):*** the lowest concentration at which an adverse physiological or toxic effect has been observed.

The maximum concentration must not exceed 10% (*corresponding to the LOAEL value for the FK-5-1-12 Extinguishant, see Table 7*).

PROPERTIES	VALUE
NOAEL	*10 %*
LOAEL	*>10%*

Table 7 – Toxicological information for FK-5-1-12 according to NFPA-2001, according to ISO 14520 and UNE-EN 15004.

> ➢ ***NOTE****: Systems designed to exceed NOAEL (10%) shall be installed in accordance with the NFPA 2001 standard.*

The maximum concentration may exceed 10% (LOAEL) without the need to install a lock-off device since there is no risk to people in an unoccupiable area.

1.4.6 Specific types of detection

The types of detection and control panels are installed, tested and maintained meeting with the appropriated standard form NFPA regarding to signalling protection systems (see NFPA 72, *National Fire Alarm Code*). UL listed, FM approved and compatible with Siex's equipment for automatic detection and actuation should be used.

The specific sensors which can be connected to the equipment of an extinguishing system are:

-Smoke detector.
-Heat detector.
-Multisensor detector.
-Aspirating smoke detector.
-High heat sensor.

As redundant detection system as complementary of the detection systems mentioned above, a mechanical detection system (TK-SIMPLEX or TK-COMPLEX) may be used for the actuation of the extinguishing system (see components manual for detailed information).

1.4.7 Calculation of extinguishant quantity

The necessary steps to establish the estimated quantity of FK-5-1-12 to protect the hazard areas, according to the NFPA-2001, ISO 14520 and UNE-EN 15004, are shown below.

1.4.8 Determining the volume of the hazard

The first step in designing the system for FK-5-1-12 extinguishant is to determine the volume of the space to be protected. Flooding will be total, therefore the area to be flooded is considered to be a closed area without openings so that the extinguishing concentration established can be achieved and maintained.

Depending on the layout of the enclosure to be protected, for example an enclosure with several sectors or zones, may need to be divided into such sectors to later obtain the total volume of the enclosure, which will be the sum of the zones or sectors, possibly such as false ceilings, false floors, cable ducts, etc. These are considered to be enclosures adjacent to the risk and hence would need to be flooded with simultaneous discharges. Should the false ceiling and floors have very high structural strength, it might be possible to consider them as independent hazards.

As a general rule, the volume used to calculate the quantity of FK-5-1-12 needed must be based on the empty space (gross volume). Some additional considerations must be taken into account:

- ✓ The space occupied by fixed objects or parts of the structure discountable as the Extinguishant cannot penetrate them can be subtracted from the protected volume.
- ✓ Any volume open from the space to protected (*e.g. ducts without a draft regulator, openings which cannot be closed at the time when the discharge occurs, etc*).

> ➢ ***NOTE:*** *Any object which can be moved out of the protected space* ***MAY NOT*** *be subtracted from the volume considered*

1.4.9 Determining the Extinguishant

This calculation must be based on two significant criteria: *the ambient temperature of the enclosed space and the design concentration*, as explained in this manual.

To determine the quantity of extinguishant needed to produce the design concentration level, the volume of the hazard is multiplied by the factors indicated in the following formula:

$$W = \frac{V}{S} \times \left(\frac{C}{(100 - C)} \right)$$

Formula 1 – (Reference in NFPA 2001, ISO 14520, UNE-EN 15004).

Where:

- ***W = Weight of extinguishant lb (kg)***
- ***V = Volume of the hazarad to be protected ft^3 (m^3)***
- ***C = Design concentration (% by volume)***
- ***S = Specific volume ft^3/lb (m^3/kg). Specific volume of superheated FK-5-1-12 vapour at 14.69 psi (1.013bar), according to the expression:***

$$S = k_1 + k_2 x T$$

Where:

- ***k_1 = 0.9856 (0.0664)***
- ***k_2 = 0.002441 (0.0002741)***
- ***T = temperature ºF (°C)***

> ➢ ***ATTENTION***: *Any variation in the volume of the risk to cover or the addition or removal of fixed elements not included in the original design will affect the concentration of the agent. In such cases the system will need to be recalculated to achieve the appropriate design concentration.*

An Exercise is carried out below to determine the quantity of FK-5-1-12 extinguishant needed.

☑ ***EXAMPLE 1:*** ***Let us assume that we have an enclosure with a volume of 13,145.89 ft³ (372.25 m³) with an ambient temperature of 68ºF (20 °C) and a design concentration of 5.85%. The minimum temperature expected for this enclosure in exceptional cases is 41ºF (+5ºC).***

We know that:

- ***C (Design concentration) = 5.85%***
- ***V (Volume) = 13145.89 ft³ (372.25 m³)***
- ***S = 0.9856+0.002441x41ºF = 1.0856 ft³/lb (0.0664+0.0002741x5°C = 0.0677 m³/kg)*** (41ºF (5ºC) is the minimum expected temperature regardless the usual ambient temperature. The calculation must be done at the minimum expected temperature in order to consider the worse case.)

Substituting these values in the expression:

$$W = \frac{13{,}145.89\,ft^3}{1.0856\,ft^3/lb}\left(\frac{5.85\%}{100-5.85\%}\right) = 756.14lb$$

$$W = \frac{372.25m^3}{0.0677m^3/kg}\left(\frac{5.85\%}{100-5.85\%}\right) = 341.65kg$$

In this risk area we need 756.14 lb (341.65 kg) of FK-5-1-12.

Another calculation method for the quantity of extinguishant and one which is much quicker is to use Table 10 directly. (Reference NPFA 2001, Table A-5.5.1.) (Reference UNE-EN 15004-5, Table 3) (ISO 14520-9, Table 3). The quantities for total flooding are shown in the table based on Formula 1. To determine the quantity of extinguishant needed to produce the desired concentration level, the volume of the hazard is multiplied by the factor from the appropriate table (e.g.: 13,145.89 ft³ x0.0589 [5.85% @ 41ºF] = 756.14 lb (372.25 m³ x 0.9418 [5.85% @ 5 °C] = 341.658 kg).) The minimum value for the temperature given in the table is -20ºF (-20ºC).

Temp (t) (°F)	Specific volume Volume (s) (ft3/lb)	WEIGHT OF FK-5-1-12 REQUIRED PER UNIT OF PROTECTED ENCLOSED AREA, W/V (lb/ft3) DESIGN CONCENTRATION (% by volume)							
		3	4	5	6	7	8	9	10
-20	0.93678	0.0330	0.0445	0.0562	0.0681	0.0803	0.0928	0.1056	0.1186
-10	0.96119	0.0322	0.0433	0.0548	0.0664	0.0783	0.0905	0.1029	0.1156
0	0.9856	0.0314	0.0423	0.0534	0.0648	0.0764	0.0882	0.1003	0.1127
10	1.01001	0.0306	0.0413	0.0521	0.0632	0.0745	0.0861	0.0979	0.1100
20	1.03442	0.0299	0.0403	0.0509	0.0617	0.0728	0.0841	0.0956	0.1074
30	1.05883	0.0292	0.0394	0.0497	0.0603	0.0711	0.0821	0.0934	0.1049
40	1.08324	0.0286	0.0385	0.0486	0.0589	0.0695	0.0803	0.0913	0.1026
50	1.10765	0.0279	0.0376	0.0475	0.0576	0.0680	0.0785	0.0893	0.1003
60	1.13206	0.0273	0.0368	0.0465	0.0564	0.0665	0.0768	0.0874	0.0981
70	1.15647	0.0267	0.0360	0.0455	0.0552	0.0651	0.0752	0.0855	0.0961
80	1.18088	0.0262	0.0353	0.0446	0.0541	0.0637	0.0736	0.0838	0.0941
90	1.20529	0.0257	0.0346	0.0437	0.0530	0.0624	0.0721	0.0821	0.0922
100	1.22970	0.0252	0.0339	0.0428	0.0519	0.0612	0.0707	0.0804	0.0904
110	1.25411	0.0247	0.0332	0.0420	0.0509	0.0600	0.0693	0.0789	0.0886
120	1.27852	0.0242	0.0326	0.0412	0.0499	0.0589	0.0680	0.0774	0.0869
130	1.30293	0.0237	0.0320	0.0404	0.0490	0.0578	0.0667	0.0759	0.0853
140	1.32734	0.0233	0.0314	0.0397	0.0481	0.0567	0.0655	0.0745	0.0837
150	1.35175	0.0229	0.0308	0.0389	0.0472	0.0557	0.0643	0.0732	0.0822
160	1.37616	0.0225	0.0303	0.0382	0.0464	0.0547	0.0632	0.0719	0.0807
170	1.40057	0.0221	0.0297	0.0376	0.0456	0.0537	0.0621	0.0706	0.0793
180	1.42498	0.0217	0.0292	0.0369	0.0448	0.0528	0.0610	0.0694	0.0780
190	1.44939	0.0213	0.0287	0.0363	0.0440	0.0519	0.0600	0.0682	0.0767
200	1.47380	0.0210	0.0283	0.0357	0.0433	0.0511	0.0590	0.0671	0.0754
210	1.49821	0.0206	0.0278	0.0351	0.0426	0.0502	0.0580	0.0660	0.0742
220	1.52262	0.0203	0.0274	0.0346	0.0419	0.0494	0.0571	0.0650	0.0730

Table 8- Quantities of FK-5-1-12 for flooding (U.S. Units).

Temp (t) (°C)	Specific Vapor Volume (s) (m3/kg)	WEIGHT OF FK-5-1-12 REQUIRED PER UNIT OF PROTECTED ENCLOSED AREA, W/V (kg/m3) DESIGN CONCENTRATION (% by volume)							
		3	4	5	6	7	8	9	10
-20	0.0609140	0.5077	0.6840	0.8640	1.0479	1.2357	1.4275	1.6236	1.8241
-15	0.6022855	0.4965	0.6690	0.8450	1.0248	1.2084	1.3961	1.5879	1.7839
-10	0.0636570	0.4859	0.6545	0.8268	1.0027	1.1824	1.3660	1.5337	1.7455
-5	0.0650285	0.4756	0.6407	0.8094	0.9816	1.1575	1.3372	1.5209	1.7087
0	0.0664000	0.4658	0.6275	0.7926	0.9613	1.1336	1.3096	1.4895	1.6734
5	0.0677715	0.4564	0.6148	0.7766	0.9418	1.1106	1.2831	1.4593	1.6395
10	0.0691430	0.4473	0.6026	0.7612	0.9232	1.0886	1.2576	1.4304	1.6070
15	0.0705145	0.4386	0.5909	0.7464	0.9052	1.0674	1.2332	1.4026	1.5757
20	0.0718860	0.4302	0.5796	0.7322	0.8879	1.0471	1.2096	1.3758	1.5457
25	0.0732575	0.4222	0.5688	0.7184	0.8713	1.0275	1.1870	1.3500	1.5167
30	0.0746290	0.4144	0.5583	0.7052	0.8553	1.0086	1.1652	1.3252	1.4888
35	0.0760005	0.4069	0.5482	0.6925	0.8399	0.9904	1.1442	1.3013	1.4620
40	0.0773720	0.3997	0.5385	0.6802	0.8250	0.9728	1.1239	1.2783	1.4361
45	0.0787435	0.3928	0.5291	0.6684	0.8106	0.9559	1.1043	1.2560	1.4111
50	0.0801150	0.3860	0.5201	0.6570	0.7967	0.9395	1.0854	1.2345	1.3869
55	0.0814865	0.3795	0.5113	0.6459	0.7833	0.9237	1.0671	1.2137	1.3636
60	0.0828580	0.3733	0.5029	0.6352	0.7704	0.9084	1.0495	1.1936	1.3410
65	0.0842295	0.3672	0.4947	0.6249	0.7578	0.8936	1.0324	1.1742	1.3191
70	0.0856010	0.3613	0.4868	0.6148	0.7457	0.8793	1.0158	1.1554	1.2980
75	0.0869725	0.3556	0.4791	0.6052	0.7339	0.8654	0.9998	1.1372	1.2775
80	0.0883440	0.3501	0.4716	0.5958	0.7225	0.8520	0.9843	1.1195	1.2577
85	0.0897155	0.3447	0.4644	0.5866	0.7115	0.8390	0.9692	1.1024	1.2385
90	0.0910870	0.3395	0.4574	0.5778	0.7008	0.8263	0.9547	1.0858	1.2198
95	0.0924585	0.3345	0.4507	0.5692	0.6904	0.8141	0.9405	1.0697	1.2017
100	0.0938300	0.3296	0.4441	0.5609	0.6803	0.8022	0.9267	1.0540	1.1842

Table 9 – Quantities of FK-5-1-12 for flooding (I.S. Units).

1.4.10 Correction factors for altitude

The design quantity of FK-5-1-12 needs to be adjusted so as to compensate for ambient pressures which vary by over 11% (equivalent to a change of 3.28 ft (1 m) in elevation) with respect to the pressure at sea level (14.69 psi (1.013 bar) absolute) since the pressure is lower at greater altitude and therefore the quantity of extinguishant needed will be less.

To compensate for these effects, the quantity of extinguishant needed must be adjusted by means of the correction factors indicated in ***Table 10: (Reference: NFPA 2001 Table 5.5.3.3).***

Altitude, ft (km)	Enclosure pressure, mm Hg (psia)	Atmospheric correction
-3,000 (-0.92)	840 (16.25)	1.11
-2,000 (-0.61)	812 (15.71)	1.07
-1,000 (-0.30)	787 (15.23)	1.04
0.00 (0.00)	760 (14.71)	1.00
1,000 (0.30)	733 (14.18)	0.96
2,000 (0.61)	705 (13.64)	0.93
3,000 (0.92)	678 (13.12)	0.89
4,000 (1.22)	650 (12.58)	0.86
5,000 (1.52)	622 (12.04)	0.82
6,000 (1.84)	596 (11.53)	0.78
7,000 (2.13)	570 (11.03)	0.75
8,000 (2.45)	550 (10.64)	0.72
9,000 (2.74)	528 (10.22)	0.69
10,000 (3.05)	505 (9.77)	0.66

Table 8 – Correction factors for altitude.

Hence, the quantity of extinguishant is determined by multiplying the quantity of extinguishant obtained by the correction factor in cases where this needs to be applied.

1.4.11 Determining the actual concentration at the maximum temperature

The concentration level expected at the maximum temperature in the risk also needs to be calculated. This is a necessary step when designing systems for occupied spaces to evaluate the system requirements dealt with before in an appropriate manner. It is mandatory to calculate the concentration at the minimum and maximum expected temperature for the enclosure, which gives the minimum and maximum concentration respectively.

To determine the concentration expected at the minimum and maximum temperature, the following formula may be used:

$$C = \frac{100 x W x S}{(V + W x S)}$$

Where:

- ***W = Weight of extinguishant lb (kg)***
- ***V = Volume of the hazard to be protected ft^3 (m^3)***

- ***C = Design concentration (% by volume)***
- ***S = Specific volume ft^3/lb (m^3/kg). Specific volume of superheated FK-5-1-12 vapour at 14.69 psi (1.013bar), according to the expression:***

$$S = k_1 + k_2 x T$$

Where:

- ***k_1 = 0.9856 (0.0664)***
- ***k_2 = 0.002441 (0.0002741)***
- ***T = temperature ºF (°C)***

☑ **EXAMPLE 2:** ***Let us assume that we have an enclosure with a volume of 13,145.89 ft^3 (372.25 m^3) with 774 lb (350 kg) of extinguishant and an ambient temperature of 120 ºF (50 °C). The minimum expected temperature is 40ºF (+5ºC). What will be the actual concentration in the enclosure?***

- ***S = 1.27852 ft^3/lb (0.080115 m^3/kg) (from Table 8 and 9 at 120ºF (50ºC))***
- ***V = 13,145.89 ft^3 (372.25 m^3)***
- ***W = 774.29 lb (350.58 kg)***

$$C = \frac{100x(774.29x1.27852)}{(13{,}145.89 + 774.29x1.27852)} = \frac{98{,}994.52}{14{,}135.83} = 7.00\%$$ *- Maximum concentration*

$$C = \frac{100x(350.58x0.080115)}{(372.25 + 350.58x0.080115)} = \frac{2{,}808.67}{400.33} = 7.01\%$$ *- Maximum concentration*

As mentioned above, the minimum concentration in the enclosure is given by the minimum expected temperature. It is necessary to check that the minimum expected concentration (at the minimum temperature) has a value, equal or higher, than the design concentration for the hazard.

- ***S = 1.08324 ft^3/lb (0.06777 m^3/kg) (from table 8 and 9 at 40 ºF (5 °C))***
- ***V = 13,145.89 ft^3 (372.25 m^3)***
- ***W = 774.29 lb (350.58 kg)***

$$C = \frac{100x(774.29x1.08324)}{(13{,}145.89 + 774.29x1.08324)} = \frac{83{,}874.18}{13{,}984.63} = 5.99\%$$ *- Minimum concentration*

$$C = \frac{100x(350.58x0.06777)}{(372.25 + 350.58x0.06777)} = \frac{2{,}375.88}{396.01} = 5.99\%$$ *- Minimum concentration*

1.4.12 Leaks or openings in the protected area

The physical characteristics of the protected spaces must be taken into account when a design is produced for an SIEX-NC™ 1230 system. Open areas must be closed and, if they cannot be, these openings must be kept to a minimum to prevent extinguishant leaking into neighbouring spaces (*which would reduce the effectiveness of the system in extinguishing the fire*).

Simply adding a greater quantity of extinguishant is not only not very practical, ***but also ineffective***. Hence all openings need to be sealed or equipped with automatic closures.

Forced ventilation systems must be disconnected or shut off automatically if their continued operation would affect the agent's capacity to extinguish the fire. It is not necessary to disconnect internal recirculation ventilation systems, but it is advisable. Draft regulators must be of the "low smoke" or 100% closure type to ensure adequate sealing and prevent leaks. When the ventilation system is not disconnected or regulated, the associated ducting and ventilation units must be considered to be part of the total volume of the hazard in establishing the quantity of extinguishant needed.

To reach and maintain the desired concentration for sufficient time for the emergency personnel to respond, all protected enclosures must be sealed. Under normal circumstances the extinguishant will extinguish the fire quickly so limiting possible damage caused by the fire and the production of dangerous decomposition products.

Consequently, it is fundamental that the protected area is constructed so as to prevent any leak from the protected spaces.

Some guidelines are given below on controlling gas leaks from the hazard.

- ***Doors:*** All doors which lead to or from the perimeter of the protected area must be fitted with seals at the bottom, for insulation around the doorjamb and around the latch and closure mechanisms. Double doors will also need to have insulating mouldings to prevent leaks between the doors and a coordinator to ensure the appropriate closure sequence. Doors which cannot be kept shut normally must be fitted with mechanical and magnetic closures which will unblock the doors should the alarm be triggered.

- ***Ducting:*** All ducting which enters or leaves the protected area must be insulated and sealed. Closures must be of spring or motorised type to cut off the air 100% when the system is activated.

- ***Air ventilation/duct:*** It is recommended that all the air duct or ventilation units be shut down when the alarm is triggered to prevent leaks to other zones. If the air duct units cannot be disconnected, the volume of the corresponding ducting must be added to the total volume of the protected space and more extinguishant must be added to compensate for this additional volume.

- ***Break-throughs:*** All holes, cracks, openings or break-through in the walls which define the perimeter of the protected area must be sealed. This includes some less obvious leakage zones such as gutters and pipe and drain casings. To prevent leaks, it must be ensured that drains have collectors full of a product which does not evaporate.

- ***Walls:*** All the walls which define the perimeter of the protected area must extend from side to side and be sealed at the top and the bottom and inside. When the walls do not extend from side to side, partition walls will be installed to achieve the desired sealing characteristics.

- ***Air brick walls:*** Porous walls made from air bricks must be sealed or the FK-5-1-12 extinguishant will leak out.

> ➢ ***NOTE:*** *It is essential when designing a gas extinguishing system to be familiar with or to thoroughly examine hazard. An essential aspect is to examine any openings through which extinguishing gas might escape.*

SIEX *has the necessary machinery available to carry out tests to determine the integrity of the enclosure. This test is known as a "**Door fan test**". Similar conditions are generated in this test to those which would occur during the discharge of the extinguishant. It is then possible to check if the concentration is maintained during the hold time set by the standard.*

*The Integrity Test in the enclosure by means of fan pressurisation must be carried out in accordance with the requirements of the manufacturer and the **NFPA2001 Annex C and UNE-EN 15004 Annex E**.*

1.4.13 System design concept

Distribution of FK-5-1-12 extinguishant in the protected area must be carried out by means of one or more of the following pipe distribution systems.

1.- Engineered system,

2.- Modular system (engineered),

3.- Central storage system or banks of bottles (engineered).

The method used will depend on several factors, including: installation time, amount of extinguishant used, economic factors, number of protected areas, space available to locate the storage containers and the client's preferences. For larger projects with more complex pipe networks more than one method will be required to tackle the challenges posed, so designers must familiarise themselves with each of these methods as well as their advantages and disadvantages for any specific application.

1. Engineered system

Engineered systems allow a designer to create a customised pipework to adapt to the individual needs of the project. The pipe configurations can be balanced or unbalanced and the flow separations within the system can vary from one point to another. This requires a computer hydraulic flow calculation to create a model of the system and verify if its operation complies with the requirements of the NFPA 2001, ISO-14520 and UNE-EN-15004 before installation. Consequently, although more design time is usually needed, this concept offers the designer greater working flexibility. To carry out the hydraulic flow calculations you will need a copy of SIEX's flow calculation software. Engineered systems can be designed with modular cylinders and banks of cylinders.

2. Modular systems

Modular systems can be defined as a design concept where the containers are located throughout or around the protected areas. These keep the needs for discharge pipes to a minimum, but increase the quantity of electrical materials needed to reach the position of each container.

To reduce the quantity of piping and the installation work in large applications, it is often desirable (or necessary) to use a modular distribution. In some cases this concept will be necessary for the system to make the required quantity of extinguishant pass.

3. Centralised systems or banks of bottles

Bottle or cylinder bank systems can be defined as a design concept where the containers are located at one point and the pipes lead to the protected area from this point. This concept often requires more discharge piping, but needs less electrical materials to reach the container location. This concept can be more complicated to design due to the increase in piping involved and the installation work will tend to be more expensive for the same reason.

In any case, this type of installation will be preferable for the client from the aesthetic point of view as well as usually being easier to maintain and repair.

ATTENTION

The FK-5-1-12 extinguishant flow calculation program (software) is the only calculation method applicable with SIEX equipment. No other calculation method is accepted for systems supplied by SIEX.

1.5 Selection of containers, cylinders or bottles

The selection of the containers is normally determined by the quantity of FK-5-1-12 needed, considering the filling ranges permitted for the different cylinder sizes. However, other factors can also influence the decision, such as the system design concept, the location of the containers and flow calculation limitations.

1.5.1 Container size and filling range

All the containers must be filled within the filling range permitted by the NFPA 2001, ISO-14520, UNE-EN-15004 and another standars like EN, EEC, ADR, DOT and UL (2166). The filling densities recommended by ***SIEX*** are shown in ***ANNEX 1** in system components manual*.

The filling ranges for the various cylinders offered by ***SIEX*** are collected below in ***ANNEX 2,** in system components manual* along with the valve connection, cylinder length, diameter and tare. For halocarbon clean agents in a multiple container system connected to a manifold, all containers supplying the same manifold outlet for distribution of the same agent shall be interchangeable and of one select size and charge.

1.5.2 Location of containers

The location and type of storage container depend on several considerations:

1) ***Extinguishant quantity:*** The extinguishant storage container selected must have sufficient capacity to store the total volume of extinguishant necessary for the extinguishing system.

2) ***Type of system:*** Each zone must be protected either by several small containers with independent nozzles, or by a group of cylinders (*bank*) of greater capacity which discharge through a pipework with 2, 4 or more nozzles, depending on the needs of the enclosure to be protected.

3) ***Pipe lengths:*** In systems with large pipe structures the pressure drop may be too large for the selected layout and configuration. In some cases it may be necessary to relocate the containers closer to the zones to be protected. It also may be necessary to divide the pipework into smaller configurations with separate containers. It is important to take into account that FK-5-1-12 needs a propelling agent (*dry nitrogen*) and there could, therefore, be a limitation when the pipework is complex.

4) ***Container type:*** The type of container required for the installation must be taken into account (*cylinder capacity*).

5) ***Accessibility for maintenance:*** The containers shall be mounted in such a way as to facilitate maintenance and access to both the container and its contents. In general, the larger the container, the more difficult it will be to separate it from the system to carry out maintenance or repairs. However, it may also be difficult to gain access to small containers when they are located in false floors, under a computer bench or in false ceilings above the same computer bench.

6) ***Floor loading:*** This factor must be considered when selecting the location for the containers. When the loads are excessive it will be necessary to relocate the containers to an appropriate location.

7) ***Proximity:*** The FK-5-1-12 containers must be located as close as possible to the protected area. Preferably this will be outside the enclosure, although they can also be located inside the enclosure if the placement enables the risk of exposure to fire and explosion to be minimised.

8) ***Environmental effects:*** The containers shall **NOT** be located where they can be subject to physical damage, exposure to chemical products or severe atmospheric conditions. An appropriate enclosure will be needed in places where there is a risk of damage or unauthorised handling.

1.5.3 Storage temperature limitations

SIEX's equipment for FK-5-1-12 listed below is designed to **operate within a temperature range of 32ºF to 122ºF (0 to 50 °C)**.

> ***ATTENTION***
>
> The calculation program for the clean agent is designed for an operating temperature between 50ºF and 122ºF (+10ºC and +50°C). Consequently, the usage temperature for the cylinder must be within the same range of temperatures. If the cylinder operating or storage temperature is outside of this range, an insufficient quantity of FK-5-1-12 will discharge through one or more nozzles.

The containers must be located as close as possible to the protected space. The range of storage temperatures for the cylinders is from 32ºF to 122ºF (0 to 50 °C). It may be necessary to heat or cool the cylinder storage area to keep the temperature within this range.

2. Distribution piping and fittings

This section refers to design by computer calculations systems with pipework. Examine the planned configuration to ensure that the pipework and nozzles do not interfere with objects in the hazard area, and make any necessary changes before proceeding with the installation. The pipework and fittings must comply with the limitations detailed below:

2.1 Piping

All the installed piping must be in accordance with the latest requirements included in NFPA-2001, ISO-14520 and UNE-EN 15004. They must be of non-combustible material, and have physical and chemical characteristics that guarantee their integrity under the stresses to which they will be subjected. For the wall thickness calculation we must take into account that they have to withstand a pressure equal to that of the extinguishing gas when stored at 122ºF (50ºC).

Working pressure at 122ºF (50ºC) with FK-5-1-12	(filled at 360 psi (25 bar))	420 psi (29 bar)
	(filled at 460 psi (32 bar))	507 psi (35 bar)
	(filled at 490 psi (34 bar))	551 psi (38 bar)
	(filled at 610 psi (42 bar))	696 psi (48 bar)
	(filled at 725 psi (50 bar))	800 psi (55 bar)
	(filled at 800 psi (55 bar))	870 psi (60 bar)

Table 11

Acceptable piping includes galvanised or black steel to pipe Standard ANSI B31.1. **The types of pipe that must not be used are cast iron, steel pipes to ASTM A 120 specifications and all non-metallic pipes.**

ATTENTION

The calculation program for the clean agent has been investigated and validated for the types of fittings, types of pipe and pipe inside diameters included in this manual.
When the specified limitations are not maintained there is the risk that the system will not supply the required quantity of extinguishing agent.

2.2 Equivalent lengths

The resistance coefficients for the system equipment are implemented in the validated software.

FK-5-1-12	
Dip tube - hose - check valve	Equivalent length in (mm)
RGS-MAM-20	2.2 – Ø0.519 (2.2 - Ø13.2)
RGS-MAM-40	4.91 – Ø1.259 (4.91 - Ø32.0)
RGS-MAM-50	4.91 – Ø1.574 (4.91 - Ø40.0)
RGS-MAM-80	6.3 – Ø3.078 (6.3 - Ø78.2)

Table 12

2.3 Pipe layout (engineered systems)

2.3.1 Pipe joints (fittings)

The mode of joining the pipes must meet the most recent requirements of the NFPA 2001, ISO-14520 and UNE-EN 15004. Acceptable accessories include those which are threaded, with bridles, soldered high pressure grooved and those of brass.

Grooved accessories must be approved for Halocarbonated Gases (FK-5-1-12) applications and only those of high pressure in systems that use cylinders charged with a maximum pressure of 490 psi at 68ºF (34 bar at 20º).

Common grooved accessories for sprinkler networks must not be used.

Wrought iron accessories must be a minimum of 300lb.
Standard cast iron accessories or those of 150 lbs are not acceptable.

Use threaded accessories according to regulation ANSI B1.20.1. or ISO 7-1.
Use soldered accessories according to regulation ASME Boiler and Pressure Vessel Code.

2.3.2 Branching ratios at tees

SIEX's engineered systems for FK-5-1-12 have been proven to define the maximum level of imbalance which can be predicted in tee branches. This value is expressed in terms of the branch ratio at an outlet as the relationship of one with the other. Each ratio indicated refers to a percentage of the total incoming flow.

a) Bull head tee

A bull head tee type is defined as a tee configuration in which the two outlet branches change direction with respect to the inlet branch ***Figures 1-2.***

The branch ratio for a bull head tee type ranges from 25-75 to 50-50.

This means that the output from the main flow has an acceptable range which varies from 50% as a minimum to 75% as a maximum and the output from the secondary flow has an acceptable range between 25% as a minimum and 50% as a maximum. These proportions are percentages of the total incoming flow to the tee.

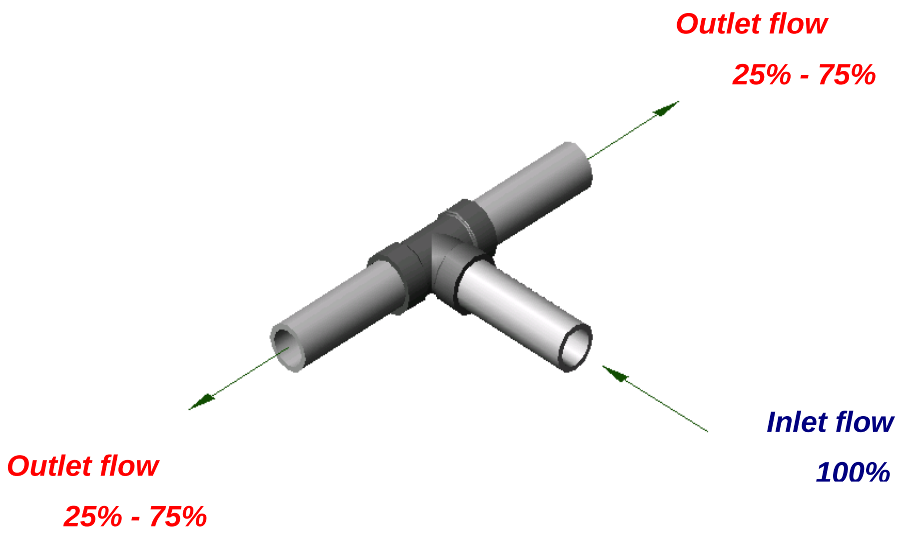


Figure 1 – 25-75% bull head tee

b) Side tee

A side tee type is defined as a tee configuration where one of the branches changes directions with respect to the input and the other continues in the same direction as the input. (***Figure 2)***

The branch ratio for a side tee goes from 10-90 to 25-75. This means that the outlet from the main flow (the branch which does not diverge with respect to the inlet) has an acceptable range which varies from 75% as a minimum to 90% as a maximum and the outlet from the secondary flow (the branch which diverges) has an acceptable range between 10% as a minimum and 25% as a maximum. These proportions are percentages of the total incoming flow to the tee.

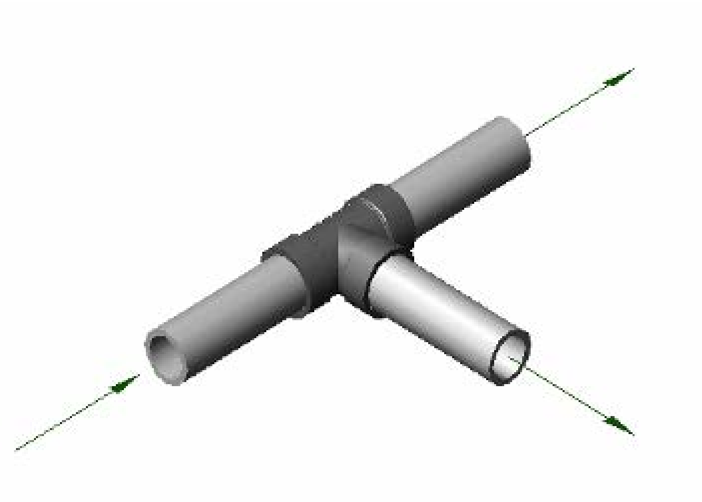


Figure 2 – side tee

c) Tee orientation

SIEX's engineered system with FK-5-1-12 has been proven to define the necessary limitations to precisely predict how the system will behave when a discharge occurs. The tee orientation is an important characteristic in maintaining the consistency of the flow diversion percentages. Therefore, simple rules **MUST** be taken into account with respect to the orientation of the tees, as presented on the next page.

1. *Bull head tees must have both outlets in the **horizontal plane**. **The inlet can be horizontal or vertical from above or below.***

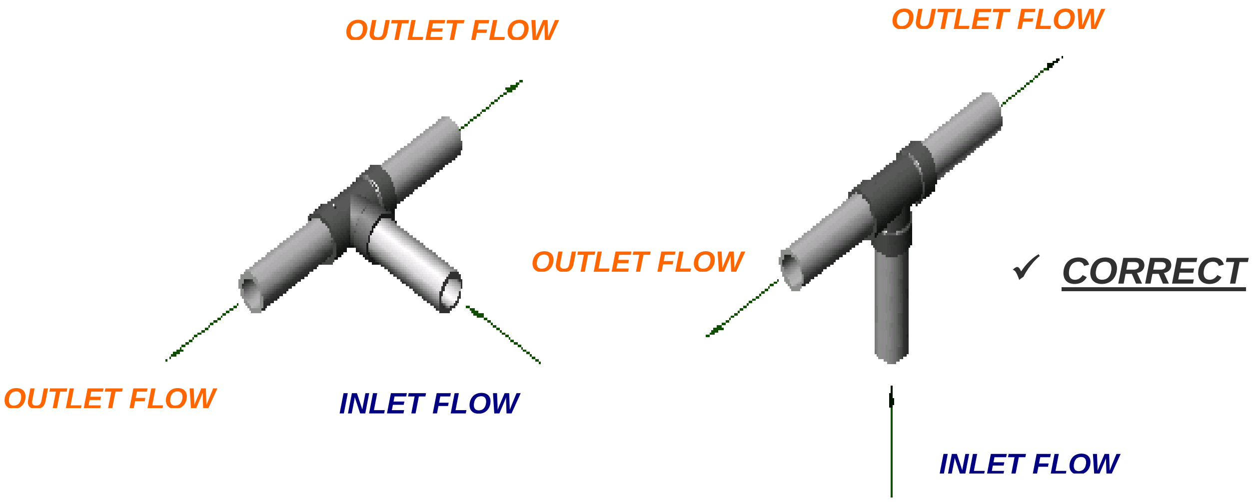


Figure 3– bull head tee

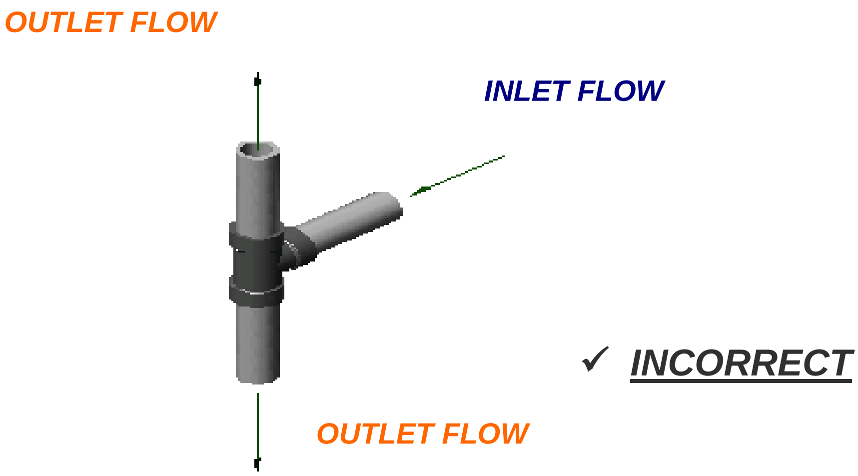


Figure 4 – bull head tee

2. *Side tees must have the **inlet and both outlets in the horizontal plane**.*

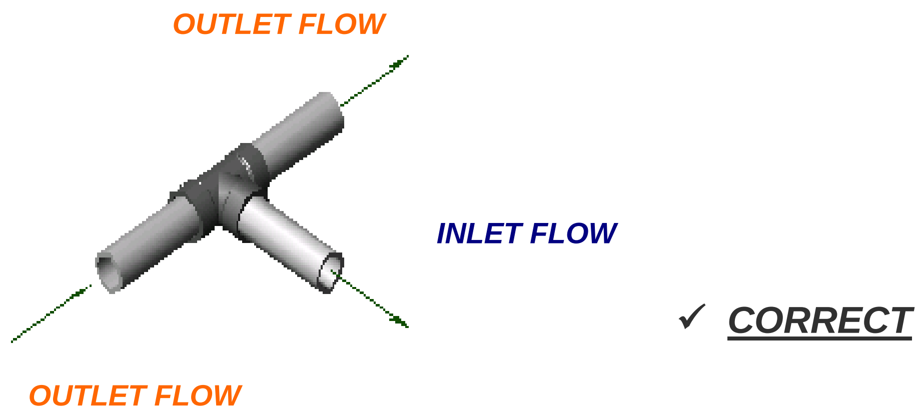


Figure 5– side tee

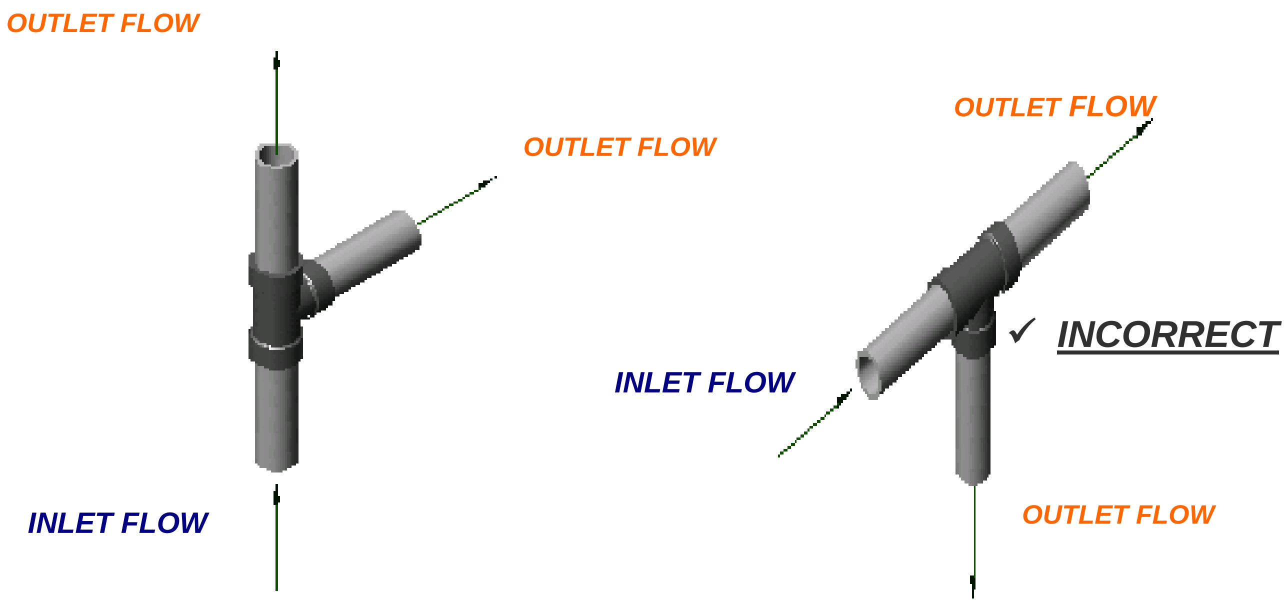


Figure 6 – side tee

2.3.3 Location of the first tee

Some pipe configurations present synchronisation problems for the system due to the high degree of hydraulic imbalance created. For example, a system which branches and supplies agent to nozzles located in the ceiling (room) and in the false floor is unbalanced due to the difference in the pipe sizes and the quantities of agent. The flow program therefore attempts to adjust the orifices in the nozzles' calibrated plates to try to provide the synchronisation needed by the system. When this synchronisation cannot be achieved, the location of the first tee becomes critical.

In this case the minimum distance from the cylinder to the first tee is 11.15 ft (3.4 metres).

2.3.4 Agent percentage in the piping

SIEX's items of equipment for FK-5-1-12 are pressurised systems which use a limited pressurisation source (*dry nitrogen at 360, 460, 490, 610, 725, 800 psi (25, 32, 34, 42, 50 or 55 bar)*) to drive the extinguishant through the pipe network to the protected compartment. Hence, a size (*volume*) limit needs to be set for the associated pipework to ensure that the agent is sent to the protected compartment within the permitted period of time for discharge.

This is a "floating" limit which depends on the size and fills weight of the cylinders or bottles involved. This makes it a design limit which is difficult to identify, but it is usually associated with very large pipe systems and with configurations with multiple tees.

This limitation is therefore defined such that: No more than 74% of the total agent mass must be in the pipework during the discharge.

2.3.5 Time to arrival of the liquid phase

The time needed for the liquid phase FK-5-1-12 to arrive at each nozzle must have a maximum difference of 2 seconds. For example, if the liquefied gas takes two (2) seconds to arrive at the first nozzle (*the closest nozzle to the cylinder*), the arrival time at the other nozzles must not exceed two (2) seconds.

2.3.6 Time to emptying of the liquid phase

The time needed for the liquid phase FK-5-1-12 to discharge at each nozzle must have a maximum difference of 2 seconds. For example, if the liquid phase takes 3 seconds to empty through the first nozzle, the emptying time through the rest of the nozzles must not exceed 5 seconds.

2.3.7 Estimation of pipe sizes (Engineered systems)

To determine the appropriate size in each pipe section, this is selected based on the design flow rate for each pipe section. The size selection depends on the design flow quantity carried by each of the different pipework branches. It must be done using the software. (*see ***Table 13** – **Estimation of pipe diameter.*** This table is only for guidance and it includes two of the most representative starting pressures).

APPROXIMATE PIPE DIMENSIONING		
NOMINAL PIPE DIA.	CHARGED SYSTEM AT 360 PSI (25 BAR)	CHARGED SYSTEM AT 610 PSI (42 BAR)
3/8”	*0 - 19.84 lb (0 - 9 kg)*	*0 - 26.45 lb (0-12 kg)*
1/2"	*13.23 - 33.07 lb (6 - 15 kg)*	*19.84 - 52.91 lb (9 - 24 kg)*
3/4"	*22.05 - 44.10 lb (10 - 20 kg)*	*41.88 - 77.16 lb (19 - 35 kg)*
1”	*46.29 - 81.57 lb (21 - 37 kg)*	*61.73 - 105.82 lb (28 - 48 kg)*
1 1/4"	*74.95 - 132.28 lb (34 - 60 kg)*	*90.39 - 253.53 lb (41 - 115 kg)*
1 1/2"	*105.82 - 249.12 lb (48 - 113 kg)*	*200.62 - 429.90 lb (91 - 195 kg)*
2”	*171.96 – 476.20 lb (78 - 216 kg)*	*332.89 - 637.13 lb (151 - 289 kg)*
2 1/2"	*198.42 - 573.20 lb (90 - 260 kg)*	*685.64 - 1058.22 lb (311 - 480 kg)*
3”	*299.83 - 899.48 lb (136 - 408 kg)*	*1060.42 - 1421.98 lb (481 - 645 kg)*
4”	*548.95 - 1250.02 lb (249 - 567 kg)*	*1424.18 - 1719.60 lb (646 - 780 kg)*
5”	*899.48 - 1999.59 lb (408 - 907 kg)*	-
6”	*1199.31 - 2504.45 lb (544 - 1136 kg)*	-

Table 13 – Estimation of pipe diameter

☑ EXAMPLE 5: ***Starting from a pipe network which discharges 441 lb (200 kg) through four nozzles at 360 psi (25 bar), what will be the section in the different branches?***

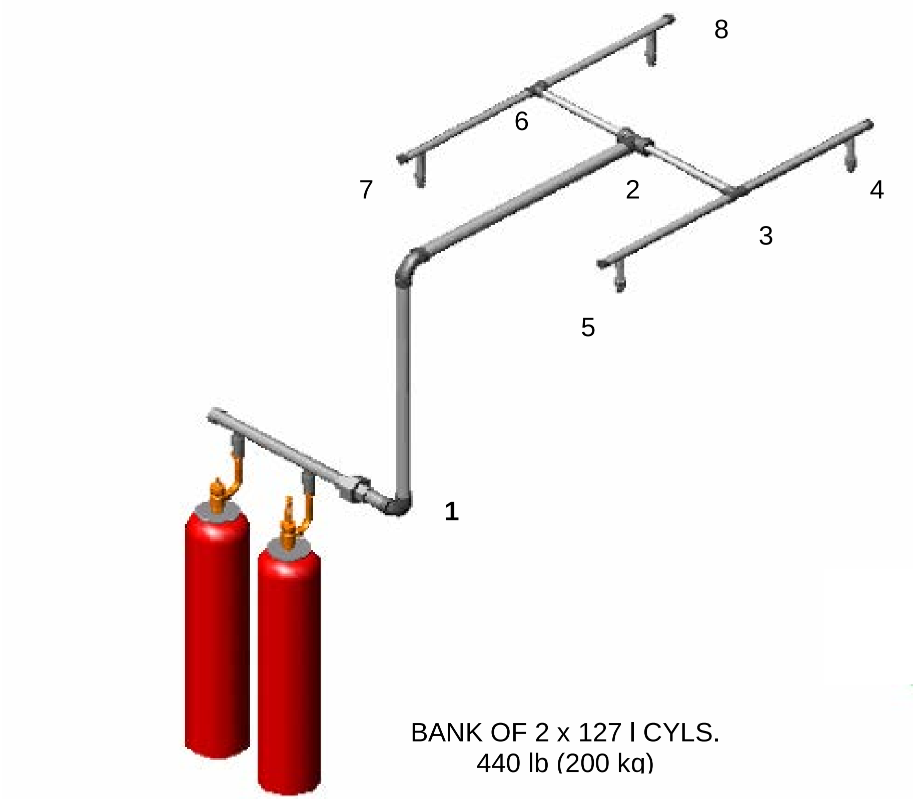


Figure 7

DESIGN FLOW	CHARGED SYSTEM	PIPE DIA.
SECTION 1-2	440 lb (200 kg)	2 1/2"
SECTION 2-3	220 lb (100 kg)	2"
SECTION 3-4	110 lb (50 kg)	1 1/4"
SECTION 3-5	110 lb (50 kg)	1 1/4"
SECTION 2-6	220 lb (100 kg)	2"
SECTION 6-7	110 lb (50 kg)	1 1/4"
SECTION 6-8	110 lb (50 kg)	1 1/4"

Table 14

2.3.8 Piping characteristics

The wall thickness of the pipe is calculated as a function of the pressure at the maximum storage temperature in the bottle, this being not less than 122 ºF (50 °C), in accordance ASME B31.1. These storage pressures are presented in the table below.

Working pressure at 122ºF (50 °C) (360 psi (25 bar) charge)	**420 psi (29 bar)**
Working pressure at 122ºF (50 °C) (460 psi (32 bar) charge)	**507 psi (35 bar)**
Working pressure at 122ºF (50 °C) (490 psi (34 bar) charge)	**551 psi (38 bar)**
Working pressure at 122ºF (50 °C) (610 psi (42 bar) charge)	**696 psi (48 bar)**
Working pressure at 122ºF (50 °C) (725 psi (50 bar) charge)	**800 psi (55 bar)**
Working pressure at 122ºF (50 °C) (800 psi (55 bar) charge)	**870 psi (60 bar)**

Table 15

Fittings must have a rated working pressure equal to or greater than the maximum pressure in the cylinder at 122ºF (50 °C) when this is at its maximum fill density for the agent used.

2.3.9 Reducers

All reductions in the pipe size must be made using reducing fittings such as concentric reducers. Double elbow reducers are not acceptable.

The system installation drawings (calculation software) must be taken as a reference for sizes and lengths of pipes.

2.3.10 Cleaning

All pipe sections must be fitted and assembled with the appropriate sealants, e.g. Teflon tape or paste (in the case of threaded pipe). All rough edges and residual oils must be removed afterwards.

2.3.11 Threads

It is recommended that Teflon tape be used, applied only to the male threads of the pipe. When Teflon paste is used, impregnate at least one turn of the male thread and one of the female thread. The threads of all the pipes and fittings must be properly sealed. Threads must meet ANSI B1.20.1 or ISO 7-1.

When 3000 lb fittings with NPT threads are used, ensure that the pipes also have NPT threads.

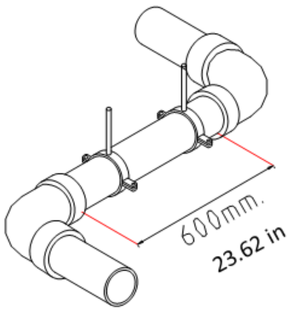
2.4 Installation

All piping must be installed in line with industry best practice. The pipework must be secured with supports that allow for its expansion and contraction.

DISTANCES BETWEEN PIPE SUPPORTS										
Pipe diameter DN (mm)	15	20	25	32	40	50	65	80	100	125
Pipe diameter (inches)	1/2"	3/4"	1”	1 1/4"	1 1/2"	2”	2 1/2"	3”	4”	5”
Maximum distance between supports ft (m)	59.05 (1.5)	70.86 (1.8)	82.68 (2.1)	94.48 (2.4)	106.29 (2.7)	133.85 (3.4)	137.79 (3.5)	145.67 (3.7)	169.29 (4.3)	188.98 (4.8)

Table 16

- Supports must be located between elbows that are 23.62 in (600 mm) apart (see figure A).
- Supports must be fitted 11.81 in (300 mm) from any discharge nozzle (see figure B).
- Supports must be secured to structures capable of supporting the pipework.



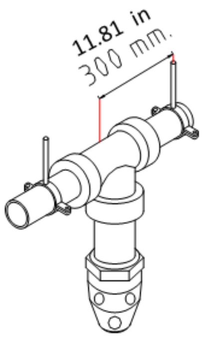


Figure 8

2.5 Electrical clearances

Where electrical conductors are present, the minimum distances stipulated in the High Voltage Regulations must be observed (ANSI C2, NFPA 70 or 29CFR 1910, Subpart S). Should it not be possible to comply with these distances, approved insulators must be fitted to the pipes. It is recommended that the system pipework be earthed in order to discharge any static electricity generated during the discharge of the extinguishing agent (FK-5-1-12).

3. Nozzle selection

The selection of nozzles is generally determined by the quantity of FK-5-1-12 required related to the capacity of the nozzles to allow the flow to pass. Other factors such as the area covered, nozzle layout, obstructions to the discharge duct, etc can also influence the decision.

3.1 Type of system

Designers must take into account the type of system they are going to use. This manual is intended only for engineered systems.

3.2 Flow through the nozzle

The majority of SIEX-NC™ 1230 systems **discharge into the protected space in 8 to 10 seconds**, (in any case the maximum discharge time to achieve the 95% of the design concentration is 10 seconds. The minimum discharge time is 8 seconds) following the requirements of the NFPA 2001, ISO-14520 and UNE-EN 15004. Therefore, the number of nozzles installed must be capable of carrying the required flow to comply with this time criterion.

Each nozzle is capable of carrying a certain range of flow. Table 17 will be used to determine approximately the number and size of the nozzles needed for each area.

> ➢ ***NOTE:*** *The Table must be considered as additional information. The design of the pipe network and the nozzles* ***MUST*** *be verified the SIEX flow calculation program.*

The data in Table 17 must not be used for the design of an engineering system. This table is only for guidance and it includes two of the most representative staring pressures.

FLOW RATES IN NOZZLES (U.S. Units)		
NOMINAL PIPE DIA.	**DESIGN FLOW RATE AT 360 PSI (Min. – Max.)**	**DESIGN FLOW RATE AT 610 PSI (Min. – Max.)**
3/8”	0 - 1.984 lb/s	0 - 2.645 lb/s
1/2”	1.323 - 3.307 lb/s	1.984 - 5.291 lb/s
3/4”	2.205 - 4.410 lb/s	4.188 - 7.716 lb/s
1”	4.629 - 8.157 lb/s	6.173 - 10.582 lb/s
1 1/4"	7.495 - 13.228 lb/s	9.039 - 25.353 lb/s
1 1/2"	10.582 - 24.912 lb/s	20.062 - 42.990 lb/s
2”	17.196 - 47.620 lb/s	33.289 - 63.713 lb/s
2 1/2"	19.842 - 57.320 lb/s	68.564 - 105.822 lb/s

FLOW RATES IN NOZZLES I.S. Units)		
NOMINAL PIPE DIA.	**DESIGN FLOW RATE AT 25 BAR (Min. – Max.)**	**DESIGN FLOW RATE AT 42 BAR (Min. – Max.)**
3/8”	0 - 0.9 kg/s	0 - 1.2 kg/s
1/2”	0.6 - 1.5 kg/s	0.9 - 2.4 kg/s
3/4”	1.0 - 2.0 kg/s	1.9 - 3.5 kg/s
1”	2.1 - 3.7 kg/s	2.8 - 4.8 kg/s
1 1/4"	3.4 - 6.0 kg/s	4.1 - 11.5 kg/s
1 1/2"	4.8 - 11.3 kg/s	9.1 - 19.5 kg/s
2”	7.8 - 21.6 kg/s	15.1 - 28.9 kg/s
2 1/2"	9.0 - 26.0 kg/s	31.1 - 48.0 kg/s

Table 17- Flow rates in nozzles.

***EXAMPLE:* We have a compartment to protect with 1124 lb (510 kg) of extinguishant stored at 360 psi (25 bar). How many nozzles do we need and of what diameters?**

- ***Flow rate: 1124 lb/10s=112.4lb/s (510 kg/10 s = 51 kg/s)***

Table Flow Rate, we see that the maximum design possible for a 2" nozzle is 32.63 lb/s (14.80 kg/s), therefore a minimum of four 2" nozzles is needed, giving a flow through each nozzle of 28.11 lb/s (12.75 kg/s).

3.3 Types of nozzles

The FK-5-1-12 extinguishant distribution within the area to be protected is carried out through the discharge nozzles. Two different nozzle models are available – R°-180 and R°-360:

1.- R°-180 or wall nozzle: The R°-180° or wall nozzle is designed to be installed around the wall for the protected area so that the discharge is directed away from the wall where it is installed. These nozzles have 7 outlet orifices at two levels. Each level has a different angle of inclination to improve gas distribution.

Figure 9 – R°-180 nozzle

2. R°-360 or ceiling nozzle: The R°-360° or ceiling nozzle: is designed to be installed in the centre of the protected area. These nozzles have 8 outlet orifices at two levels. Each level has a different angle of inclination to improve gas distribution.

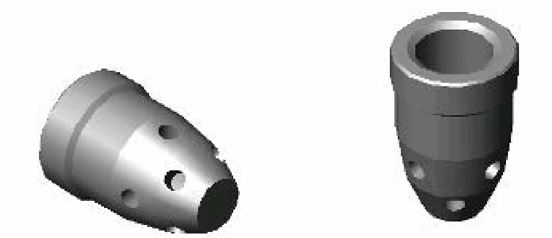


Figure 10 – R°-360 nozzle

The minimum orifice area which may be used for R°-180° or 360° nozzles for an engineered system is 10% of the transverse pipe section. The maximum orifice area must be less than 96% of the transverse section of the pipe. A computer flow calculation program must therefore be used to select the appropriate nozzles to comply with the limitations of the orifice area (maximum/minimum) and with the **minimum pressure restriction in the nozzle of 123 psi (8.5 bar) for systems up to 23.3 ft (7.1m) height and 60.9 psi (4.2 bar) for systems with a max. height of 16.4 ft (5 m).**

WARNING

SYSTEM INSTALLATION MUST NOT START UNTIL THE FINAL PIPE NETWORK DESIGN HAS BEEN VERIFIED USING THE SIEX FLOW CALCULATION PROGRAMM

3.4 Nozzle coverage

It is important to know the maximum coverage of the nozzles when designing a system with FK-5-1-12 so as to determine how many nozzles need to be used in the protected compartment. Each nozzle model (R°180 or R°-360) has been verified for its coverage area limitations.

The maximum area coverage for each nozzle is described as the distance in a straight line from the nozzle to the farthest corner of the protected space. Figures 11 and 12 show the maximum coverage area of for R°-180° and R°-360° nozzles.

360º and 180º nozzle models can be located a maximum of 11.81in (300 mm) below the ceiling (or the highest protected point when the nozzles are stacked). Additionally, the 180° nozzles can be located a maximum of 11.81 in (300 mm) from the wall.

For FM approved systems, the pressure ranges that can be used are 360, 460, 490, 610, 725, 800 psi (25, 32, 34, 42, 50 or 55 bar) for risks up to 5.00m hight and *490, 610, 725, 800 psi (34, 42, 50 or 55 bar)* for risks up to 7.10m hight.

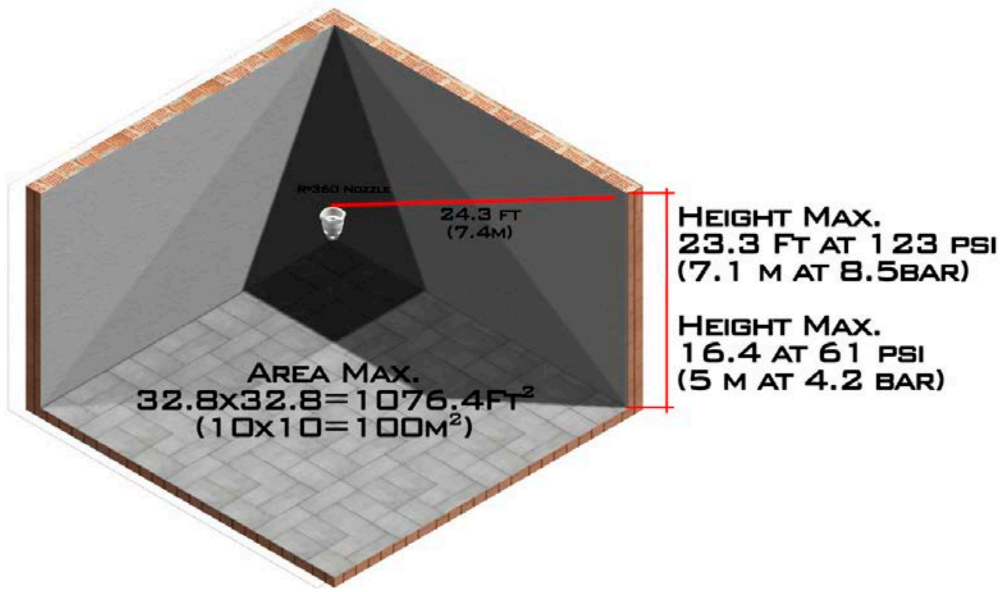


Figure 11 – Radius of coverage for the R°-360 nozzle.

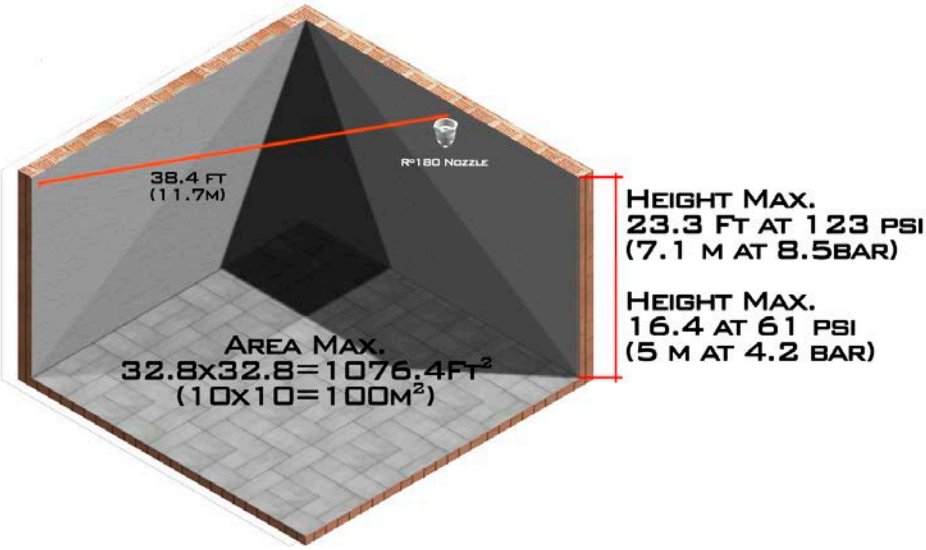


Figure 12 – Radius of coverage for the R°-180 nozzle.

The nozzle sizes available are shown in ***Table 18.***

NOZZLE SIZE	CONNECTION TYPE
3/8" ***1/2"*** ***3/4"*** ***1"*** ***1 1/4"*** ***1 1/2"*** ***2"*** ***2 ½"***	***FEMALE BSP***

Table 18 – Nozzle sizes.

3.5 Nozzle location

Nozzles must be located symmetrically or almost symmetrically within the protected area. The 360° nozzles are designed to be located above or close to the centre line of the protected area to discharge towards the perimeter of the area covered.

The system designer must locate the nozzles on the floor plan and verify that the whole protected area is appropriately covered with no blind spots.

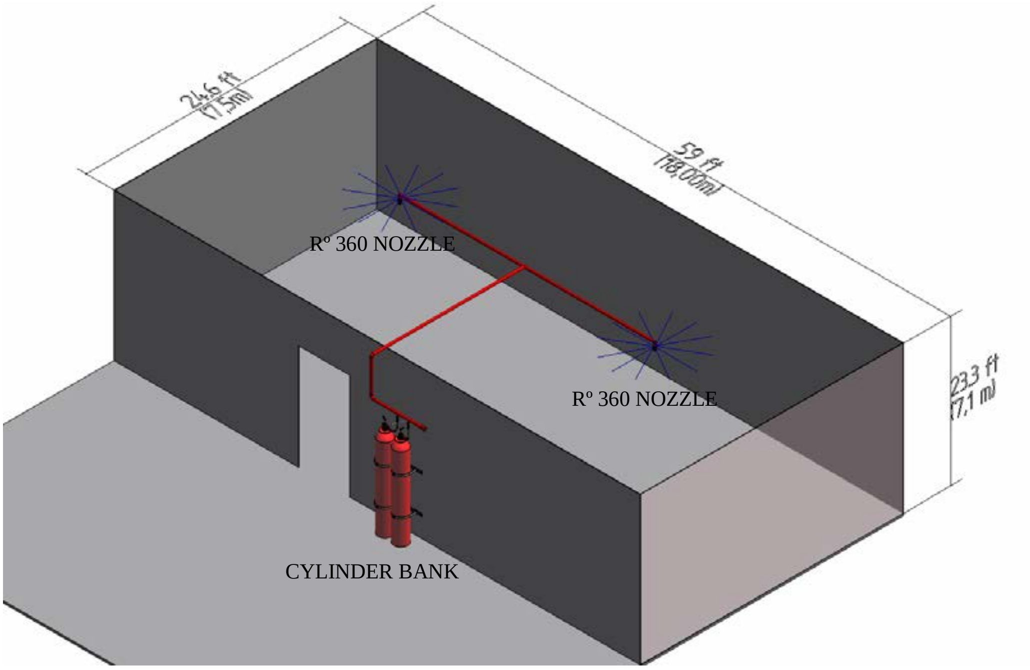


Figure 13

However, the location of the 180° nozzles is different as they are designed to be located around the perimeter of the protected area to discharge towards the opposite side as shown in the plan view. The maximum distance from the wall **MUST NOT** be greater than 11.81 in (300 mm) measured from the centre of the nozzle to the wall.

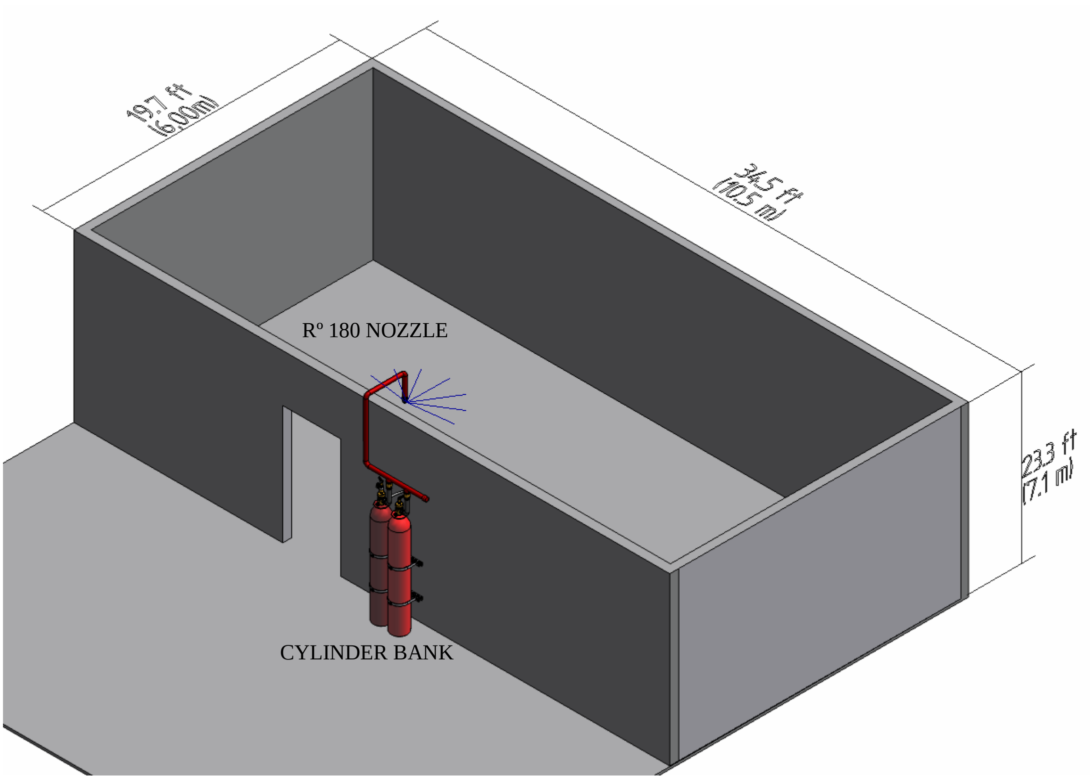


Figure 14

A series of guidelines presented below must be taken into account in locating the nozzles.

Rº180 or wall nozzle:

- Compartment height of 11.8 in to 275.5 in (300 to 7000 mm):

Coverage = 1076.4 ft^2 (100.0 m^2)(for example = 32.8x32.8 ft 10.0x10.0 m)

- Must be installed in the protected compartment so that the discharge is directed away from the wall.

➢ ***NOTE:*** *ALL DISCHARGE NOZZLES MUST BE LOCATED A MAXIMUM OF 11.81 IN (300 MM) BELOW THE CEILING*

Rº360 or ceiling nozzle:

- Compartment height of 11.8 in to 275.5 in (300 to 7000 mm):

Coverage =1076.4 ft^2 (100.0 m^2)

*➢ ***NOTE:*** *In false floors or ceilings with heights between 5.91 and 11.8 in (150 and 300 mm) a lower coverage per nozzle must be established as these areas are normally full of cables, supports, etc, a reduction of the coverage space must be considered when there may be obstacles which impede the uniform distribution of the FK-5-1-12 in the whole area. Please, consult Siex for further guidance.*

*This is not part of the FM approved

3.6 Maximum elevation differences in pipe runs

The maximum elevation difference between horizontal pipe runs or nozzles is limited to 39.3 ft (12 metres).

3.7 Maximum coverage height

The maximum ceiling height when using either R°-180° or R°-360° nozzles with FK-5-1-12 is 23.3 ft at 123 psi (7.1 metres at 8.5 bar) or 16.4 ft at 61 psi (5 m at 4.2 bar). A double height or additional level of nozzles will be needed for room over 23.3 ft (7.1 metres) high. Therefore, when the compartment to be protected exceeds this height nozzles must be installed at several levels (elevations).

EXAMPLE: We need to protect a compartment up to 315 in (8 metres) high. Therefore, the lowest level of nozzles COULD be located at a height of 13.1 ft (4 metres) and the second (upper) level of nozzles MUST be located a maximum of 11.81 in (300 mm) from the ceiling.

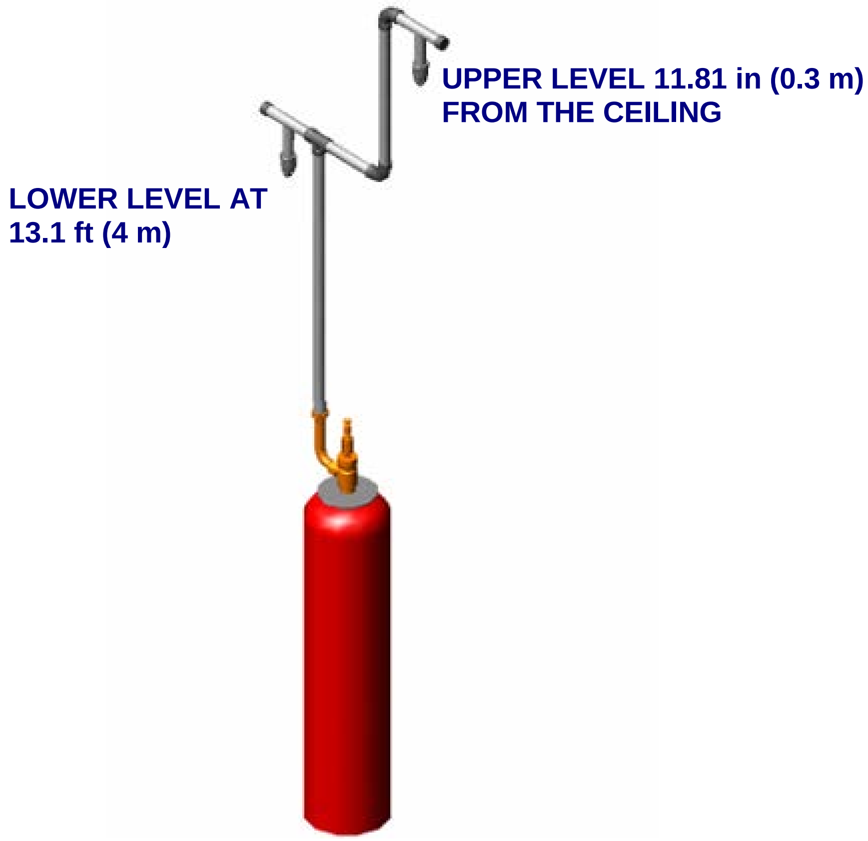


Figure 15. Example of pipework at two discharge levels

3.8 Obstructions to nozzle discharge

It must be taken into account when there are racks, shelves, partitions and tall items of equipment in the protected compartments which may represent an obstacle to the gas discharge through the nozzles when extinguishant discharge occurs. Hence, the “route” of the discharge from the nozzles must be taken into account when the number of nozzles required is determined.

All the permanent solid obstructions which could interfere with the “line of sight” of the discharge route must be considered as separate areas. All the nozzles must be located in such a way that the discharge route reaches all the extremes of the protected space.

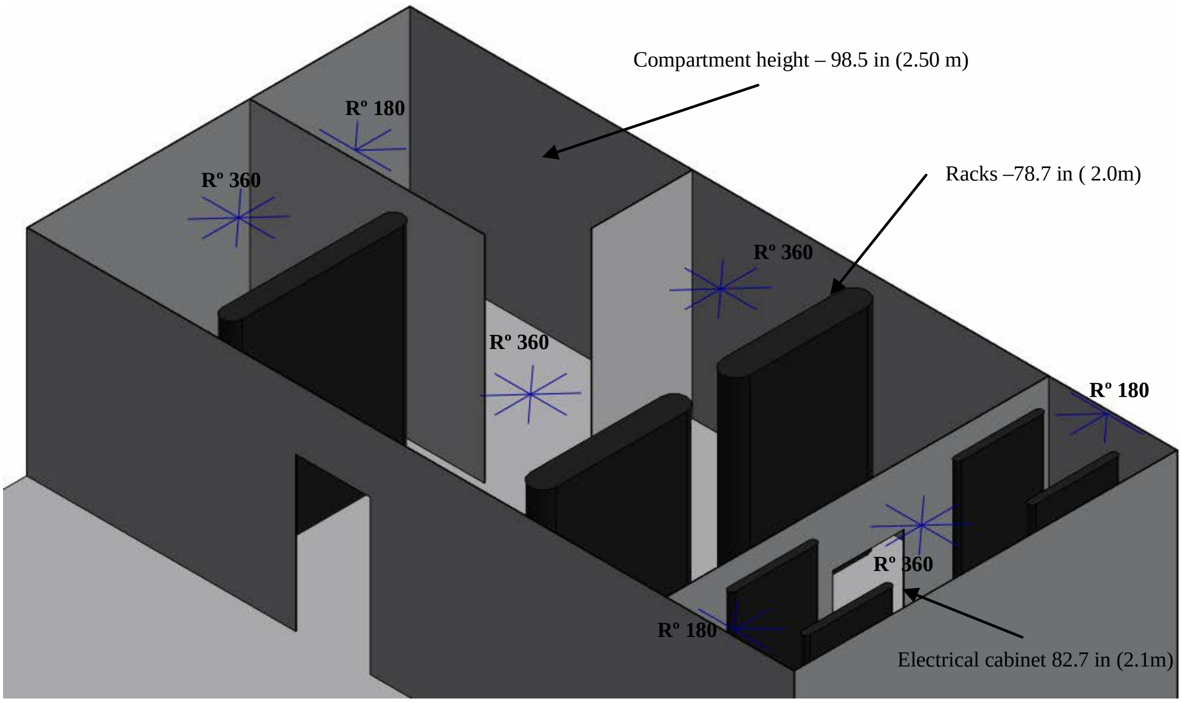


Figure 16 – Nozzle distribution.

4. Summary of the steps to follow to calculate a FK-5-1-12 system

After the explanation given previously in this manual, we are going to carry out a small exercise in which all the steps to be followed for the design of an SIEX-NC™ 1230 system are brought together.

☑ ***EXAMPLE 5:*** ***You wish to protect a DP room 49.2 ft (15 m) long by 23.3 ft (7.10 m) wide and 8.2 ft (2.5 m) high with an ambient temperature of 68ºF (20 °C). It also has a 1.31 ft (0.40 m) high false ceiling, which is also to be protected.***

1. The type of fire is determined and this determines the design concentration according to the standard. In this case there will be a Design Concentration of 4.51%.
The compartment will be occupied by people, therefore the NOAEL must not be exceeded.

2. Calculate the quantity of extinguishant necessary for each area to be protected, assuming the areas are flooded simultaneously.

$$W = \frac{VxC}{Sx(100 - C)}$$

Where:

• *W = Weight of extinguishant lb (kg)*
• *V = Volume of the hazard to be protected* ft^3 *(*m^3*)*
• *C = Design concentration (% by volume)*
• *S = Specific volume*ft^3*/lb (*m^3*/kg). Specific volume of superheated FK-5-1-12 vapour at 14.7psi (1.013 bar), according to the expression:*

$$S = k_1 + k_2 xT$$

Where:

• k_1 *= 0.9856 (0.0664)*
• k_2 *= 0.002441 (0.0002741)*
• *T = temperature ºF (°C)*

Substituting all the values in the above expression we obtain:

$$S = 0.9856 + 0.002441 \times 68^{o} F = 1.1515\ ft^3/lb$$

$$W_{ambient} = \frac{9{,}400.15\ ft^3 x4.51\%}{1.1515\ ft^3/lb\ \ x(100 - 4.51\%)} = 385.56 lb \approx 386 lb$$

$$W_{fal\sec eiling} = \frac{1501.73\ ft^3 x4.51\%}{1.1515\ ft^3/lb\ \ x(100 - 4.51\%)} = 61.59 lb \approx 62 lb$$

$$Wtotal \ = W_{ambient} + W_{fal\sec eiling} = 386 lb + 62 lb = 448 lb$$

$$S = 0.0664 + 0.0002741 \times 20^{o} C = 0.07188\, m^3/kg$$

$$W_{ambient} = \frac{266.25 m^3 x4.51\%}{0.07188 m^3/kg\ \ x(100 - 4.51\%)} = 174.94 kg \approx 175 kg$$

$$W_{fal\sec eiling} = \frac{42.6 m^3 x4.51\%}{0.07188 m^3/kg\ \ x(100 - 4.51\%)} = 27.99 kg \approx 28 kg$$

$$Wtotal \ = W_{ambient} + W_{fal\sec eiling} = 175 kg + 28 kg = 203 kg$$

In this example the altitude correction factor will not be considered; it is assumed to be at sea level.

3. Now select the cylinders, since these are determined as a function of the quantity of extinguishant needed, although we also know that other factors can be of influence, such as their location, the flow calculation limitations, etc.
In this case we have 448 lb (203 kg) which will be stored in a bank of two 4.48 ft^3 *(127 litres) bottles.*

CYLINDER TYPE	MAX. FILL LEVEL	MAX. CHARGE
4.48 ft^3 (127 l)	50 lb/ft^3 (0.80 kg/litre) for bank systems	253.53 lb (115 kg)
No. of bottles needed: 2 cylinders of 4.48 ft^3 with 224lb each (127 litres with 101.5 kg each)		

Table 19

4. Once the bottles have been decided, we choose the nozzles. Nozzles must be placed in the room area and in the false ceiling. In the room we will discharge 386 lb (175 kg) and 62 lb (28 kg) in the false ceiling.

We calculate the flow rate in the room: 386 lb / 10s = 38.6 lb/s (175 kg / 10s = 17.5 kg/s).

In Table 17– Flow Rate, we can see that the maximum possible design flow is 32.63lb/s (14.8 kg/s); hence we need two nozzles, obtaining a flow through each nozzle of 20.15 lb/s (9.15 kg/s), the nozzles being of 2".

Now we calculate the flow rate for the false ceiling: 62 lb / 10s = 6.2 lb/s (28 kg / 10s = 2.8 kg/s). We have had to place two nozzles in the false ceiling as in the room area. In this case they will be 1" ones.

The nozzles selected will be R°-360°s with coverage of 24.6x23.3 ft (7.5 x 7.1 m) in both the room and the false ceiling.

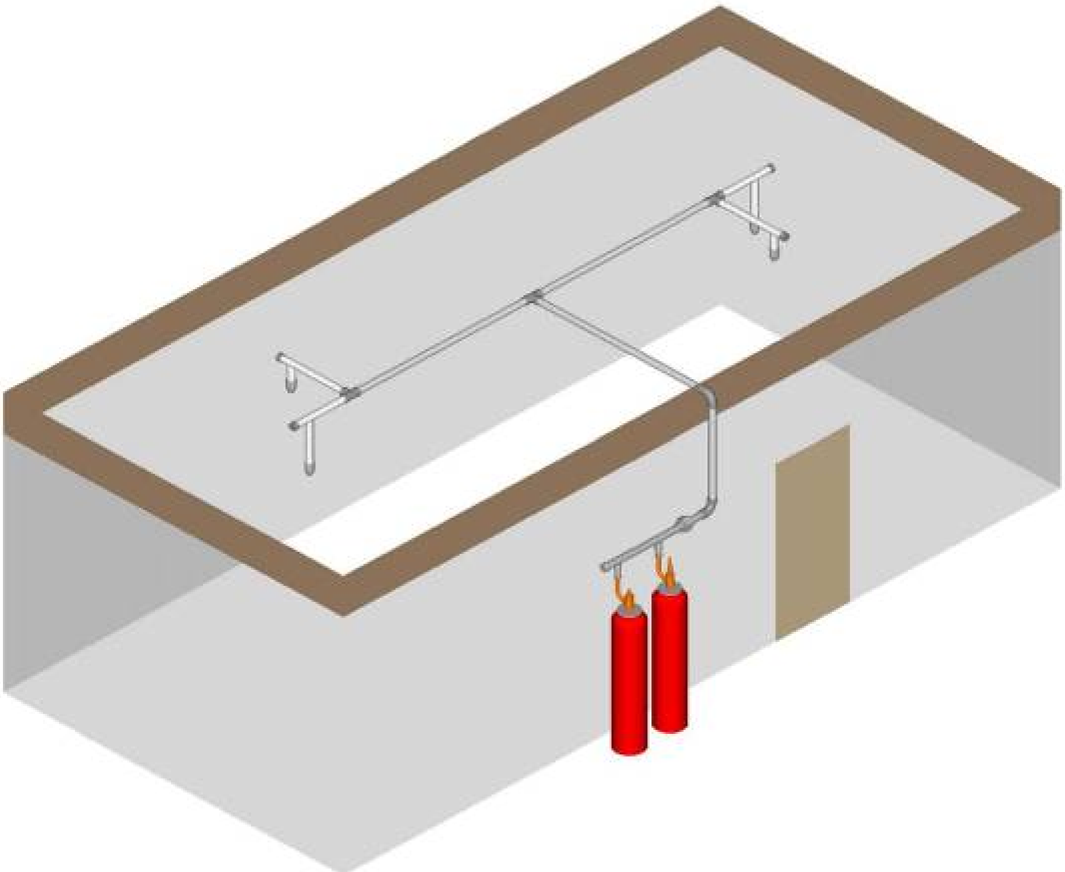


Figure 17 - Diagram – Pipework layout

SIEX NC 1230

5. These are guidelines for making an approximate calculation of the nozzles needed as well as their diameter, but as has been stated, ***SIEX*** *has flow calculation software for FK-5-1-12 extinguishant which is the only calculation method applicable to* ***SIEX*** *equipment.*

5. Sotware discharge calculation

The application of SIEX-NC™ 1230 fire extinguishing systems requires a good knowledge of the flow processes in an expanding liquid-vapour-mixture. The basis for the VdS-calculation program SIEX-NC™ 1230 fire extinguishing systems is a calculation method which has been developed by the VdS. This calculation method takes into account the two phase flow in SIEX-NC™ 1230 installations and is qualified by measurements in the VdS laboratories.

The calculation software is able to calculate SIEX-NC™ 1230 installations of very different constructions. Special files contain the characteristic values of the components for the installation as valves, nozzles and pipe-types. These data are adapted to SIEX specific requests. The resistance coefficients of valves and nozzles have been determined in the VdS-laboratories.

The calculation software allows a simultaneous calculation up to 21 zones with 450 pipe system sections and 200 nozzles.

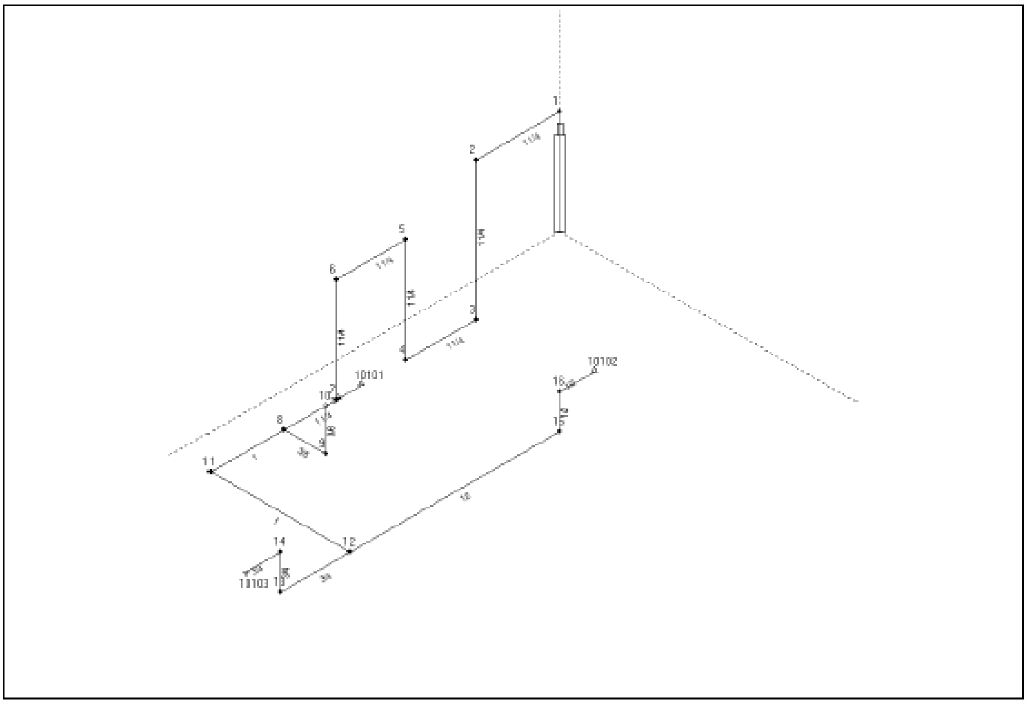
The calculation software has been tested with DIN 2440, SCHEDULE 40, SCHEDULE 80 and SCHEDULE 160 pipes with accessories of 300 lb at 348 psi (24 bar), 600 lb at 610 psi (42 bar) and 3000 lb at higher pressures.

In the case of systems with selector valves, that is, a single cylinder or a cylinder bank which protects several hazards simultaneously, each hazard is required to be calculated independently with the software. The use of the selector valves has no effect on the hydraulic calculation in terms of equivalent length or pressure drop, but the effect related to the dead volume of the selector valve manifold in relation to the total volume of the pipe network must be considered. The limit of the ratio between the volume of the selector valves which are not opened in case of actuation of the system and the inner volume of the system piping shall be observed. Additional information of the limits can be found in section 40. Selector valves (SVD) in “System components manual”.

FK-5-1-12 -Calculationprogram Version 7.4
Licenced to: SIEX 2001
File : Example

Page : 1
Serial no: NC08208
22/12/2016

Project:	Example
Project-No:	
Building:	
Object:	
Contractor:	
Owner:	
Project engineer:	
Date:	22/12/2016
Altitude above sealevel:	0 m
Regulation rule for calculation of FK-5-1-12 quantities:	ISO 14520-1, Edition 2000
Pipe catalogue:	pipes.rkl
Component catalogue:	rgsmam_UL_FM.arm
Nozzle catalogue:	nozzles_UL_FM.noz



Pipesystem data:

Section-No:	Starting-node	Endnode	Length [m]	Height [m]	Pipetype	Diameter [mm] **	Fitting *	Component code	Component coefficient	Nb of containers FK-5-1-12 quantity
1	0	1	0,100	0,100	12	32,0	C	740	4,910	1,0
2	1	2	0,800	0,000	13	35,9	E	-	-	0,0
3	2	3	2,000	-2,000	13	35,9	E	-	-	0,0
4	3	4	1,000	0,000	13	35,9	E	-	-	0,0
5	4	5	6,000	6,000	13	35,9	E	-	-	0,0
6	5	6	1,000	0,000	13	35,9	E	-	-	0,0
7	6	7	6,000	-6,000	13	35,9	E	-	-	0,0
8	7	8	0,500	0,000	13	35,9	E	-	-	0,0
9	8	9	0,600	0,000	13	12,5	T-90°	-	-	0,0
10	9	10	0,600	0,600	13	12,5	E	-	-	0,0
11	10	10101	0,500	0,000	13	12,5	E	-	-	0,0
12	8	11	1,050	0,000	13	27,2	T-0°	-	-	0,0
13	11	12	2,000	0,000	13	27,2	E	-	-	0,0
14	12	13	1,000	0,000	13	21,6	T-90°	-	-	0,0
15	13	14	0,500	0,500	13	21,6	E	-	-	0,0
16	14	10103	0,500	0,000	13	21,6	E	-	-	0,0
17	12	15	3,000	0,000	13	16,0	T-90°	-	-	0,0
18	15	16	0,500	0,500	13	16,0	E	-	-	0,0
19	16	10102	0,500	0,000	13	16,0	E	-	-	0,0

* C=Component, B=Bend, T=T-Piece, E=Elbow
** If a pipe diameter is equal zero see the extra table of the calculated diameters

Legend of pipetypes

Type	Pipeclass	Pipe roughness
12	DIN-2440	hose
13	DIN-2440	black pipe

Legend of components

Code	Type	Resistance coefficient
750	RGS-MAM-40 (dip-tube, hose and check valve)	4,910

Nozzle data:

No.	Calculation zone	Diameter [mm]
10101	v1	6,0
10102	v2	6,0
10103	v3	10,0

Legend of nozzles:

Type	Number of orifices	C1	C2	C3	C4	C5	C6
1 FEDR 1/2"-11/4"	1	0,00014	0,70424	0,00000	0,00000	0,00000	0,00000

Calculation zone data:

Calculation of design quantity:

Zone	Total volume [m3]	Volume of building parts [m3]	Calculated volume [m3]	Max. Over-pressure [mbar]	Design temp. [°C]	Extinguish-conc. [% Vol]	Design factor	Design conc. [% Vol]	Design quantity [kg]
1 v1	11,5	0,0	11,5	1,000	20,0	4,1	1,30	5,3	8,96
2 v2	13,3	0,0	13,3	1,000	20,0	4,1	1,30	5,3	10,41
3 v3	31,7	0,0	31,7	1,000	20,0	4,1	1,30	5,3	24,72

Regulation rule for calculation of FK-5-1-12 quantities: ISO 14520-1, Edition 2000
Altitude above sealevel: 0,0 m

FK-5-1-12 storage input data:

Container volume:	100,0 l
Filling ratio:	-0,440 kg/l (fixed value)
Filling pressure:	25,0 bar abs
Storage temperature:	10,0 °C
Supplement factor:	1,00
Minimum storage quantity:	44,08 kg
Number of containers:	1

Discharge time (input value): 10,0 s

Further information:
Design with predeterminated orifice diameters

Calculation results:

FK-5-1-12 storage data:

Design quantity:	44,1 kg
Supplement factor:	1,00
Minimum storage quantitiy:	44,1 kg
Container volume:	100,0 l
Filling ratio:	0,44 kg/l
Filling pressure:	25,0 bar abs
FK-5-1-12 -mass per container:	44,0 kg
Number of containers:	1
Actual storage quantity:	44,0 kg
Storage temperature:	10,0 °C
Starting container pressure:	24,0 bar abs

Discharge time:

Discharge time air:	0,9 s
Total gas discharge time:	2,3 s
Two-phase discharge time:	8,3 s
Total discharge time:	10,5 s

System information:

Container working pressure:	16,5 bar abs
Container working temperature:	10,0 °C
Total network volume:	21,1 l
Medium pipe content:	30,7 kg FK-5-1-12
Filling portion in pipe system:	0,70 kg FK-5-1-12 /kg FK-5-1-12 -storage

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Pipe system:

Section-No:	Starting-node	Endnode	Pressure [bar abs]	Flowrate [kg/s]	Pipedimension Di [mm]	DN
1	0	1	15,86	5,03	32,0 *	--
2	1	2	15,65	5,05	35,9	1 1/4
3	2	3	15,69	5,05	35,9	1 1/4
4	3	4	15,47	5,05	35,9	1 1/4
5	4	5	14,14	5,05	35,9	1 1/4
6	5	6	13,90	5,05	35,9	1 1/4
7	6	7	14,24	5,05	35,9	1 1/4
8	7	8	14,03	5,05	35,9	1 1/4
9	8	9	13,57	1,04	12,5	3/8
10	9	10	12,50	1,04	12,5	3/8
11	10	10101	11,50	1,04	12,5	3/8
12	8	11	13,84	4,01	27,2	1
13	11	12	13,23	4,01	27,2	1
14	12	13	12,71	2,83	21,6	3/4
15	13	14	11,94	2,83	21,6	3/4
16	14	10103	11,22	2,83	21,6	3/4
17	12	15	12,37	1,19	16,0	1/2
18	15	16	11,95	1,19	16,0	1/2
19	16	10102	11,59	1,19	16,0	1/2

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Nozzle data:

Calculation-zone no:	Nozzle no.	Nozzle type	Number of orifices	Pipeconnection Di [mm]	DN	Orifice [mm]	FK-5-1-12 out-put [kg]
1	10101	1	1	12,5	3/8	6,0	9,1
2	10102	1	1	16,0	1/2	6,0	10,4
3	10103	1	1	21,6	3/4	10,0	24,8

Two-phase discharge time: 8,3 s

MAXIMUM TRANSPORT TIME DIFF. BETWEEN NOZZLES: 10102./ 10101. IS 1.36 S

Calculation-zone no:	Nozzle no.	Outlet velocity [m/s]	Transport time [s]	Jetdistance [m]
1	10101	41,8	5,28	4,53
2	10102	33,4	6,64	3,86
3	10103	29,2	6,07	5,84

Concentrations:

Calculation-zone no:	Gascomposition after discharge [%] O2	FK-5-1-12	N2
1	19,8	5,2	74,0
2	19,8	5,2	74,1
3	19,8	5,2	74,1

Pressure relief opening:

Calculation-zone no:	Recommended area against overpressure Area [m²]	Overpressure [mbar]	Max. flow [kg/s]
1	0,010	1,0	
2	0,012	1,0	
3	0,028	1,0	

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Component list:

Component	Number	Code	Coefficient
RGS-MAM-40	1	750	4,910

Nozzle-type	Number	C1	C2	C3	C4	C5	C6
1	3	0,00010	0,70400	0,00000	0,00000	0,00000	0,00000

Pipe-type	Di [mm]	DN	Length [m]
12	32,00	--	0,100
13	35,90	1 1/4	17,300
13	12,50	3/8	1,700
13	27,20	1	3,100
13	21,60	3/4	2,000
13	16,00	1/2	4,000

Number of bends (+) and elbows (-)

Bend-type	Di [mm]	DN	Number
-90	35,90	1 1/4	7
-90	12,50	3/8	2
-90	27,20	1	1
-90	21,60	3/4	2
-90	16,00	1/2	2

Number of T-distributors (in- and outdiameter)

Number	Input	90-out	90-out	0-out
1	35,9	12,5	0,0	27,2
1	27,2	21,6	16,0	0,0

6. Installation and maintenance

Installation and maintenance must be executed according to SIEX-NC™ 1230 Installation manual and maintenance manual.