

Dry Chemical Extinguishing Systems

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1. Introduction

Dry chemicals remain one of the most efficient extinguishing media available. On a weight basis, a *dry* chemical system frequently outperforms any gaseous system, including Halon, although their applicability to manned areas is not as wide.

In the US *dry* chemical fixed systems are used in many applications, including gasoline filling stations, restaurant cooker protection, mining vehicles and other associated machinery. This paper will give examples of typical systems, and a brief overview of some of the relevant legislative standards.

In Europe a new "Machinery Directive" calls for all new machines to have some form of fire protection system designed in from the start. The efficiency of *dry* chemicals, in particular the pre-formed Aerosols (XAs), makes them an obvious choice where space and weight are at a premium. Applications where XAs are being used include the protection of spark erosion machines, and walk-in fume cupboards. Again, typical systems will be illustrated, and the relevant legislation reviewed and contrasted with the situation in the US.

2. US Viewpoint

2.1 **Legislation: NFPA 17, UL1254 & UL300**

NFPA 17 [1] is a general overview standard pertaining to *dry* chemical usage. It indicates where standard *dry* chemical (also referred to as BC powder or sodium bicarbonate) and where multipurpose dry chemical (**ABC** powder, monoammonium phosphate, **MAP**) should be used. It also differentiates between total flooding and local application, and gives guidelines for both suppression approaches. Unlike NFPA 12 (the equivalent standard for gaseous suppressants) no concentration requirements are given. This is because the

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suppression efficiency of a *dry* chemical depends in part on its chemical identity (including its purity) and in part on its particle size distribution. Therefore, all standards for *dry* chemical systems are based on the results of specific tests.

UL1254 [2] is a standard for pre-engineered *dry* chemical systems used in:-

- a) Industrial total flooding protection systems;
- b) Class B local application protection systems;
- c) Restaurant cooking area protection systems;
- d) Automobile service station fuelling area protection systems;
- e) Industrial paint spray booth protection systems;
- f) Off-road vehicle protection systems;

The standard includes pertinent fire tests to evaluate potential *dry* chemical suppression systems in each of the above areas. In addition, other performance-related tests are carried out including-

- a) Hydraulic testing of cylinders;
 - b) Elevated temperature (max. operating temp for 30 days);
 - c) Temperature cycling;
 - d) Salt spray corrosion test;
 - e) 500 Cycle operation test;
 - f) One year leak test;
 - g) Mounting device test;
 - h) Flexible hose low temperature test (where applicable);
 - i) Vibration and shock tests;
- etc.*

UL300 [3] is the standard containing the fire extinguishing tests specifically for restaurant cooking areas. Standard fire threats encompassed include:-

- a) Deep fat fryers;
- b) Griddles;
- c) Broilers (many varieties including gas, electric, lava pumice, upright *etc.*);
- d) Woks.

The standard specifies how extinguishing tests should be carried out including fuel type, loading temperature measurement *etc.*

2.2 General Industrial Systems (total flooding vs. local application)

NFPA 17 states that if the area is predominantly enclosed, with the sum of the uncloseable openings not exceeding 15% ~~of~~ the surface area of all the walls, then a total flooding system may be employed, subject to the provisions below. If the area of uncloseable opening is less than 1%, then no additional *dry* chemical suppressant is required. Between 1 and 5%, extra *dry* chemical

suppressant is required, and if the area of uncloseable openings exceeds **5%**, then a screening system, or approved local application system is required.

If the above conditions cannot be met **then** the system is designated local application, and needs to be tested **as** such.

2.3 Restaurant Systems

UL300 describes the various cooking area fire threats that a Restaurant Fire Protection system (*dry* chemical or wet chemical) needs to be able to extinguish. In addition, there are provisions for nozzle spacing, nozzle height from the fire threat, and provisions for the suppression system not to cause splashing of the hot fat.

2.4 Gasoline Filling Stations

The *dry* chemical fire suppression systems used are typified by the Kidde **IND-25** and **IND-50** cylinders, utilising sodium bicarbonate (gasoline is a typical Class B **risk**) and **2 & 4** nozzles respectively. These are pre-engineered systems, each cylinder being used to protect a designated area. The starting module (a single **IND-50** cylinder and four overhead nozzles) can protect a single “island”, **6' x 12'** and its associated parking area, **as** shown in Figure 1. A second **IND-50** module can then be added to protect the “end area”, also shown in Figure 1. **Thus** the total area covered by a basic **IND-50** cylinder containing 50 lb. of sodium bicarbonate **is 288** square feet, whereas a *two* cylinder system can protect an additional area of 432 square feet. Further examples of more complex modular systems may be found in reference 4. In addition to the overhead nozzles, “groundswEEP” nozzles can be used to provide extra protection. In certain circumstances further modules may be mandated to allow for special hazards, such **as** prevailing wind *etc.* Again the reader is referred to the instruction manual for further details [4].

2.5 Paint Spray Booths

Paint spray booths are divided into *two* categories: open face and enclosed. They fall with the “General Industrial” section of UL 1254. Both types are usually large and complex enough to need a multiple system as described in **2.2** above, requiring a combination of total flood, screening or local application [5]. A typical suppression system for a paint spray booth (14'-0" x 10'-0" x 9'-10") is shown in Figure 2.

An analysis of the hazard reveals that the open face represents 13% of the total surface area, so a “total-flooding plus screening” approach is acceptable [1,5].

The design codes then define how many of each class of nozzles are required, and how many detectors are needed (one). The total system comprises:-

3 x IND-50 cylinders;

1 x **IND-25** cylinder;

8 x screening nozzles protecting the open face of the booth;

2 x total flood nozzles protecting the work area;

2 x duct/plenum nozzles protecting the plenum area;

2 x duct/plenum nozzles protecting the duct area;

Not all paint spray booth systems are this complex, but this serves to illustrate the approach used.

3. European Viewpoint

3.7 *New Legislation*

The principal new legislation concerning fixed *dry* chemical systems (as opposed to hand extinguishers) in Europe is the Machinery Directive currently being formulated by working group CEN/TC/WG 16N 171 [6]. It is a full ranging EU directive which will eventually be integrated into many other standards, but is at the moment still very much at the draft stage. The scope of the directive is shown by the organisation chart (Figure 3) outlining proposed fire-risk reduction measures in Europe.

The approach is to perform a risk assessment, and if necessary, take appropriate steps to reduce the risk to an acceptable value. This may involve elimination of ignition sources or the use of non-flammable components, or other “passive” fire protection measures, or it may require the inclusion of an active fire suppression system. It is the latter approach which is discussed here.

This directive does not explicitly call for dry chemical fire extinguishing systems, but in Germany in particular, the use of gaseous fire-fighting agents which have perceived detrimental atmospheric effects (either ODP or GWP) is outlawed. Hence there is an increased use of other forms of fire protection: conventional sprinklers, water mist, inert gas systems, CO₂ and, of course, dry chemical.

Currently the retrofit market is not being addressed; only *new* machines will be covered by this proposed legislation.

3.2 *Extinguishing Aerosols (XAs)*

Extinguishing Aerosols (XAs) are special class of dry chemical fire extinguishant. They are chemically similar to conventional BC powders, being

based on potassium bicarbonate, but are much more efficient, owing to their much smaller particle size distribution (1-5 μm , compared with 20-150 μm for standard *dry* chemical powders). They are made by a unique spray drying process developed recently by Kidde International [7]. In addition to their small size, the unique morphology of XAs (loosely aggregated hollow spheres) gives them a tremendous surface area, further enhancing their fire suppression properties. In certain circumstances, they can be up ten times more efficient than Halon 1301. As the current fixed *dry* chemical suppression technology in place in Europe is much less advanced than in the USA, it seemed logical to launch XAs (as **KD-A-96**) into a less developed market, given their extremely high efficiency. The following sections describe two potential applications of this novel fire suppression technology.

3.3 Spark Erosion Machines

One category of machinery that combines a **high** fire risk with a high capital value is that of spark erosion machinery. These use a high voltage to cause a spark which erodes or etches precision machined components. These small work-pieces get hot during this process, and are cooled in a bath of mineral oil. Thus all three of the corners of the fire triangle are present: a source of ignition (the spark), a source of fuel (the hot mineral oil), and oxygen.

Figure 4 shows a typical spark erosion system. The overall volume of the spark erosion chamber was *ca.* 5.4m^3 and the oil bath area was 1m^2 . Kidde Deugra have successfully demonstrated suppression of real spark erosion fires in this machine using only 200 g of potassium bicarbonate XA. This equates to approximately 37g/m^3 , although the chamber is not sealed, so this suppression scenario is a cross between total flooding and local application.

The choice of an aerosol suppressant was made largely due to the space consideration within the machine. There is not sufficient space to install an inert gas or CO₂ system. Furthermore, the high pressure used in these systems would have blown the burning oil outside the oil bath container, causing a hazardous situation. Therefore a “low” pressure system was employed (20 bar), and to ensure even dispersion of suppressant, a spray ring with many small holes was chosen. This approach was successful, as suppression was achieved without spraying burning oil outside the chamber.

3.4 Fume Hood Protection

Another category of “high-risk” that has been successfully tackled with XAs is that of difficult or dangerous fuels in full height “walk-in” fume hoods. These larger fume hoods are often encountered in pharmaceutical, medicinal or fine chemical research and development laboratories, where large quantities of

extremely flammable solvents may be used, possibly well above their flash-point. Fire occurrence is a reality not a potential hazard.

In a recent series of tests at Kidde International Research, Colnbrook, a mock-up of a typical fume hood was constructed, as shown in Figure 5, and a number of fire tests carried out. Table 1 below summarises the results obtained for a variety of fuel threats. It should be noted that the figures in this table are not necessarily minimum extinguishing concentrations; no attempt was made to optimise the suppression system, and there was not sufficient time or (in some cases) fuel to bracket the pass/fail criterion accurately.

Fuel	Extinguishing Concentration (g m⁻³)*
n-heptane	62
diethyl ether	93
methyl magnesium chloride in THF	93
n-butyl lithium in hexane	93

* Halon 1301 at 5.0 volume% \cong 330 g m⁻³

It should also be noted that the last two chemical reagents are air (moisture) sensitive, and can be pyrophoric, spontaneously combusting in air. During an initial test, following a successful suppression, re-flash occurred when the airflow was restored, and the aerosol suppressant removed, thus indicating the hazardous nature of these materials. However, if the aerosol is allowed to settle in the vicinity of the fuel, it will inert the fuel, for long enough to allow it cool to below its autoignition temperature, thus preventing re-ignition.

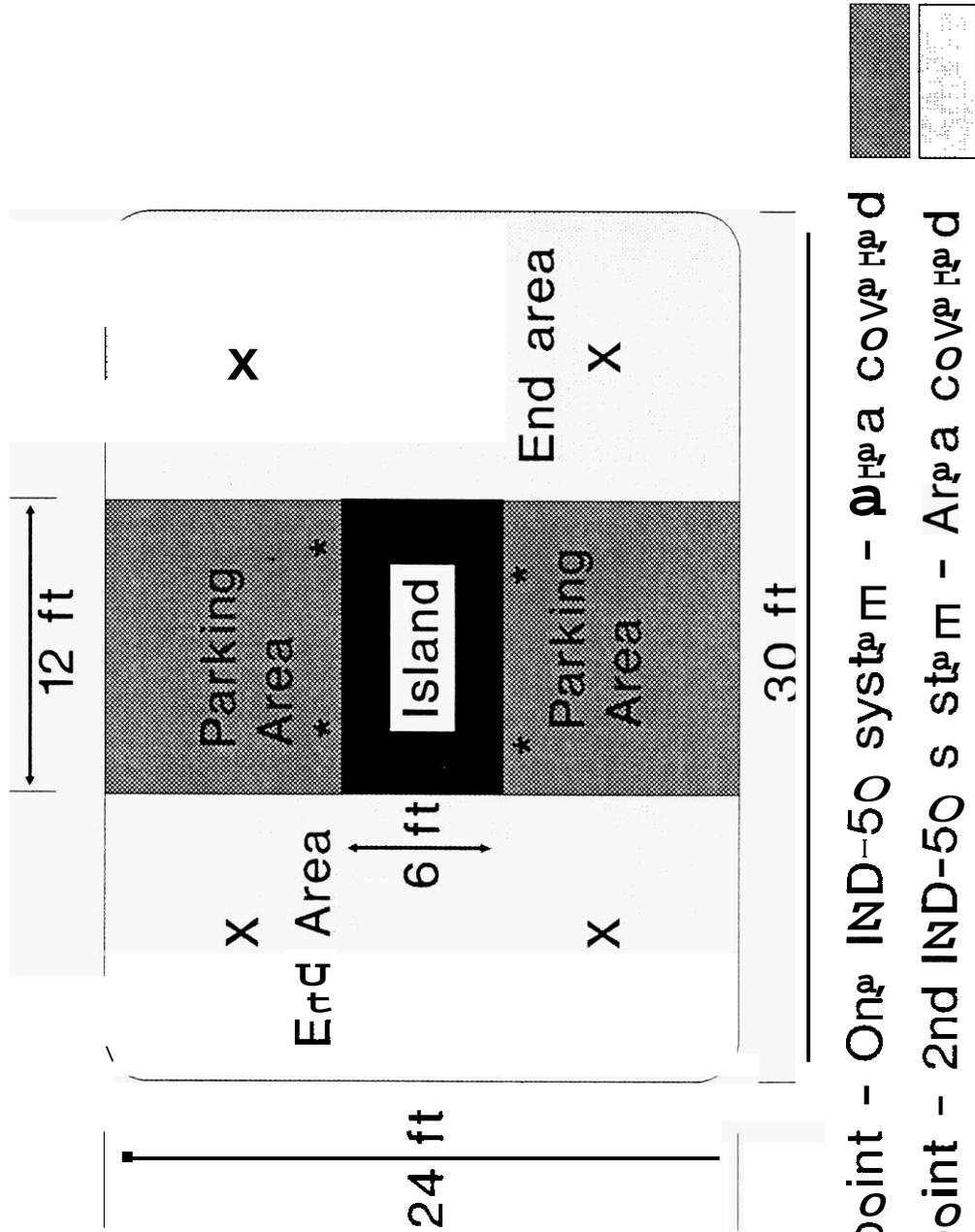
4. Summary

This brief overview gives some insight into the potential areas of application of dry chemical suppression systems. In any application where the need for high suppression efficiency outweighs the need for a truly “clean” agent, dry chemicals offer many advantages over all other extinguishing media. Thorough system design, however, is the key to obtaining a safe, reliable system. In the US, the design codes of NFPA 17, UL 1254 & UL 300 specify how a system should be designed for optimal fire protection. In Europe, as far as the use of aerosol suppressants is concerned, that state of affairs is yet to come. It is an area where Kidde Deugra are working closely with design authorities and insurance organisations, such as the VdS, with assistance from Kidde International Research.

5. References

- [1] Standard for Dry Chemical Extinguishing Systems **NFPA 17**, National Fire Protection Association, 1980.
- [2] Standard for Safety **UL 31254: Pre-Engineered Dry Chemical Extinguishing System Units**, Underwriters Laboratories Inc. Jan 12, 1994.
- [3] Standard for Safety **UL 300: Fire Extinguishing Systems for Protection of Restaurant Cooking Areas, Fire Testing of**, Underwriters Laboratories Inc. Jan 12, 1994.
- [4] Walter Kidde Gas Station Dry Chemical Fire Suppression System Model **IND-50 & IND-25** Instruction Manual, UL-EX2153, Jan 15 1987.
- [5] Industrial Dry Chemical Fire Protection System. Installation, Operation and Maintenance Manual, UL EX-2153, Nov 1994.
- [6] European Directive 89/392/EEG "Safety of Machinery—Fire Prevention and Protection" Draft Issue March, 1997.
- [7] A Chattaway, R G Dunster, R Gall & D J Spring; "*The Evaluation of Non-Pyrotechnically Generated Aerosols as Fire Suppressants*", Proceedings of the 1995 Halon Options Technical Working Conference, May 9-11 1996, Albuquerque, pp 473-483.

Figure 1: Gas Station, System Area Coverage



* One IND-50 system - Area covered

X 2nd IND-50 system - Area covered

Figure 2: Typical Paint Spray Booth Suppression System

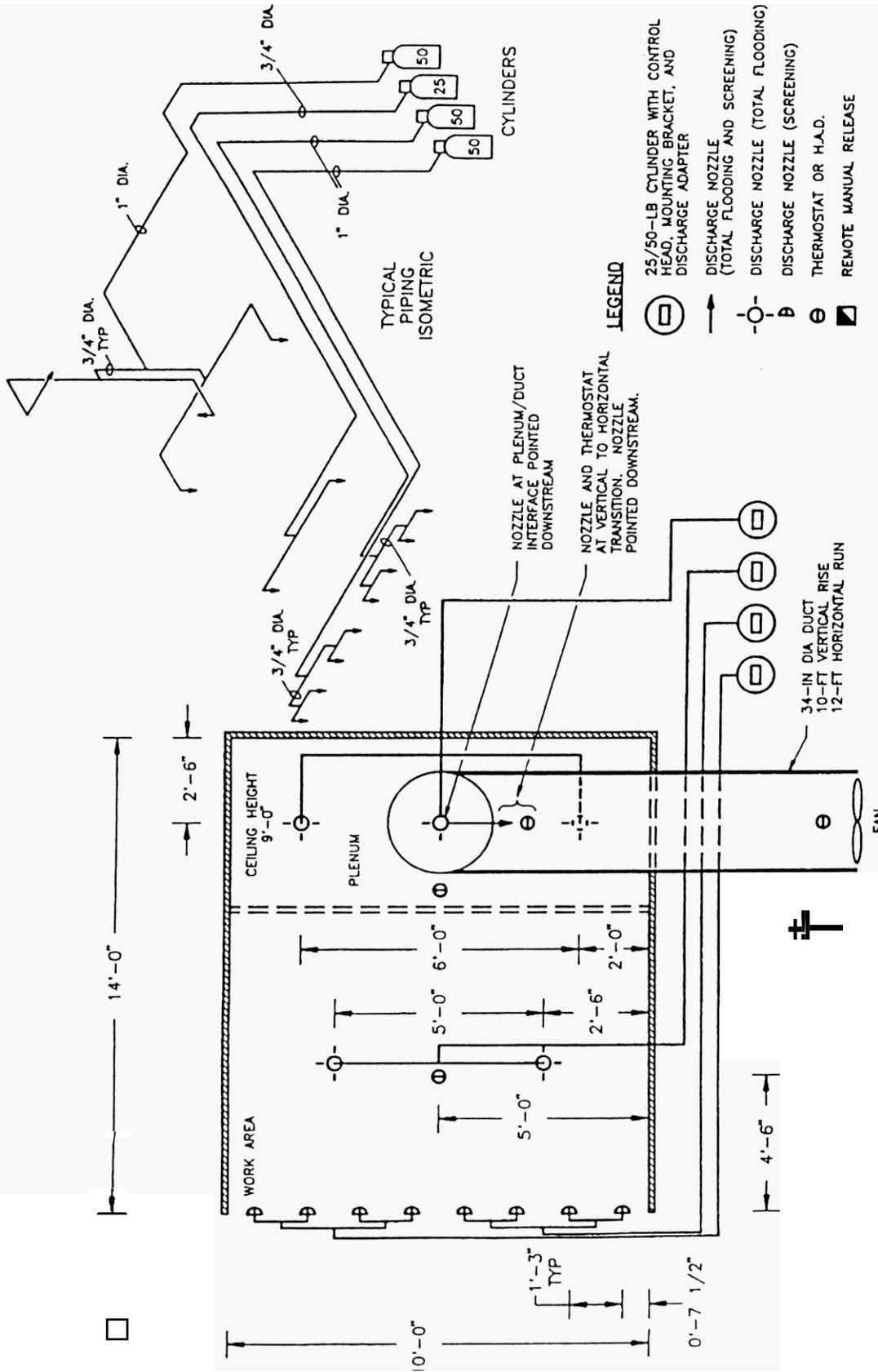


FIGURE 3: FIRE RISK REDUCTION MEASURES

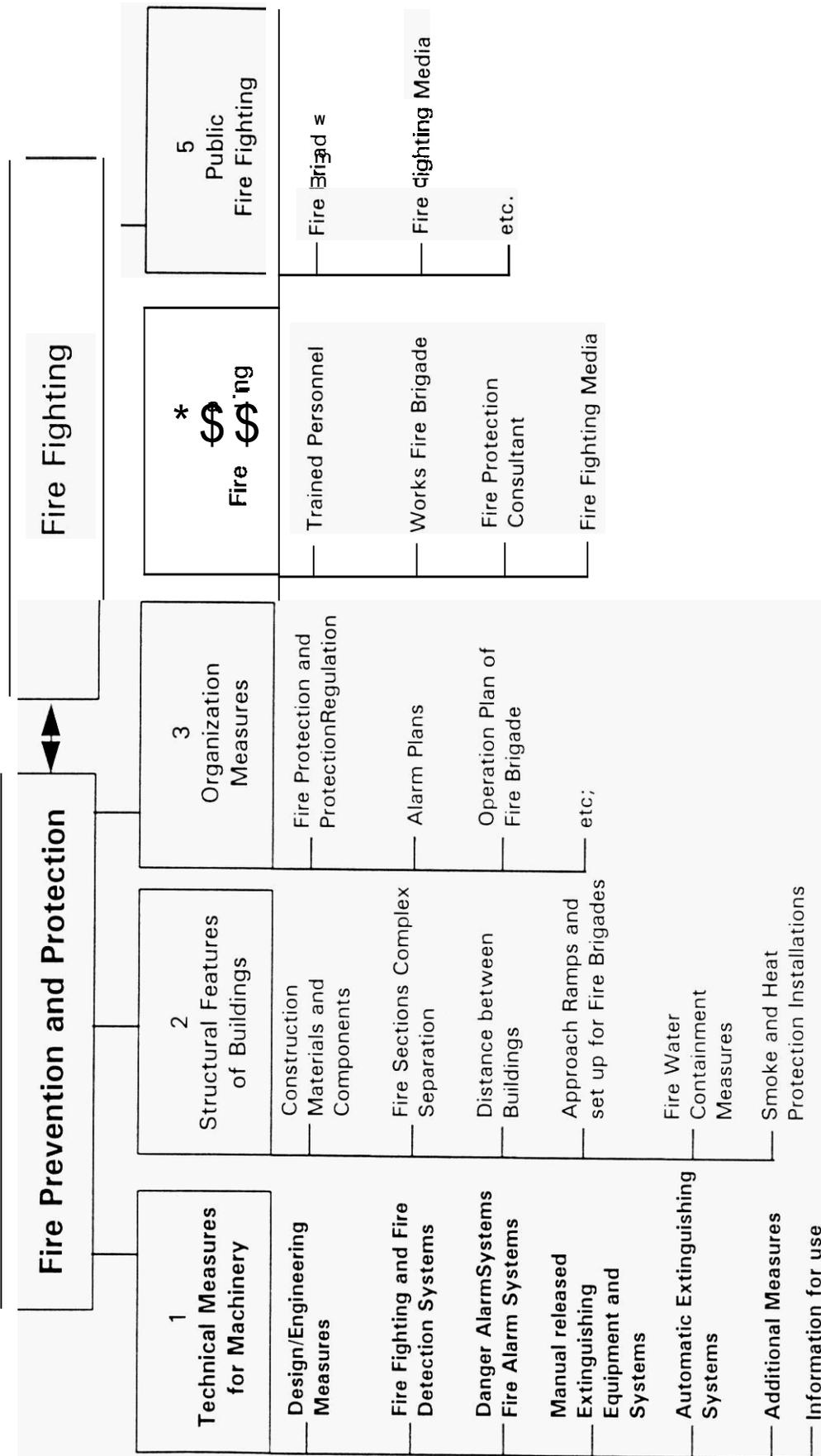
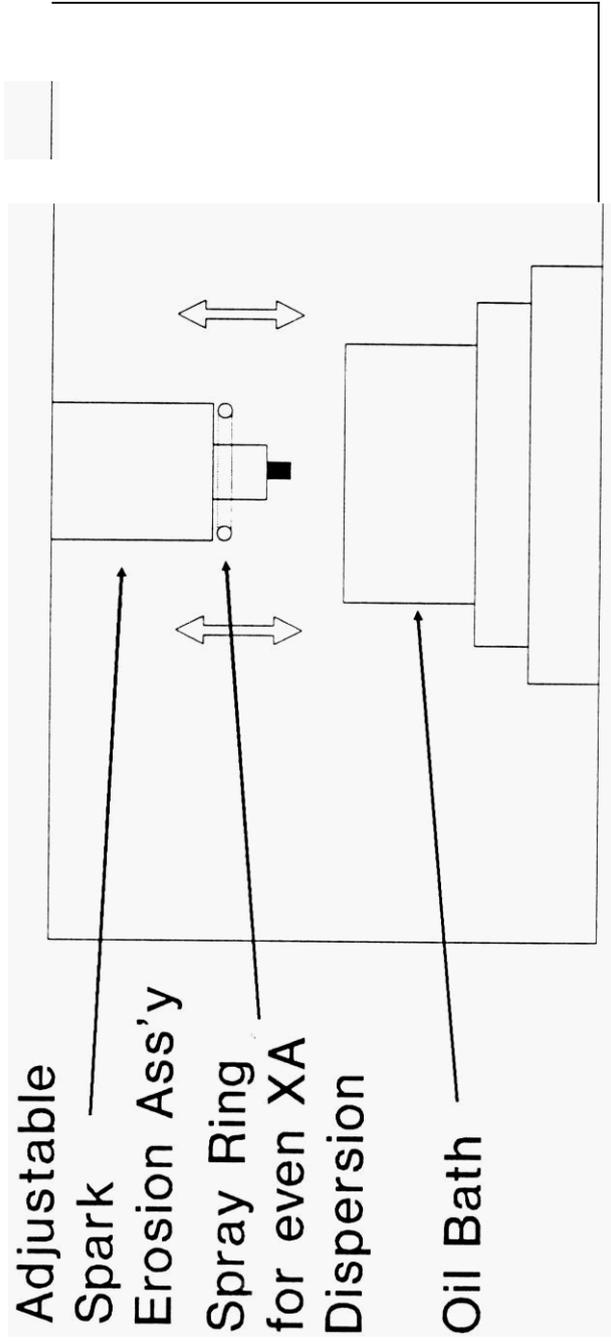
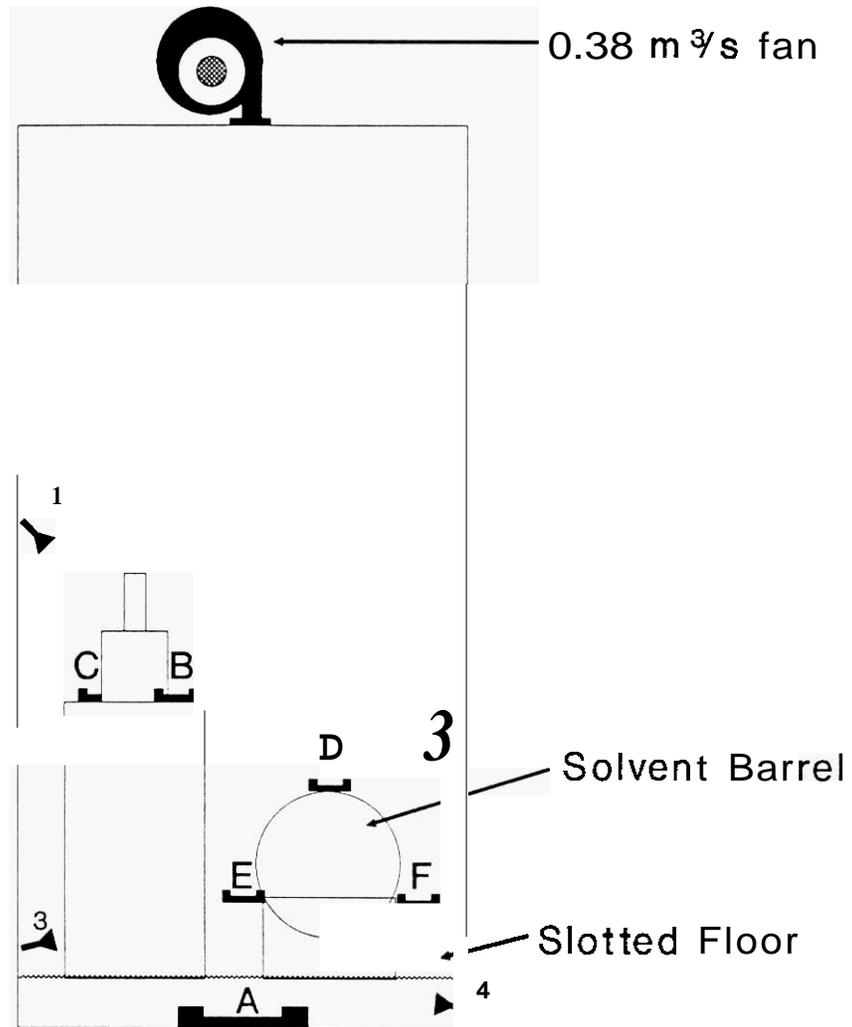


Figure 4: Spark Erosion System



Volume = 5.4 m³
Area of fire = 1 m²

Figure 5: Walk-in Fume Hood



A..F Fire Threats
1..4 Nozzles