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HEATING, AIR-CONDITIONING AND VENTILATION; FACILITIES; AND LIGHTING

Addendum

Fume Cupboards and Exhaust System 1/

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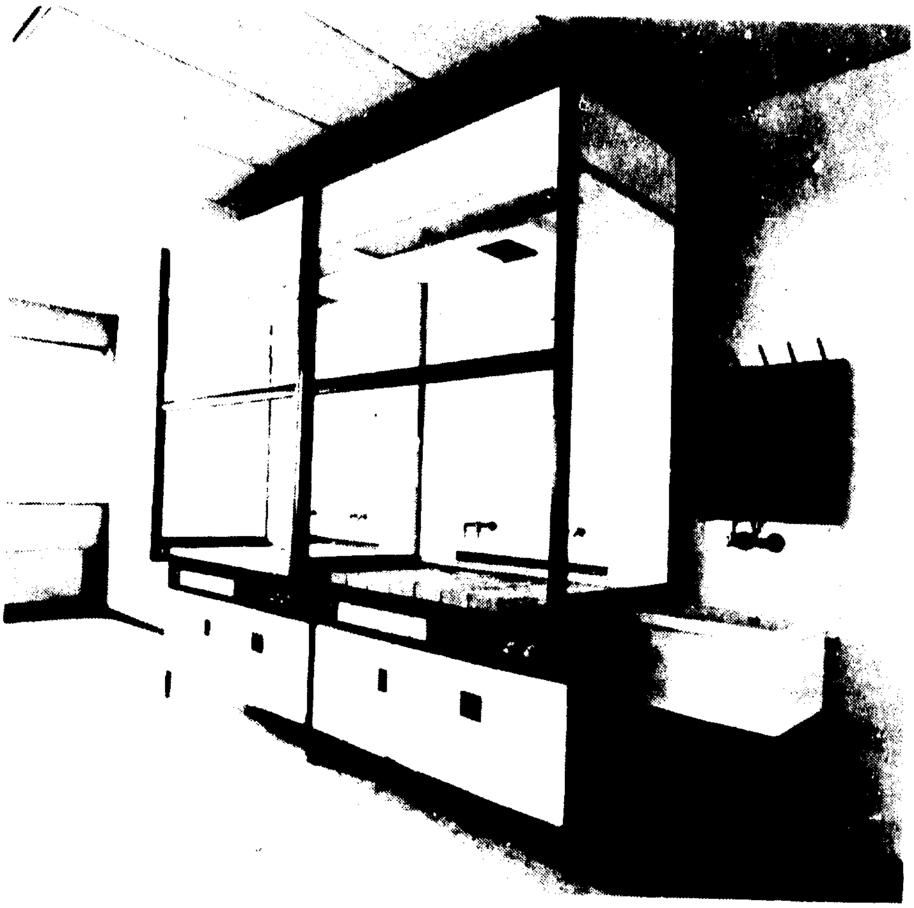


Fig. I Fume cupboards on steel framework, bench tops covered with ceramic tiles

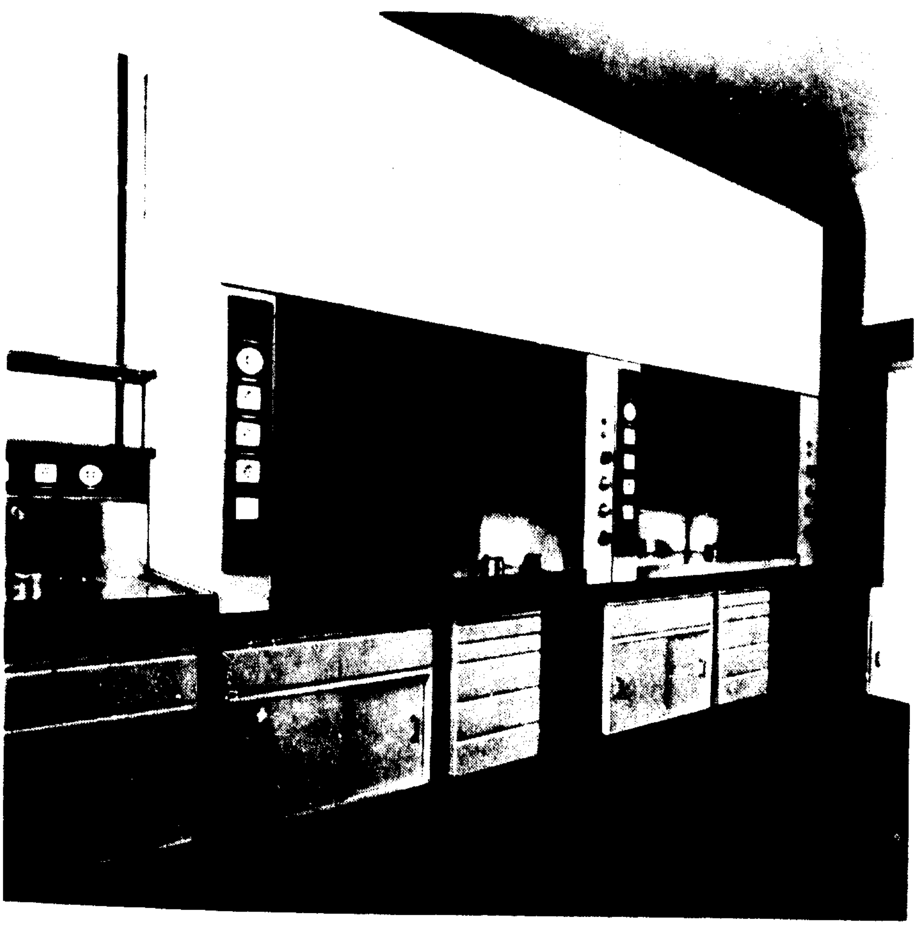


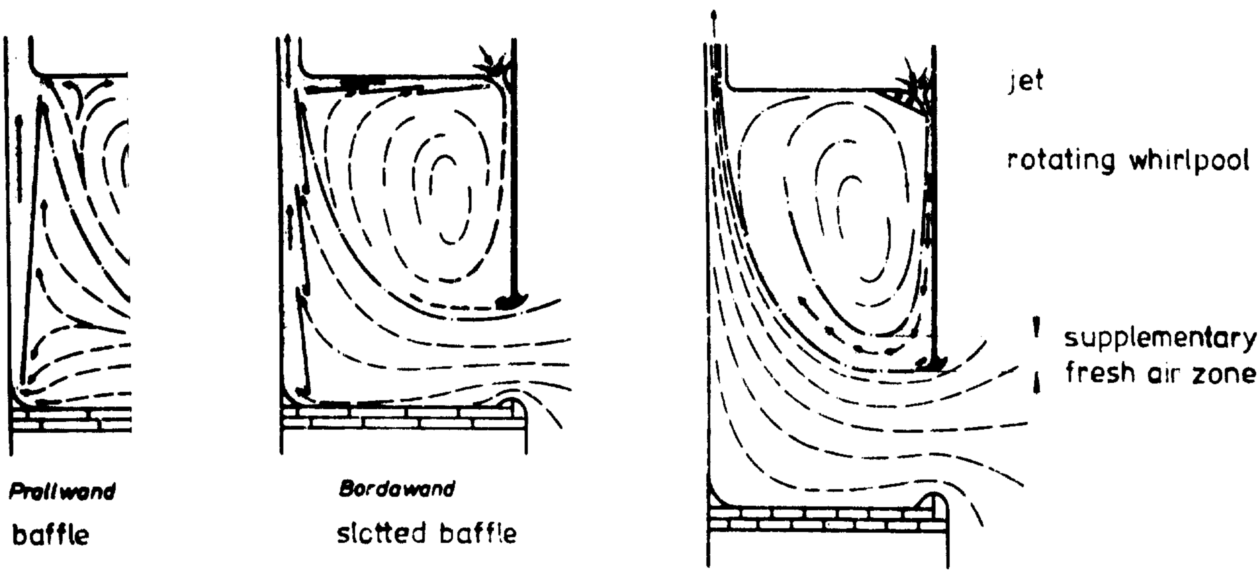
Fig. II Fume cupboards with baffle and by-pass, on concrete cantilevers, bench top covered with stainless steel, carcasses on casters

1. PURPOSE AND DESIGN OF FUME CUPBOARDS

Fume cupboards are accident-preventing units in laboratories for work involving hazardous gases or vapours. To obtain a protective effect, the "cabin", i.e. the enclosure over the proper work surface, is joined to an exhaust system, and is readily surveyable and accessible at least at the front side, through vertically or laterally movable sashes. The outlets for water, gas compressed air etc. located in the cabin are front-control-operated (see fig. I and II). The essential dimensions as usually applied to fume cupboards are given in table 1.

For fire protection reasons, the interior surface of the fume cupboards should consist of non-inflammable material such as glass, steel, asbestocement etc., because experience has shown that fires in laboratories frequently start in the fume cupboards. Exhaust ducts leading through "fire sections" must be jacketed with concrete or bricks, at least 10 cm thick, even when they are of ceramic non-inflammable materials (5.02, 5.11). This is necessary because ceramic ducts may easily burst from thermal shock caused by firefighting water. Smoke and fire may then rapidly spread to other fire sections.

The fume cupboards must have openings for air exhaust over the whole back, located a short distance above the work surface and at the highest point of the cabin. The best method is the use of a baffle (see fig. III, IV, V) It should be possible to guide tho air stream flowing inside the fume cupboard towards the lower or upper exhaust opening (3, 15, 17).



Prallwand
baffle

Fig. III

Bordawand
slotted baffle

Fig. IV

Fig. V

2. AIR CONSUMPTION OF FUME CUPBOARDS

Fume cupboards must be regarded as terminals of the exhaust system. The function of a chemical laboratory depends considerably on the design of its exhaust system.

In Germany, 8 to 13 air changes per hour and exhaust of ob-

Table 1 Conventional fume hood dimensions

in mm

Dimensions	DIN 12 923	BS 3202	American: Fisher	American: NII	American: Hamilton	British: Grundy	French: Catlin	German: Köttermann	German: Waldner
			Manufacturers						
front length	-	91	-	890	-	-	-	-	-
	1200	1220	1220	1195	1195	-	1150	1220	1200
	1500	-	-	1500	-	c) 1500	-	1520	1500
	1800	-	-	1800	-	d) 2000	-	-	1800
depth of	600	610	610	-	610	-	-	-	-
working space	750	760	-	692	-	690	730	770	750
height of bench	a) 900	914	914	914	914	900	900	900	915
top from	b) 500	-	-	457	-	-	580	500	465
floor	c) 0	0	0	0	-	-	-	-	-
interior height	a) 1450	-	1145	-	-	-	a) 1500	-	1450
from	b) 1850	-	-	-	-	-	b) 1820	-	1850
bench top	c) 2350	-	-	-	-	-	-	-	-
height of	1800	1800	1675	a) 1704	1600	1640	1800	1800	1750
sash opening	-	-	-	b) 1676	-	-	-	-	-
from floor	-	-	-	c) 1672	-	-	-	-	-
total height	2850	2740	2440	2633	2413	c) 2430	a) 2480	2850	2945
maximum (<3000)	-	-	-	-	(2543) with blower	d) 2580	b) 2680	-	-

Table 2 F u m e h o o d s

minimum face velocities per m front length and rate of flow

Level	USA NIH 1807			UK BS 3202		Germany VDI 2051	
	cross section of sash opening						
	5,6 ft^2 = 0,51 m^2			0,81 m^2		0,81 m^2	
	fpm	m/s	m^3/h	m/s	m^3/h	m/s	m^3/h
low toxicity level	50	0,25	470	0,1-0,2	400 to 600	0,2	600
average toxicity level in research	75	0,38	700	0,2-0,5	600 to 1500		

Table 3 Air exhausting from rooms with fume hoods

Institution	Type of laboratory	Conditioned air %	Auxiliary air %*
Hercules, Wilmington	Industrial	30	70
St. Louis	University	50	50
M.I.T. Life sciences	University	40	60
M.I.T. Chemistry	University	30	70
M.I.T. Materials	University	30	70
Parke-Davies	Industrial	40	60
Esso Research (Neubau)	Industrial	40	60
National Institute of Health	Research	30	70

*) In winter heated, in summer not cooled.

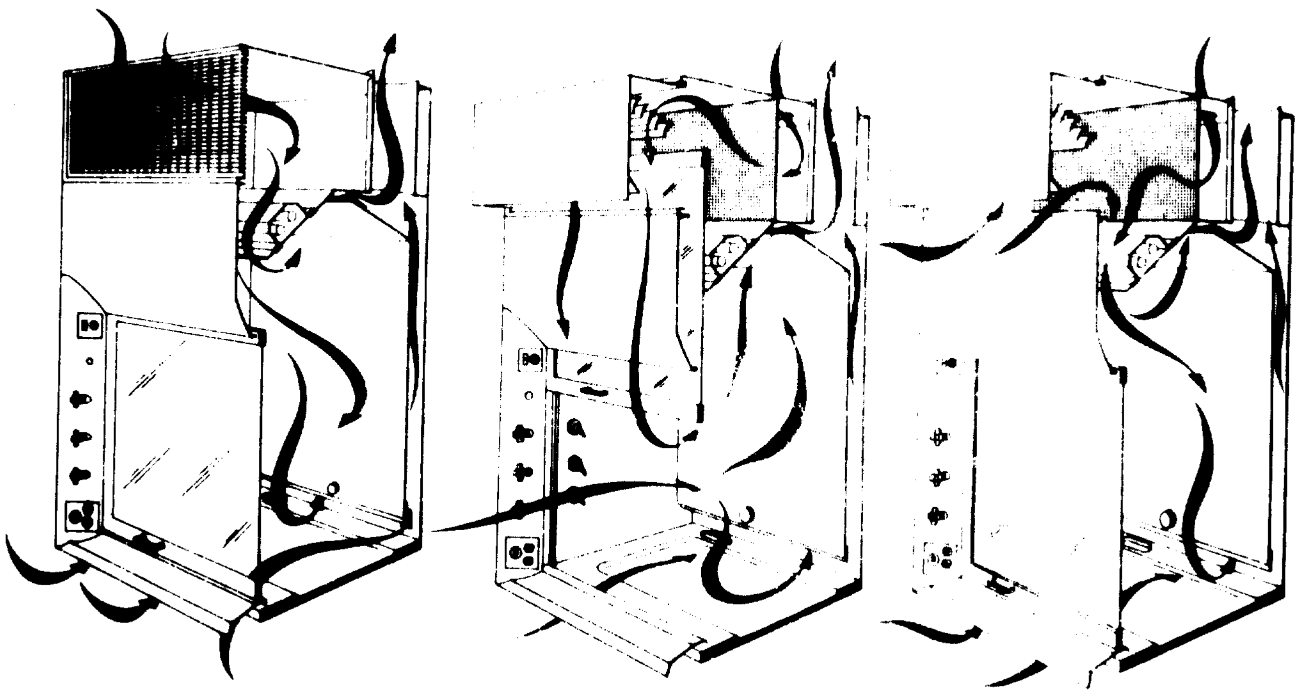
jectionable air through the fume cupboards are recommended for chemical laboratories (5.13). In the N I H publication 1807 (2) 6 to 8 air changes are required. Recirculation is excluded in both recommendations and in the German accident prevention rules (8,9) also. The exhausted air must be fully replaced by outdoor air. Table 2 shows the required air volume to be taken from the room.

In respect of air flow, there are three types of fume cupboard:

1) Fume cupboards with variable volume of exhausted air and variable face velocities, depending on the position of the sash, and by-pass for room ventilation (see fig. [illegible])

2) Fume cupboards with constant volume of exhausted air and constant face velocity, independent of the sash position (see fig. VI)

3) Fume cupboards with auxiliary air supply that is not cooled and dehumidized in summer and not fully heated in winter (see fig. VII, VIII, table 3)



fume cupboards made of epoxy-coated steel
with by-pass
with auxyliary air supply controlled by the sash

Fig. VI Fig. VII Fig. VIII

All three types influence the dimensioning of the whole ventilation system of the building to a considerable degree and, consequently, the investment and operating costs of a research centre if numerous fume cupboards are to be provided (see Table 3).

Type 3 is particularly recommended for institutions equipped with a large number of fume cupboards. Although the investment costs for the air-conditioning system are higher, the operating costs can be considerably reduced. The type of the fume cupboards should be known from a very early stage of planning. It should be

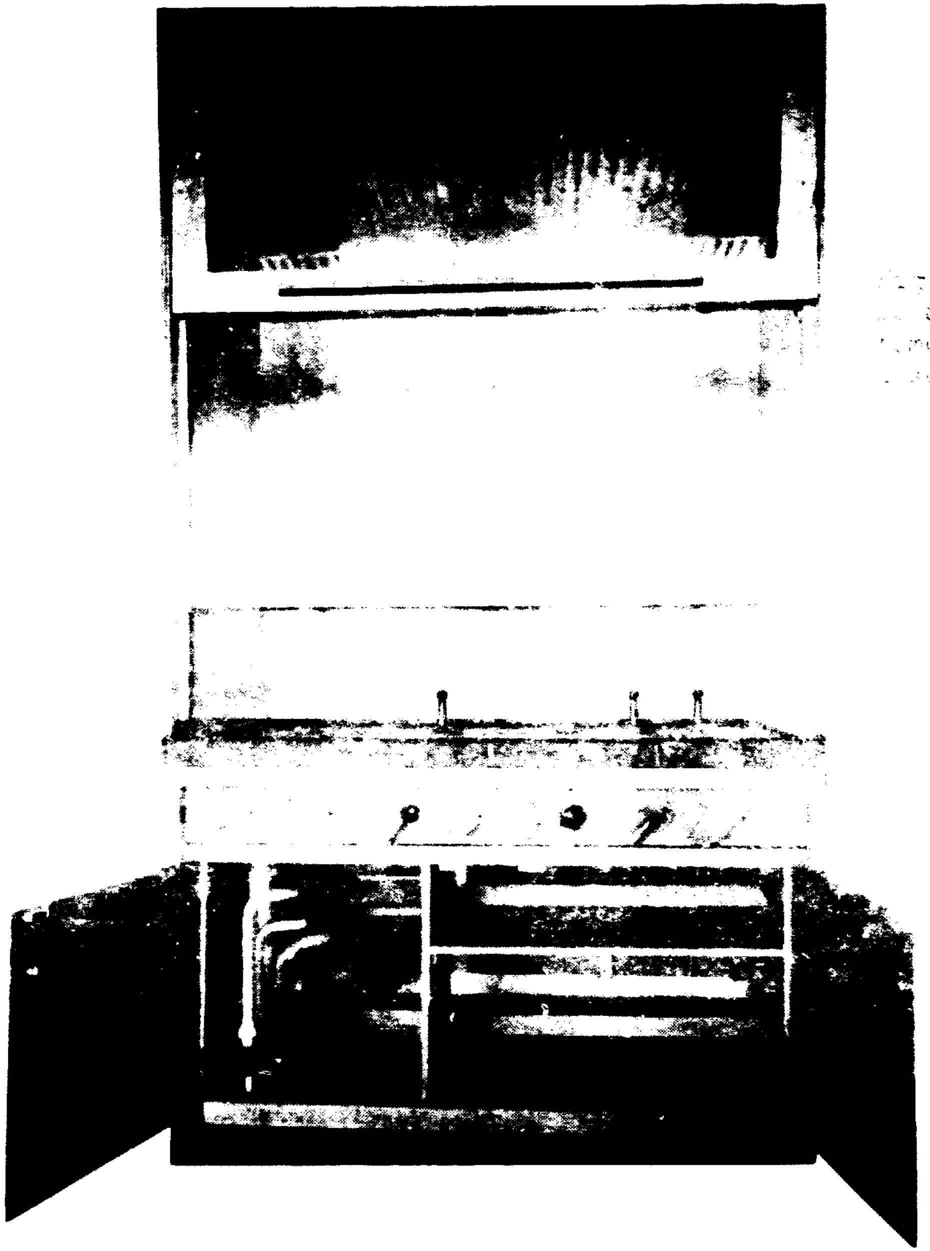
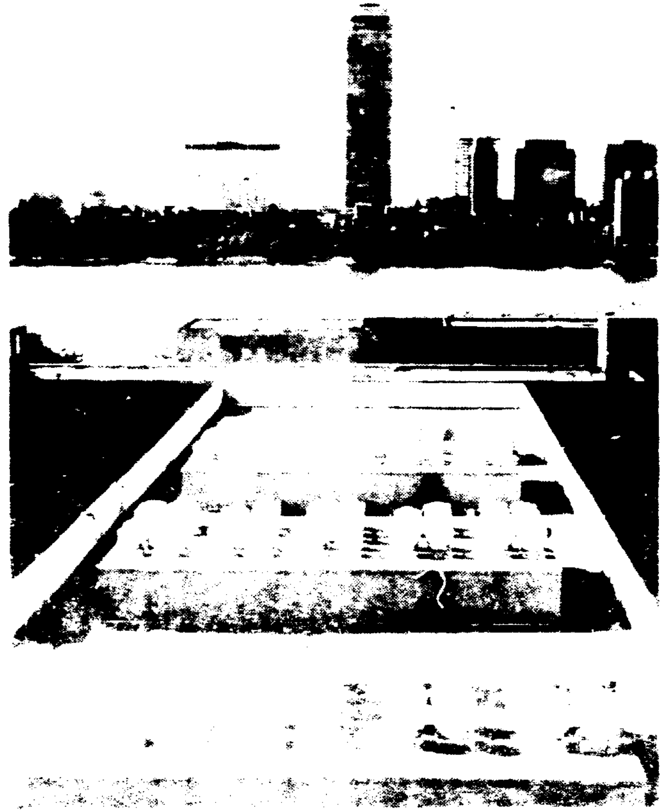


Fig. IX
...ally manufactured
fume cupboards...



... on the roof for the
exhaust of the fume cupboards in a
research centre (4)

borne in mind that, in general, type 1 can be manufactured by the local industry (fig. IX), while types 2 and 3 (see fig. VII and VIII) must be imported. Only a few American companies deliver such equipment to overseas countries.

In the United States, types 2 and 3 of fume cupboards were developed during the Second World War along with the development of nuclear engineering and were subsequently applied to general laboratory engineerimg. In spite of repeated efforts, these types have not been successful in European countries. Even the newest research centres of the German chemical industry still use type 1 (see fig. I). The reason for this is that air conditioning of laboratories in Europe is limited to heating and humidity control, thus causing much lower costs than the cooling of outdoor air.

3. DUCTWORK FOR THE EXHAUST OF FUME CUPBOARDS

If type 2 and 3 fume cupboards are utilized, one should take into account that each fume cupboard or at least the fume cupboards in one laboratory space are to be exhausted through separate ducts and by separate blowers. As a result, higher expenditures for the ductwork and a large number of blowers an the roof (see fig. X) must be expected. The connection of fume cupboards to separate ducts with separate blowers or to manifolds depends on the work conditions in the laboratories. H. Beck (3,18) has summarized his observations made over many years in the chemical industry as shown in fig. XI.

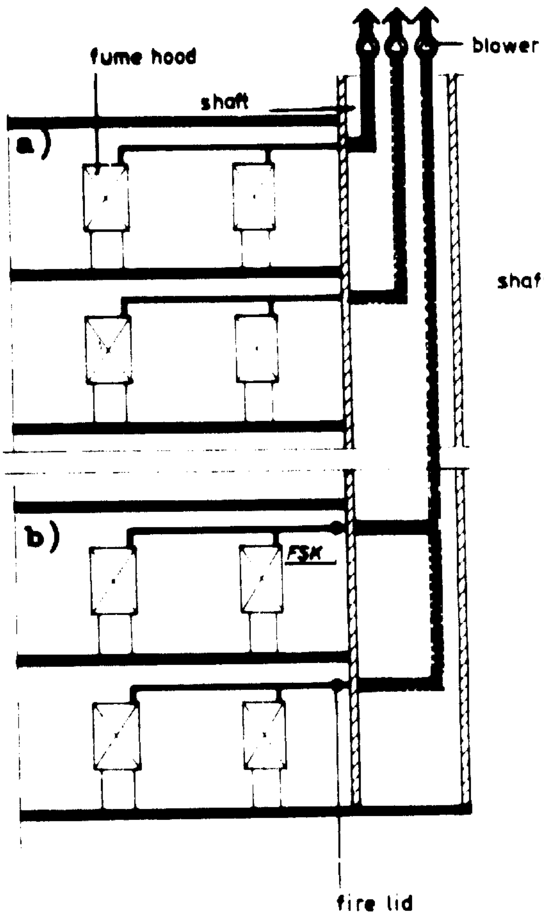
The optimum design for fume cupboards has often been discussed in Germany. It appear that even several fume cupboards, arranged in several rooms, can be joined to a graded manifold.

N I H publication 1807 recommends the connection of several fume cupboards for one manifold only when the fume cupboards are located in the same room and the exhausted gases or vapours are not reactive when combined in the air stream, which effect is difficult to predict.

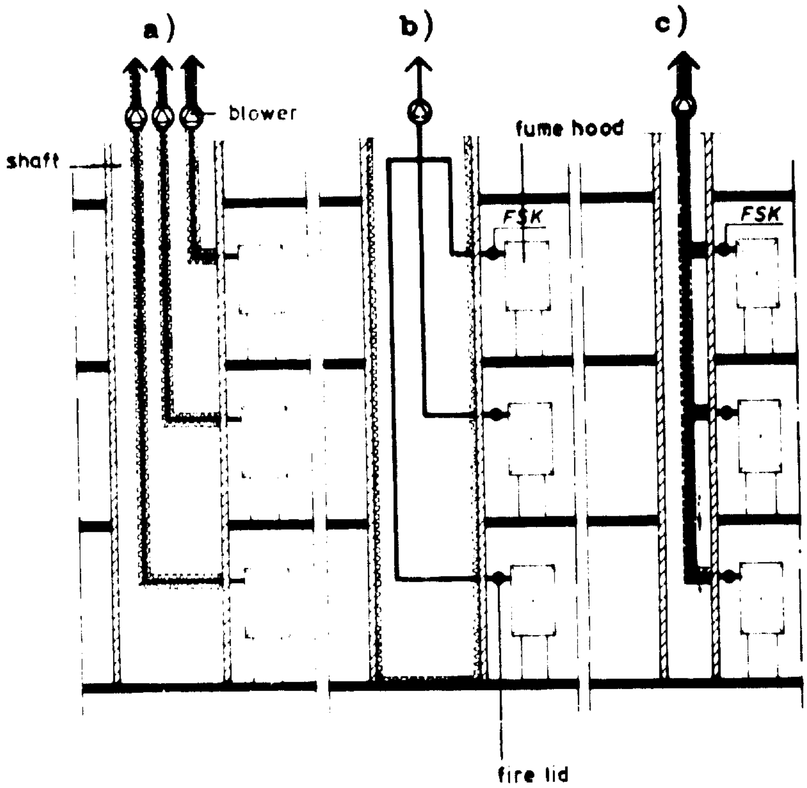
4. OPTIMUM RATE OF FLOW

A similar opinion is expressed in BS 3202 (1). Investigations carried out at the BASF and in German nuclear research centres (3,16) show clearly that the decrease in the concentration of objectionable matter in fume cupboards is only accelerated up to an optimum rate of air flow. The diagrams (see fig. XII and XIII) were obtained from measurements on the decrease of concentration of metaldehyde flakes fed into a cupboard and exhausted at a variable rate of air flow between 330 and 1340 $m^3/h/m$. Optimum efficiency was stated at a rate of flow between 400 and 600 m^3/h. This range corresponds to face velocities at the fully-opened sash (opening area about 0,8 m^2) of 0,14 - 0.2 m/s (table 2) and of 1,3 to 1.7 m/s for an air slot 10 cm high.

I. Horizontal conduction of exhausted air



II. Vertical conduction of exhausted air



I. Horizontal conduction of exhausted air

Evaluation I

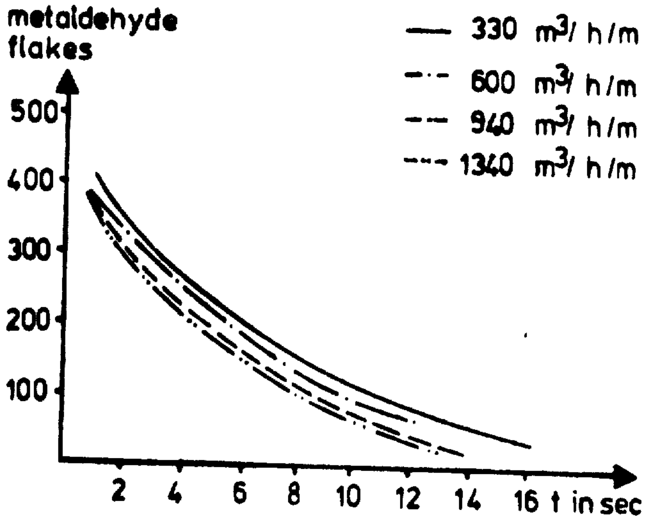
mutual influence	costs	space need	fire protection of ducts	co-ordination of air supply and exhaust
a) small	medium	large	non-infl. jacketing	good
b) medium	low	medium	non-infl. jacketing and fire lid	medium

II. Vertical conduction of exhausted air

Evaluation II

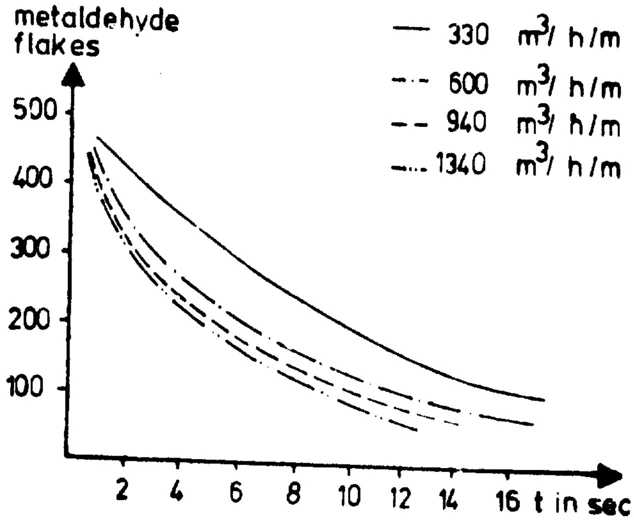
mutual influence	costs	space need	fire protection of ducts	co-ordination of air supply and exhaust
a) none	high	large	jacketing of the single ducts	good
b) few	medium	medium	fire lid and jacketing of the shaft	medium
c) heavy	low	small	fire lid and jacketing of the duct	bad

Figure XI



decrease of flakes
in the not occupied fume hood

Fig. XII



decrease of flakes
in the occupied fume hood

Fig. XIII

The question arises as to whether an air volume of 600 m^3/h per 1 m front length exhausted through the fume cupboard can be taken as a basic value instead of a minimum face velocity at the fully-opened sash. Such a reference might induce work with permanently fully-opened sashes, so that its secondary function, to serve as a protective shield, would be forgotten. Moreover, the principle of minimum face velocity cannot be applied to low bench fume cupboards and walk-in fume cupboards, because of the excessive air consumption involved. The basic requirement must remain: when working, shut the fume cupboard sash (8, 9)!

Horizontal sliding panels in the sash are to be provided for occasional handling inside the cabin.

The described work methods and the corresponding design of cupboards might be representative of the actual situation of laboratory techniques in Europe.

Bibliography see report of Friedrich Geyer on laboratory furniture and fittings.

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