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ECONOMIC EVALUATION OF CHIP AND DUST EXHAUST EQUIPMENT *

by

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CONTENT

Introduction

Chip and dust exhaust systems are installed in most wood processing industries and many wood workshops for environmental protection. Moreover, they are indispensable for trouble-free operation of wood working machines. Plants without chip and dust exhaust systems are susceptible to frequent machine down-time , consequently the machining quality is inadequate and the machine longevity shortened. Thus, more and more official regulations are prepared to guarantee good working conditions in the wood industry but the many national specifications are not yet harmonized. Therefore it is important to contact the relevant authorities when planning wood processing industries and the appropriate chip and dust exhaust plants.

1. Criteria to be considered when planning exhaust plants:

- Dust concentrations;
- Dust fires and dust explosions;
- Air pollution;
- Noise pollution;
- Fuel wood and dust firing;
- Noxious dust from tropical hardwoods.

2. Planning and calculating an exhaust system:

The following items are subject to clarification when projecting wood industries.

2.1 Type and number of machines to be hooked up to the exhaust system;

- which machine will operate from time to time simultaneously or will operate together because of the production flow (simultaneity factor) ?
- which regulations regarding air volume and exhaust speed have to be considered ?
- are there any machines where direct exhaust cannot be applied ?

2.2 Kind and volume of chip and dust material to be exhausted, derived from wood, lacquer, plastics, etc. and where it is generated.

Which of these materials has to be collected separately and may not enter the main plant ? Are there any wood splinters or coarse chips to be conveyed ? (size and quantity).

2.3 Location, size and type of chip/dust storage bunker or silo:
What is the distance between the machine shop and the silo (floor plan, side elevation if necessary) ? Which materials have to be stored spearately (e.g. plastics or wood dust) ?
Dimensions of existing or planned silo.
Will the material be conveyed directly to the storage station or is an intermediate exhaust station needed for constructional or economic reasons ?

That a certain chip bin pressure not be exceeded (e.g. if an automatic firing system is not available); Type of silo (concrete, steel or other construction).

2.4 How can chips and dust particles be separated from the carrying air ?

2.5 Should individual central or machine group exhaust systems be applied ?

2.6 Regulations have to be considered in addition to standard specifications.

3. <u>Projecting and layout of the exhaust system</u>

Planning will proceed when all these items are clarified. Here one has to refer to the importance of the "simultaneity factor" necessary for calculating the total amount of air for a sufficient chip and dust exhaust and satisfactory operation of a plant with a well planned production flow. This factor indicates which machines in relation to the total number of installed machines should be connected to a central exhaust system or should be considered for a machine group exhaust system. Type and number as well as capacity of the fans, their power requirement and also the size of the dust exhaust plant is calculated on the basis of these factors.

In most cases machine group exhaust is the better solution and machines which run within a group cannot often be hooked up to an individual exhaust system. When planning machine group exhaust one should combine all those machines which run simultaneously according to the operation sequences. (pictures 1,2)

Unless otherwise specified by the machine manufacturer, the air speed at the tooling is 22 to 30 m/sec to guarantee a sufficient chip and dust exhaust.

In order to reduce the air speed required, the risk of operating failures and also the power requirement (energy saving) it is essential that the exhaust hoods are properly designed. The chip flow trajectory should follow nearly parallel to the walls of the hood. An optimum design of an exhaust hood can only be achieved after the machine has been observed in operation. If this requirement cannot be fulfilled for technical reasons an increased air speed has to be applied.

Machines Technical Data	exhaust hood duct diameter	airspeed m/s	air volumn m3/h	layout drawing	Notes
Surfacer/Thicknesser Working width 630 mm up to 810	140 160	24 24	1340 1730	drawing	
Sizing circular saw	120 140	22-24	910/995 1230/1340	drawing	Subfloor exhaust, handhole + min. exhaust hood diameter overhead exhaust total 100 ø
Spindle moulder	120	24	995	drawing	bottom exhaust in addition 120 ø
Frame saw up to 600 trough 800 trough	200 220	26-28 26-28	2950/3190 3560/3840		with grillcover only, hand hole
drum sander working width	300	24	6100	machine layout	airspeed according to manufacturers' advice
Four side moulder 4 - 8 heads Bottom (truing) Fence side Moulding Nearside Top Bottom (universal)	working width - 170 mm - 250 mm 120 140 120 120 120 120 120 120 120 140 120 140	- 26	Addition of individual capacities	machine layout	follow manufacturers' advice

Exhaust hood duct connection diameter for different machines

For optimum rating of the exhaust fans the volume of air required and the overall pressure difference has to be determined; i.e. the resistance caused by friction in hoods, ducts, elbows, branches, filters or centrifugal separators etc. The overall pressure difference is expressed as Δpt in kp/m2 or in Pa. The resistances in the case of recirculated air or at the point of air outlet (bird screen, louvres, etc.) must also be taken into account.

$$\Delta P_t = \sum 1 \cdot Pr + \sum Pv + Pdy \quad (kp/m2)$$

In order to keep the overall pressure difference as low as possible the following factors must be considered during the planning phase:

Distance between the machine exhaust point and the silo. Select the shortest possible duct line;

Use as few bends as possible with large radii;

Select appropriate rated filter units or centrifugal separators.

Friction losses for the different duct components are listed in tables.

The fan can then be selected on the basis of the flow rate in m3/h or m3/sec and the overall pressure difference in ΔP_t in kp/m2 (Pa).

With these values one can calculate the power requirement on the fan shaft.

$$Nw = \frac{\Delta P_t \cdot V}{3600 \cdot 102 \cdot n} \text{ (kW)}$$

The motor is selected according to the listed capacity range + 15 per cent capacity reserve.

ΔP_t	=	total pressure difference - (kp/m2)
Σ l	=	length of duct line in m (sum of individual runs)
Pr	=	friction resistance per meter duct line
Σ Pv	=	sum of individual resistance incl. coefficients
Pdy	=	dynamic pressure (kp/m2)
Nw	=	power requirement at the fan shaft (kW)
V	=	air volume flow rate (m3/h)
n	=	fan efficiency

4. Selection of the separation system

4.1 Gravity separator

For separation by gravity the air stream is blown into a room which is large enough in relation to the air blown in to reduce the humidity sufficiently for the material conveyed to drop down by gravity. This system is not appropriate for wood dust and light chips, in this case filters have to be added.

4.2 Centrifugal Separator (Cyclone)

Tangential in flow into a cylindrical vessel, the lower part of which is usually funnel-shaped, cuases the air to whirl. The particles are thrown against the cyclone wall following a downward spiral pass to be ejected at the bottom.

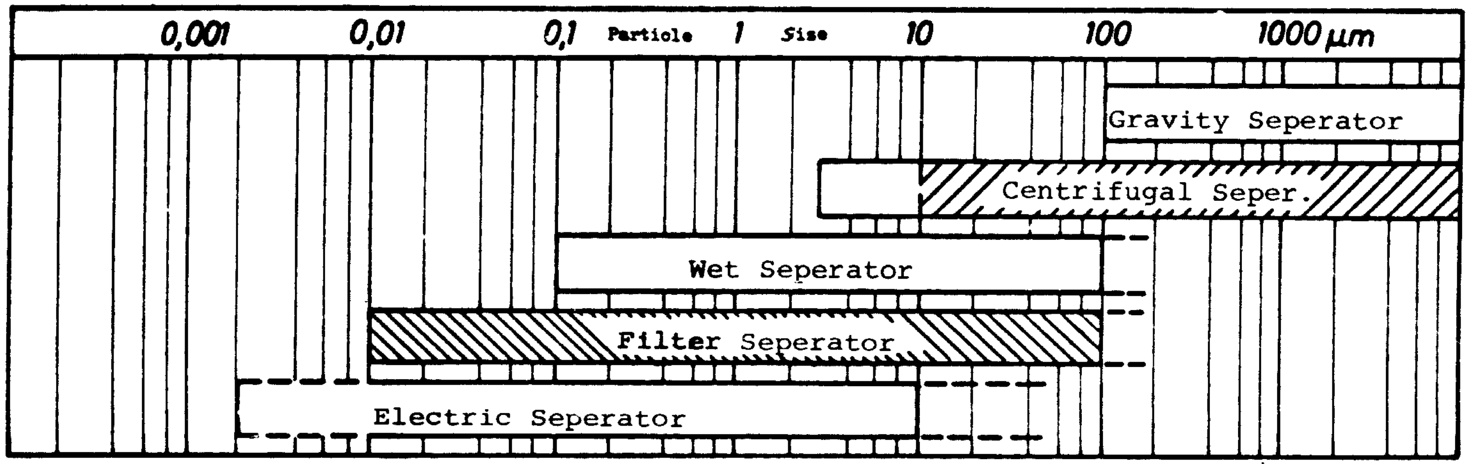
The dust free air up streams through a centre duct of the cyclone. Separation is caused as a result of exceeding the critical loading of air on the walls. The application of centrifugal separators (cyclones) is limited because of the low efficiency of separation, particularly with particle sizes larger than 10 um. In wood processing the dust particle size is 20 per cent and more. Even if the separation efficiency is 90 per cent or possibly higher, these separators still do not satisfy up to date requirements. Centrifugal separators are appropriate only for the separation of coarse or wet saw dust of sawmills. However, centrifugal separators (cyclones) are often used as pre-separators in connection with additional, down-stream filtering.

4.3 Filter Separator

The efficiency of filter separators is 99.9 per cent depending upon the selection of the filter materials. Gauze and needle felt are used for wood dust filtering. The filter hoses have to be cleaned either manually or require maintenance by mechanical or pneumatic shaking. The filter resistance for dust exhaust plants is about 60 kp/m2 when appropriately rated and can rise up to 100 kp/m2 during operation,so have in mind filter cleaning is essential.

4.4 Wet Separator (Water Wash Deduster)

These units are used in wood working exclusively in lacquer sanding sections. Several different washing systems are used but they are always based on the principle of intensive mixing of the dustladen air and the flowing or sprayed water. The lacquer dust separation efficiency is about 99 per cent. The disposal of the dust sludge sometimes presents considerable problems, especially if local regulations specify its transport to special dumps. Figure 4 shows the application ranges of the various separation systems in relation to particle sizes. The value ranges are guidelines for a first selection only.



Separator application in dependency of particle size

The decision for selecting the appropriate separation system would in most cases probably be in favour of the filter dust. With regard to air circulation they are most efficient. As already mentioned the selection of filter materials is dependent on the material being processed, local regulations and the work place requirements. The filter load rate is fixed at 80 m3/h per m2 filter area for fine dust when air purifying requirements are high and 180 m3/h filter area for coarse chip material.

The following filter arrangements can be recommended: the optimum solution of filter arrangements is on the top of the chip bin with direct air in-flow. During the cleaning operation gravity causes the filtered chips to drop from the filter surface into the bin. (Picture3,4,5)

5. Fire and explosion security

A proper selected and well established chip and dust exhaust system reduces the fire risk in silos or offer chip storage areas. A fire is often caused through sparks with circular saw blades jamming with wood waste. Safety precautions have to be considered in the planning stage. Chip bins are a separate section with special fire risk protection and should be erected in a safety distance from the factory. Even steel chip bins have to be off the buildings (about 10 m) as they emit heat in case of fire and can easily deform and even hang over on to neighbouring buildings. Exhausted dust should be stored separately.

Bridge formation is caused when chips are stored in silos for a long time. This tendency can be avoided by tapering the silo at the bottom and making it smooth-walled. Silos should be equipped with pressure relief areas such as doors, covers, flaps or other surfaces which open in case of explosion without creating a hazard. There are statutory regulations governing their size. This arrangement reduces pressure increase in the case of dust gas explosion. Doors must be fire-resistant and openings in the fire wall must be equipped with fire protection flaps. Moreover, there are various alarm systems which can release a sprinkler system in case of spark or smoke formation. Suction as well as delivery pipes have to be of non-combustible material with smooth inner wall surfaces. The minimum air velocity in the duct lines should not be below 20 m/sec to prevent dust and chip deposits. A minimum distance of 0.10 m must be maintained between wooden components and duct lines which would get very hot in the case of a fire. Cyclone outlets, chimney openings have to be at least 10 m away to prevent sparks from the chimney creating a hazard. If necessary, cyclones must be equipped with vent bends. The entire heat system has to be earthed so that static loads caused by particle friction on the duct walls and against each other are eliminated.

6. Considerations on economy of operation

The economic evaluation of chip/dust exhaust plants depends on the type of factory to be equipped with exhaust system, the equipment costs, cost of labour for manual chip removal, etc.

6.1 Comparison of different exhaust systems

6.11 Individual exhaust.

Each machine is connected to a unit with exhaust duct for hooking up the machine. These systems are 25 to 30 per cent more expensive than group exhaust systems but the advantage is that the capacity is adjusted to the machine.

The operating costs of such systems are considerably less expensive depending on the number of machines running simultaneously. This can be shown by way of an example of a small woodworking shop with the following machines:

Panel-sizing saw, spindle moulder, surface planer, thicknesser, band saw - the total air volume required is about 5700 m3 at a pressure difference of 250 kp/m2.

Motor capacity 5.7 kw
Fan (open-type fanwheels) efficiency 68 per cent.

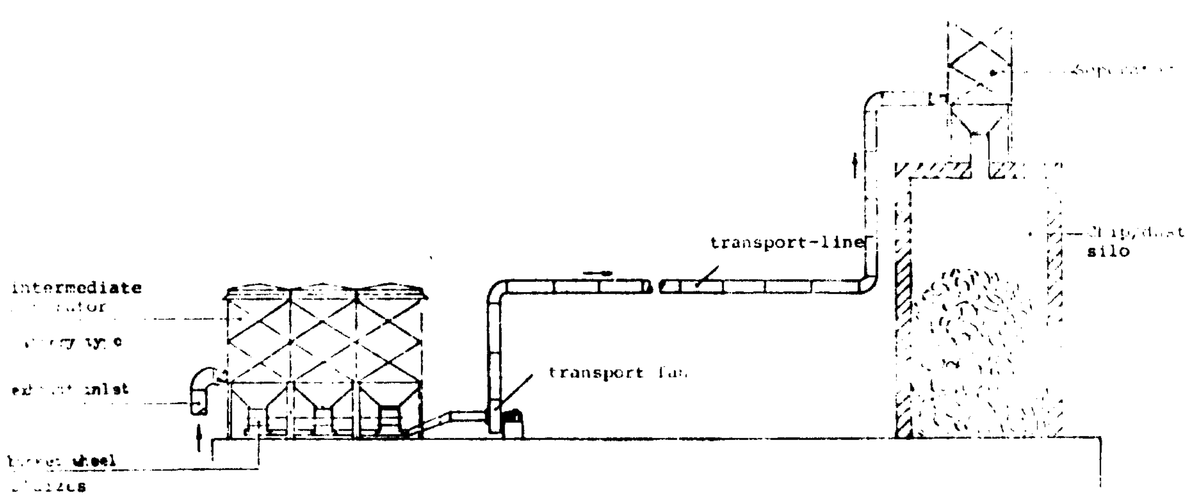
When a single fan will be used for chip/dust exhaust on these machines, 5.7 kw/h the same capacity will be applied for operating one machine only, even if 0.7 kw or 1.7 kw/machine is required for dust exhaust.

This example of a small machine group which could represent the entire equipment of a small workshop can also be applied to large and medium sized firms who install several machine groups to suit their production flows. The comparison can be done to any size of company.

If the fixed maximum rate of 70 per cent of the exhaust capacity for each of these groups is used permanently, the total investment and operating costs could be reduced by 30 per cent as compared to the assumption of a simultaneity factor of 100 per cent. A cost comparison should be made when distances between exhaust station and chip bin are more than 50 metres.

Intermediate exhaust renders possible to locate filters very close to the machinery area, filtering the large volume of exhausted air and return it to the workshop. The concentrated chip waste is fed by bucket wheel sluices or other mechanical devices to a conveyor duct and requires at this point only 10 per cent of the air volume which is necessary to collect the chip waste at the machine. Transportation to the distant chip bin therefore takes place with substantially less air and consequently requires considerably less power. An advantage is the regaining warm air, assuming that the machine shops are heated. Apart from the 50 metre distance the comparison should also take into account a minimum air volume of 30.000 m3.

The air volume ratio for material transport should not be less than 1 : 3 where the relative density of the dust/chip mixture is 130 kg/m3 (1 kg dust and chips to 3 kg air).



Intermediate separator with pneumatic conveyance to main silo

5.12 Exhaust for machine groups

Example : 3 machine groups each of which is connected to one fan Total capacity of 17.000 m3/h, from machine shop to chip bin 100 metres require a motor capacity of approx. 18.5 kW.
However, the actual transport of material by a fan with an air capacity of 4500 m3/h and total pressure difference of 300 kp/m2 requires only 6 kW. This produces a saving of 12 kW/h in favour of intermediate extraction. A low pressure balance is necessary when dust exhaust plants operate in closed rooms which can be compensated by an air recirculating system. Where tropical woods are machined air recirculation is not permitted although this depends on local conditions, because of allergic influence caused by these dusts. The average dust concentration in a room will not increase by the residual dust in the recirculated air as one could assume for the room air in an enclosed system.

The economy of operation considerations have to be supplemented by the following factors: Centrifugal separator should be installed when the chip material justifies its selection both from an investment and operating cost point of view. Filter plants necessitate a greater degree of maintenance and are subject to a higher rate of wear. The profitability of recirculating air systems requires the consideration of realistic facts. The daily temperature difference in European latitudes does not exceed 18°C . Assuming temperature differences from -15 to +20° C are unrealistic. Taking into account a temperature difference of 18° and a total air volume of 50.000 m3/h, the heat loss can be calculated as follows:

$$QL = V \cdot \gamma \cdot c_p \cdot \Delta t$$

This value can be further reduced when not all fans operate at the same time or the full day.

60 per cent of the total volume per shift equals a heat loss of 160.000 kcal/h. Heat regained through recirculated air will not increase operating costs or save investment costs for the installation of the heating system. The heat losses through heat transmission caused by emmission from ductlines, the chip bin or filter system from where the hot air recirculates has to be calculated.

$QT = k.A.\ \Delta t$

Q_L	=	ventilation heat requirement	(kcal/h)
V	=	flow rate	(m3/h)
γ	=	specific gravity of air at 20°C	(kg/m3)
c_p	=	specific heat of air	(kcal/kg °C)
Δt	=	temperature difference	(°C)
k	=	coefficient of heat transmission	(kcal/m2 h °C)
A	=	area of building	(m2)

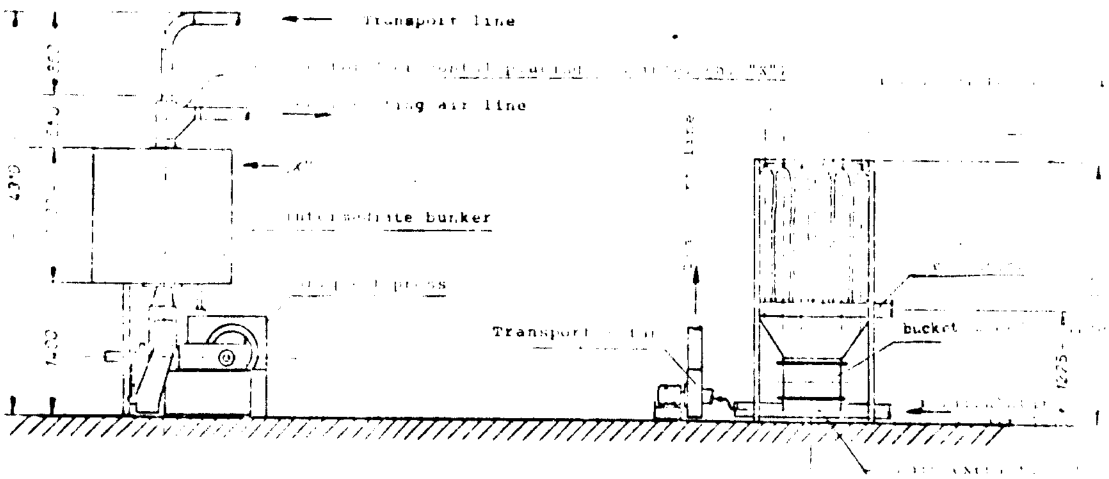
Generally speaking, recirculating air systems are of interest only in European or similar latitudes from an economic point of view.

7. <u>Utilization of chip material in solid form.</u>

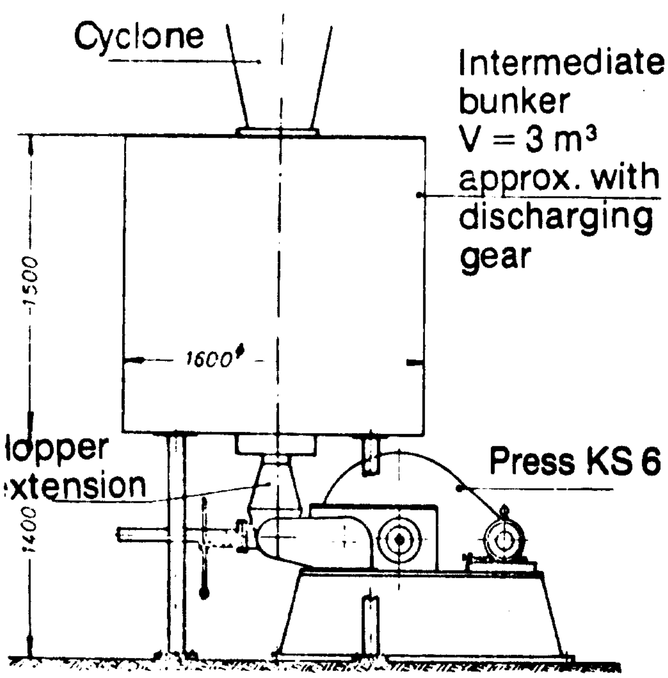
Solutions for recycling or disposal of the chip/dust materials collected in the silo is of significance in economic operation of a dust exhaust plant.

Chip removal from the bin, when manually operated, is time consuming and extremely unpleasant because of the amount of dust generated. Automatic systems can be applied to facilitate discharging.

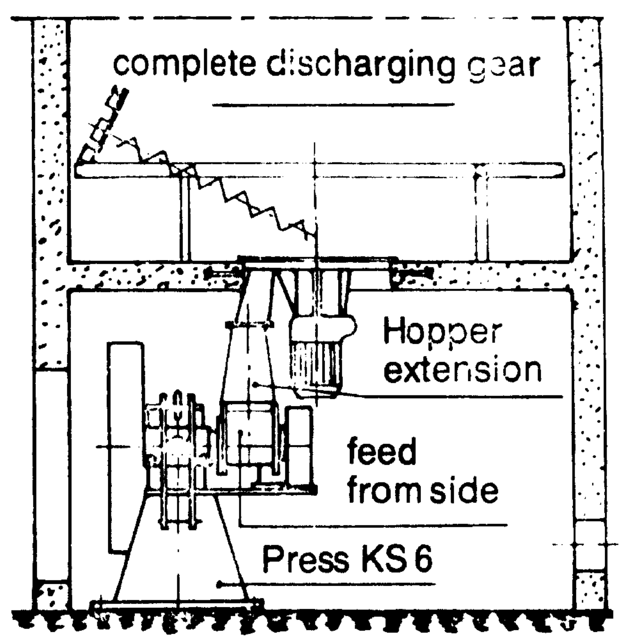
A valuable solid fuel material can be obtained by briquetting the chip and dust material. Chip in briquette form can also be used for further recycling operations, viz: pulp and paper. Wood chip briquettes are relatively dense, up to 30 per cent more than the original wood, and therefore possess a higher calorific value per volume unit. Briquetting presses can replace chip bins which is of interest in areas with dense population in town centres where the installation of chip bins is not permitted. Chip waste can also be utilized in particle board manufacture, but screened chips are accepted only. This is a good reason for storing chips from different production processes separately. (see page 11)



Wood chip briquetting press connected to an intermediate chip dust exhaust system



Briquetting Press with intermediate bunker V = approx. 3 m³



Briquetting Press installed beneath a silo

8. QUESTIONNAIRE FOR INSTALLING A CHIP/DUST EXHAUST SYSTEM

Customer | Dealer

Order Number: | Date:

Offer Number: | Date:

Factory Size:

Number of labourers:

1. Layout scale 1:50 or 1:100
   with sectional views, top plan view,
   when necessary machine location, operation facilities, duct lines,
   bin and fan location has to be included

2. Central or machine group exhaust system

   2.1 Number of machines

   2.2 How many machine groups

3. Production machinery

   3.1 Which machines will be grouped
   (will operate at the same time)

   3.2 Which group exhaust units (fans)
   are working simultaneously.

   3.3 Are there any special requirements regarding air consumption
   and air speed at certain points on the machines.
   Check manufacturers' advice (maintenance manual).

   3.4 Are there duct swivel joints necessary on machine hoods
   (e.g. on double end tenoners, edge banding machines, automatic
   contour shapers)

   3.5 On which machines have hoods, hood ducts or connecting ducts to be
   installed.

4. **Material to be exhausted:**

   4.1 Wood chips, shavings,

   4.2 Wood sanding dust

   4.3 Material from particle board; percentage as ratio of other chips.

   4.4 Saw dust

   4.5 Plastic material dust/chips (which kind of plastics).
   Is a separation and special storage necessary ?

   4.6 Coarse particle waste amount (cbm per month)

<u>Note:</u> Details are needed in case of varying chip and dust waste material or high amount of the latter on special machines or machine groups to be exhausted.

5. Chip bin (Silo)

   5.1 Brick or concrete construction

   5.2 Prefab-Bunker (make:)

   5.3 Inside dimensions
   Height: Width: Length: Diameter:

   5.4 Is it necessary to collect chips and dust separately?

   5.5 In addition to dimensions of tube filters specified on the attached drawing will cover more details

   5.6 Pressure release space (total space, dimensions)
   Have explosion covers to be considered ?

   5.7 Are there any special requirements regarding the pressure of the bin (automatic loading)

6. **Separation of exhausted air and material**

   6.1 Tube filter system without/with vibrator

   6.2 Cyclon

   6.3 Special

7. **Duct installation**

   7.1 Interior installation

   - ceiling mounted
   - floor channel
   - cellar ceiling mounted

7.2 Exterior installation
- cantilever self supporting
- additional supports are built in at distances more than 20 m
- mounting on building wall

8. Shifting of Ducts

8.1 Mounting height of ceiling

8.2 Can ducts be mounted to ceiling girders or joists ?

8.3 Are special mounting parts viz. duct clamps, supports, sleeve joints, hangers, necessary ?

8.4 Has the open air duct line to be supported (on roof, wall, etc.)

8.5 Who takes care for supplying fixings ?

8.6 Should cantilever self supports (up to 20 m) be delivered ?

8.7 Is a roof break through necessary and has it to be retightened after duct mounting ?

9. Fan

9.1 Who delivers the base support or wall support for the fans ?

9.2 Are fans already installed (make:)
Fan capacity:
Supply details

9.3 Is thermisto safety (cold conduct check) for motors required ?

9.4 Details on electric power:
Voltage: Cycles:

9.5 Should fans be installed outside the building ? Who will prepare the roofing ?

10. Mounting of the exhaust system

10.1 Are scaffoldings, cranes and equipment for both indoor and outdoor mountings of cyclones, duct lines, etc. available ?

10.2 Who will pay costs for scaffolding, crane and other auxillary material and equipment ?

10.3 Is alternating current (AC) voltage 220 or three phase current (DC) voltage 380 and a sufficient number of sockets for power tools available ?

10.4 How many helpers are available to assist the fitters ?

11. General conditions

11.1 Is a detailed offer requested ? (Additional deliveries caused by changes or replanning will be calculated separately) Mounting costs are calculated on an hourly rate according to national regulations of the manufacturer.

11.2 Is an offer requested on the basis of:

- fixed price
- without/with mounting costs

11.3 If an existing machine should be used in addition it has to be clarified who will be responsible for demounting and which parts will be re-used;

12. Details on machines to be connected to the exhaust system

Nr.	Make	Machine	Type	Year of Manufact.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

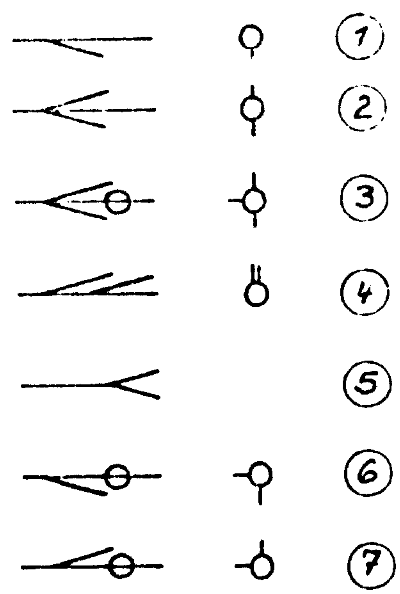
For special machines viz: automatic sanders, multi-unit machining systems, as well as machines of foreign make, exhaust layouts and literature have to be included.

When stating the order it is necessary to include scaled drawings for exhaust hood connections.

Duct branches:

Nr.	Symbol Nr.
I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	
XI	
XII	
XIII	
XIV	
XV	

Branch type



Standard length 1000 m

9. SUPPLEMENT TO THE LAYOUT WITH FIXED DATA FOR THE PROJECT PLAN.

Obligatory data necessary for setting up of project.

Offer Order

Customer

Dealer

1. Customer's layout or drawing as drafted on the reverse page. Drawing has to include feed direction of machines

2. Location of chip bin (silo)
   - 2.1 Distance from workshop
   - 2.2 Height
   - 2.3 Inside dimensions

3. Type of chip bin (silo)

4. Storage height

5. How to separate exhausted a.. and chips

By:		
5.1	Cyclone filter within the workshop area	return air into the workshop saving heating costs, pressure balance
5.2	Tube filter set within the workshop area	
5.3	Variety filter within the chip bin	
5.4	Cyclone separator on top of bin	Loss of air blown into the open air, need of high heating costs; uplift pressure
5.5	Vent chutes in the bin or other means	

6. Factory (workshop) size
   - 6.1 How many labourers are employed
   - 6.2 How many labourers are in the machining department
     - Average man rate:
     - Maximum man rate:

7. How to bed the exhaust ducts:
   - 7.1 Below floor level
   - 7.2 In the cellar
   - 7.3 Below workshop ceiling
   - 7.4 On floor level or other arrangements

8. Are there any machines running permanently at the same time ?
   8.1 Which machines
   8.2 Never

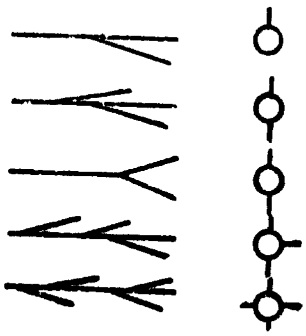
9. Is an individual group or complete central exhaust system requested ? Group- or central exhaust systems are lower priced (20 - 30 % lower than individual exhaust systems but basic operating costs for individual machine exhaust are more convenient thus preferable to install).

Details about the machines to be connected with the exhaust system: The listed machine number has to be identical with the number in the layout or drawing.

Type No.	Make	Type of machine and working width	Type	Year of manufacture	Type No.
1					
2					
3					
4					
5					
6					

Exhaust hoods can be manufactured when all data are available.

Details about branch ducts:



Branch ducts according to layout or drawing including designation:

Required branch types as a symbol:

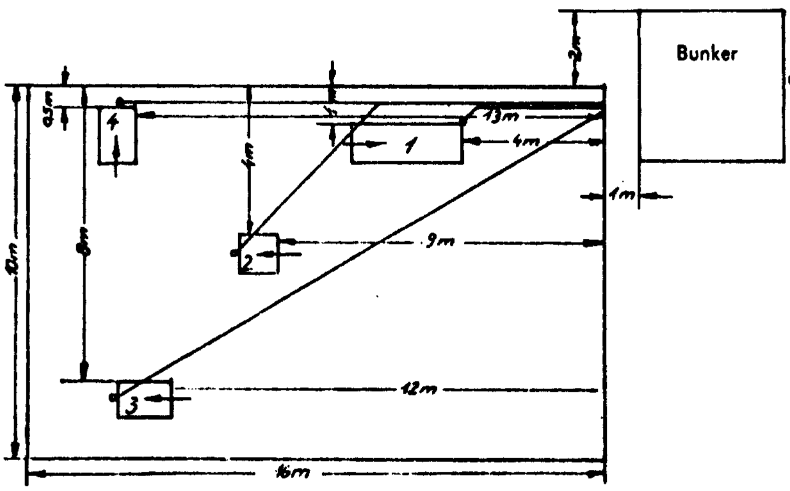
I	VII
II	VIII
III	IX
IV	X
V	XI
VI	XII

II 180/100/140/120 *)

Example:

*) The first two diameters are sizes of the main duct, the second two diameters are sizes of the branches.

Example covering the necessary data of the drawing:



Duct diameter mm	Sizes equ. cm
100	78
120	110
140	155
160	200
180	255
200	315
220	[illegible]
300	705

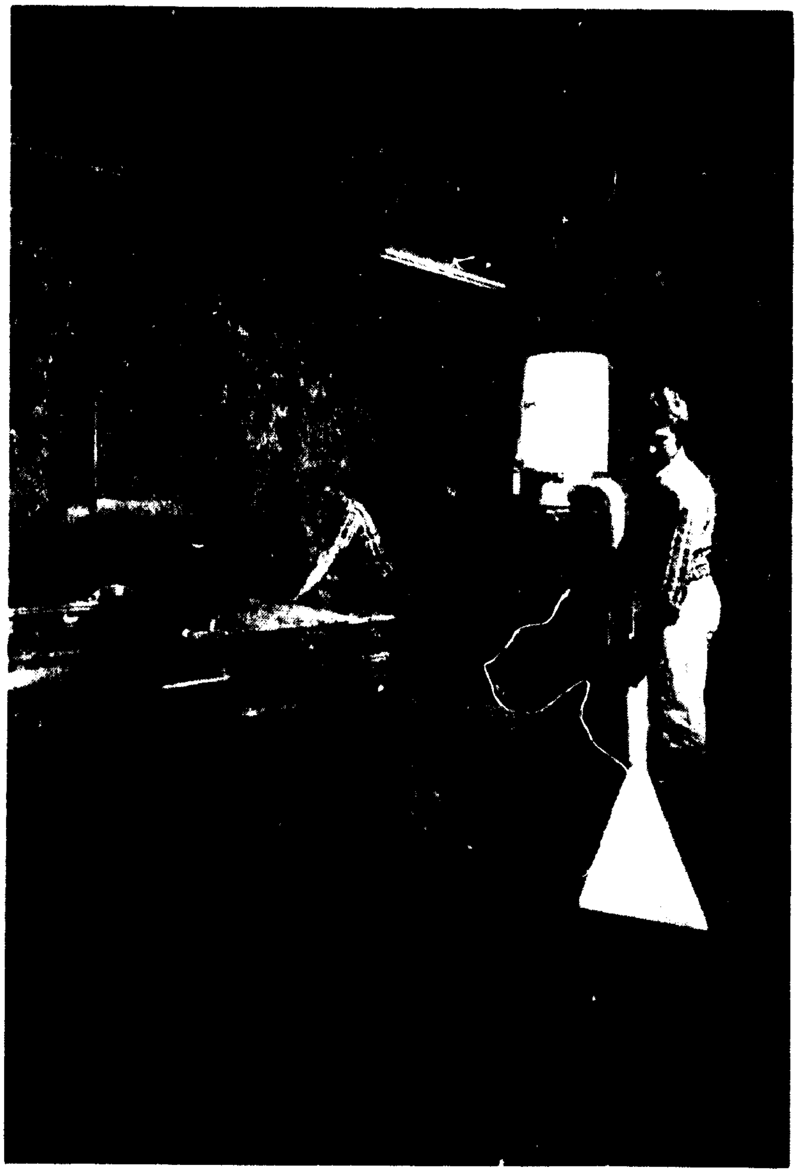
If joists are below the ceiling, give details as to size and height. The drawing has to include duct lines and the location of the blower.

No offer can be prepared and no offer can be presented when the basic data is not available.

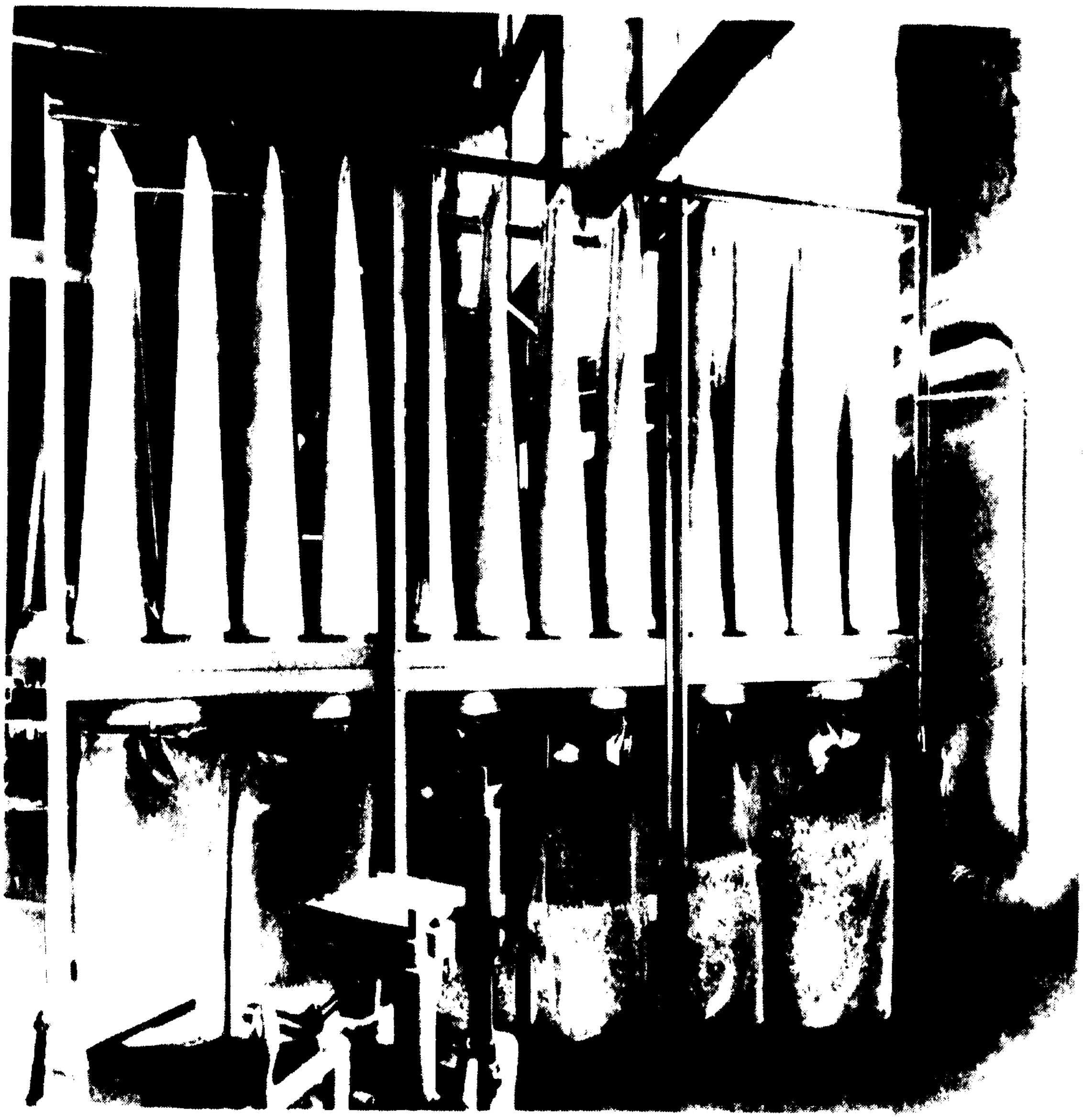
Pict.1 : Machine group chip exhaust
(for each group of machines 1 fan)

Pict. [illegible] : Individual [illegible]
for thicknesser, [illegible],
circular saw. [illegible]
stroke belt sander.
1 fan for [illegible]

Pict. 3 : Chip silo with filter tubes



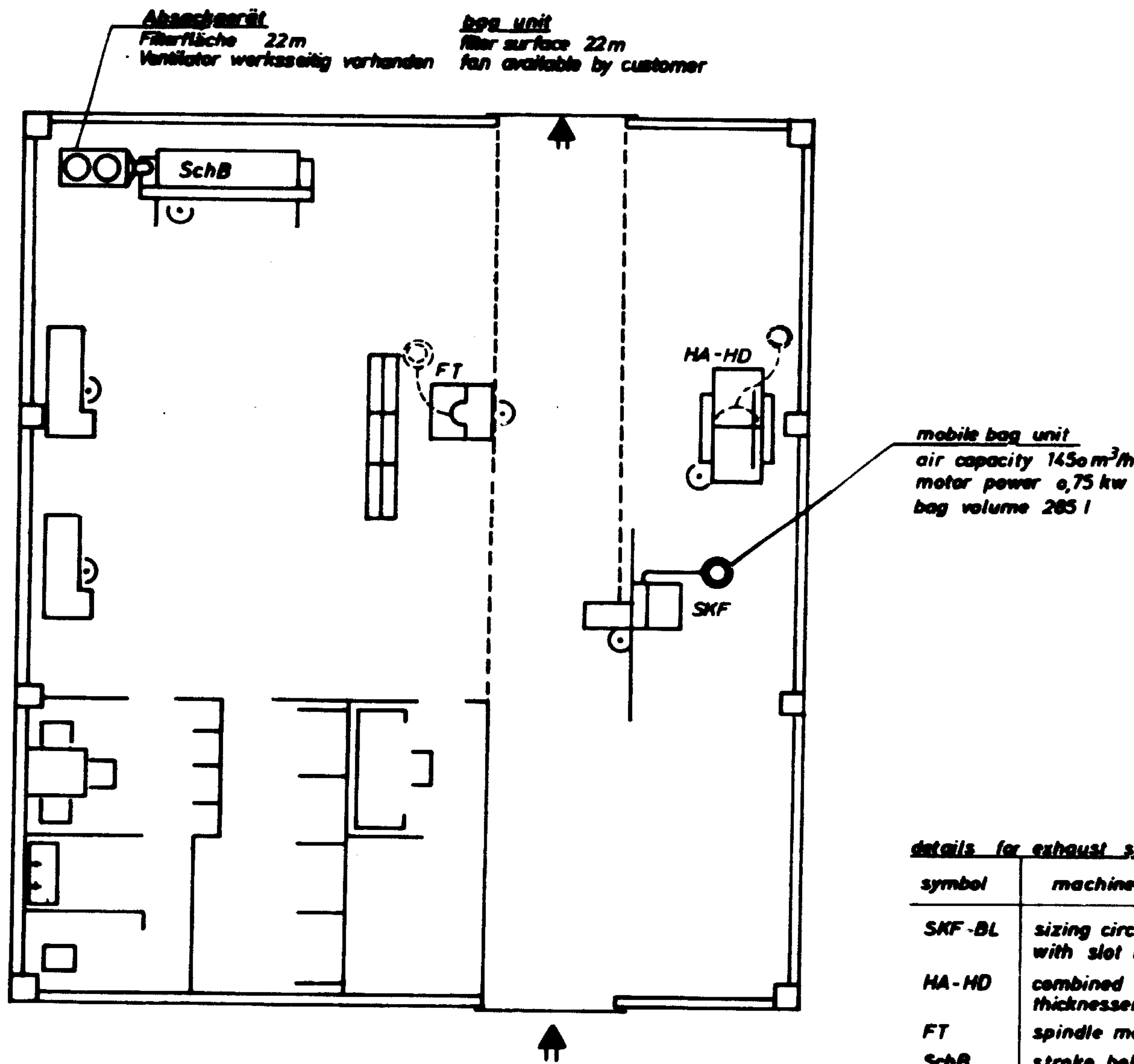
Pict. 4 : mobile dust exhaust equipment with horizontal fan; in this case it is used for vacuum cleaning



Pict. 5 : **Filter exhaust (modular system) with plastic bag collectors**

Annex 1

mobile bag unit for chip exhaust- and stationary bag unit for sanding dust exhaust

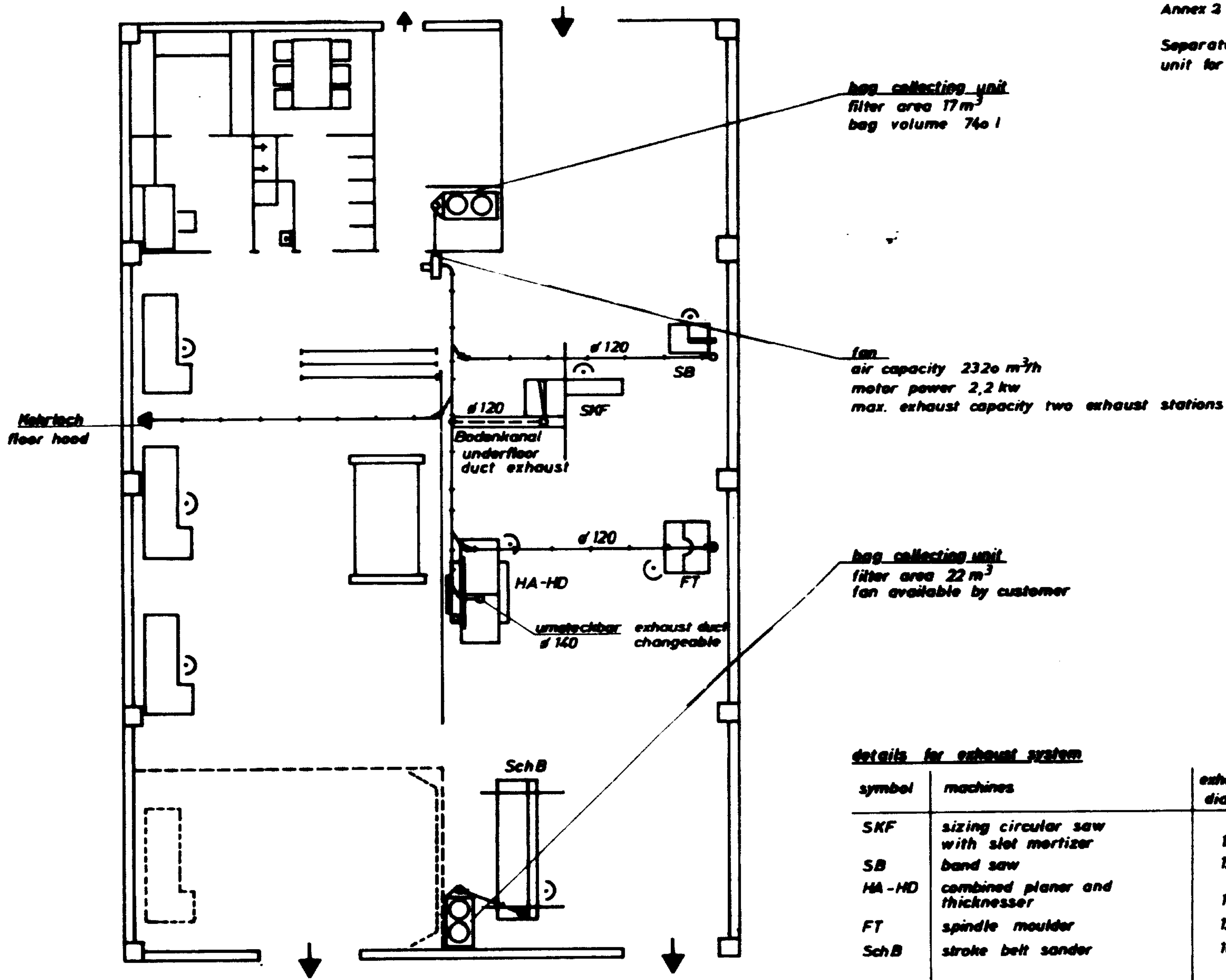


details for exhaust system

symbol	machines	exhaust hood diameter	required air m³/h
SKF-BL	sizing circular saw with slot mortizer	120	980
HA-HD	combined planer and thicknesser	140	1345
FT	spindle moulder	120	980
SchB	stroke belt sander	180	fan available

Annex 3

Separate indoor bag collecting unit for chip and dust exhaust

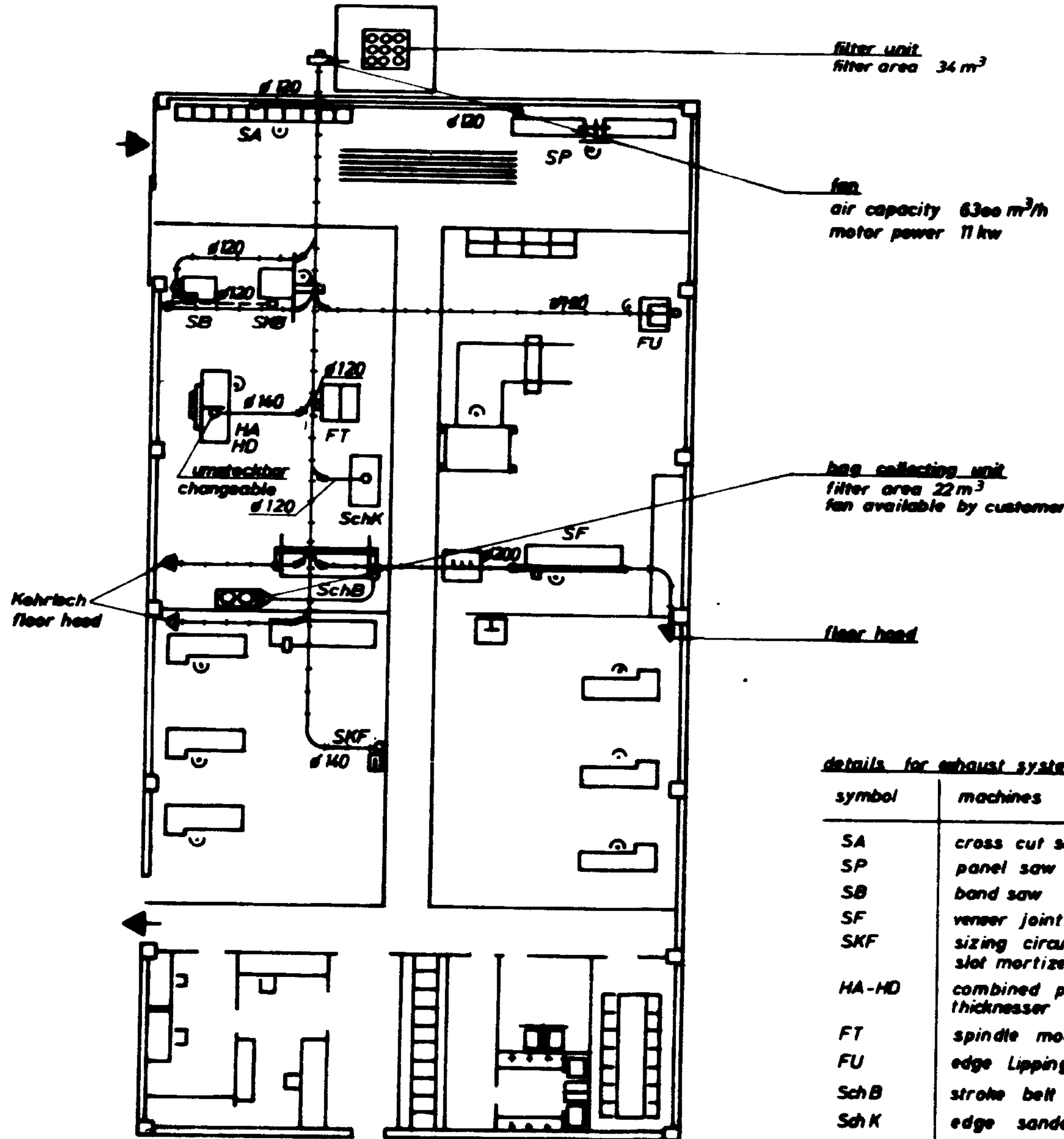


details for exhaust system

symbol	machines	exhaust hood diameter	required air m³/h
SKF	sizing circular saw with slot mortizer	12o	98o
SB	band saw	12o	98o
HA-HD	combined planer and thicknesser	14o	134o
FT	spindle moulder	12o	98o
SchB	stroke belt sander	18o	fan available

Annex 3

chip and dust exhaust plant with outdoor filter unit



details for exhaust system

symbol	machines	exhaust head diameter	required air m^3/h
SA	cross cut saw	120	980
SP	panel saw	120	980
SB	band saw	120	980
SF	veneer jointing saw	200	2710
SKF	sizing circular saw with slot mortizer	140	1340
HA-HD	combined planer and thicknesser	140	1340
FT	spindle moulder	120	980
FU	edge Lipping machine	120	980
SchB	stroke belt sander	180	fan available
SchK	edge sander	120	980
SKB	rip saw	120	980

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

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80.06.24