4.2.3 Bone Meal Plant C

(1) Outline of the factory

1) Name of factory	:	Sungserm Bone Meal (Thaprautsahagen)
2) Name of owner	:	Mr. Amunut Patanapaibunsin
3) Address of factory	:	27 Soi Wat-nangsaw, Setakit 1 Road, Moo 5, Ta Mai District, Amphor Kratumban, Samutsakhon
4) Date of establishment	:	1956
5) Industrial category	:	animal bone grinding and boiling
6) Manufacturing products	:	bone meal : 90 tons/yr. bone oil : 5 tons/yr. salted hide
7) Raw materials	:	animal bone : 100 tons/yr. animal hide
8) Operating hours	:	7 :30 ~ 17:00 (8 hours/day)
9) Number of employees	:	30 (2 engineers)
10) Surrounding land usage	:	industrial area
11) Site area	:	32,000 m^2
12) Building area	:	factory building : 3,090 m^2 garage : 1,700 m^2 warehouse : 960 m^2
13) Factory layout	:	Shown in Figure 4-17.

(2) Production process and operation management

1) Bone meal and bone oil are produced from the bones of cattle and water buffalo at this factory. The production process is shown in Figure 4-14 and the specifications of major equipments are shown in Table 4-10.

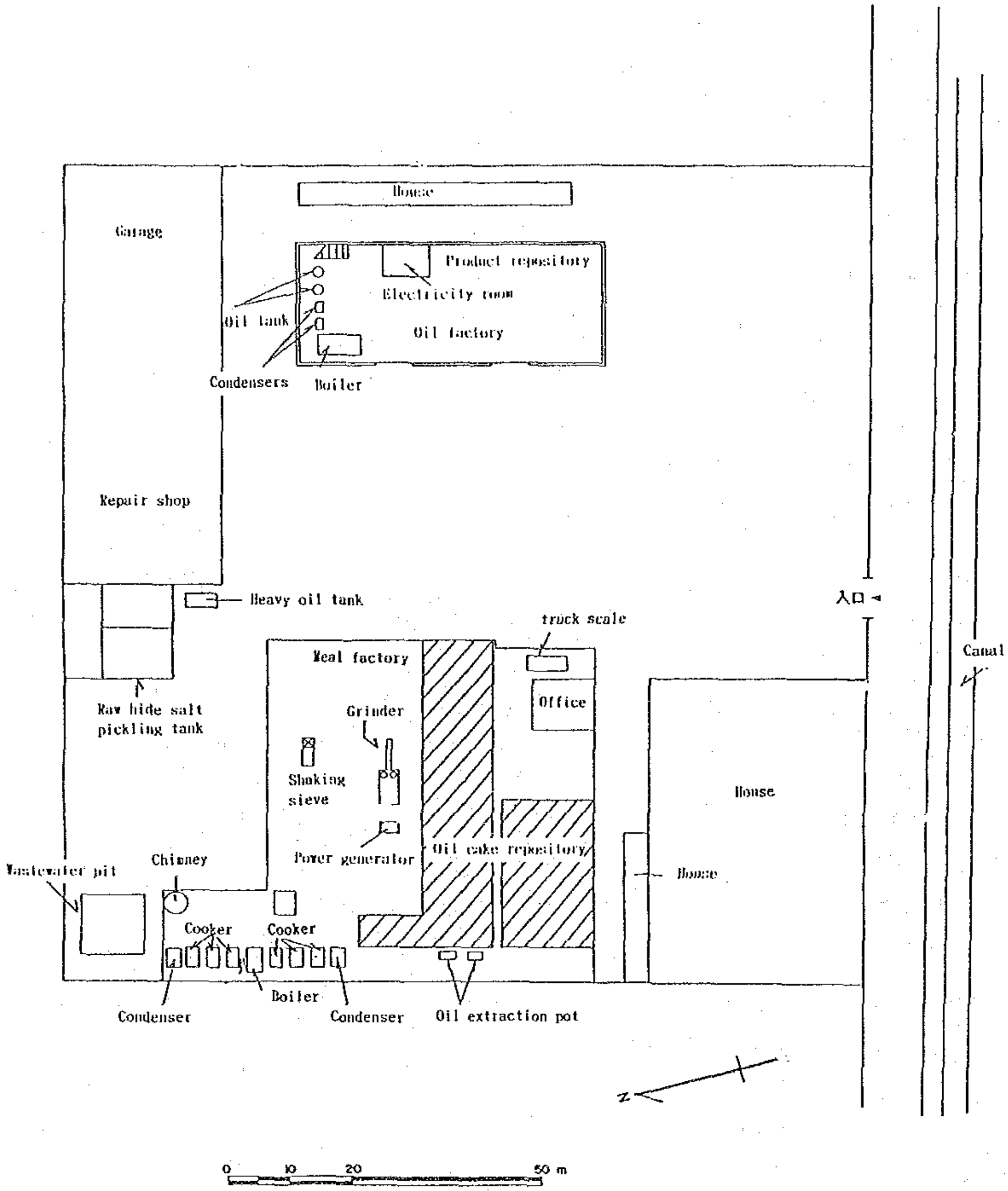


Figure 4-17 Layout of the Factory (Bone Meal Plant C)

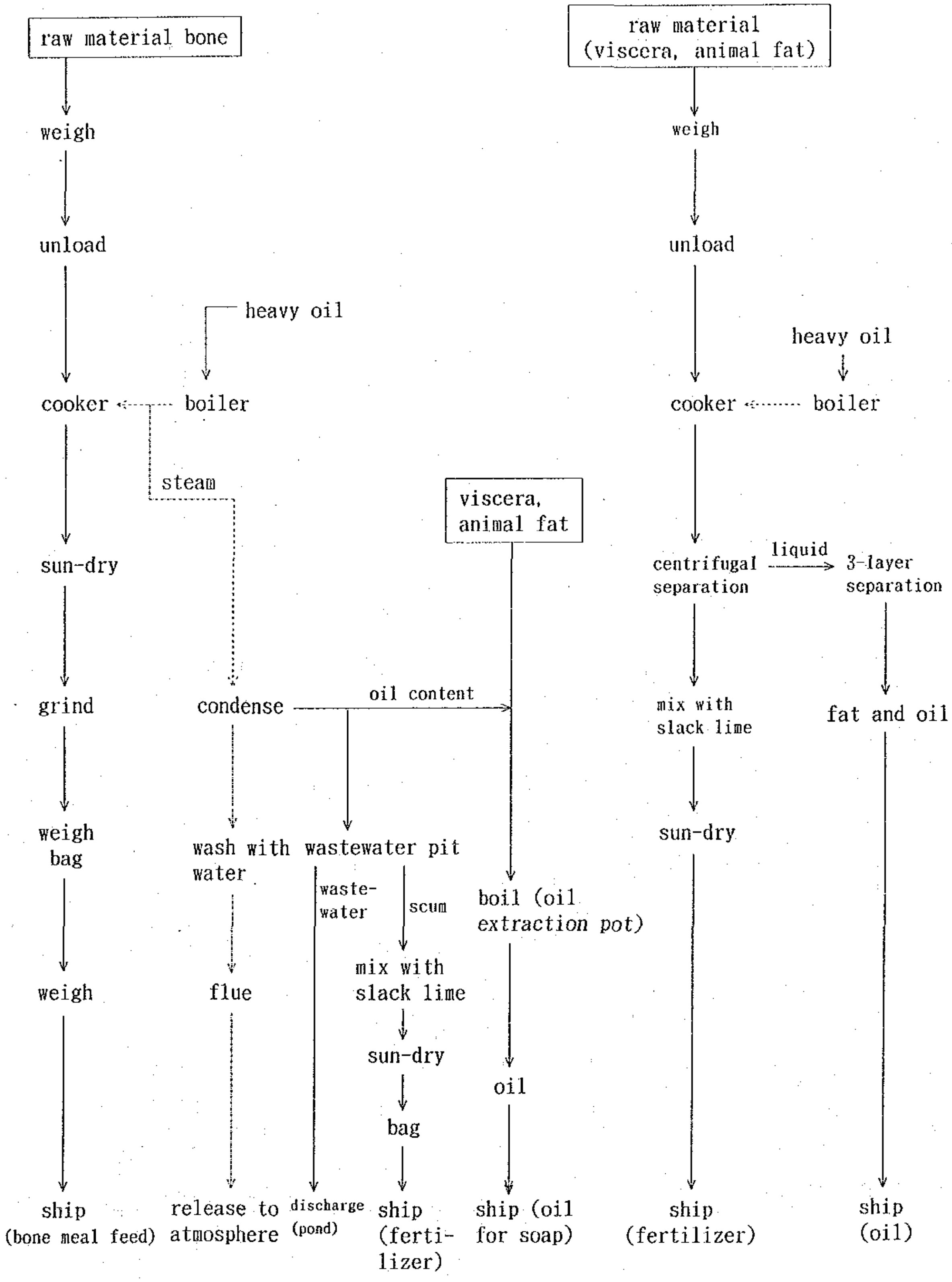


Figure 4-18 Production Process (Bone Meal Plant C)

Table 4-10 Machine List (Bone Meal Plant C)

No.	Name of Equipment	Qty.	Specifications	Remarks
1.	truck scale	1		
2.	cooker	6	$1,550^{\phi} \times 3,400^{L}$	SS
3.	condenser	1	$1,400^{\phi} \times 4,600^{L}$	SS
4.	condenser	1	$1,800^{\phi} \times 3,240^{L}$	SS
5.	boiler (for bone meal factory)	1	heavy oil burning $2,000^{\phi} \times 4,700^{L}$ 1 burner	SS refractory material
6.	water supply tank	1	$1,270^{W} \times 1,440^{L} \times 1,230^{H}$ 2 m^3	SS
7.	sand filter column	2	$600^{\phi} \times 1,800^{H}$ water supply tank x 2 units	SS
8.	exhaust chimney	1	lower part water washing column $1,600^{\phi} \times 2,500^{H}$ upper part $400^{\phi} \times 37,000^{H}$	SS
9.	grinder	1	connecting belt conveyer x 1 unit diesel power generator x 1 unit	
10.	shaking sieve	1	platform scale x 1 unit	
11.		2	slake lime hopper	SS
12.	cylinder with cone bottom	2	8 m^3	SS
13.	oil extraction potboiler (pot cooker)	2	$1,200^{W} \times 2,500^{L} \times 650^{H}$	SS
14.	boiler (for oil factory)	1	$2,050^{\phi} \times 4,600^{L}$ burner, evaporator oil pump, feed pump, chimney	
15.	animal fat cooker	2	$1,300^{\phi} \times 2,000^{L}$	SS/FC
16.	animal fat tank	2	$1,450^{\phi} \times 3,950^{L}$	SUS
17.	3-phase separator	2		SUS
18.	vacuum pump	1		SS/FC

2) After being weighed, the received animal bones are piled in the courtyard and then steam boiled by means of 6 cookers (autoclaves). The cookers are old-fashioned and worn out and raw materials are processed for long hours at low temperatures and low steam pressures. It is assumed that this is why large quantities of waste water and oil crud (cooking oil), which is the major odor source, are generated.

3) Although the production process at the oil factory was a general process that did not require much manpower, the bone production process consisted mainly of manual work such as drying, bagging and mixing of slake lime for oil crud recovery.

4) Besides the bone meal for livestock feed and the bone oil, fertilizer was produced from the oil crud and low-grade oil for soap was recovered from animal grease, etc. at this factory. Also, a salting tank for raw hide was installed at one corner of the grounds for salting cattle and water buffalo hides to be sold to tanning firms.

5) Only two truck loads of raw material were received at the most and the operation rate was low. The factory owner also pointed out the shortage of raw material. On the day of the diagnostic investigations, the amount of raw material bone remaining was about $2m^3$ and the meal factory and oil factory were stopped for half a day and a full day respectively due to lack of raw material.
There was a reception of raw hides on that day and five employees were steeping about 30 to 40 sheets of raw hide in water as part of the salting process.

6) At the time of the First Field Study, the area for

outdoor storage and sun-drying of steamed bone, the wastewater pit and the wastewater conduits were full and the scattering of offensive odor sources such as product scraps, raw material scraps and waste fluids was seen. But such conditions were not seen during the Second Field Study due to the low operation rate and conditions were quite improved due to cleaning, etc. However, the indoor oil crud drying area and the northwest side drains were in the same conditions they were in previously.

7) Directions within the factory were given directly by the factory manager. There were also two employees who were cleaning.

(3) Conditions of offensive odor generation

1) Raw material storage area

The processing capacity of the factory is small and the raw material received cannot be processed immediately. But an adequate raw material storage area has not been secured and the raw material animal bones were placed outdoors. Although the factory grounds are spacious, the decomposition odor spread throughout the factory and even outside the factory grounds.

2) Boiling and drying processes

Because raw material bones are processed by boiling, the gases emitted constitute an offensive odor. Also the process at the present factory, in which steamed bone from the boiling process and the residue from the oil factory are spread outside in the courtyard to be sun-dried, instead of being machine dried, constitutes a large source of offensive odors.

3) Oil fertilizer production process

The oil crud discharged from the cooker is mixed with slaked lime to produce fertilizer. But since the crud is dried naturally over a large area inside a poorly enclosed building, strong offensive odors are generated.

4) Wastewater treatment process

The wastewater from the cooker is one of the large offensive odor sources at the bone meal factory. But the wastewater treatment facility at the present factory is maintained poorly and overflowing with scum (oil crud). It is one of the offensive odor sources.

5) Others

The odors from the raw hide salting process and from the oil factory were of relatively low levels.

(4) Present state of measures for prevention of offensive odors

1) The present factory has a structure by which the offensive odor components of the cooker emission gas, which is the greatest source of offensive odors at the factory, are reduced at a scrubbing tower installed below the exhaust chimney. But since the attached pump was damaged and could not be used, the exhausts were emitted practically without any treatment.
2) There were no other measures taken in this factory for offensive odor prevention or deodorization.

(5) Present state in the surroundings

The present factory is located in an industrial zone in the northern part of Samut Sakhon province. Figure 4-19 shows the layout of the surroundings of this factory.

Although there are various factories neighboring the present factory, there was an odor that was unmistakably of the bone meal factory at the street next to the factory on the northeast side and in the vicinity of the entrance to the textile factory to the north.

A five-floor apartment is located about 50 m north of the present factory and it is surmised that, depending on the wind direction, odors from the factory could be smelled strongly.

Although the waterways around the factory did not flow, was turbid from decomposition and emitted gases, the odor was not very strong on the day of the survey.

The oil crud discharged from the cooker flowed towards the pond from the boundary walls on the north side of the present company and emitted offensive odors.

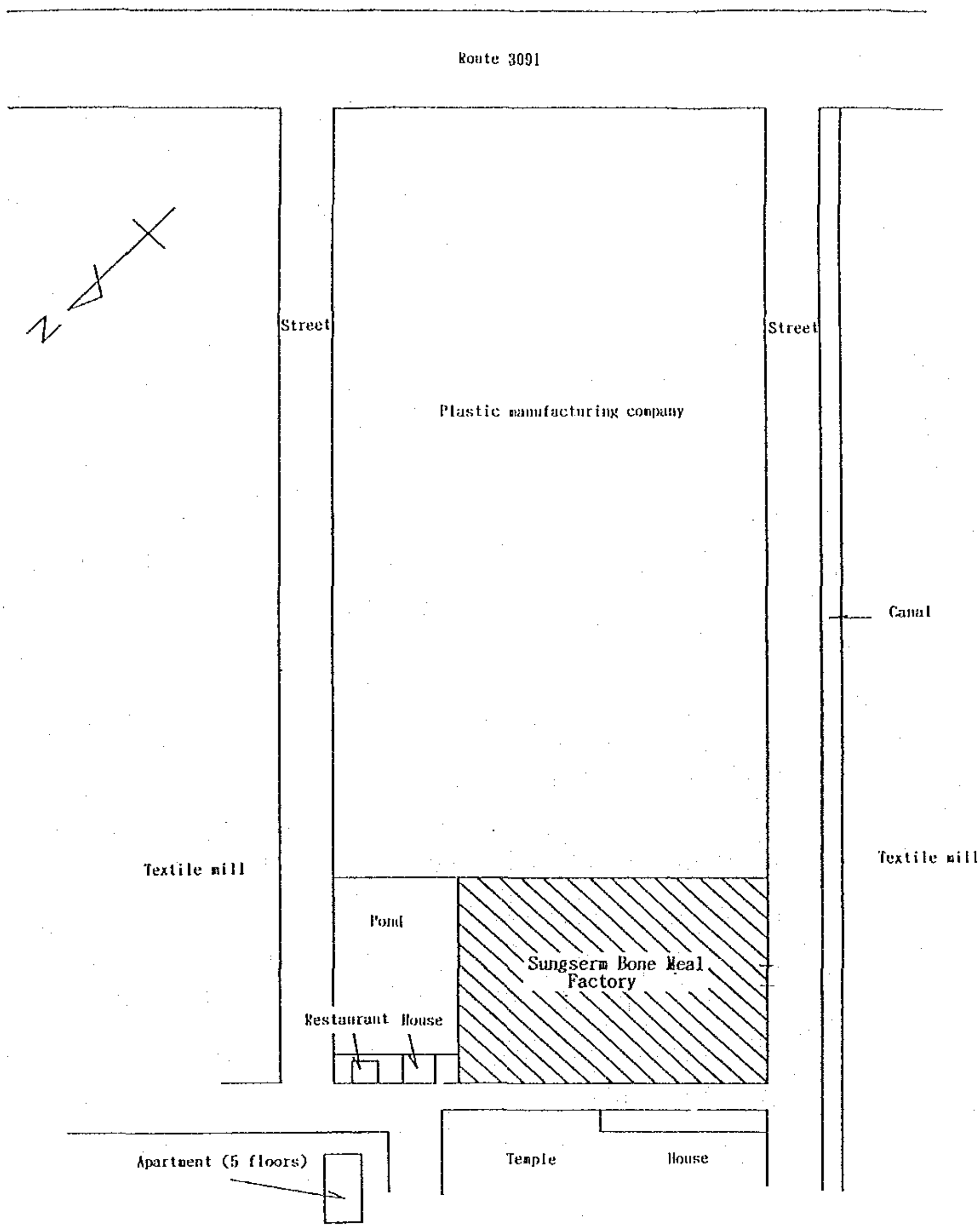


Figure 4-19 Surrounding Layout of the Factory
(Bone Meal Plant C)

(6) Results of hearing investigation

Q 1 : From where are the raw materials received ?

A : Raw materials are carried in by three-ton trucks or smaller trucks from Samut Sakhon province. Large quantities are carried in by large vehicles from Ubon and Udon provinces in northeastern Thailand. Most come from slaughterhouses.

Q 2 : About how much raw materials are received ?

A : Two large truck loads when the amount is large and 1 truck load when the amount is small. The amount is not stable.

Q 3 : How many hours a day is the boiler opera- ted ?

A : On the average, about five to six hours a day.

Q 4 : Tell us the cooking hours and the cooking conditions at the bone meal factory.

A : The cooking hours are one to two hours at a time and the pressure at that time is 60 pounds. The temperature is not known.

Q 5 : How frequently are the drains behind the cooker cleaned ?

A : The drains are cleaned once a week.

Q 6 : When are the busy periods during the year ?

A : It is irregular throughout the year and cannot be specified.

Q 7 : About how many hours are the steamed bones sun-dried ?

A : When sun-drying is not possible, drying is performed indoors. But during the dry season, sun-drying is performed five to six hours a day. The factory is far from private houses and so far there have not been any complaints.

Q 8 : Tell us the price of the products produced at this factory.

A : Oil is sold at 7,000 to 8,000 bahts per ton. Fertilizer products are used as organic fertilizer in agriculture, especially for fruit trees.

Q 9 : How frequently is the cleaning of the factory interior performed ?

A : Cleaning is performed daily.

Q 10 : Is there anyone with the responsibility among the employees ?

A : Yes there is.

Q 11 : Does the factory get flooded at times during the rainy season ?

A : There is no flooding. It is possible to drain via the waterways within the factory.

Q 12 : How is the supply of raw material bone in Thailand ?

A : The raw materials are extremely scarce.

Q 13 : It seems that a lot of the oil in the cooking wastewater is discharged. How is the oil recovered ?

A : The oil is manually collected with absorbent paper.

Q 14 : We can smell the odors from the waterways around the factory. What do you think of this ?

A : I don't smell any odors. However, there is a household sewage odor.

Q 15 : Please tell us where the products produced at the factory are shipped to.

A : Export prices for foreign nations are not so good. On the other hand, prices within Thailand are higher. As far as foreign nations go, there are many shipments to Japan.

Q 16 : How much does the electricity, water and fuel used in the factory cost ?

A : It takes about 15,000 to 20,000 bahts per day.

(7) Results of odor measurement

The odor measurement and analysis results for the interior and exterior of the factory are shown in Table 4-11 and 4-12; odor sampling locations are shown in Figure 4-20.

The odor concentration from the cooker chimney, being 9,800, was relatively low considering that it was untreated. However, this value was measured by operating the fan with the cooker being empty since there were no raw material animal bones at the time of sampling. Thus when the cooker is in actual operation, it is thought that the odor would be much stronger.

Among other measurement points, the upper part of the wastewater pit showed the highest odor concentration of 23,000 and the dried oil crud extracted from the cooker showed an odor concentration of 4,100. The odor concentration at the courtyard, where the steamed bones were being dried, was 170. The odor concentrations at the boundary grounds and at the side facing private homes were low, being 18 and 10 or less, respectively.

The results of instrumental analysis showed high values of ammonia, trimethylamine and acetaldehyde.

Table 4-11 Results of Odor Measurement by Sensory Test and Detection Tube (Bone Meal Plant C)

No.	Odor Concentration	Detection tube NH_3	Detection tube H_2S	Sampling Point
<First Field Study> (November 4, 1992)				
C- 1	18	2	N D	On the boundary line (beside entrance)
C- 5	98	15	N D	Over extracted fat sludge
C- 5(*)	---	9	N D	Over extracted fat sludge
C- 6	4,100	2	N D	Over remnants of fresh meat
C- 8	170	8	N D	Over steamed bone drying yard outside
C- 9	---	2	N D	Beside boiler for tallow production
C-10	---	2	N D	Center of bone meal storage house
C-11	23	2	N D	Inside salt-pickling shed of raw hide
C-12	23,000	10	N D	Over wastewater treatment facility
C-13	---	2	N D	Beside bone cooker
<Second Field Study> (March 8, 1993)				
C- 2	< 10	0.4	N D	On the boundary line (north side)
C- 3	41	2	N D	Outdoor stockyard of raw materials
C- 4	9,800	---	---	Smoke stack of gases from autoclave
C- 5	130	2.5	N D	Drying shed of limed bone oil
C- 6	310	2	N D	Workshop of bone oil extraction
C- 7	41	0.5	N D	Storage space of bone meal
C- 9	41	0.3	N D	Inside bone meal storage house
C-11	23	N D	N D	Salt-pickling shed of raw hide

Notes 1. ND : Below the value of detectable limit.

2. --- : Non measured.

Table 4-12 Concentration of Odor Substances Determined by Instrumental Analysis (Bone Meal Plant C)

Sample No	C-2	C-4	C-3	
1. Ammonia (ppm)	0.2	2.3	362	
2. Methyl mercaptan (ppm)	ND(<0.003)	ND(<0.003)	ND(<0.003)	
3. Hydrogen sulfide (ppm)	ND(<0.003)	ND(<0.003)	ND(<0.003)	
4. Methyl sulfide (ppm)	ND(<0.001)	ND(<0.001)	ND(<0.001)	
5. Methyl disulfide (ppm)	ND(<0.001)	ND(<0.001)	ND(<0.001)	
6. Trimethylamine (ppm)	ND(<0.001)	0.015	22	
7. Acetaldehyde (ppm)	0.054	23.3	0.2	
8. Styrene (ppm)	ND(<0.1)	ND(<0.1)	ND(<0.1)	
9. Propionic acid (ppm)	ND(<0.002)	ND(<0.002)	ND(<0.002)	
10. N-butyric acid (ppm)	ND(<0.001)	ND(<0.001)	ND(<0.001)	
11. N-valeric acid (ppm)	ND(<0.001)	ND(<0.001)	0.001	
12. Isovaleric acid (ppm)	ND(<0.001)	ND(<0.001)	ND(<0.001)	
Odor Concentration	< 10	130	---	
Detection tube NH_3(ppm)	0.4	2.5	---	
Detection tube H_2S(ppm)	N D	N D	---	
Point of sampling	Boundary line	Stockyard of raw bone	Smoke stack of gas from autoclave	

Notes 1. Date of Sampling : March 8, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

4. Emission Rate Measurement Results

C-4 (cooker chimney)

Emission rate (measured) Q = 2,970m³/h

Emission temperature : 41°C

Emission velocity : 0.5m/sec

Moist gas flow rate Q_N = 2,580Nm³/h

Dry gas flow rate Q_N = 2,380Nm³/h

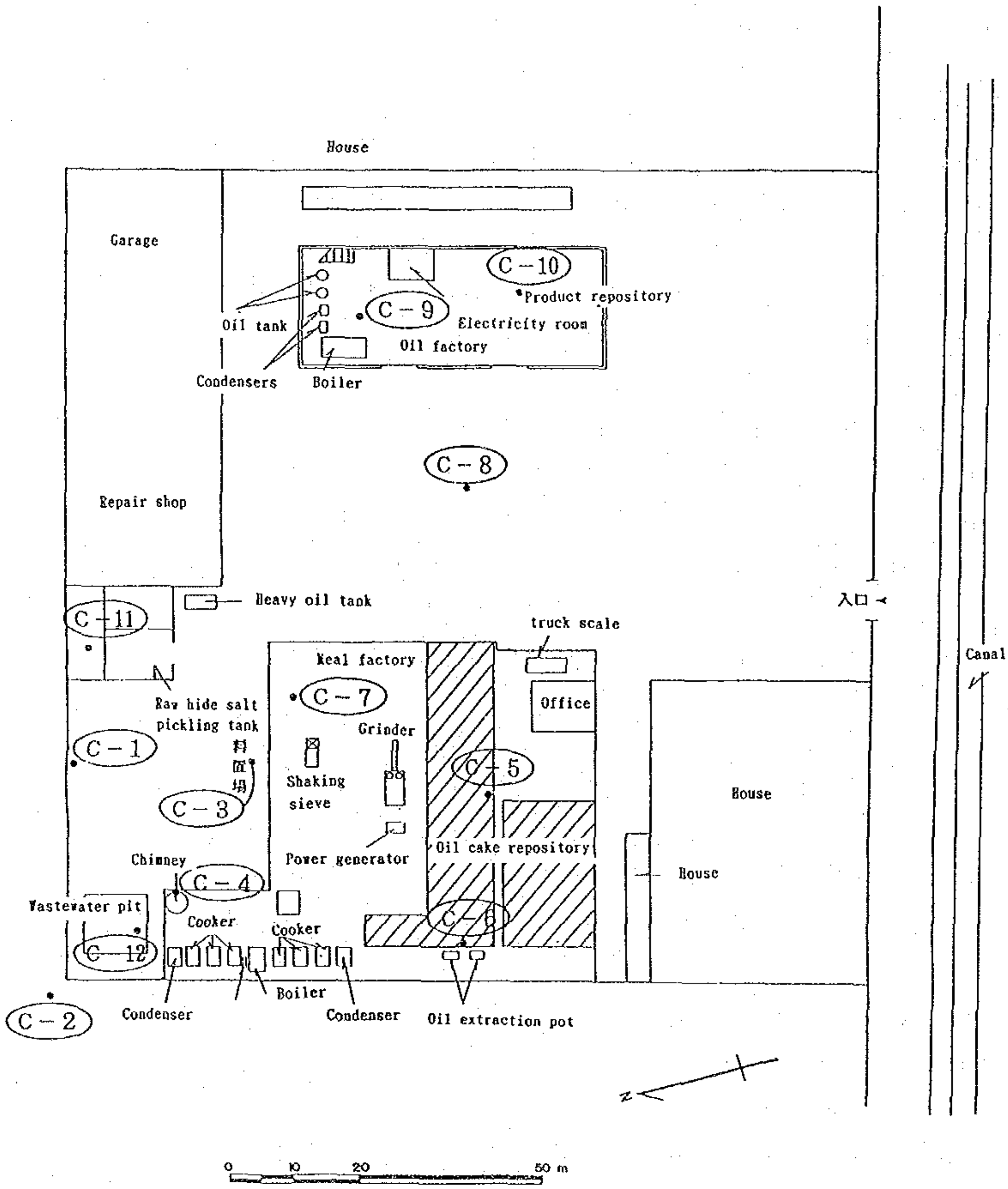


Figure 4-20 Odor Sampling Points (Bone Meal Plant C)

Table 4-13 shows the OER, for the major offensive odor sources, calculated from the odor measurement results. The cooker emission is the greatest offensive odor source. The influence of the animal bones, that are stored outdoors upon reception, is also thought to be great.

Table 4-13 OER of Offensive Odor Source (Bone Meal Plant C)

No.	Sampling Point	Odor Concentration	Emission Gas Flow (Nm^3/min)	OER
C-4	cooker flue	9,800	160	1.6×10^6
C-5	oil cake repository	130	980	1.3×10^5
C-9	animal fat extraction apparatus	41	264	1.1×10^4

(8) Problems

1) 35 years have passed since the present factory was constructed and the factory shows significant wear. Although modifications seem to have been made several times, most of the facilities are old and worn out with the exception of the animal oil extraction facilities in the recently built oil factory. Also, many facilities are not automated and much of the work depend on manual labor.

2) Although there are 6 cookers, they are small and lack in processing capacity. Therefore, raw materials cannot be processed rapidly upon reception and are stored within the grounds where they generate animal bone odors and decomposition odors. There are no raw material storage containers installed and the raw materials are stored outdoors in the courtyard until they are processed.

3) Because the processing capacity of the cookers are low, the steam boiled products are dried naturally outdoors where they generatew a strong offensive odor.

4) The reception periods of raw materials are sporadic and unsteady. The factory therefore faces financial difficulties and investments for new facilities are difficult.

5) The factory building is an open structure with only a roof and pillars. Shielding of odors is therefore impossible.

6) Although the grounds are spacious, since most of the facilities are concentrated near the boundary of the grounds and the spatial arrangement of operations is poor. Maintenance and cleaning therefore become inadequate, leading to the generation of offensive odors.

7) Although a deodorization apparatus was installed for the cooker emission initially, it is left in a faulty condition. The deodorization is a very simple water washing type with a low processing capacity.

4.2.4 Bone Meal Plant D

(1) Outline of the factory

1)	Name of factory	: Thai Bones Industry Co.Ltd.
2)	Name of owner	: Mr. Lek Sretabhakdi
3)	Address of factory	: 27/1 Paholyothin Road, Muh 5, Tambol Klongnuang, Amphur Klongluang, Patumthanee
4)	Date of establishment	: 1963
5)	Industrial category	: bone meal industry (Code No. 32-1/28)
6)	Manufactured products	: steamed bone powder : 16,000 tons/yr. ossein : 2,400 tons/yr. calcium phosphate : 5,000 tons/yr animal horns, animal hooves animal grease (tallow) fertilizer
7)	Raw materials	: cattle : 24,000 tons/yr. bone oil : 5,000 tons/yr. cattle horn
8)	Operating hours	: 24 hours/day continuous (three shifts)
9)	Number of employees	: about 300 (4 engineers)
10)	Surrounding land usage	: industrial area
11)	Site area	: 24,200 m^2 (entire factory : 160,000 m^2)
12)	Building Area	: 11,300 m^2 (entire factory : 16,000 m^2) warehouse : 960 m^2
13)	Factory Layout	: Shown in Figure 4-21.

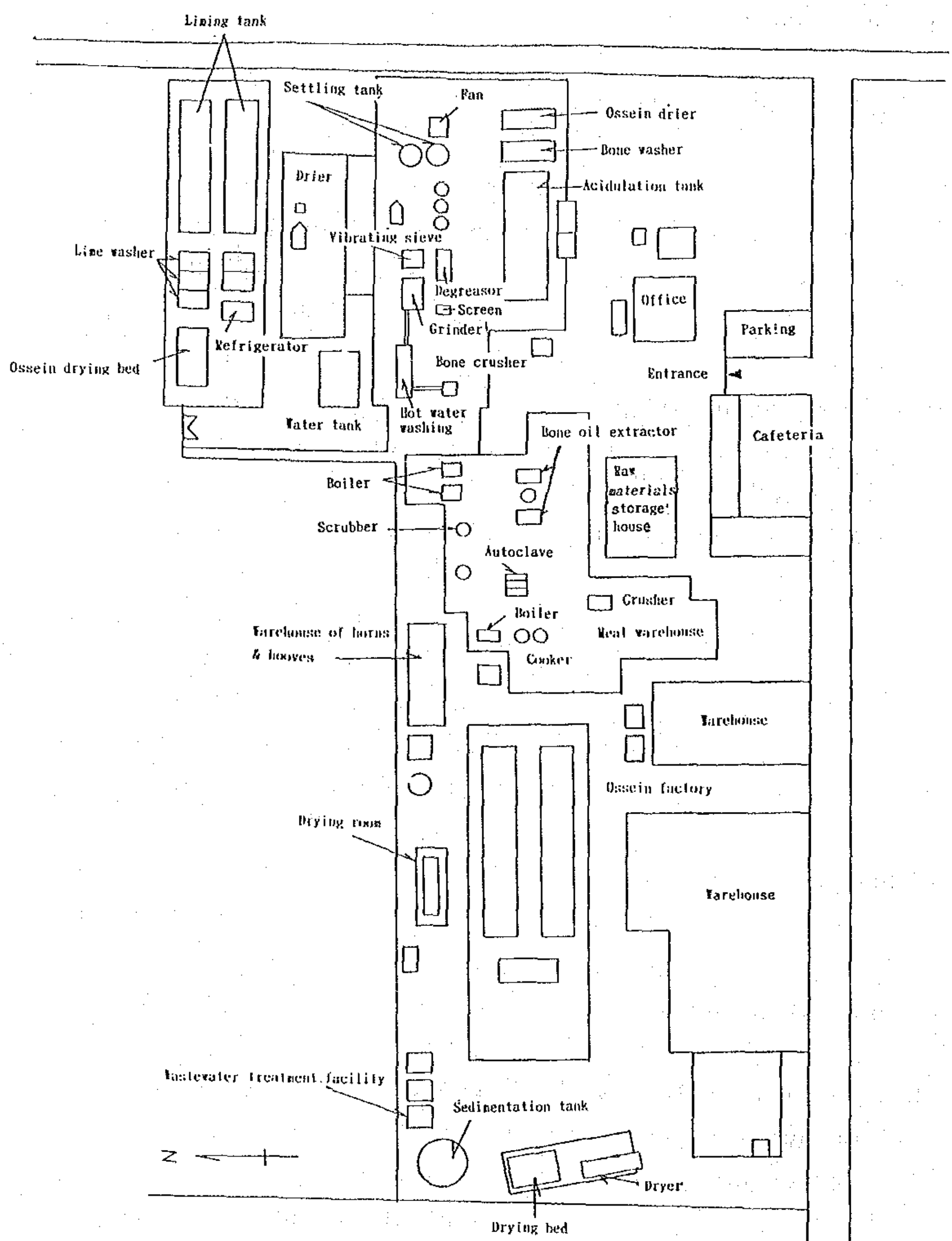


Figure 4-21 Layout of the Factory (Bone Meal Plant D)

(2) Production process and operation management

1) The present factory is a rendering factory where bone meal, etc. are produced from animal bones. It is one of the larger rendering factories in Thailand in terms of scale. Along with bone meal and bone oil production, steamed bone powder (bone meal) production, which takes up about 70 % of the raw material bone, manufacturing of ossein, which is the protein separated from animal bones, and the recovery of dibasic calcium phosphate from the calcium, which is the main constitutent of bones dissolved in hydrochloric acid in the ossein manufacturing process, are performed here. The main production processes are shown in Figure 4-22.

Such complex processes as the oil manufacturing process, in which oil is produced as a by-product of animal bones and sold to soap firms, the steaming of horns and hooves for use in craftwork (stamp material, buttons, etc.) and the production of fertilizer from the sludge, etc., formed from raw material scraps, product scraps and wastewater treatment,are also performed. Thus, most of the processes performed in the rendering industry are performed here.

2) After being weighed, the bones of cattle and water buffalo are carried to the platform where the horns and hooves are cut off. The bones are then ground and after being degreased with hot water, the bones are divided among the 3 production processes; the steamed bone powder production process, the ossein production process and the dibasic calcium phosphate production process. The present company receives technical cooperation from a Japanese fat and oil factory concerning theses processes.

3) The bone oil production process is performed in a factory building in the center of the grounds and animal bone and animal hide are processed together. This factory building is an open structure with only a roof and without walls. The structure shows considerable wear. The raw material bones are steamed in an autoclave to extract bone oil. The steam bones are forced dried by a fan in a drying room and then ground to produce bone meal.

4) The raw materials are collected from a wide area; the animal bones are collected by trucks and carts from the entire areas of central and southern Thailand.

5) With regards to the operation conditions of the factory, although one main boiler was stopped for periodic inspection and maintenance, there were no problems in each of the production process and average operations were being conducted. Directives from those responsible for the horn production process were carried out well and processes were performed smoothly from reception to processing and shipment.

6) Although the factory interior was cleaned relatively well, due to the nature of the raw material, fats and oils adhered onto the floors and drains of the grounds and the bone oil production process was particularly messy among the processes performed.

Ossein Production Process

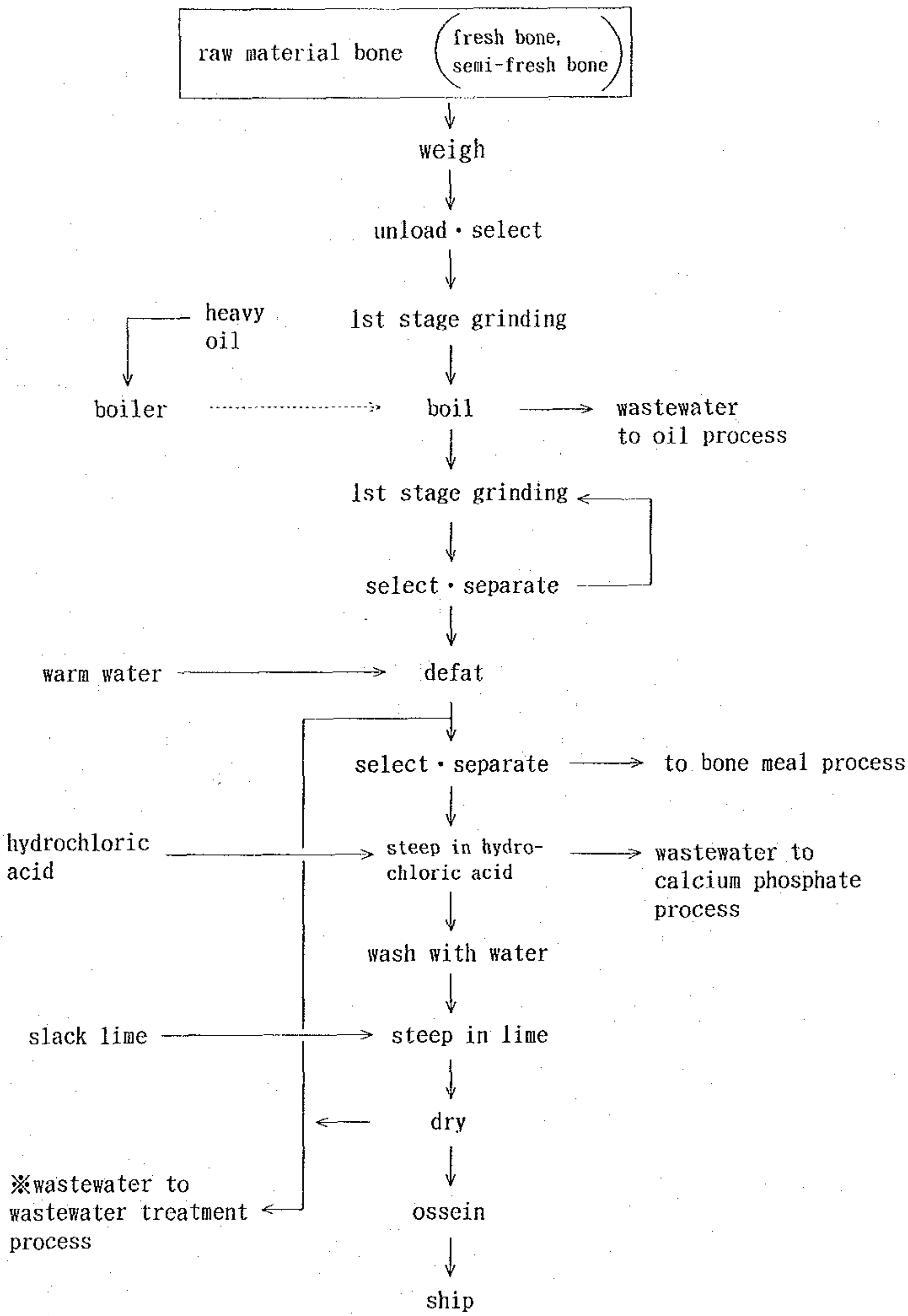


Figure 4-22(1) Production Process (Bone Meal Plant D)

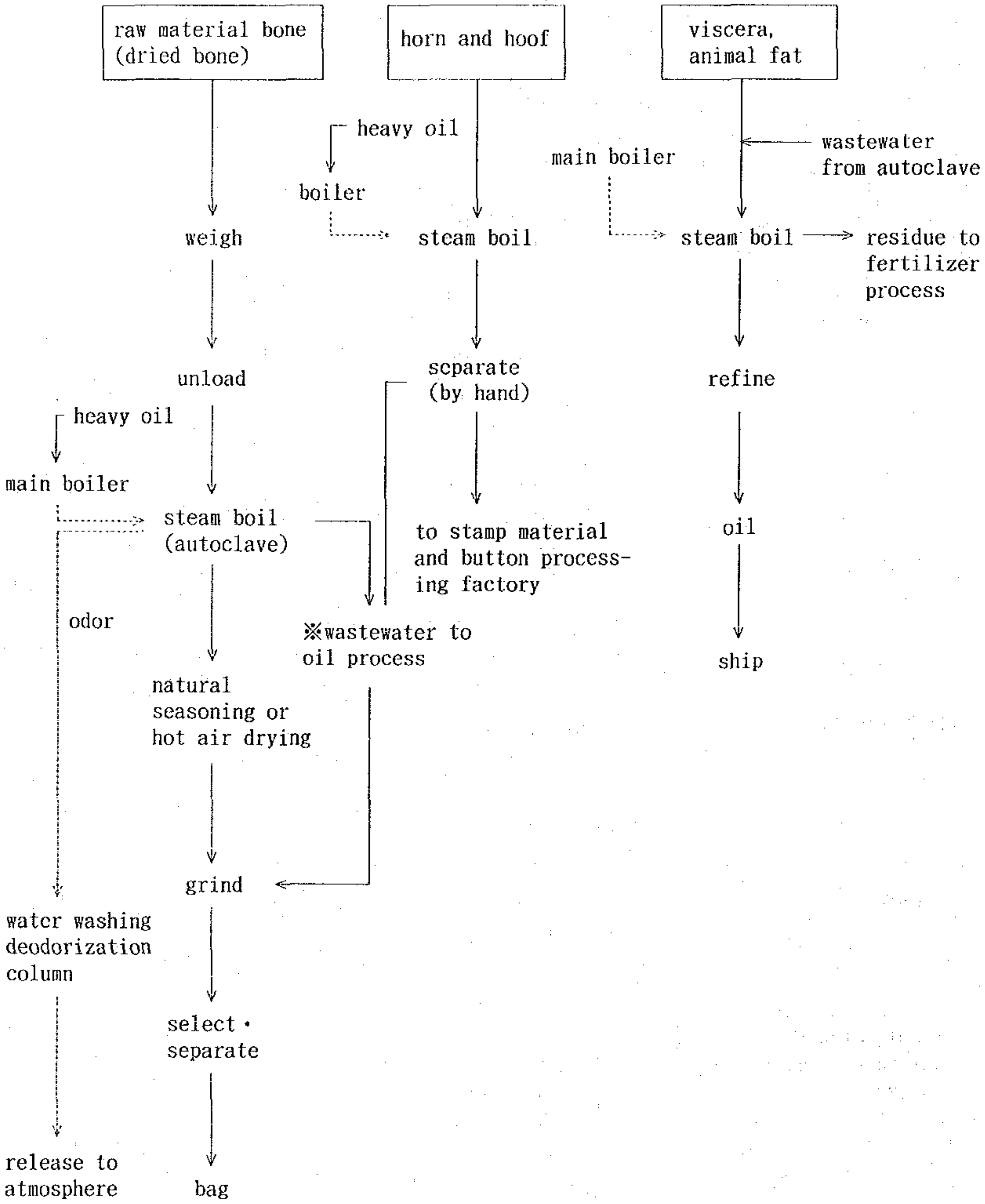


Figure 4-22(2) Production Process (Bone Meal Plant D)

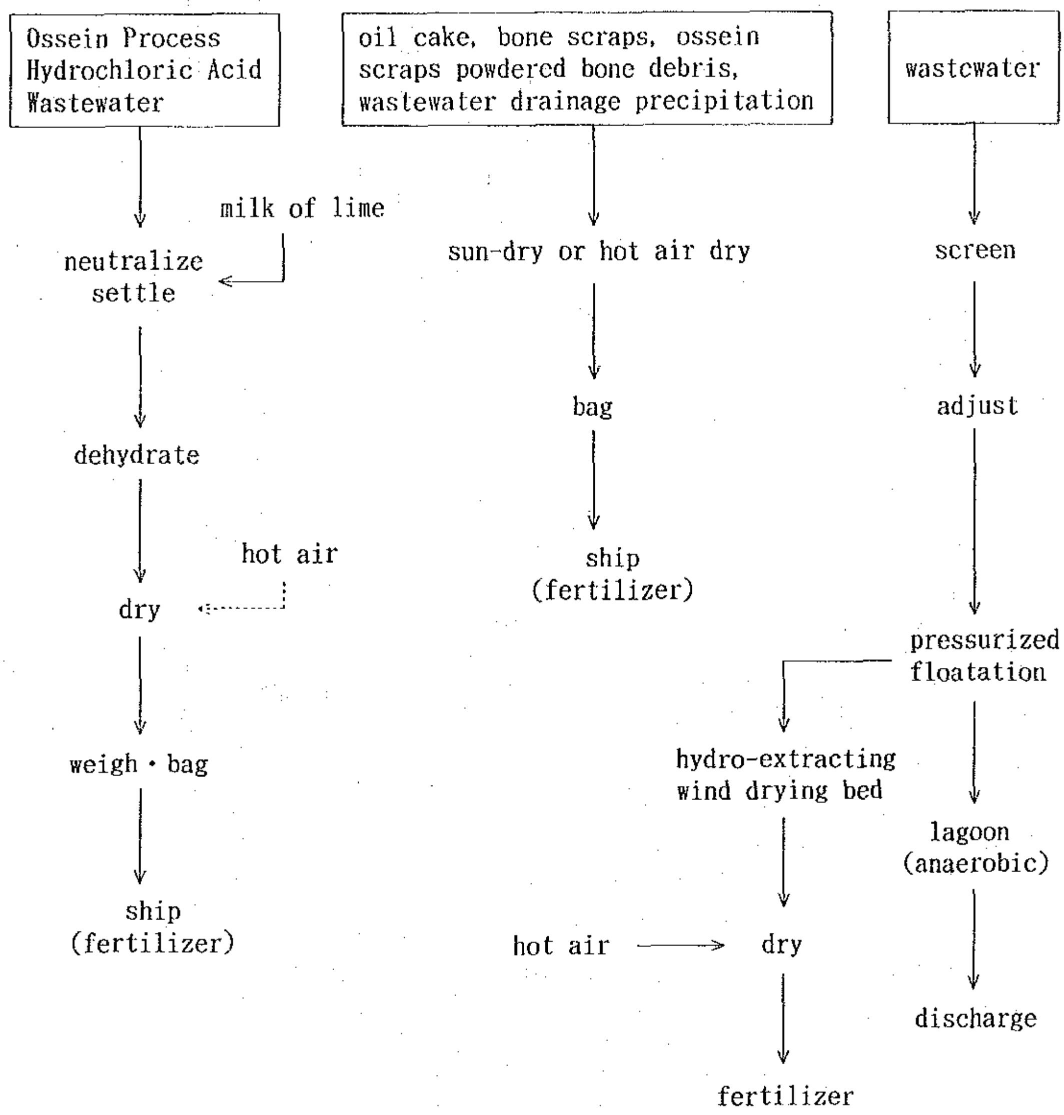


Figure 4-22(3) Production Process (Bone Meal Plant D)

Table 4-14(1) Machine list (Bone Meal Plant D)

No.	Name of Equipment	Qty.	Specifications	Remarks
A. Reception Management				
1.	truck scale	1	max. 25 tons	SS
2.	raw material storage	1	block structure, three inner rooms 18m^W x 21m^L x 5.5 m^H (3.0m^H effective) capacity: approx. 1,100m^3	
3.	raw material storage	6	1.4m x 2.0m	SS
4.	air fan	2	approx. 200~250 m^3/min.	SS
5.	water washing deodorization column	2	1,400^W x 2,500^L x 1,500^H	
6.	washing water circulation pump	2	approx. 1 m^3/hr.	
B. Ossein Process				
1.	raw material bone feeding conveyer	1	belt conveyer 500^W x 5,000^L	SS rubber
2.	First stage grinder	1		FC/SUS
3.	cooker feeding conveyer	1	screw conveyer 800^W x 4,000^L	
4.	cooker	1	semi-cylindrical, continuous type 1,500^W x 3,600^L x 2,100^H 80 ℃	
5.	cooker discharge conveyer	1	screw conveyer 600^W x 5,200^L, with chute	
6.	cooker discharge conveyer	1	belt conveyer 400^W x 10,000^L	
7.	Second stage grinder	1	1,000^W x 1,300^L x 2,500^H	
8.	screen	4	rotary type 600$^\phi$ x 1,500^L x 2 units 500$^\phi$ x 2,500^L x 2 units	
9.	delivery conveyer	1	belt conveyer 600^W x 6,000^L	
10.	shaking sieve	1	1,500^W x 4,500^L x 7,000^H with chute	
11.	bucket conveyer	1	6,500^H	
12.	degreaser	1	3,000^W x 5,000^L x 5,000^H warm water type	

Table 4-14(2) Machine list (Bone Meal Plant D)

No.	Name of Equipment	Qty.	Specifications	Remarks
13.	shaking sieve	1	3,000^{W} x 5,000^{L} x 5,000^{H} warm water type	
14.	pump for washing	1	portable	unusable
15.	hydrochloric acid steeping tank	14	3,000^{W} x 3,000^{L} x 3,500^{H}	concrete
16.	hydrochloric acid waste-water tank	1	3,000□ x 1,600^{H}	concrete
17.	acid washing tank	2	2,600^{W} x 5,000^{L} x 4,500^{H} with stirring device	
18.	washing water pump for above	2		
19.	ossein drying fan	1	for acid steeping, six interior compartments 4,000^{W} x 12,800^{L}	
20.	ossein drying fan	1	with hot air furnace and burner	11~15KW
21.	lime steeping tank	22	5,500^{W} x 7,500^{L} x 2,800^{H}	concrete
22.	lime washing tank	3	3,300^{W} x 5,500^{L} x 2,000^{H} with stirring device	
23.	ossein drying bed	1	for lime steeping, four interior compartments 2,800^{W} x 5,000^{L} x 2,400^{H} with air fan	
24.	lime steeping wastewater	2	5,000^{W} x 5,000^{L}	concrete
25.	refrigerator	1 set		
26.	compressor	3		1 unit damaged
27.	cooling tower	3		
28.	water intake well and pump	4	10 m^3/hr., 20 m^3/hr., 25 m^3/hr., 45 m^3/hr., Total: 100 m^3/hr.	
29.	fresh hydrochloric acid tank	7	3,300^{W} x 4,000^{L} x 2,300^{H}	
C.	calcium phosphate			
1.	lime dissolving tank	3	3,000$^{\phi}$ x 2,400^{H} with stirring device	SS
2.	calcium phosphate precipitation tank	3	4,600$^{\phi}$ x 2,700^{H} with gathering device	SS

Table 4-14(3) Machine list (Bone Meal Plant D)

No.	Name of Equipment	Qty.	Specifications	Remarks
3.	drawing pump for above	3		
4.	compressor	2	1,200 L/min. x 8 kg/cm^2	5.5Kw
5.	hot air drier	2	$1,200^\phi$ x $2,500^L$ with gas burner	
6.	cyclone	2	with fan	
7.	product hopper	2		
8.	centrifugal drier	3	centrifuge x two units belt press x one unit	
D.	Bone Meal Process			
1.	main boiler One unit is under overhaul	2	$3,500^\phi$ x $2,500^L$	fire in brick
2.	autoclave	3	$1,500^\phi$ x $3,300^L$ 110 ℃, 1.5 kg/cm^2	
3.	hood for autoclave	1	$1,700^W$ x $8,000^L$	SS
4.	truck for autoclave	7		FC/SS
5.	washing water pump for autoclave	1	$1,600^\phi$ x $3,500^H$	SS
6.	washing water pump for above	1		
7.	dry bone grinder	1	$2,800^W$ x $3,600^L$ x $2,900^H$	
8.	cyclone	2		SS
9.	shaking sieve	1	$1,300^W$ x $4,000^L$ x $2,800^H$ with chute	
10.	drying chamber	1	wooden, one-story structure $24m^W$ x $25m^L$ x $8m^H$	
11.	waste oil collection tank	1	$1,800^\phi$ x $1,200^H$	SS
E.	Oil Process			
1.	raw material feeding conveyer	1	bucket conveyer	
2.	cooker No.1	1	$2,200^\phi$ x $3,500^L$	
3.	cooker No.2	1	$1,000^\phi$ x $4,000^L$	
4.	oil pressurizing tank	1	$1,800^\phi$ x $2,000^H$	
F.	Horns, Hooves, etc.			
1.	boiler	2	$1,600^\phi$ x $3,500^L$	
2.	autoclave	2	$1,500^\phi$ x $3,000^H$	

Table 4-14(4) Machine list (Bone Meal Plant D)

No.	Name of Equipment	Qty.	Specifications	Remarks
3.	hot air drying chamber	1	wooden, 1-storied structure 6m^{W} x 15m^{L} x 3.5m^{H}	
4.	hot air drying bed	6	2,000^{W} x 3,000^{L} (6 fans, 1 burner)	
5.	horn and hoof drying chamber	1	wooden structure	
G. Wastewater Treatment				
1.	wastewater pit	1	4,000□ x 3,000^{H} with screen	concrete
2.	precipitation tank (pressurized floatation)	1	12,000$^{\phi}$ gathering device	concrete
3.	wastewater feed pump	2		
4.	floated sludge drying bed	1	500^{W} x 8,500^{L}	
5.	sludge drier	1	semi-cylindrical; 2,000ϕ x 12,000^{L} direct flame	
6.	lagoon	12		

(3) Conditions of offensive odor generation

Since this factory possesses almost all of the production processes of a rendering industry and is a large-scale factory, animal bone odors typical to the rendering industry may be detected at various parts of the factory. Also, strong odors are generated from the wastewater, waste and their respective treatment processes. The results of all three Investigations, from the 1st to the 3rd, show that odors of approximately the same level, mainly consisting of ammonia, sulfur oxides and fatty acids, were generated at the same locations.

The platform, the vicinity of the animal bone grinder, the vicinity of the cooker, the vicinity of the bone oil extractor, the steamed bone drying room, the raw material storage and the vicinity of the dryer for the wastewater sludge were sources of particularly large amounts of offensive odors. Offensive odors were also generated from the vicinities of the grinder, degreaser and sieves of the ossein production process, the acidulation process, the liming process and the wastewater pond.

(4) Present state of offensive odor prevention measures

As measures for offensive odor prevention, a deodorization apparatus (water scrubber) is installed for gases emitted from the autoclave and from within the raw material storage and a wastewater treatment facility is also installed. However, conditions are such that these measures are not functioning sufficiently and effectively.

Besides the office and the ossein factory, which are made of reinforced concrete, the factory buildings are open structures of iron frame or wood which are inadequate in terms of shielding odors.

(5) Present state in the surroundings

The present factory is located in the northern part of the Bangkok metropolitan area and is situated along Route one which is a major national road. Figure 4-23 shows the layout of the surroundings of this factory.

The east side of the factory faces a major public street and the north and west sides are next to factories. Private homes are located about 100m away at the nearest, Bangkok University is located about 300m to the north while a golf course is located about 500m further north. There are times when the offensive odors from the present factory are detected even at the golf course and people there have complained.

Although the influences of offensive odors generated from the present factory to the surrounding area depend on the wind direction and velocity, it is presumed that the entire surrounding area is influenced. During the 3rd Investigation, wastewater treatment odors and odors from gases emitted in the drying process were detected along with smoke at a downwind location on Route 1.

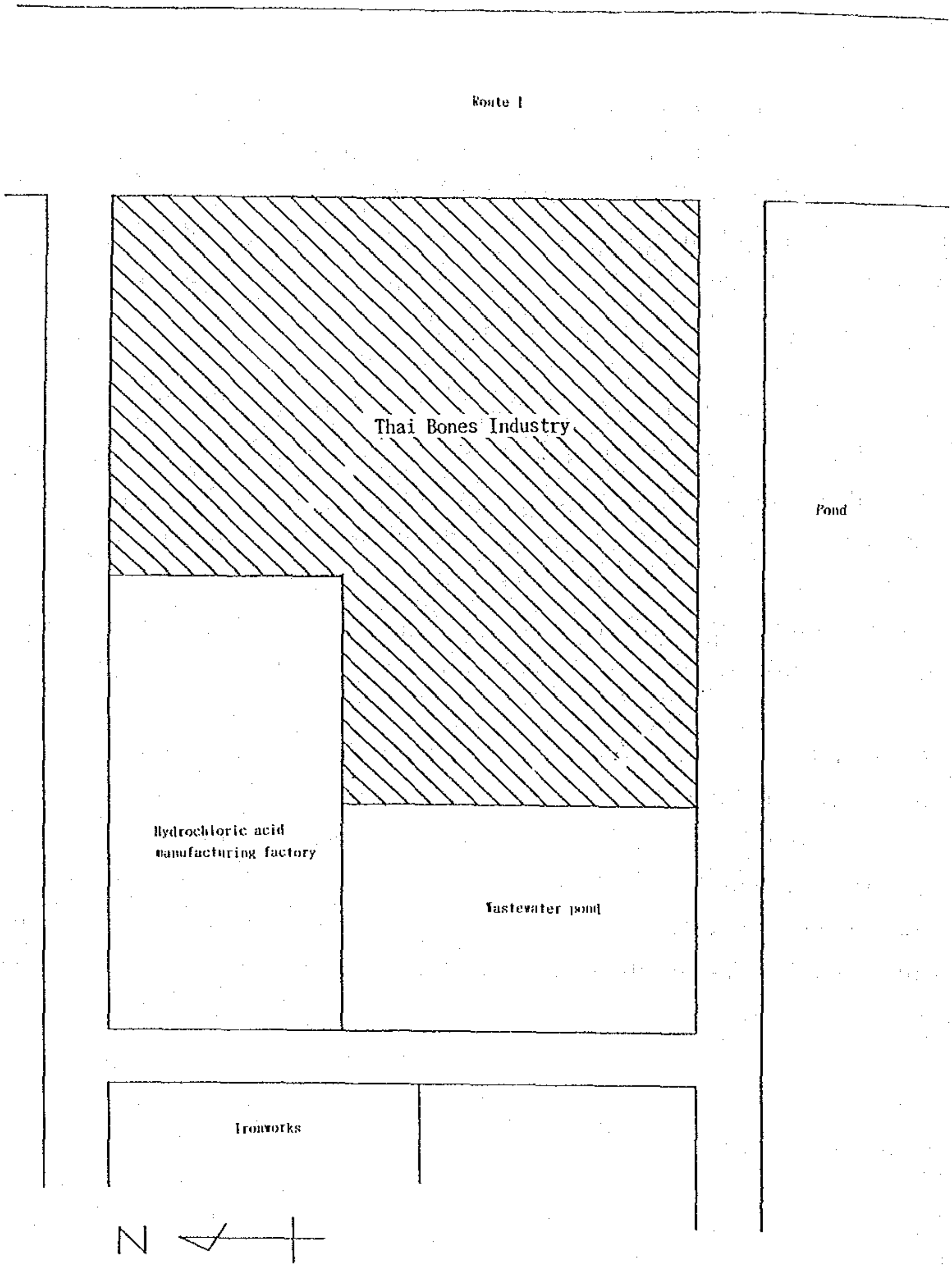


Figure 4-23 Surrounding Layout of the Factory
(Bone Meal Plant D)

(6) Results of hearing investigation

Q 1 : From where are the raw materials for this factory received ? Also what sort of places are the discharging sources of these raw materials ?

A : Raw materials are received from all most all areas in central Thailand. Most of the raw material bones are collected in cargo and there are collecting firms that specialize in this matter. Also there are cases in which raw materials are received from farmers in northeastern Thailand.

Q 2 : Are there any variations in the amount of raw materials received ?

A : With regard to weekly variations, only 50 % of the usual amount is received on a Buddhist day while more than the usual amount is received on the previous day. During the year, since meat is not eaten during the Enshrining of Buddha (Wampra), hardly any raw materials are received during that time. The amount received also becomes low in July and August.

Q 3 : About how long are the received raw materials stored ?

A : As a rule received raw materials are processed on that day. The part that could not be processed is put into storage.

Q 4 : Please tell us the present processing capacity of this factory.

A : Operations are usually performed at 100 % capacity and there is not much room. Conditions are such that accomodations cannot be made when the amounts received are increased and when problems occur.

Q 5 : How are the maintenance and repair of production facilities and equipments in the factory handled ?

A : Problems concerning facilities and equipments are handled by the maintenance factory within the factory. Equipments that have become unusable are replaced by new or second-hand equipments.

Q 6 : About how much wastewater is discharged from this factory ?

A : The water used within this factory is taken from four wells (a total of about 100 m^3/min.). The daily wastewater quantity is therefore about 2,000 to 2,400m^3.

Q 7 : Please tell us about the management organization system of this factory.

A : The management organization consists of one factory manager (administrative matters) and two production managers (one for the ossein process, one for others). There are 300 employees working in two shifts. The factory is divided into 10 sections and a person responsible is placed in each section (sections having two-shift services have one each for the day shift and the night shift).

The ten sections are:

1. button factory; 2. raw bone factory; 3. steam factory; 4. ground bone factory; 5. equipment repair factory; 6. ossein factory; 7. oil factory; 8. warehouse; 9. shipment and 10. miscellaneous work.

Q 8 : How is cleaning performed in and around the factory ?

A : Four full time cleaners are stationed. When there is a shortage, assistance is provided from other sections. I think some parts are not thorough yet.

Q 9 : About how much is the capacity of the boiler used within the factory ?

A : Concerning the two main boilers, the capacity is four t/unit·day.

Q 10 : Please tell us the processing capacity of the autoclave, the steaming time, etc.

A : The processing capacity is 80 to 100 t/day. It is not continuous, but of a batch-type and the steaming time is 1 hour for 1 time, the conditions for 1 time being; a pressure of 1.5 kg/cm^2 and a temperature of about 110°C. The gas emitted from the autoclave is treated 24 hours a day with a water washing scrubber. The washing water is not circulated but passed through once.

Q 11 : Please tell us about the working system in this factory.

A : The bone meal process lasts from 7:00 to 12:00 midnight and is a two-shift operation. Overtime is performed when the amount received is large.

Q 12 : Do you think that there still may be some recoverable matter of value in the wastewater discharged from the factory ?

A : I think that there would be more effective substances if further recovery is performed.

(7) Results of odor measurement

1) Results of odor measurement

The odor measurement and analysis results for the factory interior and exterior are shown in Tables 4-15 and Table 4-16; odor sampling locations are shown in Figure 4-24.

The locations next to the 1st stage grinder (odor concentration 23,000), below the 2nd stage grinder (73,000), within the raw material bone storage house (23,000), the vicinity of the dryer for the wastewater sludge (41,000) and next to the steamed bone and dried bone dryer (9,800) had high odor concentrations. The odor concentration is also 44 ~ 56 at the boundary lines next to the factory entrance.

The instrumental analysis results show that all offensive odor substances tested for besides styrene are detected within the grounds and that large amounts are detected in the vicinity of the grinder.

Table 4-15(1) Results of Odor Measurement by Sensory Test and Detection Tube (Bone Meal Plant D)

No.	Odor Concentration	Detection tube NH_3	Detection tube H_2S	Sampling Point
<First Field Study> (November 11, 1992)				
D- 6	23,000	25	N D	In front of fresh bone storage room
D-11	9,800	20	N D	Over wastewater treatment facility
D- 7	2,300	9	N D	Inside raw bone & hide platform shed
D- 9	1,700	5	N D	Horns and hooves storage yard
D-10	550	20～30	N D	Inside bone meal drying room
D- 8	550	4	N D	Beside steam bone meal autoclave
D-18	310	N D	N D	Over dry bone meal
D- 2	98	2	N D	Beside fresh bone crusher
D- 1	56	0.5	N D	On the boundary line (beside entrance)
D- 2(*)	---	5	N D	Over fresh bone on platform
D-22	---	N D	N D	Beside drier inside ossein factory
<Second Field Study> (March 11, 1993)				
D- 2	---	10	N D	Over storage of bones before crusher
D- 2	---	5	N D	Beside first bone crusher
D- 3	---	25	5	Under second bone crusher
D- 4	---	100	N D	Over ossein stockyard
D- 5	---	18	N D	Beside watermill of limed ossein
D- 8	---	5	N D	In front of steam autoclave (boiling)
D- 9	---	N D	N D	Stockhouse of horns and hooves
D-10	---	50	N D	Drying room of horns and hooves
D-11	---	0.5	N D	Wastewater treatment facility
D-14	---	50	10	Under bone screening machine
D-15	---	0.5	N D	100mm over acidulation tank
D-16	---	10	N D	1500mm over acidulation tank
D-17	---	N D	N D	Ossein dry bed
D-18	---	0.5	N D	Stockyard of dicalusium phosfate
D-19	---	N D	N D	Over liming tank
D-22	---	1	N D	Inside of ossein process building

Table 4-15(2) Continued — Bone Meal Plant D —

No.	Odor Concentration	Detection tube NH3	Detection tube H2S	Sampling Point
D- 6	---	4	N D	Stockyard of fresh bone
D- 7	---	5	N D	Beside bone oil extractor
D- 8(*)	---	15	1	In front of steam autoclave (open)
D-13	---	11	N D	Beside steamed and dried bone crusher
D-20	---	5	N D	In front of boiler
D-21	---	15	N D	Back of bone autoclave
<Third Field Study> (September 6, 1993)				
D- 1	44	2	N D	On boundary line (beside entrance)
D- 2	23,000	2	N D	Over fresh bones on platform
D- 2(*)	--	3.5	0.2	On corridor beside bone crusher
D- 3	73,000	15	3	Over conveyer for crushed and washed bone
D- 4	23,000	3	N D	Over ossein stockyard after acidulation
D- 5	730	2	N D	Beside washer of limed ossein
D- 6	--	13	0.7	Warehouse of fresh bones
D- 7	--	2	N D	Corridor beside bone oil extractor
D- 8	--	4	N D	In front of steam autoclave (under hood)
D- 9	--	N D	N D	Drying room of horns and hooves
D-10	9,800	50	N D	Drying room of autoclaved bone
D-11	--	2	N D	Over wastewater treatment facility
D-12	41,000	120	N D	Beside drier for wastewater sludge
D-13	9,800	15	N D	Beside steamed and dried bone crusher
D-14	--	30	4	Under bone screening machine
D-15	--	2	3	100mm over acidulation tank
D-16	--	1	2.5	1500mm over acidulation tank
D-17	--	1	N D	Ossein drying bed
D-18	--	2	N D	Stockyard of calcium phosphate
D-19	--	5	N D	Over bone liming tank
D-22	--	1	N D	Inside of ossein process building
D-20	--	11	0.5	In front of main boiler
D-21	--	10	N D	Back of bone autoclave

Notes 1. ND : Below the value of detectable limit.

2. --- : Non measured.

Table 4-16 Concentration of Odor Substances Determined by Instrumental Analysis (Bone Meal Plant D)

Sample No		D-1	D-3	D-10	
1. Ammonia (ppm)		0.4	40	247	
2. Methyl mercaptan(ppm)		ND(<0.003)	2.6	ND(<0.003)	
3. Hydrogen sulfide(ppm)		ND(<0.003)	22.3	ND(<0.003)	
4. Methyl sulfide (ppm)		ND(<0.001)	0.33	ND(<0.001)	
5. Methyl disulfide(ppm)		ND(<0.001)	0.033	ND(<0.001)	
6. Trimethylamine (ppm)		0.002	0.59	2.9	
7. Acetaldehyde (ppm)		ND(<0.01)	1.01	1.83	
8. Styrene (ppm)		ND(<0.1)	ND(<0.1)	ND(<0.1)	
9. Propionic acid (ppm)		ND(<0.002)	0.016	0.072	
10. N-butyric acid (ppm)		0.002	0.017	1.09	
11. N-valeric acid (ppm)		0.001	0.002	0.017	
12. Isovaleric acid(ppm)		ND(<0.001)	0.012	1.21	
Odor Concentration		44	73,000	9,800	
Detection tube	NH_3(ppm)	2	15	50	
	H_2S(ppm)	N D	3	N D	
Point of sampling		Boundary line	Conveyer for crushed bones	Drying room of bones	

Notes 1. Date of Sampling : September 6, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

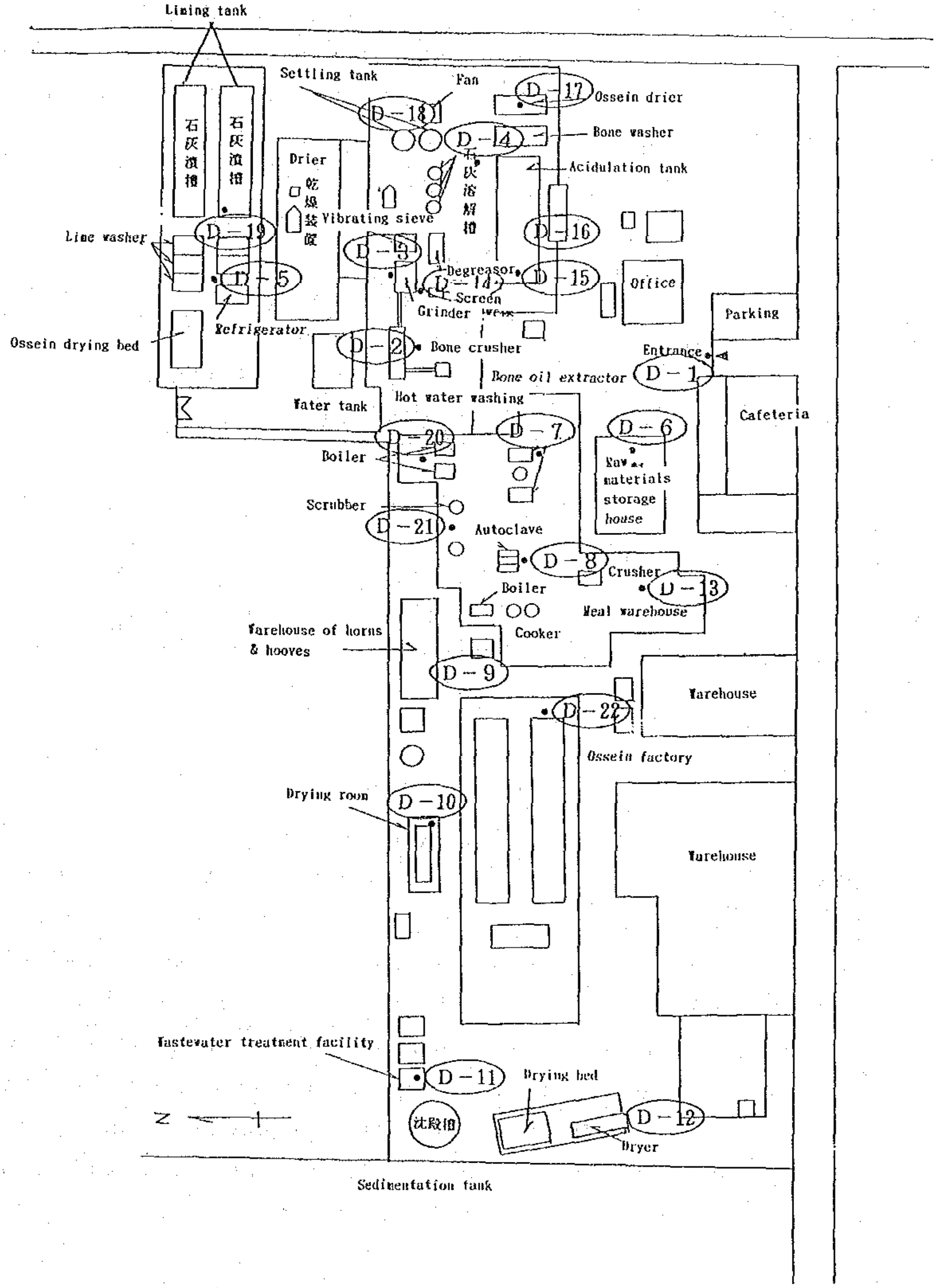


Figure 4-24 Odor Sampling Points (Bone Meal Plant D)

The OER calculated from the odor measurement results for the major offensive odor sources are shown in Table 4-17. It can be seen that strong odors are generated at all locations. It is also presumed that large amounts of odors are discharged from the outlets of the deodorization apparatus and the chimney.

Table 4-17 OER of Offensive Odor Source (Bone Meal Plant D)

No.	Sampling Point	Odor Concentration	Emission Gas Flow (Nm^3/min)	OER
D- 3	below second stage grinder	31,000	30	$9.3x10^5$
D-10	horn and hoof drying chamber	9,800	100	$9.8x10^5$
D-12	next to drainage sludge	41,000	100	$4.1x10^6$

(8) Problems

1) Since the present factory which performs almost all of the processes found in the rendering industry, it can be said that the offensive odor generation is inevitable. However, additions to the structure have been repeated several times since the founding of the factory and there are many processes for which the facilities are outdated. In particular, buildings and equipment for the raw material reception, grinding process, bone meal production process and bone oil process are old and inadequate in terms of shielding odors.

2) Although deodorization facilities are installed for the cooker emission and interior ventilation of the raw material storage house, the deodorization method is not suitable and the deodorizing performances are

inadequate. Hardly any deodorization measures are provided for the other processes.

3) Although the operation rate of the factory is very high and the production management system is relatively good, cleaning of the grounds and accomodations for pollution prevention such as wastewater and waste treatment are inadequate.

4.2.5 Tannery E

(1) Outline of the factory

1) Name of factory	:	Lotus Leather and Trading (Kwang Ha Huad)
2) Name of owner	:	Mr. Somsak Bongrot Pannaral
3) Address of factory	:	175 Sukhumvit Road Km 30, Tai Ban Road, Amphur Muang, Samutprakan
4) Date of establishment	:	1961
5) Industrial category	:	tannery (Code No. 29-51/25)
6) Products	:	leather : 140,000 m^2/yr
7) Raw Materials	:	raw hide : 2,000 tons/yr synthetic hide : 200 tons/yr.
8) Operating hours	:	8:00 ~ 17:00 (8 hours/day)
9) Number of employees	:	62 (2 engineers)
10) Surrounding land usage	:	industrial area
11) Site area	:	4,100 m^2
12) Building area	:	dye factory and office : 670m^2 (4 fls.) tannery : 2,500m^2
13) Factory Layout	:	Shown in Figure 4-25.

(2) Production process and production management

1) The present factory is located near the center of the Samutprakan Tannery Industrial Estate and is medium in scale among the tanneries.

2) The tanning and dyeing of cattle and water buffalo hide are performed at the present factory. Synthetic leather is also dyed along with the leather tanned at the factory.The production process is shown in Figure 4-26

and the specifications for major equipments are shown in Table 4-18.

3) The raw material hide are salted hides imported from the USA, Australia, etc. After being unloaded, the raw hides shipped into the factory under go such preprocessing such as steeping in water, liming and decalcification. Most of the hides are then chrome tanned. Production processes and equipment that are pretty much standard are implemented.

4) Although there are other factories in which tanned hides are sun-dried, due to the small plottage of this factory, drying is performed with a dryer and the finishing of the drying process is performed in the attic.

5) Although the areas for the preparation process and the tanning process at the eastern side of the factory had low floor levels, drainage was poor. Conditions were filthy and shaved hide scraps were scattered in these areas.

6) The central passageway serves as a repository for chemicals, painting materials, raw hide etc. But this area was not arranged properly and in disorder.

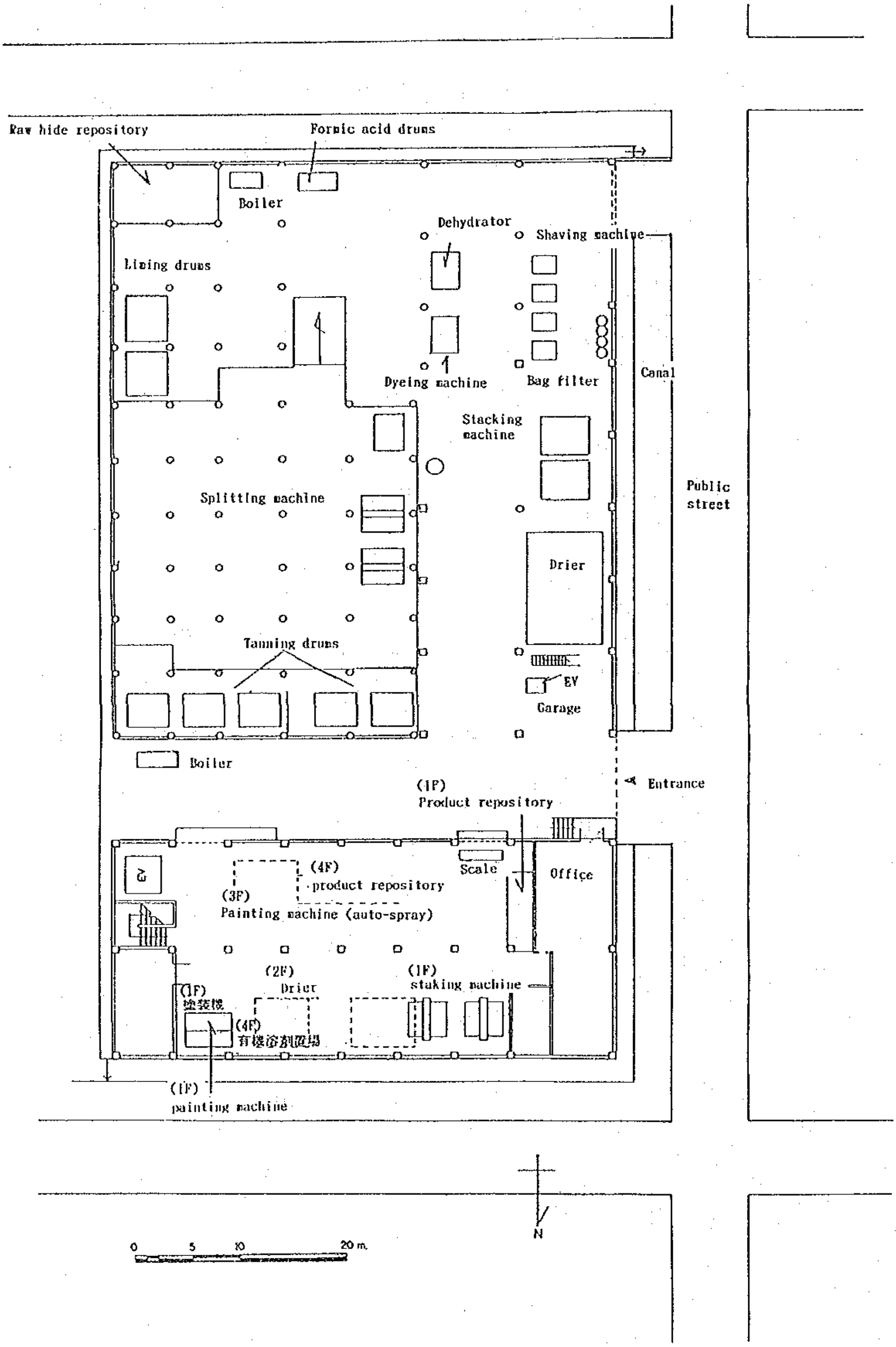


Figure 4-25 Layout of the Factory (Tannery E)

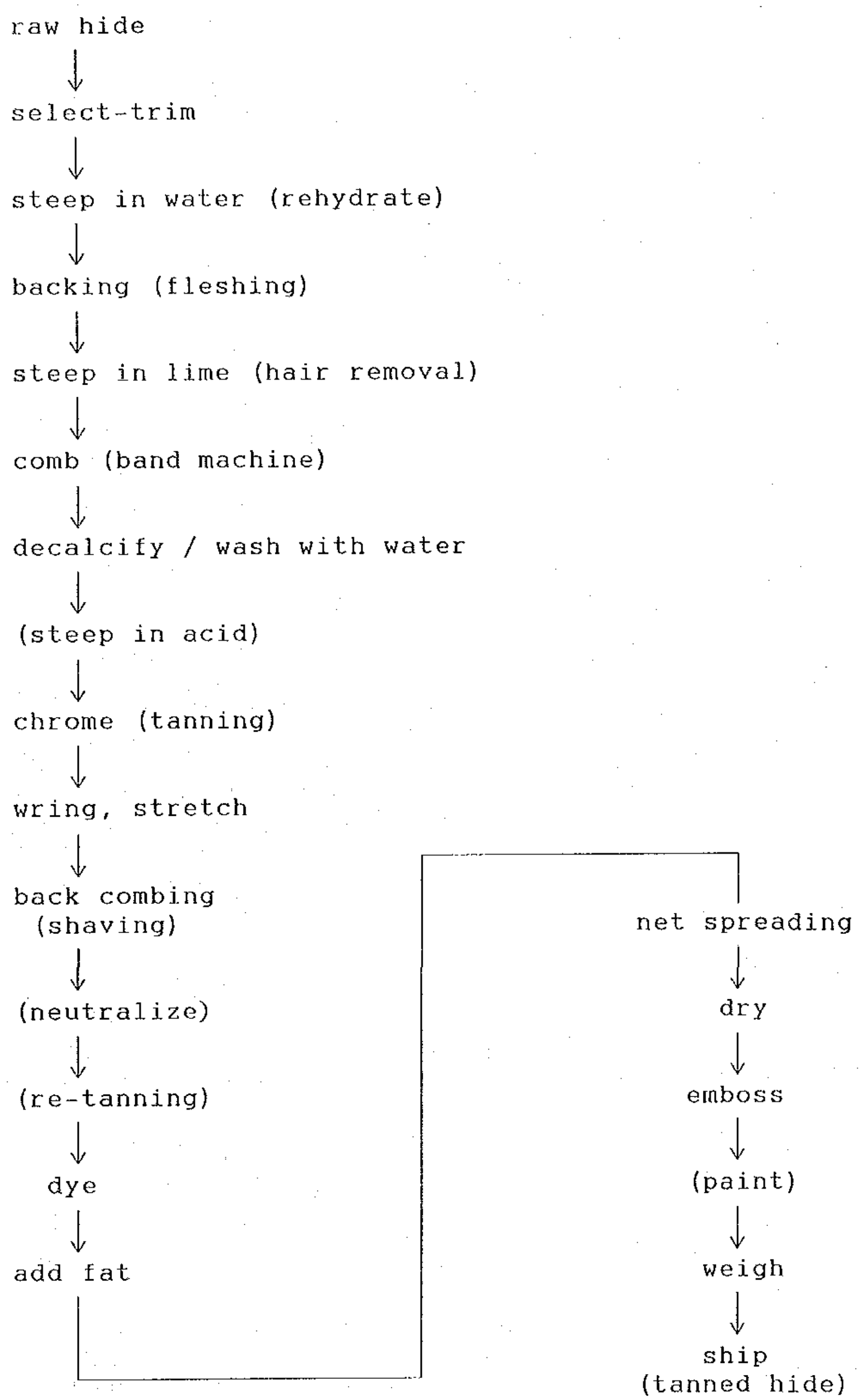


Figure 4-26 Production Process (Tannery E)

Table 4-18 Machine List (Tannery E)

No.	Name of Equipment	Qty.	Specifications	Remarks
1.	rehydration, lime steeping drum	2	paddle type; 3,000$^{\phi}$ x 4,000^{L}	
2.	decalcification, water washing drum	4	2,000$^{\phi}$ x 4,000^{L} (existed until the time of the Second Field Study)	
3.	tanning drum	5	2,600$^{\phi}$ x 2,500^{L}	
4.	tanning drum	1	1,200$^{\phi}$ x 900^{L}	
5.	acid steeping drum	1	2,200$^{\phi}$ x 2,200^{L}	
6.	scraping machine (band knife machine)	3	2,500^{W} x 3,500^{L} x 2,150^{H}	
7.	polishing machine (buff machine)	2	1,500^{W} x 3,500^{L} x 1,300^{H}	
8.	bag filter	1 set	1,000^{W} x 4,000^{L} x 3,000^{H} 1 fan, 60 filter elements	
9.	shaving machine	2	1,000^{W} x 1,500^{L} x 1,500^{H}	
10.	dyeing machine (1F)	1	2,100$^{\phi}$ x 2,300^{L} x 2,300^{H}	
11.	drier	1 set	direct drying of net-spreaded hide 4,000^{W} x 10,500^{L} x 4,000^{H} 3 air fans	
12.	drier (office bldg. 2F)	1	3,000^{W} x 3,300^{L} x 3,000^{H}	
13.	drier (office bldg. 2F)	1	4,000^{W} x 5,100^{L} x 3,200^{H}	
14.	dyeing machine (office bldg. 1F)	1	2,200$^{\phi}$ x 2,300^{L}	
15.	embossing machine (office bldg. 1F)	2	1,000^{W} x 2,300^{L}	
16.	truck scale (office bldg. 1F)	1	1,800^{W} x 3,500^{L} x 1,400^{H}	
17.	painting apparatus (office bldg. 1F)	2 sets	5,000^{W} x 28,000^{L} with drier, with autospray	
18.	boiler	1	with 1 heavy oil tank with 1 feed pump	

(3) Conditions of offensive odor generation

The major offensive odor sources in the present factory are as follows:

1) Offensive odors generated from raw hides and final products

Although the raw materials are dry when received and emit little odor, when they become wet after the water steeping process, they emit odors. Also the odor generated from the hides during the drying process cannot be ignored.

2) Odors generated from the wastewater in the preparation process and the tanning process

The wastewater generated in the production processes are said to be the greatest source of odors and offensive odors are generated from wastewater puddles found here and there within the factory.

There are no wastewater treatment facilities that are installed within the present factory and wastewater is discharged into drains in the factory surroundings from where it is transported to the central wastewater treatment plant for treatment. The contamination of the water in the drains is significant and a large amount of odor is emitted.

3) Odors generated from wastes such as hide scraps and debris

Hide scraps, hide debris, epidermal fats, etc., generated from such processes as fleshing (removal of meat from raw hide), hair removal, decalcification and bating, constitute one of the odor sources. Most of these waste materials are not separated sufficiently and are dissolved within the wastewater.

4) Odors generated from the dyeing process

Odors from the organic solvents in the dyes used in the dyeing process are adrift around the dyeing machines and exhausts from the machines are emitted to ambient air.

(4) Present state of measures for prevention of offensive odors

Although there are no deodorization apparatuses installed within the factory, a dust collection apparatus (bag filters) for the dust from the tanned leather dryers and a ventilation apparatus for the dyeing machine are installed.

(5) Present state in the surroundings

The present factory is located in the midst of an industrial estate for tanneries and is surrounded by other tanneries. Therefore odors from tanneries other than the present factory are obviously included in the odors outside the factory. Figure 4-27 shows the layout of the surroundigs of this factory.

The untreated wastewater from each factory, which contain large quantities of organic matter as well as chromium from the tanning process, flows into the drains next to the factory.Although the drains near the entrance of the present factory is 2.5m wide and 1.8m deep, since sludge has deposited to a depth of approximately 1m, there is flow of water only to a depth of about 0.8m.

The water in the drains is colored black or green. Methane and hydrogen sulfide are generated from anaerobic fermentation. Indicator tube measurements showed that this water contains about 10 ppm of hydrogen sulfide. Conditions were observed in which the gases evolved in the sludge collect within the sludge and floatate masses of sludge to the water surface at once. At such times, the hydrogen sulfide concentration temporarily reaches nearly 100 ppm and a strong odor is noticed.

Although some of the odors within the industrial estate are odors discharged from each factory, it is not an exaggeration to say that almost all of the odors in the entire industrial estate are generated from these drains.

Work is presently being performed near the central wastewater treatment plant to cover part of the drains. Odor conditions have improved in parts where this work has been completed and the odor in the streets is very low. But since the covered conduits are of steel-reinforced concrete, sufficient examination and maintenance are necessary. Also, since high concentrations of hydrogen sulfide (100 ppm by indicator tube measurements) are generated within the covered conduits, sufficient safety measures are required for inspecting and maintaining the inside of the covered conduits.

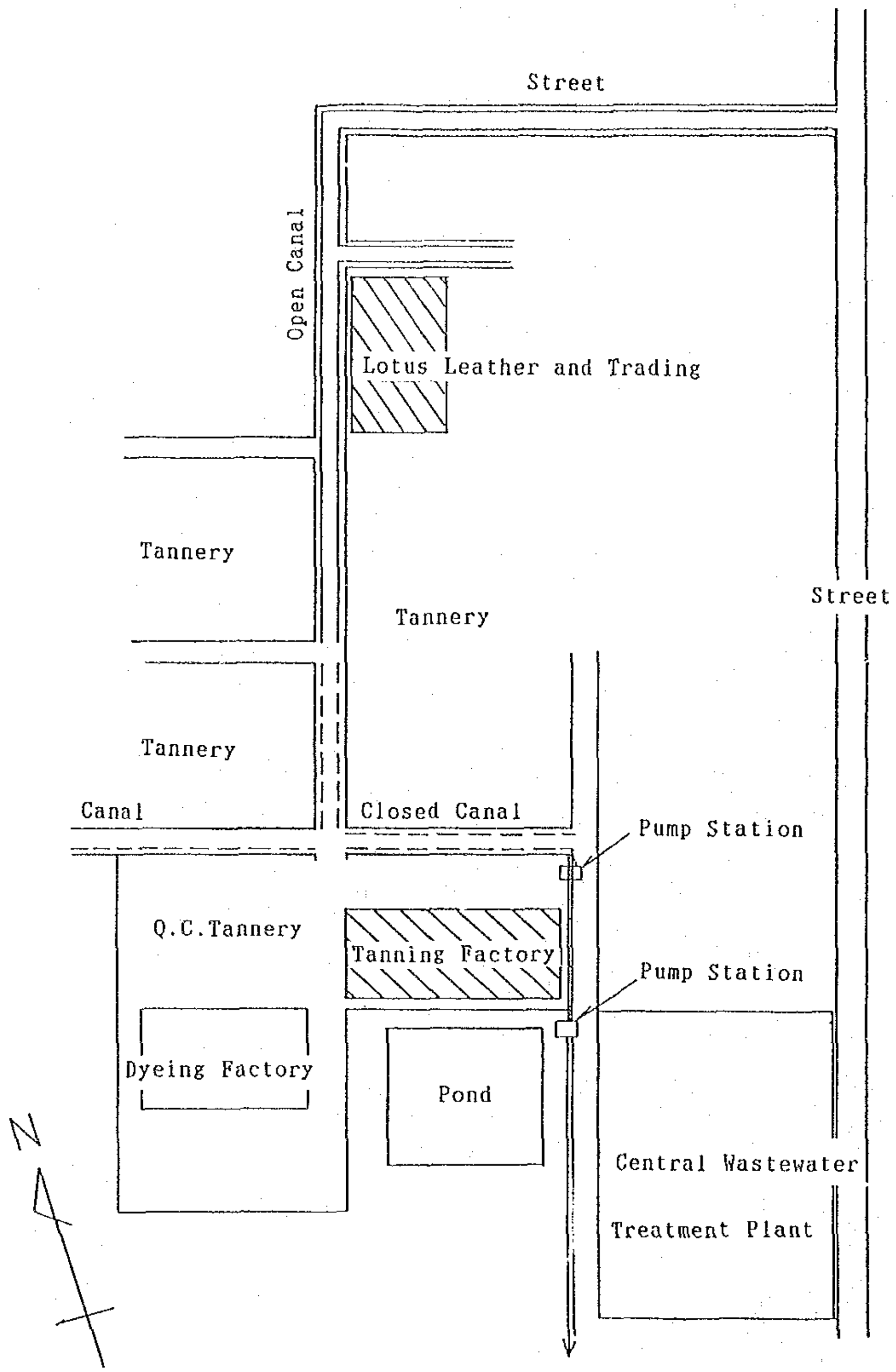


Figure 4-27 Surroundings Layout of the Factory (Tannery E and F)

(6) Results of hearing investigation

Q 1 : How is the management organized in this factory ?

A : Four to Five people with responsibility are stationed below the factory manager.

Q 2 : From where are the raw hides used as raw material received ?

A : All raw hides are imported.

Q 3 : How are the grease from the scraping process, etc. in the production process treated ?

A : They are delivered to a factory in the back. They seemed to be processed into dog food.

Q 4 : About how frequently is cleaning performed inside the factory ?

A : Cleaning is performed every day.

Q 5 : How are the hide debris discharged from the shaving process, etc. disposed ?

A : Firms that specialize come to receive them.

Q 6 : About how much water is used in this fact- ory ?

A : I do not know for sure.

Q 7 : Please tell us where the leather produced in this factory is shipped to.

A : Mainly central east Asia.

(7) Results of odor measurement

The odor measurement and analysis results for the factory interior and exterior are shown in Tables 4-19 and 4-20; odor sampling locations are shown in Figure 4-28. Although the highest odor concentrations were that measured above the drain flowing in front of the factory (3,100) and that of the dyeing machine exhaust (3,100), high values of 1,300~1,700 were also measured within the factory. The odor concentration is also 1,300 at the road outside the front of the factory.

Table 4-19(1) Results of Odor Measurement by Sensory Test and Detection Tube (Tannery E)

No.	Odor Concentration	Detection tube		Sampling Point
		NH_3	H_2S	
<First Field Study> (November 9, 1992)				
E- 1	1,300	1	N D	Beside padding drum
E- 3	150	1	N D	On the boundary line (south fence)
E- 5	140	1	N D	In front of leather drier
E- 9	730	N D	N D	Vapor from dyeing machine
E-10	---	N D	N D	Inside products stock room (4F)
E-11	230	2	N D	Over drainage canal outside the factory
E-12	---	N D	N D	Over drainage canal outside
E-13	---	N D	N D	Center of the front road
E-14	---	2	N D	Raw hide unloading platform shed
<Second Field Study> (March 10, 1993)				
E- 2	---	2	N D	Over raw fur washing drum
E- 4	---	2	N D	Beside tanning drum (No 1)
E- 4(*)	---	2	N D	Beside tanning drum (No 2)
E- 6	---	2	N D	Beside bag filter
E- 7	---	8	N D	Center of courtyard under roof

Table 4-19(2) Continued (Tannery E)

No.	Odor Concentration	Detection tube NH_3	Detection tube H_2S	Sampling Point
E- 8	---	0.5	N D	Beside drier for treated fur (2F)
E- 9	---	N D	N D	Inside painting process room (3F)
E-10	---	N D	N D	Storage room of products
E-11	---	2	12	Over wastewater canal beside entrance
E-14	---	1	N D	Beside fur shaving mill
E-15	---	0.5	N D	Inside elevator
E-16	---	1	N D	Out of window in dyeing room (2F)
E-17	---	N D	N D	Over stockyard of organic solvents
<Third Field Study> (September 13, 1993)				
E- 1	690	1	2	On boundary line (beside entrance)
E-11	3,100	3	10	Over wastewater canal beside entrance
E- 4	1,700	2	N D	Workshop beside tanning drum
E- 2	--	3	0.1	Over raw fur pickling drum
E- 3	--	0.5	0.2	Southern part of workshop
E- 4(*)	--	1	N D	Beside tanning drum
E- 5	--	1	N D	Beside fur shaving machine
E- 6	980	0.5	N D	Beside bag filter for shaved fur
E- 7	1,300	1	0.2	Center of courtyard under roof
E- 8	980	N D	N D	Beside drier for treated fur (2F)
E- 9	3,100	N D	N D	Inside painting room (3F)
E-10	--	N D	N D	Storage room of leather products
E-15	--	0.5	N D	Inside elevator

Notes 1. ND : Below the value of detectable limit.

2. --- : Non measured.

Table 4-20 Concentration of Odor Substances Determined by Instrumental Analysis (Tannery E)

Sample No		E-1	E-4	E-11	
1. Ammonia(ppm)		0.5	2.0	4.0	
2. Methyl mercaptan(ppm)		ND(<0.003)	ND(<0.003)	0.024	
3. Hydrogen sulfide(ppm)		0.55	ND(<0.003)	12.4	
4. Methyl sulfide(ppm)		ND(<0.001)	ND(<0.001)	ND(<0.001)	
5. Methyl disulfide(ppm)		ND(<0.001)	ND(<0.001)	0.001	
6. Trimethylamine(ppm)		0.002	0.004	0.004	
7. Acetaldehyde(ppm)		ND(<0.01)	ND(<0.01)	ND(<0.01)	
8. Styrene(ppm)		ND(<0.1)	ND(<0.1)	ND(<0.1)	
9. Propionic acid(ppm)		ND(<0.002)	ND(<0.002)	ND(<0.002)	
10. N-butyric acid(ppm)		ND(<0.001)	ND(<0.001)	ND(<0.001)	
11. N-valeric acid(ppm)		ND(<0.001)	ND(<0.001)	ND(<0.001)	
12. Isovaleric acid(ppm)		ND(<0.001)	ND(<0.001)	ND(<0.001)	
Odor Concentration		690	1,700	3,100	
Detection tube	NH_3(ppm)	1	2	3	
	H_2S(ppm)	2	N D	10	
Point of sampling		Boundary line	Workshop by tanning drum	Wastewater canal (entrance)	

Notes 1. Date of Sampling : September 13, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

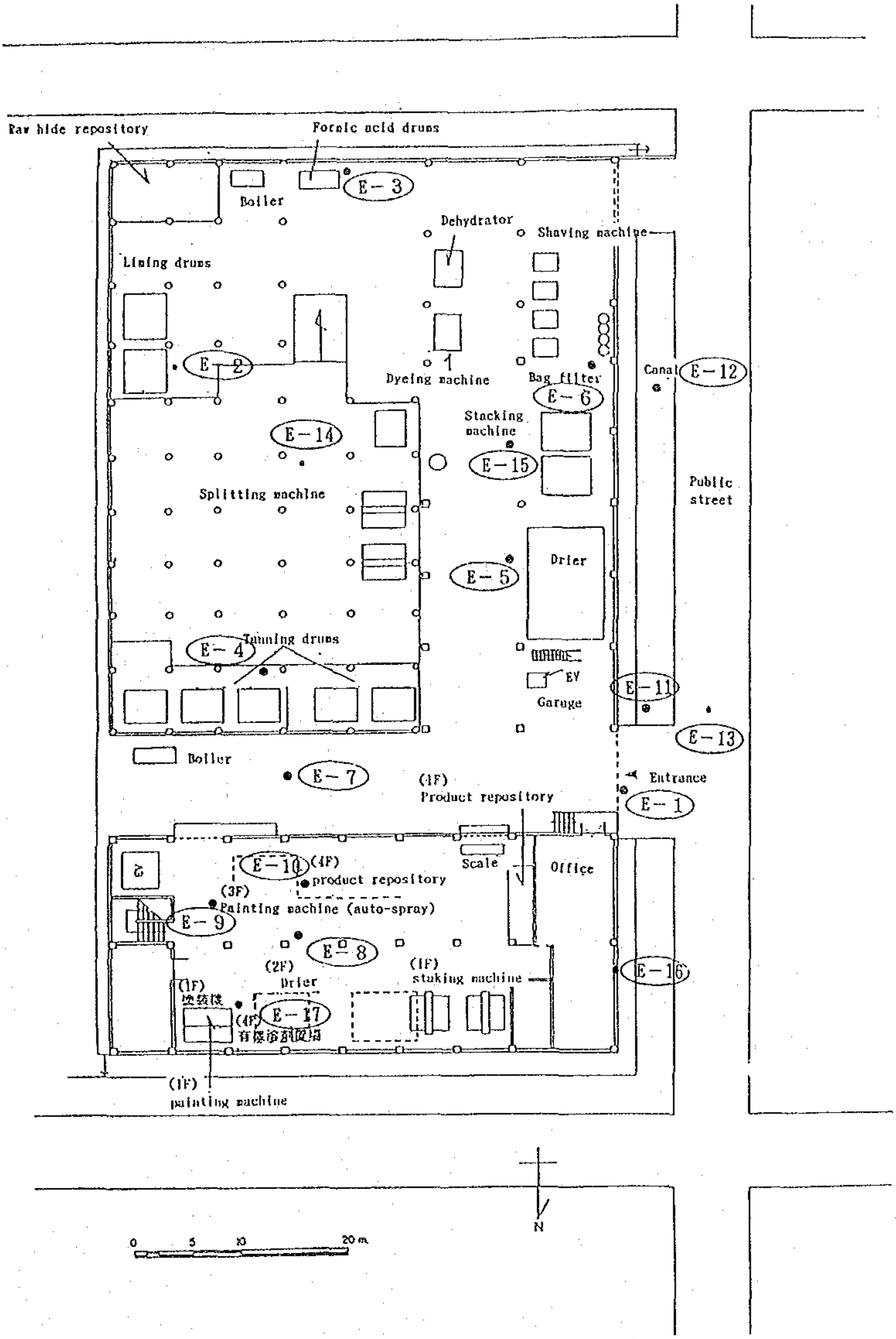


Figure 4-28 Odor Sampling Points (Tannery E)

The OER calculated from the measurement results for the major source of offensive odors is shown in Table 4-21.

Table 4-21 OER of Offensive Odor Source (Tannery E)

No.	Sampling Point	Odor Concentration	Emission Gas Flow (Nm^3/min)	OER
E-4	vicinity of tanning drum	1,700	1,000	1.7×10^6

(8) Problems

1) The present factory is located within the tannery industrial estate and its production processes are pretty much the same as those performed in the other factories. However, due to the small plottage, expansion of production capacities is becoming difficult.

2) The wastewater, which is the greatest offensive odor source at the tannery, is discharged into the drains without treatment. Also, although wet processes are arranged in one place, due to the inadequate inclination of the floors, there is accumulation of wastewater within the grounds.

3) The hide crud and hide scraps generated from the fleshing, hair removal and other processes are not collected and most of it is suspended in wastewater and discarded.

4) Offensive odors fill the entire industrial estate and there is a limit to how much can be accomplished through offensive odor countermeasures by individual factories. Because of this, there is a lack of awareness by each factory towards pollution prevention measures for odors, wastewater, etc. It is therefore necessary to clarify the range of responibilities of the factories.

4.2.6 Tannery F

(1) Outline of the factory

1)	Name of factory	: Q.C. Tannery
2)	Name of Owner	: Mr. Samart Srisakuarakul
3)	Address of factory	: 209 Sukhumvit Road Km 30, Tai Ban Road, Amphur Muang, Samutprakan
4)	Date of establishment	: 1967
5)	Industrial category	: tannery (Code No. 29-1/34)
6)	Products	: leather : 892,000 m^2/yr.
7)	Raw materials	: raw hide : 240,000 animals/yr
8)	Operating hours	: 8:00 ~ 17:00 (8 hours/day)
9)	Number of employees	: 200 (incl. 10 experts)
10)	Surrounding land usage	: industrial area
11)	Site area	: 40,000 m^2
12)	Building area	: 8,000 m^2 (tannery only)
13)	Factory layout	: Shown in Figure 4-29 and Figure 4-30.

(2) Production process and production management

1) The present factory is divided into the tanning factory and the painting factory. This investigation is concerned only with the tanning factory from the standpoint of odor generation. The production process is a standard process as shown in Figure 4-31. The specifications of major equipments are given in Table 4-22.

2) The factory has a relatively large processing capacity as a tannery and the annual number of animals processed amount to 240,000. The quantity of leather produced from one cattle or water buffalo is, on the average,

approximately 40 square feet (approx. 3.7m^2)

3) The factory building is spacious and is constructed from reinforced concrete. There are 20 water steeping/liming drums, 10 decalcifying/washing drums, 9 tanning drums, 4 acidulation drums and 4 splitting machines. However, only 1/3 ~ 1/4 of the machines for each process were being operated and several drums were not being used.

4) Although the grounds were well cleaned in general, there was accumulation of wastewater and conspicuous soilage along the passageway at the factory entrance, especially around the raw material repository.

4) The tanned hide is sun-dried at the empty lot within the grounds.

5) A dyeing factory is presently being constructed at a site adjacent to the tannery and the hide drying area. The new factory is almost complete, leaving only the furnishing of the interior and there were some processes in which operations have partly begun.

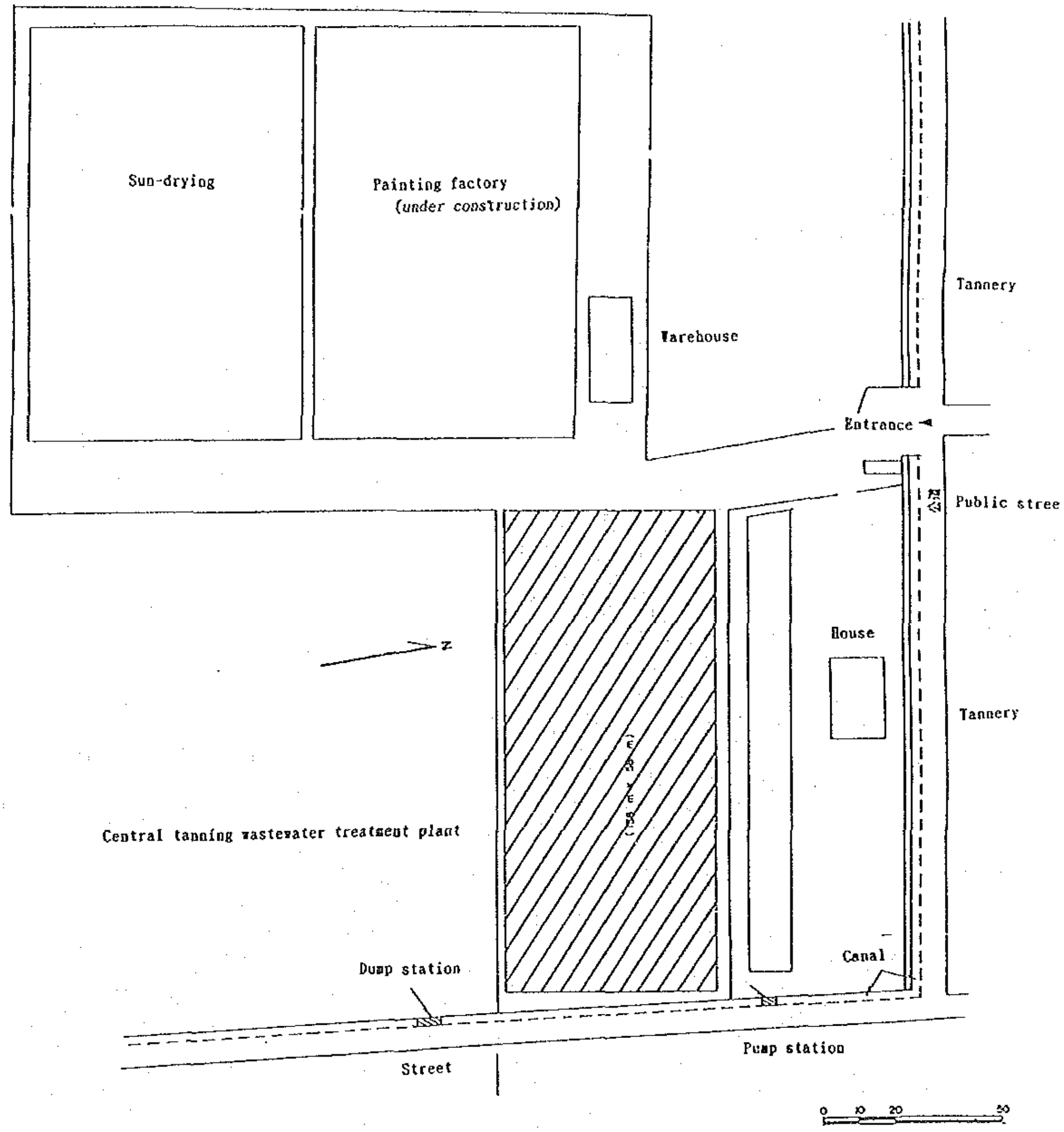


Figure 4-29 Site Plan of the Factory (Tannery F)

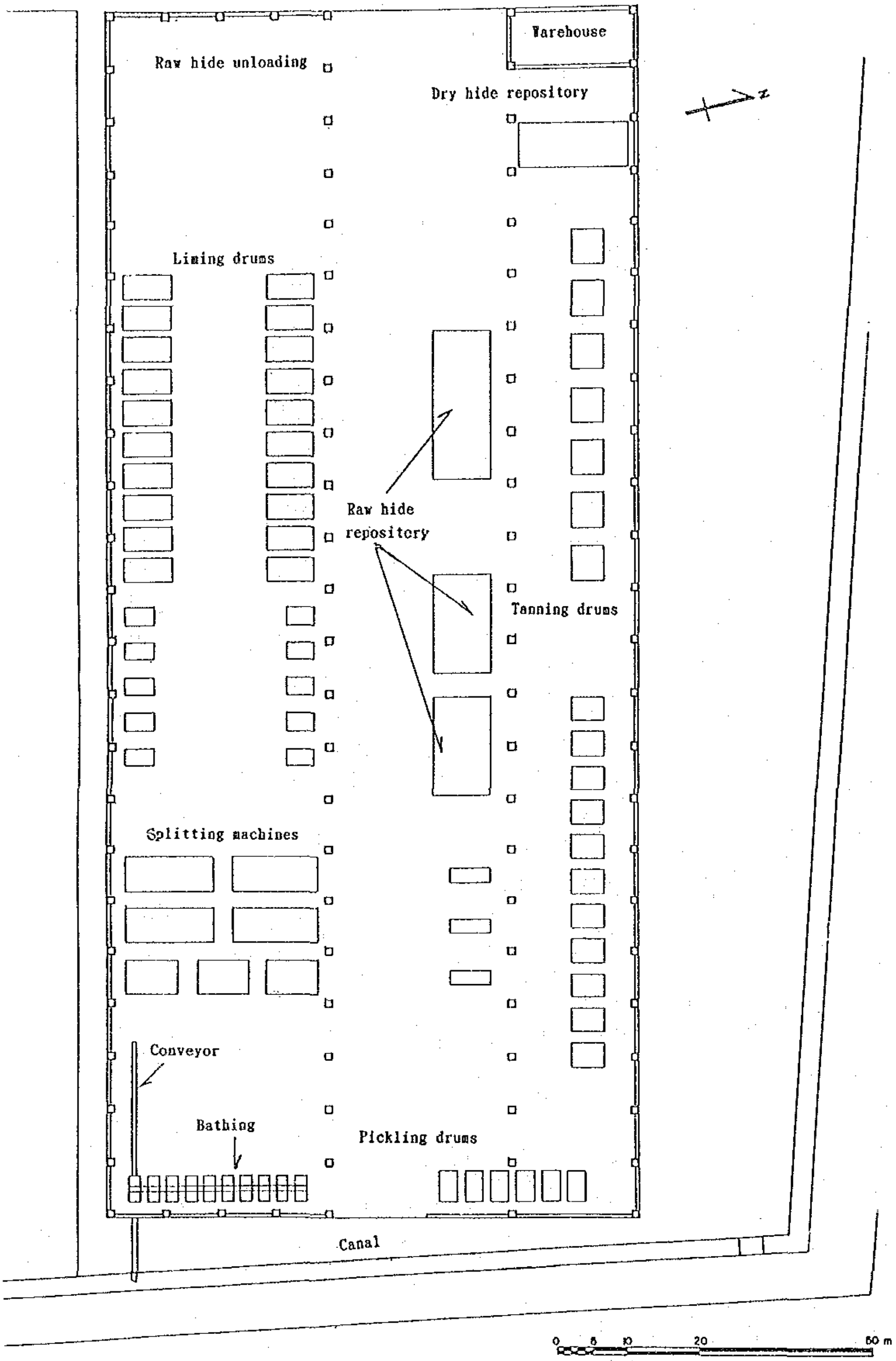


Figure 4-30 Layout in the Factory (Tannery F)

raw hide

↓

selection-trimming

↓

steep in water
(rehydrate)

↓

backing (fleshing)

↓

steep in lime
(hair removal)

↓

combing
(band machine and hand combing)

↓

decalcify, wash with water

↓

(chrome) tanning

↓

neutralize

↓

sun-dry

↓

to dye factory

Figure 4-31 Production Process (Tannery F)

(3) Conditions of offensive odor generation

The major offensive odor sources are the same as those at the Tannery E. Offensive odors are generated from the wastewater and wastes discharged from the raw material repository, tanned leather repository, preparation process and tanning process.

Although the factory building is large, there was drainage that accumulated on the floor which were discharged to the outdoor drain without treatment.

Also, the tanned leather, that are sun-dried at the empty lot on the southwest side of the grounds, generate offensive odors.

The dyeing process is performed at another factory and although a new factory for this purpose is under construction within the grounds, investigations concerning this process were not performed.

(4) Present state of measures for prevention of offensive odors

There are no facilities for odor prevention/deodorization installed at this factory; nor are there any ventilation facilities.

(5) Present state in the surroundings

The present factory is located within an industrial estate for tanneries and is approximately 300m to the south of Tannery E. The southeast side faces the central wastewater treatment plant all the other sides face other tanneries. Figure 4-27 shows the layout of the factory surroundings.

The sides of the roads in the front of the factory are strewn with drains. The covering of the drains at the north side of the factory has been completed. The drains are surrounded by concrete on four sides and 12 inspection ports are installed.

Although offensive odors fill the entire tannery industrial estate area, much has been improved by the covering of the drains.

(6) Results of hearing investigation

Q 1 : Please tell us where the raw materials are received from. Also, are there any variations in the quantity received ?

A : Raw materials are received from out of the province and through foreign imports. Quantities are stable.

Q 2 : Please tell us the quantity and source of water used in the factory.

A : All of the water used is taken from the well but I do not know the quantity.

Q 3 : How are the grease, etc. from the scraping of the raw hide in the production process handled ?

A : These are sent out to outside firms as fish food.

Q 4 : How is the management organized in this factory.

A : There is one person in charge.

Q 5 : How frequently is the factory cleaned ?

A : The factory is cleaned once a day in the morning by all employees.

Q 6 : Please tell us how the new factory in construction next to this building will be used.

A : The painting process which is being performed at a separate place presently will be transferred into the new factory.

(7) Results of odor measurement

The odor measurement and analysis results for the factory interior and exterior are shown in Tables 4-22 and Table 4-23; odor sampling locations are shown in Figure 4-32.

Among the measurement locations, the location above the drains had a high odor concentration (1,700 ~ 5,500). High values between 730 and 980 were also detected at such places within the factory as the areas for the fleshing process and the hair removal process and the raw hide repository.

Table 4-22 Results of Odor Measurement by Sensory Test and Detection Tube (Tannery F)

No.	Odor	Detection tube		Sampling Point
	Concentration	NH_3	H_2S	
＜First Field Study＞ (November 9, 1992)				
F- 2	980	2	N D	Over salt-pickled raw hide storage
F- 3	730	8	N D	Beside trim-soak-depilation drum
F- 4	170	2	N D	Beside squeezing operation
F- 6	---	1 ~ 3	N D	Center of factory
F- 7	310	40~50	N D	Beside tanning drum
F- 8	---	9	N D	Beside tanning drum
F-12	49	1	N D	On the boundary line (south-east end)
＜Third Field Study＞ (September 20, 1993)				
F- 1	55	N D	N D	On boundary line (beside entrance)
F- 2	980	3	N D	Over storage of raw hide
F- 3	310	1	N D	Beside lime-pickling and hand cutting
F- 4	730	0.5	N D	Under shaving machine
F- 5	410	3	N D	In front of tanning drum
F- 9	---	6	3	Inside new wastewater underdrain canal
F-10	5,500	2	2	Beside drainage pump behind facility
F-11	1,700	1	1	Over outlet of drain pipe
＜Second Field Study＞ (March 17, 1993)				
F- 2	---	3	1	Over storage of raw hide
F- 3	---	2	N D	Over storage of raw hide
F- 4	---	2	0.5	Over storage of raw hide
F- 5	---	3	N D	Over storage of raw hide
F- 6	---	9	N D	Over storage of raw hide
F- 7	---	5	0.5	Over storage of raw hide
F- 8	---	2	1	Over storage of raw hide
F-10	---	2	22	Over storage of raw hide
F-11	---	1.2	7	Over storage of raw hide

Table 4-23 Concentration of Odor Substances Determined by Instrumental Analysis (Tannery F)

Sample No		F-1	F-2	
1. Ammonia (ppm)		0.2	1.9	
2. Methyl mercaptan (ppm)		ND(<0.003)	ND(<0.003)	
3. Hydrogen sulfide (ppm)		0.032	ND(<0.003)	
4. Methyl sulfide (ppm)		ND(<0.001)	ND(<0.001)	
5. Methyl disulfide (ppm)		ND(<0.001)	ND(<0.001)	
6. Trimethylamine (ppm)		ND(<0.001)	0.006	
7. Acetaldehyde (ppm)		ND(<0.01)	ND(<0.01)	
8. Styrene (ppm)		ND(<0.1)	ND(<0.1)	
9. Propionic acid (ppm)		0.024	0.038	
10. N-butyric acid (ppm)		ND(<0.001)	ND(<0.001)	
11. N-valeric acid (ppm)		ND(<0.001)	ND(<0.001)	
12. Isovaleric acid (ppm)		ND(<0.001)	ND(<0.001)	
Odor Concentration		55	980	
Detection Tube	NH_3 (ppm)	N D	3	
	H_2S (ppm)	N D	N D	
Point of Sampling		Boundary line	Storage of raw hide	

Notes: 1. Date of sampling : September 20, 1993

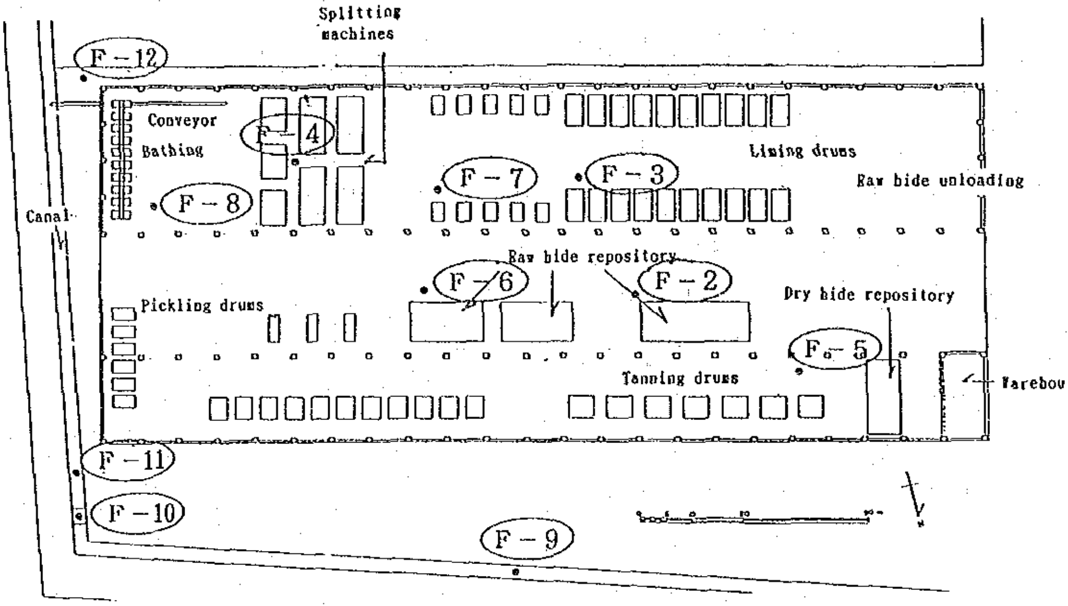
2. N D : Below the value of detectable limit.

3. --- : Non measured.

The OER calculated from the measurement results at major odor sources are shown in Table 4-24.

Table 4-24 OER of Offensive Odor Source (Tannery F)

No.	Sampling Point	Odor Concentration	Gas Flow (Nm^3/min)	OER
F-2	raw materials repository	980	1,400	1.4×10^6
F-3	lime steeping drum	310	2,100	6.5×10^5
F-5	tanning drum	410	900	3.7×10^5



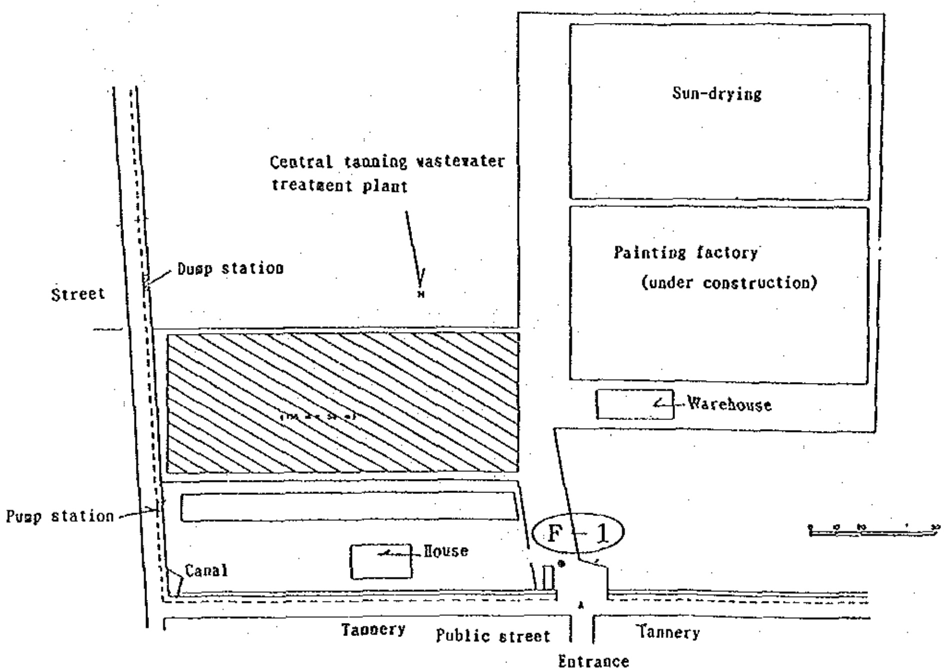


Figure 4-32 Odor Sampling Points (Tannery F)

(8) Problems

1) The present factory is located within the tannery industrial estate. A dyeing factory is under construction to integrate the dyeing process with the tanning process. The site is spacious and the buildings are spacious structures built of reinforced concrete. Expanision of the factory scale is also being planned. However, ventilation and accomodations for odor prevention and deodorization seem to be inadequate.

2) The wastewater is discharged into the drains without treatment. Also, due to the inadequate drainage inclination of the floors for the wet processes, there is accumulation of wastewater within the grounds.

3) Most of the hide crud and hide scraps generated from the tanning processe is suspended in the wastewater are and discarded.

4) The tanned leather is sun-dried outdoors and this is another cause of offensive odors.

5) Offensive odors fill the entire industrial estate and there is a limit to how much can be accomplished through offensive odor countermeasures by individual factories. Because of this, there is a lack of awareness by each factory towards pollution prevention measures for odors, wastewater, etc. It is therefore necessary to clarify the range of responibilities of the factories.

4.2.7 Automobile Painting Factory G

(1) Outline of the factory

1)	Name of factory	: Narong Rungrueng
2)	Name of Owner	: Mr. Narong Sombatborisut
3)	Address of factory	: 42/8-9 Ratana Tibet Road, Tambon Bangkraso District, Amphur Muang, Nonthaburi
4)	Date of establishment	: February, 1989
5)	Industrial category	: automobile painting (Code No. 95(1)-3/33)
6)	Products	: automobile repairs: 10 ~ 20 vehicles/day
7)	Raw materials	: sheet iron: 30 sheets/month paint : 50 gallons/month
8)	Operating hours	: 8:00 ~ 17:00 (8 hours/day)
9)	Number of employees	: 70 (incl. 3 experts)
10)	Surrounding land usage	: commercial area
11)	Site area	: 1,600 m^2
12)	Building area	: Office : 224m^2 Factory : 1,000m^2
13)	Factory layout	: Shown in Figure 4-33.

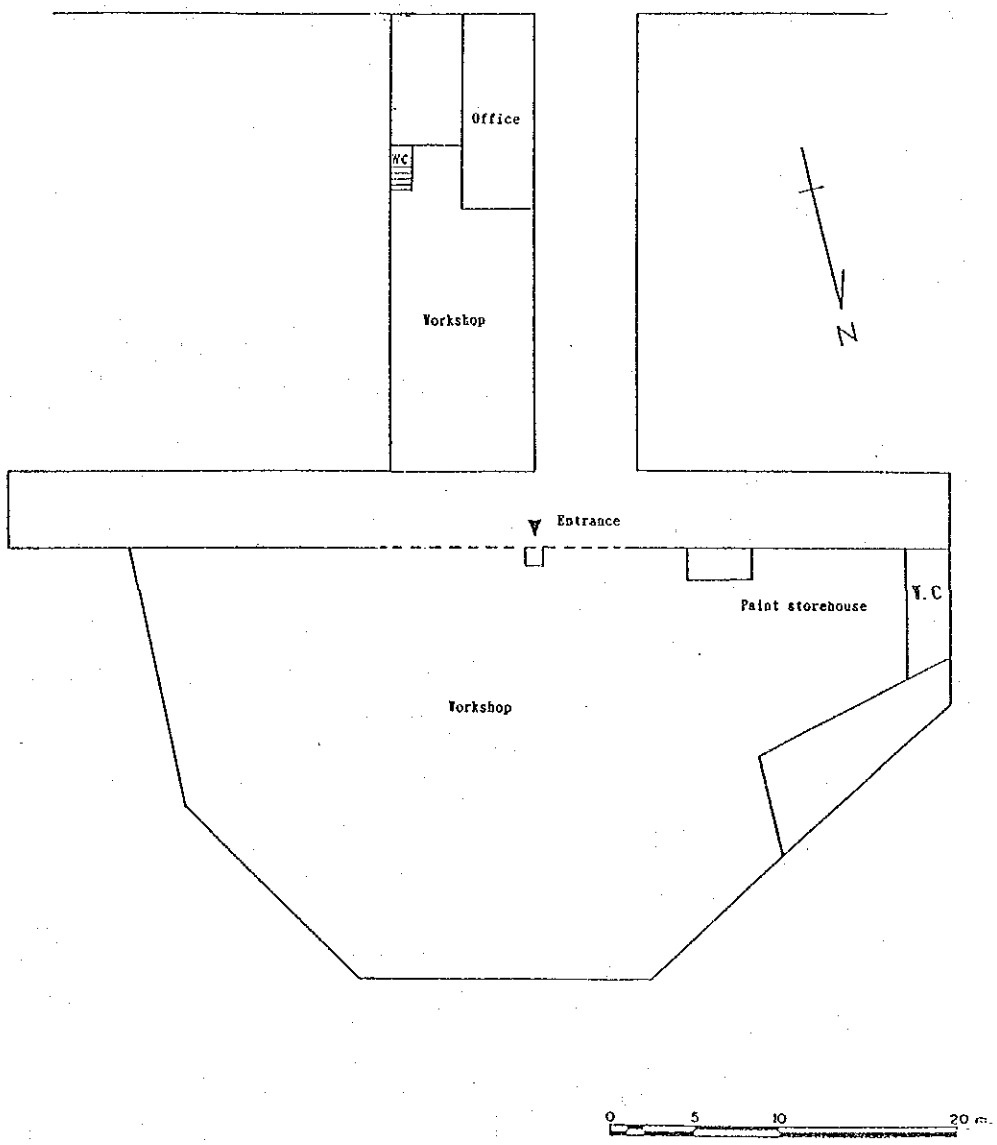


Figure 4-33 Layout of the Factory
(Automobile Painting Factory G)

(2) Production process and operation management

1) The present factory is a small-scale automobile repair factory located in the suburbs of Bangkok. Painting is performed alongside car repairs. The painting process is a standard process as shown in Figure 4-34.

2) Due to its location along a national route and within a commercial district, business is good. There were always 40 to 50 cars in the main factory behind the office and the factory was always full. Putty painting and painting were being performed on four cars respectively, or on a total of eight cars on the day of the investigation.

3) Employees are not assigned car repair and painting jobs according to process but are left up to their own responsibility upon performing the job. The working areas therefore did not seemed to be fixed. Painting was being performed near the entrance and further inside to the left side of the factory at the time of the investigation. It was explained that there were plans to improve the painting room.

4) The major equipment maintained at the factory include 2 welding apparatus, 2 compressors, 1 drying fan and 3 electric sanders. Paints and solvents are stored far inside the factory on the left side.

5) Since the painting area and the area where flames are being used in the automobile repairs are relatively close to each other and since there are no dividing walls, the location of each job should be set from the standpoint of safety. Also cars, tools and machines were scattered around in the inside of the factory, bringing about conditions with poor foothold for work and much

dust.

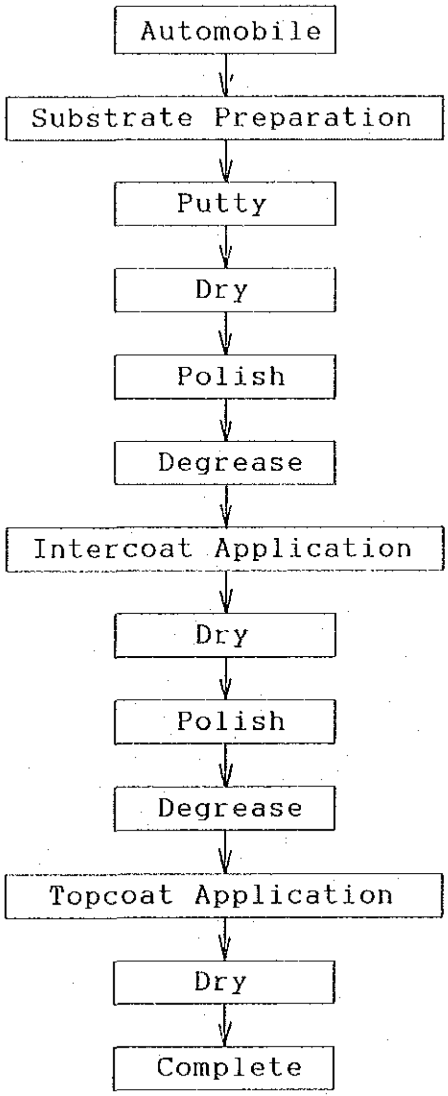


Figure 4-34 Painting Process
(Automobile Painting Factory G)

(3) Conditions of offensive odor generation

Organic solvent odors were generated when painting was being performed. Since walls surround the factory boundaries and since indoor ventilation depended on natural ventilation, the odors do not disperse easily. Organic odors were extremely strong around the painting areas.

Sometimes painting is performed outside at the passageway in front of the factory and neighboring residences may be affected.

Odors from inside the factory leaked outside and some odors could be noticed at the boundaries of the grounds.

(4) Present state of measures for offensive odor prevention

A painting room was installed behind the office (at the time of the 1st Investigation). But because the painting room was small and because it was difficult to access the painting room due to there being too many cars within the factory, the painting room was not used. The painting room was removed by the time of the 2nd Investigation. According to factory personnel, there were plans for modifications.

There are no ventilation facilities within the factory and ventilation depended on natural ventilation through openings at the upper part of the outer block walls and through the entrance.

(5) Present state in the surroundings

The office is in a building facing the trunk road and is next to a shop. The repair and painting factory is located behind the office and an adjacent road provides the entryway to the factory. Residences comprise the second to the fourth floors above the office and shop. Figure 4-35 shows the layout of the surroundings of this factory.

Although odors could not be detected a few ten meters away from the factory, offensive odors from the factory may affect the shops and residences nearby.

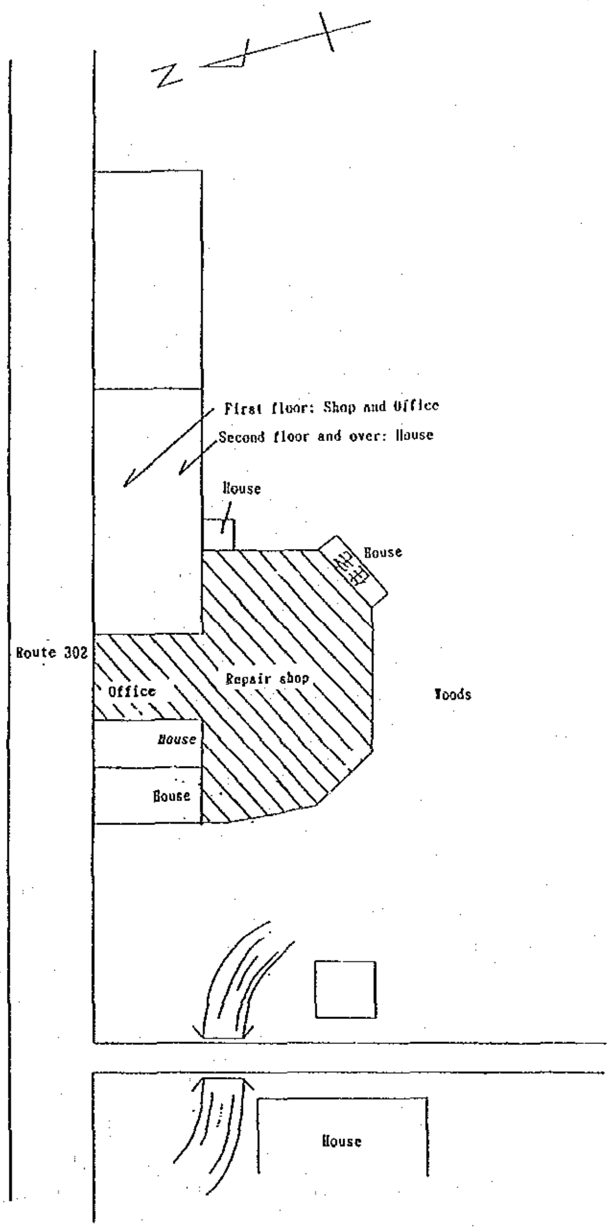


Figure 4-35 Surrounding Layout of the Factory
(Automobile Painting Factory G)

(6) <u>Results of hearing investigation</u>

Q 1 : Are areas for painting fixed in this fact- ory ?

A : The factory is being renovated presently and we are thinking of fixing the area for painting.

Q 2 : Please tell us the kinds and amounts of the materials used in this factory.

A : Most of the paints are acryl lacquers and thinner is used as the solvent. We do not know the amount used off hand. Leftover paints are stored to be used the next day. Empty paint cans and empty thinner cans are discarded.

Q 3 : How do the employees feel about the solvent odor?

A : It seems like they are used to it. They say that it doesn't bother them.

Q 4 : It seems like many cars are brought in. How much overtime is performed ?

A : Each employee is responsible for himself and does overtime for about 1 hour (up to about 6 P.M.) to finish off the day's work.

Q 5 : Tell us the kinds of cars that are handled at this factory.

A : Most are small passenger cars. Pickup trucks come next.

Q 6 : Please tell us the capacity and number of compressors used in the factory.

A : Two 3.7kW compressors (about 1,000 L/min., atmospheric pressure) are used but due to a power shortage, only one is in operation today.

(7) Results of odor measurement

The odor measurement and analysis results for the factory interior and exterior are shown in Table 4-25 and Table 4-26; odor sampling locations are shown in Figure 4-36. Although odor concentrations attain levels of 4,100 to 23,000 within the factory, the values at the boundaries are about 37 to 39. Toluene and xylene were detected by instrumental analysis.

Table 4-25 Results of Odor Measurement by Sensory Test and Detection Tube (Automobile Painting Factory G)

No.	Odor Concentration	Detection tube		Sampling Point
		NH_3	H_2S	
<First Field Study> (November 11, 1992)				
G- 1	79	N D	N D	On the boundary line (beside entrance)
G- 4	---	N D	N D	Center of inside factory
G- 5	7,300	N D	N D	Inside paints warehouse
G- 6	23,000	N D	N D	Beside painting operation
<Third Field Study> (September 15, 1993)				
G- 1	37	Toluene : ND		On the boundary line (east side)
G- 4	4,100	Toluene : 80		In the car repair shop

Table 4-26 Concentration of Odor Substances Determined by Instrumental Analysis

(Automobile Painting Factory G)

Sample No		G-2	G-4	
13. Acetone (ppm)		ND(<0.6)	ND(<0.6)	
14. Toluene (ppm)		ND(<0.2)	39	
15. Ethyl benzene (ppm)		ND(<0.2)	ND(<0.2)	
16. Xylene (ppm)		ND(<0.2)	2	
Odor Concentration		---	---	
Detection tube	NH_3 (ppm)	---	---	
	H_2S (ppm)	---	---	
Point of Sampling		Boundary line painting	Beside spray	

Notes 1. Date of Sampling : March 11, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

The OER calculated from the measurement results for the major source of offensive odors is shown in Table 4-27.

Table 4-27 OER of Offensive Odor Source

(Automobile Painting Factory G)

No.	Sampling Point	Odor Concentration	Gas Flow (Nm^3/min)	OER
G-4	painting room	4,100	120	4.9×10^5

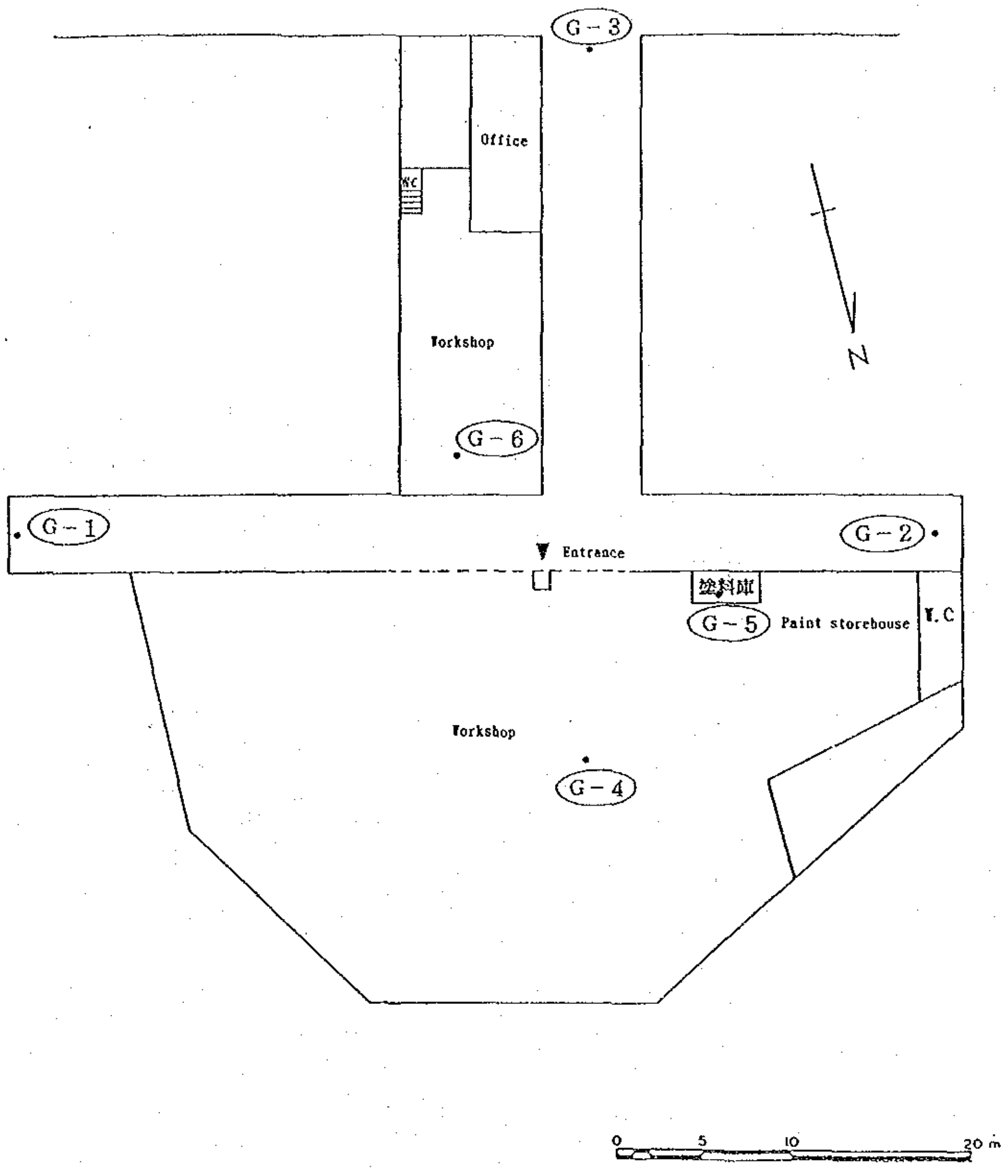


Figure 4-36 Odor Sampling Points
(Automobile Painting Factory G)

(8) Problems

1) The present factory is located along a national route within a commercial district and handles a large number of vehicles. But due to the small plottage, the grounds are congested and the working environment is poor.

2) Although a painting room was installed, because it was small and of a structure which was hard to use, it was not used. Therefore, painting was and still is performed within the factory or outdoors. Also, the painting room did not have deodorization facilities nor ventilation facilities.

3) Storage areas for tools and paints are not properly designated and working areas are not fixed. The awareness of the employees towards offensive odors and the working environment are low and not even masks are worn.

4.2.8 Automobile Painting Factory H

(1) Outline of the factory

1)	Name of factory	: Tavan Garage
2)	Name of Owner	: Mr. Montri Monthienkaserm
3)	Address of factory	: 90/70 Soi Tavon, Patanakarn Road, Tambon Suanluang, Amphut Pravert, Bangkok
4)	Date of establishment	: February, 1992
5)	Industrial category	: automobile painting (Code No. 95(1)-22/35)
6)	Manufacturing roducts	: automobile repairs : 30 vehicles/month
7)	Raw materials	: paint : 30 cans/month
8)	Operating hours	: 8:00 ~ 17:00 (8 hours/day)
9)	Number of employees	: 8 (1 expert, 7 inexperienced)
10)	Surrounding land usage	: residential area
11)	Site area	: 783 m^2
12)	Building area	: 368m^2
13)	Factory layout	: Shown in Figure 4-37.

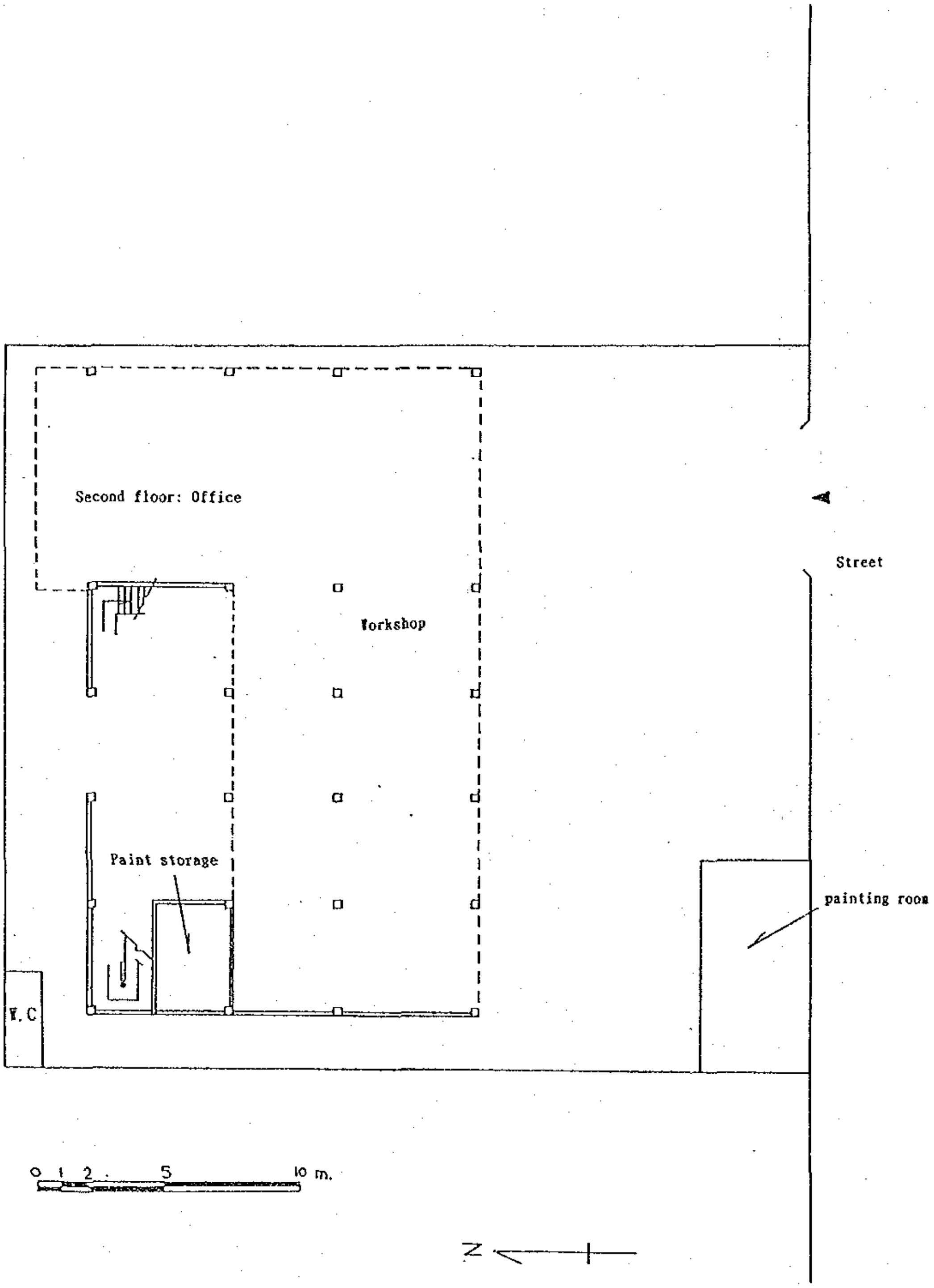


Figure 4-37 Layout of the Factory
(Automobile Painting Factory H)

(2) Production process and operation procedures

1) The present factory is a small-scale factory in which only sheet metal painting for cars are performed. Car repairs are not performed. A standard painting process is adopted as shown in Figure 4-38.

2) Painting is performed in a painting room that is installed within the grounds and emissions of the painting room are passed through filters.

3) With less than two years after establishment, the factory is a new, relatively small factory. The number of vehicles brought in seems to be increasing gradually.

4) Although there are only a few employees, there were two persons with responsibility who each managed their own section.

5) The factory has 1 welding apparatus, 1 compressor (2.2 kW), 1 ventilation fan (5.5 kW), 3 electric sanders and 1 paint mixing device. A warehouse for the storage of paints and solvent is installed and the maintenance conditions of tools and paints were good.

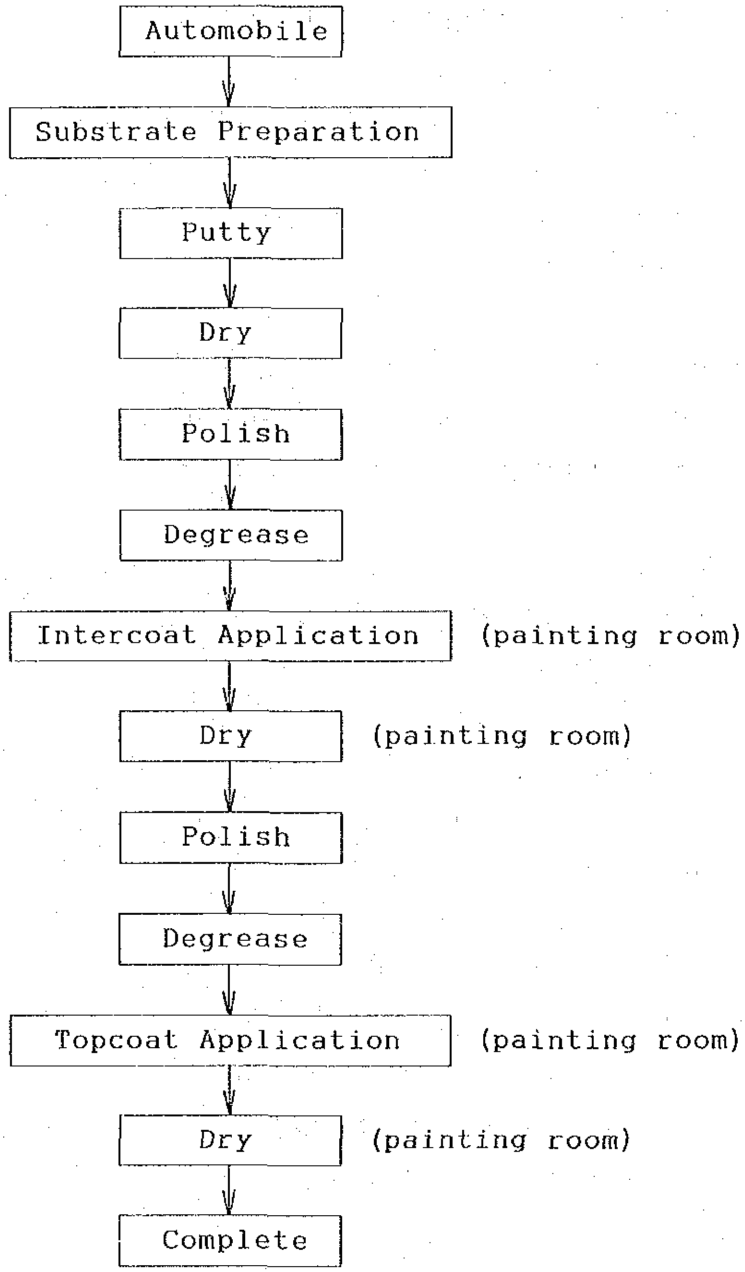


Figure 4-38 Painting Process
(Automobile Painting Factory H)

(3) Conditions of offensive odor generation

Perhaps because the number of automobiles in the factory is still small, offensive odors were hardly generated. There were hardly any solvent odors within the grounds; in fact, toilet odors and cooking odors were stronger.

(4) Present state of offensive odor prevention

The painting room that is installed is provided with facilities that ensure the discharge of indoor solvent odors outdoors by an exhaust fan during painting and drying. The air in the painting room is taken in from the ceiling and drawn out from the floor and filters are installed for the air inlet and outlet. Also, spilt solvents and paints are collected.

(5) Present state in the surroundings

Figure 4-39 shows the layout of the surroundings of this factory. Although a automobile repair factory is located adjacently, there are only a few residences in the surrounding area and the factory is located away from the trunk road.

Since the painting is performed within the painting room the generation of odors is small and it can be said that there are no effects on the surroundings.

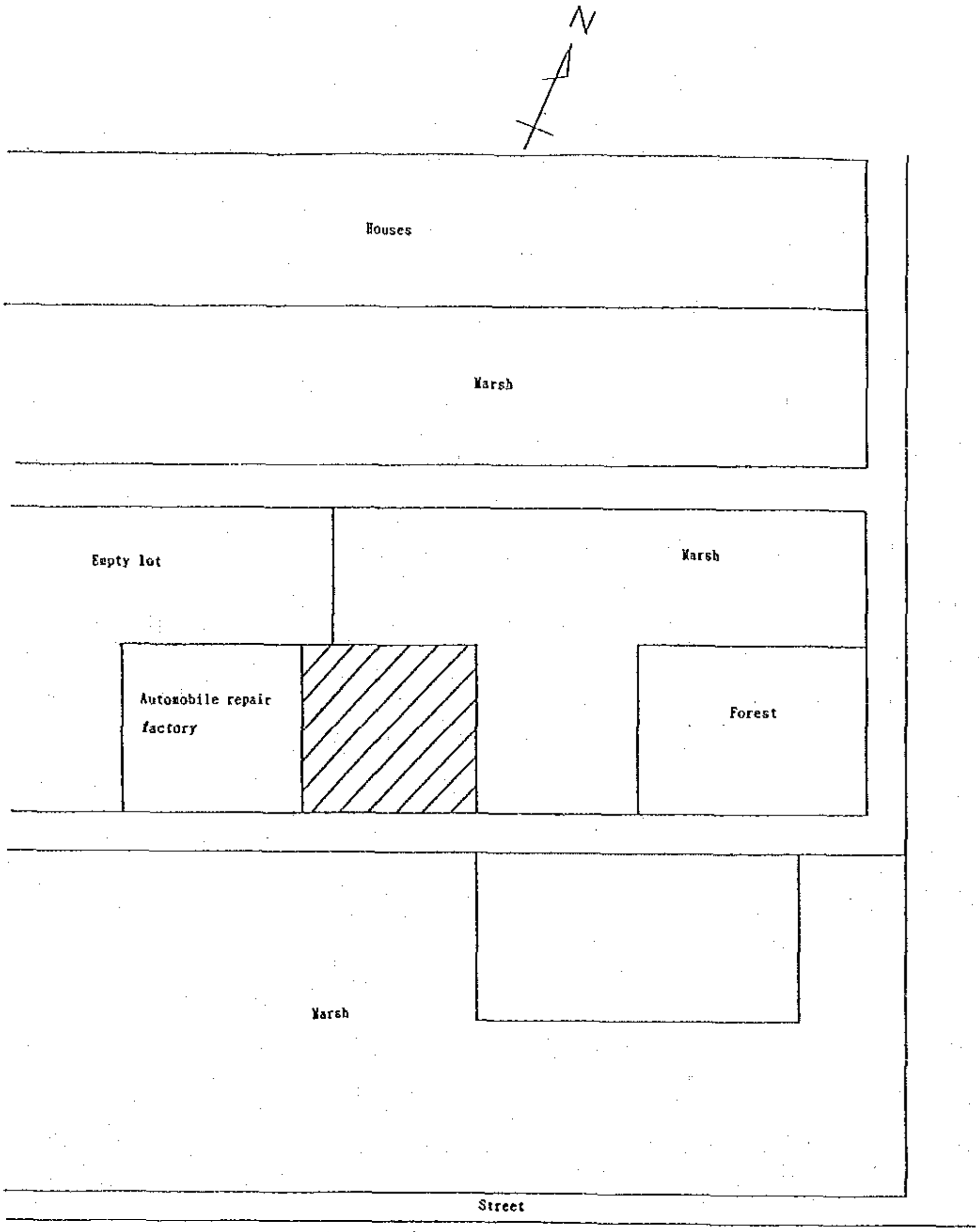


Figure 4-39 Surrounding Layout of the Factory
(Automobile Painting Factory H)

(6) Results of hearing investigation

Q 1 : Please tell us the kinds and amounts of the materials used in this factory.

A : The paints used are acryl lacquers. The solvent is thinner and 1 gallon (3.7853 L) is used per vehicle. Since about 30 cars are painted a month, 30 gallons are used per month.

Q 2 : Please tell us the capacity and number of compressors used in the factory.

A : Presently one 22kw compressor is used but we wish to have some more.

Q 3 : About how much is dissolution ratio of paint to solvent upon painting ?

A : It is 1:1.

Q 4 : Is there anybody responsible for the storage of the paint and solvent used ?

A : There are two persons with responsibility under the factory manager and one of them is responsible for storage. The paint storage does not have a lock.

Q 5 : What types of automobiles are painted ?

A : Almost all are small, passenger cars.

Q 6 : Do you know how the employees feel about the solvent odor during painting ?

A : They are used to the smell and do not like it nor dislike it.

Q 7 : Has there been any complaints about the smell from the surroundings of this fact- ory ?

A : The factory is away from private homes and so far there hasn't been any complaints.

Q 8 : When was that painting room built ? Also, please tell us about its system.

A : It was completed three months ago after spending 400,000 Bahts on it. In this system, outdoor air is drawn in through display filters for air intake and the spray exhaust is sucked via the filter installed on the floor to the air chamber installed outside by means of an exhaust fan and then discharged outdoors via a 5 m high flue. Solvent that has dripped on the floor is collected into an indoor drain on the outer circumference of the room and is then drained outdoors. Also several lightings are installed in the room so that the drying process can be performed faster.

Q 9 : What are the working hours ?

A : Work is done from 8:30 to 19:00 and overtime is hardly ever done.

Q 10 : Please tell us about the services of the factory once more.

A : The present factory is only concerned with automobile sheet metal and painting; maintenance is not performed.

(7) Results of odor measurement

The odor measurement and analysis results for the factory interior and exterior are shown in Tables 4-28 and 4-29; odor sampling locations are shown in Figure 4-40.

Although the odor concentrations at the boundaries are between 13 to 75, painting is not performed there and it is thought that these odors are not due to organic solvents.

Table 4-28 Results of Odor Measurement by Sensory Test and Detection Tube
(Automobile Painting Factory H)

No.	Odor Concentration	Detection tube NH_3	Detection tube H_2S	Sampling Point
<First Field Study> (November 16, 1992)				
H- 2	13	N D	N D	On the boundary line (west side)
H- 4	98	N D	N D	Inside paints warehouse
<Second Field Study> (March 16, 1993)				
H- 1	75	---	---	On the boundary line
H- 3	73	---	---	Center of the car repair shop
H- 4	17	---	---	In the paint stock room

Notes 1. Date of Sampling : March 16, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

Table 4-29 Concentration of Odor Substances Determined by Instrumental Analysis (Automobile Painting Factory H)

Sample No		H-1	H-3	H-4
13. Acetone	(ppm)	ND(<0.6)	ND(<0.6)	ND(<0.6)
14. Toluene	(ppm)	ND(<0.2)	ND(<0.2)	ND(<0.2)
15. Ethyl benzene	(ppm)	ND(<0.2)	ND(<0.2)	ND(<0.2)
16. Xylene	(ppm)	ND(<0.2)	ND(<0.2)	ND(<0.2)
Odor Concentration		75	73	17
Detection Tube	NH_3 (ppm)	---	---	---
	H_2S (ppm)	---	---	---
Point of Sampling		Boundary line	Center of workshop	Inside paint stock room

Notes 1. Date of Sampling : March 16, 1993

2. N D : Below the value of detectable limit.

3. --- : Non measured.

The OER calculated from the measurement results for the major sources of offensive odors are shown in Table 4-30.

Table 4-30 OER of Offensive Odor Source (Automobile Painting Factory H)

No.	Sampling Point	Odor Concentration	Gas Flow (Nm^3/min)	OER
—	painting room	4,100(※)	120	3.3×10^5
H-4	paint warehouse	98	10	9.8×10^2

Note: ※ Since the odor concentration of the painting room was not actually measured, it was estimated from the measured value for the painting work at the Automobile Painting Factory G.

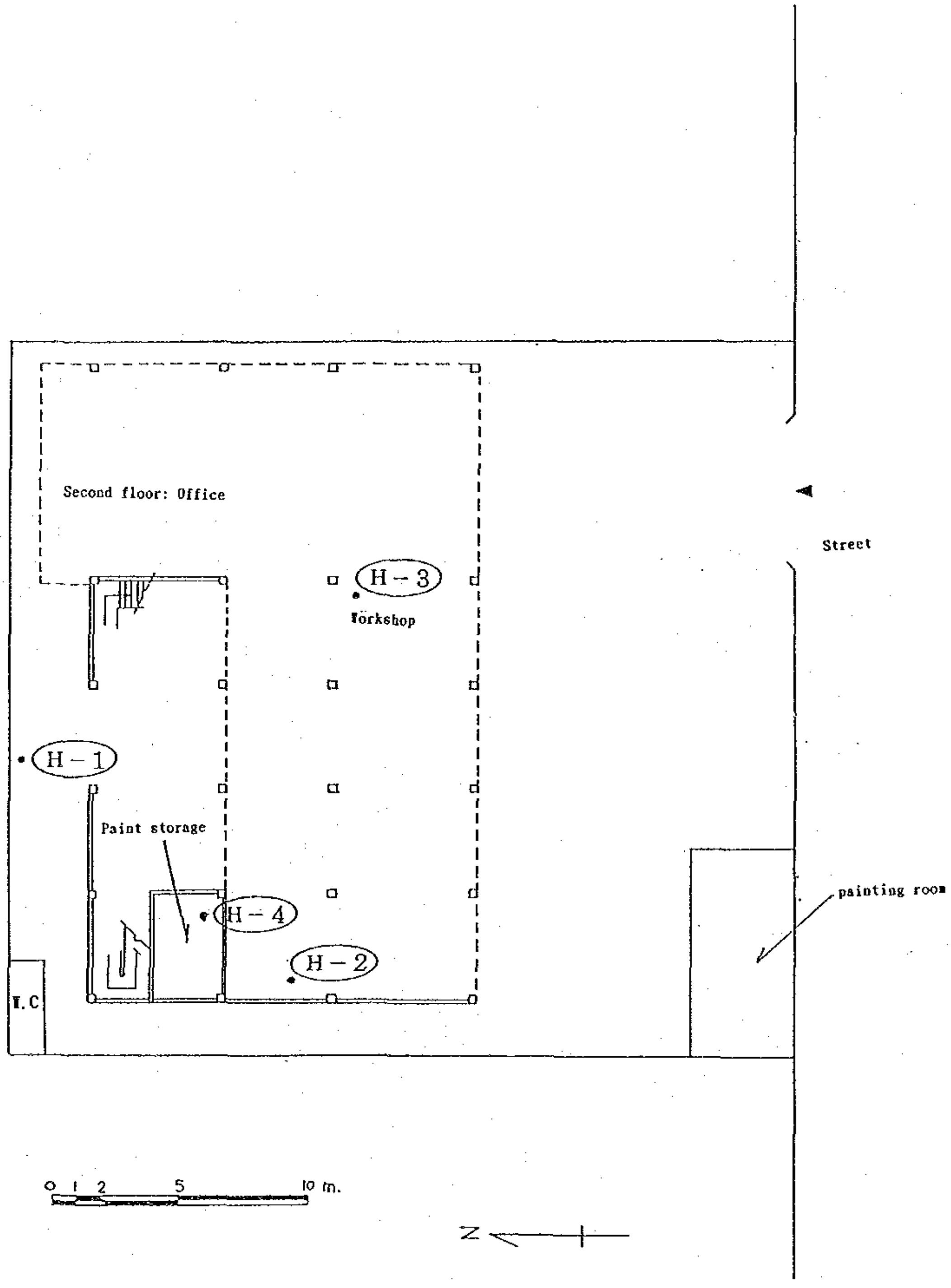


Figure 4-40 Odor Sampling Points
(Automobile Painting Factory H)

(8) Problems

1) The present factory is a new factory which is only a little over a year old and with a well-furnished painting room. Although presently there are no problems because the number of vehicles handled are still low, since the factory area is small and there are no outer walls, it is important in terms of management that painting is always performed inside the painting room even in the future.

2) Although the ventilation facility of the painting room has an adequate capacity and the emissions are filtered, more advanced deodorization processes should be considered for the future when the number of residences in the surroundings may increase.

4.2.9 Central Tanning Wastewater Treatment Plant

(1) Outline of the plant

The industrial wastewater and the household wastewater within the tannery industrial estate are not treated by each factory individually but all flow together with rainwater through the open drains installed along the streets in all directions to the central wastewater treatment plant (constructed jointly by the tanneries) located in the southern part of the industrial estate to be treated all together.

Besides lime, chromium, acids and other chemical waste fluids discharged from the tanning process, this wastewater also contains large quantities of solid organic matter such as the hair, blood, grease, meat pieces and mud attached to raw hide as well as hide scraps produced in the processing. Because of this, the wastewater is characterized by settling and decomposing readily and having a green, chromic color.

The present wastewater treatment plant is a treatment plant for the wastewater discharged from the tanneries within the industrial estate and was constructed between 1979 and 1982. An outline of the treatment plant according to material from the Ministry of Industry is as shown below and the treatment flow is shown in Figure 4-41.

1) 30 km district

Treatment capacity	4,500 m^3/day
Treatment method	Activated Sludge Method
Discharge rate	2,000 ~ 4,000 m^3/day
Area of plant	13 rai
Construction costs	10 million Bahts
Operation costs	200,000 Bahts/day

Number of factories

Current accomodated 77

Requesting approval 6

Requesting expansion 5

2) <u>34 km district</u>

Treatment capacity	4,500 m^3/day
Treatment method	Activated Sludge Method
Discharge rate	2,000 ~ 3,000 m^3/day
Area of the plant	12 rai
Construction costs	10 million Bahts
Operation costs	200,000 Bahts/day
Number of factories	
Current accomodated	52
Requesting approval	5
Requesting expansion	3

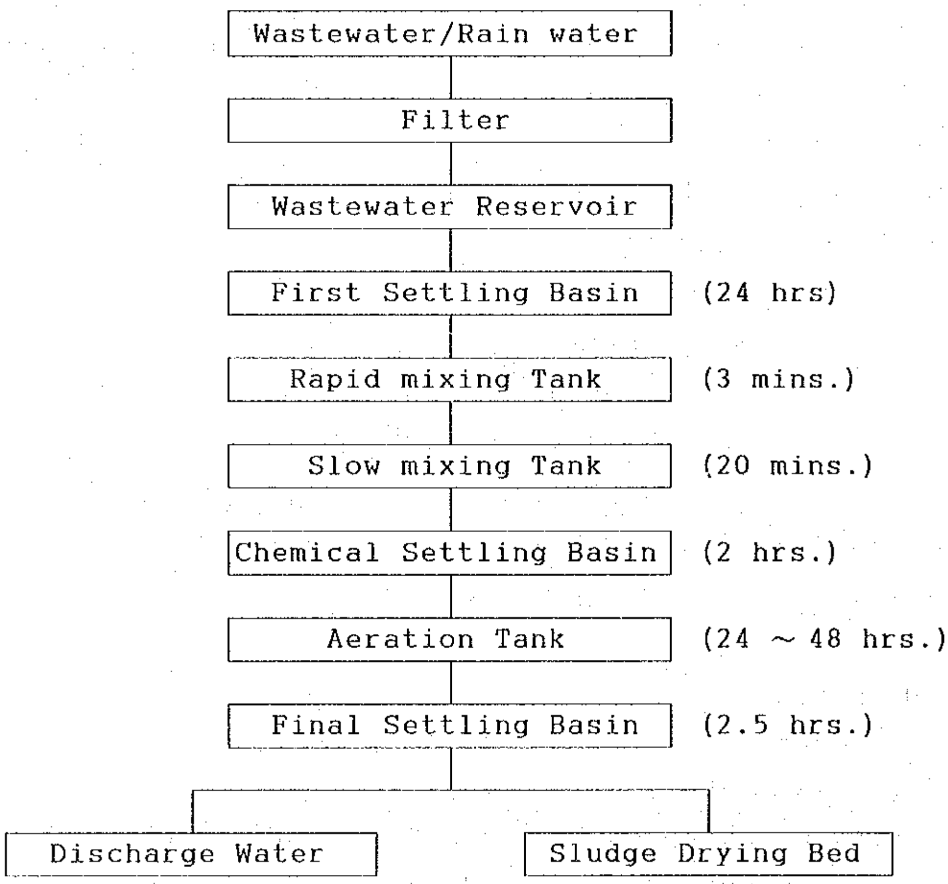


Figure 4-41 Treatment Process of Central Tanning Wastewater Treatment plant

(2) Conditions of the operation and management

1) Due to the heavy rain in the morning on the day of the investigation, water accumulated in the streets within the industrial estate. The said wastewater treatment plant was not capable of handling the amount and part of the water was directly discharged. But because the capacity of the raising pump was insufficient, the water that had overflown into the industrial estate did not seem to decrease.

2) The aeration tank is divided into three tanks and surface aeration is performed at each tank. 8 ~ 12 aerators are installed on each tank. Although the final settling pond also has three tanks, flock was flowing out and it is surmised that the extraction balance of the slurry had been lost.

3) The treatment rate (inflow rate) of the wastewater treatment plant was approximately 1,400 m^3/Hr (measured value of flow rate at the drain).

4) Within the treatment plant, relatively strong odors were detected at the inflow conduits and drain conduits, the initial settling pond and at the sludge drying bed. The aeration tank and settling ponds are also sources of offensive odors. The tanks are of an open structure and covering lids are not provided.

5) Although there is a control building at the center of the wastewater treatment plant, there did not seem to be any operators who were stationed there full-time. Also, although pumps were being repaired, no information was available concerning equipment inspection, cycle, etc.

(3) Conditions of the surroundings

1) The treatment plant is located in the south of the tannery industrial estate and is surrounded on all sides except for the south side by factories. Offensive odors drift throughout the entire industrial estate and, in particular, hydrogen sulfide concentrations were extremely high above the drains. It seemed that offensive odors were stronger outside on the roads than inside the factories.

2) Although the drains are dug along the sides of the streets within the industrial estate, the flow of water is not good because of the shallow incline.
Also, since most of the drains are open and factory wastewater and rain water are not differentiated, roads within the estate become flooded and the operations of factories become impaired during the heavy rains of the rainy season.

3) Presently, construction is being performed to enclose the drains and raise the level of the streets. The construction is being performed successively, starting from the treatment plant area and is partly near completion. On comparing closed and open parts of the drains, the odor is clearly reduced by the enclosure and it is thought that an effect has been achieved in terms of countermeasures for odors.
However, if the properties of the wastewater (low pH, generation of H_2S) are considered, there are many points that need to be attended to such as the degradation of concrete and precautions for inspecting and cleaning the inside of the drains.

4) Damaged sections in the drain walls and concrete walls ,

caused by land subsidence due to excessive drawing up of ground water and degradation of concrete degradation by the wastewater, were noted at several places along the drains.

(4) Results of odor measurement

The odor measurement and analysis results for the interior and exterior of the treatment plant are shown in Tables 4-31. A hydrogen sulfide concentration of 110 ppm was detected within the closed sections of the drains while above the drains the concentration reaches 20 to 40 ppm. A considerably high odor concentration between 170 to 550 was detected within the treatment plant.

Table 4-31 Results of Odor Measurement by Sensory Test and Detection Tube

(Central tanning wastewater treatment plant)

No.	Odor Concentration	Detection tube		Sampling Point
		NH_3	H_2S	
<First Field Study> (November 16, 1992)				
I-10	170	1.5	N D	Beside control cabin
I-11	550	5	3	Over sludge drying bed
<Second Field Study> (November 16, 1992)				
I- 1		2	2	Pump station at entrance
I- 2		1	0.3	Over canal on the north
I- 3		0.5	N D	Beside aeration tank
I- 4		3	22	Pump station back of tannery
I- 5		6	3	Inside canal
I- 6		N D	N D	On the road of tanning complex
I- 7		10	110	Inside canal
I- 8		5	40	Over canal
I- 9		N D	0.5	On the road in fron of tannery

(5) Problems

The problems of the wastewater treatment plant at present can be summarized as follows:

1) Eleven years have passed since the plant was constructed and many of its facilities are outdated and worn out.

2) Since the plant is a confluent facility for both wastewater and rain water, wastewaters are discharged without treatment for the removal rainwater during heavy rains in the rainy season.

3) Although the total daily treatment capacity is 9,000m^3, this includes the rain water. It is therefore becoming impossible to accomodate for increases in the wastewater quantity due to increases in the number of tanneries.

4) Although the activated sludge method is used mainly and the coagulation settling method is used supplementarily, because the facility is of a confluent type, the wastewater treatment efficiency is poor and operation costs are high.

5) The number of operation/maintenance personnel is few and there is lack of water quality management facilities such as pH meters, etc. Water quality checks are not being performed regularly.

6) No odor prevention/deodorization measures are being implemented at the treatment plant. In particular, the sludge is being treated by sun-drying and due to poor management, it is unsanitary and is a source of offensive odors. Wastes are also thrown into the sludge.

The following problems can also be pointed out with regards to pollution such as wastewater and offensive odors of the tanning industrial complex as a whole.

1) Individual wastewater treatment facilities are not installed within each tannery and monitoring system is not established for wastewaters from each tannery.

2) Because tanning industrial complex is located in flat lowland area, wastewaters in the drains are stagnant. Also, since most tanneries discharge their wastewater without treatment, offensive odors is generated in the progress of sedimentation of suspended matter and decomposition of organic matter within the wastewater.

3) Since drainage of both wastewater and rainwater are being performed in a confluent manner, the drains often spill over during rains.

4) Tanneries use large amounts of water. But since much of the water for industrial use is underground water that is pumped up, there is danger of land subsidence.

4.3 Measurements and Analyses of Offensive Odors

4.3.1 Outline of Odor Measurement Survey

In the periods of First, Second and Third Field Study, odor measurement surveys were carried out in eight selected factories and central tanning wastewater treatment plant of Samut Prakan.

Three methods were employed for odor measurement; sensory test (triangle odor bag method), detection tube method and instrumental analysis method.

The equipment and devices for odor measurement and analysis was prepared and dispatched by JICA. The devices for sensory test and detection tube was sent before the First Field Study and the equipment and devices for instrumental analysis before the Second Field Study, which were installed and used in the Bang Yie Kang office of the Department of Industrial Works, MOI.

The date of odor gas sampling at each factory is shown in Table 4-32 and the number of samples is shown in Table 4-33.

Table 4-32 Date of Sampling Survey of Offensive Odors

Name of Factories	First Field Study	Second Field Study	Third Field Study
Fish meal			
A.Niwat Fish Meal	Nov. 4, 1992	Mar.15, 1993	——
B.Samutprakan Fish Meal	Nov.16, 1992	Mar.22, 1993	——
Bone meal			
C.Sungserm Bone Meal	Nov. 4, 1992	Mar. 8, 1993	
D.Thai Bones Industry	Nov.11, 1992	Mar.11, 1993	Sept. 6, 1993
Tannery			
E.Lotus Leather and Trading	*Nov. 9, 1992*	*Mar.10, 1993*	*Sept.13, 1993*
F.Q.C.Tannery	Nov. 9, 1992	Mar.17, 1993	Sept.20, 1993
I.Central Wastewater Plant	Nov. 9, 1992	——	——
Automobile Painting			
G.Narong Rungrueng	Nov.11, 1992	Mar.11, 1993	Sept.15, 1993
H.Tavon Garage	Nov.16, 1992	Mar.16, 1993	——

Table 4-33 Number of Sampling for Measurement and Analysis of Offensive Odors

	First		Second			Third			Tatal		
	S/T	D/T	S/T	D/T	G/C	S/T	D/T	G/C	S/T	D/T	G/C
Fish meal Plant											
A	5	7	8	13	4	—	—	—	13	20	4
B	5	6	8	14	4	—	—	—	13	20	4
Bone meal Plant											
C	6	10	8	7	3	—	—	—	14	17	3
D	9	11	—	22	—	8	23	3	17	56	3
Tannery											
E	5	9	—	13	—	7	13	3	12	35	3
F	5	7	—	9	—	7	8	2	12	24	2
Automobile Painting Factory											
G	3	4	—	—	2	2	2	—	5	6	2
H	2	2	3	—	3	—	—	—	5	2	3
Central Tanning Wastewater Plant											
I	2	2	—	—	—	—	—	—	2	2	—
Total	42	58	27	78	16	24	46	8	93	182	24

Notes : S/T Sensory Test
D/T Detection Tube Method
G/C Instrumental Analysis Method

4.3.2 Methodology of Odor Measurement

Odor measurement survey was performed according to the following official methods of measuring offensive odors in Japan.

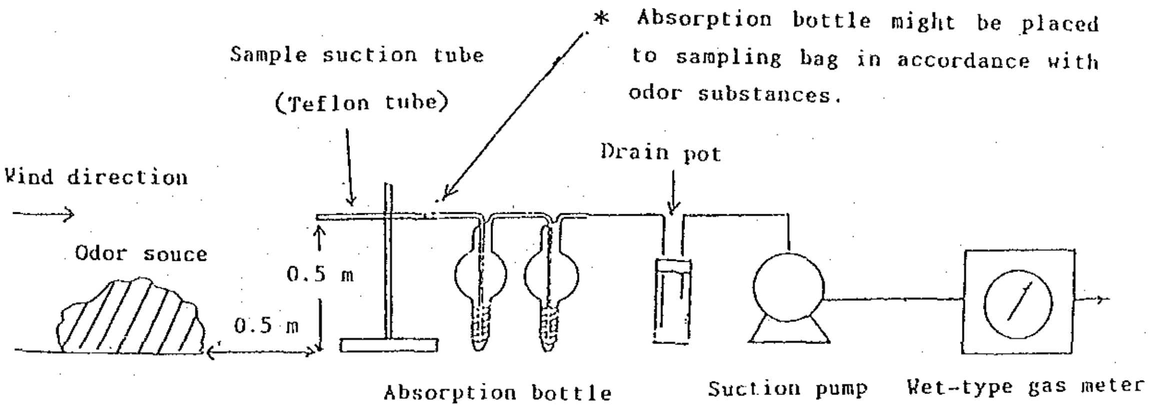
a. Sensory test :
   Triangle odor bag method prepared by the Association of Study and Research on Odor Control
b. Detection tube method :
   Manual of facile methods of measuring offensive odor substances (1990) prepared by the Environment Agency in Japan
c. Instrumental analysis method :
   Notification No.47 (1989) of the Environment Agency, method of measuring offensive odor substances

JICA Study Team prepared the English manual of each methods of odor measurement and submitted to Thai side and carried out the survey according to these manuals.

After starting the Study, the Environment Agency of Japan has notified the "method of odor test using olfactory sense" on December 1992, which contents are almost the same as the methods of sensory test prepared by the Association of Study and Research on Odor Control. With the supplement *of designation of offensive odor substances from 12 to 22*, the Environmental Agency had notified the revision of the official methods of measuring offensive odor substances in September 1993, which shall be effective from April 1994. The revision includes the reform of gas sampling procedures and the alternation of analysis method for trimetylamine. However, they are not so big change in the procedures and methods employed in the Study.

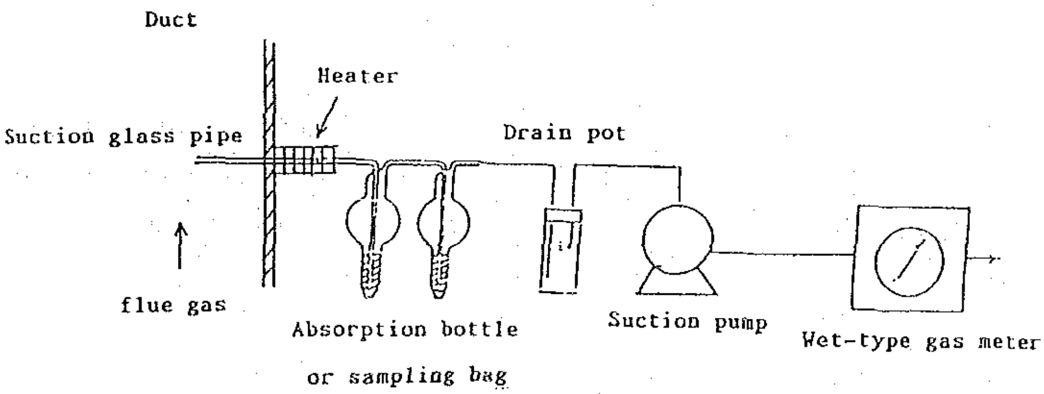
(1) Preparation of odor gas sampling in the field

1) Gas sampling of odor sources on the ground



In case of gas sampling of odor source which was heaped up on the ground level, a sample suction tube was fixed on a holding stand leeward at a height and a distance of 0.5 m, and the sample gas was sucked through absorption bottle.

2) Gas sampling at the flue, stack and duct

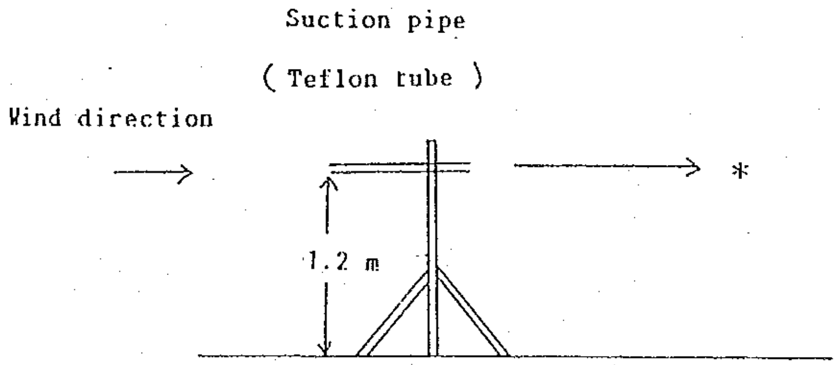


In case of gas sampling in a flue, suction flow rate was also measured by means of a pito-meter, together with measurements of pressure, temperature and water content.

Specific density of flow gas, however, was calculated as air density because of lack of CO_2/O_2 analyzers. Water content also has been expressed in the calculated value, provided temperature in the flue was low and water was thought oversaturated.

After the suction pipe had been fixed with a silicone-rubber plug in the center of the flue at the measuring position, sample gas was sucked, confirming the operation of warming and heating to avoid coagulation of water content.

3) Sampling on the boundary line



* The gas suction parts are the same as those described above in (1).

For gas sampling on the boundary line, a suction pipe was set at a height of about 1.5 m from the ground level using a tripod to suck gas at the constant flow rate for five minutes.

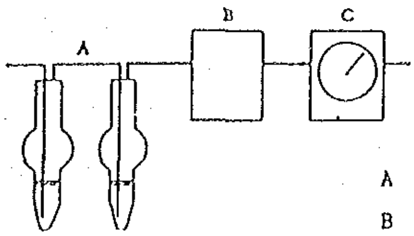
(2) Procedures of odor gas sampling and the apparatus

1) Ammonia (NH_3)

Absorbing solution : 0.5 % boric acid

Sucked air : 50 ℓ at the flow rate of 10 ℓ/min.

Gas sampling apparatus



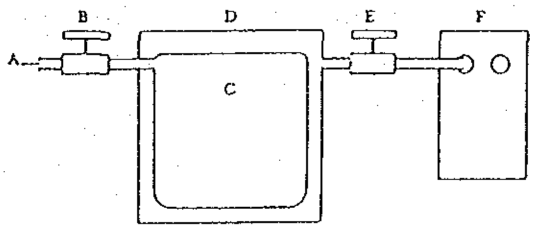
A : Absorption bottle
B : Suction pump
C : Gas meter

2) <u>Methyl mercaptan (MM), hydrogen sulfide (H_2S), dimethyl sulfide (DMS) and dimethyl disulfide (DMDS)</u>

The calibration gas was prepared for each of substances according to the prescriptions.

Each sample gas was taken by running the suction pump and then depressing the suction case to let the sample gas pass into the sampling bag made of vinyl-polyfluoride and having an internal volume of about 5 ℓ.

Gas sampling apparatus



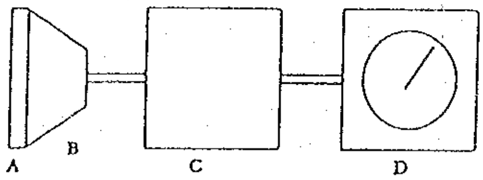
A: Sampling tube
B: Fluorine plastic cock
C: Sampling bag
D: Suction case
E: Suction cock
F: Suction pump

3) <u>Trimethylamine (TA, on the boundary line)</u>

Sampling filter : silica filer paper dripped with sulfuric acid after being baked in an electric oven.

Sucked air : 50 ℓ at the flow rate of 10 ℓ/min.

Gas sampling apparatus



A: Sampling filter paper B: Holder
C: Suction pump D: Gas meter

4) Trimethylamine at the flue

Absorbing solution : 0.1 N sulfuric acid (H_2SO_4)

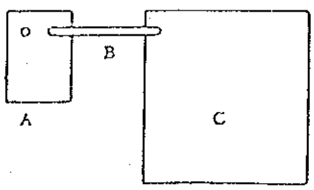
Sucked air : 50 ℓ at the flow rate of 10 ℓ/min.
Gas sampling apparatus was the same as that for ammonia sampling.

5) Acetaldehyde (AA)

Sample gas was sucked at the flow rate of 10 ℓ/min. into a sampling bag, made of vinyl polyfluoride film and having the inner volume of about 50 ℓ.

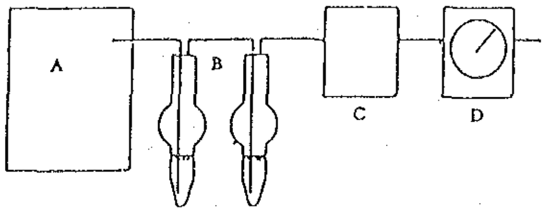
Then, the sample gas was extracted into the absorbing solution of 2,4-dinitrophenylhydrazine by sucking at the rate of 1 ℓ/min.

Gas sampling container



A: Suction pump
B: Fluorite plastic pipe
C: Sampling bag

Extraction apparatus of sample gas in solution

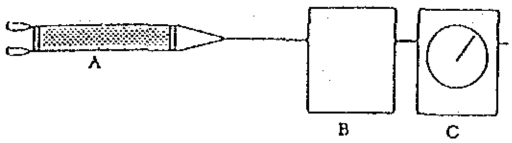


A: Sampling bag containing gas B: Absorption bag
C: Suction pump D: Gas meter

6) Styrene

The sample gas was taken, by sucking 1 ℓ of air at the flow rate of 200 mℓ/min. into the gas sampling tube made of borosilicate glass and filled with the polymer beads.

Gas sampling apparatus



A: Gas sampling tube B: Suction pump
C: Gas meter

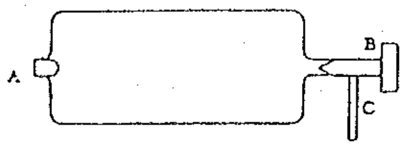
7) Propionic acid (PA), Normalbutyric acid (n-BA), Normalvaleric acid (n-VA) and Iso-valeric acid (i-VA)

Each gas sample was taken, by sucking 30 ℓ of air at the flow rate of 5 ℓ/min., into the gas sampling tube.
The apparatus for gas sampling was similar to that for styrene sampling.

8) Organic solvents; Acetone, Toluene, Ethylbebzene, Xylene

The sample gas was taken into the sampling container made of grass and having 1 ℓ of the inner volume, which had been preliminarily evacuated sufficiently with a vacuum pump.

Gas sampling apparatus



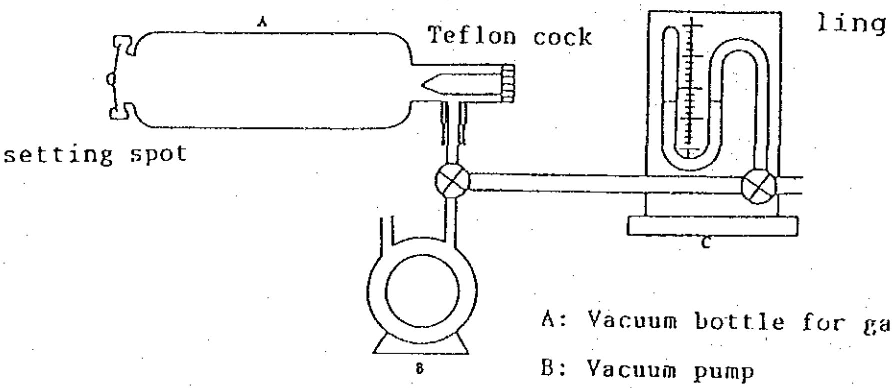
A: Silicore rubber plug
B: Fluorine plastic valve
C: Silicone rubber tube

(3) Procedures of sensory test

1) Sampling on boundary line :

The sample gas was taken by opening the valve of the gas sampling container, which had been previously evacuated below 10 mmHg with a vacuum pump. The inner volume of the container was 10 ℓ, and the sampling was carried out at the very moment when odor seemed to be at the strongest level.

Gas sampling apparatus



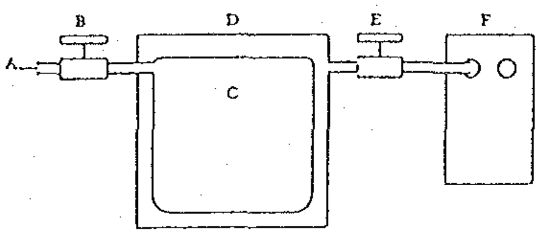
A: Vacuum bottle for gas sampling
B: Vacuum pump
C: Vacuum gauge
D: Three-way cock

2) Sampling at odor sources :

10 ℓ of the sample gas were collected into the sampling

bag placed inside the suction case which had been depressed sufficiently with a suction pump.

Gas sampling apparatus



A: Sampling tube
B: Fluorine plastic cock
C: Sampling bag
D: Suction case
E: Suction cock
F: Suction pump

3) Panel Test

Panel test was carried out by members of JICA Study Team and two operators of Thai side as well as 9 ~ 11 panelists on the day after of sampling. Specific points of the test are as follows.

a. For execution of the test, at least four operators was required; chief operator engaged in data management and works to inject sample odors to odor bags, one operator in charge of work to inject odor free air to odor bags, one operator in charge of collection of panel sheets and finished odor bags, and one or two operators in charge of treatment and arrangement of odor bags.

b. Two team of Panelists, six members for one team, was to engage in the test, one team for one sample. Even when members was not sufficient, the members had changed as frequently as possible to take a rest by turn.

c. The panel test had taken around six or nine hours from 9 am to 3 or 6 pm for eight sample with two team of Panelists.

(4) Measurement of gas flow rate

The Second Field Study had included the odor measurement of flue gas.

In case of flue gas sampling at smoke stack or in the duct, gas flow rate was also measured as well as gas pressure, temperature and velocity. Specific matters in the survey are as follows.

1) Specific density of flue gas has been calculated as air, which consists of N_2 (79.4%), O_2 (20.6%) and CO_2 (0.0%), because of lack of Co_2/O_2 analyzer.
2) When the temperature was observed so low to be saturated, water content has been expressed in a calculated value.
3) When the sampling hole was too small to use pito tube for determination of flue gas flow rate, only static pressure and temperature had been measured.
4) Section area of the flue had been measured to calculate the flow rate.

(5) Instrumental analysis of odor substances

To determine the concentration of odor substances in five factories, instrumental analysis was carried out, using gas chromatograph and spectrophotometer.

Number of analysis items is 12; ammonia (NH_3), methyl mercaptan (MM), hydrogen sulfide (H_2S), methyl sulfide (DMS), methyl disulfide (DMDS), trimetylamine (TM), acetaldehyde (AA), styrene, propionic acid (PA), normal butyric acid (n-BA), normal valeric acid (n-VA) and isovaleric acid (i-VA) except for the automobile painting factories in which was analyzed for four items; acetone, toluene, ethylbenzene, and xylene. Table 4-34 shows the actual condition of instrumental analysis.

The outlines of method for analyzing offensive odor substances are summarized in Table 4-35 .

Table 4-34(1) Methods for Measuring Offensive Odors Substances

Odor Substances	Method for measurement and analysis
Ammonia	(Site border concentration measurement) Catch ammonia by passing a lot of air through a parchment paper filter, and determine the ammonia amount by absorption spectrometry (pyridine-pyrazolone method). (Outlet port concentration) Japanese Industrial Standards (JIS) K 0099.
Methyl mercaptan Hydrogen sulfide Metyl sulfide	(Site border concentration measurement) Catch these offensive odor substances by passing sample air of about one (1) liter sucked into a vacuum bottle through a U-figured tube chilled with liquid oxygen, and separate and determine the amount of these substances by gas chromatography. (Outlet port concentration) Catch these substances by passing sample air of about one (1) liter sucked into a bottle depressured by 1/10 through a U-figured tube chilled with liquid oxygen, and separate and determine the amount of these substances by gas chromatography.
Trimethylamine	(Site border concentration measurement) Catch trimethylamine as salt by passing a lot of air through a parchment paper filter, decompose the salt with strong alkali so as to produce trimethylamine, and pass it through a U-figured tube chilled with liquid oxygen, and separate and determine its amount with the gas chromatograph provided with a flame ionization detector. (Outlet port concentration) Catch the substance by passing sample air of about one(1) liter sucked into a bottle depressured by 1/10 through a U-figured tube chilled with liquid oxygen, and separate and determine its amount by gas chromatography.

Table 4-34(2) Methods for Measuring Offensive Odors Substances

Odor Substances	Method for measurement and analysis
Acetaldehyde	Catch acetaldehyde-2,4-dinitrophenylhydrazone by passing gas taken in the sampling bag through phosphoric acid solution of 2,4-dinitophenylhydrazine. Extract acetaldehyde from the caught compound with carbon tet, and separate and determine its amount by introducing the solution into the gas chromatograph provided with a flame ionization detector.
Styrene	Catch styrene as thickened by passing gas taken in the sample gas container (a vacuum bottle) through a sample thickening tube chilled with liquid oxygen. By heating the thickening tube, introduce styrene directly into the gas chromatograph with a flame ionization detector and determine its amount. (Other method) Catch styrene as thickened by passing sample gas through a catching tube filled with porous polymer beads at the room temperature. By heating the catching tube, introduce styrene directly into the gas chromatograph with a flame ionization detector and determine its amount.
Methyl disulfide	Catch dimethyl disulfide as thickened by passing gas taken in the sample gas container (a vacuum bottle) through a sample thickening tube chilled with liquid oxygen. By heating the thickening tube, introduce styrene directly into the gas chromatograph with a flame ionization detector and determine its amount.
Normalbutyric acid Isovaleric acid Normalvaleric acid Propionic acid	Catch lower fatty acids in the air into the sample catching tube filled with glass beads covered with strontium hydroxide at the room temperature. By injecting formic acid into the catching tube and heating it, introduce the lower fatty acids directly into the gas chromatograph with a flame ionization detector and determine their amount.

Table 4-34(3) Methods for Measuring Offensive Odors Substances

Odor Substances	Method for measurement and analysis
Toluene Xylene Acetic ether Metyl isobutyl ketone Isobutyl alcohol	Catch these components as thickened in the sample thickening tube by passing gas taken in the sample bag through it. By heating the tube, introduce these components directly into the gas chromatograph with a flame ionization detector and determine their amount. (Other method, except for isobutanol) Catch these components as thickened by passing gas taken in the sample bag through the catching tube filled with porous polymer beads. By heating the tube, introduce these components directly into the gas chromatograph with a flame ionization detector and determine their amount. (Note) If these components have high concentration, their amount can be determined by introducing sample gas directly into the gas chromatograph with a flame ionization.
Propionic aldehyde Normalbutylaldehyde Isobutylaldehyde Isovaleraldehyde	Catch these components as thickened by passing gas taken in the sample bag through the sample catching tube filled with silica gel covered with DNPH (2,4-dinitrophenylhydrazine). Elute these components from the tube with acetnitrile, evaporate the acetnitrile, dissolve the residue into acetic ether and introduce a part of the solution into the gas chromatograph with a flame ionization detector to determine the amount. (Other method) Catch these components as thickened by passing gas taken in the sample bag through the sample catching tube filled with TENAX-GC or the like. Then, rethicken these components in the sample thickening tube chilled with liquid oxygen. By heating the thickening tube, introduce these components directly into the gas chromatograph mass analyzer and determine their amount.

Table 4-35 Conditions of Instrumental Analysis

1. Gas chromatograph

Items		Objective Substances: Sulfide compound	Trimethylamine	Acetaldehyde	Styrene	Fatty acids
Type of detector		FPD	FID	FID	FID	FID
Column	Length x Inner diameter	1.6m x 3mm	4.1m x 3mm	1.6m x 3mm	1.6m x 3mm	1.6m x 3mm
	Material	Grass	Grass	Grass	Grass	Grass
	Carrier	Uniport HP (60/80)	chromosorb W AW DMCS (80/100)	Uniport HPS (80/100)	Uniport HPS (80/100)	Carbopack B (60/80)
	Liquid phase	25% β,β'-ODPN	Diglycerol+TEP +KOH (15+15+2)	2% Silicone OV-17	SP-1200+Benton34 (5+1.75)	FFAP 0.3% + H_3PO_4 0.3%
Temperature of column oven		70°C	70°C	220°C	80°C	80 → 220°C
Temperature of vaporizing room		130°C	130°C	240°C	180°C	230°C
Carrier gas and its flow rate		N_2, 20mℓ/min	N_2, 100mℓ/min	N_2, 100mℓ/min	N_2, 80mℓ/min	N_2 (110kPa)
Pressure of hydrogen gas		70 kPa/cm²	70 kPa/cm²	70 kPa/cm²	70 kPa/cm²	70 kPa/cm²
Pressure of air		70 kPa/cm²	70 kPa/cm²	70 kPa/cm²	70 kPa/cm²	70 kPa/cm²
Chart speed		5 mm/min	5 mm/min	5 mm/min	5 mm/min	5 mm/min
Apparatus for analysis		Shimadzu GC-14B	Shimadzu GC-14B	Shimadzu GC-14B	Shimadzu GC-14B	Shimadzu GC-14B

Note : FPD refers a Flame Photometric Detector. FID refers a Flame Ionization Detector.

2. Spectrophotometer Objective substance: Ammonia

Wavelength of determination	Clearance of slit	Shape, material & length of cell	Solvent	Apparatus for analysis
640 nm	1 nm	Square, Grass, 10mm	Water	Shimadzu UV-1201

4.4 Conclusion of the Survey

4.4.1 Factory Investigation

The field survey on selected eight factories had been carried out in the First Field Study on October and November 1992, the Second Field Study on February and March 1993 and Third Field Study on August and September 1993. The general data such as scale, layout, production process, and others were checked in the First Field Study period, whereas the list of facilities was made and hearing survey was executed with regard to production process and production management of each factories in the Second and Third Field Study period.

Both of the fish meal plants dischrge considerable amount of offensive odors because both factories have become too old as a whole, including production facilities and buildings. As the preventive measures for offensive odors, a deodorizer is equipped in the main process line in both factories. The measures, however, is not sufficient to interrupt the offensive odors to the surroundings. The facilities in the factories work so intermittently because of the lack of raw materials, mainly fishes and shrimps, that the management is forced to be unstable.

Both of the bone meal plants also have very old building structure and production facilities and they have many troubles in terms of operation and management. The quality of odors is the most disgusting among four industries as a result of the characteristics of raw materials or animal bones, and the offensive odors are generated in most process of the factories. Compared with two factories, Bone Meal Plant C is the comparatively small like typical bone meal factory, whereas Bone Meal Plant D is larger than it and has complex processes including refining process of calcium phosphate and ossein in addition to the production process of bone meal and bone oil.

Most of tanneries are located in the tanning industrial complex in Samut Prakan. Major sources of offensive odors are preparation process before tanning, drying process after tanning, painting process, and wastewater from the factories. From the point of prevention of offensive odors, it is important to treat the residues of treated fur and the wastewater from the raw fur washing, liming, and fur dregs shaving process. Actually the wastewater is not treated in each factories but transferred to the central wastewater treatment facility in the tanning complex. The tanning industry of Thailand has been developed rapidly until now, however the recent performance of business shows the signs of depression due to the pursuit of other developing countries such as China and Vietnam.

Both of the automobile painting factories are small auto repair shops where the source of the offensive odors is organic solvents for the most part. The environmental impact, however, is comparatively small because the factories are small. Automobile Painting Factory G has old and messy workshop and the painting room is too small to be used for painting, whereas Automobile Painting Factory H is a new factory where the modern painting room is installed.

The JICA Study Team had checked the influence sphere of offensive odors from each factories by field reconnaissance around the factories. Based on the survey, Fish Meal Plants A and B and Bone Meal Plant C extend the influence of offensive odors as far as about 100-200 meters leeward. Bone Meal Plant D influences wider areas, about 500-1,000 meters far from the factory. Tanning industrial complex, in where selected factories are located with other dozens of tanneries, is full of offensive odors inside and outside the factories without regard to the intensity from each factories. Automobile painting factories have smaller influence in offensive odors as far as dozens of meters.

4.4.2 Measurement and Analysis of Offensive Odors

Offensive odors had been measured and analyzed in eight factories and the central tanning wastewater treatment plant.

According to the results, the odor sensory test is defined the best method being effective for the formulation of preventive measures against offensive odors in the factories as the odor concentration determined by sensory teat is roughly corresponding with human olfactory sense. On the contrary, most of the results of ammonia and hydrogen sulfide measured by detection tube are under detection limit value except the points at where the level of smell is considerably high, and the concentrations of odor substances determined by instrumental analysis are also shown as below the quantitative limit except for ammonia and a few items even at the points such as the flue where the concentration must be high.

On boundary line, odor concentration determined by sensory test is desirable to be below the value of 10 and needs to be below 60 even in the industrial district, whereas actual results of measurement indicates beyond 10 at most points and still beyond 60 in some factories. Odor concentration of smoke stack should under 300, and needs to be below 1,000 or 3,000 at the worst. However, the results at most points of odor sources are beyond 300; for example, odor concentration of flue gas is 170,000 at inlet of deodorizer and 23,000 or 98,000 even at outlet of deodorizer in fish meal factories.

At any rate, the results of sensory test has indicated the intensity of offensive odors quantitatively in each points and reflected the value of olfactory sensation.

The concentration of ammonia by instrumental analysis are about 0.2-0.7 ppm on boundary line and 40-362 ppm at outlet of deodorizer. However, most results of analysis for other substances by gas chromatograph are divided in value, and shows the value of below detectable limits even at the point where the concentration is supposed to be high.

Table 4-36 shows the performance of failures to meet the Japanese regulation standards of offensive odors to evaluate the results bacause the standards are not established in Thailand. Japanese standards are adapted for only on boudary line and at smoke stack but here includes the comparison in other places.

The results of odor measurement in Fish Meal Plant A and Automobile Painting Factory G are in compliance with the standards on the boundary lines. However, this is simply bacause the sampling points are far from the odor sources. In other points any items failed the standards.

Table 4-36(1) Achievement and Failure to Meet Japanese Emission Standards of Offensive Odors

Sampling Points	Odor Concentration		Concentration of Odor Substances													
			NH3	MM	H2S	DMS	DMDS	TA	AA	Styrene	PA	n-BA	n-VA	i-VA	Toluene	Xylene
Niwat Fish Meal																
A-1 Boudary line	▲	18	○	○	○	○	○	○	○	○	○	○	○	○		
A-2 Inside workshop	●	7,300	▲	○	●	○	○	▲	▲	○	○	○	○	○		
A-7 Inlet of deodorizer	●	170,000	●	○	●	○	○									
A-3 Outlet of deodorizer	●	23,000	●	○	○	○	○	●	▲	○	○	○	○	○		
Samutprakan Fish Meal																
B-1 Boundary line	●	390	○	○	○	○	○	▲	○	○	○	○	○	○		
B-4 Inside workshop	●	2,300	▲	○	○	○	○	●	○	○	○	●	○	▲		
B-6 Inlet of deodorizer	●	17,000	●	●	●	●	○									
B-7 Outlet of deodorizer	●	9,800	●	●	●	●	○	●	●	○	○	○	○	○		
Sungserm Bone Meal																
C-2 Boundary line	○	< 10	○	○	○	○	○	○	▲	○	○	○	○	○		
C-4 Flue from autoclave	●	9,800	●	○	○	○	○	●	●	○	○	○	▲	○		
C-3 On courtyard	●	130	▲	○	○	○	○	▲	▲	○	○	○	○	○		
Thai Bones Industry																
D-1 Boundary line	▲	44	○	○	○	○	○	○	○	○	○	▲	▲	○		
D-3 Beside crusher	●	73,000	●	●	●	●	▲	●	●	○	○	●	▲	▲		
D-5 Inside drying room	●	9,800	●	○	○	○	○	●	●	○	▲	●	●	●		

Note : ○ In compliance with the standards ▲ Within the range of the standards ● Failure to the standards

Here the standards indicate the concentrations corresponding to 2.5 or 3.5 of odor intensity. (Refer to Table 6-4)

Table 4-36(2) Achievement and Failure to Meet Japanese Emission Standards of Offensive Odors

	Odor Concentration		Concentration of Odor Substances													
			NH3	MM	H2S	DMS	DMDS	TA	AA	Styrene	PA	n-BA	n-VA	i-VA	Toluene	Xylene
Lotus Leather and Trading																
E-1 Boundary line	●	690	○	○	●	○	○	○	○	○	○	○	○	○		
E-4 Inside workshop	●	1,700	▲	○	○	○	○	○	○	○	○	○	○	○		
E-11 Over canal	●	3,100	▲	●	●	○	○	○	○	○	○	○	○	○		
Q.C. Tannery																
F-1 Boundary line	▲	55	○	○	▲	○	○	○	○	○	○	○	○	○		
F-2 Inside workshop	●	980	▲	○	○	○	○	▲	○	○	▲	○	○	○		
Narong Rungrueng																
G-2 Boundary line															○	○
G-4 Inside workshop															▲	▲
Tavon Garage																
H-1 Boundary line	●	75													○	○
H-3 Inside workshop	●	73													○	○
H-4 Inside paint storage	○	17													○	○

Note : ○ In compliance with the standards ▲ Within the range of the standards ● Failure to the standards

Here the standards indicate the concentrations corresponding to 2.5 or 3.5 of odor intensity. (Refer to Table 6-4)

CHAPTER 5 PREVENTIVE MEASURES OF OFFENSIVE ODORS IN THE SELECTED FACTORIES

Chapter 5 PREVENTIVE MEASURES OF OFFENSIVE ODORS IN THE SELECTED FACTORIES

5.1 Approach to Preventive Measures of Offensive Odors

5.1.1 Fundamentals of Preventive Measures of Offensive Odors

Offensive odors occur as a mixture of trace amounts of various odor components. Offensive odors are thus difficult to remove once they are generated. Countermeasures against odor sources are therefore the most important aspect of offensive odor prevention measures. Production processes which minimalize the amount of odor generated must be adopted and suitable production management must be practiced. Also, in order to prevent leakage of odors outside the factory, efforts must be made to enclose the odor source and to implement effective and efficient deodorization measures.

Comprehensive measures. that are the most effective, lasting and efficient, should be implemented based on the odor prevention measures given below. Among these measures, odor prevention facilities consist of the odor collection → treatment → discharge steps. Odors of low concentration may be accomodated for at times simply by dilution ventilation and deodorization may not be necessary.

1) Improvements in the production processes (processing capacity, processing method, etc.).
2) Improvements in the way offensive odor sources are utilized (cleaning, inspections, repairs).
3) Optimization of operations management (reception of raw materials, storage methods).
4) Enclosing of offensive odor generating facilities

(equipment, buildings, etc.)

5) Installation or improvement of odor preventive facilities.

6) Provision of open areas for buffering purposes.

The following points should be considered upon taking measure for the prevention of offensive odors from factories:

1) Investigate and grasp the exact sources of offensive odors as well as the odor emission rate, the substances causing offensive odors and odor generation time.
2) Select production and processing processes that do not emit offensive odors easily or improve processes so that offensive odors are not easily emitted.
3) Improve methods of handling raw materials and wastes to reduce odor emission rates.
4) Reduce the number of odor sources. Also, prevent odors from being discharged in a concentrated manner.
5) Odor prevention measures should be implemented step-by-step, starting with sources with the greatest effects and highest odor emission rates (gas flow rate x concentration).
6) Enclose the odor sources to prevent the leakage and diffusion of offensive odors as small as possible. It is desirable to take multiple enclosing measures from equipment to rooms to the entire factory building. Suitable duct work that would keep the building interior under negaive pressure are also important.
7) At each odor source, odor collection and installation of deodorization apparatus should be performed separately for each type of odors with similar properties and/or concentrations. Discharge out of a chimney, without treatment, may be adequate at times for low concentration odors.

8) Collect odors efficiently by induction with an adequate flow of air. Excessive induction may have no effects at times.
9) Since the cost of odor preventive measures are not low, consider measures which are lasting and cost-effective.
10) Operate and maintain the deodorizing equipment adequately. Inspection of the effects for deodorizer is also important as well as the condition of installation such as capacity.
11) Endeavor to get rid of public complaints as well as to satisfy the legislative standards. Evaluate the effect of the measures based on human olfactory sensation, not on the removal rate of odor substances.
12) It is desirable to select factory locations far from urban areas and with few residences in the surroundings in order to avoid complaints priorly.
13) Provide enough extra space around the factory to provide odor buffering zones.

5.1.2 Procedures to Establish Preventive Measures of Offensive Odors

To establish the preventive measures of offensive odors, the most important is to grasp the actual state of offensive odors and to identify the cause of the impact. The investigator must identify the source of offensive odors and verify the quality, quantity, concentration and generation time of the odors.

The preventive measures of offensive odors from factories is orderly proceeded according to the following procedures.

1) Compile and analyze public complaints around the

factory.

2) Perform surveys of the awareness of neigboring residents towards pollution.
3) Perform an inspection of the odor sources to determine the degree of the problem in the factory, including odor measurement by sensory test and instrument analysis.
4) Perform a field survey of the environmental state around the factory.
5) Plan the preventive measures of offensive odors (set objectives, set prospective values of treated air flow/concentration, select treatment methods, etc.)
6) Estimate and asses the odor removal rate and the concentration at the boundary line.
7) Install deodorizing equipment.
8) Check the effects of measures (influences at landing points and boundaries).

Upon planning odor preventive measures, set how much odor (concentration) will be treated, to what level the odors will be treated to and what kind of emission rates will be used in treating the odors. Upon performing the survey of odor sources, it is desirable to find out the Total OER (TOER) as shown in Figure 5-1 so that measures can be implemented starting from the source of the greatest effect.

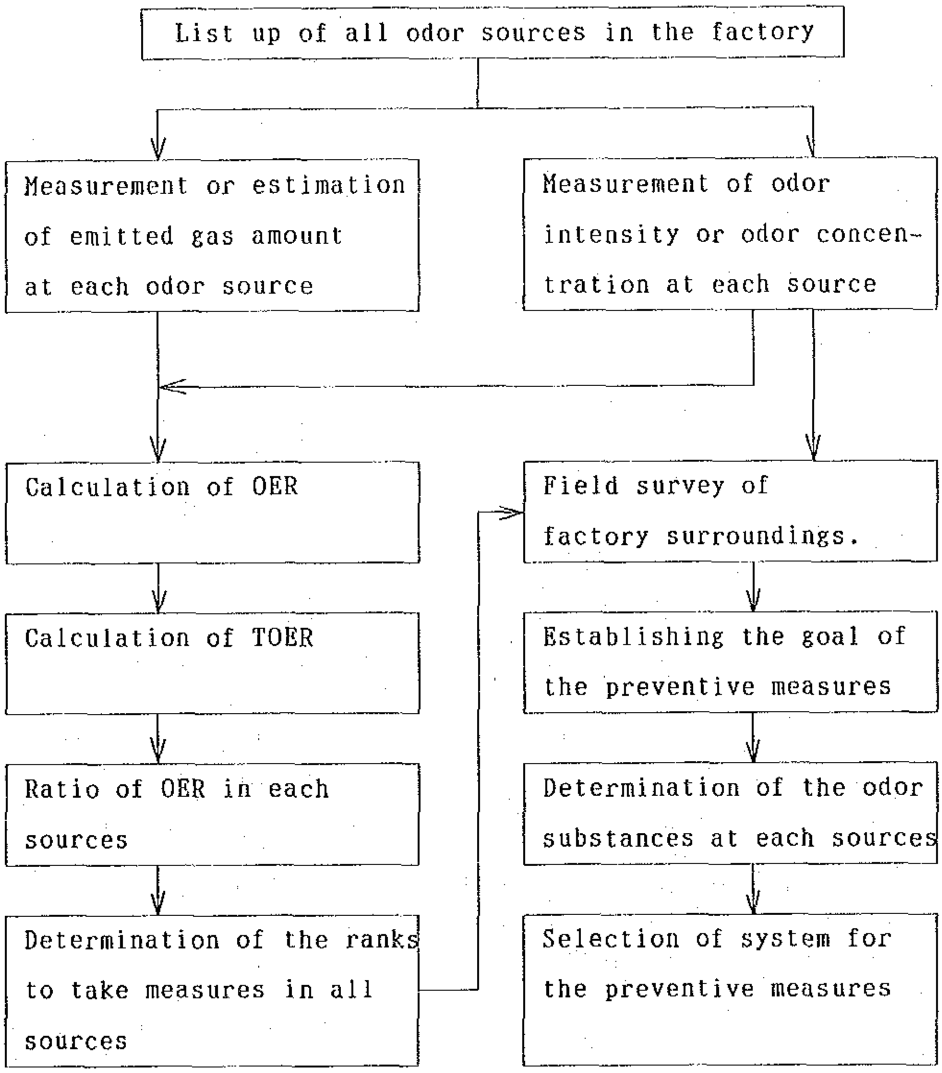


Figure 5-1 Flowchart of the Survey and Planning of Odor Prevention

5.1.3 Outline of Odor Trapping

Various offensive odor sources are present within a factory. These include equipment such as cookers and dryers, reception pits and repositories for raw materials, treatment facilities and outlets thereof for wastewater and wastes and repositories for products, by-products and wastes. Since the conditions of odors, such as constituents, quantity and concentration, differ widely for each process, odor preventive measures must be implemented according to the characteristics of each source. Figure 5-2 shows an example of how odorization facilities may be arranged.

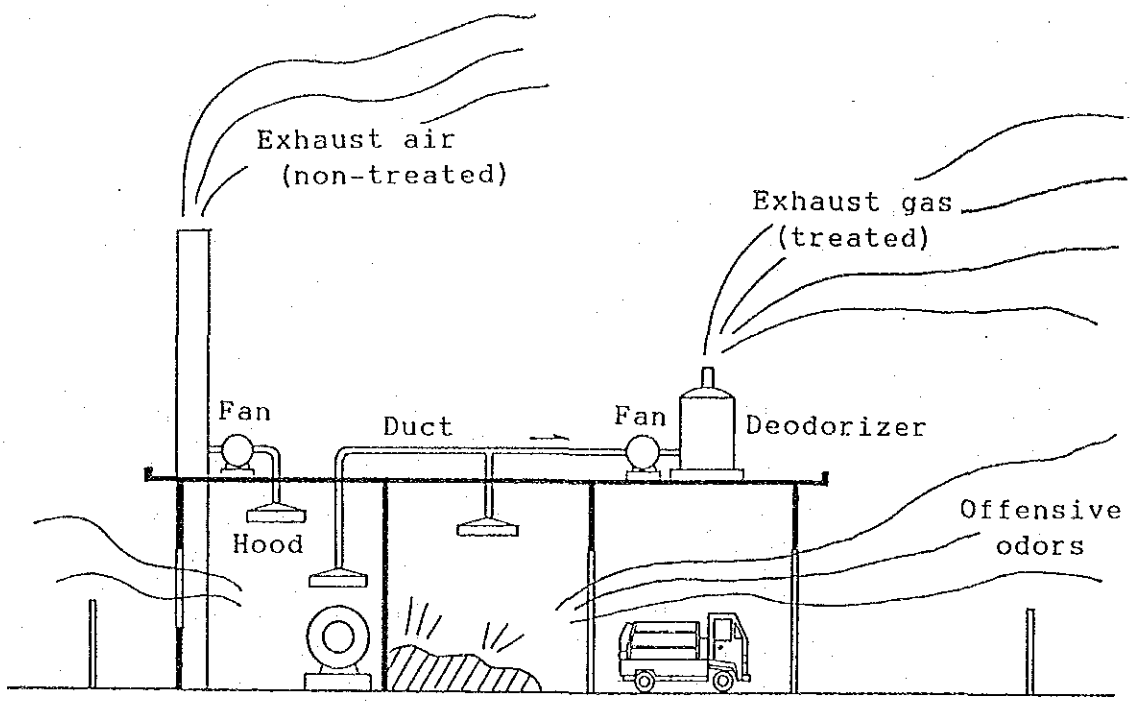


Figure 5-2 Schematics of Arrangement of Deodorization Facility

With regards to the deodorization of offensive odor gases, the rational procedure would be to trap the offensive odor at locations as near as possible to the odor source and to introduce the trapped odors to the deodorization apparatus. Ventilation apparatus for this purpose are comprised of a fan, duct and hood. It is desirable that these apparatus be made of polyvinyl chloride in order to avoid corrosion. Since the performance of the fan has a large effect on the running cost, it is necessary to select fans of suitable power and to design ducts so that the pressure loss is small.

The ventilation rates for trapping odors are basically set so that induction is performed by a minimum air flow rate. Figure 5-3 shows a good method for enabling efficient odor trapping by use of hood. Although ventilation rates of buildings differ for different types of buildings, these rates are usually designed so that a volume that is 10 times the volume of a room is ventilated in one hour. Also, since trapping of odors is difficult for offensive odor sources that are located outdoors, it is desirable to perform odor generating operations indoors and to trap the odors at locations as near to the odor source as possible.

Odors should be classified into those of high concentration, medium concentration and low concentration and these should be trapped accordingly and separately. High concentration odors and medium concentration odors require treatment suited for each odor quality. Low concentration odors may be handled by simple treatment methods or, at times, by simply discharging from a tall chimney.

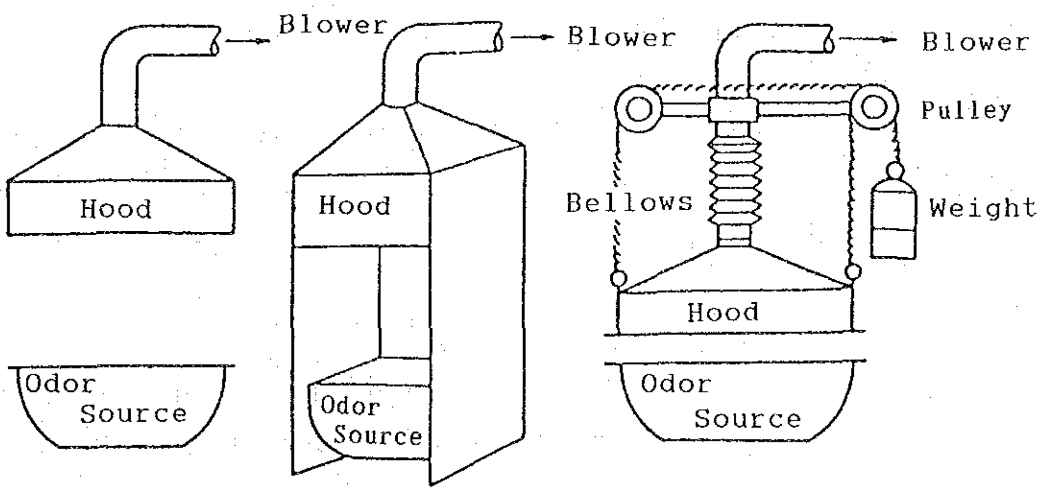


Figure 5-3 Odor Trapping by Use of Hoods at Odor Source

5.1.4 Outline of Deodorization Technologies

(1) Outline of deodorization methods

Deodorization is a process for removing odor-creating substances from emitted and atmospheric gases. Deodorization methods can be classified as shown in Figure 5-4 but is usually roughly classified into three methods, wet deodorizing method, dry deodorizing method and combustion deodorizing method.

Wet deodorization is a general term for deodorization methods that use water, chemical agents and/or sludge. These methods use a scrubbing process generally, but in some cases, employ an aeration process in the activated sludge tank of waste water treatment. This method is classified into the water scrubbing method, the chemical scrubbing method and the biological (sludge) deodorizing method depending on liquid used.

Dry deodorization is a process for removing offensive odors without water, using adsorption, bio-chemical action and others. The typical methods are activated carbon adsorption method and soil-filter deodorizing method.

Combustion deodorizing is a process for removing offensive odors by combustion, which is classified in to two methods; thermal combustion method and catalytic oxidation method.

Other deodorization methods include the ozone oxidation method, ion exchange method and the masking method.

Deodorization methods for the industries subjected to the survey shall be described in outline here.

Physical Methods

- Water scrubbing methods
- Adsorption methods
- Condensation methods
- Dilution methods

Chemical Methods

- Chemical absorption methods
  - Oxidative absorption methods (ozone, chlorine, sodium hypochlorite, etc.)
  - Acidic absorption methods (sulfuric acid, hydorchloric acid, etc.)
  - Basic absorption methods (sodium hydroxide, etc.)
- Chemical adsorption methods (ion-exchange resins)
- Combustion methods
  - Thermal combustion method
  - Catalytic oxidation method
- Neutralization methods (masking agents, neutralization agents)

Biological Methods

- Soil adsorption method
- Activated sludge method
- Oxygen agent method

Figure 5-4 Classification of Deodorization Methods

1) <u>Water scrubbing</u>

This is a scrubbing deodorization method in which water is used and is effective for water-soluble odor substances such as ammonia but is not effective for such substances as hydrogen sulfide, mercaptans, higher amines and fatty acids which are not highly soluble in water. Although the facility and operation costs for this method are low, because it does not have a strong effect by itself, it is used in conjunction with other deodoroization methods.

Figure 5-5 is a flow diagram of the water scrubbing method. The odor drawn by the fan enters the scrubber. The scrubbing tower contains packings (usually of polyethylene) and a shower of water is applied from the upper part.

As the odor gas, that enters the lower part of the tower, ascends through the packing, the odor gas comes in contact with the water and deodorization takes place as the odor-causing substances are absorbed by the water. The water drops within the gas are removed at the mist separator above the spray and the gas is discharged into the atmosphere as treated gas.

The spray water may consist partially of recirculated water or totally of supply water depending on the constituents and concentration of the odor. Although the deodorization effect of water lowers as it is recirculated, relatively high levels of deodorization may be enabled by the constant use of fresh water. Odors that can be deodorized by this method are those that contain water-soluble components and that are low in concentration. Thus, this method is used in many cases as a pretreatment process for other deodorization methods. Mists, fumes and dust may also be removed by the water scrubbing method.

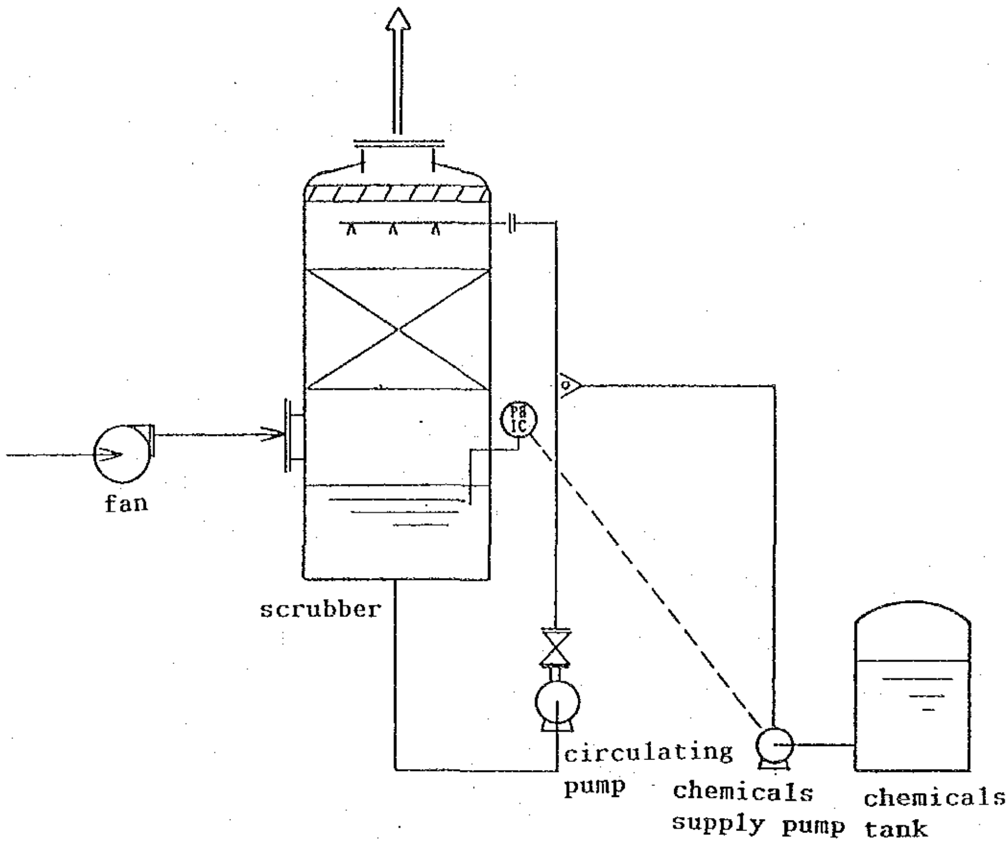


Figure 5-5 Schematic of Water Scrubbing

2) Chemical agent scrubbing

This is a method by which the odor is removed by chemicals such as acids and bases. A suitable chemical is selected for use according to the constituents of the odor. The chemicals generally used for different odor components are shown in Table 5-1. Sulfuric acid is used for odors that mainly contain ammonia while sodium hydroxide or sodium hypchlorite is used for odors that contain hydrogen sulfide. The formulas for the reactions between the odor components and chemicals are shown in Table 5-2. Although hydrogen sulfide can be removed by sodium hydroxide, the results may not be good at some pH values. Sodium hypochlorite is therefore generally used for the removal of hydrogen sulfide.

Since the chemical agents used depend on the objective odor components, the scrubbing towers may be dual or triple type. In many cases, odor is issued from putrid organic matter (particularly proteins) and contains ammonia and hydrogen sulfide simultaneously. Therefore, dual scrubbing towers using acidic + alkaline hypochlorite are often used for such odors.

Figure 5-6 shows the process flow of this method. Although similar to the water scrubbing method, the scrubbing fluid is recirculated by a recirculation pump in this method.

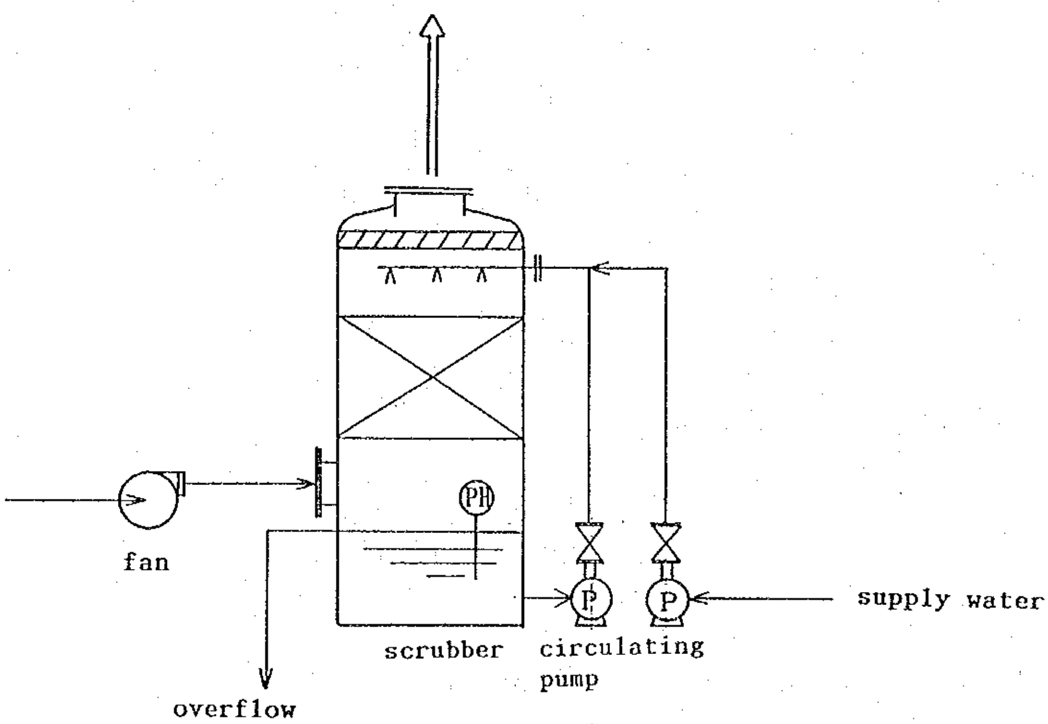


Figure 5-6 Schematic of Chemical Scrubbing

Concentrations of acid and alkali are continuously measured with pH meters. If the amount of chemical falls below the specific amount, it is automatically supplied with an injection pump. The effective chlorine concentration in the sodium hypochlorite solution may also be measured with an exclusive meter (residual chlorine concentration meter) and automatically controlled so as to maintain stable performance even if there are variations of inlet concentration and air flow rate.

Table 5-1 Correlation Between Odor Components and Chemical Agents

Odor component	Molecular Formula	Chemical agent to be applied
Ammonia	NH_3	sulfuric acid, or hydrochloric acid
Trimethylamine	$(CH_3)_3N$	ditto
Hydrogen sulfide	H_2S	sodium hydroxide, or sodium hypochlorite (alkaline)
Methyl mercaptan	CH_5SH	ditto
Methyl sulfide	$(CH_3)_2S$	sodium hypochlorite (alkaline)
Methyl disulfide	$(CH_3)_2S_2$	ditto
Propionic acid	C_2H_5COOH	sodium hydroxide
n-Butylic acid	C_3H_7COOH	ditto
n-Valeric acid	C_4H_9COOH	ditto
i-Valeric acid	C_4H_9COOH	ditto

Table 5-2 Reaction Formulas Between Odor Substances and Chemical Agents

Odor component	Reaction formula
Ammonia	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$
Trimethylamine	$(CH_3)_3N + H_2SO_4 \rightarrow (CH_3)_3NHHSO_4$
Hydrogen sulfide	$H_2S + 2NaOH \rightarrow Na_2S + 2H_2O$ $Na_2S + 4NaClO \rightarrow Na_2SO_4 + 4NaCl$ $Na_2S + NaClO + H_2O \rightarrow S + NaCl + 2NaOH$
Methyl mercaptan	$CH_3SH + 3NaClO \rightarrow CH_3SO_3H + 3NaCl$
Dimethyl sulfide	$(CH_3)_2S + NaClO \rightarrow (CH_3)_2SO + NaCl$
Dimethyl disulfide	$(CH_3)_2S_2 + 5NaClO + H_2O \rightarrow 2CH_3SO + 5NaCl$
Propionic acid	$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$
n-Butylic acid	$CH_3(CH_2)_2COOH + NaOH \rightarrow CH_3(CH_2)_2COONa+H_2O$
n-Valeric acid	$CH_3(CH_2)_3COOH + NaOH \rightarrow CH_3(CH_2)_3COONa+H_2O$
i-Valeric acid	$(CH_3)_2C_2H_3COOH + NaOH \rightarrow (CH_3)_2C_2H_3COONa+H_2O$

3) Sludge deodorization

This is a biological deodorization method. Although the schematic is fundamentally the same as the water scrubbing method as shown in Figure 5-7, sludge (in many cases, activated sludge from wastewater treatment) is recirculated as the scrubbing fluid and the odor is removed at the absorption tower. Since the concentration of suspended solid (SS) of the recirculated sludge is high, the scrubbing tower of this method employs a system of trays with perforated boards instead of the layer packings as in the chemical scrubbing tower in order to prevent blocking.

With this system, nearly every type of odor can be removed. But, unlike deodorization methods that use chemical reactions, it requires a certain amount of time before the sludge (bacteria) becomes adapted to odor components. Hence, this system is hard to control in cases where the changes of odor concentration with time are large or in cases where odor components change quickly.

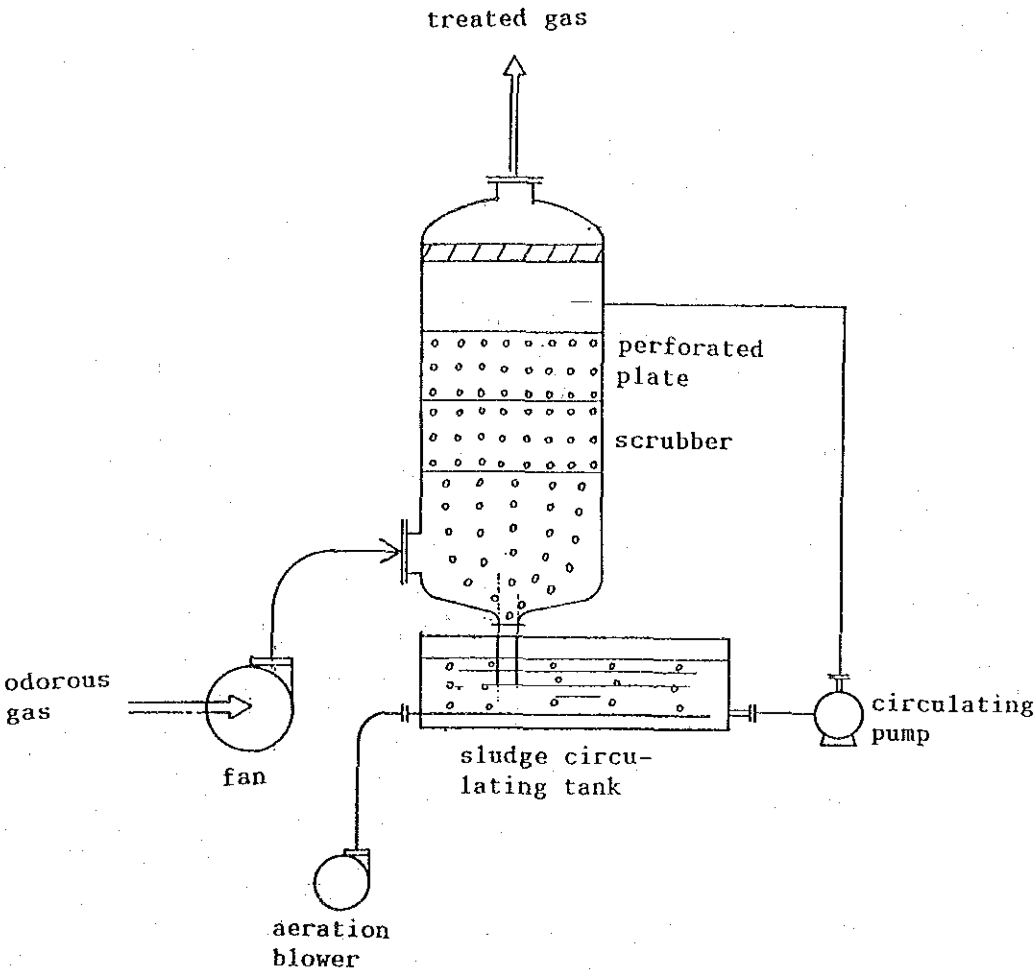


Figure 5-7 Schematic of Sludge Deodorization

4) Activated carbon adsorption

In this method, the odorous gas is passed through layers of activated carbon which remove odor components by adsorption. The activated carbon must be that for gas phase use only since nearly no effects can be obtained with that for water use.

Crushed coal grains of 4 to 8 meshes are generally used as the activated carbon. Grains of 4 to 6 meshes are most popularly used to reduce pressure loss since small grains increase the pressure loss extremely.

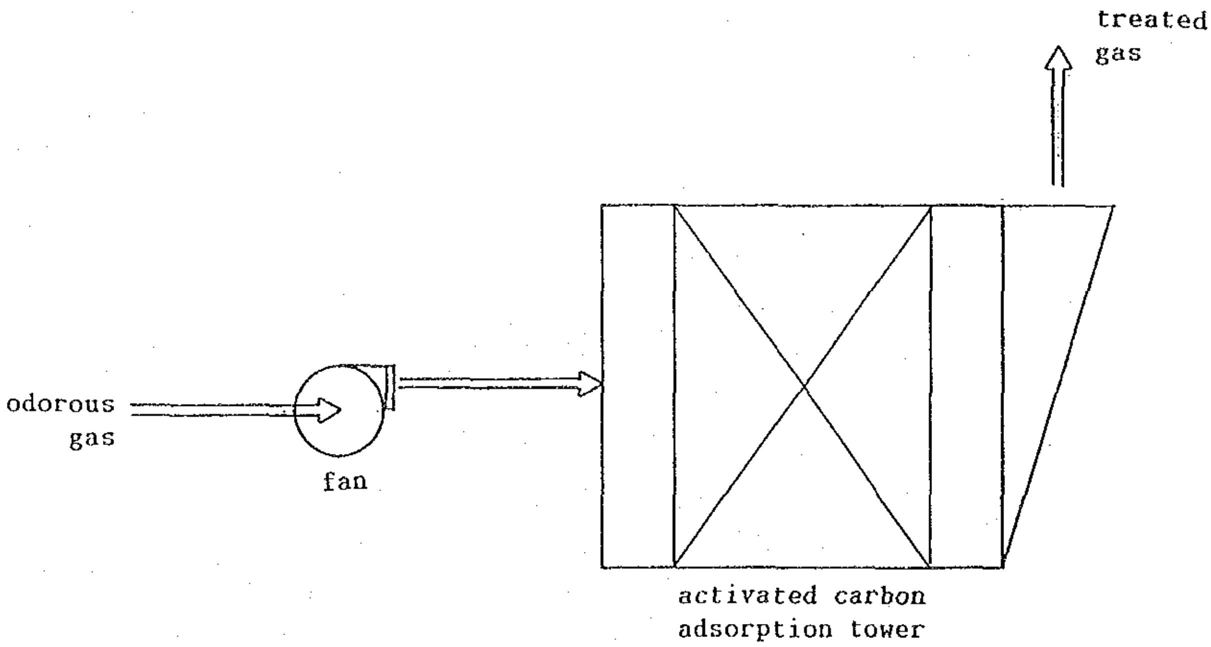


Figure 5-8 Schematic of Activated Carbon Adsorption

A raised LV (Linear Velocity at which gas passes through the layer) may be effective in reducing the size of the tower. But pressure loss in the packing layer increases exponentially with LV^2. Hence, It is important to achieve a reasonable balance between the initial cost and the running cost by selecting a suitable LV value. In the usual design, LV is set to approx. 0.3 m/sec., bringing about a pressure loss of approx. 100 mmAq. per meter thickness of activated carbon packing.

Activated carbon adsorbs odor components physically. Consequently, some components cannot be adsorbed (e.g. ammonia). But a special activated carbon has been developed through chemical treatment. This type of active carbon can remove almost all odor components. Another type of deodorizing equipment makes use of fibrous activated carbon aimed to remove and recover organic solutions. But it is not yet used practically for deodorization in automobile painting nor in any of the other three industrial fields covered in this survey.

Activated carbons exhibit excellent adsorption capacities for organic substances and are effective for a wide variety of odors. These are especially effective for alcohols, fatty acids, mercaptans but are not as effective for ammonia, anines and aldehydes. Activated carbons are suited for the deodorization of odorous gases of low concentration and high emission rates. However, the number of replacements and/or recoveries become large for high concentration odors. Otherwise, activated carbons are affected little by variations in the load of odorous gases and are easily maintained.

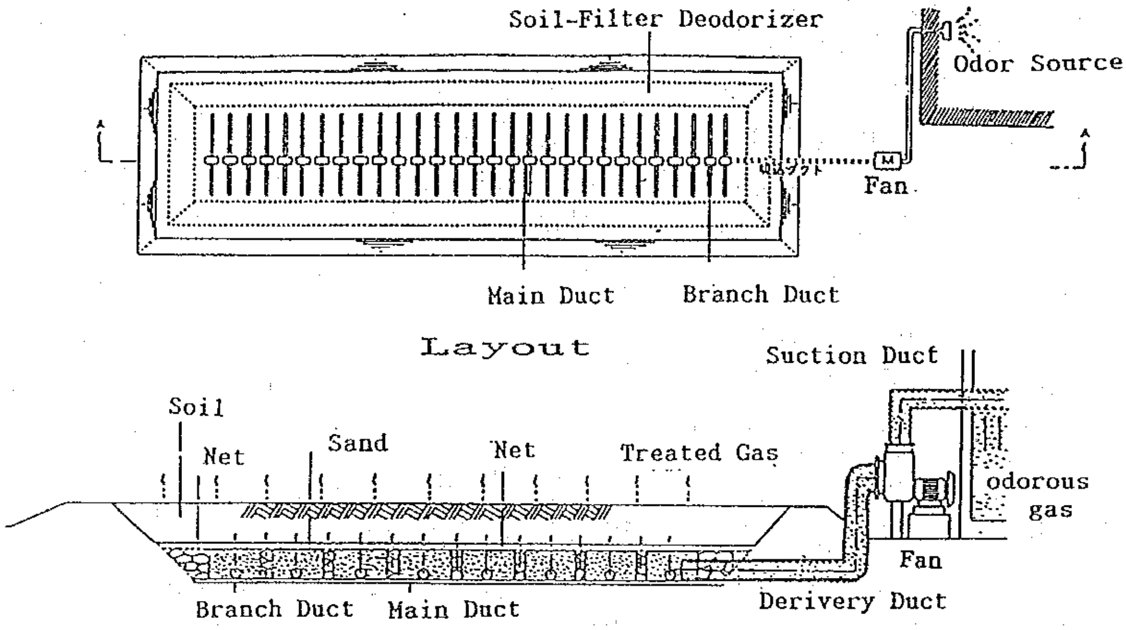
5) Soil-filter deodorization

This method deodorizes the sucked odorous gas by passing it through a soil layer, in which bacteria removes the odor components by decomposition.

LV in the soil layer is usually near 10 mm/sec., bringing about a pressure loss of 250 mmAq. or less. Hence, a large area of land is necessary for installation of this type of deodorizing equipment. Actually, an area of 800 m^2 (29 m x 29 m) is required to treat a gas flow of 500 m^3/min., together with some additional area for installation of appended machines such as fans.

When soil is dampened wet by rain, the pressure loss increases. When draining is poor, the system is blocked and rendered useless with water in the soil. Hence, this type of equipment should be located with sufficient care in the draining of the soil in the vicinity.

Whereas this type of equipment can handle almost every odor component, its performance is temporarily degraded if odor component concentration changes largely or quickly, similarly to the sludge deodorizing method.



Section A-A

Figure 5-9 Schematic of Soil-Filter Deodorization

6) Thermal combustion

This method decomposes odor components by oxidation at a high temperature of 600 to 800 ℃ to deodorized gas, and can treat a wide variety of odors. The temperature must be held for approx. 0.3 to 1 sec. (retension time). If hydrogen sulfide is included in odor components, associating desulfurization equipment should be installed, if the component concentration is high, in order to avoid adverse effect of sulfur oxides (SO_x).

Combustion uses heavy oil, kerosine or gas. The key for low running cost is effective recovery of heat for minimization of the total fuel consumption in the factory. If a lot of steam is contained in odorous gas, consideration is necessary in the removal of water by condensation through pre-treatment (cooling the gas) before deodorization.

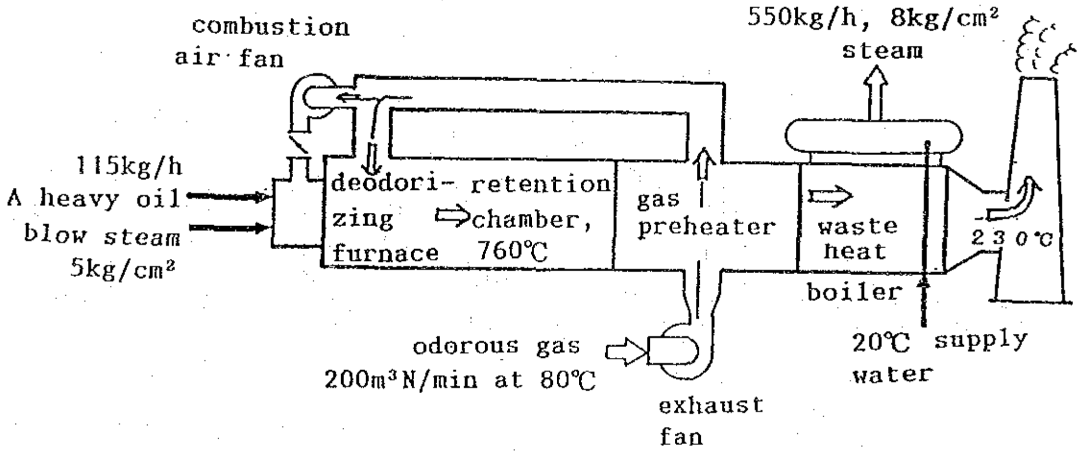


Figure 5-10 Schematic of Thermal Combustion

7) Catalytic combustion

This method passes odor gases through a catalyst layer at a temperature of 300 to 400 ℃ and decomposes them by oxidation. Thus, the fundamental concept is similar to the thermal combustion system.

An advantage of this method is that it deodorizes at a temperature lower than the thermal combustion system, because it uses a catalyst. Additionally, if the heat generated in the oxidizing decomposition process can hold the temperature in the catalyst layer, the burner operation can be stopped after the start-up stage.

The deodorizing effect of it is higher than that of the thermal combustion system, especially when the odor concentration is comparably low, because oxidizing decomposition proceeds quickly in the former process.

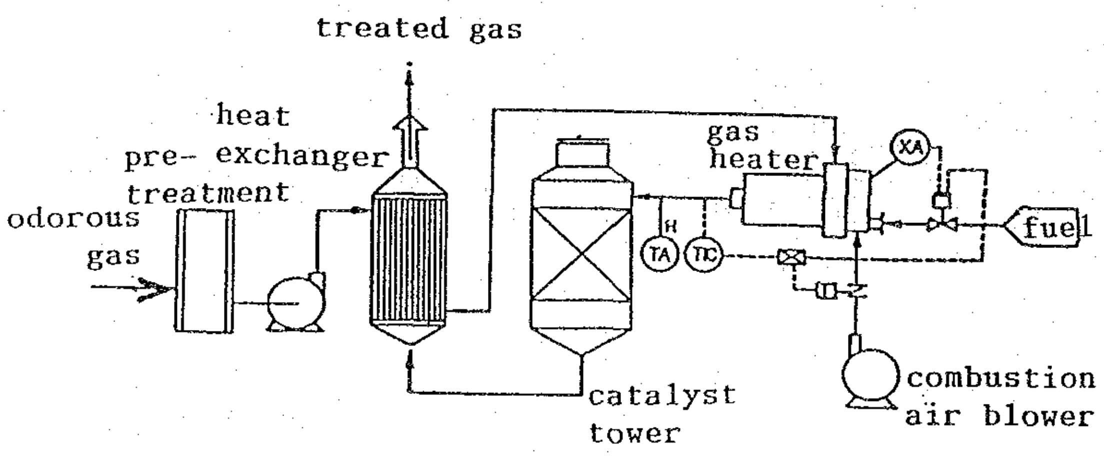


Figure 5-11 Schematic of Catalytic Combustion

The catalyst is constituted of metal stuck to the carrier, and is largely divided into three systems as listed in the table below:

Table 5-3 List of Catalysts

System	Metal	Remark
Noble metal system	Pt(platinum) Pd(palladium) Rh(rhodium)	Vigorous catalytic activity. Strong to poisons. Long life, Recoverable, high price.
Base metal oxide system	Co(cobalt) Mn(manganese) Cu(copper) Cr(cromium) & others	Effective metal depends on object component. More than three metals having to be combined. Unrecoverable. Cheap price.
Metal sulfide system	Th(thorium) Ni(nickel) Mo(morybdenum) Co(cobalt) & others	for odor components containing sulfur (such as hydrogen sulfide and SO_x), for which the two systems above cannot treat

In the usage of the catalysts, care should be taken against catalyst poisons. If they are contained in odorous gas, they must be removed preliminarily. Catalyst-damage by poison can be divided into two categories, temporary and permanent. Temporary catalyst-damage can be regenerated, but permanent catalyst-damage cannot be regenerated and must be eliminated.

Table 5-4 Catalyst Poisons

Category	Poisonous substance
Permanent damage	heavy metals
Temporary damage	sulfur, halogen, excessive water, carbon dioxide, tar, dust

(2) Comparison of deodorization methods

Table 5-5 shows the comparison of deodorization methods with regard to effective type of odor substances, gas flow, concentration and temperature for which the method is suited to as well as ease of maintenance, accomodation of load variation, initial cost and running cost.

Upon actually designing deodorization facilities or arrangements thereof, the deodorization methods shown below are either used singularly or in combination according to the type, composition, emission rate, concentration of the odor. For example, high concentration odors may be handled by thermal combustion while medium concentration odors may be handled by a combination of chemical scrubbing and activated carbon adsorption.

The most popular methods among the above methods are the chemical scrubbing, the activated carbon adsorption and the thermal combustion methods. Table 5-6 shows the estimation of running costs for these three methods for a low concentration odor consisting of about 1 ppm ammonia and 0.2 ppm hydrogen sulfide (Case 1), a medium concentration odor consisting of about 10 ppm ammonia and 2 ppm hydrogen sulfide (Case 2) and a high concentration odor consisting of about 100 ppm ammonia and 20 ppm hydrogen sulfide. The conditions that were assumed for this estimation are as follows and the details of the estimation for the medium concentration odor case is shown in Table 5-7.

Gas flow	:	100 Nm^3/min.
Gas temperature	:	30 ℃
Operation time period	:	24 hr/day, 365 days per year
Pressure loss at ducts	:	100 mmAq

Table 5-5 Comparison of Deodorization Methods

Deodorizing Method		Water Scrubbing	Acid Scrubbing	Alkali Scrubbing	Sludge Deodorization	Activated Carbon Adsorption	Soil-Filter Deodorization	Thermal Combustion	Catalytic Combustion	Ozone Oxidation
Odor Substance	NH_3	△	○	×	△	△	△	○	○	×
	H_2S	×	×	○	△	○	△	○	△	○
	Solvent	△	×	×	△	○	△	○	○	×
Concentration	High	○	△	△	×	×	△	○	○	△
	Low	○	○	○	○	○	○	△	△	○
Gas flow	High	○	○	○	△	△	×	×	△	×
	Low	△	△	△	○	○	○	○	○	○
Gas temperature	High	△	△	△	×	×	×	○	○	×
	Low	○	○	○	○	○	○	×	×	○
Maintenance		○	△	△	×	○	×	△	△	×
Load variation		○	○	○	×	○	×	△	△	○
Initial cost		○	△	△	△	○	×	×	×	×
Running cost		○	△	△	○	×	○	×	△	×

Note : ○ Effective or inexpensive

△ Moderate

× Ineffective or expensive

Table 5-6 Comparison of Annual Running Costs

(Unit: Bahts)

Case	Item	Chemical scrubbing	Thermal combustion	Activated carbon adsorption
Low concentration odor	Chemicals	111,000	2,102,400	573,600
	Electricity	199,900	168,600	191,200
	Total	310,900	2,271,000	764,800
Medium concentration odor	Chemicals	208,900	2,102,400	2,770,600
	Electricity	299,900	168,600	191,200
	Total	408,800	2,271,000	2,961,800
High concentration odor	Chemicals	1,126,300	2,102,400	23,614,00
	Electricity	199,900	168,600	191,200
	Total	1,426,200	2,271,000	23,805,600

Note : Gas flow : 100 Nm^3/min (30°C)

Operation hours of deodorizer : 24 hr/day, 365 days/year

Pressure loss at ducts : 100 mmAq

Activated carbon method employs three-bed system using treated carbon.

Concentration of odor substances (CO_2 : 1,000 ppm)

(units: ppm)

	NH_3	H_2S	MM	DMS	DMDS
Low concentration odor	1	0.2	0.02	0.01	0.005
Medium concentration odor	10	2	0.2	0.1	0.05
High concentration odor	100	20	2	1	0.5

Table 5-7 Breakdown of Running Cost for Deodoriziation of Medium Concentration Odor

a. Chemicals (including Water, Oil, Activated Carbon)

Item		Chemical scrubbing		Thermal combustion		Activated carbon adsorption
Annual Consumption (kg/yr)	SA	2,816kg	HO	525,600kg	AC	990kg
	CS	4,956kg	—		AL	5,655kg
	HP	24,324kg	—		NT	1,403kg
	WT	268m^3	—			
Unit Price (Baht/kg)	SA	6/kg	HO	4/kg	AC	282/kg
	CS	9/kg			AL	353/kg
	HP	6/kg			NT	353/kg
	WT	5.6/m^3				
Annual Cost (Baht/yr)	SA	16,896	HO	2,102,400	AC	279,529
	CS	44,604			AL	1,995,882
	HP	145,944			NT	495,176
	WT	1,501				
(total)		208,945		2,102,400		2,770,588

b. Energy (Electricity)

Item		Chemical scrubbing	Thermal combustion	Activated carbon adsorption
Ratings	Fan	7.5kW	7.5kW	11kW
	Pump	3kW	—	—
	Others	1.1kW	2.2kW	—
	Total	11.5kW	9.7kW	11kW
Effective rating		9.2kW	7.76kW	8.8kW
Annual consumption		80,592kWh	67,978kWh	77,088kWh
Unit Price (Baht)		2.48/kWh	2.48/kWh	2.48/kWh
Annual Cost(Baht)		199,868	168,584	191,178

c. Sum-up (Bahr/yr, %)

	Chemical scrubbing	Thermal combustion	Activated carbon adsorption
Chemicals cost	208,945 (51.1)	2,102,400 (92.6)	2,770,588 (93.5)
Electricity cost	199,868 (48.9)	168,584 (7.4)	191,178 (6.5)
Total	408,813(100%)	2,270,984(100%)	2,961,766(100%)

Note : SA: sulfuric acid, CS: caustic soda, HP: sodium hypochlorite, WT: water, HO: heavy oil, AC: acidic gas, AL: alkaline gas, NT: neutral gas

Chemical concentrations

sulfuric acid	98.0%
caustic soda	50.0%
sodium hypochlorite	10.0%

Unit price of activated carbon

acidic gas use	1,200 ¥/kg
alkaline gas use	1,500 ¥/kg
neutral gas use	1,500 ¥/kg

(Japanese domestic price)

Table 5-6 shows that among the three methods, chemical scrubbing is the cheapest, regardless of the odor concentration.

The fuel consumption of the thermal combustion system depends only on the gas flow rate, nearly independent of odor concentration because the temperature of the odorous gas must be raised to about 800 ℃ . The running cost of this method is therefore pretty constant.

On the other hand, the running cost of the activated carbon adsorption method is nearly in proportion with odor concentration because the necessary quantity of activated carbon depends on the quantity of odor components. Hence, this method is advantageous when odor concentration is low -- such as the deodorization of room atmosphere and the finishing deodorization of gas pretreated by chemical scrubbing. It is also effective, even if the concentration is high, when the absolute quantity of odor component generation is limited as in the case when the generation time is short.However, as the daily control of the operation of the activated carbon adsorption method is very easy, in some cases, decision based on running cost may be modified.

Therefore, the deodorizing method should be selected based not only on running cost but on comprehensive conditions including the maintenance of the equipment and the state of the odor generation.

(3) Selection of deodorization methods

1) *High concentration odors of fish meal plant and bone meal plant*

These odors are generated from the raw material heating processes such as those involving the cooker. The components include high concentrations of nitrogen containing compounds (such as ammonia and trimethyl-amine) and sulfides (such as hydrogen sulfide and methyl mercaptan) which are generated from putrid proteins. Besides those components, aldehydes and organic acids are also found. It should be noted that high boiling point components like fats and oils and a lot of water (steam) are also generated, which must be sufficiently taken into account in selecting the deodorizing system.

The systems practical for these factories include the thermal combustion method, the chemical (or water) scrubbing method, and the soil deodorizing method. However it can generally be said that the thermal combustion method is effective for these high concentration odors, reasonable economy cannot be attained without using the treated gas as the boiler's combustion air for the efficient recovering of heat, because running cost will be raised unreasonably when an exclusive deodorizing furnace is appended.

While the soil deodorizing method is effective, the decision is largely affected by the location of the factory. This method requires the large area of land as well as the soil of good draining quality such as one looking blackish. Actually, the area of approx. 170 m^2 is necessary for deodorizing gas at a rate of 100 m^3/min., and draining channels must be secured to prevent water ponds generated by rain. Considering that flooding is prevalent in the moderately rainy areas in the vicinity of Bangkok and

Samutprakan Prefecture, the soil deodorizing method might be hard to use in this project.

Although flexible to odor generating conditions, the chemical scrubbing method requires the combination of several scrubbing towers, because it uses chemical agents specific to each odor component. Whereas sufficient care should be taken for handling agents, this method may be more efficient than the soil deodorizing or the thermal combustion methods.

2) Low and medium concentration odors of fish meal plant, bone meal plant and tannery

Most of the medium and low concentration odor gases are those generated at room temperature and mainly consist of ventilated room atmosphere. As a large amount of gas must be induced, the chemical (including water) scrubbing method, the activated carbon adsorption method, and the soil deodorizing method may be suitable.

Since the soil deodorizing method requires a large installation space, it is disadvantageous when the gas flow rate is large, especially in such a case as treating ventilated room atmosphere which would require a vast area of land.

The chemical scrubbing method is effective and can handle large gas flow rate. But the problem is the complicated maintenance and control of the chemicals and the instruments.

The activated carbon adsorption method is effective for low concentration odor. Whereas the cost of this method for unit quantity of odor is rather expensive, but its operation, maintenance and control is very easy with this method, since a daily operation procedures are limited to the start and stop of the fans.

3) Organic solvent odors of automobile painting factory

The odor of organic solvents can be treated by most of the deodorizing methods, particularly the activated carbon adsorption method and the combustion (including catalytic oxidation) method, but not the water scrubbing method since organic solvents hardly react with inorganic chemicals.

The activated carbon adsorption method is effective for odor in car coating workshops since a daily operation control is limited to the start and stop of the fans.
The running cost of the combustion method is comparably high due to such factors as auxiliary combustion agents unless the organic solvent odor is generated at a concentration more than a certain level continuously for a certain period. The maintenance and control of the equipment requires a lot of man-power because the equipment is more complicated than the activated carbon adsorption method. The combustion (or catalytic oxidation) method may be in-efficient for the deodorization of the odor in car coating shops, where odor concentration changes greatly.

5.2 Concepts of Deodorization by Industy

5.2.1 Fish Meal Plant

(1) Outline of fish meal industry

Fish meal manufacturing is an industry processing fish entrails and bones to recover fats and oils and fertilizers (proteins and inorganics) as the final products. Fish entrails are the uneaten parts of the fish including the head, internal organs, bones and fins and are discharged from marine product retailers, supermarkets, fish markets and sea food manufacturing factories, etc.

The raw materials of a fish meal factory can be divided into the fish itself, processed fish scraps and urban fish scraps. Factories which use the fish itself and processed fish scraps are located near fishing ports while factories using urban fish scraps are located near fish markets in and around urban areas. In an areas where there are no fish meal factories, these raw materials are usually disposed as urban waste.

The fish meal production process is shown schematically in Figure 5-12. Since the water content of fish and other marine products is high (about 75 %), the raw materials are usually not steam-boiled and dried in the same cooker but are separated into liquid and solid parts with a screw press, etc. after being steamed. The solid parts are then dried with a dryer to produce fish meal. The liquid part is removed of the solid content with a decantor (centrifugal separator) and is then separated into fish oil and stick water (fine solids) with a 3-phase separator. The stick water is concentrated further at reduced pressure to produce solubles.

The fish meal product is used as livestock feed and the fish oil is refined for food and industrial use.

The ratio of product (fish meal) to raw material is about 22 % when fish itself is used but becomes lower when other substances are mixed together. Urban fish scraps may be unfresh depending on the season and may contain such miscellneous matter as plastic, vegetable scraps, metal scraps etc. which may cause plant failure.

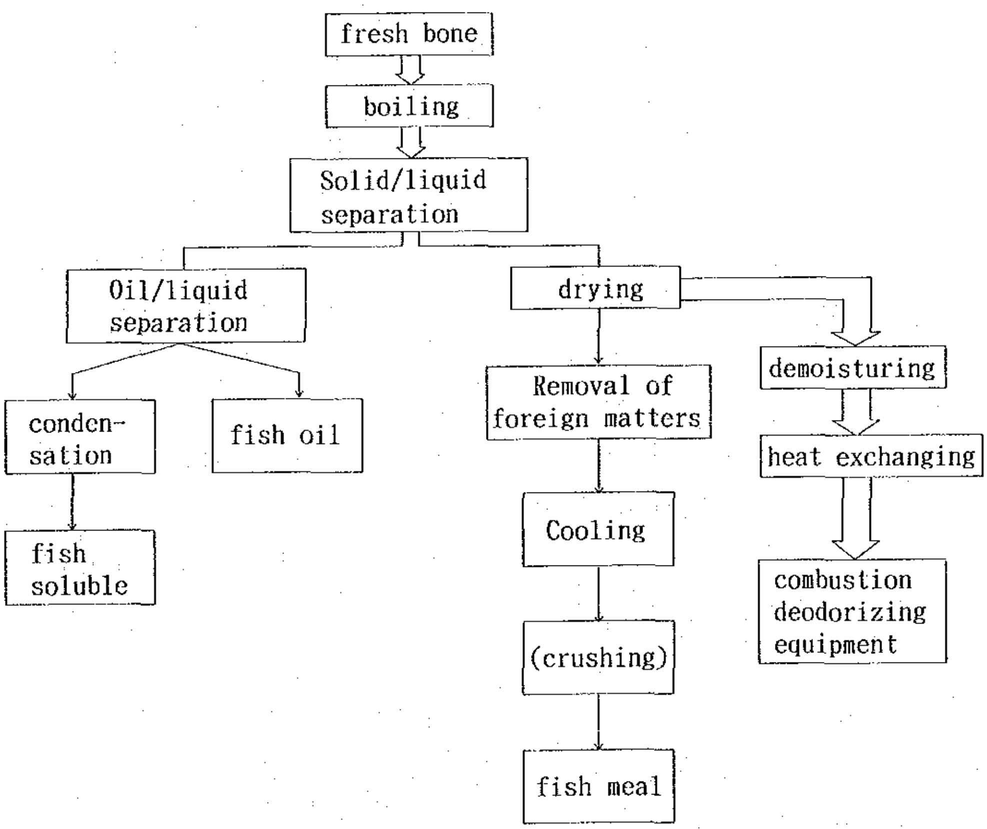


Figure 5-12 Process of Fish Meal Production

(2) *Odor generation in fish meal plant*

Odor is generated in all processes including the unloading, storage and selection of raw material, the steaming/pressurizing process, the drying/grinding process, the oil treatment process, the wastewater treatment process, the storage of products and the combustion of wastes. The quantities and intensities of the odors depend on the operation conditions of the factory. Generally, the biggest sources are the exhausts from the cooker and the drying process after cooking. Other odors include odors of the raw material itself and the decomposition thereof, offensive odors leaking from the connections and openings of equipmentand odors due to heating of the product.

Table 5-8 and Table 5-9 show the results of offensive odor measurments performed at fish meal plants in Japan. At the plant for Table 5-8, the odors were collected from the major odor sources within the factory and deodorized. The OER at the outlet of the deodorization apparatus constituted 58 % of the TOER of this factory while the OER due to leakage of odors from the roof fan and naturally opened parts constituted 42 % .

The odors of fish meal plant have high concentrations of ammonia, trimethylamine and fatty acids and may contain hydrogen sulfide, methyl mercaptan, methyl sulfide, methyl disulfide and aldehydes.

Table 5-8 Results of Odor Measurement in Fish Meal Plant (Japan)

Sampling Point	Odor Concentration	Gas Flow (Nm^3/min)	OER	Ratio (%)
IDF over cooker	570	232.8	1.3×10^5	16.0
Ventilation over cooker	280	31.4	0.9×10^4	1.1
Ceiling opening	570	214.8	1.2×10^5	14.8
Ceiling ventilation	280	14.4	0.4×10^4	0.5
IDF over cyclone	570	60.2	3.4×10^4	4.2
Over cyclone	570	12.2	0.7×10^4	0.9
IDF over vibrator	570	61.1	3.4×10^4	4.2
Outlet of deodorizer	1,100	417.3	4.7×10^5	58.0
T.O.E.R			8.1×10^5	100.0

Table 5-9 Results of Odor Measurement in Fish Meal Plant (Japan)

Sampling Point	Odor Concentration	Characteristics of odors	Concentration of Offensive Odors (ppm)					
			H_2S	CH_5SH	C_2H_6S	$C_2H_6S_2$	NH_3	TMA
Material room	230	fishy odor						
Auto feeder	4,100	fishy odor	0.020	0.011	0.011	0.003		
Over screw press	55,000	roasting fishy odor	0.42	0.44	0.14	0.05		
Conveyor after screw press	55,000	burning fishy odor	0.62	0.40	0.12	0.03		
Inlet Conveyer of drier	2,300	fish meal's odor	0.009	0.005	trace	0.003		
Press water heat tank	17,000	burned fish odor	0.10	0.03	0.07	0.002		
Jey steam of 3-phs separater	73,000	fish meal's stimulous odor						
Products storage eoom	310	ditto						
Inlet of boiler	550,000	burned fishy stimulous	0.14	0.50	0.10	0.06		
Outlet of boiler	1,300	stimulous odor with burning	ND	ND	ND	ND	0.189	0.0087
Water scruber	980,000	Fish meal's odor	ND	trace	0.12	0.13		
Chemical scruber	1,300,000	ditto	0.22	0.25	0.17	0.03		213
Aration tank exhaust tower	73	musty, rawish odor						

(3) Preventive Measures of offensive odor in fish meal plant

1) *General measures of prevention and removal of offensive odor*

a. Process materials while fresh to prevent the generation of odor due to putrefaction.

b. Remove all interfering matter within the raw material prior to processing in order to prevent plant failures.

c. Select production processes which enable production in the shortest time possible.

d. Use concentrators and other apparatus with enough capacity margins for handling liquid flows greater than the amount of raw materials processed.

e. Enclose each process in the factory to prevent leaks and diffusion of odor, and to suck and remove odor efficiently

f. Install deodorization apparatus which will provide a balanced relationship between the local induction performed at each process and the total ventilation of the factory interior.

g. Install wastewater treatment facilities for treating the wastewater generated from raw materials etc. within the factory and discharge the wastewater as rapidly as possible.

h. Execute good production control so as to prevent putrefaction of sewage and waste water including wasted materials, which causes odor generation, together with perfect cleaning of the factory.

2) <u>Deodorization system</u>

Each production process should be enclosed to prevent the leakage/dispersion of odors. Odors from each process should be trapped separately according to the concentration (high, medium and low) in order to deodorize the gases by the methods most suitable for each odor concentration. The treated gas should then be discharged.

Figure 5-13 shows examples of desirable odor collection locations and deodorization methods. Depending on the odor strength, low concentration odors may be treated by a combination of chemical scrubbing and activated carbon adsorption or by activated carbon adsoprtion alone. Since recovery of fish oil is not performed in many of the fish meal factories in Thailand, the high concentration odors from the fish oil recovery process may not apply. Chemical scrubbing or combustion methods may be used to deodorize high concentration odors. For cases wherein the entire production facility is renewed, as in the construction of a new factory building, combustion methods may be more effective.

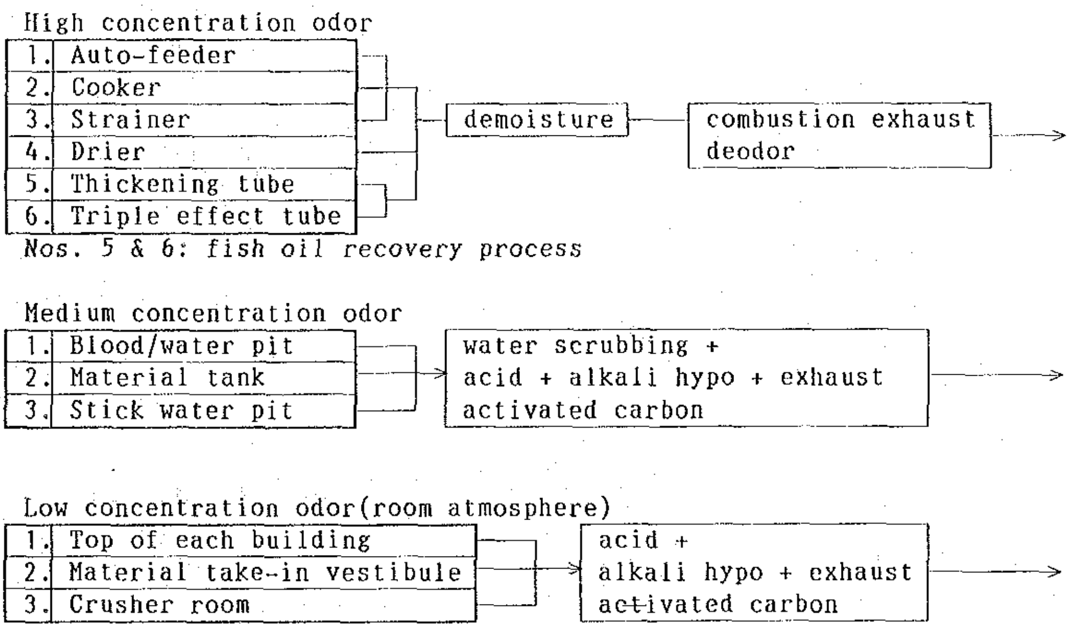


Figure 5-13 Deodorization Flow in Fish Meal Plant