9.4 Non-metallic Minerals Industry

9.4.1 Wolomin (glass)

(1) Glass Melting Furnace

a. Purpose of measurement

The purpose is to grasp the current state of operation in order to perform the heat balance of a glass melting furnace.

b. Measurement items, measurement time, measuring equipment and data processing

Measurement items		Measurement time	Measuring equipment	Data processing
Raw material, glass	① Batch consumption	24 h	Operation record	Memo
	② Cullet consumption	24 h	Operation record	Memo
	③ Raw materials ratio	Moment	Operation record	Memo
	④ Batch & cullet temperatures	24 h	(Operation record)(*1)	Memo
	⑤ Water % in batch	Moment	(Operation record)(*2)	Memo
	⑥ Glass composition	Latest	Operation record	Memo
	⑦ Molten glass quantity	24 h	Calculation	Memo
Furnace temperature	⑧ M.T. down temperature	30 min	Thermocouple (*3)	to Recorder
	⑨ F.H. entrance glass temperature	30 min	Thermocouple	to Recorder
	⑩ F.H. exit glass temperature	30 min	Thermocouple	to Recorder
Fuel	⑪ Fuel consumption	24 h	Operation record	Memo
	⑫ Fuel heat value	Latest	Operation record	Memo
	⑬ Fuel composition	Latest	Operation record	Memo
	⑭ Fuel temperature	24 h	Thermocouple (*4)	to Recorder
	⑮ Burner atomizing gas quantity & temperature	spot	(*5)	
	⑯ Electricity for booster	24 h	Clamp meter	to FDD
Combustion air	⑰ Air consumption	24 h	(Operation record)(*6)	to Recorder
	⑱ Air suction temperature	spot	(*7)	Memo
	⑲ Air preheat temperature	30 min	Suction pyrometer (*8)	to Recorder
Exhaust gas	⑳ Fuel quantity ratio at every port	Moment	Operation record	Memo
	㉑ Exhaust gas quantity	Calculation		Memo
	㉒ O_2 % in exhaust gas	30 min	O_2 meter + ceramic tube	to Recorder
	㉓ Exhaust gas temperature	30 min	Suction pyrometer (*8)	to Recorder
Preheating boiler	㉔ Water quantity	30 min	Ultrasonic flowmeter	to Recorder
	㉕ Water temperature ΔT	30 min	Glass thermometer	Memo

	Measurement items	Measurement time	Measuring equipment	Data processing
Radiation heat	㉖ Furnace wall temperature	spot	Surface thermometer	Memo
	㉗ Port wall temperature	spot	Radiation pyrometer	Memo
	㉘ Regenerator wall temperature	spot	Surface thermometer	Memo
	㉙ F.H. wall temperature	spot	Surface thermometer	Memo
	㉚ Opening parts inside temperature	spot	Radiation thermometer	Memo
Cooling	㉛ Cooling water quantity & temperature ΔT	spot	Stop watch and glass thermometer (*9)	Memo
	㉜ Cooling air quantity & temperature ΔT	spot	(*10)	Memo

Note: *1: If no operation record is available, measure the room temperature every hour for 24 hours as a substitute.

*2: If no operation record is available, take samples at the inlet, dry them at 100 °C in a drying oven, and find their moisture content.

*3: If there is no measuring hole, take a memo from the operation record.

*4: If the fuel is not preheated, substitute it with room temperature as with item ④.

*5: If the atomized gas is steam, it will be added to the volume of exhaust gas (wet), therefore the burner should be placed in a specified amount of water, and the amount of increase in moisture over a specified length of time should be obtained. If the value is listed in the burner's catalog or other reference material, that value can be used instead.

*6: If operation meters are not available, measurements should be taken with an anemomaster at the suction part of the air blowers for combustion. If a straight pipe portion of sufficient length and a measuring hole are available, a Pitot tube may be used instead.

*7: If air consumption (⑰) is measured with an anemomaster, the temperature should also be measured with the anemomaster. Or, it can be substituted with room temperature as with item ④.

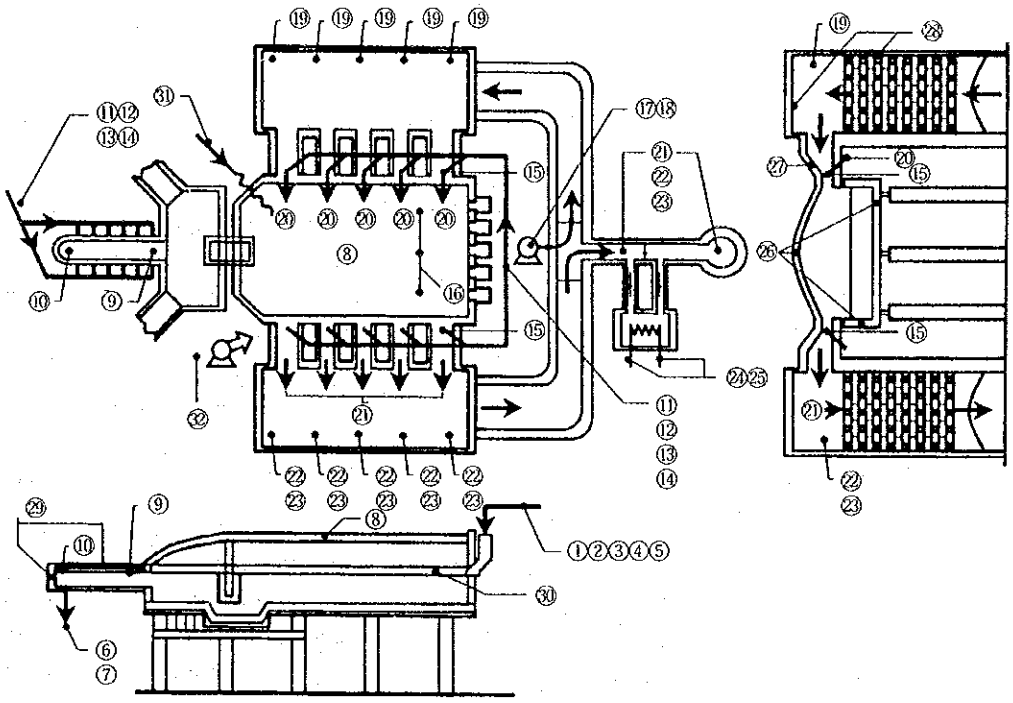
*8: If there are many blowoff openings, measure the other blowoff parts with a thermocouple.

*9: Collect the drainage in a container (such as a bucket), and measure the length of time spent on the collection, and the amount of drainage collected. At the same time, measure the temperature difference compared with the water supply.

*10: Measure it with an anemomaster at the suction part of the air blower. Or, the design performance value can be used as a substitute.

c. The measurement points for a glass melting furnace are shown in Figure 9.4.1.

Figure 9.4.1 Measuring Points of Melting Furnace



(2) Glass Annealing Lehr

a. Purpose of measurement

The purpose is to perform the heat balance of a glass annealing lehr and thereby grasp the current operation state.

b. Measurement items, measurement time, measuring equipment, and data processing

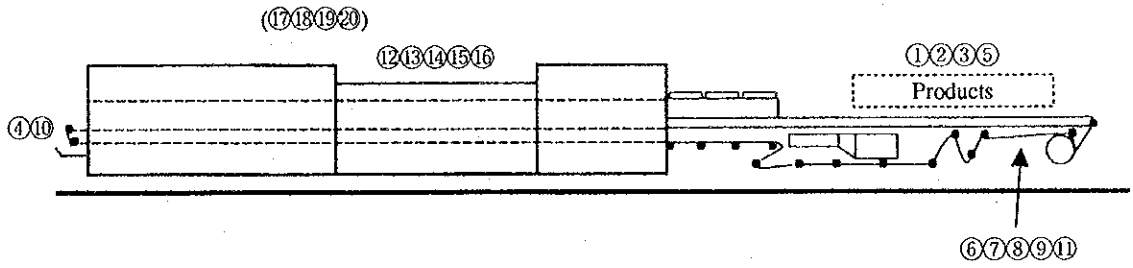
	Measurement items	Measurement time	Measuring equipment	Data processing
Glass product	① Product shape and thickness	hearing	Operation record	Memo
	② Product weight t/h	24 h	Operation record	Memo
	③ Product strain μm/cm	hearing	Operation record	Memo
	④ Annealing lehr inlet temperature (*1)	spot	Bar thermometer, balance	Memo
	⑤ Annealing lehr outlet temperature (*2)	spot	Bar thermometer, balance	Memo
Chain belt	⑥ Weight kg/m²	hearing	Operation record	Memo
	⑦ Material	hearing	Operation record	Memo
	⑧ Width	hearing	Operatoin record	Memo
	⑨ Inlet temperature	spot	Surface temperature	Memo
	⑩ Outlet temperature	spot	Surface temperature	Memo
	⑪ Traveling speed	spot	stopwatch	Memo
Annealing lehr	⑫ Dimensions and structure	hearing	Operation record	Memo
	⑬ Wall thickness and material	hearing	Operation record	Memo
	⑭ Ambient temperature (6 points)	24 h	Thermocouple	to Recorder
	⑮ Outside surface temperature	spot	Surface temperature	Memo
	⑯ Area of openings and furnace inside temperature	spot	Thermocouple (at the same time as for ⑭)	to Recorder
Energy	⑰ Fuel consumption and fuel temperature	24 h	Operation record	Memo
	⑱ Power consumption	24 h	Operation record	Memo
	⑲ Combustion air flow rate and temperature	spot	anemomaster	Memo
	⑳ Cooling air volume	spot	anemomaster	Memo

Note: *1, *2: To be obtained from the difference, ΔT, in water temperature produced after putting the product into a specified volume of water (10 L).

c. Measuring points

Figure 9.4.2 shows the measuring points of the glass annealing lehr.

Figure 9.4.2 Measuring Points of Annealing Lehr



(4) Energy Utilization Facilities

Equipment	Targeted equipment or location	Measurement time
Electricity management	Booster (Shops A and B)	24 h
	Entire factory(Power receiving station)	24 h
	Annealing furnace	6 to 8 h
Fan/blower	132 kW × 2 and others	spot
Air compressor	200 kW × 4	spot
	450 kW	24 h
Electric motor	Main equipment for shops A and B	spot
Transformer	TA1, 2	24 h
	RNN1, 2	24 h
	Annealing furnace	24 h
Lighting	Various locations in the factory	spot
Pump	Vacuum pump	spot
Boiler	Boiler room	24 h
Steam pipe	Various locations in the factory	spot

For the measuring method and the measuring points, see "10. ENERGY UTILIZATION FACILITIES".

Check List for Glass Works (1)

1 General Items

① Production (tonne) / Operation (hours) (Annual data)

[Plant = Tank]

	Design Capa.	1992	1993	1994	1995	1996
No.1 Plant						
No.2 Plant						
No.3 Plant						
No.4 Plant						
No.5 Plant						
No.6 Plant						
No.7 Plant						
No.8 Plant						
Plant						
Plant						
Plant						
Plant						

② Utility Consumption (Annual data)

	Design Quant.	1992	1993	1994	1995	1996
Coal (t)						
Heavy Oil (kl)						
Kerosene (kl)						
Natural Gas (Nm^3)						
Other Gas (Nm^3)						
Electric Power (kWh)						
Water: Circulate (t)						
Water: fresh supply (t)						

③ Quality and Price of Energy (Existing)

	Coal	H-Oil	Kerose.	Natu.G.	Other G.	Elec.
Sp. gr.						
C (%)						
H (%)						
S (%)						
Hh (Kcal/kg)						
Hl (Kcal/kg)						
Price (Zl)						

4. Ratio of Energy cost Product cost (Existing)

No.1 Plant %, No.2 Plant %, No.3 Plant %

⑤ Chemical Composition of Products (Existing)

	Vacum bottle	TEMISIL -2	TEMISIL -3	TEMISIL -5	Packing glass	No.8 Tank
SiO_2 (%)						
Al_2O_3 (%)						
Fe_2O_3 (%)						
CaO (%)						
MgO (%)						
Na_2O (%)						
K_2O (%)						
Li_2O (%)						
B_2O_3 (%)						
BaO (%)						
(%)						
(%)						
(%)						
(%)						
(%)						

⑥ Grain size Distribution of Silica sand (Existing)

	<125$^{\mu}$	125$^{\mu}$ ~	250$^{\mu}$ ~	500$^{\mu}$ ~	1190$^{\mu}$ <
Plant					
Plant					
Plant					

⑦ Kind of Soda ash (Existing)

☐ Synthetic ☐ Natural

☐ Dense ☐ Heavy ☐ Light

8. Batch Composition (Existing)

[T: Tank furnace] (kg/Batch)

		T－1	T－2	T－3	T－5	T－7	T－8
○	Silica sand						
	Dolomite						
	Lime stone						
○	Feldspar						
	Calumite, Slag						
○	Soda ash						
	Salt cake						
	Sodium nitrate						
	Spodumene						
○	Boric oxide, Brax,Colemanite, Ulexite						
	Carbon						
	Refining agent						
	Water in batch (%)						
○	Cullet(circulation) in the factory						
○	Cullet(recovery) from town						

Check List for Glass Works (4)

⑨ Melting Quality of Products (Existing)

	Seed count	Stone count
Vacum bottle	PCS/gr	PCS/kg
TERMISIL - 2		
TERMISIL - 3		
TERMISIL - 5		
Packing glass		
No.8 Tank		

⑩ Operation Progress (Bar Chart)

	1985	'8	'87	'88	'89	'90	'91	'92	'93	'9	'95	'96
Example												
T - 1												
T - 2												
T - 3												
T - 5												
T - 7												
T - 8												

⑪ Break - down of Energy Consumption (Estimate % 1995)

	Furnace			Forming			Annealing			Processing			Others
	N-Gas	L-O_2	Elec.	N-Gas	L-O_2	Elec.	N-Gas	L-O_2	Elec.	N-Gas	L-O_2	Elec.	
T - 1													
T - 2													
T - 3													
T - 5													
T - 7													
T - 8													
													N-Gas 100%
Total													L-O2 100% Elec. 100%

⑫ List of Main Equipments and Machinery

Name	Type	Rated Capacity		Motor (kW)	No. (PCS)	Actual load(%)
		Quant.	Press.			

13. Intormation of Glass industry in Poland (1995)

(tonne)	Production	Sales	Import	Export
Flat glass total				
Float glass				
Sheet glass				
Figured glass				
Hollow glass total				
○ bottle glass				
○ Table ware glass				
○ Oven proof glass				
○ Laboratory glass				
Electric glass				
○ Vacum bottle glass				
Other hollow glass				
Optical glass				
Fiber glass				
Crystal glass				

2 No.1 Plant (Tank - 1)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Morton glass(t)	Cullet (t)	Room Temp. A.V.(℃)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCS.

○ Partition : ☐ DC, ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber :

Canal, Forehearth : No. PCS

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O_2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCS, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCS

5. Temperature

○	M. T. Crown Arch	℃,	max.	℃
○	M. T. Glass M. T. Bottom	Glass : ℃,	Bottom :	
	Port End	℃,	℃,	℃
○	Flue	℃,	℃	
○	Air Preheat	℃,	℃,	℃
	Bridge Wall		℃	
	R. T. or Working Chamber	℃,	℃	
○	Forehearth	℃,	℃,	℃
	Gob	℃,	℃,	℃

⑥ Heat Recovery

☐ Regenerator ☐ Recuperate ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCS

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperate ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air : (Nm^3/h) × (PCS)

Wall cooling Air : (Nm^3/h) × (PCS)

F. H. Heating Burner (Nm^3/h) × (PCS)

Bubblier : (Nm^3/h) × (PCS)

8. Cooling Water

Batch charger : (t/h) × (PCS)

Reversal Damper : (t/h) × (PCS)

Burner cooler : (t/h) × (PCS)

Electrode holder : (t/h) × (PCS)

Tuck cooler : (t/h) × (PCS)

Throat cover cooler (t/h) × (PCS)

Stirrer : (t/h) × (PCS)

Sheet cooler, Floate (t/h) × (PCS)

Other coolers : (t/h) × (PCS)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (°C)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (11)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

3 No.2 Plant (Tank - 2)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Molton glass(t)	Cullet (t)	Room Temp. A.V.(℃)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCs.

○ Partition : ☐ D.C., ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber : mm

Canal, Forehearth : No. PCs

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCs, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCs

5. Temperature

○	M. T. Crown Arch	°C,	max.	°C
○	M. T. Glass	Glass : °C,	Bottom :	
	M. T. Bottom			
	Port End	°C,	°C,	°C
○	Flue	°C,	°C	
○	Air Preheat	°C,	°C,	°C
	Bridge Wall		°C	
	R. T. or Working Chamber	°C,	°C	
○	Forehearth	°C,	°C,	°C
	Gob	°C,	°C,	°C

⑥ Heat Recovery

☐ Regenerator ☐ Recuperator ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCs

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperator ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air :	(	Nm^3/h)	×	(	PCs)
Wall cooling Air :	(	Nm^3/h)	×	(	PCs)
F. H. Heating Burner	(	Nm^3/h)	×	(	PCs)
Bubblier :	(	Nm^3/h)	×	(	PCs)

8. Cooling Water

Batch charger :	(	t/h)	×	(	PCs)
Reversal Damper :	(	t/h)	×	(	PCs)
Burner cooler :	(	t/h)	×	(	PCs)
Electrode holder :	(	t/h)	×	(	PCs)
Tuck cooler :	(	t/h)	×	(	PCs)
Throat cover cooler	(	t/h)	×	(	PCs)
Stirrer :	(	t/h)	×	(	PCs)
Sheetcooler, Floater	(	t/h)	×	(	PCs)
Other coolers :	(	t/h)	×	(	PCs)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (℃)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (16)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

4 No.3 Plant (Tank - 3)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Molton glass(t)	Cullet (t)	Room Temp. A.V.(℃)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCs.

○ Partition : ☐ D.C., ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber : mm

Canal, Forehearth : No. PCs

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O_2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCs, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCs

5. Temperature

○	M. T. Crown Arch	℃,	max.	℃
○	M. T. Glass M. T. Bottom	Glass : ℃,	Bottom :	
	Port End	℃,	℃,	℃
○	Flue	℃,	℃	
○	Air Preheat	℃,	℃,	℃
	Bridge Wall		℃	
	R. T. or Working Chamber	℃,	℃	
○	Forehearth	℃,	℃,	℃
	Gob	℃,	℃,	℃

⑥ Heat Recovery

☐ Regenerator ☐ Recuperator ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCs

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperator ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air : (Nm^3/h) × (PCs)

Wall cooling Air : (Nm^3/h) × (PCs)

F. H. Heating Burner (Nm^3/h) × (PCs)

Bubblier : (Nm^3/h) × (PCs)

8. Cooling Water

Batch charger : (t/h) × (PCs)

Reversal Damper : (t/h) × (PCs)

Burner cooler : (t/h) × (PCs)

Electrode holder : (t/h) × (PCs)

Tuck cooler : (t/h) × (PCs)

Throat cover cooler (t/h) × (PCs)

Stirrer : (t/h) × (PCs)

Sheetcooler, Floater (t/h) × (PCs)

Other coolers : (t/h) × (PCs)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (°C)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (21)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

5 No.5 Plant (Tank – 5)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Morton glass(t)	Cullet (t)	Room Temp. A.V.(℃)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCS.

○ Partition : ☐ DC, ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber :

Canal, Forehearth : No. PCS

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O_2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCS, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCS

5. Temperature

○	M. T. Crown Arch	°C,	max.	°C
○	M. T. Glass M. T. Bottom	Glass : °C,	Bottom :	
	Port End	°C,	°C,	°C
○	Flue	°C,	°C	
○	Air Preheat	°C,	°C,	°C
	Bridge Wall		°C	
	R. T. or Working Chamber	°C,	°C	
○	Forehearth	°C,	°C,	°C
	Gob	°C,	°C,	°C

⑥ Heat Recovery

☐ Regenerator ☐ Recuperate ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCS

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperate ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air : (Nm^3/h) × (PCS)

Wall cooling Air : (Nm^3/h) × (PCS)

F. H. Heating Burner (Nm^3/h) × (PCS)

Bubblier : (Nm^3/h) × (PCS)

8. Cooling Water

Batch charger : (t/h) × (PCS)

Reversal Damper : (t/h) × (PCS)

Burner cooler : (t/h) × (PCS)

Electrode holder : (t/h) × (PCS)

Tuck cooler : (t/h) × (PCS)

Throat cover cooler (t/h) × (PCS)

Stirrer : (t/h) × (PCS)

Sheet cooler, Floate (t/h) × (PCS)

Other coolers : (t/h) × (PCS)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (°C)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (26)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator.		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

6 No.7 Plant (Tank - 7)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Morton glass(t)	Cullet (t)	Room Temp. A.V.(°C)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCS.

○ Partition : ☐ DC, ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber :

Canal, Forehearth : No. PCS

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O_2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCS, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCS

5. Temperature

○	M. T. Crown Arch	℃,	max.	℃
○	M. T. Glass M. T. Bottom	Glass : ℃,	Bottom :	
	Port End	℃,	℃,	℃
○	Flue	℃,	℃	
○	Air Preheat	℃,	℃,	℃
	Bridge Wall		℃	
	R. T. or Working Chamber	℃,	℃	
○	Forehearth	℃,	℃,	℃
	Gob	℃,	℃,	℃

⑥ Heat Recovery

☐ Regenerator ☐ Recuperate ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCS

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperate ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air : (Nm^3/h) × (PCS)

Wall cooling Air : (Nm^3/h) × (PCS)

F. H. Heating Burner (Nm^3/h) × (PCS)

Bubblier : (Nm^3/h) × (PCS)

8. Cooling Water

Batch charger : (t/h) × (PCS)

Reversal Damper : (t/h) × (PCS)

Burner cooler : (t/h) × (PCS)

Electrode holder : (t/h) × (PCS)

Tuck cooler : (t/h) × (PCS)

Throat cover cooler (t/h) × (PCS)

Stirrer : (t/h) × (PCS)

Sheet cooler, Floater (t/h) × (PCS)

Other coolers : (t/h) × (PCS)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (°C)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (31)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

7 No.8 Plant (Tank - 8)

① Production and Energy Consumption (Monthly data)

1996	Product (t)	Fuel (Nm^3)	Elec. (kWh)	Morton glass(t)	Cullet (t)	Room Temp. A.V.(℃)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						
Total						

2. Furnace

Furnace Life : months

○ Area of Melter : (W : mm) × (L : mm)

○ Depth of Melter : mm

Port : Width mm, Pitch mm, No. PCS.

○ Partition : ☐ DC, ☐ Neck, ☐ Throat, ☐ Skimmer

Area of Refiner, Working chamber : (W : mm) × (L : mm)

Depth of Refiner, Working chamber :

Canal, Forehearth : No. PCS

3. Combustion

○ Burner Pressure : kg/cm^2

Atomizer : ☐ None, ☐ Air, ☐ Steam, Nm^3/h

Purging Air or steam : Nm^3/h

Position of Burner : ☐ Top, ☐ Side, ☐ Under, ☐ Through

Distribution Ratio : 1P %,2P %,3P %,4P %,

O_2 % in Exhaust Gas : 1P %,2P %,3P %,4P %,

〃 Under Chimney %

○ Oxygen Burner : No. PCS, Nm^3/h

④ Electrode Heating

Electrode : Capacity kW, Nor. kWh/h

〃 ☐ Top ☐ Side ☐ Bottom , Total PCS

5. Temperature

○	M. T. Crown Arch	℃,	max.	℃
○	M. T. Glass M. T. Bottom	Glass : ℃,	Bottom :	
	Port End	℃,	℃,	℃
○	Flue	℃,	℃	
○	Air Preheat	℃,	℃,	℃
	Bridge Wall		℃	
	R. T. or Working Chamber	℃,	℃	
○	Forehearth	℃,	℃,	℃
	Gob	℃,	℃,	℃

⑥ Heat Recovery

☐ Regenerator ☐ Recuperate ☐ Waste heat Boiler

Regenerator : (W : mm) × (L : mm) × No. PCS

Volume of Checker : m^3, Height : mm

Type of Checker : ☐ Pigeon hole ☐ O. B. W. ☐ Cruciform

Checker Brick Size : (W : mm) × (L : mm) × (T : mm)

Type of Recuperate ☐ Convection ☐ Radiation ☐ Ceramic

Waste heat Boiler : Capacity t/h , Pressure kg/cm^2

7. Cooling Air, Heating Gas and Bubblier

Sheet cooling Air : (Nm^3/h) × (PCS)

Wall cooling Air : (Nm^3/h) × (PCS)

F. H. Heating Burner (Nm^3/h) × (PCS)

Bubblier : (Nm^3/h) × (PCS)

8. Cooling Water

Batch charger : (t/h) × (PCS)

Reversal Damper : (t/h) × (PCS)

Burner cooler : (t/h) × (PCS)

Electrode holder : (t/h) × (PCS)

Tuck cooler : (t/h) × (PCS)

Throat cover cooler (t/h) × (PCS)

Stirrer : (t/h) × (PCS)

Sheet cooler, Floate (t/h) × (PCS)

Other coolers : (t/h) × (PCS)

9. Heat Loss from Wall Surface

			Outer Surface Area (m^2)	Surface Temp (℃)	Unit Heat Loss (kcal/m^2h)	Heat Loss (kcal/h)	Remark
Bottom Block	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Side Block	M.T.	Upper					
		Under					
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Crown Arch & Cover	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Back Wall							
Breast Wall	M.T.						
	Throat						
	R.T.,Wor.Ch.						
	Canal						
	Forehearth						
Breast Wall							
Wing Wall	Front Wall						
	F.H.End						
Port	Arch						
	Side						
	Bottom						
Regene-rator	Crown						
	Side Wall	Upper					
		Middle					
		Lawer					
	End Wall						
	Bottom						
Total							

Check List for Glass Works (36)

⑩ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Application
Raw material	1	Improvement of raw material's character		
	2	Recirculating use of city cullet		
Utilities	1	Conversion of fuel		
	2	Introduction of electric booster		
	3	Introduction of oxygen burner or oxygen enriched burner		
Fuel	1	Increase in furnace scale		
	2	Improvement of furnace structure		
	3	Insulation of furnace crown, side wall and bottom		
	4	Improvement of sealing of opening parts		
	5	Improvement of cooling loss (water cooler, air cooling)		
	6	Improvement of Recuperator.		
	7	Improvement of checker height or shape in regenerator		
Operation	1	Increase in melting load (t/m^2)		
	2	Increase in productivity (Yield rate up)		
	3	Improvement of excess air ratio		
Forming	1	Improvement of forming machine		
Annealing	1	Improvement of annealing lehr		
Others	1	Installation of waste heat boiler etc.		
Management	1	Enrichment of instrumentation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

9.4.2 Silica Block (Silikaty)

(1) Autoclave

a. Purpose of measurement

The purpose is to grasp the current operation status in order to perform the heat balance of the autoclave.

b. Measurement item, measurement time, measuring equipment, and data processing

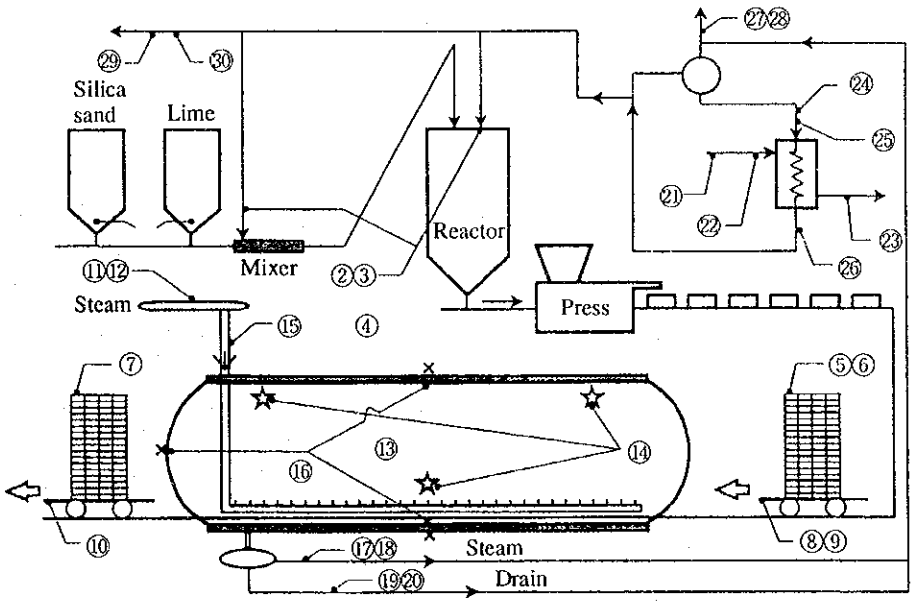
	Measurement items	Measurement time	Measuring equipment	Data processing
Material	① Silica sand/lime mixing ratio	–	Operation record	Memo
Raw glass	② Content of water added (%)	–	Operation record	Memo
plate	③ Temperature of water added	24 h	Thermocouple	to Recorder
Product	④ Ambient temperature	24 h	Thermocouple	to Recorder
	⑤ Temperature of raw glass plate immediately before being carried in ACV	spot	Radiation thermometer	Memo
	⑥ Amount of raw glass plate carried in ACV	24 h	Operation record	Memo
	⑦ Product temperature immediately after being carried out of ACV	spot	Radiation thermometer	Memo
Charging car	⑧ Weight and material of the charging car	–	–	Memo
	⑨ Charging car temperature immediately before being carried in ACV	spot	Surface thermometer	Memo
	⑩ Charging car temperature immediately after being carried out of ACV	spot	Surface thermometer	Memo
Steam	⑪ Temperature and pressure of steam for ACV	24 h	Meters for operation	Memo
	⑫ Steam consumption for ACV	24 h	Operation record	Memo
Autoclave	⑬ ACV time schedule	1 cycle	Operation record	Memo
(ACV)	⑭ ACV temperature/pressure	1 cycle	Meters for operation	Memo
	⑮ ACV steam flow rate	1 cycle	Meters for operation	Memo
	⑯ ACV surface temperature	1 cycle	Thermocouple	to Recorder
	⑰ Amount of steam emitted from ACV	1 cycle	Meters for operation	Memo
	⑱ Temperature of steam discharged from ACV	1 cycle	Thermocouple	to Recorder
	⑲ Amount of condensate discharged from ACV	1 cycle	Meters for operation	Memo
	⑳ Temperature of condensate discharged from ACV	spot	Thermocouple	to Recorder

	Measurement items	Measurement time	Measuring equipment	Data processing
Heat exchanger	㉑ Boiler pure water flow rate	24 h	Ultrasonic flowmeter	to Recorder
	㉒ Pure water temperature at heat exchanger inlet	24 h	Thermocouple	to Recorder
	㉓ Pure water temperature at heat exchanger outlet	24 h	Thermocouple	to Recorder
	㉔ Temperature of recovered hot water at heat exchanger inlet	24 h	Thermocouple	to Recorder
	㉕ Temperature of recovered hot water at heat exchanger outlet	24 h	Thermocouple	to Recorder
	㉖ Flow rate of recovered hot water	24 h	Ultrasonic flowmeter	to Recorder
Discharge	㉗ Amount of steam discharged	24 h	Meters for operation	Memo
	㉘ Temperature of steam discharged	24 h	Thermocouple	to Recorder
	㉙ Amount of condensate discharged	24 h	Meters for operation	Memo
	㉚ Temperature of condensate discharged	24 h	Thermocouple	to Recorder

c. Measuring points

Figure 9.4.3 shows the measuring points of the autoclave.

Figure 9.4.3 Measuring Points of Autoclave



(2) Energy utilization facilities

Equipment name	Targeted equipment or location	Measurement time
Electricity control	Power receiving facilities	24 h
Fan/blower	For boiler	24 h
Air compressor	Mixer, press	24 h
Electric motor	Mixer	24 h
Transformer	Major equipment	24 h
Lighting	Various locations of the factory	spot
Pump	For boiler feedwater	24 h
Boiler	Boiler room	24 h
Steam pipe	Various locations of the factory	spot

For the measurement method and the measuring points, see "ENERGY UTILIZATION FACILITIES".

Check List for Silica Block Works (1)

1 General Item

① Production (Annual data)

(tonne or PCS)

	Design Capa.	1992	1993	1994	1995	1996

② Operation Hours (Annual data)

	Design Hours	1992	1993	1994	1995	1996

③ Utility Consumption (Annual data)

	Design Quant.	1992	1993	1994	1995	1996
Coal (t)						
Others Fuel						
Electric Power (kWh)						
Steam for Actoclave (t)						
Water for Boiler (t)						
Water for Others (t)						

④ Quality and Price of Energy (Existing)

	Coal		Electric	
Sp. gr.				
C (%)				
H (%)				
S (%)				
Hh (Kcal/kg)				
Hl (Kcal/kg)				
Price (Zl)				

5. Ratio of Energy cost Product cost (Existing)

Fuel %, Electricity %

⑥ Quality of Products (Existing)

CaO (%)			
SiO_2 (%)			
Density (kg/m^3)			
Specific (kcal/kg°C)			
Heat conductivity (kcal/mh°C)			
Modulus of Rupture (kg/cm^2)			

2 Specification of Rawmaterials

① Chemical Composition and grain size Distribution

Silica sand	
Lime	

② Mixing Rate

Silica sand	%	%	%
Lime	%	%	%
	%	%	%
Water	%	%	%

③ Monthly Data of Production and Utility Consumption

1996	Product (t or PCS.)			coal (t)	elec. (kWh)	water (t)
Jan.						
Feb.						
Mar.						
Apr.						
May.						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.						
Nov.						
Dec.						

④ List of Main Equipments and Machinery

Name	Type	Rated Capacity		Motor	No.	Actual
		Quant.	Press.	(kW)	(PCS)	load (%)

Check List for Silica Block Works (5)

⑤ Energy Conservation Technology

A : Installed / Introduced
B : Under Construction
C : Under Planning

Process		Items	Application	Year of Appreciation
Rawmaterials	1	Improvement of rawmat-erial's character		
	2	Improvement of mixing rate and water content		
Forming		Improvement of press form-ing method		
Fuel and Boiler	1	Improvement of coal's character for boiler		
	2	Exchange of boiler's type or capacity		
	3	Improvement of boiler for energy conservation		
	4	Improvement of operation control of boiler		
	5	Improvement of application control of boiler		
Autoclave	1	Exchange of size of auto-clave		
	2	Improvement of autoclave (insulation and so on)		
	3	Improvement of filling rate into the auto clave		
	4	Improvement of operation pressure and temperature		
	5	Improvement of time circle (from carry in to carryout)		
	6	Improvement of rotation schedule of autoclaves		
	7	Improvement of recovery me-thod of waste steam and drain		
Product	1	Improvement of productivity (yield rate up)		
	2	Improvement of quality of product		
Management	1	Enrichment of instrum-entation		
	2	Introduction of computer control system		
	3	Promotion of campaign for TQC, TPM and so on		

Check List / Building Brick

Autoclave

Date: _____

Factory / Company: _____

Written by: _____

General Information:

No. of autoclaves installed _____

Steam come from:

Concept of autoclave system (diagram, handwritten)

_____

Specification (designed):

Type _____

Manufactured by _____

Installed at _____

Body size _____

Diameter, cylindrical length _____

Heat insulation _____

Material / thickness _____

Operating condition

Charged material _____

Tons/charge _____

Specific heat _____

Water content _____

Charging temperature _____

Discharging temperature _____

Charging car

Material / weight _____

Time cycle chart

charging / steaming / discharging / waiting _____

Condensate recovery

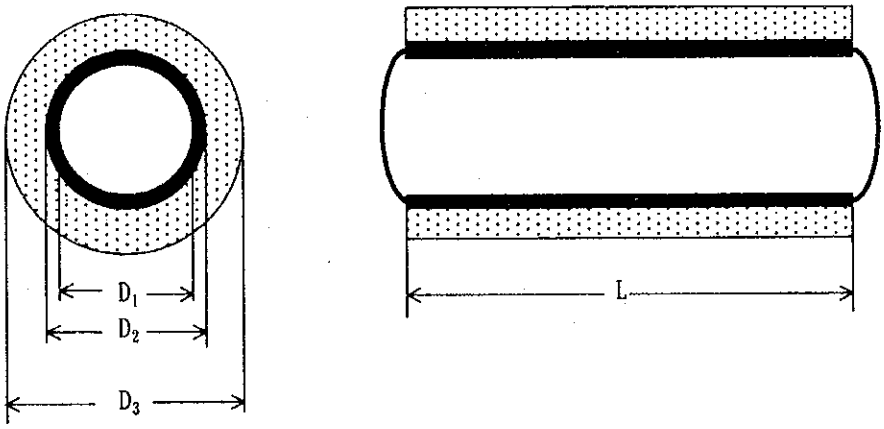
_____

Annual Working Condition:

Yearly working days or hours _____

Daily running hours _____

Dimension and Material



D_1 = mm

D_2 = mm

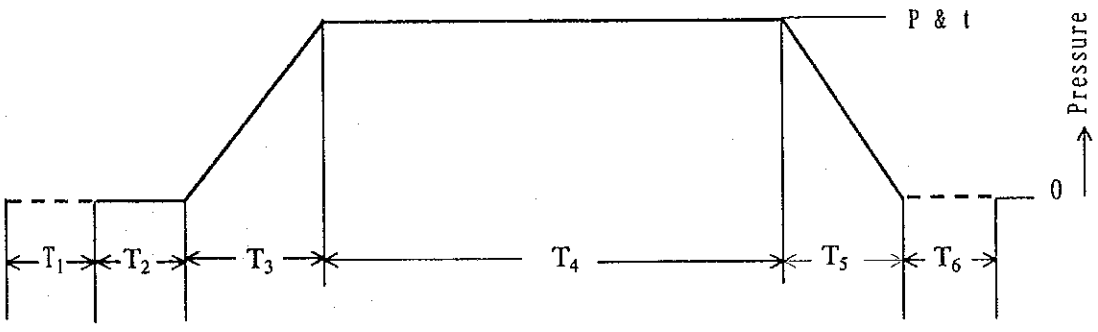
D_3 = mm

L = m

Material of Body :

Material of Heat Insulator :

Operation Time circle and Pressure and Temperature



Time (min) : carry in T_1( ), air purge T_2( )

pressure up T_3( ), hot ding T_4( )

pressure down T_5( ), carry out T_6( )

Pressure (kg/cm^2) P :

Temp (℃) t :

Heat Recovery of Exhaust Steam and Drain

☐ Yes ☐ No

→ Application _____

Supply Users of Steam except Autoclave

☐ Yes ☐ No

→ What place ? How many ?

9.5 Food Industry

9.5.1 Olvit (Vegetable oil)

(1) Deodorizer

a. Purpose of measurement

The purpose is to grasp the heat utilization state in a deodorizer.

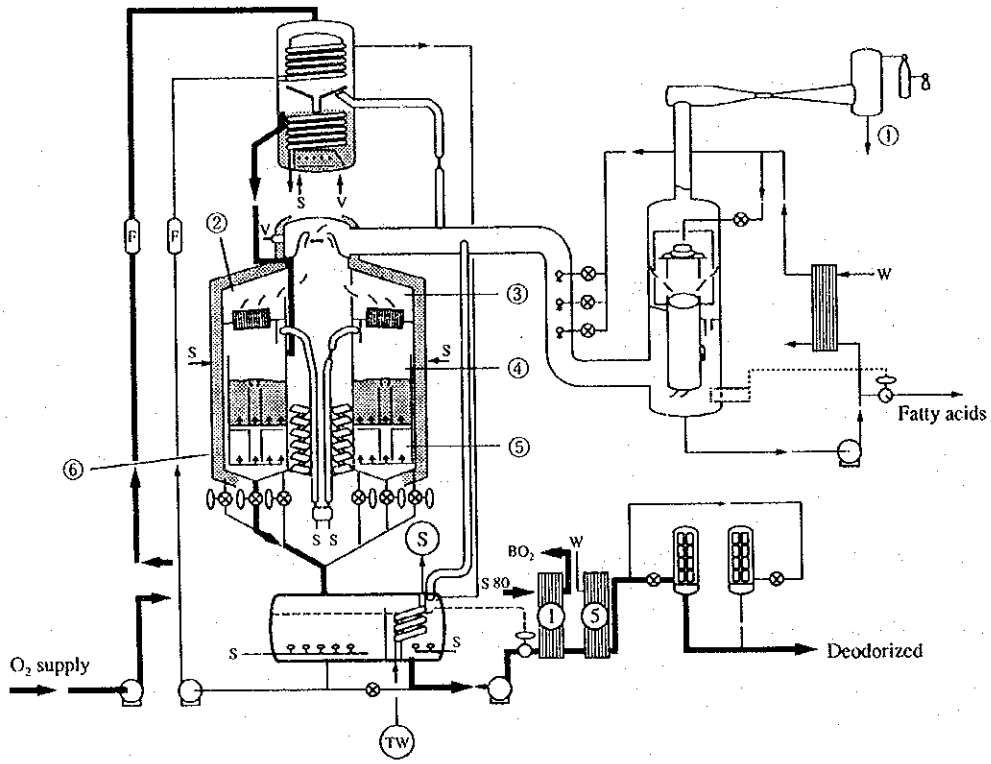
b. Measurement items, measurement time, measuring instruments, and data processing

Measurement items	Measurement time	Measuring equipment	Data processing
① Steam pressure of steam ejector	24 h	Meter for operation	Memo
② Vacuum	24 h	Meter for operation	Memo
③ Deodorizer upper stage temperature	24 h	Meter for operation	Memo
④ Deodorizer middle stage temperature	24 h	Meter for operation	Memo
⑤ Deodorizer lower stage temperature	0.1 h × 4 times	Meter for operation	Memo
⑥ Deodorizer wall temperature	0.1 h × 4 times	Thermocouple	to Recorder

c. Measuring points

The measuring points are shown in Figure 9.5.1.

Figure 9.5.1 Measuring Points of Deodorizer



(2) Hydrogenation Tank

a. Purpose of measurement

The purpose is to grasp the heat utilization state in a hydrogenation tank.

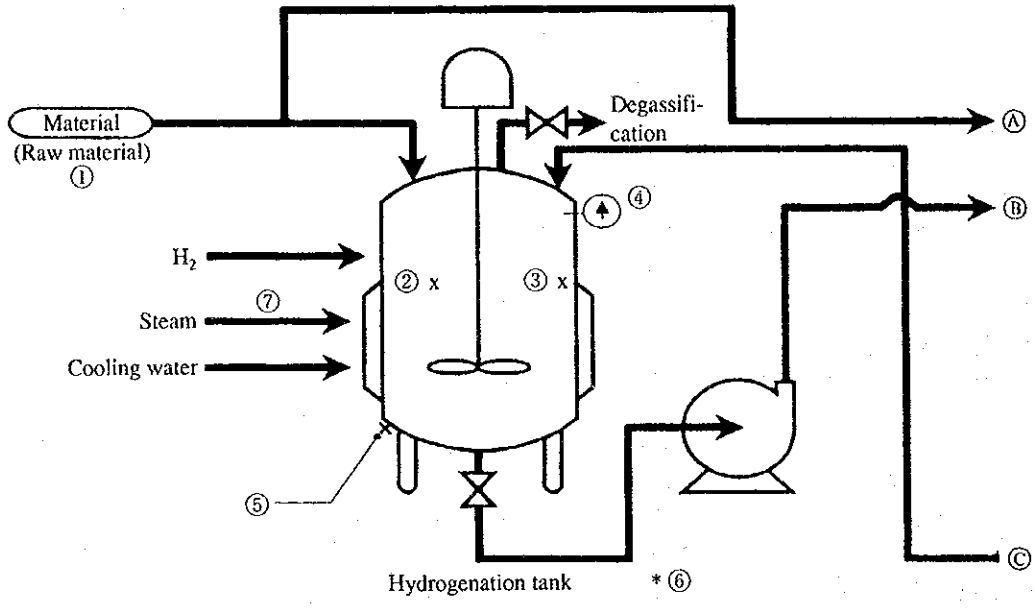
b. Measurement items, measurement time, measuring equipment and data processing

Measurement items	Measurement time	Measuring equipment	Data processing
① Raw oil temperature	24 h	Thermocouple	to Recorder
② Internal temperature at blowing hydrogen	24 h	Thermocouple	to Recorder
③ Internal pressure on completion of hydrogen blowing	24 h	Thermocouple	to Recorder
④ Pressure of the hydrogenation tank	24 h	Meter for operation	Memo
⑤ Hydrogenation tank wall temperature	0.1 h × 4 times	Thermocouple	to Recorder
⑥ Room temperature	0.1 h × 4 times	Thermocouple	to Recorder
⑦ Steam pressure	24 h	Pressure transmitter	to Recorder

c. Measuring points

Figure 9.5.2 shows the measuring points of a hydrogenation reactor.

Figure 9.5.2 Measuring Points of a Hydrogenation Reactor



(3) Energy Utilization Facilities

Equipment	Tatgeted equipment or location	Measurement Time
Electricity management	Power receiving station	24 h
	Electrolytic cell	24 h
	Deodorization of oil	spot
	Agitator for refining	spot
	Mixer of margarine	spot
	Vacuum for refining	spot
Fan/blower	Cooling fan for margarine	spot
Electric motor	NH_3 refrigerator	
Air compressor	NH_3 compressor	24 h
	H_2 compressor	spot
Pump	Cooling water pump	24 h
Transformer	Electrolytic cell	24 h
Lighting	Each process	spot
Boiler	Boiler room	24 h
Steam pipe	Various locations in the factory	spot

For the measurement method, measuring points, etc., see "10. ENERGY UTILIZATION FACILITEIS".

Check List for Vegetable Oil (1)

Date
Surveyor

Factory Name

No.	Process Equipment	Item		Data		Note
1	Raw Oil	Name				
		Moisture			%	
		Oil Content			%	
2	Degumming	Centrifuge	Type			
			Number			
		Feed	Flow		l/min	
			Temp		℃	
		Water	Flow		l/min	
			Temp		℃	
		Dryer	Press		Torr	
			Temp		℃	
		Ejector St.	Press		kg/cm^2	
			Flow		kg/h	
			Diameter		mm	
		Aftercooler	Area		m^2	
			Temp	In	℃	
				Out	℃	
		Oil Moisture		Out	%	
		Dealing with Gum				
3	Neutralization	Centrifuge	Type			
			Number			
		Feed	Flow		l/min	
			Temp.		℃	
		NaOH	Flow		l/min	
		Phos. Acid	Flow		l/min	
		Dryer	Press		Torr	
			Temp.		℃	
		Room	Temp.		℃	
4	Bleaching	Auxiliaries			%	
		Bleach Tank	Type			
			Press		Torr	
			Temp.		℃	
		filter	Type			
			Number			
			Flow		l/min	
		Filteraid			ton/day	
5	Dewaxing	Reaction	Time		min	
			Temp		℃	
		Filter	Type			
			Number			
			Flow		l/min	
		Refrigerator	Type			
			Number			
			Capacity		kW	
			Flow		l/min	
			Temp	In	℃	
				Out	℃	
		Process Flowchart			℃	

Check List for Vegetable Oil (2)

No.	Process Equipment	Item	Data	Note
6	Deodorizing-1	Type Name		
		Reciever Tank		
		Capacity	No. 1 m^3	
			No. 2 m^3	
			No. 3 m^3	
		Temp.	No. 1 ℃	
			No. 2 ℃	
			No. 3 ℃	
		Mixing Tank		
		Capacity	No. 1 m^3	
			No. 2 m^3	
		Temp.	No. 1 ℃	
			No. 2 ℃	
		Out door Temp.	℃	
7	Deodorizing-2	Vacuum	Torr	
		Motor	kW	
		Ejector St. Press	kg/cm^2	
		Flow	kg/h	
		Diameter	mm	
		Barometric Condenser		
		Tray No		
		Capacity	t	
		Temp.	℃	
		Steam	kg/cm^2	
		Steam	kg/h	
		Stay Time	min.	
		Heater		
		Heat Transfer Area	m^2	
		Flow	l/min	
		Temp.	℃	
		Temp.	℃	
		Steam Pressure	kg/cm^2	
		Steam Flow	kg/h	
		Waste Heat Recovery		
		Heat Exchanger	spiral m^3	
			plate m^3	
		Room Temp.	℃	
		Water Temp.	℃	
8	Others	Running Cost		
		Steam	Zl/t	
		Electric Power	Zl/kWh	
		Filter	℃	
		Yield		
		Oil		
		Groats		
		Storage Tank	m^3	
		Product Quality		
		Water Content		
		Color		
		Acidity		
		Phospholipid		
9	Total Consumption (1995)	Refined Oil	kl	
		Sales	Zl or $	
		Electricity	kl	
			Zl or $	
		Fuel	kl	
			Zl or $	
		Water	kl	
			Zl or $	

Check List for Vegetable Oil (3)

No.	Process Equipment	Item	Data	Note
10	Hydrogenation			
	Bleached Oil Feed Pump	Capacity Flow Rate Temperature	kW L/min ℃	
	Preheater	Temperature	℃	
	Reactor	Capacity Temperature Time	m^3 ℃ h/batch	
	Oil Circulating Pump	Capacity	kW	
	Bleaching-Tank	Capacity Temperature Time	m^3 ℃ h/batch	
	Hydrogenation Transfer Pump	Capacity Flow Rate	kW m^3/min	
	Vacuum Pump	Capacity Pressure	kW mm/Hg	
	Hydrogenation Oil	Production Temperature	kL/day kL/month kL/year ℃	

Check List for Vegetable Oil (4)

Process	Item		Unit	Design	Actual
Bleaching	Productivity		t/hour		
	Filter		L/min		
	Working time		hour/day		
	Bleach tank	Press	Torr		
Deodorizing	Vacuum		Torr		
	Flow		L/min		
	Temperature in		deg.		
	Temperature out		deg.		
	Steam pressure		kg/cm^2		
	Steam flow		kg/cm^2		
	Productivity		t/day		
Hydrogenazation	Bleached oil	Productivity	t/day		
	Flow rate		L/min		
	Vacuum pump	Capacity	kW		
		Pressure	mm/Hg		
Plant total	Electricity consumption		kWh/t		
	Fuel consumption		Mcal/t		
	H_2 consumption		Nm^3/t		
	Cooling water consumption		m^3/t		

Check List for Vegetable Oil (5)

12. Production and Energy Consumption

	Unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

13. Energy consumption in 1995-1996

	Unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Steam												
Electricity												

14. Production

	Unit	1992	1993	1994	1995	1996
Raw oil						
Refined oil						
Hydrogenated oil						
Others						
Total						

15. Production in 1995-1996

	Unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Raw oil												
Refined oil												
Hydrogenated oil												
Others												
Total												

16. Production in 1995-1996 (%)

	Unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Raw oil	%	100	100	100	100	100	100	100	100	100	100	100
Refined oil	%											
Hydrogenated oil	%											
Others	%											
Total	%											

Check List for Vegetable Oil (6)

17. Energy consumption in 1996

	Production		Electricity	Natural gas	Oil	Compressed air	Hydrogen	Coal	Steam	Recycle water
Unit	Name	ton	10^3kWh	10^3Nm^3	L	10^3Nm^3	10^3Nm^3	ton	ton	10^3m^3
Bleaching of raw oil										
Deodorizing										
Others										
Total consumption										
Hydrogenation										
Packing										
Water										
Recycling										
Waste water										

	Production	Electricity	Natural gas	Oil	Compressed air	Hydrogen	Coal	Steam	Recycle water
Unit	ton	10^3kWh	10^3Nm^3	L	10^3Nm^3	10^3Nm^3	ton	ton	10^3m^3
Generated									
Purchased									
Process									
Others									
Total									
Max. demand									

Check List for Vegetable Oil (7)

31. Energy Conservation Method

Process	Item	Application	Year of application
Bleaching	1. Control of steam pressure 2. Insulation of tank 3. Vacuum system		
Deodorizing	1. Control of steam pressure 2. Heat recovery 3. Vacuum control 4. New deodorizing system		
Hydrogenation	1. Insulation of tank 2. Hydrogen generator 3. Recycle system of H_2 4. Heat recovery		
Packing	1. Heat recovery 2. Recovery of cooling water		
Cooling system	1. Temperature control 2. Recycle of water		
Boiler	1. Check of dowsum boiler 2. Pressure control 3. Heat recovery		

(A): Operating/Installed
(B): Not perfect but operating/Under construction
(C): Not operating/Under planning

9.5.2 Meat Processing Factory (Lubmeat, Koscian)

(1) Meat processing

a. Purpose of measurement

The purpose is to grasp the status of heat use in the manufacturing processes.

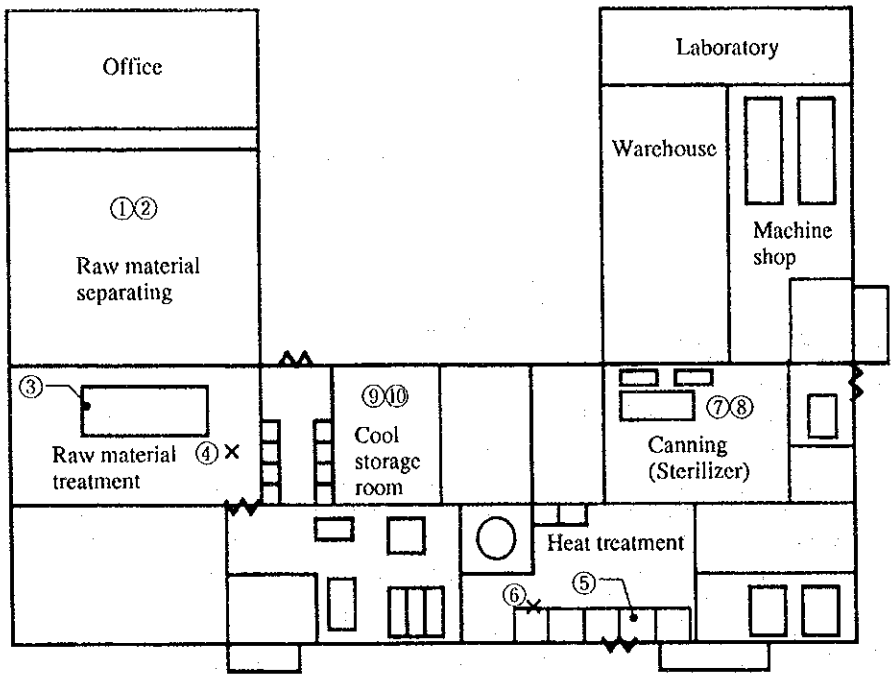
b. Measurement item, measurement time, measuring equipment, and data processing

	Measurement items	Measurement time	Measuring equipment	Data processing
Dissection room	① Temperature of hot water washing tank	0.1 h	Glass thermometer	Memo
	② Room temperature	0.1 h × 4 times	Glass thermometer	Memo
Raw material treatment room	③ Product temperature	0.1 h	Surface thermometer	Memo
	④ Room temperature	0.1 h × 4 times	Glass thermometer	Memo
Heat treatment room	⑤ Automatic smoking/decating room temperature	24 h	Thermocouple	to Recorder
	⑥ Steam pressure	24 h	Pressure gauge	to Recorder
Meat canning	⑦ Sterilizing temperature	24 h	Thermocouple	to Recorder
	⑧ Steam pressure	24 h	Pressure gauge	to Recorder
Refrigerator (Freezer)	⑨ Refrigerator inside temperature	0.1 h × 4 times	Glass thermometer	Memo
	⑩ Outdoor temperature	0.1 h × 4 times	Glass thermometer	Memo

c. Measuring points

Figure 9.5.3 shows the measuring points for the meat manufacturing processes.

Figure 9.5.3 Measuring Points of Meat Process



(2) Energy utilization facilities

Equipment name	Targeted equipment or location	Measurement time
Electricity control	Power receiving facilities	24 h
Fan/blower	Major equipment	spot
Electric motor	For NH_3 refrigerator	spot
Air compressor	NH_3 compressor	24 h
Pump	Cooling water pump	24 h
Transformer	Major equipment	24 h
Lighting	Various locations of the factory	spot
Boiler	Boiler room	24 h
Steam pipe	Various locations of the factory	spot

For the measurement method and the measuring points, see "ENERGY UTILIZATION FACILITIES".

Check List for Meat (1)

Factory name _____

No.	Process	Item			Note
1	Raw chicken	Handling			
2	Washing style	Container	Room temp.	deg.	
			Water temp.	deg.	
3	Chiller	Auto		t/year	
		Manual		t/year	
4	Treatment	Bath	Size	m^3	
			Temp.	deg.	
			pH		
5	Washing		Temp.	deg.	
6	Cooling	Spin chiller	Temp.	deg.	
7	Take to pieces	Capacity		t/day	
8	Packing	Capacity		t/day	
9	Freezing	Refrigerator	Temp.	deg.	
		Capacity		kW	
10	Waste	Waste water		m^3/year	
		BOD		m^3/year	
11	Total consumption (1996)	Steam		t/t-product	
		Electricity		kWh/t-product	

12	Chicken	Name	
		Yield	%
		Room temp.	deg.
		Feed flow	t/month

Monthly energy consumption (1995-1996)

	unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Steam												
Electricity												

Production and energy consumption (t/year)

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Waste water						

Check List for Meat (2)

No.	Process	Item			Note
13	Canning meat	Raw handling			
		Name			
		Capacity		t/day	
		Room temp.		deg.	
14	Defrost	Capacity		deg.hour	
15	Heating	Bath	Size	m^3	
			Temp.	deg.	
		Capacity		t/hour	
16	Meat slicer	Feed flow		kg/min	
17	Neoder	Bath	Size	m^3	
			Temp.	deg.	
			Batch	kg/min	
18	Packing	Capacity		t/day	
19	Sterilization	Capacity		t/batch	
		Temp.		deg.	
		Time		/day	
20	Total consumption (1996)	Steam		t/t-product	
		Electricity		kWh/t-product	

Check List for Meat (3)

21 Prepared food and instant food

Name
Slicer type
number
Feed flow kg/min
Feed temp. deg.
Room temp. deg.
Packing type
Capacity packs/hour

22 Preparator food

Monthly production in 1996 (t/year)

	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Production											

Production (t/year)

	1992	1993	1994	1995	1996
Production					

23 Instant food

Monthly production in 1996 (t/year)

	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Production											

Production (t/year)

	1992	1993	1994	1995	1996
Production					

24 Total consumption (1996)

Monthly energy consumption (1995-1996)

	unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Steam												
Electricity												

Production and energy consumption (t/year)

	unit	1992	1993	1994	1995	1996
Steam						
Electricity						

Check List for Meat (4)

No.	Process	Item			Note
25	Sliced ham	Capacity		t/day t/month t/year	
26	Pressed ham	Capacity		t/day t/month t/year	
27	Sausage	Capacity		t/day t/month t/year	
28	Chopper	Type Capacity		 t/day kW	
	Cutter	Type Capacity		 t/day kW	
	Injector	Feed temp. Capacity		deg. kW/h	
	Boiling house	Dry base Wet base Capacity	Temp. Temp. Size	deg. deg. kg/house	
	Vacuum packer	Vacuum Capacity Power		mm/$H_2$0 packs/h kW	

29. Design and operation information

Process	Item	Unit	Design	Actual
Raw chicken	Handling	t/day t/hour		
Chiller	Capacity Temperature Electricity	R.T. deg. kW		
Canning meat	Handling Sterization	t/day t/hour t/batch		
Preparated food	Productivity	t/hour t/day t/month		
Instant food	Productivity	t/day t/year		
Ham	Productivity	t/day		
Sausage	Productivity	t/day		

30. Energy Consumption in 1996

Process	Production	Electricity	Coal	Steam	Water
Unit	ton	10^3kWh	ton	ton	10^3m^3
Raw chicken					
Canning meat					
Prepared food					
Instant food					
Ham					
Sausage					

Process	Production	Electricity	Coal	Steam	Water
Unit		10^3kWh	ton	ton	10^3m^3
Generated					
Purchased					
Process					
Others					
Total					
Max. demand					

Check List for Meat (7)

31. Energy Conservation Method

Process	Item	Application	Year of application
Broiler	1. Speed control 2. Room temperature control system 3. Water control 4. Cooling system (Refrigerator)		
Ham, sausage, bacon	1. Steam control 2. Speed control 3. Vacuum control 4. Demand control 5. Chiller system 6. Others		
Canned food meat	1. Insulation 2. Steam pressure control 3. Time control 4 .Heat control 5. Cooling water control 6. Room temperature control 7. Boiler control system		
Others	1. Utility control		

(A): Operating/Installed
(B): Not perfect but operating/Under construction
(C): Not operating/Under planning

9.5.3 Milk Products (Obrzanska, Mlecz)

(1) Milk

a. Purpose of measurement

The purpose is to grasp the usage status of heat and electricity in the manufacturing processes.

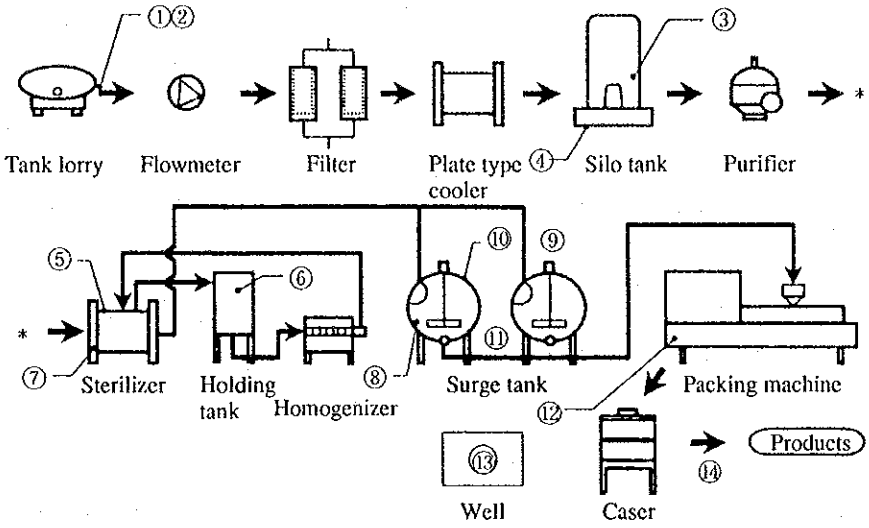
b. Measurement item, measurement time, measuring equipment, and data processing

	Measurement items	Measurement time	Measuring equipment	Data processing
Tank lorry Silo tank	① Outdoor temperature	0.1 h × 2 times	Glass thermometer	Memo
	② Raw milk cooling temperature	0.1 h × 4 times	Meters for operation	Memo
	③ Holding temperature	24 h	Operation record	Memo
	④ Chilled water temperature	24 h	Thermocouple	to Recorder
Sterilizer	⑤ Sterilizer temperature	0.1 h × 4 times	Surface thermometer	Memo
	⑥ Holding tank temperature	0.1 h × 4 times	Surface thermometer	Memo
	⑦ Steam temperature	0.1 h × 4 times	Meters for operation	Memo
Surge tank	⑧ Product temperature	24 h	Operation record	Memo
	⑨ Outdoor temperature	0.1 h × 4 times	Glass thermometer	Memo
	⑩ Tank side wall temperature	0.1 h × 4 times	Surface thermometer	Memo
	⑪ Chilled water temperature	24 h	Thermocouple	to Recorder
Paper container filling machine	⑫ Power consumption	24 h	Clamp meter	to FDD
Refrigerator	⑬ Well water temperature	0.1 h × 4 times	Glass thermometer	Memo
	⑭ Indoor/outdoor temperature	0.1 h × 4 times	Glass thermometer	Memo

c. Measuring points

Figure 9.5.4 shows the measuring points for the milk product manufacturing processes.

Figure 9.5.4 Measuring Points of Milk Process



(2) Powder milk

a. Purpose of measurement

The purpose is to grasp the status of heat use in the manufacturing processes.

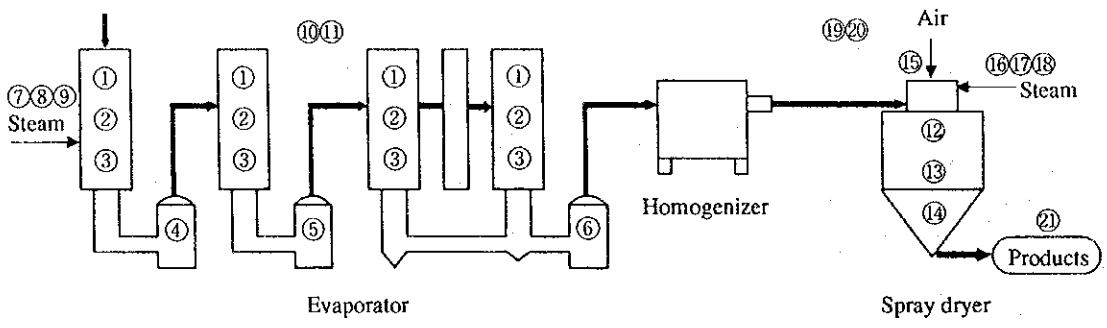
b. Measurement item, measurement time, measuring equipment, and data processing

	Measurement items	Measurement time	Measuring equipment	Data processing
Evaporator	① Evaporator surface temperature	spot	Radiation thermometer	Memo
	② Evaporator surface temperature	spot	Radiation thermometer	Memo
	③ Evaporator surface temperature	spot	Radiation thermometer	Memo
	④ Condensed fluid temperature	spot	Meters for operation	Memo
	⑤ Condensed fluid temperature	spot	Meters for operation	Memo
	⑥ Condensed fluid temperature	spot	Meters for operation	Memo
	⑦ Steam pressure	1 charge	Pressure gauge	to Recorder
	⑧ Steam temperature	spot	Meters for operation	Memo
	⑨ Steam flow rate	1 charge	Vortex flowmeter	to Recorder
	⑩ Evaporator room temperature	spot	Glass thermometer	Memo
	⑪ Outdoor temperature/humidity	spot	Thermo-hygrometer	Memo
Dryer	⑫ Dryer surface temperature	spot	Radiation thermometer	Memo
	⑬ Dryer surface temperature	spot	Radiation thermometer	Memo
	⑭ Dryer surface temperature	spot	Radiation thermometer	Memo
	⑮ Hot blast volume	spot	Hot-wire anemometer	Memo
	⑯ Steam pressure	1 charge	Pressure gauge	to Recorder
	⑰ Steam temperature	spot	Meters for operation	Memo
	⑱ Steam flow rate	1 charge	Vortex flowmeter	to Recorder
	⑲ Dryer chamber inside temperature	spot	Glass thermometer	Memo
	⑳ Outdoor temperature/humidity	spot	Thermo-hygrometer	Memo
Product	㉑ Product temperature	spot	Meters for operation	Memo

c. Measuring points

Figure 9.5.5 shows the measuring points for the powder milk manufacturing processes.

Figure 9.5.5 Measuring Points of Powdered Milk Process



(3) Energy utilization facilities

Equipment name	Targeted equipment or location	Measurement time
Electricity control	Power receiving facilities	24 h
Fan/blower	Major equipment	24 h
Electric motor	For NH_3 refrigerator	24 h
Air compressor	NH_3 compressor	24 h
Pump	For city water	24 h
Transformer	Major equipment	24 h
Lighting	Various locations of the factory	24 h
Boiler	Boiler room	24 h
Steam pipe	Various locations of the factory	24 h

For the measurement method and the measuring points, see "ENERGY UTILIZATION FACILITIES".

Check List for Dairy (1)

Factory name _____

No.	Process	Item			Note
1	Receiving	Raw milk		kL/year	
			Temp.	deg.	
		Silo			
		Tank number			
			Size	kL	
		Flow meter		kL/day	
2	Clarification	Clarifier		deg.	
		Centrifuge		rpm.	
				kW	
3	Pasteurization	UHT		deg.	
		Holding tank		kL	
				deg.	
		time		min.	
		Homogenizer		kW	
		press		kg/cm2(G)	
4	Storage		Temp.	deg.	
			Capacity	kL	
5	Packing		Capacity	packs/h	
				kL/day	
				kL/month	
				kL/year	
6	Production & energy consumption	Monthly energy consumption (1995-1996)			

	unit	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May
Steam												
Electricity												

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

Check List for Dairy (2)

No.	Process	Item			Note
8	Cream	Plate type heater		m2	
		Heating surfac	Temp.	deg.	
		Centrifuge		kW	
				rpm.	
		Pasteurizer	Temp.	deg.	
			HTST	sec.	
		Homogenizer		kW	
				kg/cm2(G)	

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

9	"Symidal" yogurt	Mixing tank	Temp.	deg.	
		Homogenizer		kW	
			press	kg/cm2(G)	
		Packing	Capacity	kL/day	
			Power	kW	
		Fermenter	Temp.	deg.	
		Room		hour	

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

10	Dry milk	Packing		t/day	
		Pasteuriger temp		deg	
		HTST		sec.	
		Dryer Temp		deg.	
		Steam Press		kg/cm^2	
		Dryer Capacity		t/h	
		Evaporator Capacity		t/day	
		Vacuum		No.1	
				No.2	
				No.3	
		Temp		No.1	
				No.2	
				No.3	

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

Check List for Dairy (3)

No.	Process	Item			Note
11	Butter	Plate type		deg.	
		Pasteurizer	Temp.	deg.	
			HTST	sec.	
		Aging tank	Temp.	deg.	
				hour	
			Power	kW	
		Metal charn	Power	kW	
		Butter machine	Power	kW	
		Packing		kg/day	
			Power	kW	

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

12	Cheese	Packing		t/day		
		Pasteurizer	Temp.	deg.		
			HTST	sec.		
		Mechanical cheese bat (mixer)	Power	kW		
			Temp.	deg.		
		Mold press	Power	kW		
		Fermentation	Temp.	deg.		
			Stay	days		

Production and energy consumption

	unit	1992	1993	1994	1995	1996
Production						
Steam						
Electricity						
Water						

13. Design and operation information

Process	Item	Unit	Design	Actual
Receiving	Raw milk	kL/day		
Clarification	Centrifuge	kL/day kL/hour		
Pasteurization	UHT Max. Temp. Time Productivity	deg/min deg min t/day t/hour		
Packing	Capacity	t/day t/hour		
Storage	Temp. Capacity	deg. kL		
Chiller	Handling Capacity	deg. R.T.		
Cream	Handling	kL/day		
Yogurt	Handling	kL/day		
Butter	Handling	kL/day		
Cheese	Handling	kL/day		

14. Energy Consumption in 1996

Process	Production	Electricity	Oil	Natural gas	Compressed air	Steam	Rcycle water
Unit		10^3kWh	L	10^3Nm^3	10^3Nm^3	ton	10^3m^3
Generated energy							
Consumed energy							
Milk line (UHT)							
Cream line (Evaporator)							
Yogule line (Packing)							
Butter line (Packing)							
Cheese line (Packing)							
Waste water							

Process	Production	Electricity	Oil	Natural gas	Compressed air	Steam	Rcycle water
Unit		10^3kWh	L	10^3Nm^3	10^3Nm^3	ton	10^3m^3
Generated							
Purchased							
Process							
Others							
Total							
Max. demand							

Check List for Dairy (6)

15. Energy Conservation Method

Process	Item	Application	Year of application
Raw milk	1. Stock system control of temperature 2. Recovery of cooling water 3. Chiller		
Clarification	1. Room temperature control system 2. Insulation		
Pasteurization	1. UHT system 2. Heat recovery 3. Recycle water 4. Cooling tower		
Chiller	1. Temperature control 2. Measure and control system 3. Other control		
Evaporator	1. Steam effect 2. Vacuum control		
Flow speed control	1. Process 2. Packing 3. Others		

(A): Operating/Installed
(B): Not perfect but operating/Under construction
(C): Not operating/Under planning

10. ENERGY UTILIZATION FACILITIES

10. ENERGY UTILIZATION FACILITIES

10.1 Lighting

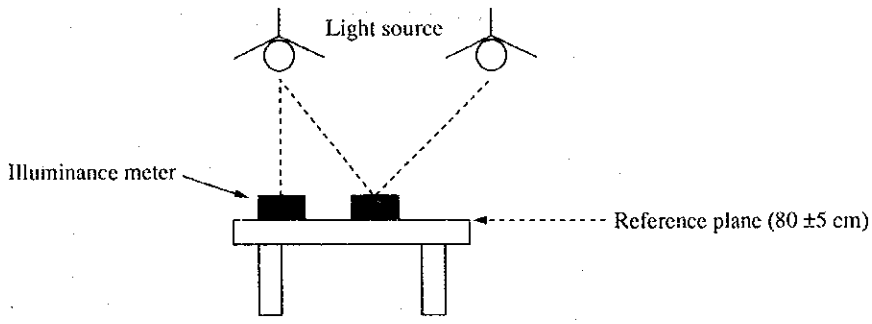
10.1.1 Purpose of Measurement

The purpose is to grasp whether or not illumination is provided in a manner that matches the illuminance standard for the type of work and the location.

10.1.2 Measurement Method (See Figure 10.1.1)

Measurement items : Illuminance on the reference working plane
Measuring instrument: Portable illuminance meter

Figure 10.1.1 Illuminance Measuring Method



10.1.3 Method of Diagnosis

If the level of illuminance measured exceeds the illuminance standard, energy conservation measures such as reducing the number of lamps should be taken. For reference, the JIS (Japanese Industrial Standard) illuminance standard for factories and that for offices are shown in Table 10.1.1 and Table 10.1.2, respectively.

10.1.4 Energy Conservation Measures

Energy conservation measures to be taken for lighting include the following. (For details, see "IV Guidelines".)

(1) Reduction of the length of lighting time

Turn off lights when they are not needed, etc.

(2) Securing the appropriate level of illuminance

Obtain the illuminance levels that conform to the illuminance standard.

(3) Localized illumination

Concentrate lighting on locations where it is actually needed.

(4) Adoption of high-efficiency lamps and lighting apparatus (luminaires)

Replace the existing lighting with high-pressure sodium lamps and high-efficiency luminaires.

(5) Improvement of utilization factor

Give careful consideration to the luminous intensity distribution of luminaires and their installation positions.

(6) Improvement of maintenance frequency

Perform periodical cleaning and replacement of lamps.

(7) Utilization of natural light

Introduce ways to utilize daylight.

Table 10.1.1 Illuminance Standard for Factories (JIS Z 9110)

Illuminance lx	Category of Work	Location
3,000 2,000	Manufacture of precision machinery, electronic devices, and highly detailed close visual work at printing factories • Assembly (a), • Inspection (a), • Testing (a) • Screening (a), • Design, • Drawing	Instrument panels and control panels in control rooms and other such areas
1,500 1,000	Close visual work such as screening and inspection at textile factories, composing and proofreading at printing factories, and analysis at chemical plants • Assembly (b), • Inspection (b), • Testing (b) • Screening (b)	Designing rooms, Drawing rooms
750 500	Regular visual work at general manufacturing processes • Assembly (c), • Inspection (c), • Testing (c) • Screening (c), • Wrapping (a), • Clerical work inside warehouses	Control rooms
300 200	Less detailed visual work • Limited types of work • Wrapping (b), Packing (b), (c)	Electric rooms Air conditioning machine rooms
150 100	Light visual work • Limited types of work • Wrapping (b), • Packing (b), (c)	Entrance/exit, Hallways, Passages Warehouses where work is conducted Stairways, Powder rooms, Lavatories
75 50 30	• Works such as loading, unloading and moving packages	Indoor emergency stairways, Warehouses, Indoor power facilities
		Outdoor (passages, plant security facilities, etc.)
20		
10		

Note: (a): indicates situations requiring fine details, weak contrasts, and high precision.
(b): indicates work that falls in a category somewhere between (a) and (c).
(c): indicates less detailed work aided by stronger contrasts.

Table 10.1.2 Illuminance Standard for Offices (JIS Z 9110)

<table>
<tr><th>Illuminance lx</th><th colspan="3">Location</th></tr>
<tr><td>2,000</td><td colspan="3"></td></tr>
<tr><td>1,500</td><td colspan="3" rowspan="2">Office type a, Sales offices, Designing rooms, Drawing rooms, Reception halls
(during the day)</td></tr>
<tr><td>1,000</td></tr>
<tr><td>750</td><td>—</td><td colspan="2" rowspan="2">Office type b, Board rooms, Conference rooms, Printing rooms,
Telephone operator rooms, Computer rooms, Control rooms,
Medical examination rooms, Switch board and instrument panels
in electric rooms and engine rooms, Reception desk</td></tr>
<tr><td>500</td><td rowspan="2">Meeting rooms, Reception rooms,
Waiting areas, Cafeterias, Kitchens,
Recreation rooms, Relaxation centers,
Security guard posts, Reception halls
(at night), Elevator halls</td></tr>
<tr><td>300</td><td rowspan="2">Archives, Miscellaneous rooms,
Work areas, Inside safes,
Electric rooms, Auditoriums,
Engine rooms, Elevators</td><td>—</td></tr>
<tr><td>200</td><td>—</td><td rowspan="2">Laundry rooms,
Hot water supply rooms,
Shower and bathing areas,
Hallways, Stairways,
Powder rooms, Lavatories</td></tr>
<tr><td>150</td><td colspan="2" rowspan="2">Coffee rooms, Rest areas, Overnight accommodations,
Dressing rooms, Warehouses, Reception areas
(porte-cochere, or curbs for motor vehicles)</td></tr>
<tr><td>100</td><td>—</td></tr>
<tr><td>75</td><td colspan="3" rowspan="3">Indoor emergency stairways</td></tr>
<tr><td>50</td></tr>
<tr><td>30</td></tr>
</table>

Note: For offices, "a" is desirable if visually intensive tasks are performed, or if it feels darker indoors than outdoors due to the effect of daylight.

Lighting Fitting

Date _____
Surveyor _____

1. Lighting system	☐ General	☐ General and Local	
2. Method of Turning on and off	☐ Automatic	☐ Manual	☐ Both automatic and manual
③ Circuit Separation (In case of General Lighting)	☐ One switch per Room ☐ Several switches per Room ☐ One switch per Room (Turn, Line by Line from Window side)		
④ Kind of Lamp	☐ incandescent Lamp ☐ Fluorescent Lamp (White) ☐ Fluorescent mercury Lamp ☐ Good-Color High Pressure Sodium Lamp ☐ Metal halide Lamp. (High efficiency type)	☐ fluorescent Lamp (Daylight) ☐ Energy Conservation type F.L	
5. Cleaning Frequency of Lighting Fittings	Time/year		
6. Utilization of Daylight	done ( )	no ( )	

Measurement Record for Lighting Fitting

(Time at AM or PM . Date)

Place			
Illminance			
Distribution System			
Kind of Lamp			
Wall Color			

Power Consumption for Lighting
Day time : _____kWh/h (from daily Record)
Night : _____kWh/h

10.2 Air Compressor

10.2.1 Purpose of Measurement

The purpose is to understand the actual load operation status (air flow rate, pressure, temperature, electricity consumption, etc.) against the compressor design capacity

10.2.2 Method of Measurement (See Figure 10.2.1)

Measurement time: On a basis of 24 h, day or month (depending on the load condition)

Figure 10.2.1 Air Compressor Measuring Points

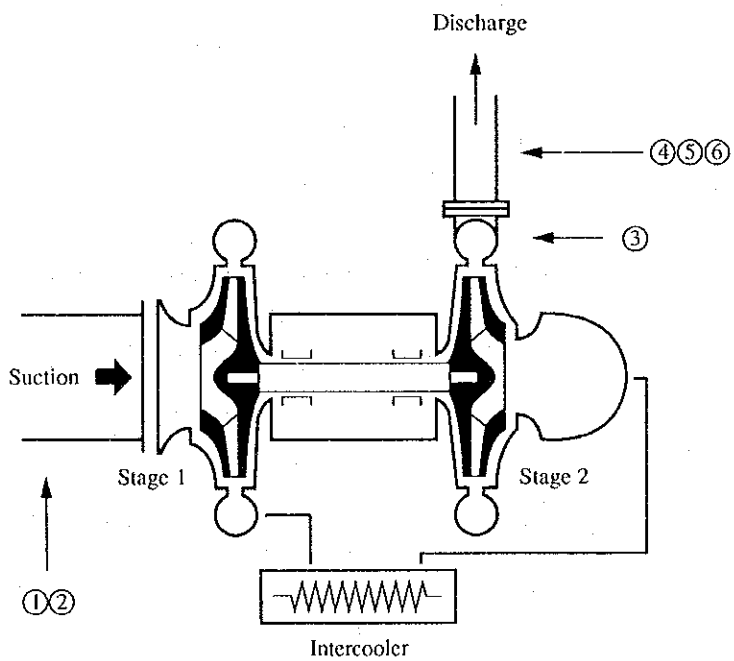


Table 10.2.1 Items to be Measured for Air Compressor and Measuring Equipment

	Items to be Measured	Measuring Equipment	
①	Air temperature at a flow rate measuring point	Thermometer	→ Value converted on a basis of standard state
②	Static pressure at compressor inlet	Pressure gauge	→ Suction pressure
③	Static pressure at compressor outlet	Pressure gauge	→ Discharge pressure
④	Static pressure at an air flow rate measuring point	Pressure gauge	
⑤	Dynamic pressure at an air flow rate measuring point	Orifice	→ Air flow rate
⑥	Outlet cross-sectional area		
⑦	Voltage	Clamp meter	
⑧	Current	Clamp meter	
⑨	Electric power	Clamp meter	

*When measurement on site is not available, use the reading on the local indicator.

Efficiency is calculated using the following shaft power formula.

$$L = \frac{(a + 1)K}{K - 1} \cdot \frac{P_s Q_s}{6120} \cdot \left\{ \left(\frac{P_d}{P_s} \right)^{\frac{K-1}{K(a+1)}} - 1 \right\} \cdot \frac{1}{\eta_c \eta_t}$$

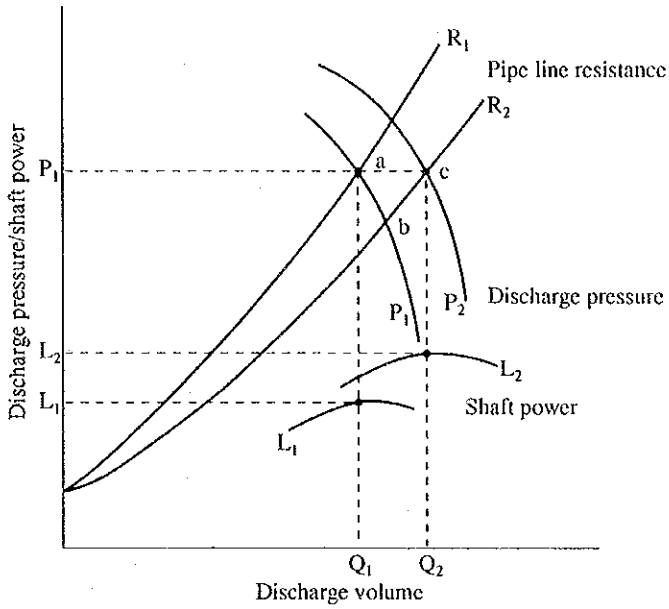
L : Required power [kW]
P_s : Absolute pressure of intake air [kg/m².abs]
P_d : Absolute pressure of discharged air [kg/m².abs]
Q_s : Volume of air per unit of time converted on a basis of intake state [m³/min]
a : Number of intercoolers
K : Adiabatic index of air
η_c : Total adiabatic efficiency of compressor
η_t : Transmission efficiency

10.2.3 Method of Diagnosis

Using the measurement and calculation results, the discharge quantity, discharge pressure, and shaft power are plotted on the performance curve. The extent to which the discharge quantity and discharge pressure can be reduced for energy saving is reviewed based on this actual load. (Reduction of required power)

An example of a performance curve is shown in Fig.10.2.2.

Figure 10.2.2 Air Compressor Performance Curves



10.2.4 Energy Conservation Measures

Energy conservation measures to be taken for air compressors include the following. (For details, see "IV. Guidelines")

(1) Reduction of discharge pressure

Discharge pressure should be supplied at the minimum level required.

(2) Maintenance of piping

Measures such as leakage prevention, and periodic draining, etc. should be implemented.

(3) Optimization of pressure setting

Settings for minimum pressure, maximum pressure, and yield pressure, etc. required by the line should be optimized.

(4) Reduction of intake resistance

Periodic cleaning of filters and other such apparatus should be carried out.

(5) Reduction of intake temperature

Fresh air should be taken in.

(6) Control of the number of machines to be used

Operation should be controlled on a multiple machine basis.

(7) Introduction of small capacity compressors

Machines exclusively used for light load operations during holidays, etc. should be installed.

Measurement Record
for Motor Driven Machine (Compressor)

Date _____

Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating kW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Date _____

Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating KW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Date _____

Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating KW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Leakage volume _____ L/H

10.3 Motor

10.3.1 Purpose of Measurement

The purpose is to grasp the present operating situation as compared with the motor rated capacity.

10.3.2 Method of Measurement (See Figure 10.3.1)

Measurement time: On a basis of 24 h, day, or month (depending on the load condition)

Figure 10.3.1 Motor Measuring Points

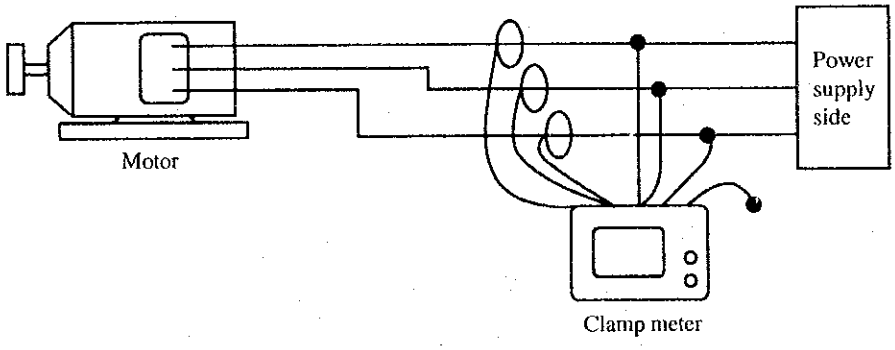


Table 10.3.1 Measurement Items for Motors and Measuring Equipment

	Items to be Measured	Measuring Equipment
①	Electricity (Current)	Clamp meter
②	Voltage	Clamp meter
③	Power factor	Clamp meter

*If no voltage terminal connection is available, the electric current may be measured instead.

10.3.3 Method of Diagnosis

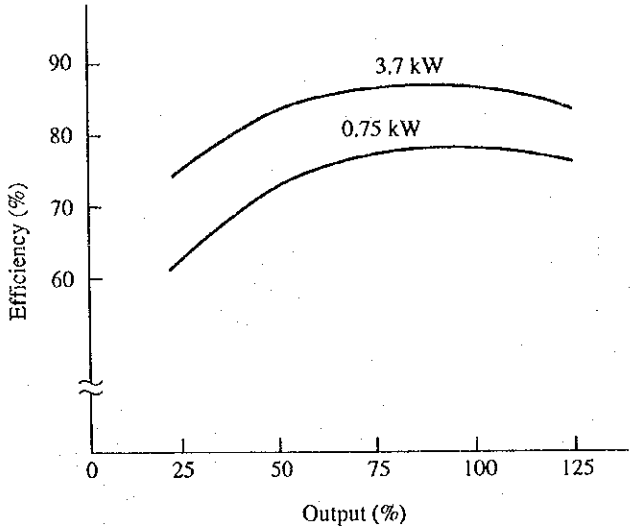
The efficiency of a motor should be most preferable at the load factor of 70 % to 100 % of the rated capacity. (See Figure 10.3.2)

The present load factor is obtained based on the measurement results.

When the result shows a load factor of 70% or less, some appropriate measure, such as replacement of motors, should be considered.

$$\text{Load factor} = \frac{\text{Actual load (kW)}}{\text{Rated output (kW)}} \times 100\ [\%]$$

Figure 10.3.2 Efficiency – Load Factor Curves (An example of induction motor)



10.3.4 Energy Conservation Measures

Energy conservation measures to be taken for motors include the following: (For details, see "IV Guidelines".)

(1) Replacement of motors

Motors that match the load, high-efficiency motors, etc. should be used.

(2) Control of power supply voltage

The power supply voltage should be carefully managed when using 3-phase induction motors and other such motors that are susceptible to voltage fluctuations.

(3) Prevention of idle rotation and reduction of starting loss

Motors should be stopped when not in use, and direct-on-line starting should be adopted.

(4) Rotational speed control

The number of poles, the power source frequency, etc. should be changed.

Check List for Motor Driven Machine (1)
(30 motors of higher rank of output)

Date _____
Surveyor _____

Name of Shop	Location	No.
1	Name of Equipment	Number of similar Equipment
②	Kind of motor	( ) AC ( ) Induction ( ) Wound Rotor ( ) Squirrel Cage ( ) Others ( ) Synchronous ( ) DC ( ) Series ( ) Shunt ( ) Compound
③	Rating of Motor	Out put _____ kW Voltage _____ V Current _____ A Frequency _____ Hz RPM _____ rpm. Num. of Pole _____
4	Starting method	( ) Full Voltage ( ) Star-delta (Y - △) ( ) Rotor-resistance ( ) Others
5	Coupling Apparatus	( ) Direct ( ) Belt ( ) Gear ( ) Others Meterial ( ) Natural _____ Tension _____ ( ) Synthetic _____ Num. _____
⑥	Load	( ) Pump ( ) Blower ( ) Compressor ( ) Others
7	Kind and Density of Fulid	( ) Air ( ) Water ( ) Others ( ) Density (or Specific Gravity)
⑧	Flow Control Method	( ) Automatic ( ) Valve ( ) Speed Control ( ) manual ( ) Damper ( ) Others
⑨	Speed Control	( ) Motor ( ) Pole Change ( ) Voltage ( ) Mechanical ( ) Frequency ( ) Others
10	Automatic Turn-off (when off load)	( ) Yes ( ) No
11	Lubrication	time/year
12	Filter cleaning	time/month
13	Flow Chart of fluid	

Check List for Motor Driven Machine (2)

Date ______ Factory ______ Surveyor ______ (Blower, Pump)

Name of Shop					Location					No.		
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power			Temp. of Fluid	Flow m^3/min Rated / Actual	Pressure	Pipe dia	Valve Position	Velocity of Fluid	Estimated load	Efficiency
	Time	Volt V	Current A	Power kW	℃	Max. Min.	kg.cm²	(ID)		m/s		%

Name of Shop					Location					No.		
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power			Temp. of Fluid	Flow m^3/min Rated / Actual	Pressure	Pipe dia	Valve Position	Velocity of Fluid	Estimated load	Efficiency
	Time	Volt V	Current A	Power kW	℃	Max. Min.	kg.cm²	(ID)		m/s		%

Name of Shop					Location					No.		
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power			Temp. of Fluid	Flow m^3/min Rated / Actual	Pressure	Pipe dia	Valve Position	Velocity of Fluid	Estimated load	Efficiency
	Time	Volt V	Current A	Power kW	℃	Max. Min.	kg.cm²	(ID)		m/s		%

(1) Required Power of Blower

$$P = \frac{A \cdot Q \cdot PT}{6120 \cdot \eta} \quad (kW)$$

PT : Total Pressure (mmAq or kg/m^2)
A : Allowance (1.1 - 1.3)
η : Efficiency of blower (0.72 - 0.78)
Q : Flow (m^3/min)

Adequate Velocity of Fluid

Adequate Velocity	Velocity (m/sec)	Pressure (kg/cm^2)
Air	8 - 15	1 - 2

(2) Required Power of Pump

$$P = \frac{A \cdot \gamma \cdot Q \cdot H}{6.12 \cdot \eta} \quad (kW)$$

A : Allowance (1.05 - 1.2)
γ : Density (kg/l)
Q : Flow (m^3/min)
η : Efficiency of Pump
H : Head (m)

Adequate Velocity of Fluid

Adequate Velocity	Velocity (m/sec)	Pressure (kg/cm^2)
Water	1.5 - 3.0	3.0 - 10

Measurement Record
for Motor Driven Machine (Compressor)

Date _____
Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating kW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Date _____
Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating KW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Date _____
Surveyor _____

Name of Shop						Location				No.	
No.	Time	Rating KW	Actual Voltage V	Actual Current A	Actual kW Power	Inlet Temp ℃	Pressure Outlet kg/cm²	Pressure End Use kg/cm²		Remark (On - Off Time)	

Leakage volume _____ L/H

Log Sheet of Operation of Motors
(Others)

Date ________________
Surveyor ________________

Name of Shop			Location							No.	
No.	Process Use	Manu-facturer (Year Built)	Month. oper. hours	Rated Power kW	Actual				Rev. rpm	Speed Control	Note
					Vtg. V	Amp. A	kW	p. f. %			

Date ________________
Surveyor ________________

Name of Shop			Location							No.	
No.	Process Use	Manu-facturer (Year Built)	Month. oper. hours	Rated Power kW	Actual				Rev. rpm	Speed Control	Note
					Vtg. V	Amp. A	kW	p. f. %			

Date ________________
Surveyor ________________

Name of Shop			Location							No.	
No.	Process Use	Manu-facturer (Year Built)	Month. oper. hours	Rated Power kW	Actual				Rev. rpm	Speed Control	Note
					Vtg. V	Amp. A	kW	p. f. %			

10.4 Transformers

10.4.1 Purpose of Measurement

The purpose is to grasp the actual load condition against the design capacity of transformers.

10.4.2 Method of Measurement (Figure 10.4.1)

Measuring time: On a basis of 24 h, day, month (depending on the state of the load)

Figure 10.4.1 Measuring Points of a Transformer

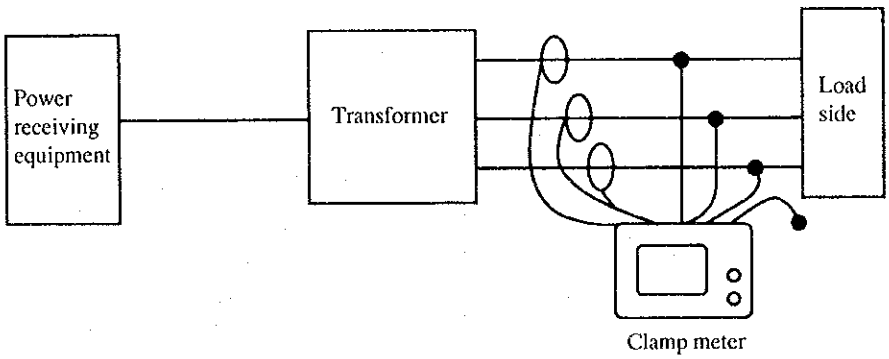


Table 10.4.1 Items to be Measured for Transformer and Measuring Equipment

	Items to be Measured	Measuring Equipment
①	Electricity (Current)	Clamp meter
②	Power factor	Clamp meter
③	Voltage	Clamp meter

10.4.3 Method of Diagnosis

The efficiency of transformers reaches the maximum when the load loss and no-load loss are equal, with most of them at around 50 to 70 % load. (Figure 10.4.2)

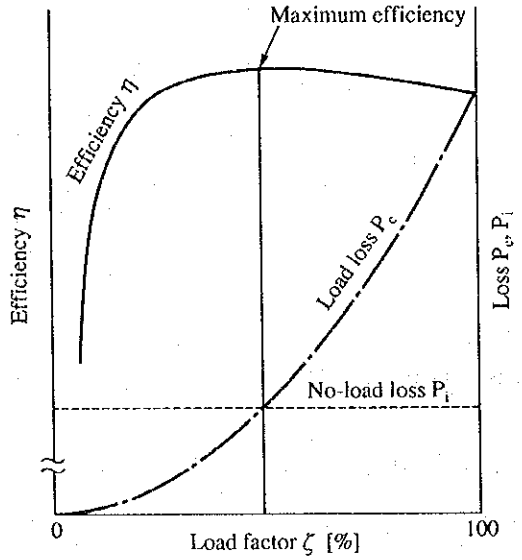
The extent to which the efficiency can be raised should be studied based on the actual load measured, design performance, and tables of test results.

Because the load on the transformer does not remain constant throughout the day, operating methods that will improve efficiency on a day long basis should be considered.

$$\text{All day efficiency} = \frac{W_o}{Wo + 24\,P_i + \sum_{24} p_c t} \times 100\ [\%]$$

W_o: Cumulative output per day [Wh]
Pi : No-load loss [W]
Pc : Load loss (changes with fluctuations in load over time) [W]

Figure 10.4.2 Relationship between Load Factor, Efficiency and Loss



10.4.4 Energy Conservation Measures

Energy conservation measures to be taken for transformers include the following: (For details, see "IV. Guidelines".)

(1) Stopping the transformers operating under light load

Electrical facilities which may be stopped during the nighttime and on holidays should be concentrated in one location.

(2) Control of the number of operating transformers

Switching the operation type to parallel operation or individual operation should be considered.

(3) Reviewing the capacity

Smaller capacity transformers should be adopted.

(4) Management of load group voltages

The voltage fluctuations and unbalanced voltage should be improved.

Check List for Transformer

Date
Surveyor

	Name of Shop	Location	No. of Bank	No.
1	Type of Transformer	( ) Oil Immersed Self Cooling ( ) Dry type ( ) Forced coil Air Cooling ( ) Others		
2	Number of Phase	( ) Three phase ( ) Single phase		
③	3 Phase connection (for Single Phase Tr)	( ) △ - Y ( ) Y - △ ( ) △ - △ ( ) Y - Y ( ) V - V		
④	Rated Output	kVA	Num. of Bank	
⑤	Rated Voltage	Primary kV	Secondary	V
	Rated Current	A		A
6	Rated Frequency	Hz		
7	% impedance	% at	kVA base	
8	Manufacturer			
9	Year built			
10	Loss	Iron loss	kW	
		Copper loss at full load	kW	

Measurement Record (1)

Time	Voltage V	Corrent A	Apparent Power kVA	Power kW	Power factor %	Oil Temp. ℃	Watt Hour Meter Reading	Coeff't Factor	kWh	Remark

Measurement Record (2)

Date ________________

Surveyor ________________

Location of Board							Branch		Users		No.
No.	Time		Volt		Ampere		kW	Cos ϕ	kVA	Remark	

Date ________________

Surveyor ________________

Location of Board							Branch		Users		No.
No.	Time		Volt		Ampere		kW	Cos ϕ	kVA	Remark	

Date ________________

Surveyor ________________

Location of Board							Branch		Users		No.
No.	Time		Volt		Ampere		kW	Cos ϕ	kVA	Remark	

10.5 Fans and Blowers

10.5.1 Purpose of Measurement

The purpose is to grasp the actual load operation situations (flow rate, pressure, temperature, power consumption, etc.) as compared with the fan/blower design performance

10.5.2 Measurement Method (See Figure 10.5.1)

Figure 10.5.1 Fan and Blower Measuring Points

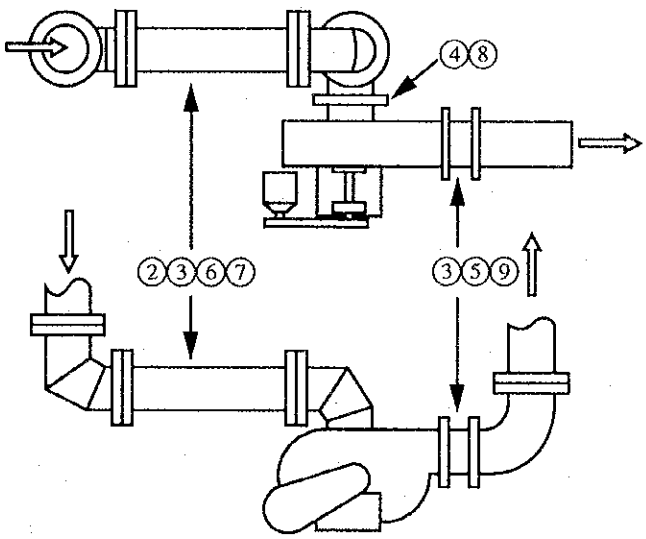


Table 10.5.1 Items to be Measured for Fans and Blowers and Measuring Equipment

	Items to be Measured	Measuring Equipment	
①	Dry bulb thermometer at fan outlet	Thermometer	
②	Suction dry bulb thermometer at an air flow rate measuring point	Thermometer	
③	Suction wet bulb thermometer at an air flow rate measuring point	Hygrometer	→ Specific weight
④	Static pressure at fan inlet	Pressure gauge	
⑤	Static pressure at fan outlet	Pressure gauge	→ Fan static pressure
⑥	Static pressure at an air flow rate measuring point	Pitot tube or anemomaster	
⑦	Dynamic pressure at an air flow rate measuring point	Pitot tube or anemomaster	→ Air flow
⑧	Suction port sectional area		
⑨	Discharge port sectional area		→ Value converted to specification state
⑩	Voltage	Clamp meter	
⑪	Current	Clamp meter	(→ Efficiency)
⑫	Electric power	Clamp meter	→ Efficiency
⑬	Damper opening (Inlet)	Visual check	Load
⑭	Damper opening (Outlet)	Visual check	Load

*When measurement on site is not available, use the reading on the local indicator.

Efficiency is obtained based on the following shaft power calculation formula.

$$L = \frac{L_T}{\eta_F} \text{ [kW]}$$

where

η_F: Blower efficiency
L_T: Air motive power [kW]

$$L_T = \frac{K}{K-1} \cdot \frac{P_{t1} \cdot Q}{6120} \left\{ \left(\frac{P_{t2}}{P_{t1}} \right)^{\frac{K-1}{K}} - 1 \right\} [kW]$$

where

P_{t1}: Suction side absolute pressure [kg/m²·abs]
P_{t2}: Discharge side absolute value [kg/m²·abs]
Q : Air flow [m³/min]
K : Specific heat ratio (1.4 for air)

When the pressure ratio is 1.03 or less, the following equation may be used.

$$L_T = \frac{QP_T}{6120} [kW]$$

where

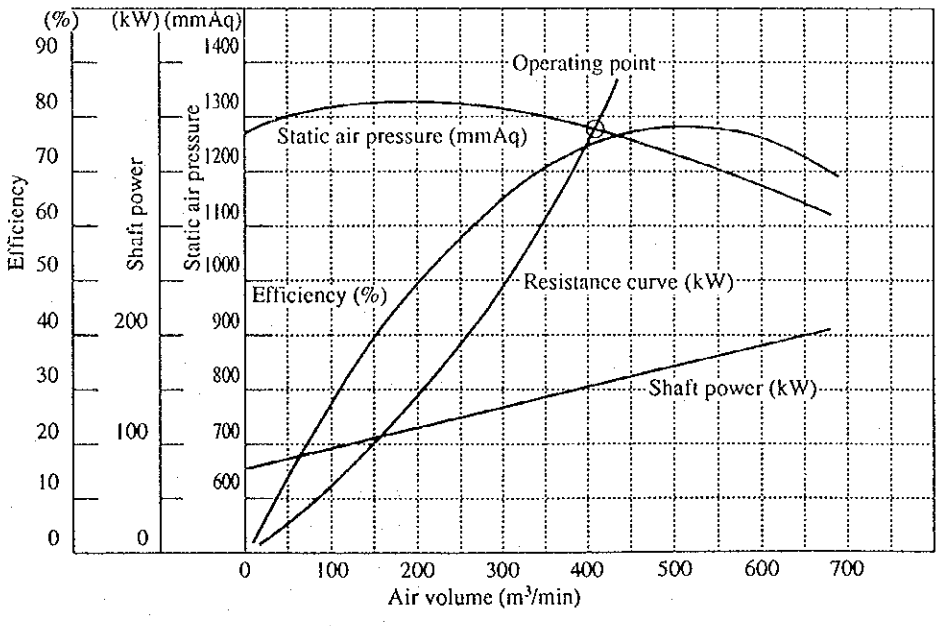
P_T: Total pressure of blower [mmAq]

10.5.3 Method of Diagnosis

Air flow, resistance curve and shaft power are plotted on performance curves based on the measured and calculated results. With these actual load curves for reference, the extent to which air flow volume and static pressure can be reduced should be considered. (e.g. controlling the rotational speed, cutting blower impellers, etc.)

Figure 10.5.2 shows examples of performance curves.

Figure 10.5.2 Fan/Blower Performance Curves



10.5.4 Energy Conservation Measures

Energy conservation measures to be taken for blowers include the following: (For details, see "IV. Guidelines".)

(1) Reduction of shaft power

Operating with optimum air flow volume, preventing air leakage, etc.

(2) Reduction of operating time

On/off operation, etc.

(3) Replacement of blowers

Replacing with a blower which matches the current load

(4) Modification of impellers

Modifying the outer diameter of impellers (Impeller cutting)

(5) Control of rotational speed

Rotational speed control for the load (VVVF)

(6) Control of the number of machines to be used

Managing the operation on a multiple machine basis

(7) Use of high-efficiency equipment

Adopting high-efficiency equipment for the blower body, power transmission devices and motors

Check List for Motor Driven Machine (1)
(30 motors of higher rank of output)

Date _____
Surveyor _____

Name of Shop	Location	No.
1	Name of Equipment	Number of similar Equipment
②	Kind of motor	( ) AC ( ) Induction ( ) Wound Rotor ( ) Squirrel Cage ( ) Others ( ) Synchronous ( ) DC ( ) Series ( ) Shunt ( ) Compound
③	Rating of Motor	Out put _____ kW Voltage _____ V Current _____ A Frequency _____ Hz RPM _____ rpm. Num. of Pole _____
4	Starting method	( ) Full Voltage ( ) Star-delta (Y - △) ( ) Rotor-resistance ( ) Others
5	Coupling Apparatus	( ) Direct ( ) Belt ( ) Gear ( ) Others Meterial ( ) Natural _____ Tension _____ ( ) Synthetic _____ Num. _____
⑥	Load	( ) Pump ( ) Blower ( ) Compressor ( ) Others
7	Kind and Density of Fulid	( ) Air ( ) Water ( ) Others ( ) Density (or Specific Gravity)
⑧	Flow Control Method	( ) Automatic ( ) Valve ( ) Speed Control ( ) manual ( ) Damper ( ) Others
⑨	Speed Control	( ) Motor ( ) Pole Change ( ) Voltage ( ) Mechanical ( ) Frequency ( ) Others
10	Automatic Turn-off (when off load)	( ) Yes ( ) No
11	Lubrication	time/year
12	Filter cleaning	time/month
13	Flow Chart of fluid	

Check List for Motor Driven Machine (2)

Date ____________ Factory ____________ Surveyor ____________ (Blower. Pump)

Name of Shop			Location						No.			
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power										
	Time	Volt V	Current A	Power kW	Temp. of Fluid °C	Flow m^3/min Rated Actual Max. Min.	Pressure kg.cm^2	Pipe dia. (ID)	Valve Position	Velocity of Fluid m/s	Esti-mated load	Effici-ency %

Name of Shop			Location						No.			
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power										
	Time	Volt V	Current A	Power kW	Temp. of Fluid °C	Flow m^3/min Rated Actual Max. Min.	Pressure kg.cm^2	Pipe dia. (ID)	Valve Position	Velocity of Fluid m/s	Esti-mated load	Effici-ency %

Name of Shop			Location						No.			
No.	Name of Machine							Rating of Motor			kW, Pole	
		Actual Power										
	Time	Volt V	Current A	Power kW	Temp. of Fluid °C	Flow m^3/min Rated Actual Max. Min.	Pressure kg.cm^2	Pipe dia. (ID)	Valve Position	Velocity of Fluid m/s	Esti-mated load	Effici-ency %

(1) Required Power of Blower

$$P = \frac{A \cdot Q \cdot PT}{6120 \cdot \eta} \quad (kW)$$

PT : Total Pressure (mmAq or kg/m^2)
A : Allowance (1.1 - 1.3)
η : Efficiency of blower (0.72 - 0.78)
Q : Flow (m^3/min)

Adequate Velocity of Fluid

Adequate Velocity	Velocity (m/sec)	Pressure (kg/cm^2)
Air	8 - 15	1 - 2

(2) Required Power of Pump

$$P = \frac{A \cdot \gamma \cdot Q \cdot H}{6.12 \cdot \eta} \quad (kW)$$

A : Allowance (1.05 - 1.2)
γ : Density (kg/l)
Q : Flow (m^3/min)
η : Efficiency of Pump
H : Head (m)

Adequate Velocity of Fluid

Adequate Velocity	Velocity (m/sec)	Pressure (kg/cm^2)
Water	1.5 - 3.0	3.0 - 10