No. 25

Japan International Cooperation Agency (JICA)
The Republic of Poland
Ministry of Economy
Polish National Energy Conservation Agency (KAPE)

THE MASTER PLAN FOR ENERGY CONSERVATION IN THE REPUBLIC OF POLAND

FINAL REPORT

V. Measurement Manual for Auditing

June 1999

The Energy Conservation Center, Japan (ECCJ)
The Institute of Energy Economics, Japan (IEEJ)

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V. MEASUREMENT MANUAL FOR AUDITING

1. INTRODUCTION

1. INTRODUCTION

A factory energy audit is intended to clarify the state of energy use at a given factory and thereby propose measures to reinforce energy management at the factory, improve energy efficiency and prevent energy loss through modification of facilities and changing of processes.

In order to understand the state of energy use at a factory, it is necessary to acquire data on the amount of fuel and electricity used, temperatures of materials subjected to heating, and composition of exhaust gas, all of which can be done by reading the measurement instruments in the factory and keeping records of them. In this regard, however, although most factories have production related measurement instruments installed, many of them do not have enough energy management related measurement instruments for conducting a satisfactory energy audit. Hence, data not provided by the factory must be obtained by taking measurements using instruments that are the property of either the energy audit team or the factory. Upon taking measurements at a factory, accurate readings must be obtained within a limited amount of time, and this requires important procedures such as installation of measurement instruments, mounting of detecting elements, confirmation of data being measured, recording of data, and check of the reliability of data.

This manual on diagnosis and measurement was compiled from results of investigating 12 factories in 5 industrial sectors in Poland in 1997 and 1998, and principally summarizes procedures for conducting energy audit of factories and measuring techniques, methods of data analysis, and methods of preparing energy audit reports at factories. We hope that this manual will serve as a guide for engineers in Poland who implement energy audit projects and also contribute to achieving significant results in the promotion of energy conservation at their factories.

2. FACTORY ENERGY AUDIT PROCEDURE (OVERVIEW)

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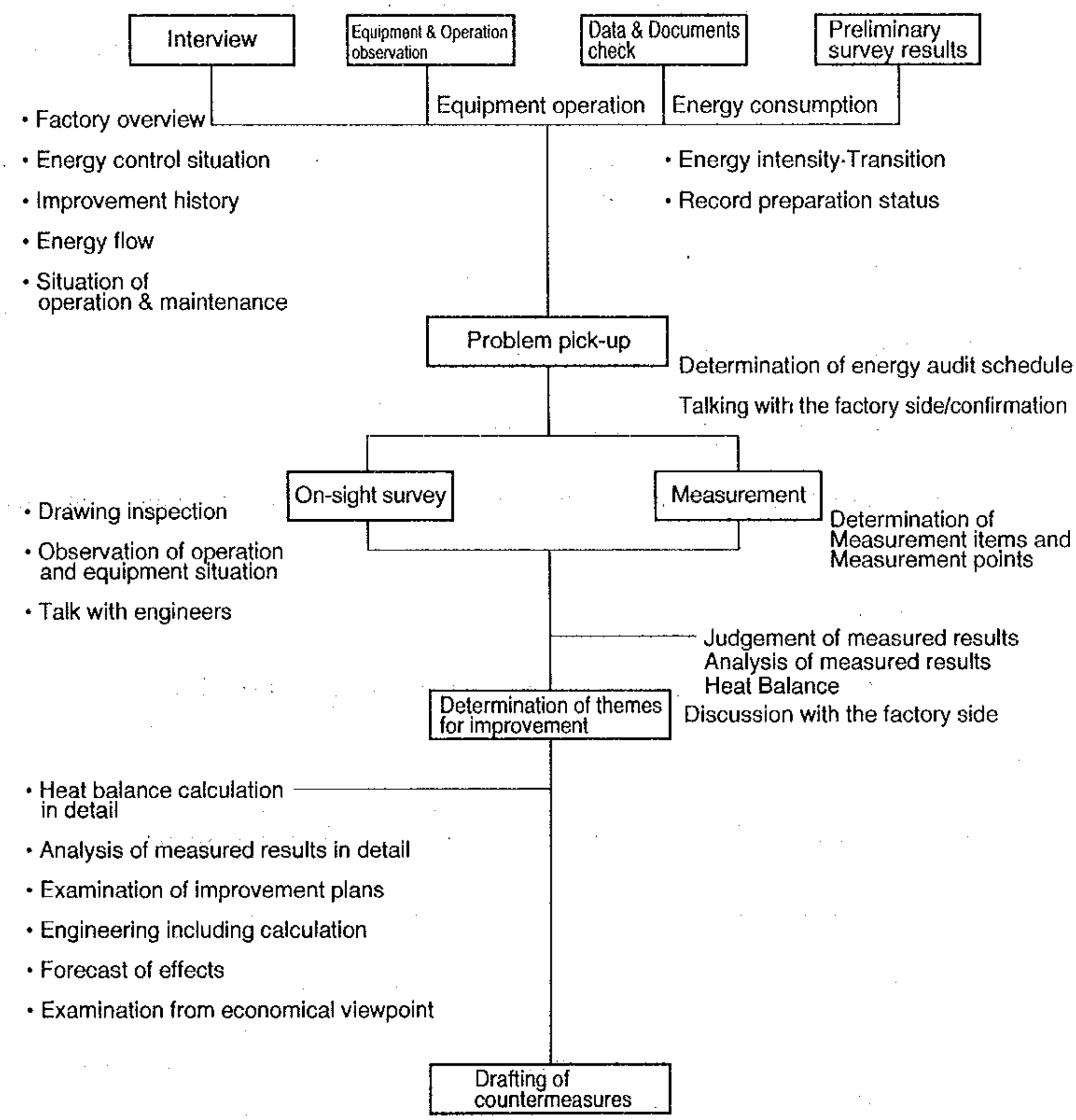
Figure 2.1 shows the general procedure for factory survey:

Figure 2.1 Flowchart of Factory Energy Audit



(1) Factory overview

Experts in factory energy audit should have correct information on the scale, production volume, energy consumption, and other such data of a given factory, which are specifically mentioned below.

It is equally necessary to get correct information on the level of understanding and enthusiasm of the management persons for energy conservation, the efforts made in the past and the points considered as problems by the factory.

a. Factory overview (factory name, type of industry, capital, number of employees, organization, history, share and position in the industry)

b. Trend of the production volume of major products for the last five years

c. Trend of the energy consumption for the last five years

d. Production process chart of major products

e. Type, capacity and operating conditions of energy consuming equipment such as boilers, etc.

f. Energy flow

g. Electricity one line diagram and power receiving equipment specifications

h. Factory layout

i. Items which the factory considers as problems and wishes to be studied

j. Items for energy conservation actions taken in the past

k. Items for energy conservation actions to be taken in future

l. Economic environment for the industry and the factory, and the factors inhibiting the promotion of energy conservation measures

(2) Working out the energy audit program

a. Preparing a check list

Based on the preliminary survey results, observation results, data and documents and the information obtained in interviews conducted beforehand with factory management personnel, energy audit experts should list up the items to be measured and surveyed in order to prepare a checklist so that no omission will occur in the survey. The check list is then distributed to the energy audit team members (experts in process, heat, electricity, and measurement) and policies of the measurement and survey as well as task assignment are to be discussed in an internal meeting.

b. General observation of the factory should be conducted while listening to the explanation of the factory persons, and the outline of the following points should be grasped by checking the preliminary questionnaire, energy consumption and production record:

- Problems in the equipment and operation
- Points which should be given priority in energy audit
- Technical level of the factory
- Deterioration degree and maintenance level of the equipment
- Trend of operation rate
- Energy intensity and its transition

c. Determining the energy audit program

According to the information acquired in paragraph b above, the energy audit experts revise or add the contents of the checklist, and hold an internal meeting to make decisions on the following items.

- Measurement, investigation and study schedule
- Equipment or processes which should be given energy audit priority
- Measuring point, measuring items and measuring time
- Partition of the works

d. Explaining the energy audit program to the factory to get understanding and cooperation about the following items:

- Adjustment with the production program
- Preparing the holes for taking samples or installation of measuring sensors
- Preparation of power supply
- Appointment of factory side persons in charge

(3) Measurement and investigation to be implemented according to the energy audit program

- Selection and arrangement of the measuring equipment
- Setting of the measurement conditions in the measuring equipment
- Monitoring to see if the adequate data have been gained or not
- Investigation of detailed structure and dimensions of the equipment according to equipment drawings or actual measurement
- Determining the problems by observation of the operation
- Interviewing engineers
- Study of data required to evaluate the economic effect of the improvement plan such as the energy price, funds and cost

(4) When the measurement results and the survey data have been obtained, items should be described in the report to propose improvement measures after the analysis, be picked up and be explained to the factory people to confirm such items.

(5) Study of improvement measures

Based on the data entered in the check list, measurement record chart, data floppy disc, and drawings, heat management as well as electric management including calculation of heat balance, heat transfer and fluid conveyance power should be analyzed, and study should be made to seek ways for energy conservation by modification or addition of the equipment, thereby working out the plan best suited to the current situation of the factory.

On the basis of this plan, the approximate cost and expected effect required for improvement should be calculated, and economic evaluation of various improvement measures should be made according to the common indices or techniques, thereby determining feasibility and priority.

A study should be made of the impact accompanying these improvement measures, showing the points to be noted for implementation.

3. POINTS TO BE NOTED FOR ENERGY AUDIT

3. POINTS TO BE NOTED FOR ENERGY AUDIT

In Japan, the Ministry of International Trade and Industry (MITI) provides the items to be used as standard criteria for judgment when the factory manager plans rationalization in the use of energy within the technically and economically feasible range.

According to this provision, the energy conservation technique is classified into seven categories as given below, showing the observable criteria and target level for major items:

(1) Rationalization of fuel combustion
(2) Rationalization of heating, cooling and heat transfer, etc.
(3) Prevention of heat loss due to heat radiation and conduction
(4) Waste heat recovery and reuse
(5) Rationalization in conversion of heat into power, etc.
(6) Prevention of electric loss due to resistances, etc.
(7) Rationalization in conversion of electricity into power and heat

The target level is observable criteria in new installations and criteria for efforts to be made in existing installations.

Thus, these items provide a guideline for diagnosis of energy conservation. The following gives the confirmation criteria in the Japanese standards by way of reference.

The following also introduce examples of rationalization and improvement measures for each item:

(1) Rationalization of fuel combustion

Tables 3.1 to 3.4 show the observable criteria and terget level for air-fuel ratios for boilers and industrial furnaces.

Table 3.1 Standard Air Ratio for Boilers

Classification	Load Factor (%)	Solid Fuel		Liquid Fuel	Gas Fuel	Blast Furnace Gas and Other by-Product Gases
		Fixed Bed	Fluidized Bed			
Large-sized boiler for electric utilities	75 - 100	–	–	1.05 - 1.2	1.05 - 1.1	1.2
Other boilers						
30 t/h or more	50 - 100	1.3 - 1.45	1.2 - 1.45	1.1 - 1.25	1.1 - 1.2	1.2 - 1.3
10 to 30 t/h	50 - 100	1.3 - 1.45	1.2 - 1.45	1.2 - 1.3	1.2 - 1.3	–
5 to 10 t/h	50 - 100	–	–	1.3	1.3	–
< 10 t/h	50 - 100	–	–	1.3	1.3	–

Table 3.2 Target Air Ratios for Boilers

Classification	Load Factor (%)	Solid Fuel		Liquid Fuel	Gas Fuel	Blast Furnace Gas and Other by-Product Gases
		Fixed Bed	Fluidized Bed			
Large-sized boiler for electric utilities	75 - 100	–	–	1.05 - 1.1	1.05 - 1.1	1.15 - 1.2
Other boilers						
30 t/h or more	50 - 100	1.2 - 1.3	1.2 - 1.25	1.05 - 1.15	1.05 - 1.15	1.2 - 1.3
10 to 30 t/h	50 - 100	1.2 - 1.3	1.2 - 1.25	1.2 - 1.25	1.2 - 1.25	–
5 to 10 t/h	50 - 100	–	–	1.2 - 1.3	1.2 - 1.25	–
< 10 t/h	50 - 100	–	–	1.2 - 1.3	1.2 - 1.25	–

Table 3.3 Standard Air Ratio for Industrial Furnaces
(Except for solid fuel furnace or the furnace with rated burner capacity of 500 Mcal/h or less)

Classification	Continuous Type	Intermittent Type
Metal melting furnace for casting	1.30	1.40
Continuous billet heating furnace	1.25	–
Other metal heating furnace	1.25	1.35
Metal heat treating furnace	1.25	1.3
Petroleum heating furnace	1.25	–
Thermal cracking furnace and reforming furnace	1.25	–
Cement kiln	1.30	–
Lime kiln	1.30	1.35
Drying oven (only the combustion chamber)	1.30	1.50

Table 3.4 Target Air Ratio for Industrial Furnaces
(Except for solid fuel furnace or the furnace with rated burner capacity of 500 Mcal/h or less)

Classification	Continuous Type	Intermittent Type
Metal melting furnace for casting	1.25	1.3
Continuous billet heating furnace	1.2	–
Other metal heating furnace	1.2	1.3
Metal heat treating furnace	1.2	1.3
Petroleum heating furnace	1.25	–
Thermal cracking furnace and reforming furnace	1.25	–
Cement kiln	1.25	–
Lime kiln	1.25	1.35
Drying oven (only the combustion chamber)	1.3	1.5

(1)-1 Selection of burners	Type, capacity, turndown ratio Maintenance, tip worn
(1)-2 Improvement in atomization	Fuel temperature, viscosity Volume of atomizing air and steam Fuel pressure Dispersion reagent, emulsion
(1)-3 Prevention of entry	Furnace pressure control, Narrowing of the opening, master/slave door, air seal improvement, Reduced opening time
(1)-4 Fuel-air ratio control improvement	O_2 control, and CO control in exhaust gas Cascade control, Cross limit control
(1)-5 Load stability	Load distribution improvement and control of the number of units, distribution of small-sized boilers, and control of the number of units, Steam accumulator
(1)-6 Combustion temperature rise	Combustion by oxygen enrichment, Gas atomization, Fluidized bed combustion
(1)-7 Complete combustion at a low temperature	Combustion by catalyst

(2) Rationalization of heating, cooling and heat transfer

(2)-1 Heating in industrial furnace

(2)-1-1 Optimization of heating temperature	Setting the operatoin standards
(2)-1-2 Heat pattern improvement	Temperature distribution, temperature rise speed, In-furnace gas flow
(2)-1-3 Thermal load optimization	Furnace floor thermal load, Thermal load distribution to plural equipment, Thermal load equalization

(2)-1-4 Material charging method improvement	
(2)-1-5 Furnace profile improvement	
(2)-1-6 Reduction of thermal capacity of furnace body and heat transfer device	Reduced weight
(2)-1-7 Luminous flame radiation improvement	
(2)-1-8 Direct heating	Modification into direct flame heating type furnace, Submerged combustion, Direct resistance heating Far-infrared rays heating, Microwave heating, Induction heating Dielectric heating
(2)-2 Heating by steam	
(2)-2-1 Optimization of steam pressure	
(2)-2-2 Air purging	
(2)-2-3 Direct steam blow-in method improvement	
(2)-3 Heat transfer	
(2)-3-1 Reduction in resistance for heat transfer	Prevention of scale, sludge and frost from growing on heat transfer surface, Boiler water quality control, chemicals supply, water blowing optimization, Removing condensed film, defrosting, Cleaning, soot blowing, filter cleaning
(2)-3-2 Improvement of heat transfer coefficient	Gas velocity increase, heating by jet flow, high-speed gas flame burner, Fluidized heat transfer, Atomized mist cooling

(2)-3-3 Heat exchange system	Optimization, Increase in unit numbers
(2)-3-4 Heat exchanger	Use of material with high heat conductivity Heat transfer tube shape Heat transfer tube arrangement Expanded heat transfer area, fin plate, Buffer plate, turbulence accelerator
(2)-4 Operation	
(2)-4-1 Optimization of start and stop time	Use of remained pressure of boiler
(2)-4-2 Reduction in thermal load	Optimaization of air conditioning temperature, and rate of ventilation Use of potential heat in the preceding process, Reduction in process wait time Reduction in empty furnace time, lot concentration Optimization of distillation column reflux ratio, selection of feed/ extraction tray
(2)-5 Process	
(2)-5-1 Improvement of control method	Reduction of margin
(2)-5-2 Introduction of automated system	
(2)-5-3 Cascade use of heat	Multi-effect evaporator, vapor re-compression Increase in the number of distillation tower tray layers Plant integration Pooling of energy among plants
(2)-5-4 Change of separation method	Mechanical separation Separation by membrane Adsorption Extraction and super-critical extraction

(2)-5-5 Layout change	Reduction in transport distance Avoiding the complicated transports Reduction in idle operation time by reduced transport distance
(2)-5-6 Mitigation of reaction conditions	Catalyst improvement Chemicals improvement Bio reactor
(2)-5-7 Change of product standards	Avoiding the excessively high quality product Materials requiring no heat treatment in the next process
(2)-5-8 Change of raw materials	Recycling
(2)-5-9 Scale up	Reduction of operating time by increased electric power
(2)-5-10 Introduction of continuous operation	
(2)-5-11 Introduction of higher speed operation	
(2)-5-12 Omission of some processes	Hot charging
(2)-5-13 Use of highly efficient equipment	

(3) Prevention of heat loss due to heat radiation and conduction, etc.

Tables 3.5 and 3.6 show the judgement criteria for the surface temperatures of the industrial furnace outer wall.

Table 3.5 Standard Temperatures of Furnace Outer Walls
(except for the rotary furnace and the furnace with the rated burner capacity of 500 Mcal/h or less) (outer air temperature: 20 °C)

	Temperature Outside the Furnace Wall (°C)		
TemperatureInside the Furnace (°C)	Ceiling	Side Wall	Hearth Contacting with the Outer Air
1,300 °C or more	140	120	180
1,100 °C to 1,300 °C	125	110	145
900 °C to 1,100 °C	110	95	120
Less than 900 °C	90	80	100

Table 3.6 Target Temperatures of Furnace Outer Walls
(except for the rotary furnace and the furnace with the rated burner capacity of 500 Mcal/h or less) (outer air temperature: 20 °C)

Temperature Inside the Furnace (°C)	Target Temperature of Furnace Outer Wall (°C)		
	Ceiling	Side Wall	Hearth Contacting with the Outer Air
1,300 °C or more	120	110	160
1,100 °C or more but less than 1,300 °C	110	100	135
900 °C or more but less than 1,100 °C	100	90	110
Less than 900 °C	80	70	90

(3)-1 Prevention of leakage

Inspection, repair at earlier stage,
Selection and maintenance of steam trap
Improved seal for the rotary section and joint

(3)-2 Reduction in heat release area

Improvement of piping route
Removal of unnecessary piping
Closing of the master valve for unused piping and putting blind plate

(3)-3 Heat insulation

Improved heat insulation for flange and valve,
Use of heat insulation material with low heat conductivity
Reduced thermal emissivity of the outer surface
Installation of covers or lid
Maintenance of heat insulations
Introduction of light weight insulation material for batch furnace
(Specific bulk density should be less than 1.3.)

(3)-4 Prevention of gas flowing into the furnace and radiation loss

Reduced aperture size, closing, installation of the door
Reduced door open/close time

(3)-5 Optimization of boiler water blow volume

(4) Waste heat recovery and reuse

Tables 3.7 to 3.10 show the judgement criteria for exhaust gas temperatures for boilers and industrial boilers.

Table 3.7 Standard Exhaust Gas Temperatures for Boilers
(Load factor: 100 % at the outer temperature of 20 °C)

(unit: °C)

Classification of Evaporation	Solid Fuel		Liquid Fuel	Gas Fuel	Blast Furnace Gas and Other by-Product Gases
	Fixed Bed	Fluidized Bed			
Large-sized boiler for electric utilities	–	–	145	110	200
Other boilers					
30 t/h or more	200	200	200	170	200
10 to 30 t/h	250	200	200	170	–
5 to 10 t/h	–	–	220	200	–
< 5 t/h	–	–	250	220	–

Table 3.8 Target Exhaust Gas Temperatures for Boilers
(Load factor: 100 % at the outer temperature of 20 °C)

(unit: °C)

Classification of Evaporation	Solid Fuel		Liquid Fuel	Gas Fuel	Blast Furnace Gas and Other by-Product Gases
	Fixed Bed	Fluidized Bed			
Large-sized boiler for electric utilities	–	–	135	110	190
Other boilers					
30 t/h or more	180	170	160	150	190
10 to 30 t/h	180	170	160	150	–
5 to 10 t/h	–	300	200	180	–
< 5 t/h	–	320	220	200	–

Table 3.9 Standard Waste Heat Recovery Ratio for Industrial Furnaces

Gas Temperature at Furnace Iutlet (°C)	Waste Heat Recovery Rate (%)		
	> 20 Gcal/h	5 -20 Gcal/h	1 - 5 Gcal/h
< 600	25	25	–
600 - 800	35	30	25
800 - 900	40	30	25
> 900	45	35	30

Table 3.10 Target Waste Heat Recovery Ratio for Industrial Furnaces

Gas Temperature at Furnace Outlet (°C)	Waste Heat Recovery Rate (%)		
	> 20 Gcal/h	5 -20 Gcal/h	1 - 5 Gcal/h
< 600	30	30	–
600 - 800	35	30	25
800 - 900	40	35	30
> 900	50	40	35

(4)-1 Waste energy

Exhaust gas, exhaust air
Waste water, waste liquid
Condensate
High-temperature solids (red hot cokes)
Mechanical energy (water head)
Gas pressure (blast furnace top gas pressure fluid coker)
By-product gas (steel converter)
Coldness (liquefied natural gas)
Natural energy (solar light, heat and outer air temperature)

(4)-2 Purpose of use	Heating of material and raw materials Preheating of combustion air or feed air Preheating the boiler feed water Preheating the fuel (oil) Steam generation Power generation, electric power generation Air conditioning District heat supply Refrigeration Fish cultivation Heating of green house Snow melting
(4)-3 Means	Heat exchanger, fluidized bed Heat pipe Heat pump Use of heat medium Waste heat boiler Reduced pressure type heat recovery boiler Turbine (organic solvent and steam) Total enthalpy heat exchanger Regenerative burner

(5) Rationalization in conversion of heat into power

(5)-1 Improvement of energy efficiency	Improvement of steam conditions Combined system Cogeneration Power recovery at steam pressure reduction such as a back pressure turbine

(5)-2 Rationalization in power plant	Improvement of turbine and nozzle design Stabilized condenser vacuum control (cleaning, water temperature control, leakage prevention) Generator operation control Control of the number of auxiliary equipment to be used, speed control Optimization of back pressure and extraction condition Peak shift (use of electric power during mid-night hours and on holidays, heat storage)
(5)-3 Direct power generation	Fuel cell
(5)-4 Engine efficiency improvement	Optimization of the number of steps and steam pressure
(5)-5 Rationalization of steam ejector	Conversion to vacuum pump

(6) Prevention of electric heat loss due to resistances

(6)-1 Power transmission

(6)-1-1 Increase in voltage

(6)-1-2 Reduction in temperature

(6)-1-3 Conversion into DC power

(6)-2 Wiring	Power receiving substation facilities, load distribution improvement,
(6)-2-1 Minimizing the wiring length	Wiring route improvement

(6)-2-2 Wiring system improvement

(6)-2-3 Selection of wire diameters

(6)-2-4 Balancing loads between 3-phase	
(6)-3 Transformer	
(6)-3-1 Optimum capacity	
(6)-3-2 Load distribution control and adjustment of the number of operating units	
(6)-3-3 Wire connection method	
(6)-3-4 Disconnected when not in use	
(6)-4 Electric equipment	Reduced contact resistance
(6)-5 Power factor improvement	Installation of a phase advance capacitor, load interlocking ON/OFF Optimization of load factor of equipment Use of a synchronous generator
(6)-6 Operation	
(6)-6-1 Maximum power control	Load leveling Demand control
(6)-6-2 Optimization of circuit voltage	
(6)-7 Use of the equipment with minimum loss	Superconductivity

(7) Rationalization in conversion of electricity into motive power, heat, etc.

(7)-1 Motor	Use of high-efficiency motor Optimum capacity
(7)-2 Power transmission	Transmission device improvement, Lubrication control, Belt (material and relaxation adjustment)
(7)-3 Operation	Prevention of idle operation, intermittent operation, Maintenance of optimum voltage, Intermittent charge for electric precipitator

(7)-4 Fluid transport	
(7)-4-1 Load reduction	Reduction in flow rate (leakage prevention) Reduction in pipe resistance (rationalization of pipe route and cleaning) Reduction in suction fluid temperature Change of transport system Highly efficient equipment, impeller, variable blade
(7)-4-2 Optimization of equipment capacity	Impeller cut
(7)-4-3 Control	Speed control (VVVF, clutch, pole change) Control of the number of units
(7)-5 Energy recovery	Regenerative braking
(7)-6 Electric heating	
(7)-6-1 Load reduction	Hot charge Improvement of marerial charging method into the furnace Improvement of power input method Reduction in contact resistance
(7)-6-2 High-efficiency equipment	Higher efficiency of frequency converter Direct heating (direct resistance heating, induction heating, dielectric heating, microwave heating, plasma heating)
(7)-6-3 Comparison with combustion heating	

(7)-7 Air conditioning	Load reduction, Building shape, structure, direction, surroundings, Prevention of outer air from entering (automatically operated door, curtain) Optimization of volume and frequency of air ventilation Heat insulation improvement such as paired glass and carpet Separation of heat generating bodies, isolation of illumination heat sources, Local air conditioning, Zoning (change of air conditioning requirements according to the location) Local space heating by far-infrared radiation heater
(7)-7-1 Air supply	Filter cleaning, Reduced duct resistance Fan speed control Increased size of humidifier nozzle Uniformness of temperature distribution by adjustment of louvers of air outlet
(7)-7-2 Improvement of control system	Operation control and optimum control by computer system
(7)-7-3 Operation control	Return water temperature control of chilled water Water temperature control of cooling tower Cleaning of heat exchanger
(7)-8 Illumination	
(7)-8-1 Optimum illuminance	
(7)-8-2 Interior	Wall color
(7)-8-3 Improved lighting fixture arrangement	

(7)-8-4 Use of sun light	
(7)-8-5 Turning off the unnecessary lights	
(7)-8-6 Illumination control	
(7)-8-7 Fixtures cleaning	
(7)-8-8 Lamp replacement at proper intervals	
(7)-8-9 Use of high-efficiency equipment	Lamp, stabilizer and high-frequency lighting up
(7)-9 Electrolysis	
(7)-9-1 Reduced contact resistance	
(7)-9-2 Reduced voltage	Reduction of overvoltage Improvement of electrodes
(7)-9-3 Operating condition control	Bath temperature, concentration, distance between electrodes

4. RECOGNITION OF OVERVIEW OF THE FACTORY

4. RECOGNITION OF OVERVIEW OF THE FACTORY

General factory information mentioned above in section 2 (1) needs to be collected before starting audit of the factory. The following preliminary survey list is distributed and answered as a means of obtaining such information. Also, it is vitally important to have interviews with the factory management and engineers in order to resolve any unclear point or question as a preparation to factory audit.

Table 4.1 Preliminary Survey List for Factory Energy Conservation

Replied by	
Division	
Date	

1. General

1	Name of Factory	
2	Address	
3	President Factory Manager Energy Manager	
4	Type of Industry	
5	Capital	
6	Annual Sales Amount	
7	Number of Employees	
8	Number of Engineers	
	Electricity Engineers Heat Engineers	
9	Organization Chart	

2. Production of Major Products

No.	Name of Production	Production Capacity	1995			1996			1997			1998		
			Annual Operating Hour	Production Volume	Sales Amount	Annual Operating Hour	Production Volume	Sales Amount	Annual Operating Hour	Production Volume	Sales Amount	Annual Operating Hour	Production Volume	Sales Amount

3. Annual Utility Consumption

No.	Name of Utility	Lower Heat Value	1995			1996			1997			1998		
			Consumption	Unit Price	Purchase Amount	Consumption	Unit Price	Purchase Amount	Consumption	Unit Price	Purchase Amount	Consumption	Unit Price	Purchase Amount
1	Fuel Oil (kl)													
2	Diesel Oil (kl)													
3	Kerosene (kl)													
4	Gasoline (kl)													
5	LPG (t)													
6	Natural Gas (m^3)													
7	Others													
8	Coal (t)													
9	Electricity (kWh)	–												
10	Sea Water (t)	–												
11	River Water (t)	–												
12	Well Water (t)	–												
13	City Water (t)	–												

4. Electric Power Receiving

No.	Items	Unit	1996	1997	1998	Note
1	Receiving Voltage	kW				
2	Maximum Demand	MW				
3	Annual Electricity Consumption	MWh				
4	Paid Amount of Electricity	PLW/y				
5	Power Factor					
6	Annual Operating Hour	h/y				
7	Average Electricity	MW				
8	Maximum Electricity	MW				
9	Transformer Capacity per Unit	MVA				
10	Number of Transformers					
11	Inhouse Generation Capacity	MW				

5. Boiler

No.	Boiler No.	1	2	3		
1	Type					
2	Built Year					
3	Nominal Capacity (Steam) Steam Pressure (kg/cm^2G) Steam Temperature (°C) Evaporating Volume (t/h)					
4	Nominal Capacity (Electricity) Generated Electricity (kWh) Generated Voltage (kV) Power Factor					
5	Kind of Fuel Fuel Consumption					
6	Operating Period (Hours/Day) 1995 1996 1997 1998					
7	Operating Period (Hours/Year) 1995 1996 1997 1998					

6. Major Energy Consuming Facilities

No.	Name of Production Equipment	Built Year	Kind of Product	Kind of Energy	Nominal Output of Product	Operating Period and Output											
						1995			1996			1997			1998		
						H/Day	D/Y	Output	H/Day	D/Y	Output	H/Day	D/Y	Output	H/Day	D/Y	Output

7. Necessary Drawings and Documents

No.	Items
1	Plant Layout
2	Process Flowchart of Major Products
3	Energy Flowchart
4	Electric Skeleton Diagram
5	Structural Drawing of Major Equipment
	Measuring Points and Name of Instruments for Energy Consumption
6	Specification and Structural Drawings of Boiler

7	Energy Intensity Energy Consumption/Output of Products						
No.	Kind of Product	Kind of Energy	Unit	1995	1996	1997	1998
a		Production Rate					
b		Production					
c		Production					
d		Production					
e		Production					
f		Production					

8. Energy Conservation Plan

9. Energy Conservation Items in the Past (including results)

10. Energy Conservation Items Undergoing (including expected results)

11. In case you have any problem(s) in your course of promotion of energy conservation, please circle the number(s) of applicable item(s) among the following.

1	Uncertainty of energy prospect
2	Less impact of energy cost to the whole cost of enterprise
3	Expectation of canceling the increasing cost to the rising price
4	Little possibility of energy shortage
5	Little potential for promoting further energy conservation
6	Shortage of engineers
7	Difficulty in obtaining good energy efficient equipment
8	Unreliable results from energy efficient equipment
9	Uncertainty about return on investment in energy conservation facilities
10	Difficulty in obtaining good information such as active case
11	Insufficient system of research and development
12	Shortage of fund for facility improvement
13	Out-of-date facilities
14	Low consciousness of employees
15	Lack of personnel who can educate the employees
16	Shortage of measuring equipment
17	No time to analyze energy consumption rate
18	Shortage of information on government's measures
19	Shortage of government's subsidiary measures
20	Others

5. WORKING OUT A MEASUREMENT PLAN

5. WORKING OUT A MEASUREMENT PLAN

Measurement tasks are normally performed as a factory's state of operation would allow. Therefore, it becomes necessary to devise a detailed measurement plan in order to obtain high accuracy data within a limited amount of time.

A measurement plan is created based on the factory's preliminary survey list, preliminary discussions with the factory manager, check lists, and internal meetings of the audit team, and then finalized after getting the factory's approval.

(1) Finalizing a measurement schedule

The measurement schedule is determined by the factory's operation plan and items surveyed for the energy audit. Work partition is determined through consultations between the specialists in charge of measurement and the specialists in charge of energy audit. An example of a measurement schedule is shown in Table 5.1.

The factory side is requested to carry out necessary adjustments of loads, and take action to prevent accidents during measurements in accordance with the factory's operation plan. If there should be any continuous measurement that goes on for over 8 hours, the factory is asked to monitor the recording meters and keep records of the factory measuring instruments.

It is important not to impede the factory's production activities.

Table 5.1 Measurement Time Schedule in AAA Factory

Period:

"Member: Mr. A, B, C, D & E"

No.	Equipment	Measuring Items	Team Member	Factory Member	1st Day AM	1st Day PM	2nd Day AM	2nd Day PM	3rd Day AM	3rd Day PM	Remarks
1	Reheating furnace heat balance										
1.1		Fuel flow rate	A	M		■	■				
1.2		Fuel temperature	A	M		■	■				
1.3		Combustion air temperature	A	M		■	■				
1.4		Exhaust gas O_2	B & C	M		■	■				
1.5		Exhaust gas temperature	B & C	M		■	■				
1.6		Furnace temperature	A	M		■	■				
1.7		Furnace O_2	B & C	M		■	■				
1.8		Billet temperature	B & C	M		■	■				
1.9		Billet volume		M		■	■				
1.10		Furnace surface temperature	B & C	M		■	■				
1.11		Air fan motor ampere	D & E	N		■	■				
		Cooling water temperature				■	■				
		Cooling water volume				■	■				
2	Sub-station										
2.1		Electricity demand	D & E	N	■	■	■				
3	Water pump										
3.1		Motor electricity	D & E	N				■	■		
3.2		Water flow rate	B & C	N				■	■		
3.3		Water pressure	B & C	N				■	■		
3.4		Water temperature	B & C	N				■	■		
4	Report to Factory		A,B,C,D&E							■	

(2) Determining measurement items and measurement methods

Each item that appears on the specialist's survey list is ranked by its order of priority. The items are then grouped into categories such as those measured by measuring equipment, those read off the factory's instrumentation, those to be output in signals from the factory's instrumentation, and those obtained from the factory's operation records, etc. The schedule, workers, and the environment of measurement tasks are the factors that determine the measurement items.

Measurement methods are determined by selecting the measurement equipment to be used, the measurement points, and objects of measurement.

(3) Determining measurement points

Measurement points are determined based on the items to be measured. When selecting the measurement points, representative measurement values must be obtainable at the site. Factors related to the measurement environment, such as sensor mount nozzles, condition of the work platform, and the presence of high temperature, water leakage, dust particles, and electric shock must be taken into consideration. It is vitally important to select the position of sensor mount nozzles, such as gas sampling nozzles, thermometer mount nozzles, anemometer mount nozzles, and pressure gauge mount nozzles. Therefore, if a current nozzle position or configuration is not appropriate, the factory side should be requested to have the nozzle's position changed, and/or new nozzles installed. For flow rate measurements of steam, compressed air, and other high pressure gases, piping must be disconnected, and orifice plate or vortex flowmeter installed. Therefore the factory must be asked to do the necessary preparation work well in advance in view of the time required for the piping.

(4) Determining the measurement time

Loads that fluctuate considerably between night and day, such as electric power loads, loads on air compressors, refrigerating machines, and boilers should be measured continuously for over 24 hours.

Machinery and equipment that are not subject to heavy load fluctuations should be continuously measured for 30 minutes to a few hours.

Spot measurements in intervals of 30 minutes to 60 minutes should be carried out on machinery and equipment that do not require continuous recording.

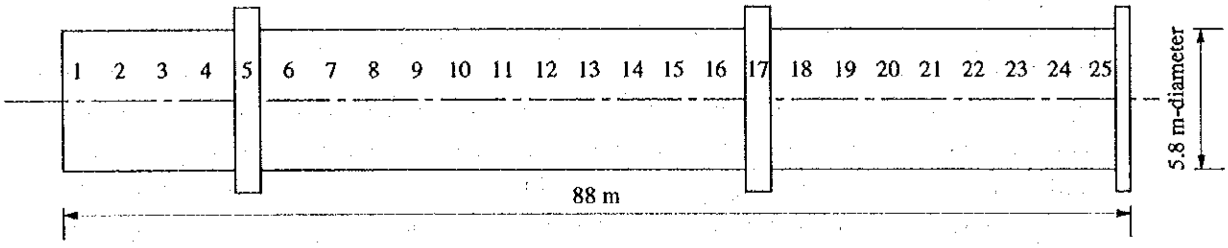
(5) Preparing forms for measurement records

Measurement records should be written down on record forms by personnel in charge of the measurement except when the measurement equipment itself is equipped with a recording device such as a magnetic disk, or when a record meter records its reading on recording paper, or magnetic disk, etc. The forms for recording should be prepared before initiation of measurements and personnel assigned to the measurement tasks should be asked to record the measurements without fail.

It is recommended to include flow sheets and cross-sectional drawings of the facility in the format of record forms so that measurement points can be easily collated with measurement data, and abnormalities in recorded data can be easily spotted. An example of a record form is shown in Figure 5-1.

Figure 5.1 Measuring Data Sheet

Rotary Kiln: Surface temperature
Date and time:



Measuring data record

No.	Maximum (°C)	Average (°C)	Minimum (°C)	Maximum to Minimum (°C)
1	279	271	264	15
2				
3				
6				
8				
10				
12				
14				
20				
22				
24				

Measuring equipment: Portable radiation pyrometer

(6) Processing measurement data

Measurement data is first subjected to a primary process by a measurement specialist and then handed over to an energy audit specialist along with the original measurement record. The method and output of the primary process for the measurement data are determined through consultation with the energy audit specialist.

6. MEASURING EQUIPMENT

6. MEASURING EQUIPMENT

This section provides a list, overview and handling procedures of measuring equipment. Annex I provides a general description of exhaust gas analyzers, thermometers, flowmeters, pressure gauges and hygrometers.

6.1 Lists of Measuring Equipment

Table 6.1 Equipment List

Classification	No.	Item	Quantity
1. Pressure gauges	P-1	Pressure gauge (bourdon tube) 0-1.0 MPa	1
	P-2	Pressure gauge (bourdon tube) 0-2.0 MPa	1
	P-3	Pressure gauge (bourdon tube) 0-3.5 MPa	1
	P-4	Pressure gauge (bourdon tube) 0-5.0 MPa	1
	P-5	Digital low pressure indicator	1
	P-6	Steam pressure transmitter	2
2. Thermometers	T-1	Glass thermometer	4
	T-2	Thermo-hygrometer	5
	T-3	Sheathed thermocouple (type-K, 1 m)	6
	T-4	Sheathed thermocouple (type-K, 2 m)	2
	T-5	Compensation wire (type-K)	6
	T-6	Sheated thermocouple (type-R, 2 m)	3
	T-7	Compensation wire (type-R)	3
	T-8	Surface thermometer	1
	T-9	Radiation pyrometer (Low)	1
	T-10	Radiation pyrometer (High)	1
	T-11	Suction pyrometer	1
	T-12	Infrared thermovideo	1
3. Flowmeters	F-1	Ultrasonic flowmeter	1
	F-2	Vortex flowmeter	3
	F-3	Hot wire anemometer	1
4. Water quality analysis	W-1	Solution Conductivity meter	1
	W-2	PH meter	1
5. Gas analysis	G-1	Sampling gas treatment unit	1
	G-2	Oxygen analyzer (continuous)	2
	G-3	Oxygen analyzer (spot)	2
6. Steam trap	S-1	Steam trap checker	1
7. Power measurement	E-1	Low voltage detector	2
	E-2	Tester	2
	E-3	Clamp-on power meter	3
	E-4	Clip-on AC power meter	1
	E-5	Power transducer 3p-4w 1000 W 110 V/5 A	1
	E-6	AC current transducer 5 A AC	1
	E-7	AC voltage transducer 110 VAC	1
	E-8	Non-active power transducer 3p-3w 100 V/5 A	1
	E-9	Power transducer 3p-3w 1000 W 110 V/5 A	1
8. Tachometer	TM-1	Tachometer	1
9. Illuminance meter	L-1	Lux meter	1
10. Recorder	R-1	Hybrid recorder	2

Table 6.2 Equipment List

(Auxiliaries)

Classification	No.	Item	Quantity
1. Auxiliaries for gas analysis	1	Sampling pipe (SUS)	6
	2	Sampling tube (Silicon)	3
	3	Teflon tube (OD 8 mm)	1 m
	4	Teflon tube (OD 6 mm)	1 m
2. Recoder auxiliaries	1	Signal wire	100 m × 5
	2	Shield wire	100 m × 1
	3	Mini jack	50
	4	Alligator clip with cover	200
3. Electrical connection parts	1	Step down transformer (200 V/100 V)	2
	2	Power cord & real	35 m × 3
	3	Table tap (100 V)	3
	4	Table tap (200 V)	3
4. Other tools	1	Book type personal computer	1
	2	Camera	1
	3	Stop watch	1
	4	Portable light	5
	5	Heater for tube	1
	6	Tube	10
	7	Tool set	3
	8	Soldering iron	1
	9	Tape (10 m)	1
	10	Vinyl tape (20 m × 19 mm)	10
	11	Sand paper (#40, #120, #320)	30
	12	Duster	100
	13	Kao-wool strip	1
	14	Glass Plate (5 cm × 10 cm: bulue)	3
	15	Heat-proof glove	3
	16	Insulation rubber grove	3
	17	Carrying case	20
	18	Carrying cart	3
	19	Table for measuring equipment	3

Table 6.3 Equipment List of ECCJ

(Equipment carried by ECCJ)

Classification	No.	Item	Quantity
1. Gas analysis	EC-1	CO, CO_2 meter	1
2. Flowmeter	EC-2	Pitot tube type flowmeter	1

6.2 Overview of Measuring Equipment

(1) Pressure gauge (Bourdon tube)

A widely used elastic type pressure gauge assembled into the piping line for pressure measurement. It offers four measurement ranges; 0 to 1.0 MPa, 0 to 2.0 MPa, 0 to 3.5 MPa, and 0 to 5.0 MPa.

(2) Digital low pressure indicator

A handy digital low pressure indicator used to measure the pressure of a gas. The pressure measurement range is between –50 and 50 mm H_2O for both positive and negative pressures. This gauge is mainly used to measure the pressure in furnaces such as a reheating furnace. Data is output as an analog signal of 1 to 5 VDC and can be stored in a recorder.

(3) Steam pressure transmitter

This pressure transmitter uses a semiconductor strain gauge for the detecting part. Pressure is converted into an electrical signal and transmitted. The measurement range is between 0 to 10 kg/cm^2 or between 0 and 50 kg/cm^2. Data is output as an analog signal of 4 to 20 mADC and can be stored in a recorder.

(4) Glass thermometer

A widely used liquid-sealed glass thermometer. The measurement range is between –20 and 100 °C.

(5) Thrmo-hygrometer

A widely used thermo-hygrometer. Humidity is measured from the dry bulb temperature and wet bulb temperature. The measurement range is between –20 and 50 °C.

(6) Sheathed thermocouple

This thermometer uses the Seebeck effect. A metal strand is protected by a sheath member. Type K is a thermocouple made of chromel and alumel and has a measurement range of 0 to 1000 °C. Type R is a thermocouple made of platinum and platinum + rhodium (13 %) and has a measurement range of 0 to 1300 °C.

(7) Surface thermometer

This handy type thermometer employs a thermocouple and is used to measure the furnace surface temperature, etc. Since the object to be measured comes in direct contact with the sensor, the exact temperature can be measured easily. The measurement range is from –50 to 600 °C.

(8) Radiation thermometer

This contactless thermometer uses an infrared rays sensor to enable remote measurement. It can evaluate and store up to 100 sets (total 200) of the measured temperature value and the maximum value during the measurement period. With the low temperature type, the measurement range is from –30 to 1200 °C. With the high temperature type, the measurement range is from 600 to 3000 °C.

(9) Suction pyrometer

The suction pyrometer is used to measure hot gas temperature in the boiler, combustion furnace, etc. A platinum rhodium thermocouple is used as the sensor and the effects of radiation from the hot furnace wall are minimized by the radiation shield. At the same time, the other thermal effects are minimized by aspirating the gas to be measured at high speed through the space between thermocouple and protection tube to measure the temperature. Data is output as an analog signal of 1 to 5 VDC and can be stored in a recorder.

(10) Infrared thermovideo

The temperature of an object can be measured without coming in contact with it and a thermal image can be displayed on the built-in color monitor. The measurement range is from –10 to 950 °C. Data can be stored on a floppy disk and can be analyzed by using the dedicated personal computer software.

(11) Ultrasonic flowmeter

This flowmeter is used to measure the flow rate of a liquid such as water supplied to the boiler or fuel oil. Since ultrasonic waves are used for measurement, measurement can be performed from outside the piping. The meter does not come in direct contact with the liquid, which effectively prevents pressure loss. The measurement range is from –16 to 0 to +16 m/s. Data is output as an analog signal of 1 to 5 VDC and can be stored in a recorder.

(12) Vortex flowmeter

This flowmeter is assembled into the piping line to measure the flow rate. The flow rate is measured by detecting the Karman vortex street. All liquids, gases, and steam are objects to be measured. Data is output as an analog signal of 4 to 20 mADC and can be stored in a recorder.

(13) Hot-wire anemometer

This hot-wire anemometer is used to measure the exhaust gas flow rate in a boiler or combustion furnace. Hot air flow at up to 500 °C can be measured in a range of 0 to 50 m/s. Data is output as an analog signal of 0 to 1 VDC and can be stored in a recorder.

(14) Solution conductivity meter

This handy conductivity meter is used to measure the quality of water supplied to or drained from the boiler, etc. The measurement range is 0 to 200 mS/cm. The temperature of the liquid to be measured is 0 to 80 °C. Liquid temperature and conductivity can be measured at the same time.

(15) PH meter

This handy PH meter is used to measure the quality of water supplied to or drained from a boiler, etc. The measurement range is pH0 to pH14. The temperature of the liquid to be measured is 0 to 80 °C. The liquid temperature and pH can be measured at the same time.

(16) Sampling gas treatment unit

This supplementary device for a gas analyzer is used to remove dust and water vapor from exhaust gas and cool the gas before it is analyzed with an oxygen analyzer or CO-CO_2 meter. The major components of this device are the drain separator, gas suction pump, filter, electronic cooler, and flowmeter.

(17) Portable oxygen analyzer (continuous type)

This analyzer is used to measure oxygen content in the exhaust gas from a boiler, combustion furnace, etc. The measurement range is 0 to 25 %. The zirconia method using electrochemical redox (oxidation-reduction) reaction is employed for measurement. Data is output as an analog signal of 0 to 1 VDC and can be stored in a recorder.

(18) Portable oxygen analyzer (spot type)

This analyzer is used to measure the oxygen content in exhaust gas from a boiler, combustion furnace, etc. The measurement range is 0 to 25 %.

Since this is a compact galvanic cell type oxygen analyzer, it is suitable for short-term measurement.

(19) Steam trap checker

This checker records the steam trap running status. Up to 800 pieces of data can be stored. The stored data can be transferred to a PC (personal computer) and analyzed by dedicated software.

(20) Low-voltage detector

This handy, compact voltage detector has a measurement range of 50 to 600 V.

(21) Tester

This tester is widely used. The measurement ranges are as follows:

DC: 200 mV/2 V/20 V/200 V/1000 V
200 μA/20 mA/10 A
AC: 2 V/20 V/200 V/750 V
200 μA/20 mA/10 A
Ω : 200 Ω/2 kΩ/20 kΩ/200 kΩ/2000 kΩ/20 MΩ

(22) Clamp-on power meter (Hioki Denki: 3166)

This clamp type watt-meter allows single-phase to 3-phase 4-wire type measurement. The calculated reactive power, apparent power, and power factor are output to the printer based on the measured voltage, current, and effective or active power. Data is recorded in the attached FDD unit and can be analyzed using the PC's spreadsheet software.

(23) Clip-on AC power meter (Yokogawa Electric Corporation: 2433-11)

This handy power meter allows measurement of kW, Vrms, and Arms of single-phase or balanced three-phase circuits with a clamp sensor. The circuit voltage is up to 600 V(AC).

(24) Transducer

The transducer is installed between the power supply and the electric equipment to be measued. Analog signals can be output so that the power value, etc. can be directly recorded by a recorder.

Power transducer (3p-4w 1000 W, 100 V/5 A)
AC current transducer (5 AAC)
AC voltage transducer (110 VAC)
Reactive power transducer (3p-3w lag 1000 - lead 1000 var 100 V/5 A)
Power transducer (3p-3w 1000 W, 110 V/5 A)

(25) Tachometer

This tachometer provides both contact and contactless measurement methods. The measurement range is 60 to 30000 rpm.

(26) Lux meter

This handy, compact Lux meter uses a silicon photo diode as a sensor.

The measurement range is 0 to 19999 Lux.

(27) Hybrid recorder

Up to 20 analog signal outputs from measuring equipment can be received. The built-in floppy drive can be used to record the data on a floppy disk. The data can also be printed out by the built-in color printer. The data recorded on the floppy disk can be converted into data for the spreadsheet software using the dedicated software.

(28) CO/CO_2 meter

This meter is used to measure CO/CO_2 content in exhaust gas from a boiler, combustion furnace, etc. The measurement range is 0 to 0.5 vol% for CO, and 0 to 15 vol% for CO_2. The measurement is performed by a non-separated type infrared ray absorption method using the infrared ray absorption percentage. Data is output as an analog signal of 0 to 1 VDC and can be stored in a recorder.

(29) Pitot tube type flowmeter

This flowmeter is used to measure the flow rate of liquids, gases, etc. Differential pressure is obtained from the total pressure and static pressure to calculate the flow rate. Data is output as an analog signal of 1 to 5 VDC and can be stored in a recorder.

6.3 Handling the Measuring Equipment

This section outlines the measuring instruments which require careful attention for installation and setting among those listed in the Equipment Table.

For other measuring instruments and the details, please see the individual Instruction manual.

6.3.1 Pressure Gauges

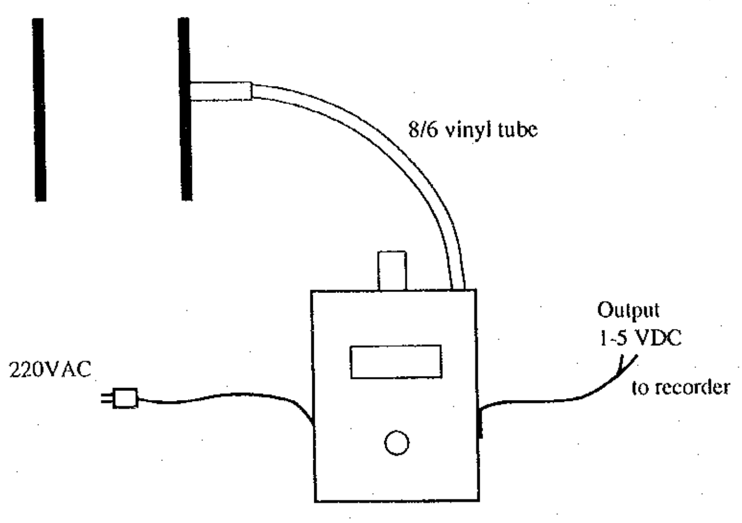
(1) Digital low pressure indicator (P-5): DLM-10 (Manufactured by Seiritsu Kogyo)

a. Specifications

Fluid to be measured	: Air and combustion gas
Measuring range	: –50 to 50 mmH_2O
Ambient temperature	: 0 to 40 °C
Resolution	: 0.1 mmH_2O
Accuracy	: ±2 %FS
Allowable overpressure	: 10 times the maximum range
Signal output	: Analog 1 to 5 VDC
Power requirements	: 220 VAC, 50 Hz

b. Installation method

Digital Low Pressure Indicator Wiring Chart



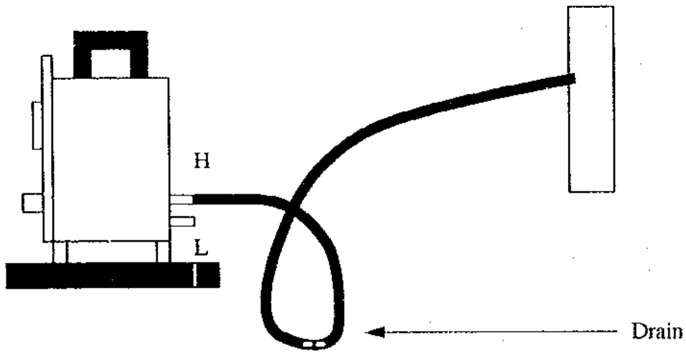
Digital low pressure indicator

c. Cautions

1) Before measurement, be sure to perform zero point adjustment (on the unit surface) with the zero calibration knob.

2) When any ripple is detected in the input pressure, perform damping adjustment with the damping adjustement volume (at the back of the unit).

3) Take care not to let the drain enter the unit during measurement. (See the figure below.)



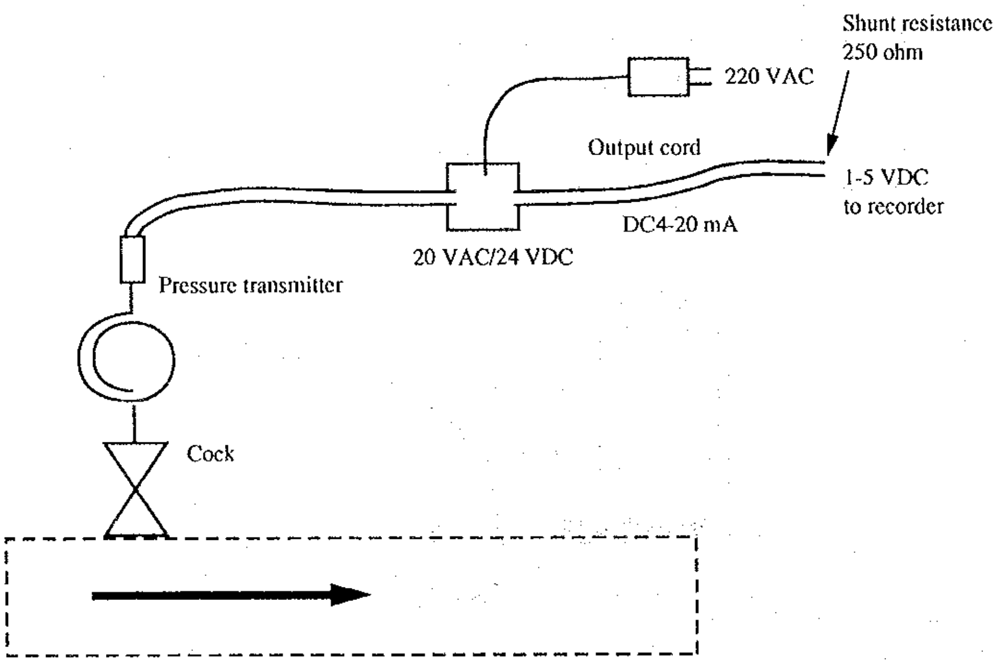
(2) Steam pressure transmitter (P-6): KH 15 (Manufactured by Nagano Keiki Seisakusho)

a. Specifications

Measuring range	:	0 to 10 kg/cm², 0 to 50 kg/cm²
Fluid to be measured:		Steam
Ambient temperatue	:	–20 to +70 °C
Accuracy	:	±0.5 %FS
Signal output	:	Analog 4 to 20 mADC
Power requirements	:	220 VAC, 50 Hz

b. Installation method

Pressure Transmitter Wiring Chart



c. Cautions

1) After installation, tighten the hexagonal portion of the connecting screw with a pipe wrench or equivalent.

2) For zero point adjustment, use the zero point adjusting trimmer on the unit.

3) Span adjustment must not be performed. (A pressure measurement standard is required.)

4) Allow the unit to warm up for at least 5 minutes.

6.3.2 Thermometers (T-9, T-10): RT70-1, RT70-2 (Manufactured by Hayashi Denko)

(1) Radiation thermometer

a. Specifications

For high temperatures

Measuring range	: 600 to 3000 °C
Measuring wavelength	: 1 μm
Sensor	: Silicon diode
Response time	: 0.55 sec
Reproducibility	: ±1 % or ±1 °C of the reading
Resolution	: 1 °C or 1 °F
Ambient temperature	: 0 to 50 °C
Ambient humidity	: 10 to 85 %
Signal output	: Analog 1 m VDC/°C
Power requirement	: Four AA dry cells

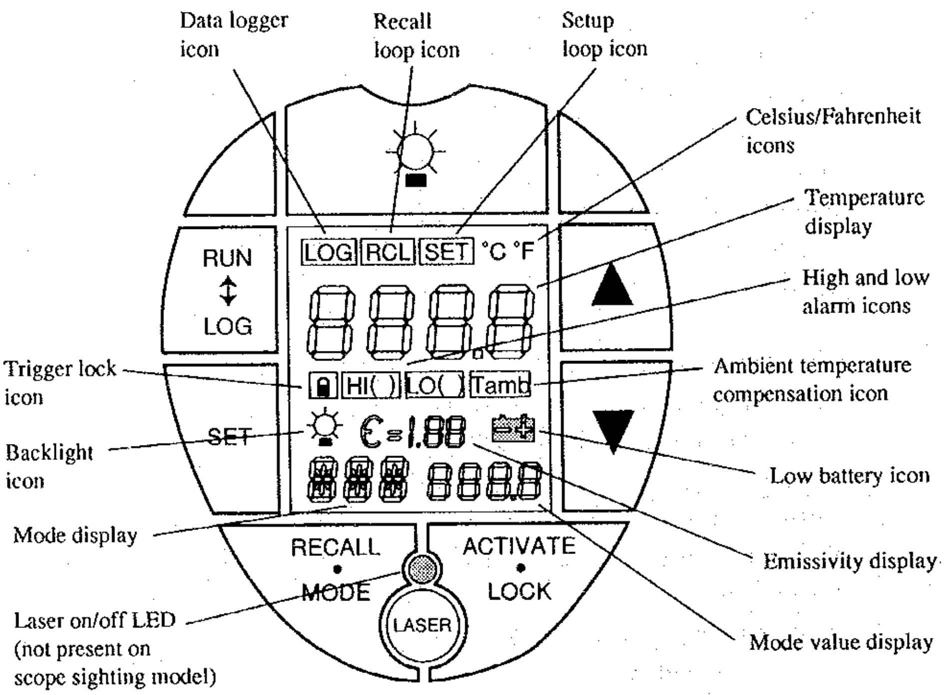
For low temperatures

Measuring range	: –30 to 1200 °C
Measuring wavelength	: 8 to 14 μm
Sensor	: Thermopile
Response time	: 0.5 sec
Reproducibility	: ±1 % or ±1 °C of the reading
Resolution	: 1 °C or 1 °F
Ambient temperature	: 0 to 50 °C
Ambient humidity	: 10 to 85 %
Signal output	: Analog 1 m VDC/°C
Power requirement	: Four AA dry cells

b. Installation method

The main settings for measurements in RUN Loop include the three items given below.

1) SET Loop
2) RUN Loop
3) RECALL Loop



1) Set Loop

① Release or unlock the trigger.
② Press the SET button. The SET icon will be activated.
③ Press the RUN/LOG button. The LOG icon is not activated
④ Press ACTIVATE to toggle between °C or °F for the display and data output.
⑤ Press the ▲ or ▼ button to change the HAL, LAL, TAM and DOI setting. (Press the MODE button to switch between HAL, LAT, TAM and DOI.)
⑥ Press ACTIVATE to activate the HAL, LAL or TAM.
⑦ Press the ACTIVATE to toggle between DIG (digital) or ANA (analog) outputs.
⑧ Press the ▲ or ▼ button to set DOI (digital output interval) if DIG was selected.

2) RUN Loop

① Point the instrument at the target.
② Pull the trigger.
③ Press the ▲ or ▼ button to change emissivity.
④ Press the laser button to activate the laser.
⑤ Read the temperature from the display.

3) RECALL Loop

① Release or inlock the trigger.
② Press the RECALL button. (The RCL icon will be activated.)
③ Press the RUN/LOG button. (The LOG icon is not activated.)
④ Read the recalled temperature from the display.

c. Cautions

1) Conduct measurements at right angles to the measuring surface.
2) Determine the emissivity (ε) using a contact type thermometer or black paint.

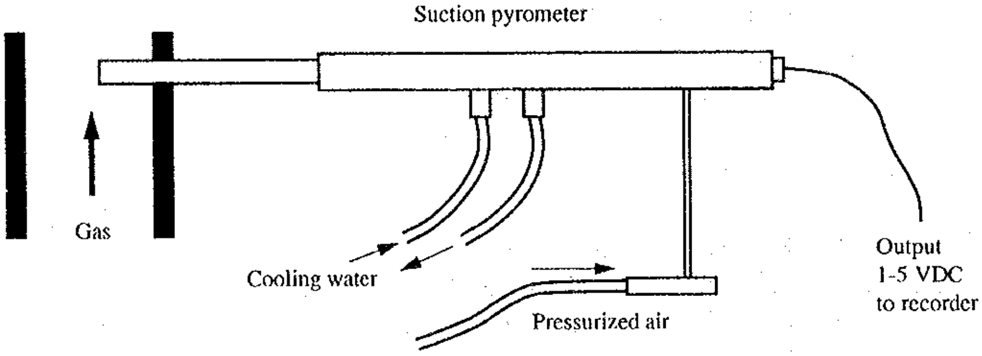
(2) Suction pyrometer (T-11): SU6-13-2.0 (Manufactured by Kawasou Denki Kogyo)

a. Specifications

Measuring range	: 1600 °C maximum
Compressed air pressure	: 5 to 6 kg/cm^2
Sensor	: Thermocouple Type R
Probe	: SUS304
Protective tube	: ϕ3 mm (Recrystallized alumina tube)
Compressed air pressure	: 5 to 6 kg/cm^2
Signal output	: Analog 1 to 5 VDC
Power requirements	: 220 VAC, 50 Hz

b. Installation method

Suction Pyrometer Wiring Chart



c. Cautions

1) The temperature difference between cooling water at the inlet and that at the outlet should be 30 °C or lower.

2) Adjust the volume of cooling water so that boiling will not occur in the probe.

3) To minimize thermal radiation absorption on the probe surface, perform maintenance on a regular basis.

4) After removing the radiation shield on the tip, handle it very carefully so that the thermocouple protection tube will not be damaged.

(3) Infrared thermovideo (T-12): TVS-120 (Nippon Abionics)

a. Specifications

Measuring range	:	–10 to 120 °C/50 to 300 °C/250 to 950 °C 30 cm to ∞
Measuring wavelength	:	3 to 5.4 μm
Ambient temperature	:	0 to 40 °C
Resolution	:	0.2 °C
Cooling system	:	Electronic cooling
Focus	:	Autofocus
Recording system	:	3.5 inch Floppy Disk Drive (30 images/disk)
Power requirements	:	12 VDC battery

b. Installation method

TVS - 120: Set Item

1. RANGE

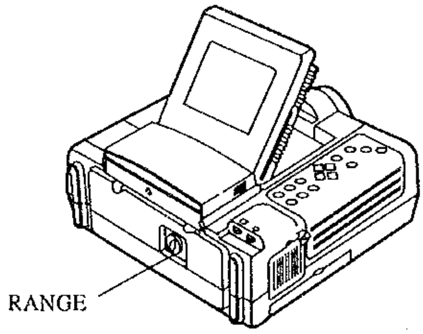
2. MODE

3. DISPLAY MODE

4. DATE/TIME

7

TVS - 120: RANGE



L: -10 – 120°C M: 50 – 300°C H: 250 –950°C

8

TVS - 120: MODE

1. MODE
   Key (MENU), Key (↑ ↓), Key (SET) MODE
2. LEVEL (256, 32, 16)
   Key (→ ←), Key (SET) 256
3. COLOR (COLOR1, COLOR2, B/W, W/B)
   Key (← →), Key (SET) COLOR1
4. TEMP. (°C, °F)
   Key (← →), Key (SET) °C
5. AREA (SMALL, LARGE)
   Key (← →), Key (SET) LARGE
   Key (SET) Rturn to MENU

3

TVS - 120: DISPLAY MODE

1. DISPLAY MODE
   Key (MENU), Key (↑ ↓)
   Key (SET), DISPLAY MODE
2. TEMP (ON, OFF)
   Key (← →), ON
3. EMIS (ON, OFF)
   Key (← →), ON
4. POINT (ON, OFF)
   Key (← →), ON
5. MESSAGE (ON, OFF)
   Key (← →), ON
6. AVE (ON, OFF)
   Key (← →), ON
7. DATE (ON, OFF)
   Key (← →), ON
8. TIME (ON, OFF)
   Key (← →), ON
   Key (SET) Return to MENU

4

TVS - 120: DATE/TIME

1. DATE/TIME
   Key (MENU), Key (↑ ↓)
   Key (SET), DATE/TIME
2. YEAR
   Key (↑ ↓ ← →), 98
3. MONTH
   Key (↑ ↓ ← →), 09
4. DAY
   Key (↑ ↓ ← →), 10
5. HOUR
   Key (↑ ↓ ← →), 13
6. MINUTE
   Key (↑ ↓ ← →), 00
7. SECOND
   Key (↑ ↓ ← →), 00
   Key (SET) Return to MENU

5

c. Cautions

1) Before measurement, recharge the battery pack (for about one and half hours).

2) Emissivity setting

a) Measure the object using a contact type thermometer. Perform adjustment with the emissivity correction key so that the temperature will be identical to the temperature measured by the TVS-120.

b) Partially coat the surface of the object with black paint and measure the temperature with the TVS-120 on which emissivity is set to 1.00. In the same way, measure the non-black part and set emissivity so that the temperature will be identical to the TVS-120 temperature.

Appendix B of this instruction manual contains an emissivity table for typical objects to be measured.

3) The measurement position must be perpendicular to the surface of the object to be measured.

6.3.3 Flowmeters

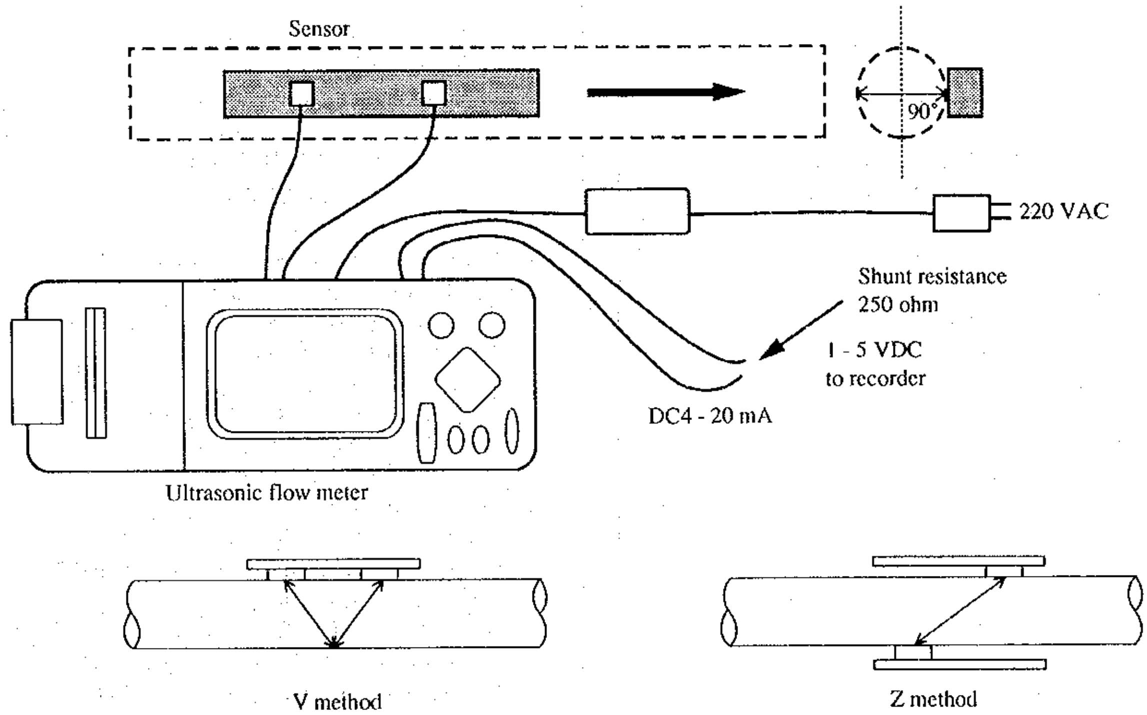
(1) Ultrasonic flowmeter (F-1): FLC (Fuji Electric)

a. Specifications

Measuring range	:	−16 to +16 m/s
Fluid temperature	:	−40 to +100 °C
Ambient temperature:		Sensor: −20 to +60 °C
		Body : −10 to +45 °C
Accuracy	:	Indicated value ±1.5 %
Response speed	:	1 sec interval setting (1 to 99 sec)
Piping specification	:	Inner diameter: 25 to 350 mm
Signal output	:	Analog 1 to 5 VDC
Power requirement	:	90 VAC to 264 VAC

b. Installlation method

Ultrasonic Flowmeter Wiring Chart



c. Setting method

FLC: Panel Setting

1. Measure
2. Site Setup
3. Logger
4. System Setup
5. Analog
6. Printer
7. System Check

1

FLC: Panel Setting
(1. MEASURE)

1. Move the cursor to page title area by ◁.
2. Select [MEASURE] by △▽ then ENT.
3. Move the cursor to[FLOW RATE UNIT] by △▽ then ENT.
4. Select [m^3/h] by ▽ then ENT.
5. Move the cursor to [RESET] by △▽ then ENT.

2

FLC: Panel Setting
(2. SITE SETUP Item)

1. PARAMETER MEMORY
   Sets 20 sites.
2. PIPE PARAMETER
   Inputs the specifications of the pipe.
3. ZERO ADJUST
   Performs zero adjustment.
4. RESPONSE SET
   Sets the response time of output.
5. CALIBRATION
   Output is correctable.
6. CUT OFF
   Low flow rate value can be excluded from output.
7. TOTALIZE
   Sets the integrating function.

3

FLC: Panel Setting
(3. LOGGER)

1. Move the cursor to page title area by ◁
2. Select [LOGGER] by ▽ then ENT.
3. Move the cursor to [MODE] by ▽ then ENT.
   Select [SETUP] by ▽ then ENT.
   Sets [FLOW RATE], [VELOCITY], [+TOTAL] [-TOTAL], [START DATE/TIME], [END DATE/TIME] and [SAMPLE INTERVAL]
4. Move the cursor to [MODE] by ▽ then ENT.
   Select [GRAPH OUT] by ▽ then ENT.
   Select [name of LOGGER DATA] by ▽ then ENT.
5. Move the cursor to [MODE] by ▽ then ENT.
   Select [PRINT out] by ▽ then ENT.
   Select [name of LOGGER DATA] by ▽ then ENT.
6. Move the cursor to [MODE] by ▽ then ENT.
   Select [name of LOGGER DATA] by ▽ then ENT.

4

FLC: Panel Setting
(4. SYSTEM SETUP)

1. Move the cursor to page title area by ◁
2. Select [SYSTEM SETUP] by ▽.
3. Move the cursor to [CLOCK SET] by ▽.
   [YY-MM-DD HH:MM:SS] then ENT.
4. Move the cursor to [BAUD RATE] by ▽ then ENT.
   Select [300] by ▽ then ENT.
5. Move the cursor to [PARITY] by ▽ then ENT.
   Select [NOTE] by ▽ then ENT.
6. Move the cursor to [STOP BIT] by ▽ then ENT.
   Select [1 BIT] by ▽ then ENT.
7. Move the cursor to [SYSTEM OF UNIT] by ▽ then ENT.
   Select [METRIC] by ▽ then ENT.
8. Move the cursor to [LANGUAGE] by ▽ then ENT.
   Select [ENGLISH] by ▽ then ENT.

5

FLC: Panel Setting
(5. ANALOG)

1. Move the cursor to page title area by ◁
2. Select [ANALOG] by ▽.
3. Move the cursor to [RANGE UNIT] by ▽ then ENT.
   Select [m^3/h] by ▽ then ENT.
4. Move the cursor to [OUTPUT MODE] by ▽ then ENT.
   Select [4-20 mA] by ▽ then ENT.
5. Move the cursor to [BURN-OUT] by ▽ then ENT.
   Select [Hold] by ▽ then ENT.
6. Move the cursor to [ADJUST] by ▽ then ENT.
   Select [20 mA ADJUST] by ▽ then ENT.

6

FLC: Panel Setting
(6. PRINTER)

1. Move the cursor to page title area by ◁
2. Select [PRINTER] by ▽.
3. Move the cursor to [MODE] by ▽.
4. Move the cursor to [FLOW RATE] by ▽ then ENT.
   Select [m^3/h] by ▽ then ENT.
5. Move the cursor to [VELOCITY] by ▽ then ENT.
   Select [on/off] by ▽ then ENT.
6. Move the cursor to [+TOTAL] by ▽ then ENT.
7. Move the cursor to [-TOTAL] by ▽ then ENT.
8. Move the cursor to [ANALOG] by ▽ then ENT.
9. Move the cursor to [TIMER MODE] by ▽ then ENT.
10. Move the cursor to [SAMPLING PERIOD] by ▽ then ENT.
11. Move the cursor to [PRINT OUT] by ▽ then ENT.

7

FLC: Panel Setting
(7. SYSTEM CHECK)

1. ERROR CHECK
   - INSIDE COMMUNICATIONAL FAIL
   - CALCULATION ERROR
   - PRINTER FAIL
   - RECEIVED SIGNAL ERROR
   - MEASURING WINDOW ERROR
   - TOO STRONG RECEIVED SIGNAL
   - NO RECEIVED SIGNAL
   - ANALOG OUTPUT ERROR
   - BACKUP BATTERY FAIL
2. SIGNAL CHECK
3. OUTPUT CHECK

8

d. Cautions

1) Conduct measurements at straight pipe portions that are at least 10 D long on the upstream side and 5D long on the downstream side.

2) Conduct measurements at locations where there is no pump or valve within 30D on the upstream side.

3) Make sure that there are no bubbles in the piping when taking measurements.

4) Install sensors at locations other than flanges and welds.

5) Make sure that areas where sensors are installed are free of dust and rusting.

6) When installing a sensor on a horizontal pipe, install it within ±45° from the horizontal plane.

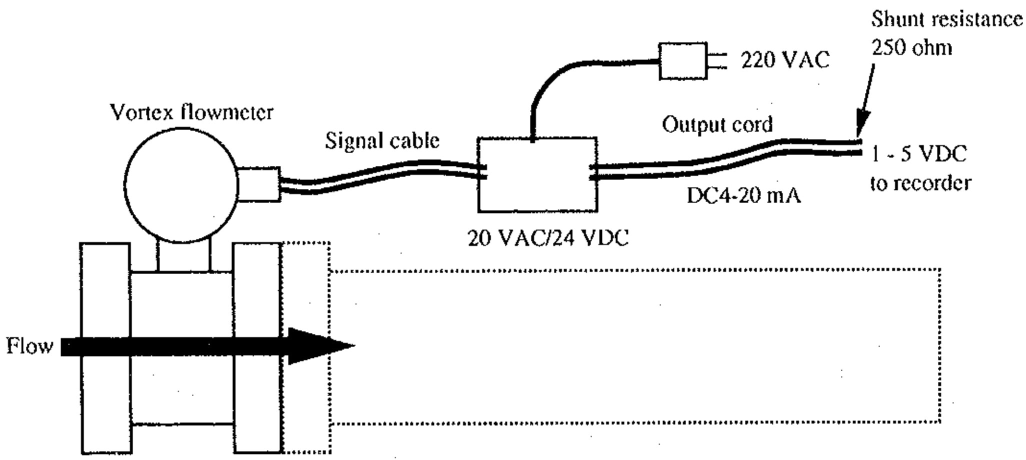
(2) Vortex flowmeter (F-2): YF100 (Yokogawa Electric Corp.)

a. Specifications

Fluid to be measured:	Liquid, gas, and steam
Measuring range :	Reynolds number 5×10^3 or more
:	Liquid : 10 m/s or lower
:	Gas and steam: 80 m/s or lower
Fluid temperature :	−40 to 300 °C
Fluid pressure :	20 kg/cm^{2}G maximum
Ambient temperature:	−40 to +80 °C
Ambient humidity :	5 to 100 %RH
Accuracy :	±1.0 % of the indicated value
Signal output :	4 to 20 mADC
Power requirements :	220 VAC, 50 Hz

b. Installation method

Vortex Flowmeter Wiring Chart



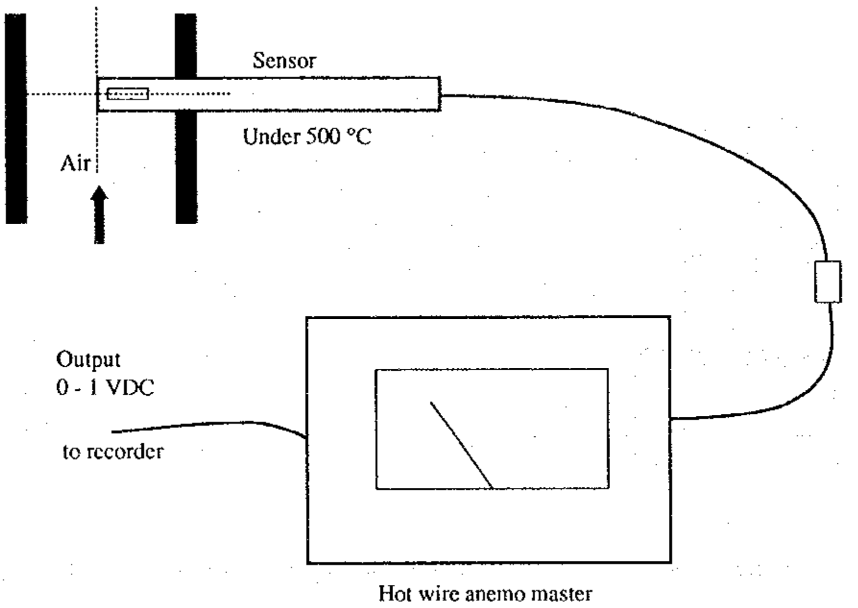
(3) Hot wire anemometer (F-3): 6161 (Manufactured by Nihon Kagaku Kogyo)

a. Specifications

Measuring range	: Velocity	: 0 to 50 m/s
	: Gas temperature:	0 to 500 °C
Ambient temperature:	5 to 40 °C	
Sensor	: Platinum winding wire resistance element	
Accuracy	: Velocity:	±10 % FS (10 m/s range)
		: ±5 % FS (50 m/s range)
	: Gas temperature:	1 % of the indicated value
Signal output	: Analog 0 to 1 VDC	
Power requirements	: NiCd battery	

b. Installation method

Hot Wire Anemo Master Wiring Chart



c. Cautions

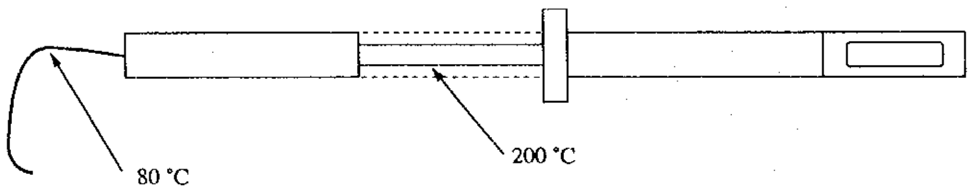
1) Charge before conducting measurements. (Approximately 7 hours)

2) Do not use inflammable gases.

3) Periodically clean the sensors.

It is especially important to clean measuring instruments after their use in gas measurements that involve a lot of tar and dust.

4) The heat resisting temperatures of the sensor's lead wire and the extension lead wire are 200°C and 80°C, respectively.



5) Sensors should be able to measure at right angles to the stream-line.

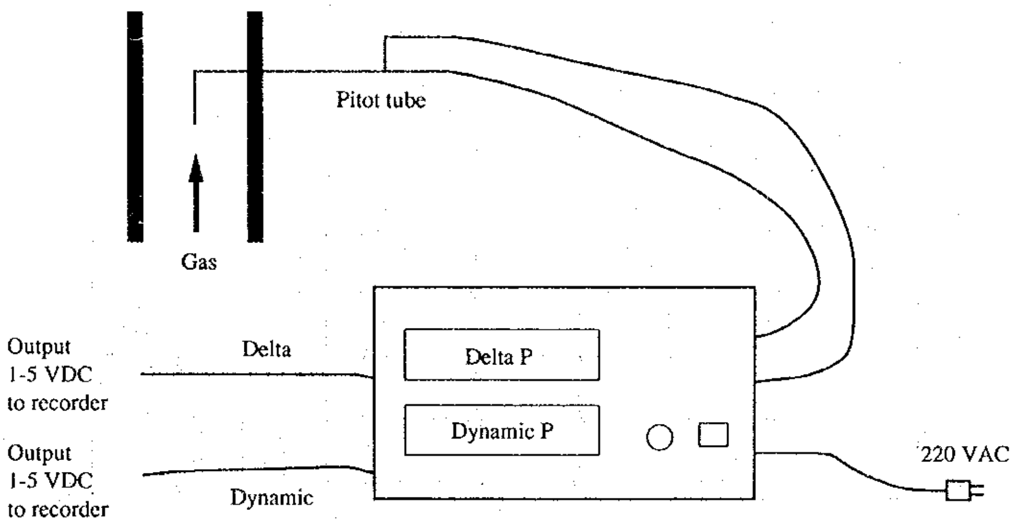
(4) Pitot tube flowmeter (EC-2): L type, Western type (Manufactured by Okano Seisakusho)

a. Specifications

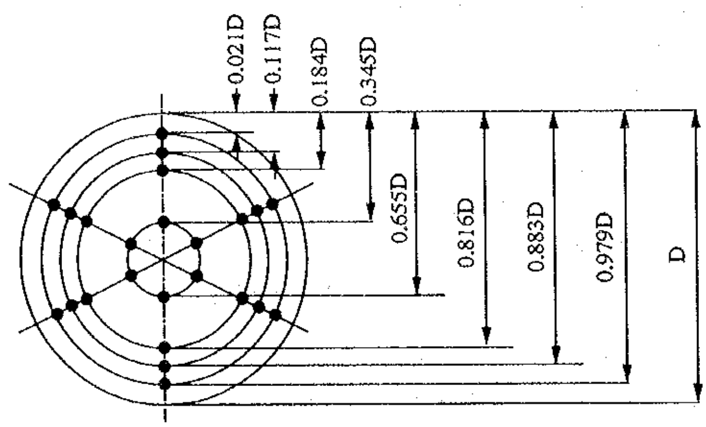
Fluid to be measured:	Fuel gas
Gas flow rate :	0 to 20 m/s
Gas duct diameter :	25 to 300, 500 to 1000 mm
Gas pressure :	3 kg/cm²G maximum
Accuracy :	±0.2 % FS ±1 dgt
Signal output :	Analog 1 to 5 VDC
Power requirements :	220 VAC, 50 Hz

b. Installation method

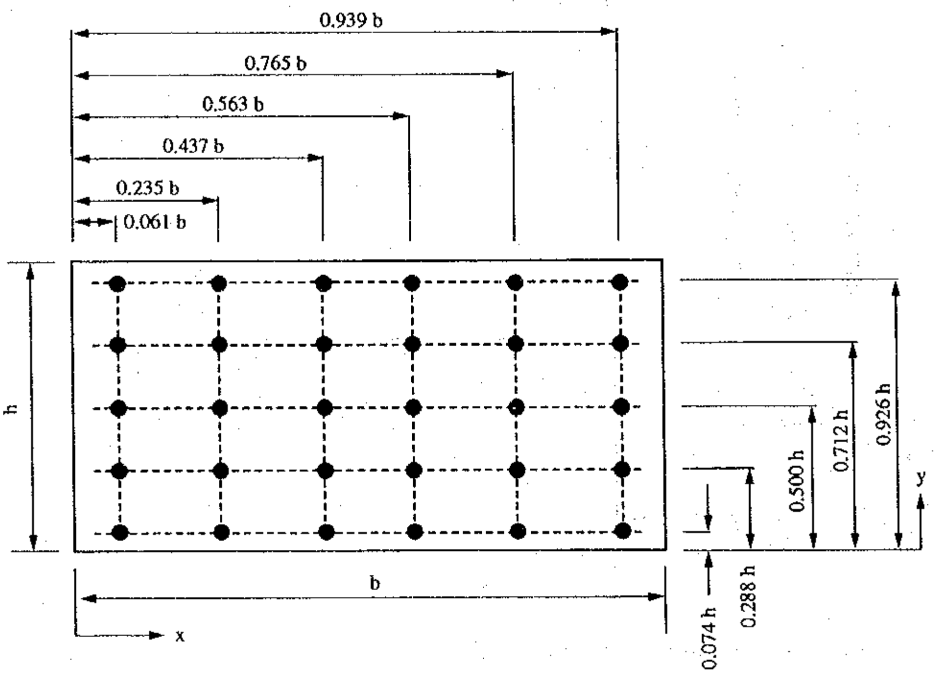
Pitot Tube Flowmeter Wiring Chart



In order to improve average values and accuracy, use the log-linear method for circular cross section tubes, and the log-Tchebycheff method for rectangular section tubes. (See the diagram for reference)



Measurement points for a circular cross section tube (log-linear method)



Measurement points for a rectangular section tube (log-Tchebycheff method)

c. Cautions

1) Conduct warming-up for 20 minutes or more after turning on the power.

2) Straight portions of pitot tubes that are 20 times the tube diameter or more in length should be measured where they are free of turbulent flows.

3) Install Pitot tubes at right angles to the air flow. (Within ±5 °C)

4) Use a 'Western' type to measure gases containing a lot of dust and moisture.

6.3.4 Gas Analysis

a. Specifications

1) Sampling gas pre-treatment system (G-1):
CFP-301 (Manufactured by Shimazu Sesakusho)

Object to be treated	:	Combustion exhaust gas
Sampling gas volume	:	1.5 L/min or less
Outlet gas dew point	:	1.5 to 3.5 °C
Filter performance	:	0.3 μm, 97% collected
Ambient temperature	:	2 to 40 °C
Inlet gas temperature	:	2 to 40 °C
Inlet gas dew point	:	2 to 40 °C
Cooler setting tempertaure	:	1 ±0.3 °C
Power requirements	:	220 VAC, 50 Hz

2) Portable oxygen analyzer (G-2):
PA-210-A (Manufactured by NGK Insulators)

Measuring range	:	0 to 25 %
Ambient temperature	:	0 to 50 °C
Sensor	:	Zirconia
Linearity	:	±2 % FS
Reproducibility	:	±1 % FS
Signal output	:	Analog 0 to 1 VDC
Warming-up time	:	3 minutes
Power requirements	:	220 VAC, 50 Hz

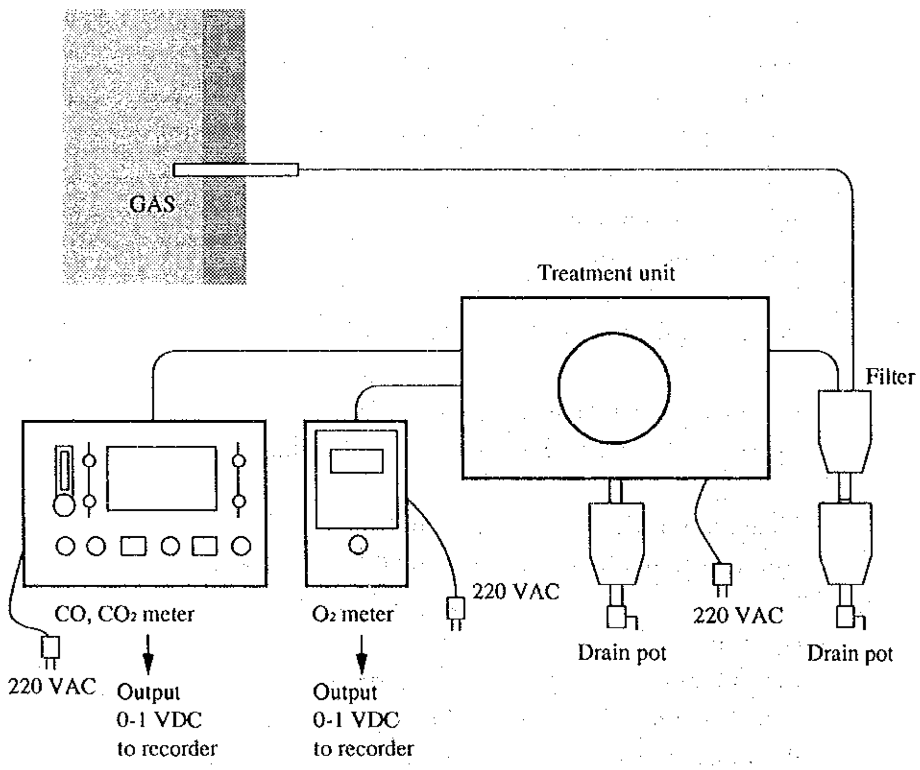
3) CO, CO_2 meters (EC-1):
CGT-10-1A (Manufactured by Shimazu Sesakusho)

Measuring range	:	CO : 0 to 0.1, 0 to 0.5 vol% CO
	:	CO_2: 0 to 15 vol%CO_2
Ambient temperature	:	5 to 40 °C
Reproducibility	:	±2 % of FS
Signal output	:	Analog 0 to 1 VDC
Warming-up time	:	30 minutes
Power requirements	:	220 VAC, 50 Hz

b. Installation method

The installation method of each measuring instrument for exhaust gas analysis is described below.

Gas Analyzers Wiring Chart



c. Cautions

1) If there is much dust or moisture content, use glass wool or silica gel for the filter to prevent these elements from entering the body of the measuring instrument.

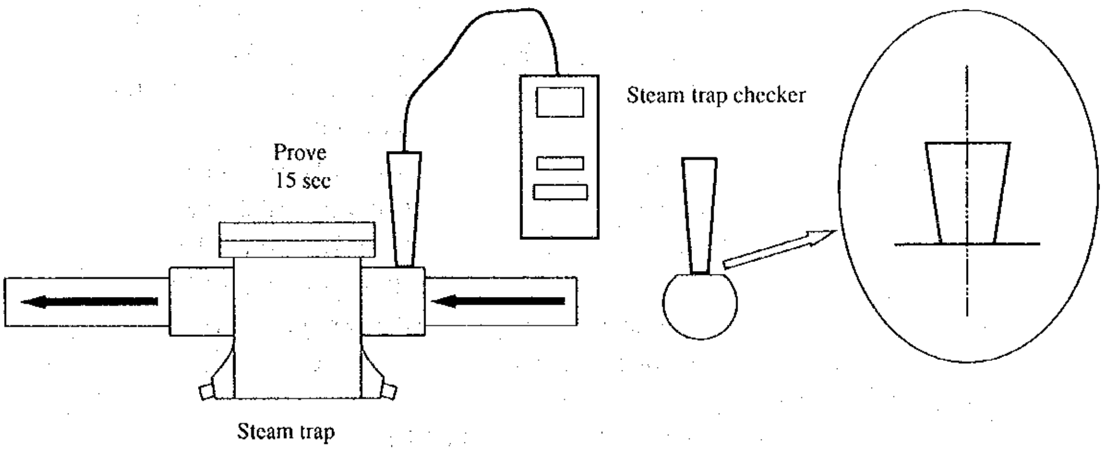
2) Provide a gas conduit sufficient length so that the gas temperature will be 40 °C or less.

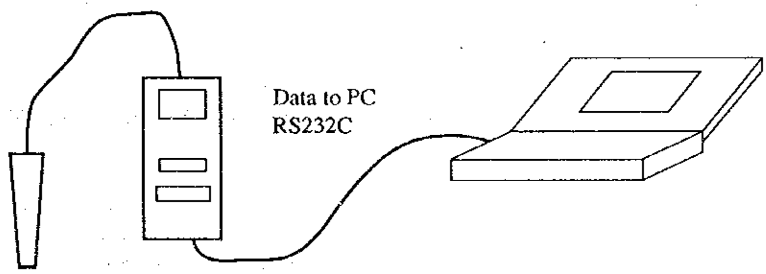
6.3.5 Steam Trap Checker (S-1): TM-2 (Manufactured by TLV)

(1) Specifications

No. of measurement data:	800
Measuring time	: 15 seconds
Surface temperature	: 0 to 250 °C
Ambient temperature	: 0 to 40 °C
Relative humidity	: 20 to 80 %RH
Power requirements	: NiCd battery

(2) Installation method





(3) Cautions

a. Charge the batteries before conducting measurements. (Approximately 6 hours)
b. Start measurements 30 seconds or more after power on.
c. The trap inlet valve must be open.

6.3.6 Power Measurement

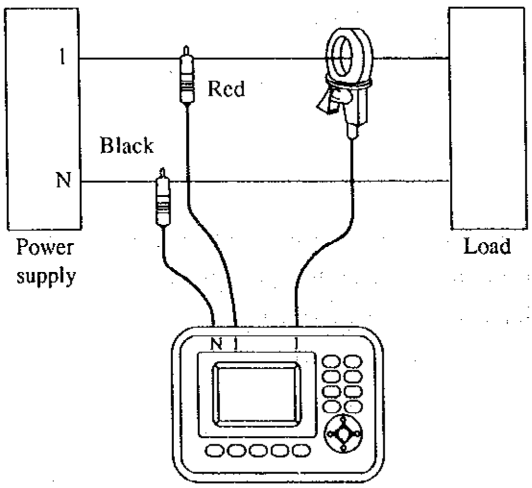
(1) Clamp-on power meter (E-3): 3166 (Manufactured by Hioki Denki)

a. Specifications

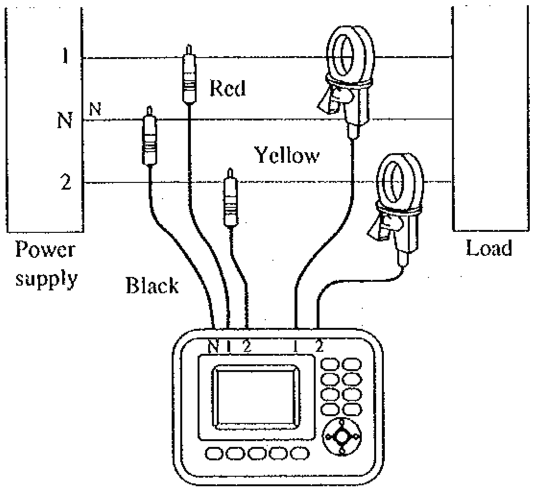
Measurement items	:	Voltage, current, active power, reactive power, apparent power, total power consumption, power factor and frequency	
Measuring range	:	Voltage	: 10 to 600 V
	:	Current	: 0.2 to 500 A
	:	Electric power	: 900 kW maximum
	:	Active power	: ±0.000 to 999999 MWh
	:	Reactive power	: ±0.000 to 999999 Mvarh
	:	Apparent power	: 0.000 to 999999 MVAh
	:	Power factor	: –1.000 to 0.000 to +1.000
	:	Frequency	: 40 to 500 Hz
Accuracy	:	Voltage	: ±0.1 %rdg ±0.2%FS
	:	Current	: ±0.1 %rdg ±0.2%FS
	:	Active power	: ±0.1 %rdg ±0.2% FS (±0.5 %rdg±0.2%FS)
	:	Frequency	: ±0.5 %rdg ±1 dgt
	:	Ambient temperature	: 0 to 40 °C
Recording system	:	3.5 inch FDD	
Power requirements	:	100 to 200 VAC, 50/60 Hz	

b. Installation method

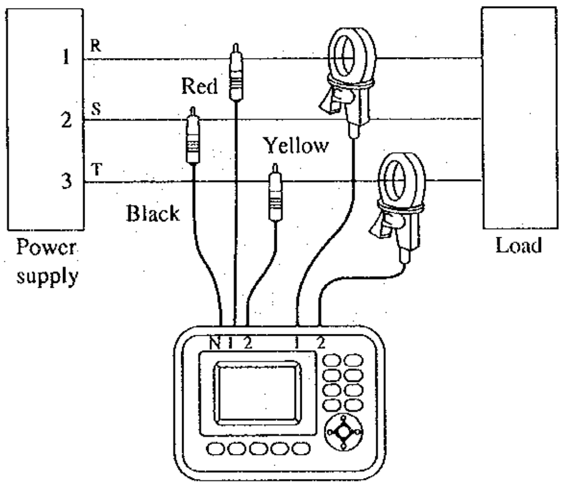
Single-phase two-wire lines (1P2W)



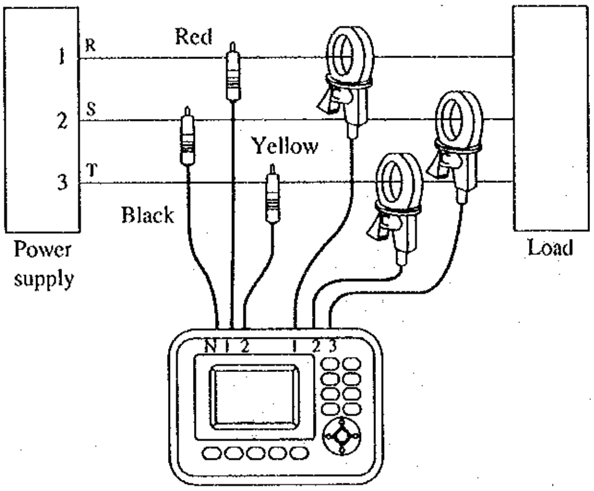
Single-phase three-wire lines (1P3W)



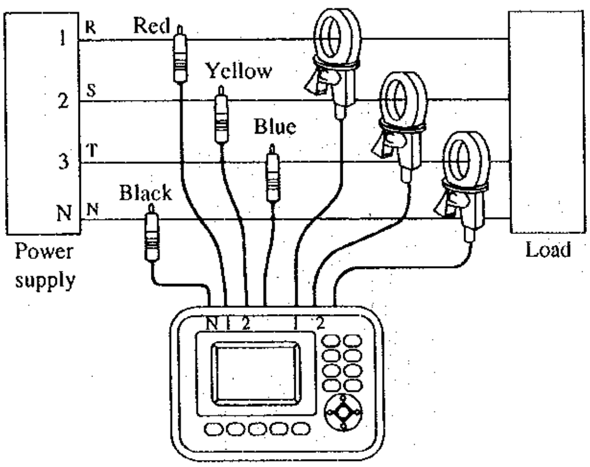
Two-voltage, two current, two power method (3P3W-2)



Three-voltage, three-current, three-power method (3P3W-3)



Three-phase four-wire lines (3P4W)



c. Cautions

1) Wear insulated gloves in order to avoid electric shocks when wiring.

2) Conduct measurements in the presence of an authorized witness from the factory.

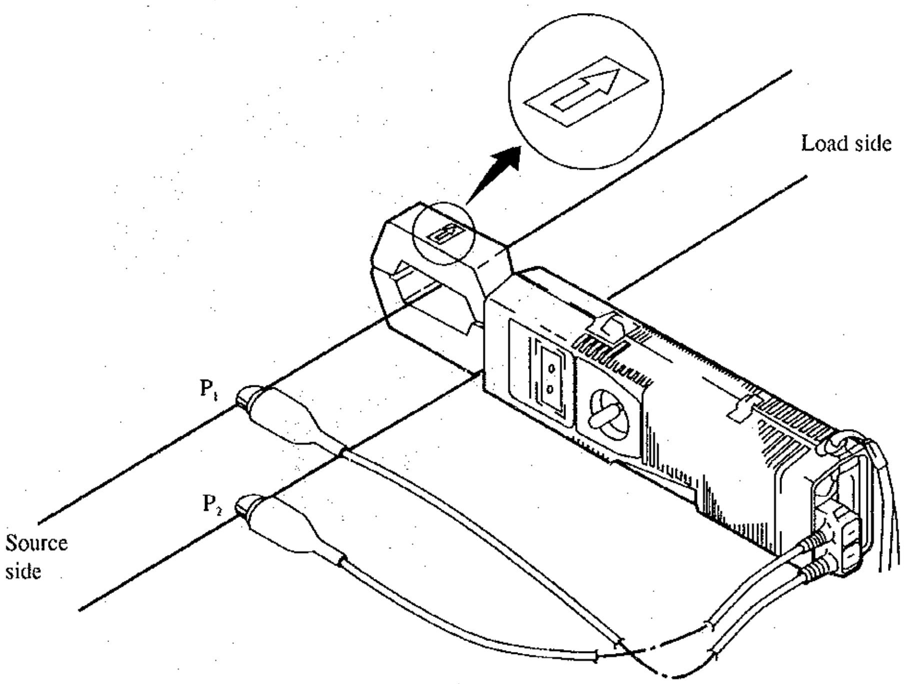
(2) Clip-on AC power meter (E-4): 2433 (Yokogawa Electric Corp.)

a. Specifications

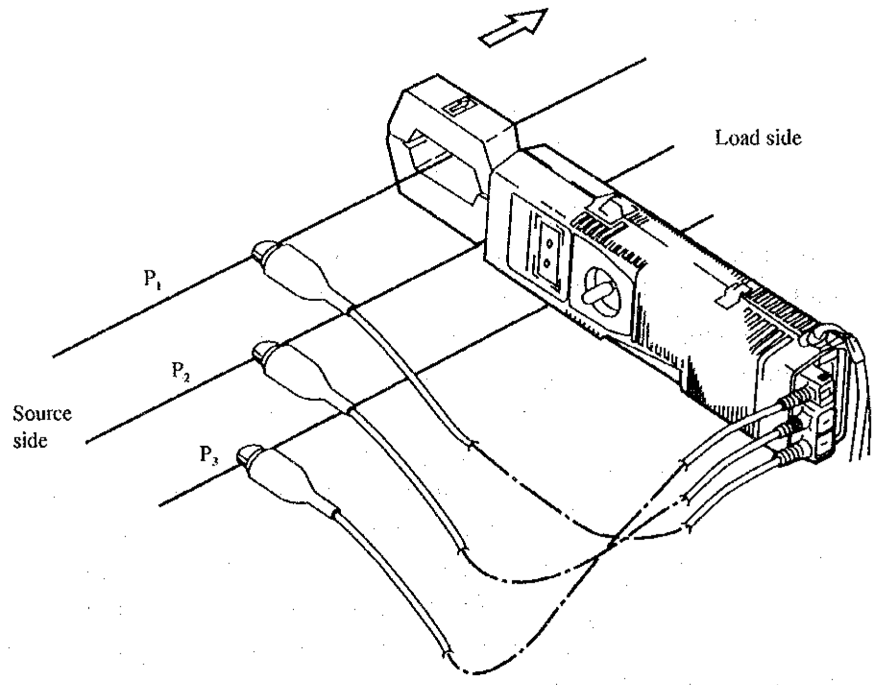
Rating	: Voltage: 200/600 Vrms
	: Current: 10 mA/dgt
	: Power : 10 W/dgt
Frequency	: 40 to 400 Hz
Circuit voltage	: 600 VAC maximum
Withstand voltage	: 2200 VAC (1 min)
Ambient temperature	: 5 to 40 °C
Accuracy	: Voltage, current
	2 % of indicated value + 1 % of rating (40 to 47 Hz)
	1 % of indicated value + 0.5 % of rating (47 to 63 Hz)
	2 % of indicated value + 1 % of rating (63 to 400 Hz)
	: Power, power factor
	2 % of indicated value + 1 % of rating (40 to 47 Hz)
	1 % of indicated value + 0.5 % of rating (47 to 63 Hz)
	2 % of indicated value + 1 % of rating (63 to 400 Hz)
Power requirements	: Three AA dry cells

b. Installation method

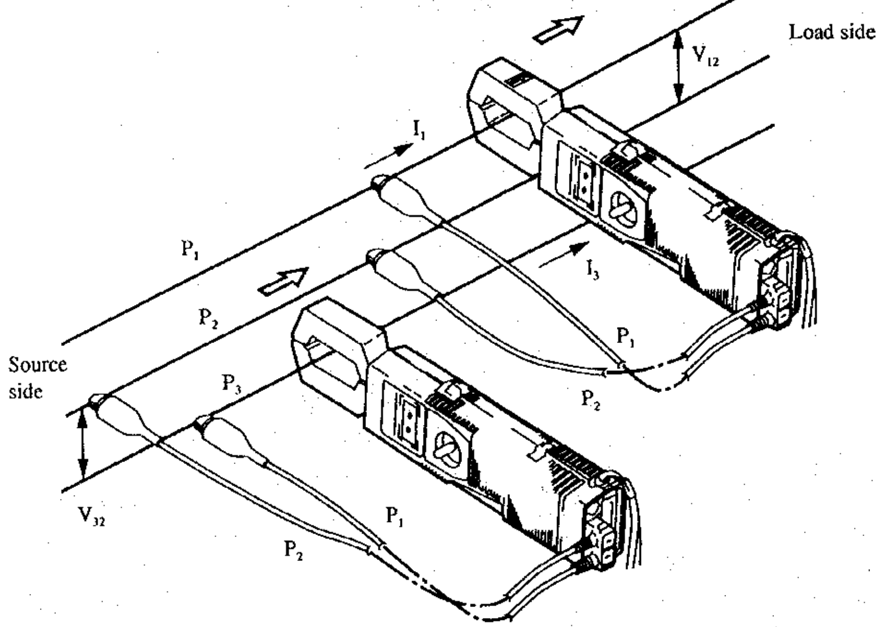
Single-phase circuit



Three-phase balanced circuit



Three-phase unbalanced circuit



c. Cautions

1) Wear insulated gloves in order to avoid electric shocks when wiring.

2) Conduct measurements in the presence of an authorized witness from the factory.

6.3.7 Hybrid Recorder (R-1): DR130 (Manufactured by Yokogawa Electric Corp.)

(1) Specifications

Measuring points	: 20 points	
Measuring range	: DC voltage	: 20 mV to 50 V
	: Thermocouple	: 12 kinds
	: Resistance temperature sensor:	13 kinds
Recording accuracy	: ±0.2 %	
Measuring cycle	: To be set within the range of 2 to 60 seconds	
Ambient temperature:	0 to 40 °C, 20 to 80 %RH	
	: 40 to 50 °C, 10 to 50 %RH	
Recording system	: 10-color dotting system	
Memory system	: 3.5 inch FDD	
Power requirements	: 220 VAC, 50 Hz	

(2) Setting method

DR 130: Data Set Item

1. Clock
2. Chart Speed
3. Data Range

1

DR 130: Clock Set

1. Press [CHART]
2. Select [SET = CLOCK] by ▽
3. ENTRY
4. Set date and time
   YY MM DD HH MM SS
5. ENTRY
6. *** SET OK ***

2

DR 130: Chart Speed

1. Press [CHART]

2. Select [SET = CLOCK] by ∇.

3. ENTRY

4. Set CHART SPEED by ∇.
   CHART SPEED = xx mm/H

5. ENTRY

6. *** SET OK ***

3

DR 130: Data Range

See the DR Data Setting List on the separate sheet.

4

DR 130 DATA Setting List

No.	Equipment	Mode	Mode'	Range	Span		Scale			Remarks
					Left	Right	Left	Right	Unit	
1	TC (CA)	TC	–	K	0.0°C	100.0°C	–	–	–	0 to 100°C
2	TC (CA)	TC	–	K	0.0°C	500.0°C	–	–	–	0 to 500°C
3	TC (CA)	TC	–	K	0.0°C	1000.0°C	–	–	–	0 to 1000°C
4	TC (PR)	TC	–	R	0.0°C	1500.0°C	–	–	–	0 to 1500°C
5	O_2 meter	Scale	Volt	2 V	0.0000 V	1.0000 V	0.00	25.00	%	
6	CO_2 = 15%	Scale	Volt	2 V	0.0000 V	1.0000 V	0.00	15.00	%	
7	CO = 0.1%	Scale	Volt	2 V	0.0000 V	1.0000 V	0.000	0.100	%	0.1% range
8	CO = 0.5%	Scale	Volt	2 V	0.0000 V	1.0000 V	0.000	0.500	%	0.5% range
9	Pitot (static pressure)	Scale	Volt	6 V	1.0000 V	5.0000 V	0.000	3.000	kg/cm^2	
10	Pitot (delat pressure)	Scale	Volt	6 V	1.0000 V	5.0000 V	0.00	100.00	mmH_2O	
11	Ultrasonic flowmeter	Scale	Volt	6 V	1.0000 V	5.0000 V	0.000	20.000	m^3/h	
12	Kanomax (low)	Scale	Volt	2 V	0.0000 V	1.0000 V	0.00	10.00	m/s	10 m/s range
13	Kanomax (high)	Scale	Volt	2 V	0.0000 V	1.0000 V	0.00	50.00	m/s	50 m/s range
14	Suction pyrometer	TC	–	R	0.0°C	1500.0°C	–	–	–	
15	Digital low pressure meter	Scale	Volt	6 V	1.0000 V	5.0000 V	–50.00	50.00	mmH_2O	
16	Pressure transmitter	Scale	Volt	6 V	1.0000 V	5.0000 V	0.00	50.00	kg/cm^2	
17	Vortex flowmeter (1")	Scale	Volt	6 V	1.0000 V	5.0000 V	0	1000	kg/h	(25 A) 1"
18	Vortex flowmeter (1.5")	Scale	Volt	6 V	1.0000 V	5.0000 V	0	2500	kg/h	(40 A) 1.5"
19	Vortex flowmeter (2")	Scale	Volt	6 V	1.0000 V	5.0000 V	0	4500	kg/h	(50 A) 2"
20	Transducer ACV/DCV	Scale	Volt	6 V	0.0000 V	0.2750 V	0.0	110.0	ACV	0 to 1.1 mA
21	Transducer ACA/DCV	Scale	Volt	6 V	0.0000 V	0.2750 V	0.0	5.0	AVA	0 to 1 mA