

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No 38

**DEPARTMENT OF ENERGY DEVELOPMENT AND PROMOTION
MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT
THE KINGDOM OF THAILAND**

**THE STUDY (AFTER-CARE)
ON
THE ENERGY CONSERVATION PROJECT
IN
THE KINGDOM OF THAILAND

FINAL REPORT
(II)**

MARCH 1995

THE ENERGY CONSERVATION CENTER, JAPAN

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Contents

1. CHARACTERISTICS OF THE DOCUMENT
2. DIAGNOSTIC PROCEDURE
3. ENERGY CONSERVATION IN STEELMAKING INDUSTRY
4. ENERGY CONSERVATION IN PAPER AND PULP INDUSTRY
5. APPENDED MATERIALS (WORKSHOP TEXT)
 - 5.1 Model Factory
 - 5.2 Model Building
 - 5.3 Energy Management
 - 5.4 Method of Energy Management in Industry
 - 5.5 Measuring Methods for Factory Energy Audit
 - 5.6 Energy Conservation Measures for Existing Building
 - 5.7 Energy Conservation in Boiler
 - 5.8 Energy Conservation in the Utilization of Steam
 - 5.9 Energy Conservation in Industrial Furnace
 - 5.10 Energy Conservation in Electric Equipment Operation
 - 5.11 Model Factory Key Sheet
 - 5.12 Model Building Key Sheet

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

PHYSICS 311

PROBLEM SET 1

DATE: _____

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REVISOR: _____

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List of Tables

- Table 2.1 Standard Air Ratio of Boiler
- Table 2.2 Standard Air Ratio of Industrial Furnace
- Table 2.3 Standard Outside Temperature of Furnace Wall
- Table 2.4 Standard Exhaust Gas Temperature for Boiler (unit: °C)
- Table 2.5 Standard Exhaust Heat Recovery Rate of Industrial Furnace
- Table 3.1 Relation between Furnace Capacity, Required Dimensions and Electric Equipment of Furnace
- Table 3.2 Comparison of Pusher Furnace & Walking-Beam Furnace
- Table 3.3 Comparison of Combustion Method
- Table 3.4 Layout of Heating Furnace
- Table 3.5 Average Electric Power Consumption Rate for Mild Steel
- Table 3.6 Heat Balance of Arc Furnace
- Table 3.7 Heat Balance Table
- Table 3.8 Items on Energy Conservation for Arc Furnace
- Table 3.9 Example of Energy Saving Effect in Scrap Preheating by Arc Furnace Exhaust Gas
- Table 3.10 Standard Air Ratios for Industrial Furnaces
- Table 3.11 Target Air Ratios for Industrial Furnaces
- Table 3.13 Points of Check and Maintenance Services for Burning Equipment
- Table 3.14 Required Viscosity of Oil at Burner Inlet
- Table 3.15 Example of Draft Resistance (Water Column mm) in Flue
- Table 3.16 Improvement Effects of Wall Composition of Reheating Furnace
- Table 3.17 Standard Temperatures of Furnace Outer Walls
- Table 3.18 Target Temperatures of Furnace Outer Walls
- Table 3.19 Main Characteristics of Insulating Fire Materials
- Table 3.20 Survey Report on the Outline of Equipment
- Table 3.21 Survey Report on Actual Long-Term Operations
- Table 3.22 Table for Measurement Items and Results of Measurement
- Table 3.23 Heat Balance Table
- Table 3.24 Standard Waste Heat Recovery Ratios for Industrial Furnaces
- Table 3.25 Target Waste Heat Recovery Ratios for Industrial Furnaces
- Table 3.26 Temperature of Heat Transfer Area
- Table 3.27 Working Temperature of Heating Pipe by Material
- Table 4.1 Example of Stepwise Promotion Plans
- Table 4.2 Chemical Components of White Liquor
- Table 4.3 H-Factor Relative Velocity

- Table 4.4 Comparison of Energy Unit Consumption in Batch Digester and Continuous Digester**
- Table 4.5 Control Items**
- Table 4.6 Evaporation Ratio**
- Table 4.7 Unit Energy Consumption of Evaporator**
- Table 4.8 The List of Japanese Standard Qualities of Waste Paper by Paper Recycling Promotion Center of Japan**
- Table 4.9 Energy Consumption Pattern of Pulp and Paper Processes in an Integrated Fine Paper Mill**
- Table 4.10 Kind and Hardness of Rolls**
- Table 4.11 Flash Tank Capacity Index**
- Table 4.12 Flash Tank Height Index**
- Table 4.13 Transition of the Unit Water Consumption of the Paper Mill in Japan**
- Table 4.14 Transition of the Unit Water Consumption and Head Box Temperature**
- Table 4.15 Causes for Paper Breaking and Remedies**

List of Figures

- Figure 2.1 Flowchart of Factory Survey
- Figure 3.1 Production Process by Arc Furnace Steel-Making Method
- Figure 3.2 Body Structure of Arc Furnace
- Figure 3.3 Electrical Machinery and Apparatuses of Arc Furnace
- Figure 3.4 Power Consumption Per Unit Charge in Japan
- Figure 3.5 Pusher-Type Single Zone Reheating Furnace
- Figure 3.6 Pusher-Type 3-Zone Reheating Furnace
- Figure 3.7 Pusher-Type 5-Zone Reheating Furnace
- Figure 3.8 Walking Beam-Type Reheating Furnace
- Figure 3.9 Electric Power Consumption Rate of Japanese Arc Furnace
- Figure 3.10 Example of Installation of Combustion Supporting Burner
- Figure 3.11 Oil Consumption Rate and Electric Power Consumption Rate Showing the Effect of Combustion Supporting (Per Ton of Mild Steel)
- Figure 3.12 Relationship between Unit Oxygen Consumption Rate and Unit Electric Power Consumption Rate in Oxygen Enriching Operation
- Figure 3.13 Scrap Preheater Using Arc Furnace Exhaust Gas for Heating Scrap in Charging Bucket
- Figure 3.14 Characteristics Diagram of Energy Conservation for Reheating Furnace
- Figure 3.15 Reduction Point for Fuel Consumption Rate
- Figure 3.16 Relation between Air Ratio and Thermal Efficiency
- Figure 3.17 Energy Saving Effect under Air Ratio Control
- Figure 3.18 Classification of Burners
- Figure 3.19 Structure of Internal Mixing Type Gas Burner
- Figure 3.20 Compact External Mixing Type Gas Burner
- Figure 3.21 Structure of External Mixing Type Gas Burner
- Figure 3.22 Structure of Semi-mixing Type Gas Burner
- Figure 3.23 Installation Chart for High-Pressure Atomizing Type Oil Burner
- Figure 3.24 Structure of High-Pressure Atomizing Type Oil Burner (Internal Mixing Type)
- Figure 3.25 Structure of High-Pressure Atomizing Type Oil Burner (External Mixing Type)
- Figure 3.26 Structure of Low-Pressure Air Type Oil Burner (Non-Proportioning Type)
- Figure 3.27 Structure of Low-Pressure Air Type Oil Burner (Proportioning Type)
- Figure 3.28 Structure of Non-Return Oil Type Oil-Pressure Burner
- Figure 3.29 Structure of Return Oil Type Oil-Pressure Burner
- Figure 3.30 Structure of Rotary Type Oil Burner
- Figure 3.31 Structure of Oil and Gas Mixture Burner
- Figure 3.32 Average Gas Temperature and Draft Force Inside Smoke Stack
- Figure 3.33 Furnace Pressure Measurement Port and Pressure Setting

- Figure 3.34 Heat Transfer to Surface by Convection
- Figure 3.35 Emissivity of Metal
- Figure 3.36 Typical Wall Temperature of Reheating Furnace
- Figure 3.37 Improvement Plan for Wall Composition of Reheating Furnace
- Figure 3.38 Inferior Reconstruction Plan for Wall Composition of Reheating Furnace
- Figure 3.39 Working Temperature Range of Typical Insulating Materials
- Figure 3.40 Factor for Determining the Equivalent of Heat Release from Openings to the Quantity of Radiant Heat from Perfect Black Body
- Figure 3.41 Double Insulation Method for Skid
- Figure 3.42 Comparison of Water Cooling Loss (Calculated Values)
- Figure 3.43 Example of Preheater of Air for Burning (Recuperator)
- Figure 3.44 Fuel Conservation Rate
- Figure 3.45 Fuel Conservation Rate When Fuel Oil is Used When Natural Gas is Used
- Figure 3.46 Temperature Difference in Case of Parallel Flow
- Figure 3.47 Temperature Difference in Case of Counter Flow
- Figure 3.48 Relationship between Temperature and Oxidation Loss
- Figure 4.1 Production Process
- Figure 4.2 Batch Type Cooking Instruments
- Figure 4.3 Continuous Type Cooking Instruments
- Figure 4.4 Heater
- Figure 4.5 Relative Reaction Velocity, Cooking Time or Temperature
- Figure 4.6 Relation of H-Factor, Pulp Yield and Lignin Content
- Figure 4.7 Continuous Washer
- Figure 4.8 Diffusion Washer
- Figure 4.9 Falling Film Type Evaporator
- Figure 4.10 Comparison of Forced Circulation Evaporator and Falling Film Evaporator
- Figure 4.11 Recovery Boiler
- Figure 4.12 Waste Paper Pulping Flow Sheet
- Figure 4.13 Comparison of Unit Electric Power Consumption
- Figure 4.14 Water Movement in Press Nip
- Figure 4.15 Chart for Characteristic Factors
- Figure 4.16 Nip Pressure and Nip Width
- Figure 4.17 Nip Width and Rubber Hardness
- Figure 4.18 Crown and Nip Width
- Figure 4.19 Drying Curve of Paper
- Figure 4.20 The Relationship between Air Conditions and Drying Speed
- Figure 4.21 Leading Dryer
- Figure 4.22 Typical Third Group Drainage System (Blow Through System)

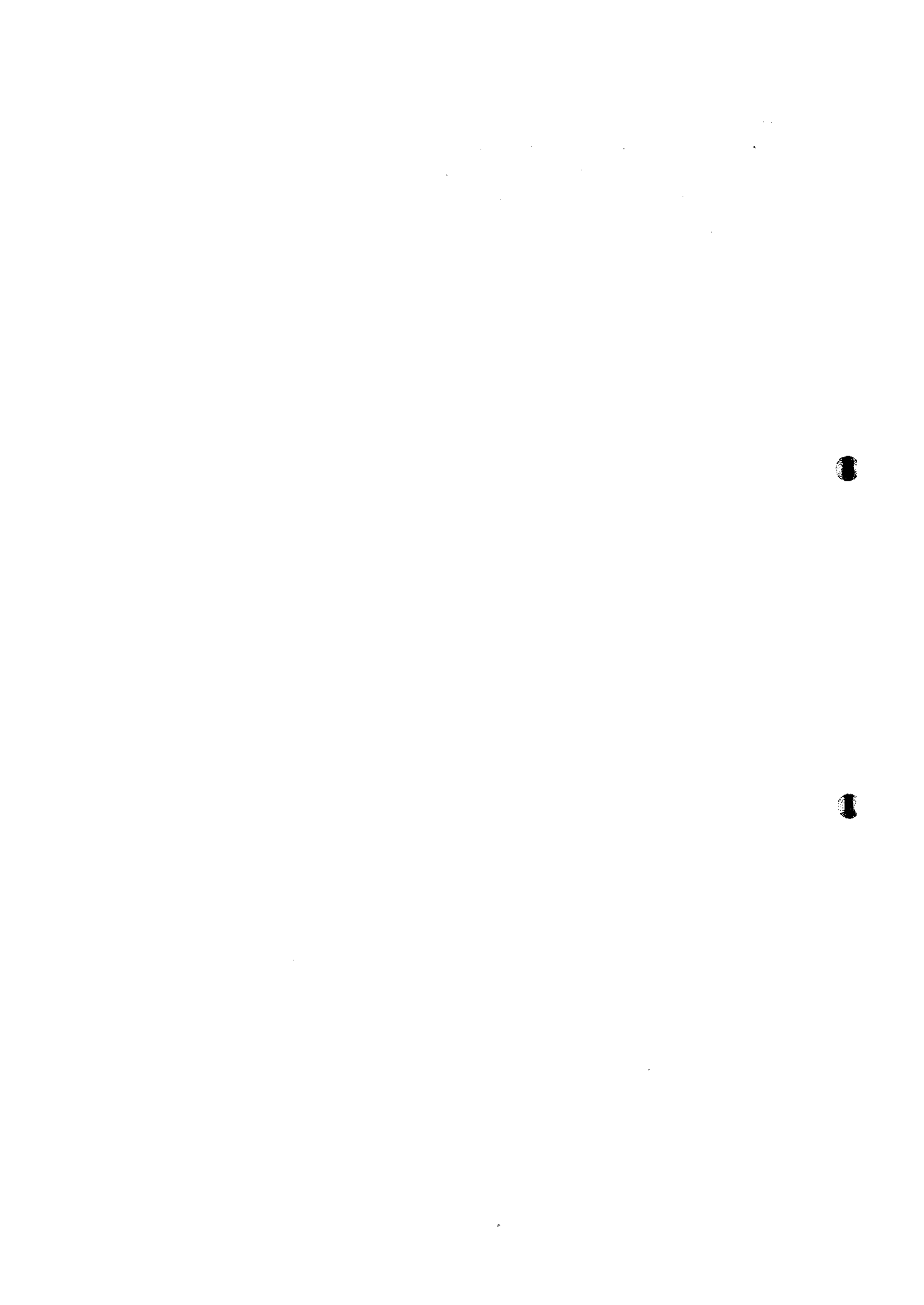
Figure 4.23 Design of Open Hood

Figure 4.24 Unit Steam Consumption Rate for Open Hood and Closed Hood

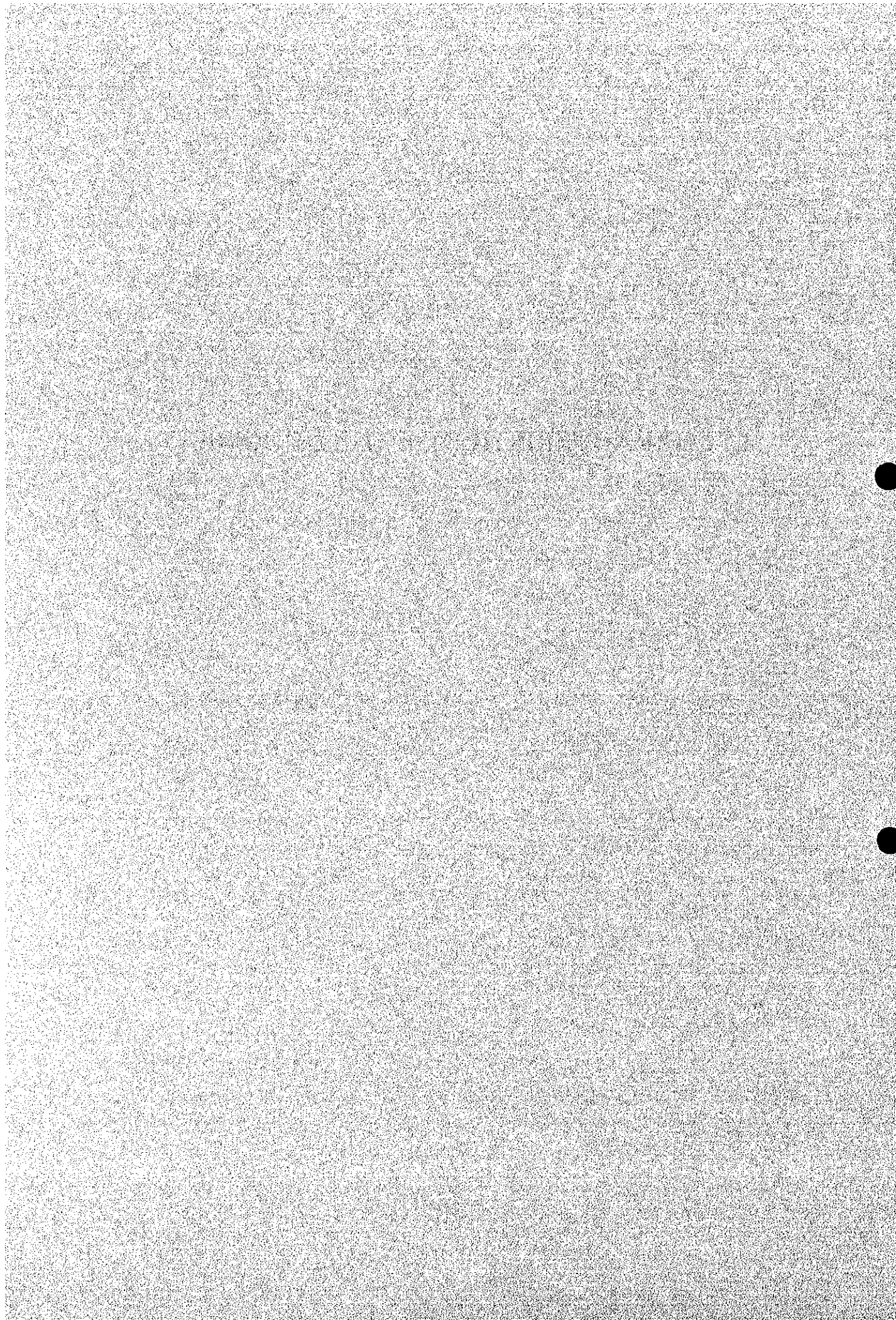
Figure 4.25 An Example of "Closed Hood Ventilation System"

Figure 4.26 Waste Heat Recovery Flow for Closed Hood Ventilation System and Control System

Figure 4.27 Cause and Effect Diagram of Paper Breaking



1. CHARACTERISTICS OF THE DOCUMENT



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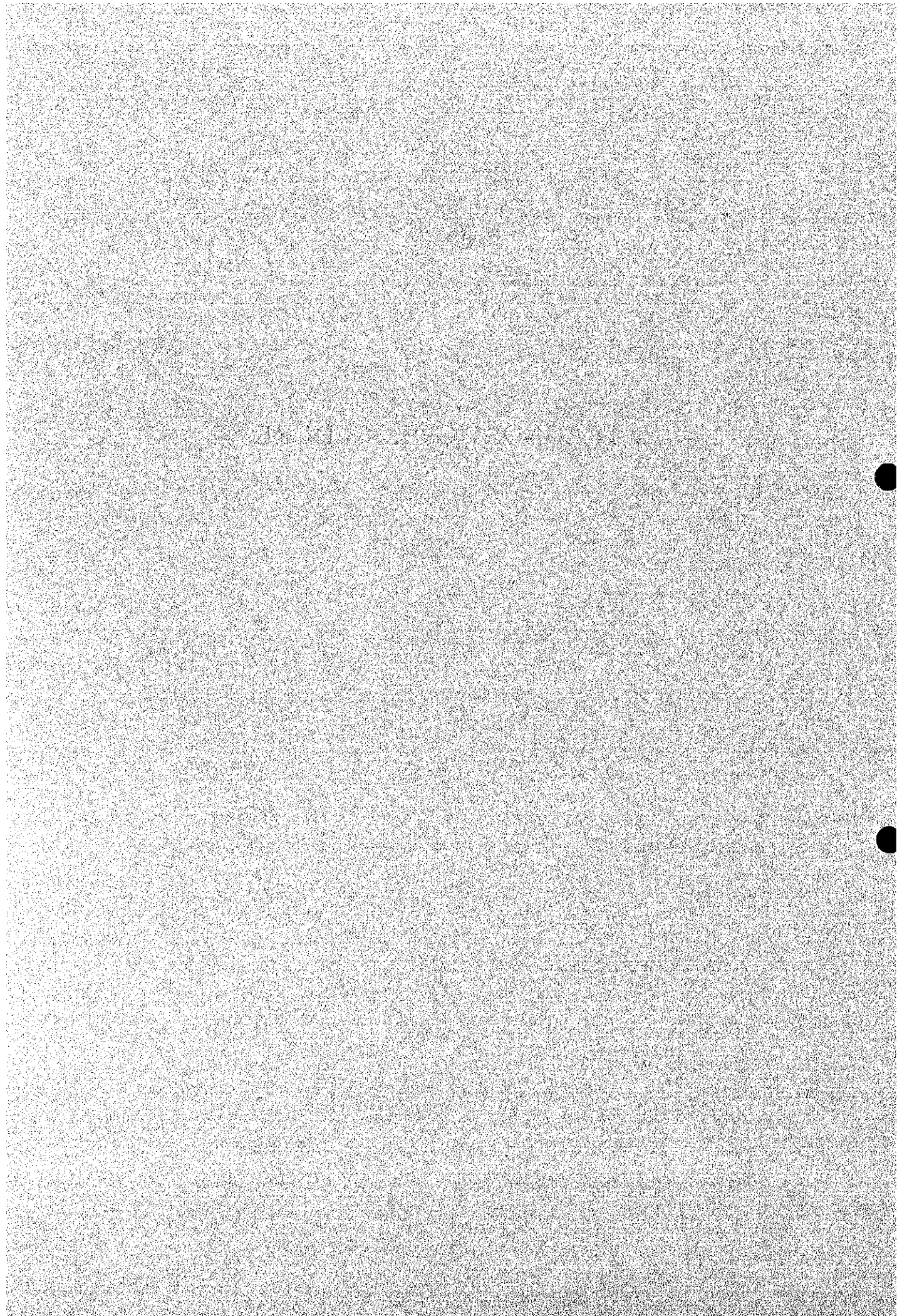
The document contained in this report describes the technical items which will be helpful in working out the guideline, with particular attention paid to the following:

- (1) The document shall provide the description which is useful to the engineers of the Department of Energy Development and Promotion or the Energy Conservation Center of Thailand as ① manual for diagnostic instruction, ② textbook for the seminar, or ③ data to determine the progress of factory rationalization or streamlining.
- (2) The document shall be described in such a way that it can be understood by the engineers four or five years after graduating from universities or colleges, even if they are not currently engaged in the relevant field of the industry.
- (3) In order to ensure that the range of the description items conforms to the current situation of the industry in the Kingdom of Thailand, the description shall be restricted to the items related to the process in the factories under the current study, and shall include basic items, numerical values for reference, and the technique and cases for energy conservation.

It is expected that this document will be used as a reference when the guideline is worked out by the Department of Energy Development and Promotion and the Energy Conservation Center of Thailand, and will be improved by adding the information which will be collected through unique factory diagnosis.



2. DIAGNOSTIC PROCEDURE

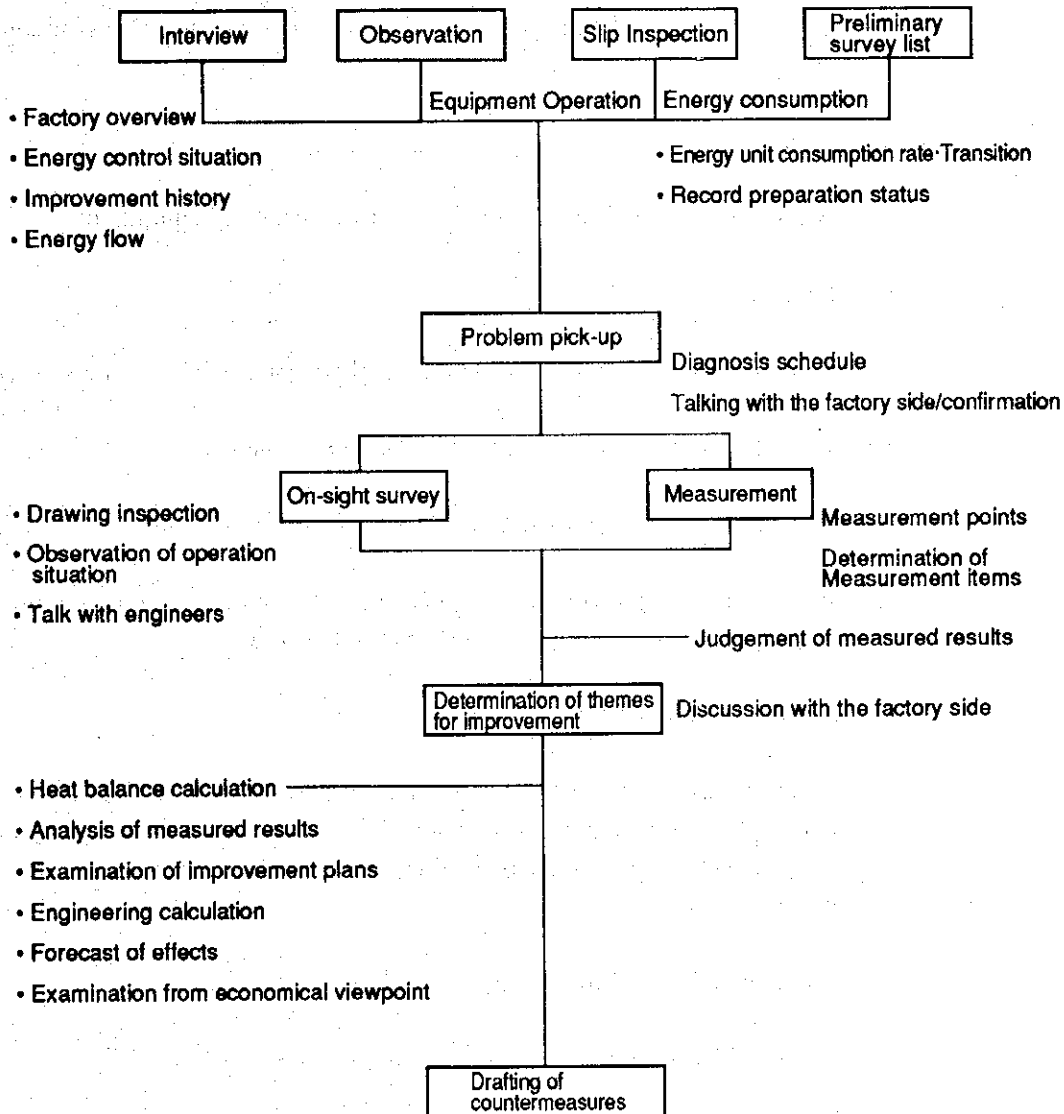


2. DIAGNOSTIC PROCEDURE

(1) Factory diagnosis procedure

Figure 2.1 shows the general procedure for factory survey:

Figure 2.1 Flowchart of Factory Survey



① Factory overview

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

1. **Factory overview (factory name, type of industry, capital, number of employees, organization, history, share and position in the industry)**
2. **Trend of the production volume of major products for the last five years**
3. **Trend of the energy consumption for the last five years**
4. **Production process chart of major products**
5. **Type, capacity and operating conditions of energy consuming equipment such as boilers**
6. **Energy flow**
7. **Electric power one line diagram and power receiving equipment**
8. **Factory layout**
9. **Items which the factory considers as problems and wishes to be studied**
10. **Items for energy conservation actions taken in the past**
11. **Items for energy conservation actions to be taken in future**
12. **Economic environment for the industry and the factory, and the factors inhibiting the promotion of energy conservation measures**

② **Working out the diagnostic program**

- (a) **General observation of the factory should be conducted while listening to the explanation of the factory people, and the outline of the following points should be grasped by checking the preliminary questionnaire, energy consumption and production record:**

Problems of the equipment and operation

Points which should take priority in diagnosis

Technical level of the factory

Deterioration and maintenance of the equipment

Trend of utilization rates

Energy unit consumption rate and its transition

(b) Determining the diagnostic program

Equipment or processes which should take diagnostic priority

Measuring point, measuring items and measuring time

Sharing the works

(c) Explaining the diagnostic program to the factory to get understanding and cooperation as follows:

Adjustment with the production program

Preparing the holes for installation of measuring instruments or taking samples

Preparation of power supply

③ Measurement and study to be implemented according to the diagnostic program

Selection and layout of the measuring instruments

Entering the set conditions in the measuring instruments

Monitoring to see if the adequate data have been gained or not

Detailed structure and dimensions of the equipment according to equipment drawings or actual measurement

Determining the problems by observation of the operation

Hearing from engineers

**Data required to evaluate the economic effect of the improvement plan
(Study of the energy price, fund and cost)**

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

⑤ Study of improvement proposal

Based on the data entered in the check list, measurement record chart, data floppy, 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 proposals 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.

(2) Points to be noted for diagnosis

In Japan, the Ministry of International Trade and Industry (MITI) provides the items to be standard for judgment when the factory manager of the factory plans rationalization or streamlining 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 conformance criteria and target level for major items:

- I Rationalization of fuel combustion
- II Rationalization of heating, cooling and heat transfer
- III Prevention of heat loss due to heat radiation and transfer
- IV Waste heat recovery and reuse
- V Rationalization in conversion of heat into power
- VI Prevention of electric heat loss due to resistances
- VII Rationalization in conversion of electricity into power

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

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

I. Rationalization of fuel combustion

Table 2.1 Standard Air Ratio of Boiler

Classification of evaporation	Solid fuel		Liquid fuel	Gas fuel	By-product gas
	Fixed bed	Fluidized bed			
Large-sized boiler for electric utilities	—	—	1.05 - 1.2	1.05 - 1.1	1.2
Other boilers					
30 t/h or more	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	1.3 - 1.45	1.2 - 1.45	1.2 - 1.3	1.2 - 1.3	—
5 to 10 t/h	—	—	1.3	1.3	—
< 10 t/h	—	—	1.3	1.3	—

Table 2.2 Standard Air Ratio of Industrial Furnace
(Except for solid fuel furnace or the furnace of below 500 Mcal/h)

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 baking furnace	1.30	1.35
Drying oven (only the burner section)	1.30	1.50

I-1 Selection of burners

Type, capacity, turndown ratio
Maintenance, tip worn

I-2 Improvement in atomization

Fuel temperature, viscosity
Volume of atomizing air and steam
Fuel pressure
Dispersion reagent, emulsion

- | | | |
|-----|--|--|
| I-3 | Prevention of air entry | Furnace pressure control,
Narrowing of the aperture, master/slave door, seal improvement,
Reduced opening time |
| I-4 | Fuel-air ratio control improvement | O ₂ control, CO control,
Cascade control,
Cross limit control |
| I-5 | Load stability | Load distribution improvement and control of the number of units,
Steam accumulator |
| I-6 | Combustion temperature rise | Combustion by oxygen enrichment,
Gas atomization, |
| I-7 | Complete combustion at a low temperature | Combustion by catalyst
Fluidized bed combustion |

II. Rationalization of heating, cooling and heat transfer

- | | | |
|------------------------------------|---|---|
| II-1 Heating by industrial furnace | | |
| II-1-1 | Optimization of heating temperature | Setting the work standards, |
| II-1-2 | Heat pattern improvement | Temperature distribution, temperature rise speed,
In-furnace gas flow |
| II-1-3 | Load optimization | Furnace floor load,
Load distribution to more than two equipment,
Load leveling |
| II-1-4 | Material loading method improvement | |
| II-1-5 | Furnace shape improvement | |
| II-1-6 | Reduction in calorific heat of furnace body and transfer tool | Reduced weight |
| II-1-7 | Flame emissivity improvement | |

II-1-8 Direct heating

Improvement by modification into direct heating furnace,
Submerged combustion,
Direct resistance heating
Far infrared heating,
Microwave heating,
Induction heating
Dielectric heating

II-2 Heating by steam

II-2-1 Optimization of steam pressure

II-2-2 Air purging

II-2-3 Direct steam blow-in method improvement

II-3 Heat transfer

II-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, blowing optimization, Removing condensed film, defrosting, Cleaning, soot blowing, filter cleaning

II-3-2 Improvement of heat transfer coefficient

Air flow rate increase, heating by jet flow, high-speed burner,
Fluidized heat transfer,
Atomized mist cooling

II-3-3 Heat exchange system

Optimization,
Increase in unit numbers

II-3-4 Heat exchanger

Use of material with high heat conductivity
Heat transfer tube shape
Heat transfer tube arrangement
Expanded heat transfer surface, fin plate,
Buffer plate, turbulence accelerator

II-4 Operation

II-4-1 Optimization of start and stop time

Use of remained pressure of boiler

II-4-2 Reduction in load

Air conditioning temperature, rate of air circulation optimization,
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

II-5 Process

II-5-1 Improvement of Control method

Reduction of margin

II-5-2 Introduction of Automated system

II-5-3 Cascade use of heat

Multi effect evaporator, steam re-compression
Increase in the number of distillation tower trays
Plant integration
Pooling of energy among plants

II-5-4 Change of separation method

Mechanical separation
Separation by membrane
Adsorption
Extraction and super-critical extraction

II-5-5 Layout change

Reduction in transport distance
Avoiding the complicated transports
Reduction in idle operation time by reduced transport distance

II-5-6 Mitigation of reaction conditions

Catalyst improvement
Chemicals improvement
Bio reactor

II-5-7 Change of product standards

Avoiding the excessively high quality product
Materials requiring no heat treatment in the next process

- II-5-8 Change of materials Recycling
- II-5-9 Scale up Reduction of operating time by increased electric power
- II-5-10 Introduction of continuous operation
- II-5-11 Introduction of higher speed
- II-5-12 Omission of some processes Hot charging
- II-5-13 Use of highly efficient equipment

III. Prevention of heat loss due to heat radiation and transfer

Table 2.3 Standard Outside Temperature of Furnace Wall
(except for the rotary furnace and the furnace with the capacity of 500 Mcal/h or less, outer air temperature 20 °C)

Temperature inside the furnace	Temperature outside the furnace wall (unit: °C)		
	Ceiling	Side wall	Bottom in contact with the outer air
1,300	140	120	180
1,100	125	110	145
900	110	95	120
700	90	80	100

- III-1 Prevention of leakage Inspection, repair at earlier stage, Selection and maintenance of steam trap
Improved seal for the rotary section and joint
- III-2 Reduction in heat release area Improvement of piping route
Removal of unnecessary piping
Closing of the master valve for unnecessary piping and putting blind plate

III-3 Heat insulation

Improved heat insulation for flange and valve,

Use of heat insulation material with low heat conductivity

Reduced thermal emissivity of the cover

Installation of covers or lid

Maintenance of heat insulations

Reduced weight of heat insulation material for batch furnace

(Specific bulk weight should be less than 1.3.)

III-4 Prevention of gas flowing into the furnace and radiation loss

Reduced aperture size, closing, installation of the door

Reduced door open/close time

III-5 Optimization of boiler blow volume

IV. Waste heat recovery and reuse

Table 2.4 Standard Exhaust Gas Temperature for Boiler (unit: °C)

(Load factor: 100% at the outer temperature of 20 °C)

Classification of evaporation	Solid fuel		Liquid fuel	Gas fuel	By-product gas
	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	—
< 10 t/h	—	—	250	220	—

Table 2.5 Standard Exhaust Heat Recovery Rate of Industrial Furnace

Gas temperature at furnace outlet (°C)	Waste heat recovery rate (%)		
	> 20Gcal/h	5 - 20Gcal/h	1 - 5Gcal/h
< 600	25	25	—
600 - 800	35	30	25
800 - 900	40	30	25
> 900	45	35	30

IV-1 Waste energy

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

IV-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 culture
 Heating of green house
 Snow melting

- IV-3 Means**
- Heat exchanger and fluidized bed
 - Heat pipe
 - Heat pump
 - Use of heat medium
 - Waste heat boiler
 - Reduced pressure type recovery boiler
 - Turbine (organic solvent and steam)
 - Total enthalpy heat exchanger

V. Rationalization in conversion of heat into power

- V-1 Improvement of energy efficiency**
- Improvement of steam conditions
 - Combined system
 - Cogeneration
 - Power recovery of steam pressure reduction
- V-2 Rationalization in power plant**
- Improvement of turbine and nozzle shape
 - Condenser vacuum control (cleaning, water temperature and leakage)
 - Power plant operation
 - Variable pressure operation
 - Control of the number of auxiliary equipment, speed control
 - Optimization of back and extraction pressure
 - Peak shift (use of electric power during mid-night hours and on holidays, heat storage)
- V-3 Direct power generation**
- Fuel cell
- V-4 Engine efficiency improvement**
- V-5 Rationalization of steam ejector**
- Optimization of the number of steps and steam pressure
 - Conversion to vacuum pump

VI. Prevention of electric heat loss due to resistances

- VI-1 Power transmission**
- VI-1-1 Increase in voltage**

VI-1-2 Reduction in temperature

VI-1-3 Conversion into DC power

VI-2 Wiring

VI-2-1 Minimizing the wiring length

Power receiving substation equipment
Sub-station system, load arrangement
improvement,
Wiring route improvement

VI-2-2 Wiring system improvement

VI-2-3 Selection of wire diameters

VI-2-4 Balancing loads between 3-phase

VI-3 Transformer

VI-3-1 Optimum capacity

VI-3-2 Load distribution, control of the
number of operating units

VI-3-3 Wire connection method

VI-3-4 Disconnected when not in use

VI-4 Electric equipment

Reduced contact resistance

VI-5 Power factor improvement

Installation of phase advance capaci-
tor, load interlocking ON/OFF
Optimization of load factor of equip-
ment
Use of synchronous generator

VI-6 Operation

VI-6-1 Maximum power control

Load leveling
Demand control

VI-6-2 Optimization of circuit voltage

VI-7 Use of the equipment with minimum
loss

Superconductivity

VII. Rationalization in conversion of electricity into power

- | | |
|---|---|
| VII-1 Motor | Use of highly efficient motor
Optimum capacity |
| VII-2 Power transmission | Transmission device improvement,
Lubrication control,
Belt (material and relaxation adjustment) |
| VII-3 Operation | Prevention of idle operation, intermit-
tent operation,
Maintenance of optimum voltage,
Intermittent charge for electric
precipitator |
| VII-4 Fluid transport | |
| VII-4-1 Load reduction | Reduction in flow rate (leakage pre-
vention)
Reduction in pipe resistance (ration-
alization of pipe route and cleaning)
Reduction in suction temperature
Change of transport method
Highly efficient equipment, impeller,
variable blade |
| VII-4-2 Optimization of equipment capacity | Impeller cut |
| VII-4-3 Control | Speed control (VVVF, clutch, pole
change)
Control of the number of units |
| VII-5 Energy recovery | Regenerative braking |
| VII-6 Electric heating | |
| VII-6-1 Load reduction | Hot charge
Furnace loading method, power input
method improvement
Reduction in contact resistance |
| VII-6-2 Highly efficient equipment | Higher efficiency of Frequency converter
Direct heating (direct electric conduc-
tion, induction heating, dielectric heating,
microwave heating, plasma heating) |

VII-6-3 Comparison with combustion heating

VII-7 Air conditioning

VII-7-1 Load reduction

Building shape, structure, direction, surroundings,
Prevention of outer air from entering (automatically operated door, curtain)
Optimization of volume and frequency of air circulation
Heat insulation
Separation of heat generating bodies, isolation of illumination heat sources,
Local air conditioning,
Zoning (change of air conditioning requirements according to the location)
Room heating by far infrared radiation

VII-7-2 Ventilation

Filter cleaning,
Reduced duct resistance
Fan speed control
Increased size of humidifier nozzle

VII-7-3 Improved control

Return water temperature control

VII-7-4 Operation control

Water quality control for cooling tower
Cleaning of heat exchanger

VII-8 Illumination

VII-8-1 Optimum illuminance

VII-8-2 Interior

Wall color

VII-8-3 Improved equipment layout

VII-8-4 Use of sun light

VII-8-5 Turning off the unnecessary lights

VII-8-6 Illumination control

VII-8-7 Fixtures cleaning

VII-8-8 Lamp replacement at proper intervals

VII-8-9 Use of highly efficient equipment Lamp, stabilizer

VII-9 Electrolysis

VII-9-1 Reduced contact resistance

VII-9-2 Reduced voltage Reduction of overvoltage
Improvement of electrodes

VII-9-3 Operating condition control Bath temperature, concentration, dis-
tance between electrodes