JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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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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

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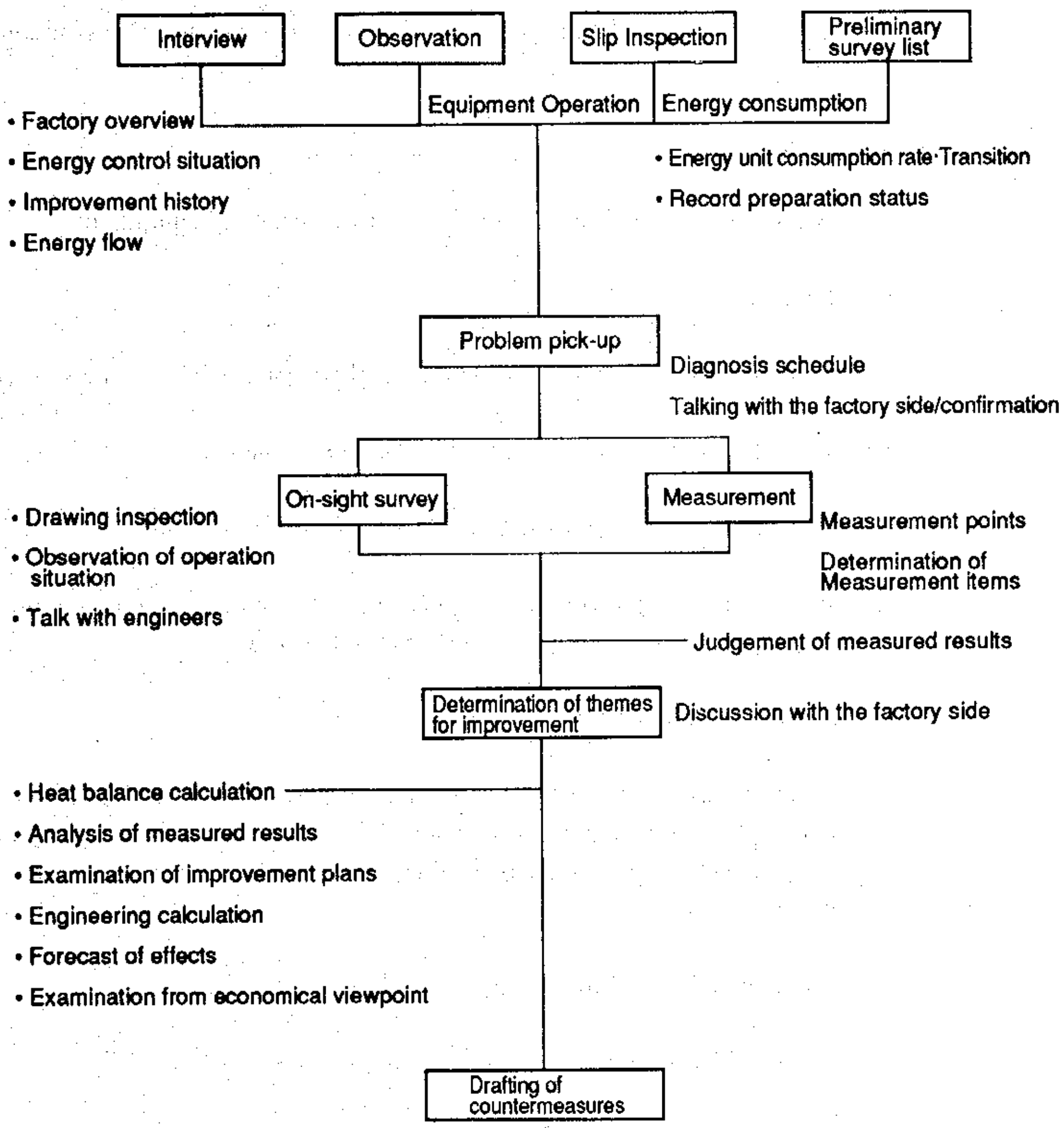
(1) Factory diagnosis procedure

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 Fixed bed	Solid fuel Fluidized bed	Liquid fuel	Gas fuel	By-product gas
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 capacitor, load interlocking ON/OFF Optimization of load factor of equipment 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, intermittent operation, Maintenance of optimum voltage, Intermittent charge for electric precipitator
VII-4 Fluid transport	
VII-4-1 Load reduction	Reduction in flow rate (leakage prevention) Reduction in pipe resistance (rationalization 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 conduction, 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, distance between electrodes