How to Proceed with Diagnostic Guidance

1. Requirements for diagnostic instructors

1.1 Preface

The duty of diagnostic instructors for energy conservation consists of "finding out problems in energy control with the private firms or enterprises, preparing and presenting their improvement plans or programs and, finally, guiding practices of the improvement plans or programs."

As a result, "the necessary requirements for a diagnostic instructor" are as shown hereunder:

— Knowledge and technology regarding energy conservation,
— Knowledge and technology concerning processes,
— Basic stance of mind and attitude worthy of diagnostic instructors, and,
— Advancing manner and technique for diagnostic guidance.

Among them, knowledge and technology concerning energy conservation and processes are expected to be their own by piling up experiences referring to the quidelines.

1.2 Basic stance of mind and attitude of diagnostic instructors

1.2.1 Basic stance of mind

The work of diagnostic guidance will not be practised, regardless of its being charged or free of charge, if there is no firm or enterprise requesting for such guidance.

Accordingly, the diagnostic instructor should put first priority on responding to what the subject firms or enterprises are wanting to do, and should give sufficient contentment to them by trying to do so.

The results of such work should be evaluated highly, as when the subject firms or enterprises come out with words of thanks, after the series of diagnostic guidances, as "it has been really good to have such a diagnosis", or "it has been very useful".

On the contrary, however, no matter how the diagnostic instructor carries out a devoted type of work, he could be blamed with a severe criticism, like "that has been of no significance", or "I have been disappointed", if he has failed in satisfying the requirements on the part of subject firms or enterprises.

Evaluation of the results of diagnostic guidance is thus defined one-sidedly by the subject firms or enterprises, and it should be well recognized that such an evaluation is by no means decided by the diagnostic instructor.

Now, in order to conduct a service to satisfy the subject firms or enterprises, the following couple of conditions should be arranged to begin with:

— Capabilities of diagnostic instructor, and
— Postures of undergoing diagnosis on the part of subject firms or enterprises.

(1) Capabilities of diagnostic instructors

Capabilities are the greatest ingredients for a diagnostic instructor, and the profits brought upon the subject enterprises depend amount of the capabilities greatly.

Capabilities are gained by an accumulation of daily efforts through studies and experiences in diagnoses.

A debutant diagnostic instructor tends to underestimate his capabilities due to inexperience, worrying about whether he could furnish the subject firms or enterprises with contentment or not, but in effect it would be good enough for him if he could come out with some 30% of the answers to the requests made by the subject firms or enterprises.

It is extremely rare that even a veteran diagnostic instructor could satisfy his counterparts by 100%.

It is very important that a new-comer exert his sincere attitude and labor up to his utmost limit, but corresponding to his capabilities as a new-comer. Some firms or enterprises would even prefer new-comers to veteran instructors.

In short, if one piles up daily studies and experiences, the capabilities should advance, so one could only be working with self-confidence, and without a condescending attitude.

(2) Postures of undergoing diagnosis of subject firms or enterprises

However sufficient the capabilities of diagnostic instructors are ready, the result will greatly be affected by the postures undergoing the diagnosis on the part of subject firms or enterprises.

(Postures undergoing diagnosis)

- To submit beforehand the related documents and problematical points to the diagnostic instructor 10 days prior to the day of diagnosis,
- To let the employees know for sure the principle and the day of undergoing diagnosis beforehand, and to cooperate with the diagnostic work on the day,
- To arrange the documents and records related with energy and to present them on the day to the diagnostic instructor, etc.

In cases of free diagnosis, or by extent of interests of managements for subject firms and enterprises, there are instances where the postures undergoing the diagnosis would invite defects and the diagnostic instructor could lose his fervor.

In short, both the agent party and the subject party would arrange conditions that they are to share, and the resulting fruits would only be collected by mutual understandings and collaborations, namely profits for the subject firms and enterprises, and gratification and motivation for the agent party.

1.2.2 Attitude

In order to be a good diagnostic instructor, sufficient capabilities and calibers should be ready, but, in addition to these, the diagnostic instructor should avail himself of an attitude or posture worthy of a diagnostic instructor.

A diagnostic instructor would be out of his caliber, if he would be blamed by the subject enterprise as, "he's got his capabilities, but we don't feel like believing in him, 'cause he's got a bad manner."

Out of the attitudes considered necessary for the diagnostic instructor, major ones would be as follows:

(1) Observance of promises

Not to be late for the time promised. To carry out the thing promised without fail.

Not to accept from the beginning what he believed not to be able to do, in consideration of his capabilities and the time available.

(2) Service intention

Work should be done with a consciousness of serving the enterprise or society. An innocent service intention would touch the heart of the counterpart and would obtain his reliance.

(3) Hold integrity in speech and action

Speaking well but doing otherwise would perplex the counterpart, losing credibility.

(4) Listen carefully to everyone's opinion

Notwithstanding the position or kind of jobs held by the counterparts, listen carefully to their speeches with a fair attitude, facing them correctly and up to the end of their speeches.

(5) Respect the standpoints of the counterparts

Everyone has a psychology of not disclosing what he think to be a disadvantage for himself, so the manner of questionning or explanation should be made according to circumstances, knowing the situations of the time and the mentalities of the counterparts.

(6) Condescending postures and words

Diagnostic instructors tend to speak in haughty manners or in arrogant attitudes and word accents. Such attitudes and speeches would only hamper the smooth progress of the work, by not only being despised by the counterparts between themselves, but also by driving them into an uncooperative stance. It will be required to associate with the counterparts, whoever they may be, in a level and fair mood at all time, and to express words of gratitude, "Thank you very much", for responses and proposals obtained from the counterparts.

Remember, a diagnostic instructor is not an inspector nor an investigator.

(7) Know-hows in speech

Speeches will be made one by one in a very concise manner, from the same level and standpoint as the counterpart, in words easy to understand, with a good intimacy, and mixing with jokes at necessary times. Never will it be a lengthy state lecture. It will be better to be understood and comprehended by the counterparts and to develop talks according to the questions put forth by the counterparts, than to insist on what the diagnostic instructors just want to say.

(8) Procedures of the work and reports

Procedures of each diagnostic guidance start first of all with the problematical point which the subject firm is now worrying about, and then they transfer to the problematical points the diagnostic instructor has discovered.

The oral and written reports should be arranged at the same level as that of the counterparts, and should be worded concretely. Any abstract report will be useless.

Also, written reports should be submitted as early as possible. It is a good example of "Strike the iron while it is hot".

(9) Never leak the secret nor confidential information got.

There are many chances to know secret or confidential informations of some firms, which should never be leaked to other firms or companies. A leakage of such information will lose the credibility of the diagnostic instructors.

2. Processing of Diagnostic Guidance

Table V–1 (1) Processing of diagnostic guidance

Application for Diagnosis from Enterprises
List of Energy Control Status

Procedures	Operational Items	Techniques
I	Preliminary Survey Preliminary knowledge and preparations 1. Planning of diagnostic program 2. Planning countermeasures for the existing (requested) problematical points 3. Arrangement of the measuring instruments brought in	1. In the field diagnosis – Acceleration of diagnotic time – Give friendly feeling and reliance to subject firms 2. Measuring instruments – Tests practising
II	Preliminary Diagnosis Field inspection and understanding (rough) 1. Interviews with managers and seniors 2. Confirmation of the existing problematical points 3. Excavation of new problematical points (as many as possible)	1. Interview – According to the check list prepared beforehand – Posture and attitude of questionners are important to obtain favorable answer from the counterparts 2. Confirmation of the existing problematical points – Collection of field original data – Interviews with field operators Some are different from those with managers and seniors – Never present the improvement plans prepared After further studies 3. Field understanding – By senses, existing instruments and records – Not only phenomena, but implications
III	Prpearation and explanation Problematical points and their diagnosis 1. Diagnostic spots, manners and time (durations) 2. Requests for collaborations	1. Problematical points – Existing problematical points – Considered as big problematical points, after preliminary diagnosis (both operations and facilities) 2. Requests for collaborations Request for understanding and cooperations, by explaining to the enterprises
IV	Main diagnosis 1. Status quo analysis 2. Discovery of problematical points 3. Planning of the solution of problematical points	1. Status quo analysis – Interviews with field responsibles and workers – By senses and instruments – Calculations Various accounts and efficiencies * Quantitatively

Table V-1 (2) Processing of diagnostic guidance

Proce-dures	Operational Items	Techniques
IV		2. Discovery of problematical points Discoveries are often made during the status quo analysis – *Be inquistive and skeptical* Any problematical point? or any defect? at all time in the course of the status quo analysis – Have criterial for judgments To have criteria to identify the problematical points or defects 3. Planning of the solution of problematical points – Knowledge and techniques – Instances and experiences obtained with other firms – Various modes of *solving the problems*
V	Preparation of Comments on Diagnosis 1. Arrangement of plans to solve problems 2. *Submission* and explanation of the solution plans for the problems 3. Questions * Comments shoud be given concretely Abstract expressions cannot obtain accords of the counterparts	1. Arrangement – What are executable (technically and financially) by the enterprises Purpose and effects of improvement, and approximate work cost – Do the improvements not affect others? 2. Submission – First submit plans to solve the existing problems (requested by the enterprises) – Plans discovered by the diagnostic in-*structor to solve the problems* 3. Explanation – In plain words on the same technical level with that of the subject firm – Concisely corresponding to the questions rather than explaining one-sidely (coercively), well considering the standpoint (mood or sentiment) *of the counterpart* A lengthy lecture would leave a psychological resistance on the counterpart – With fidelity and ardor, rather than speech techniques – *Introduction of instances of other* firms * In short, duties of the diagnostic instructors are to please, persuade and motivate the counterparts

3. Diagnostic Items

Table V–2 (1) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
I Energy Conservation Control		
1	Hoow is the grade of interest and intentions in energy conservation on the part of managers? Also, are you advising to serve in enhancement of consciousness for energy conservation with the managers?	– Plan up forecasts in the future
2	Did you establish, and are you utilizing, the intra-company regime to promote energy conservation?	– Establishment of an organization regime by all the firm and easy to operate
3	Are the training and drills in operation for the employees for energy conservation?	– ZD and QC circles
4	Are the proposals submitted from within the firm for energy conservation measures? And, are the propsals prositively encouraged and promoted?	– Adequate evaluation for the proposals
5	Are the employees' proposals constructively discussed?	– Target setting, studies on concrete measures and understanding of effects of countermeasures
II Energy Unit and Cost Analysis		
11.	Are you recording the daily energy consumption?	
12.	Are you recording the energy consumption by processes (facilities)?	– To serve for the forecast of energy demand
14.	Do you calculate the energy unit?	
15.	Are you studying the reason for increase/decrease of energy consumption and energy unit? Examples: – In crease/decrease due to operational hours – Increase/decrease due to idling and waiting hours – Increase/decrease due to seasonal factors – Increase/decrease due to changes in ambient and water temperatures – Increase/decrease due to changes in product quality and processes – Increase/decrease due to hours of facilities extension, shutdown, and suspension for trouble shooting – Reduction as effect of energy conservation	– Pursuit of causes by means of fluctuation factor analysis for energy unit

Table V-2 (2) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
	– Malfunctioning of fuel meters – Mistakes in computation – Effect of carrying out the external cleaning – Disorder in the control equipment	
16.	Do you calculate the required theoretical energy volume up to finish the products? And, do you analyze the differential factor with the actual consumable energy?	
17.	Are you comparing data regarding energy with those of other similar firms or with those of past instances?	
18.	Are you calculating shares of energy consumption amount taken in the product cost?	
19.	Are you carrying out the energy cost analyses?	
III	Measuring Instrument Control	
21.	What kind of measuring instrument do you have for energy conservation? And, are you utilizing it?	– Accomplishment of measuring instruments (fuel flowmeter, oxygenmeter, thermometer, suface thermometer and built-in manometer inside furnace)
22.	Are you practising maintenance control for the above measuring instrument, or is it functioning all in order? Aren't your records taken despite your instrument is left in trouble, or knowing it is in trouble?	
23.	Is the detecting point of instrument well studied?	
24.	Is the automatic control executed? And, is it functioning all right?	
IV	Maintenance Control	
31.	Do you have an organization to promote security?	
32.	Are the inspection criteria arranged for the facilities?	
33.	Is the inspection plan prepared for maintenance?	
34.	Are the inspections and tests carried out as shceduled for the facilities?	
35.	Are the daily inspections carried out without fail?	
36.	Are the inspection/test data recorded by facilities?	
37.	Is the person reporting or the one to whom such reports are to be made, of	

Table V–2 (3) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
	any accident at facilities, decided or appointed?	
38.	Is the prompt service system established for trouble shooting?	
39.	Are the accident records arranged? Merits: – Prevention of new accidents – Taken as evaluation material for maintenance effects	
40.	Are the ledgers prepared for and by facilities? Merits: – To be used for forecasting repair period and for calculating the necessary expenses – To be made a material to decide the renewal period for the facilities and to select better equipment – To know the trouble frequencies and maintenance cares, and to find out an economic maintenance method – As materials for reducing similar troubles, and for carrying our adequate measures at the time of trouble happening	
V Process Control/Quality Control		
41.	Aren't you heating the unoperated facilities?	
42.	Can't you eliminate bad materials?	
43.	Couldn't you enhance the products yield?	
44.	Can't you improve the operational ratio?	– Automatic transportation of materials – Extension of operational hours of facilities – Shorten the starting lag time by improving the fittings and tools
45.	Can't you set the conditions, like changing reflux ratio or density, to reduce thermal energy?	
46.	Isn't it necessary to relocate production facilities in the plant? For instance, couldn't you change raw material into one requiring less thermal energy, eliminate or replace processes or facilities? Can't you reduce facilities with the capacity balance?	
47.	Isn't the product quality excessive?	
48.	In order to carry out energy saving operation, do you prepare a concrete operational standard book on conditions, methods, procedures, etc., which are considered to be optimum	

Table V–2 (4) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
49.	Are the working environments arranged and cleaned up so as to facilitate employees to work in order, and not to give bad effects to the products.	
VI Fuel Control		
51.	Do you know properties data for the fuel applied? And, do you calculate the correction of the volume received of gas and liquid fuel by temperature, which are normally treated by volumetric units?	– In the case of fuel oil, the volume will be corrected by using the table the table of volumetric correction coefficients. By heating more than the standard temperature, the specific gravity will diminish, increasing the volume.
52.	Selection of fuel is adequate? Did you study the price and the prevention of pollution?	– Prepare the operational cirterial book
53.	Is the heating temperature fixed for fuel oil in storage and transportation? Aren't you heating it unnecessarily?	
54.	Preheating temperature for fuel oil will be different depending on kinds of fuel oil and burners, and, is the correspondent temperature control carried out?	
55.	In order to remove water and dust in fuel oil, what kind of facilities are applied, and, is the periodical maintenance of the facilities carried out?	– Switching over the standby equipment, exchange with supply parts, remove and clean with cleaning oil, clean with pressurized air, checking the packing parts, and tightening the screw parts
56.	Aren't there blocking of oil strainer, net breaks or air intrsision?	
VII Combustion Control		
61.	Is the target temperature adequate? Isn't the actual in-furnace temperature very far from the target value? Or, isn't deviation of the temperature too much?	– Introduce automatic control
62.	Do you check temperature of the combustion exhaust gas? when it is too high, do you study the cause? – Dirty surface of heat transmission in a boiler – Defects of deflector board, etc. in the furnace – Abnormal rectification of combustion flame	
63.	Do you check the composition of the combustion gas?	

Table V–2 (5) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
64.	Especially, how frequent checking of oxygen (O_2) concentration in the combustion gas is carried out (time interval, etc.)?	
65.	Is the air volume adequate?	– If the air ratio (m value is great, the exhaust gas heat loss will be great, so deal with prevention of influx air and reduction of excessive air
66.	Is the state of smoke at the stack normal?	– In the case of black smoke, improve combustion by increasing the secondary air supply. Colorless smoke is desirable.
67.	Is the combustion state good? Are the shape and color normal?	– Depending on the state of flame (reddish, long or sooty), inspect anomalies in air ratio, fuel pressure, pressure of atomizing steam or air and the nozzle chip
68.	Did the burner outlet wall turn red?	– Defective items of the burner and the countermearures:
69.	Is the burner fit to the facilities and fuel (type, atomizing method and capacity)?	Displacement of the whole burner – Correction Nozzle eccentricity – fixing of fuel pipe support, correction of supporting guide dimensions
70.	Do you care for cleaning the burner periodically and keeping the atomizing state good?	Gap between bricks and furnace hull steel – Optimization of spread of burner throat Optimization of air circling movement. Replacement of furnace hull steel plate. Insertion of sealing material. Inadequate nozzle length – Correction
71.	Is the in-furnance pressure adequate? Does the smokestack damper function normally (abt. 0.2 – 0.4mmH_2O at the furnace bed normally)	– Smooth damper operation, inspection of the bricks in the damper if any fallen-out – Chronological records will be taken over the relationship of the degree of damper – Chronological records will be taken over the degree of amper opening and in-furnace pressure
72.	Is there any blocking or breaking of air and fuel filter, or leakage from outer portion?	
VIII	Furnace Application Efficienciation	
81.	Are you conducting heat balance, and preparing heat balance sheet and heat balance chart?	
82.	Isn't there flame discharge? Or, isn't there blowing out of in-furnace gas or sucking in of outer air?	– Seal the unnecessary opening, and prevent invading air and loss heat due to flame discharge.
83.	Do you make insulation in the thermal facilities like furnace, etc.? And, aren't there anomalies like lacking in joint of sheathing materials for the furnace?	
84.	Did you revise the temperature and time setting for heating and cooling?	

Table V–2 (6) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
95.	Couldn't you improve the heat pattern, like temperature rise curve, in-furnace temperature distribution, etc.?	
86.	Is it heated universally? Isn't there a bias in the flow of hot gas?	
87.	Couldn't you improve charging method, charging volume (increase of furnace bed load and furnanace bed share)?	– Look for adequate value from the relationship of furnance bed load and energy unit
88.	Couldn't you make lot concentration to reduce start/stop frequency. Do you eliminate loss in idling/waiting hours due to waiting for charge of material (furnace)?	
89.	Do you carry out surface processing to enhance the furnance wall radiation ratio?	
90.	Isn't the heat capacity of furnace wall great?	– Alleviation of furnaace wall
91.	Couldn't you utilize heat in multi-stage application?	
IX Exhaust Heat Recovery		
101.	Have you ever studied, when the stack gas temperature is high, in use of exhaust gas heat, – Preheating of combustion air by means of heat exchanger and regenerator – Preheating of boiler feed water by means of economizer – Utilization by exhaust heat boiler – Preheating of raw material and jig tray – Reutilization of exhaust atmospheric gas – Utilization for other low-temperature furnaces – Heat exchange for warm water? If there is a utilization plan for exhaust gas heat, is it a result of sufficient studies made for adaptability to the operational state of the furnace, etc.?	
102.	Did you study possibility for heat recovery from warm water, high temperature solid (product), etc.?	
103.	Do you care for effects of acid dew point, in case of utilizing the combustion exhaust gas?	
104.	Do you classify the recovery origins by degree of contamination, in case of utilizing steam drain?	

Table V–2 (7) Check list for general inspection of energy conservation

No.	Check Items	Countermeasures
105.	Is the exhaust heat recovery equipment well utilized?	
106.	Isn't the exhaust heat recovery equipment dirty? Isn't there blocking due to exhaust gas dust?	
107.	Isn't the recuperator corroded?	
108.	Isn't there loss heat between the furnace outlet and the preheating equipment?	

Table V–3 Volume Correction Coefficient by Fuel Oil Temperature

Petroleum Products Temperature Volume Conversion Coefficient Table
(extract from the JIS K 2250 Volume Conversion Coefficient Rough Table)

S.G. at 15/4°C / Measured Temperature (°C)	Volume Conversion Coefficient at Standard Temperature 15 °C					
	(0.6417 ~ 0.6721)	(0.6722 ~ 0.7236)	(0.7237 ~ 0.7750)	(0.7751 ~ 0.8494)	(0.8495 ~ 0.9653)	(0.9654 ~ 1.0754)
0	1.0216	1.0190	1.0163	1.0134	1.0108	1.0095
1.0	1.0202	1.0177	1.0152	1.0125	1.0101	1.0089
2.0	1.0187	1.0165	1.0141	1.0116	1.0094	1.0082
3.0	1.0173	1.0152	1.0131	1.0107	1.0086	1.0076
4.0	1.0158	1.0140	1.0120	1.0098	1.0079	1.0069
5.0	1.0144	1.0127	1.0109	1.0089	1.0072	1.0063
6.0	1.0130	1.0114	1.0098	1.0080	1.0065	1.0057
7.0	1.0115	1.0101	1.0087	1.0071	1.0058	1.0050
8.0	1.0101	1.0089	1.0076	1.0063	1.0050	1.0044
9.0	1.0086	1.0076	1.0065	1.0054	1.0043	1.0037
10.0	1.0072	1.0063	1.0054	1.0045	1.0036	1.0031
11.0	1.0058	1.0050	1.0043	1.0036	1.0029	1.0025
12.0	1.0043	1.0038	1.0032	1.0027	1.0022	1.0019
13.0	1.0029	1.0025	1.0022	1.0018	1.0014	1.0012
14.0	1.0014	1.0013	1.0011	1.0009	1.0007	1.0006
15.0	1.0000	1.0060	1.0000	1.0000	1.0000	1.0000
16.0	0.9985	0.9987	0.9989	0.9991	0.9993	0.9994
17.0	0.9971	0.9974	0.9978	0.9982	0.9986	0.9988
18.0	0.9956	0.9962	0.9967	0.9973	0.9978	0.9981
19.0	0.9942	0.9949	0.9956	0.9964	0.9971	0.9975
20.0	0.9977	0.9936	0.9945	0.9955	0.9964	0.9969
21.0	0.9913	0.9923	0.9934	0.9946	0.9957	0.9963
22.0	0.9898	0.9911	0.9923	0.9937	0.9950	0.9956
23.0	0.9884	0.9898	0.9913	0.9929	0.9943	0.9950
24.0	0.9869	0.9886	0.9902	0.9920	0.9936	0.9943
25.0	0.9855	0.9873	0.9891	0.9917	0.9929	0.9937
26.0	0.9840	0.9860	0.9880	0.9902	0.9922	0.9931
27.0	0.9825	0.9847	0.9869	0.9893	0.9915	0.9925
28.0	0.9811	0.9835	0.9858	0.9884	0.9907	0.9918
29.0	0.9796	0.9822	0.9847	0.9875	0.9900	0.9912
30.0	0.9781	0.9809	0.9836	0.9866	0.9893	0.9906
31.0	0.9766	0.9796	0.9825	0.9857	0.9886	0.9900
32.0	0.9752	0.9783	0.9814	0.9848	0.9879	0.9894
33.0	0.9737	0.9771	0.9803	0.9839	0.9871	0.9887
34.0	0.9723	0.9758	0.9792	0.9830	0.9864	0.9881
35.0	0.9706	0.9745	0.9781	0.9821	0.9857	0.9875
36.0	0.9693	0.9732	0.9770	0.9812	0.9850	0.9869
37.0	0.9678	0.9719	0.9759	0.9803	0.9843	0.9863
38.0	0.9664	0.9707	0.9748	0.9794	0.9836	0.9856
39.0	0.9649	0.9694	0.9737	0.9785	0.9829	0.9850
40.0	0.9634	0.9681	0.9726	0.9776	0.9822	0.9844
41.0	0.9619	0.9668	0.9715	0.9767	0.9815	0.9838
42.0	0.9605	0.9655	0.9704	0.9758	0.9808	0.9832
43.0	0.9590	0.9642	0.9693	0.9749	0.9801	0.9825
44.0	0.9576	0.9629	0.9682	0.9740	0.9794	0.9819
45.0	0.9561	0.9616	0.9671	0.9731	0.9787	0.9813

(Application Method): The crossing point of the specific gravity (S.G.) at 15/4°C and the measured temperature in the left-hand column will be the conversion coefficient.

(Example): In case the volume at 32°C of the oil of which the specific gravity (at 15/4°C) is 0.9561, is 25895 lit., how much is the volume at 15°C?
25895 x 0.9879 = 25582 (Difference 313 lit., or 1.2%)

4. Procedure of diagnoses and countermeasures

Substantial methods are to be explained as follows, in connection with the main steps in Fig. V-1.

(1) Production process analysis (Fig. V-1, ①)

An outline of the flow sheet for manufacturing process of products and a chart for application process by energy types applied should be prepared. For instance, in the case of heat processing facility, the pattern will be as shown in Fig. V-2. Incidentally, the heat processing facility is relatively simple, and it will be good enough to prepare a chart classifying energy types by heat processing shop works only.

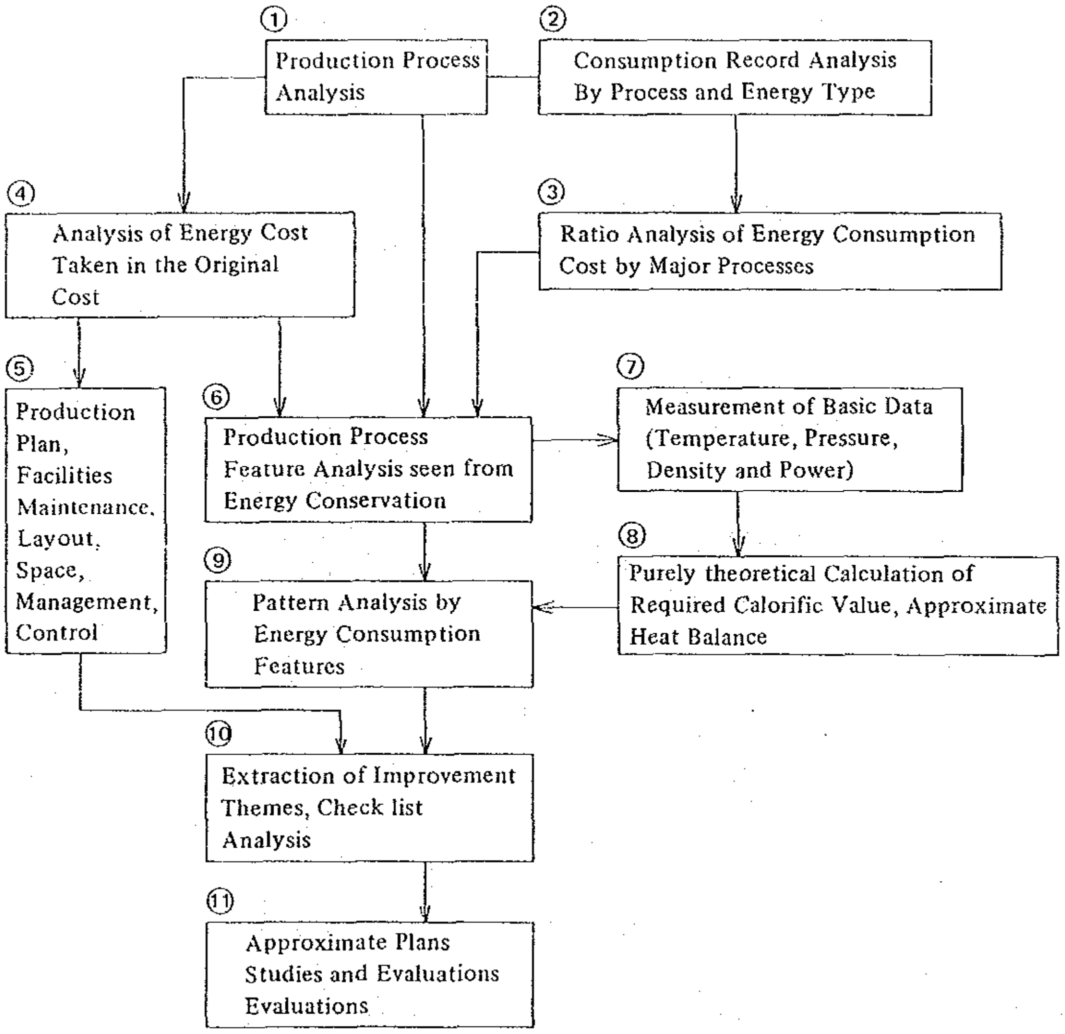

Fig. V-1 Procedure of diagnoses and countermeasures

(2) Consumption record analysis by processes and energy types (Fig. V-1, ②)

(a) Method of knowing the present state by simple data analysis

Energy conservation measures start with accurately knowing the consumption state of energy. Fuel consumption for each heat processing furnace should be accurately known. With reference to the above, the fluctuation trend will be better known by weekly or daily data than by a monthly unit, and it is desirable because of its facility to plan up countermeasures, but what is most important is to in order the recorded data so as to be utilized effectively rather than to leave them as they are. It is convenient to make them in the form of graphs. At the same time, throughout and operational hours should concurrently be recorded with energy consumption without fail. For example, the record as Fig. V-3 would be useful for knowing the present state, if it is made every month:

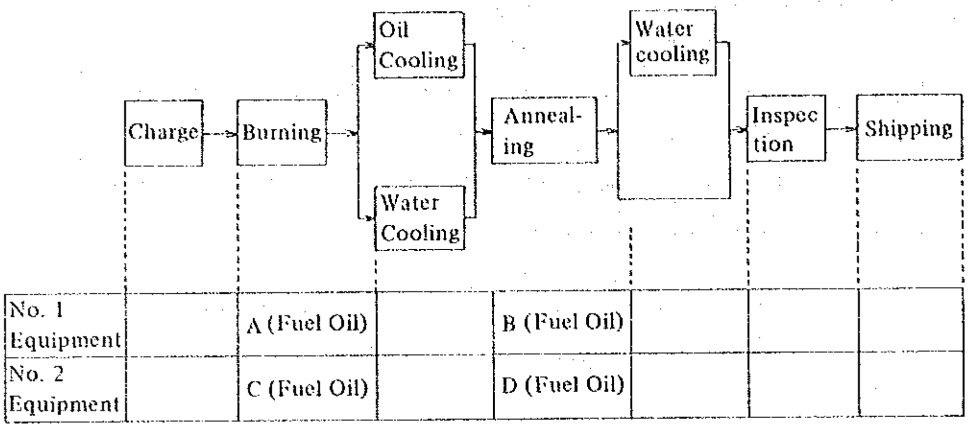

Fig. V−2 Manufacturing process of products and energy consumption records by energy types

Record data (by furnace)
(1) Fuel consumption
(2) Processing weight
(3) Operational hours

↓

(1) Processing weight, chart of monthly transition of processing weight per hour.
(2) Fuel consumption, chart of monthly transition of fuel consumption per hour.
(3) Chart of monthly transition of operational hours.
(4) Chart of monthly transition of energy consumption rate for each furnace and plant as a whole.
(5) Chart of correlationship between energy consumption rate and processing weight per hour.
(6) Table of shares of fuel consumption and processing weight by energy types.
(7) Table of monthly average and variance values of processing weight, fuel consumption and operational hours.
(8) Table of average and variance values for the past year, of energy consumption rate.

Fig. V−3 Method of knowing the present state

Examples of consideration are shown hereunder. They are the examples of five (5) furnaces applying town gas as a fuel.

Example (1): It is known from Fig. V-4 that, in August and January, processing weight decayed, but the same per hour increased, and the productivity was enhanced. The annual trend was that, the productivity increased gradually, but it remained almost the same with the turn of the year into 1983.

Example (2): It is known from Fig. V-5 that the fuel consumption was the lowest in November, different from the case with the processing weight. The processing weight is not particularly low, and the fuel consumption per hour came to be the lowest in November. The annual trend was almost pegged.

Example (3): It is known from Fig. V-6 that the operational hours were the least in August and January and, on the contrary, the same were highest in February, in contrast with the least number of days in a year.

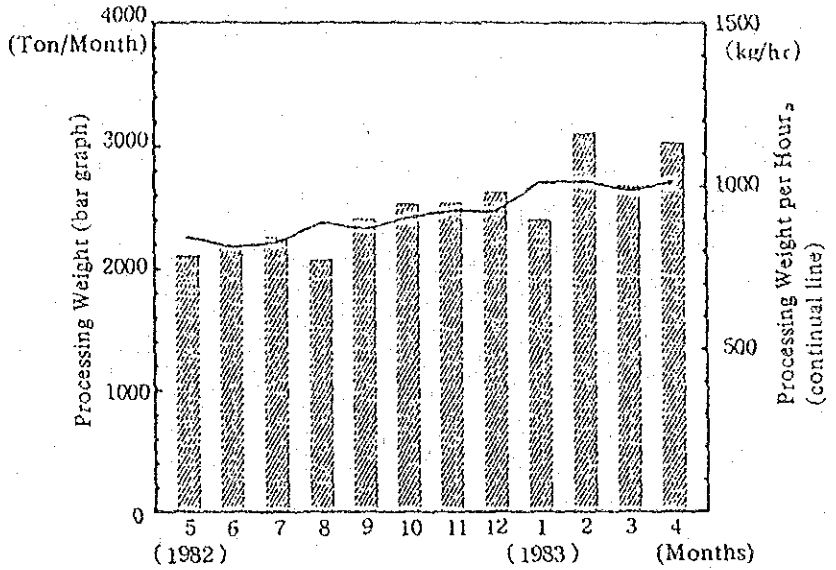

Fig. V-4 Monthly Transition of Processing Weight, Etc. (Example 1)

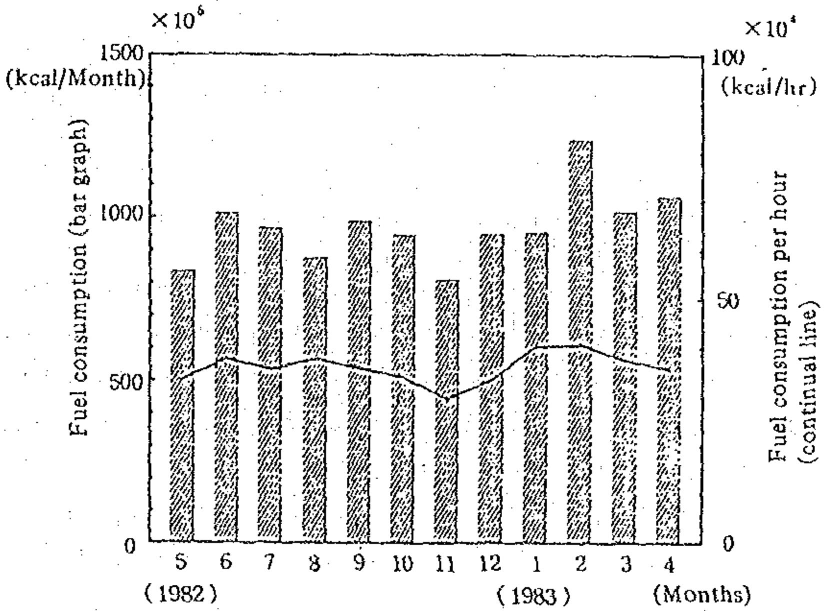

Fig. V-5 Monthly Transition of Fuel Consumption Etc. (Example 2)

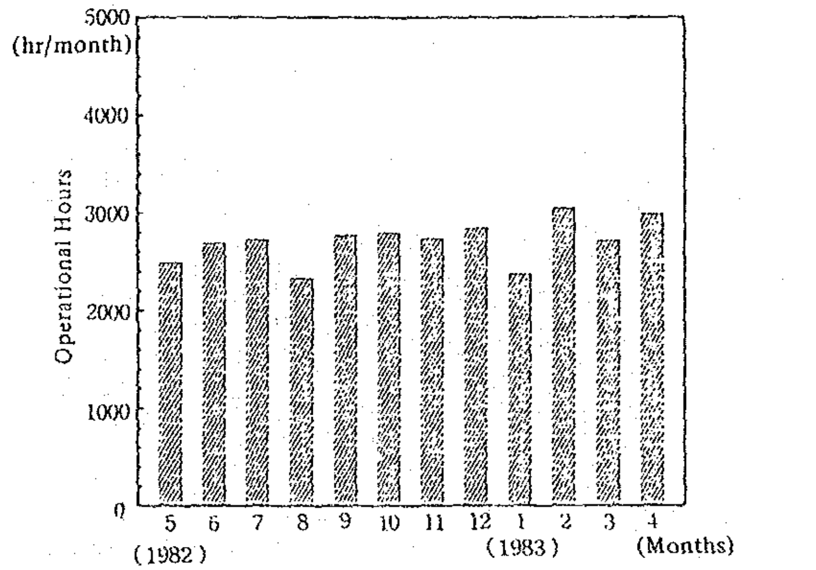

Fig. V-6 Monthly Transition of Operational Hours (Example 3)

Example (4): Fig. V-7 shows the transition trend of energy unit by the respective furnaces.

The dotted line means the grand total for the entire furnaces, and the fluctuation range was small. This shows the fact that the energy consumption features of the furnaces in the town gas group are stable.

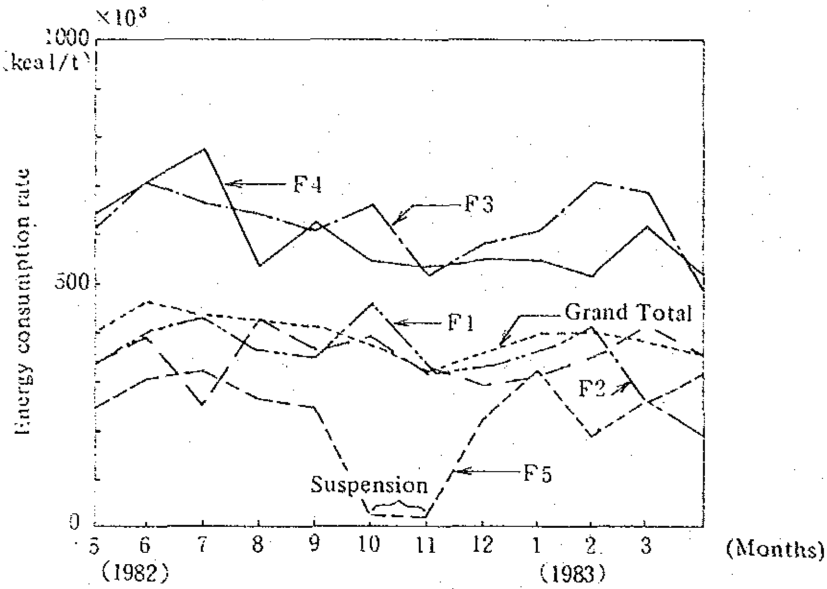

Fig. V–7 Monthly transition of energy consumption rate (Example 4)

Example (5): Looking at correlationship between the energy consumption rate and the processing weight per hour for the respective furnaces, it is known, as in Fig. V-8, that a coherency to some extent is seen with each furnace. The following fluctuation factor analyses for the energy consumption rate will serve as a quantitative analysis method for such a correlationship chart.

Example (6): It is known from Tab. V-4 that the share of processing weight is less than that of fuel consumption with furnaces consuming fuel oil and electric power.

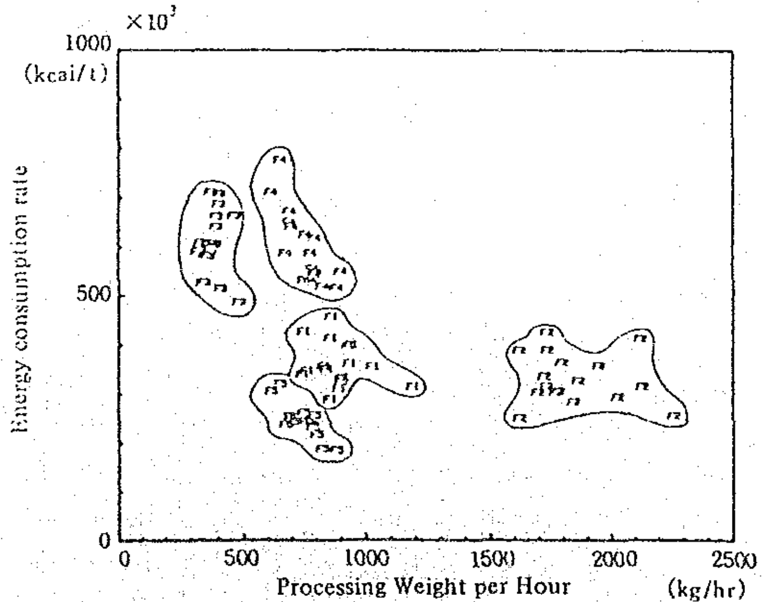

Fig. V–8 Chart of Correlationship between Energy Consumption Rate and Processing Weight per Hour (Example 5)

Table 1.4: Shares by Fuel Types (Example 6)

(%)

Month-Yr.	Comparison of Processing Weight			Comparison of Fuel Consumption		
	City Gas	Fuel Oil	Electric power	City Gas	Fuel Oil	Electric power
(82. 5)	64.3	30.2	5.5	53.0	40.0	7.0
(82. 6)	61.0	33.9	5.1	52.3	41.8	5.9
(82. 7)	63.6	32.6	3.8	54.6	40.4	5.0
(83. 1)	66.2	30.4	3.4	55.0	39.7	5.3
(83. 2)	70.2	26.3	3.5	59.6	36.4	4.0
(83. 3)	66.5	30.1	3.4	55.5	40.6	3.9
(83. 4)	64.8	30.0	5.2	51.7	42.4	6.0
Total Period	65.1	30.7	4.3	53.2	41.0	5.8

Example (7): The coefficient of variation in Tab. V-5 means ratio of fluctuation against the average value of the fuel consumption. The fluctuation ratio for the total group is 15%. The operation of the furnace F5, however, was suspended in October and November, and the influence is reflected on the coefficient of variation.

Table V–5 Simple Fluctuation Analysis (City Gas Group) (Example 7)

Furnace No.	Average Value	Variance	Standard Deviation	Coefficient of Variation
F 1	121	312	18	15
F 2	306	4525	67	22
F 3	120	483	22	18
F 4	279	2116	46	16
F 5	103	1595	40	39
Grand Total	921	20043	142	15

* Unit for average value and standard deviation is: (10^6 kcal/month)

Example (8): It is known from Tab. V-6 that the fluctuation ratio of the energy consumption rate is 10% in total, smaller than the case of fuel consumption amount.

Table V–6 Simple Fluctuation Analysis of Energy Unit (City Gas Group) (Example 8)

Furnace No.	Average Value	Variance	Standard Deviation	Coefficient of Variation
F 1	361	2113	46	13
F 2	331	2661	52	16
F 3	610	4101	64	10
F 4	597	5492	74	12
F 5	224	7269	85	38
Grand Total	384	1490	39	10

Unit for the average value and standard deviation is: (10^3 kcal/ton)

Furthermore, calculations of average (x), variance (σ_x^2), standard deviation (σ_x) and coefficient of variation (v), are, supposing data to be x_i (i = 1, 2, ..., n), as follows:

$$\bar{x} = \frac{1}{n}(x_1 + x_2 + \ldots\ldots + x_n) = \frac{1}{n}\sum_{i=1}^{n} x_i \quad \cdots\cdots (1.1)$$

$$\sigma_x^2 = \frac{1}{n-1}\left\{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right\} \quad \cdots\cdots (1.2)$$

$$v = \frac{\sigma_x}{\bar{x}} \times 100\,[\%] \quad \cdots\cdots (1.3)$$

(b) Analytic method for the coefficient of variation in energy consumption rate

$$\text{Energy consumption rate} = \frac{\text{Energy consumption (in kcal)}}{\text{Throughput (in t, kg, m}^3\text{, m}^2\text{, m, } l\text{, doz., pc., etc.)}}$$

At the calculation, the kcal conversion of fuel will be done in calorific value. An example of low calorific value of the commonly used fuel is shown in Tab. V-7.

Table V–7 Calorific value of various fuel

Fuel Type	Low Calorific Value	Properties
Pure propane	22350 kcal/Nm^3	Specific weight
Pure Butane	29510 kcal/Nm^3	S.G. (specific gravity)
Fuel Oil A	8780 kcal/ℓ	Specific weight
Gas Oil	8450 kcal/ℓ	S.G.
Kerosene	8110 kcal/ℓ	S.G.
Coal	7500 kcal/kg	Of high grade
Electric Power	860 kcal/kWh	Theoretical value

Energy consumption rate is not only a measure to define numerically the effect of heat management, but also to represent the whole productive efficiency.

Energy consumption rate will diminish when the throughput increases as compared to the energy consumption volume, or when the energy consumption volume is reduced for the same throughput. That is to say, a synthesis of efforts for productivity enhancement exist in a wide range, like decrease of material waiting, equipment troubles, etc., improvement of operational ratio by enhancement of working will, advance of production yield, decrease of defective ratio, process rationalization, acceleration of energy conservation, etc., will come to represent a decrease in energy consumption rate. In short, the energy consumption rate could be considered as showing how effectively the energy has been used and, at the same time, as a measure to denote the entire productive efficiency.

By the way, it would be a big error to evaluate it as entirely the result of energy conservation measures, even if the energy unit has simply decreased.

There are varied fluctuation factors of energy consumption rate, but it would be just as useful to quantitatively analyze into the following three (3) fluctuation factors as showed in Fig. V-9.

Data (per period)
(1) Fuel Consumption
(2) Processing Weight
(3) Operational Hours*

⇩

Analysis
(1) Production volume variance factors
Influential factors to energy consumption rate, due to loss of adequacy of production volume against the facilities capacity owing to fluctuations in production volume.
(2) Energy conservation measures effects factors
Influential factors to energy consumption rate, due to execution of the energy conservation measures.
(3) Energy control factors
Influential factors to energy consumption rate, due to adequacy or not of daily control in connection with energy.

⇩

Evaluation by Factors

(*) If unknown, skip it.

Fig. V–9 Analytic method for the coefficient of variation in energy consumption rate

(3) Analysis of energy cost taken in original cost (Fig. V-1, ④)

In order to analyze energy cost from the managerial point of view, the following methods are available.

(a) Analysis of transitional profit and loss account

Records should be taken by periods for the profit and loss account as shown in Tab. V-8 as the whole enterprise, calculating shares of each account taken in the sales output, and analysis should be made of transition of growth and share for each account. In this case, too, it will be advisable to chart for arranging the data. Among other accounts, particularly, how the energy cost affects the managerial records is known by analyzing the transitional state.

Table V–8 Cost-related data

No.	Accounts	Unit
1.	Sales output[1]	¥10^3
2	Material cost	"
3	Subcontracting[2]	"
4	Labor cost	"
5	Manufacturing expenses	"
6	Manufacturing cost	"
7	Energy cost	"
8	Processing output[3]	"
9	Machines and equipment	"
10	No. of emploees	ps
Calculation formulae: ⑥=②+③+④+⑤ ⑧=①−(②+③)		

Notes:
1) Sales output = Gross cost + profit
2) Subcontracting expenses belong to those of manufacturing direct cost.
3) Processing output = sales output − material cost − subcontracting cost
This document regards the additional value amount the same as processing output.

(b) Analysis of transitional energy consumption specific value

Prepare Tab. V-9 of energy consumption specific value by using the data in varied accounts in Tab. V-8, and analyze the transitional state. In this case, it is important to analyze the problematical points in comparison to those in other firms of the same trade.

Table V–9
Energy consumption specific accounts

No.	Accounts	Unit	Formula
11	Processing volume per capita	10^3 ¥/M	⑧/⑩
12	Energy productivity		⑧/⑦
13	Energy capital efficiency*		⑨/⑦
14	Equipment ratio	"	⑨/⑩
15	Equipment investment efficiency		⑧/⑨
16	Energy cost taken in manufacturing cost		⑦/⑥

*The reciprocal of energy capital efficiency is called energy capital productivity.

(c) Factorial experiment of energy cost — Energy loss by oppotunities

Energy cost for the subject facilities of energy conservation measures fluctuates by varied factors. For instance, the energy cost per product unit fluctuates greatly by the size of lot numbers, and it varies widely by production of defective goods, time of trouble, waiting and preparation hours.

It is said that the oppotunity loss should be recognized as the first step of solution for problematical points at the working site, and the energy oppotunity loss amount could be known likewise in energy conservation activities by way of the formula below:

$$L_c = E(H_p - H_s) / \left(\frac{H_p + H_s}{2}\right) \quad \cdots\cdots (1.4)$$

where: Lc: Energy oppotunity loss amount (Bt)

E: Energy cost (Bt)

H_p: Actual operational hours (hours)

H_s: Standard hours (hour)

A sample and calculation for preparing a table are shown in Tab. V-10.

Energy oppotunity loss is tied to an operation improvement by distinguishing the facilities. More in detail, if the actual operational hours are known in classification of trouble, waiting and preparing hours through the daily operation records, then the energy oppotunity loss for each block will be known, which will be the referential data for operational improvement.

Table V−10 An example of calculation for energy opportunity loss amount (monthly value at a heat treatment plant)

Fac. No.	Sales Output M (¥10³)	Energy cost E (¥10³)	Energy cost ratio E/M (%)	Actual oper. hours Hp (Hr)	Standard hours Hs (Hr)	Energy Opportunity loss amount Lc (¥10³)
A 1	11294	3540	31.3	489	448	310
A 2	4727	1403	29.7	546	392	461
A 3	2267	1204	53.1	213	198	88
A 4	11621	1751	15.1	693	690	8

(4) Manufacturing process specific analysis seen from energy conservation (Fig. V-1, ⑥)

Represent the relationship between the temperature change of materials and time in the course of the material flow in the manufacturing process into the distribution chart like Fig. V-10. Quality of energy could be considered by the chart. In this case, the temperature rising speed of the central part ③ is slower than the extremities, and the retention time is prolonged. With an improvement of heatingprocess at this part, the retention time could be shortened as energy conservation measures.

In general, as temperatures are high, so the quality of energy will be high, and as many repetitions are made for heating and cooling during the manufacturing process, so much will energy be squandered.

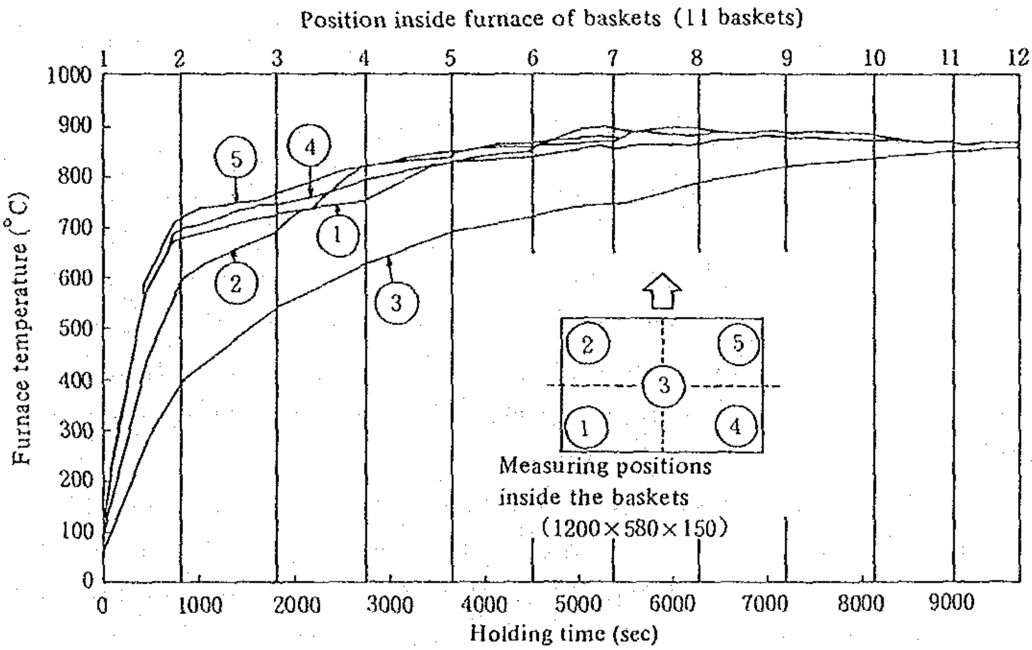

Fig. V−10 An example of furnace temperature distribution in quenching furnace

(5) Measurement of basic data (Fig. V-1, ⑦)

A majority of firms seldom conduct controls by analyses of exhaust gas, measurement of temperature, etc., at the time of combustion control, but rather the control is, at the present, consigned to visual and other judgements stemming from the experiences of a long time.

As a result, it should often be required to measure the basic data in need, at the time of diagnosis and analysis for energy conservation.

The followings are, for example, items of measuring data:

(1) Ambient temperature
(2) Moisture (humidity)
(3) Oxygen fraction in combustion gas
(4) Air temperature for combustion
(5) Fuel preheating temperature
(6) Exhaust gas temperature
(7) Temperature at inlet/outlet of materials
(8) Maximum heating temperature of materials
(9) In-furnace pressure
(10) Fuel consumption
(11) Material processing volume
(12) Furnace wall temperature
(13) Furnace wall area and dimensions
(14) Jig weight
(15) Water temperature at the inlet
(16) Steam pressure
(17) Steam temperature
(18) Steam consumption
(19) Power consumption
(20) Maximum power consumption

and they should only be precise enough for a rough heat balance.

At the time of measurement, generally, a precocious series of studies on the purpose, facilities, place, manner, precision, equipment, period, etc. of measurement should be required beforehand. The fuel flowmeter, oxygen analyzer, thermometer, surface thermometer, manometer, etc. are at least necessary as measuring instruments.

(6) Rough heat balance (Fig. V-1, ⑧)

The heat balance is also called "heat account" or "heat input/output", which is conducted to clear the relationship between the incoming heat and outgoing heat, by knowing the calorific value (including thermal conversion value in case of electricity) supplied to thermal facilities and its application state. The thermal facilities entail heat loss without fail, so by conducting heat balance, the kind and quantity of heat loss could be cleared together with the calorific value being utilized effectively. As a result, whether the operation of thermal facilities is adequate or not, or if the fuel squandering is found or not, could be judged, and reduction measures for heat loss could be conducted.

There are three stages, as shown in Fig. V-11 in heat balance, namely, the present state, trial calculation and confirmation, and, the most important in studying the energy conservation measures is, the heat balance for knowing the present state.

For the calculation, it will be important to correctly know the physical value of heated materials, exhaust gas, etc. At the same time, it is not only important for preparing the chart for heat balance, but also is important to conduct simulations to enable forecasting of an energy distribution state in the case of modified heating conditions, for instance. These calculations would only be applied to personal computers, which would rapidly present the result to be instantly evaluated, and would enable various simulations.

An example of heat balance will be shown with a heat treatment furnace. Fig. V-12 shows the range of heat balance and heat balance itself, while Tab. V-11 shows measurement data, Fig. V-13 is heat balance chart.

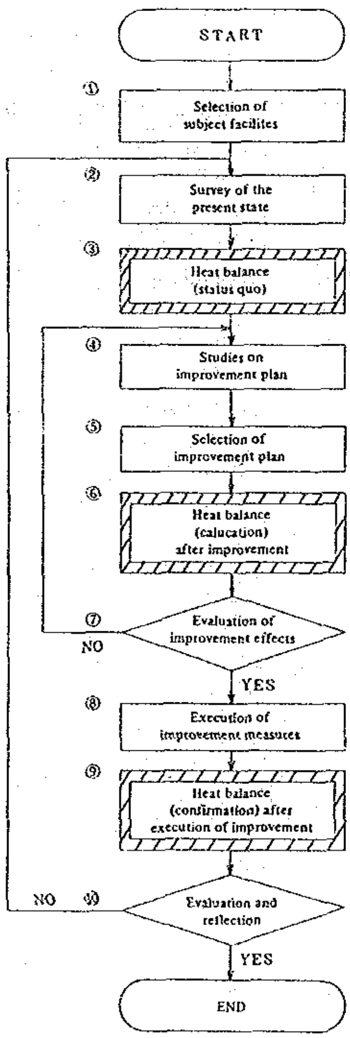

Fig. V−11 Role of heat balance in the process of energy conservation measures

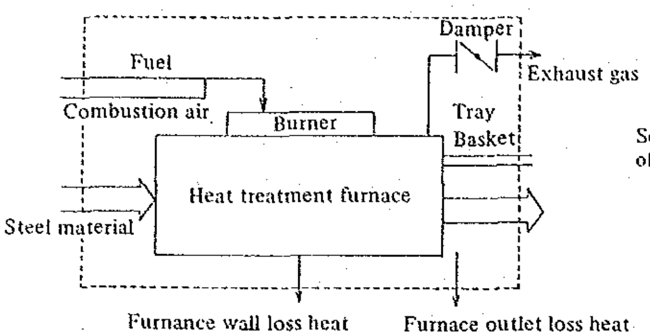

Fig. V−12 Range of heat balance

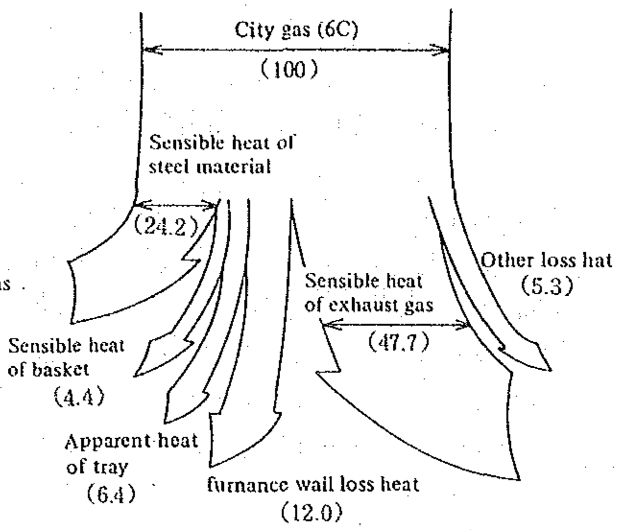

Fig. V−13 Heat balance in heat treatment furnance

Table V−11 Necessary data for heat balance of heat treatment furnace (or oven)

Items	Data	Unit	Items	Data	Unit
Equipment name	A2	—	Tray weight	770	kg
Fuel	City gas	6C	Basket weight	528	kg
Date measured	83.9.25	Day/ Month/Yr.	Exahust gas O_2 content	9.7	%
Dry bulb temperature	33	°C	Exhaust gas CO content	0	%
Wet bulb temperature	28	°C	Exhast gas temperature	712	°C
Measured hours	2.69	hr	Maximum heating temperature of heated matter	890	°C
Processing weight	2.61	t			
Fuel consumption	350	Nm^3	Temperature at furnace outlet	870	°C
Position	Ceiling	Under Furnance Bed	Side Wall	Inlet	Outlet
Furnance wall area (m^2)	19.20	15.48	13.40	2.35	2.35
Furnance wall temperature (°C)	128	98	110	170	210

(7) Extraction of Improvement Themes (Fig. V-1, ⑩)

Arrange past informations, find out the themes related to energy conservation, like varied ideas, problematical points, and the points aimed at, etc. The viewpoints for improvement are shown in Fig. V-14.

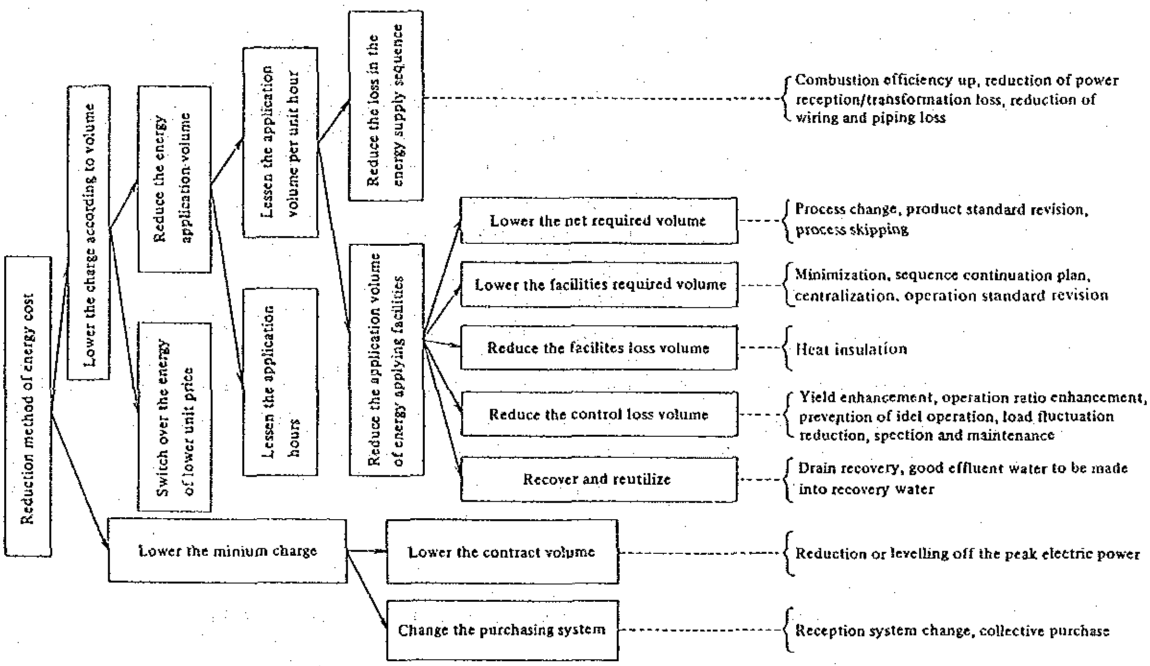

Fig. V-14 Chart showing pursuit of how to reduce energy cost

(8) Rough calculations, studies and evaluations (Fig. V-1, ⑪)

(a) Conduct arrangements and systemization of rough themes, and develop them into energy conservation themes worthy of being studied and of higher realizability.

(b) Corresponding to soluble levels, classify them into divisions shown in Tab. V-12, find out all the short-, medium- and long-term themes of energy conservation, and evaluate the respective divisions.

(c) Judging method at the time of economy evaluation of facilities investment is shown in Tab. V-13. Furthermore, in case the investment profit or original cost saving amount is supposed to be constant, the approximate evaluation method as shown in Tab. V-14 could be used since the calculation will be simple and easy.

Table V-12 An example of level classification of themes

	Level	Contents	Energy Conservation effects
Sector level	Survey and analysis will be made centering on the manufacturing sector, and the project team will assist it according to necessity.	(1) Technicall practised easily easily with calculation of profitability (2) Can be practised at the judgement of the sector, though technical confirmation is needed.	10% more or less
Project level	Survey and analysis will be made centering on the project team, and collaborations of the respective sectors are sought	(1) Technical and economic studies are required to some extent (2) Technically available, but economically somewhat risky.	20% more or less
Factory level	Judgement of the factory top and studies by more specialist engineers are required.	(1) Judgement from the viewpoint of the entire factory is required (2) Experimental level (3) Conceptual stage	30% or more

Table V-13 Evaluation method for ecomony of facilities investment

Evaluation method		Acceptance terms for investment amount
Profit amount type	Net actual price type	$\Delta P = P_2 - P_1 > 0$
	Net final price type	$\Delta S = S_2 - S_1 > 0$
Interest rate type	Net actual price type	$i < r$
Recovery period type		$n < N$

P_1 = Initial facilities investment amount
S_1 = Final price amount after n period of $P_1 = P_1(1+i)^n$
S_2 = Final price of investment profit or original price saving amount afer n period
P_2 = Actual price amount of $S_2 = S_2(1+i)^{-n}$
i = Interest rate for capital cost
n = Expected duration
r = Equal interest rate, value of i at $\Delta P = 0$
N = Recovery period, value of n at $\Delta P = 0$

Table V-14 Evaluation method for economy of facilities investment

Evaluation method	Acceptance terms for investment amount
Profit amount type	$M = a \cdot \Delta P = S_0 - P_1 a < 0$
Interest rate type	$i < r$
Recovery period type	$n < N$

S_0 = Investment profit or original cost saving amount for each period
M = Net profit amount for each period
a = Capital recovery coefficient $= \dfrac{i(1+i)^n}{(1+i)^n - 1}$
r, N : Value of i or n at $M = 0$

(Exercise) If an energy conservation facility is introduced in a process, the energy cost of 5 million yen/year could be saved for 5 years. Supposing the calculated interest rate at 12%, up to how much amount of investiment could for the above facility pay? Also, if the initial facility cost 15 million yen, how much would the equity interest rate be for 5 years? How long will the recovery period take at 12%?

(Solution) By applying the formula shown in Tab. V-14, the capital recovery coefficient a will be:

$$\alpha = \frac{(1+0.12)^5(0.12)}{(1+0.12)^5 - 1} = 0.2774, \qquad P_1 < \frac{S_0}{\alpha} = \frac{500}{0.2774} = 1802$$

Therefore, a facility investment amount of 18.02 million yen or less would pay enough.

Equity interest rate will be r = 0.153 from the formula below:

$$\frac{(1+r)^5 \cdot r}{(1+r)^5 - 1} = \frac{S_0}{P_1} = \frac{500}{1500} = \frac{1}{3}$$

Recovery period will be N = 4 years and 6 months, from the formula below:

$$\frac{(1+0.12)^N \cdot (0.12)}{(1+0.12)^N - 1} = \frac{500}{1500} = \frac{1}{3}$$

JICA