a. Enterprises operating gas-fired boilers : 2 teams
b. Enterprises operating operation of diesel-fired boilers : 2 teams
c. Enterprises operating operation of gasoil-fired boilers : 2 teams

All the participant were awarded a certificate issued jointly by INE and JICA for the completion of the course.

6.1.4 Subsequent Stage of Capacity Development

(1) Object Enterprises for Capacity Development

There are approximately 1,500 enterprises of medium to large size in ZMCM. These enterprises constitute a major part of the total air pollutant emission from stationary sources. Therefore, persons engaged in the operation of boilers in these enterprises should be the primary objectives for the capacity development in the NOx reduction.

Actual trainees are expected to be plant masters, engineers, or operators of individual enterprises. In this plan, the number of potential trainee is estimated at about 1,500 people by assuming each enterprise dispatches one person to attend the training course.

For the other combustion equipment, the reduction of NOx and smoke emissions should be pursued through another scheme of technical improvement program which should be established for a more advanced stage of emission control.

(2) Subject of Training

The subjects of training in this stage are proposed to be the following which include the subjects common with the initial stage and additional ones:

Common subjects
a. Mechanism of NOx and smoke generation through combustion
b. Principles of pollutant reduction and their application
c. Operation method for pollutant reduction (including practical exercise)
d. Energy saving operation

Additional subjects
e. Knowledge of environmental regulation related to air pollution
f. Knowledge of measurement of pollutant concentration in exhaust gas

Additional subject "e. Knowledge of environmental regulation related to air pollution" should include NOM-085 and its derivative norms in order to clarify which requirements can be met by technical improvement. The subject "f. Measurement of pollutant concentration in exhaust gas" is basically not the main job of boiler operators, but the results of the measurement

should be reflected in the operation of combustion equipment. Particularly, the oxygen concentration in the exhaust gas is a fundamental index of combustion state. Therefore, it is desirable that operators have general knowledge of the measurement of the exhaust gas.

(3) Time of Execution

The duration of one unit of the course consisting of lectures and practices is estimated at 0.5 week with about ten attendants, so that it will take 75 weeks to complete the training of all participants. This time requirement implies that it is possible to finish most of the planned training of boiler operators by the scheduled time of enforcement of the new emission standards, January 1, 1998, if the course is started promptly and conducted continually. It is desirable to finish all the training before 1998 so that the enough skill of low NOx combustion will have been disseminated to the majority of boiler owners in order to comply with the new emission standards from the start of their enforcement. This advancement of the completion can be realized by conducting the lecture sessions for several groups at one time.

(4) Executing Bodies

The training of boiler operators regarding low NOx combustion techniques is proposed to be executed as a part of the activities of INE. It is because that INE is legally responsible for the promotion of policies for NOx emission reduction from stationary sources. Boiler owners regulated by the emission standards are obliged to report on their pollutant emissions to INE every year according to the General Law for Ecological Balance and Environmental Protection. From this point of view, INE is suitable as the main executing body of the training because the owners and plant operators are directly or indirectly controlled by INE under the present regulatory system for stationary sources.

The other authorities related to the regulation of stationary sources are expected to contribute to the training in their respective fields of responsibility. A practical form of contribution to the training course would be to undertake a part of lectures and implementation of the practice aspects. At the same time, it is expected that those authorities will provide necessary facilities, fuels and other materials for the course according to their functions. Corresponding authorities and their proposed roles in the course are as follows:

1) Ministry of Labor and Social Security (STPS)

Its basic functions related to the capability development include : i) to examine the capability of applicants as boiler operator, and ii) to issue the license in view of safe operation. Before the course begins STPS is expected to cooperate with INE in supplying information on licensed boiler operators who are potential applicants for the training course. It is also

expected that STPS will give information related to instruction on boiler operation techniques as a reference material to INE and other relevant authorities who are to undertake lectures and practice parts of the course.

2) SE, IMP, PEMEX, CFE, IIE

These authorities are in charge of activities related to supplying fuel and energy, with SE making the basic policy. As for IMP and IIE, research and development of combustion techniques are considered to be a part of their regular activities, and they have a certain number of experts in this field either as employees or on cooperational status. Furthermore, IMP will own the test plant constructed in this Study in its laboratory in Pachuca, and has several staff members who have been involved in the practice of test combustion in this plant. In this connection, these authorities are expected to provide the combustion facility, fuels and other materials for the practice part of the training course, and also are expected to give lectures on low-NOx combustion techniques.

3) CONAE

CONAE has a series of educational programs for energy saving in manufacturing, including training courses on energy saving in combustion equipment operation. The number of trainees that participated in the CONAE's courses exceeds1,100. Lecturers and trainers of the courses at first were foreign experts dispatched by the governments of the European Union since 1990. However, they have subsequently been replaced by Mexican staffs. The Mexican lecturers or trainers do not usually belong to CONAE but to universities or consulting firms. These qualified persons have advanced experience in training of subjects closely related to low-NOx combustion techniques, and their experience is considered to be helpful for the planned training program of INE in both lectures and practice.

4) SINALP

SINALP is an organization having the character of a combination of the government and private sector. Its purpose is to enable persons who wish their processed goods to be improved and their quality to be verified to use a reliable laboratory capable of providing necessary services. This is aimed at promotion of international business transactions, effective utilization of available resources, and promotion of domestic industries.

The national system of certifying test laboratories was established on the basis of the nationally unified judgement criteria and work methods. Functionally, this system is operated by General Directorate of Standard as supervising body, Evaluation Committee for applicant laboratories, and Licensed Laboratories. The licensed laboratories are the

only organs which are allowed to give measurement services to determine the quantity or the state of substances for which measurement methods are prescribed in the Mexican Official Norm 093.

The licensed laboratories are expected to send instructors for exhaust gas measurements in the training course. In most cases of boiler operation, the measurement of exhaust gas composition is entrusted to those qualified laboratories in order to authorize the results in relation to the emission regulation. This means that boiler operators would have the opportunity to contact these experts as one aspect of combustion plant management, and are requested to give necessary information on the operational condition to the experts in order to secure appropriate measurements. Therefore, it is desirable for operators to know the outline of inspection so that they can understand the necessity and effect of combustion control.

(3) Form of Training

The training course is composed of lectures and practice. Participants are selected from candidate enterprises which are expected to employ advanced management techniques of boiler operation in view of low-NOx combustion. Relevant authorities are expected to support the program with the roles shown in Figure 6.1.1. Participation in the training course may be on the voluntary basis, respecting the initiative of enterprises. This is because that industrial enterprises seem generally positive towards the reduction of pollutant emissions. There are some enterprises already planning introduction of control measures as preparation for the enactment of the new emission standards. The active participation of the enterprises in the technology transfer seminar held in July and August in 1995 as the initial stage is considered to reflect such stance of the industrial sector.

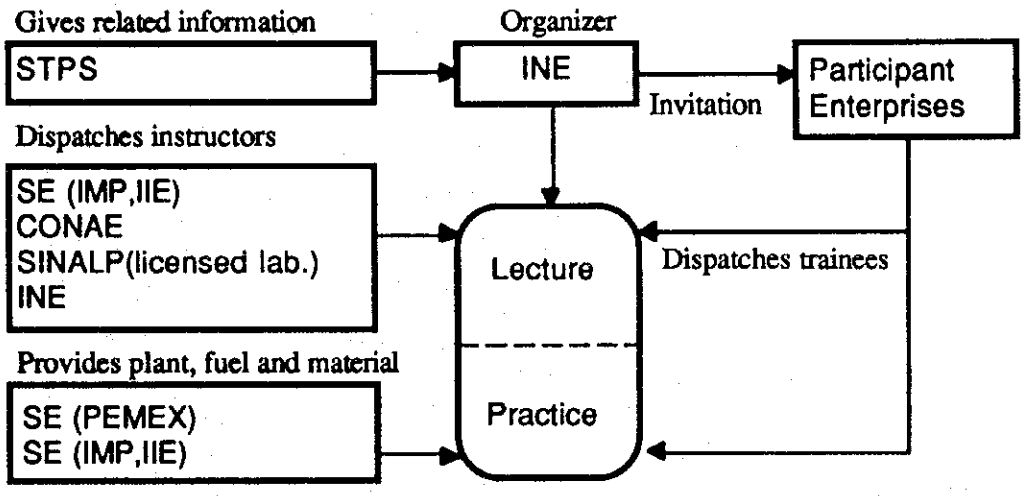


Figure 6.1.1 Organization for Implementation of Capacity Development Course

The steps of the implementation are tentatively proposed to be as follows:

1) INE prepares a list of candidate enterprises with the order of their participation in the course.
2) INE issues invitations to participate in the course.
3) INE organizes a team of instructors from the relevant authorities and gives the lectures for the participants.
4) IMP prepares the test plant, fuels and materials including a text for the practice in cooperation with PEMEX and IIE.
5) INE organizes a team of instructors from the relevant authorities and conduct the practices for the participants.

The course entails various costs for both trainers and trainees. On the trainer's side, manpower cost, operation and maintenance cost of the plant and other costs will be incurred. On the other hand, manpower cost and travel costs will be incurred on the trainee's side. The trainer costs are supposedly borne by the trainee side as a beneficiary of acquiring the ability to comply with the emission standards.

## 6.2 Reinforcement of Institutional Aspects for NOx Control

### 6.2.1 Assistance to Enterprises for Introduction of Low-NOx Combustion Technique

(1) General Aspects of Assistance Scheme in Pollution Control Policy

Institutional assistance is commonly provided to facilitate the implementation of compulsory environmental regulations. The cost incurred by such assistance is basically justified by the benefit of earlier achievement of the objective of the regulation. Of the total amount of NOx emission in ZMCM, stationary sources account for one-fourth at most, and the rest is from the transport sector. This means that the transport sector should be given emphasis in the allocation of administrative resources including application of the assistance policy from the viewpoint of administrative efficiency.

Out of the NOx emission from stationary sources, boilers account for approximately 60% and glass processing furnaces 25%; these two types of combustion facilities acount for the major part of the total NOx emission from stationary sources. As for glass processing furnaces, NOx emission control has been practiced since December 1994, and the target will be attained mainly by innovation of processes line : there is very little room to apply low-NOx combustion technique effectively due to the requirement of a too-high temperature in the furnace.

On the other hand, boilers have much room for improvement of combustion technique regarding NOx reduction. Particularly, most of the NOx emission from boilers is emitted

from those owned by large-to-medium size enterprises, so that these boilers are considered to be an important object of NOx reduction. The effect of low-NOx combustion techniques to be introduced to larger boilers may not be as large as that expected to be realized in the transport sector. However, low-NOx combustion techniques for larger boilers will still contribute much for specific locations in the vicinity of large stationary sources.

(2) Nature of Assistance Scheme

The assistance scheme to be provided by the government should have two major aspects; financial and technical. Necessary components of the both aspects are shown in Figure 6.2.1 and the following sections (3) and (4).

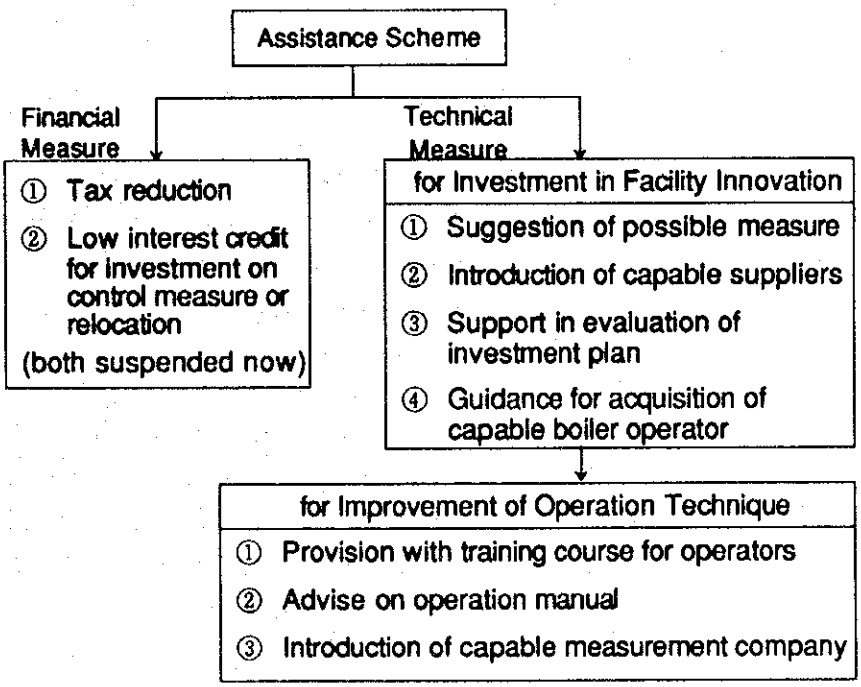


Figure 6.2.1 Possible Components of Assistance Scheme Provided by the Government

Low-NOx combustion techniques for boilers have not been disseminated enough yet in Mexico because these techniques require broad knowledge of facilities and experience in operation for adoption. Therefore the priority in assistance for introduction of low-NOx combustion techniques will be to supply technical information about low-NOx combustion facilities and to provide opportunities for training in operation of said facilities.

The other assistance schemes such as tax reduction or low interest credit for investment in pollution control measures or relocation of specific kinds of industries from ZMCM have been abolished or suspended. These stimulative measures are still considered to have positive effects on the promotion of emission control and are expected to be adopted again when the financial condition of the Federal Government is improved as a result of the expected economic recovery.

Assistance measures for introduction of low-NOx combustion techniques are proposed to be applied in the investment stage and the operation stage as described below.

(3) Assistance for Investment in Facility Innovation

In case a private enterprise does not have sufficient information to carry out investment for facility innovation in view of NOx reduction, it is helpful to have access to consultancy services. The services should cover at least the following:

1) Guide to tax reduction or low interest credit (suspended now)
2) Suggestion of possible methods of innovation
3) Introducing capable suppliers
4) Support in evaluation of investment plan
5) Guide to the course of operator training or introducing capable operators unemployed

The services are, due to their nature, suitable to be undertaken by a voluntary association organized by private industries according to type of industry. Government organizations are not able to take part directly in most consultancy services. However, they are able to support the association in selection of personnel in charge of consultation for member enterprises or by providing a subsidy for the manpower cost of the services.

One consulting body is considered to be enough for consultancy services if it has some experts who are able to respond to the most of requests presented by the members. The consulting body will then be organized as trans-association of sectoral association of industries such as, National Association of Chemical Industries, National Chamber of Cellulose and Paper Industries, National Chamber of Rubber Industries and so on.

(4) Assistance for Operation Technique (Training, Operation Manual, Measurement)

1) Provision of the training course for operators

A training course for operation staff, as proposed in the previous section, introduces some standard operation methods of low-NOx combustion in a typical plant. However, participant enterprises have various types and sizes of boilers different from that used in the course. Therefore, it is necessary for participants to devise a practical method of application of the knowledge they acquire to their plants and to prepare their own operation manual exclusively for to their plants. Giving appropriate advice for application of the techniques to individual participant enterprise will be also a function of the course.

2) Advise on Preparation of operation manuals

Application of the techniques introduced in the training course to the actual plant will inevitably require their modification. In case participants need technical assistance in preparation of the modified operation manuals, the above-mentioned consulting body would respond to the need. In addition, the operation manual should be registered to INE so that INE is able to confirm the use of advanced facilities which have been technically examined by the consulting body.

3) Introduction of capable measurement companies

Measurement of exhaust gas composition and other control parameters of combustion should be conducted, in principle, by the plant owners to adjust combustion state in a timely manner. However, the measurement except oxygen content can be entrusted to external measurement companies for the moment because the practical measuring ability of many of boiler owners is not sufficient at present. Measurement companies for flue gas are obliged to be qualified by both SINALP and INE under present legislation. Therefore, INE or SINALP can introduce qualified measurement companies to enterprises who intend to entrust the measurement work. Upgrading of their reliability is proposed as described in the following section.

(5) Financial Resources of Assistance and Executing Body

Financial resources are required to implement the above-mentioned assistance schemes. The costs are proposed to be shared by government organizations, the inter-industrial association and recipients of the assistance. The principal bearers of expenses for each scheme are suggested as shown in the following Table 6.2.1.

Table 6.2.1 Suggested Bearers of Assistance Scheme's Expense

| Scheme | Activity | Government Organization | Inter-industrial Association | Recipient Firm |
|---|---|---|---|---|
| Consultation in Investment or Operation Manual | hire and dipatch experts | √ | | |
| | provide office function | | √ | |
| | hire and dipatch clerks | | √ | |
| | bear office costs | | √ | |
| Operator Training Course | equipment investment | √ | | |
| | execution cost | | | √ |
| Measurement Company | introduction | √ | | |

Experts for consultation services should be selected and their remuneration should be borne by the government organization in order to assure the experts perform their duty impartially. Possible sources of experts are considered to be governmental research institutes or technical colleges or boiler suppliers. Other staff and an office are to be provided by the recipient side, particularly by the inter-industrial association which is closely related to boiler usage, on the basis of the polluter-pays principle. Equipment investment for the operator training course has been already made mainly by IMP as a part of the current study. However, it is natural that the execution cost of the course be borne by the participant enterprises on the same principle as the provision of staff and office. An appropriate course fee can be determined based on the actual cost for preparation and execution such as remuneration, power and material, and other expenses for coordination.

### 6.2.2 Establishment of Autonomous Monitoring Organization Within Enterprises

#### (1) Necessity of Autonomous Monitoring on Flue Gas Composition

It is necessary for boiler owners to know the actual state of exhaust gas quality not only to maintain the sound operation but also to report to INE periodical operation records on designated items of the emission regulation. Control parameters of combustion such as fuel flow, feedwater flow, and temperature, flow volume and oxygen content of the exhaust gas should be measured by the operators themselves as a part of daily operational procedure. These parameters are so vital for safe and effective operation that measuring devices should be installed.

Acquisition of measuring devices and measurement techniques is required of boiler owners because measurement is the starting point of any kind of control. But, it can not be helped at present that most enterprises, except those having well-equipped boiler units such as power plants, entrust the measurement to other companies. Therefore, the establishment of an autonomous monitoring organization is the subject to be realized in the long term. The investment cost of the measuring devices may be recovered by the economic effect of efficient fuel use. Therefore, it is not generally considered to be the object of the assistance of the Government.

#### (2) Required Function of Autonomous Monitoring Organization

The autonomous monitoring organization (see Figure 6.2.1 as an example) is expected to examine the exhaust gas composition as to whether or not it complies with the emission standards. The results of the monitoring are applied to adjust the operational condition or, if necessary, to modify the combustion equipment. The results also supply basic data to the official report obliged to be submitted to INE periodically.

To place a priority on the compliance with the emission standards, the chief of the monitoring organization must have enough power to direct the operation toward this purpose. Generally speaking, the most powerful person of the production line is the head of the factory who represents the factory on behalf of the owners of the enterprise. Therefore, the head of a factory is the most suitable person as the chief of the autonomous monitoring organization.

Practical work of the monitoring requires experts qualified in both measuring exhaust gas composition and arranging pollution control measures. These experts can be called "pollution control engineers" and are expected to cover all the aspects of pollution control in the factory. Moreover, an authoritative licensing system for pollution control engineers is necessary to those plant owners who operate air polluting equipment designated by the norm of the pollution regulation.

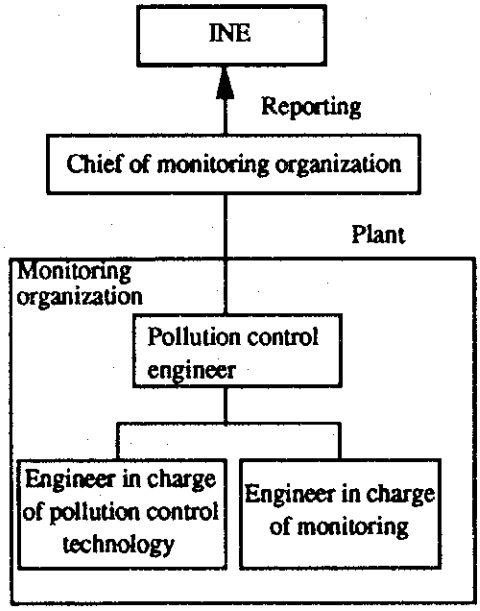


Figure 6.2.2 Autonomous Monitoring System in Enterprises

The duty of the experts who form an autonomous monitoring organization is considered as shown below:

1) Duty of Chief of Monitoring Organization

He takes measures to execute air pollution control surely and smoothly, and also inspects the practice of the execution. He undertakes the following three items as his duty by ordering pollution control engineers to execute these items, and takes necessary financial measures for execution of the duty.

a. Monitoring the usage of air pollutive equipment and the matters related to the operation method and maintenance of the smoke disposal equipment.

b. Matters related to the measurement of smoke volume emitted from air polluting equipment and the recording of measurement results.

c. Matters related to the measure in case of accident with air pollutive equipment and the measure against emergency.

2) Duty of Pollution Control Engineer

He undertakes the practice of pollution control in specified technical matters under the direction of the chief of monitoring organization. He has the following seven items as his duty:

a. Examination of fuel and raw material used

b. Checking of air polluting equipment

c. Operation, checking and maintenance of smoke disposal equipment

d. Measurement and recording of measurement results on volume and concentration of smoke

e. Checking and maintenance of measuring equipment

f. Practice of expeditious measures in case of accident

g. Practice of necessary measures such as reduction of smoke volume or smoke concentration, and restriction of use of air polluting equipment in case of emergency

It is INE who administrates the autonomous monitoring organization of private companies. However, the burden of administration will be heavy for INE as the number of organizations to be controlled grows in proportion to the dissemination of this system. Therefore, it is rational to transfer the competence of administration of the autonomous monitoring organization to the local authority. In that case, the duty of the local authority in charge is considered to consist of the following three items:

a. Oblige owners of designated air polluting equipment to register the chief of the monitoring organization and the pollution control engineer, and receive the application for registration.

b. Order the dismissal of the above-mentioned responsible persons in case they violate the regulations on air pollution control.

c. Oblige enterprises who operate the designated air polluting equipment to report the situation of the above-mentioned responsible persons' activities, and make on-the-spot inspections if necessary.

(3) Experience of Japan

In order to develop a system for the prevention of environmental pollution in factories, the Law for the Establishment of Organizations for Pollution Control in Specified Factories was enacted in Japan in June 1971. Specified factories by this law were obliged to assign licensed pollution control engineers. A total of about 20,000 specified factories had registered to the government about 40,000 licensed pollution control engineers as the chief of autonomous monitoring organizations as of March, 1993.

Besides registered pollution control engineers, about 430,000 persons have been licensed and engaged in pollution control as members of the autonomous monitoring organization belonging to the factories. Licensed pollution control engineers are basically required to pass an examination held by the Ministry of International Trade and Industry.

The entire expertise of pollution control engineer prescribed by the Law covers air pollution, water pollution, noise and vibration. The examination for the applicants to the category of air pollution covers four major test items as shown below:

1) Legislation of pollution control
2) Theory of air pollution
3) Techniques of emission control
4) Measurement of flue gas

The license is also awarded to the graduates of the training course held by a governmental education organization specially designated by the Ministry of International Trade and Industry.

Owing to the efforts of industrial sectors, no lawsuit against the violation of the Law for Prevention of Air Pollution has been brought in the part several years while about 3,000 cases of lawsuits related to public nuisance or other kind of environmental pollution are brought every year.

6.2.3 Establishment of Reliable Measurement Services for Stationary Sources

(1) Necessity of Reliable Measurement Services for Stationary Sources

The autonomous monitoring organization, discussed in the preceding section, is expected to be established at each plant where it is required, but it will take a certain time for

dissemination and furthermore difficulty should be anticipated in introducing this organization to all the enterprises including small sized factories. Therefore, adoption of the practice of commissioning measurement of exhaust gas will be a practical way to compensate for the absence of the essential function of the autonomous monitoring organization.

Legal monitoring of NOx emissions from major stationary sources is conducted by PROFEPA at present by means of examination of the reports submitted to INE and inspection visits to individual enterprises. The inspection activities of PROFEPA deal with not only air pollutant emissions, but pollutant discharges into public waters and the management of hazardous wastes and materials. Therefore, it seems difficult for PROFEPA to know precisely the actual state of air pollutant emissions in a short inspection time unless there are visible smoke or other explicit signs of pollution. And the inspection visits can be made only intermittently. Therefore, the judgments are made based on an occasional situation observed on the day of the inspection visit.

These limitations of PROFEPA's monitoring suggest the choice between two alternatives for improvement of the monitoring capacity: the capacity of PROFEPA's monitoring team to be expanded enough to cover all the targets of emission control, or the demand of accurate monitoring exceeding the capacity of PROFEPA to be fulfilled by other means. The former alternative is contrary to the concept of transfer of the responsibility now assumed by PROFEPA to local authorities that is now being discussed as part of structural reform of Mexican Government. Then the latter alternative is the matter to be studied in this section.

For proper functioning of the official inspection system, it is necessary that individual enterprises know their own state of NOx emission continuously. The self monitoring can be classified into two cases: one is done by the enterprise's own human and substantial resources, which is suitable at larger enterprises, and the other is done by external professional persons at the enterprise's expense, which is suitable for medium-to-small enterprises. If capable measurement companies are available at reasonable cost, it will be economical for plant owners. These measurement companies are expected to provide the following two services:

1) Prepare periodical monitor reports as required for the official inspection
2) Give information for daily operation management

To perform these functions, measurement companies must have a satisfactory qualities verified by the competent authority. In this respect, the level of measurement services cannot be said to be satisfactory at present. A reliable measurement service system should be established by developing indispensable system components as described in Figure 6.2.3 and in the following sections (2), (3) and (4).

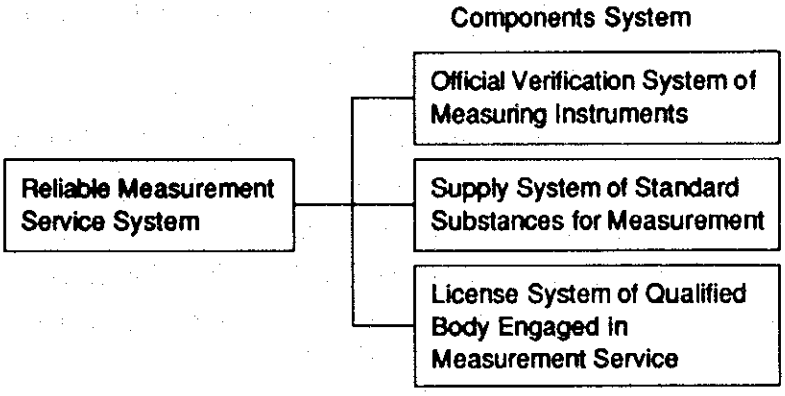


Figure 6.2.3 Proposed Components of Reliable Measurement Service System

(2) Official Verification System of Measuring Instruments

Reliable measurement requires reliable measuring instruments. Reliable measuring instruments can be defined as instruments that are verified for accuracy by an authorized official organization.

The emission standards prescribe the methods to determine the concentration of the regulated substances. However, requirements for measuring devices are not explicitly stated. Namely, though acceptable methods of measurement are designated for each regulated pollutant and factor indicating the state of exhaust gas, no further definitions of devices utilized in the methods are given explicitly. Allowable deviation of indication from the true value, legally effective method of calibration and its authorized execution body are fundamental issues to secure the reliability of the measurement. The authorizations of these basic items are indispensable elements of the reliability of measurement services. The official verification system is established through determining the following components:

1) Responsible authority and its local branches
2) Designated measuring equipment to be verified
3) Verification method and permissible deviation
4) Effective duration of the verification and indication of the verified status
5) Restriction of usage of unverified instruments in business activities prescribed by related legislation

The responsible authority for the verification of measuring instruments is expected either to execute the verification by itself or to supervise the same action entrusted to local branches. The expected function requests the authority to have a capability of calibration of measuring instruments and supplementary apparatus. According to the Law on Metrology and Normalization, the National Metrology Center (CENAM) under SECOFI is designated as the primary laboratory of the national calibration system. In connection with the competence of

CENAM, the aforesaid five components are basically prescribed in the law, but they are still conceptual and need more concrete stipulation.

Actually, the competence on this system has been transferred to the Procraduría Federal de Consumidor (PROFECO) under SECOFI. As the first step of this system formulation, the list of designated measuring equipment to be verified is now being investigated under the initiative of PROFECO, and the result is expected to be announced partly in the summer, 1995, as the earliest. The other part of the system formulation will subsequently be put in order.

(3) System of Supplying Standard Substances for Measurement

One of the essential elements to secure the reliability of measurement is traceability which is defined as "a nature that a result of measurement, in general, has the comparability through a chain in sequence to a proper standard, international or national", a basic term of international transaction over measurement. The traceability can be realized by establishment of the supply system for measurement standard throughout the country (see Figure 6.2.4). A supply system of measurement standard, in general, consists of the prototypes of weights and measures, the verification system of instruments and the supply system of standard substances. The system of the prototypes of weights and measures has been already established in Mexico, and establishment of the verification system is discussed in the previous section. Then, it is the supply system of standard substances that is the point of discussion here.

The standard substances are the special substances which are given a specific value indicating the amount related to the state of the substance, and are used for the clarification of the error of a measuring instruments with the indication acquired by measuring it. Important standard substances for the measurement of exhaust gas are standard gases, pH standard solutions and other standard solutions.

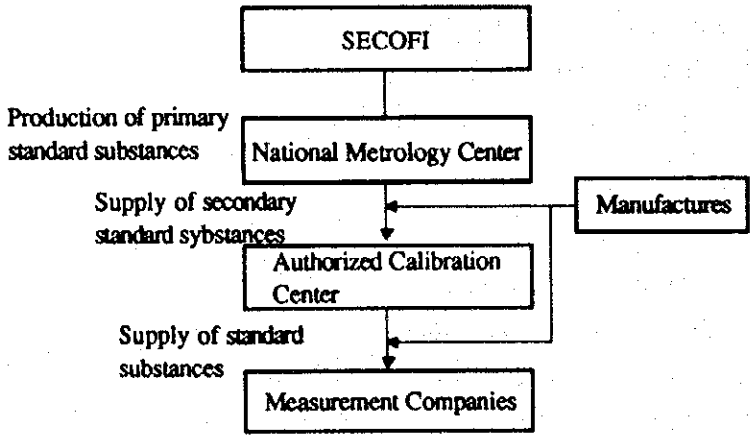


Figure 6.2.4 Proposed Supply System of Standard Substances for Measurement

If all the standard substances are supplied by the national supreme calibration organization (the National Metrology Center : CENAM), it is the surest way to secure the traceability. But, it is usually impossible for one institute to meet all demands for standard substances. Therefore, the function of the national supreme calibration organization should be partly transferred to another subordinate organization for valuation of standard substances without sacrificing accuracy and reliability; the subordinate organization can be called as the authorized calibration center.

Standard substances are classified into the primary standards and the secondary standards. The primary standards are valuated by the national supreme calibration organization and are used to valuate the secondary standards. The secondary standards are used to valuate standard substances from manufacturers at the authorized calibration center. To secure the traceability in respect of supply of standard substances, it is necessary that products of standard substances are obliged to undergo verification by authoritative organizations. This hierarchical structure of authoritative calibration organizations is thought to be the basis of building the traceability of the measurement in the country.

The practical executing body to build and manage the standard substances supply system is the Directorate of Material of CENAM, which was just established in April 29, 1994 in Querétaro. The hierarchical chain of authorized calibration what CENAM intends to build is the same as is shown in Figure 6.2.4. According to the concept of CENAM, "Authorized Calibration Center" is ranked as the Secondary Laboratory subordinate to CENAM, and the function is undertaken by the National Calibration System (SNC). And "Measurement Company" is composed of the Test Laboratories and the Verification Units.

As for the standard substances for atmospheric environmental analysis, imported standard substances verified by NIST of the United States have been utilized as the primary standard. These primary standards are used for the verification of exhaust gas analyzers installed in the vehicle inspection centers all over the country. Because CENAM can not supply secondary standards for gas analysis yet, the products of Linde are instead recommended to be used, relying on the valuation by the company for the moment. But, CENAM intends to start supplying the secondary standards for gas analysis in 1996, and to start producing the primary standards by itself in 1998.

(4) License System for Companies and Persons Engaged in Measurement Service

The Law on Metrology and Normalization prescribes two kinds of authorized bodies that conduct accurate and impartial measurement for other persons. One is the Licensed Laboratory (Laboratorio de Pruebas) and the other is the verification unit (Unidad de Verificación). These organizations are accredited by SECOFI under the condition that the applicant to the accreditation has enough ability to undertake the duty of the test laboratory

and the verification unit. The required condition for the accreditation consists of infrastructure for the operations, internal organization for execution and qualified personnel.

Designated duty of these accredited bodies is to give services to industrial enterprises in evaluating their processes, products, services and production lines in connection with the national normalization program. These prescribed services are considered to include the examination of the exhaust gas composition to check compliance with the emission standards.

The two kinds of accredited bodies by SECOFI have a potential to play the role of measuring companies for inspection. However, the accreditation by SECOFI and the registration by INE for the inspection of exhaust gas in actuality are not linked to each other at present. The regulation on pollutant emission instructs that the measurement of exhaust gas for the official inspection should be conducted according to the relevant Mexican official standards for measurement. The status of organizations who conduct the measurement is not specified by the regulation, so that the practical registration of the qualified measurement companies for exhaust gas is executed by INE independently from the accreditation system of SECOFI.

The number of accredited bodies as the test laboratories or verification units in the field of environment is still small and not enough to meet the demand of measurement under the jurisdiction of INE. Therefore, it is proposed to increase the number of accredited bodies in the fields related to INE and to have the registration system of INE for measurement company linked to the accredited system of SECOFI.

Another proposal for the licensing system of measurement companies is to create a special qualification system for the chief engineer who is responsible for the measurement activities in their technical aspects. The required skill and knowledge of the chief measurement engineer are:

1) Knowledge of the General Law for Ecological Balance and Environmental Protection in the field of prevention and control of atmospheric contamination and its derivative regulations
2) Knowledge of the Federal Law on Metrology and Normalization and its derivative regulations
3) Knowledge and practical experience of quantitative analysis of air pollutants
4) Knowledge of the calibration system and the theory of error

It is proposed that every company which intends to undertake the measurement services be obliged to assign the licensed engineer with aforesaid ability as the chief of the measurement group. The authority responsible for the licensing system should prepare the general rules, conduct the examination and award the license of the chief measurement engineer. In view of

the expected function, SINALP is considered to be suitable for the responsible body of the new licensing system at present among governmental organizations.

The proposed licensing system is shown in Figure 6.2.5.

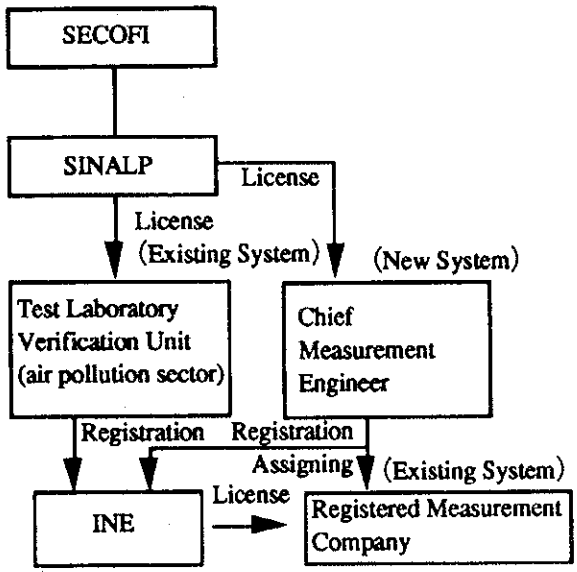


Figure 6.2.5 Proposed System for Licensing Measurement Service Companies and Individuals

# CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

# Chapter 7 Conclusions and Recommendations

## 7.1 Combustion Technology

Based on the results of the combustion test, investigation of the stationary sources in ZMCM, and the existing knowledge, the following are recommended for improving the current situation of air pollutant emissions and energy consumption in the stationary sources in ZMCM.

(1) Appropriate air ratio

The majority of combustion facilities in ZMCM are operated with an excessive amount of combustion air. The air ratio should be kept at an appropriate level in order to reduce the amount of NOx emission and promote fuel saving.

(2) Boilers burning diesel oil

For boilers burning diesel oil, it is considered that no particular NOx reduction measures are necessary to meet the new standards for NOx emission applicable from 1998 if the boilers are operated in the proper manner. However, improvements of combustion techniques are still desirable in view of reducing the total emission of NOx and saving fuel consumption. Introduction of self-recirculation type low-NOx burners and exhaust gas recirculation (EGR) is desirable.

(3) Boilers burning gas oil

For boilers burning gas oil using normal burners, it was found that the exhaust gas NOx concentration might exceed the new NOx emission standards depending on operational conditions.

For relatively large boilers, introduction of low-NOx burners and EGR is most desirable. Although required investments for these measures would be relatively large, reliable effects are expected since operational difficulties in these measures are small.

For relatively small boilers in small-to-medium enterprises, recommended measures are: 1) introduction of steam atomization of fuel instead of air atomization, 2) remodeling of existing burners into the type of self-recirculation of exhaust gas, and 3) combustion with low air ratio (this is common to all kinds of boilers). These measures bring about considerable effects and do not require large amount of investment. However, adaptation of additional components to existing boilers should be done with due cares.

(4) Boilers burning natural gas

There are no particular problems for boilers burning natural gas to meet the new emission standards. However, in view of reducing the total emission of NOx in ZMCM, it is desirable to make efforts at all air pollution sources. It is recommended to employ self-recirculation type low-NOx burners and EGR, since recirculation of exhaust gas is most effective in reducing NOx emission for fuels of low nitrogen content such as natural gas.

(5) Energy saving

Promotion of energy saving brings about not only economic effects but also reduction of pollutant emissions when appropriate measures are taken. Among them, combustion with low excess air is the fundamental step. In addition, promotion of various measures for recovering heat from exhaust gas and blow water, prevention of heat loss from heat transfer surfaces, and minimization of radiation heat loss is recommended.

(6) Control devices for combustion and safety

Installation of measuring and control devices for boiler combustion operation and safety assurance is found to be insufficient in ZMCM. The situation is similar to that in 1990 - 1991 when the previous JICA study was conducted. Promotion of installing such devices is strongly recommended, since they are basic tools for the proper operation.

(7) Particular industrial furnaces

Other than boilers, glass melting furnaces and rotary cement kilns are also significant stationary air pollution sources in ZMCM. The NOx concentrations of exhaust gases from these furnaces are very high since they are operated at high temperature. For these industries, new technologies for reduction of pollutant emissions are available, and promotion of employing these technologies are recommended.

## 7.2 Supporting Measures for Implementation

For dissemination of combustion technologies recommended above, appropriate institutional supports are necessary. The following are recommended as supportive measures for implementation of physical measures.

(1) Capacity development of operators

Development of capacity of personnel engaged in operation of combustion facilities is necessary to apply the recommended technologies. For this purpose, a training program consisting of lectures and practices should be developed and implemented through the cooperation of governmental and private organizations concerned. The combustion test plant installed for the present Study could be effectively utilized in the training program.

(2) Measures to support investment and operation

Supportive measures for enterprises are necessary for improvement of combustion facilities and their operation in both the stages of facility investment and facility operation.

The following are recommended for the investment stage:

- tax reduction or low interest credit
- consultation on possible methods of facility improvement
- introducing capable suppliers
- support of evaluating investment plans
- guide to operator training programs or introducing capable operators

The following are recommended for the stage of facility operation:

- implementation of the training program
- advice on preparation of operation manuals
- introducing capable companies for exhaust gas measurement

(3) Autonomous monitoring organization in enterprises

Establishment of a self-monitoring organization is recommended in each enterprise having pollutant emitting facilities subjected to the government emission regulation. This organization conducts measurements of pollutant concentrations of exhaust gas as well as other parameters necessary for operation of the facilities, and plans necessary improvements for them. Since smaller enterprises have difficulties in conducting the

exhaust gas measurements, the measurements can be entrusted to the professional companies of a satisfactory quality certified by the authority, except for the parameters necessary for the daily operation.

(4) Establishment of reliable measurement services

As stated above, reliable measurement companies must be made available for many enterprises. The current situation of such services is considered to be not totally satisfactory. The current legal system for the measurement of pollution related parameters should be strengthened in terms of the following components:

- certification system of measurement companies and individuals
- certification system of measuring equipment
- certification system of standard substances for measurements

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