No. 1

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR PROVIDING THE EQUIPMENT

FOR

LAHORE LABORATORIES

PAKISTAN COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

IN

THE ISLAMIC REPUBLIC OF PAKISTAN

DECEMBER 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Government of Japan has decided to conduct a Basic Design Study on the Project for Providing the Equipment for Lahore Laboratories, Pakistan Council of Scientific and Industrial Research and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Pakistan a survey team headed by Dr. Minori Sano, Senior Assistant to the Managing Director of Grant Aid Planning and Survey Department, JICA, from August 18 to September 4, 1989.

The team exchanged views with the officials concerned of the Government of Pakistan and conducted a field survey in Lahore. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss the draft report and the present report has been prepared.

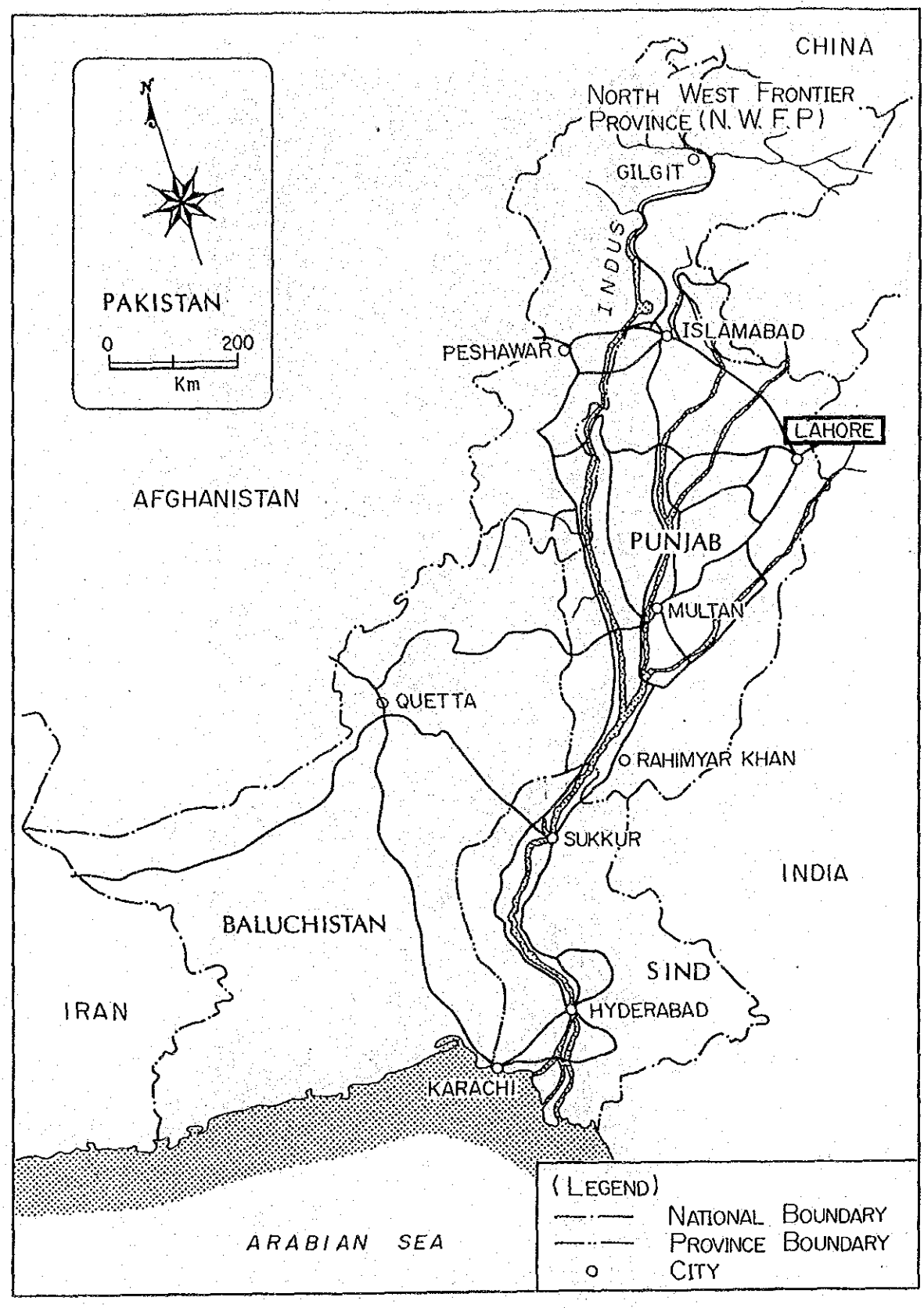
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

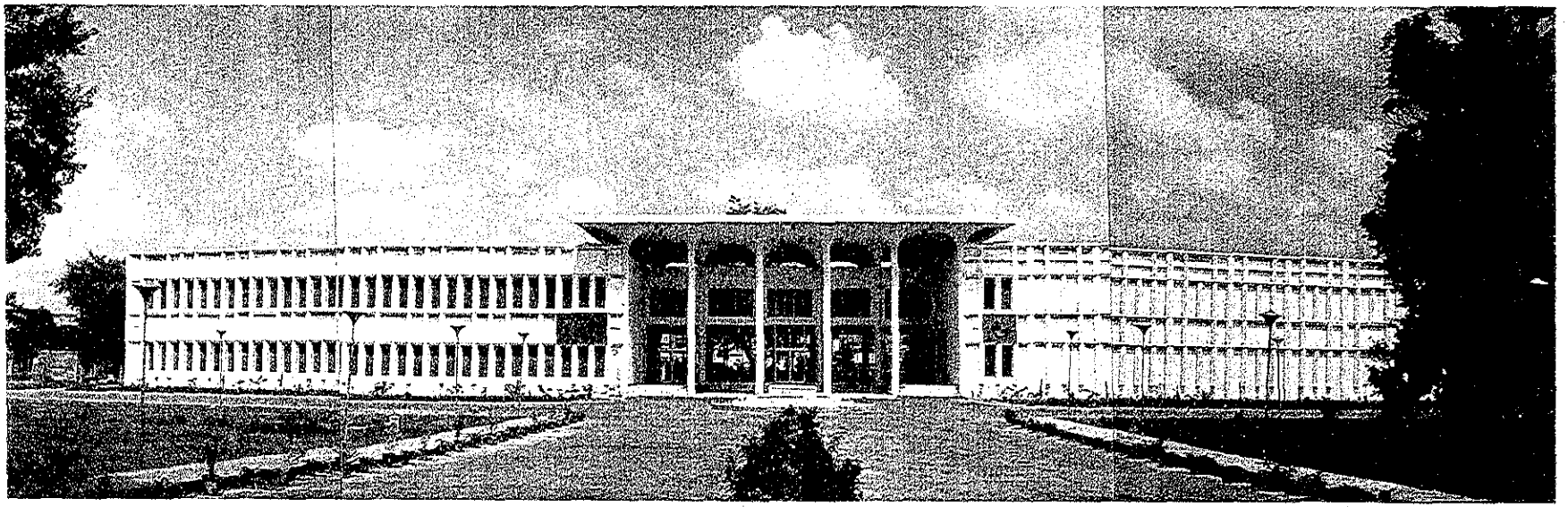
December 1989

Kensuke Yanagiya

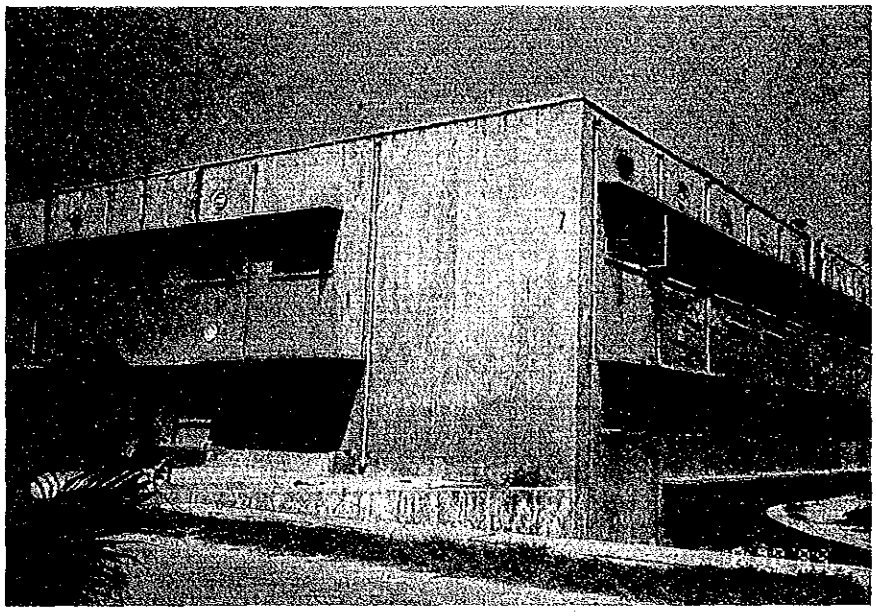
Kensuke Yanagiya
President
Japan International Cooperation Agency



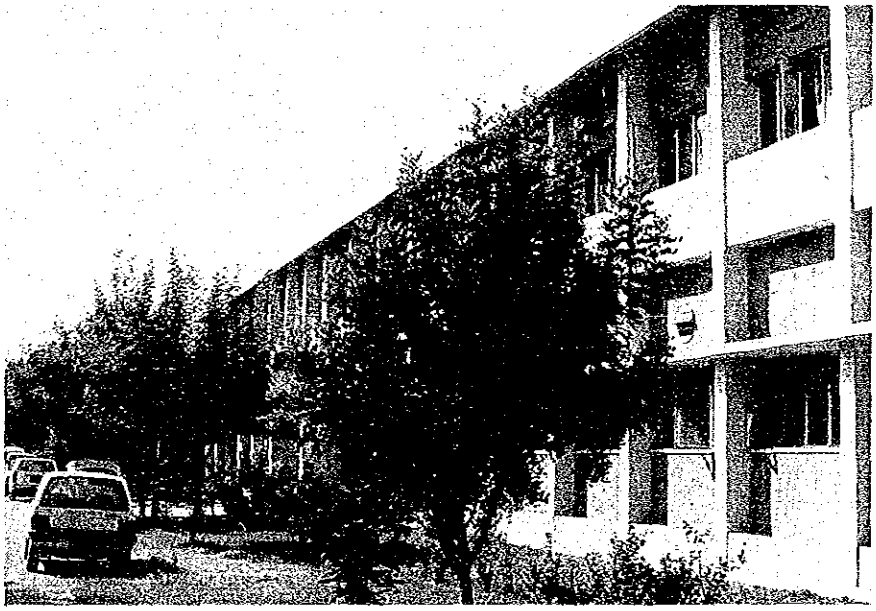
Lahore Project Site in Pakistan



PCSIR LAHORE LABORATORIES

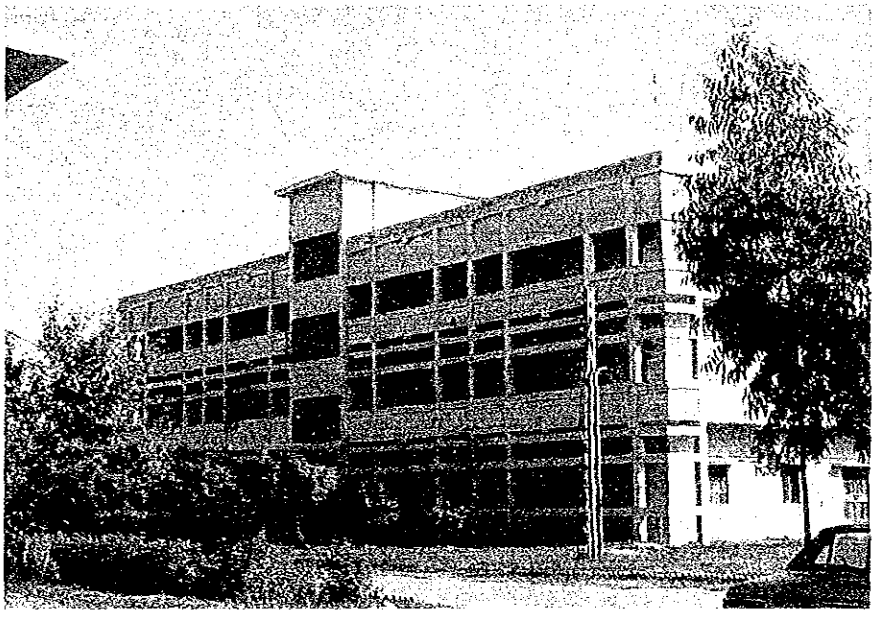


Food Technology and Fermentation Division



Applied Chemistry Division

Minerals and Metallurgy Division



Glass and Ceramics Division

SUMMARY

SUMMARY

The economic structure of the Islamic Republic of Pakistan is characterized by the predominant position of agriculture in activities of industry, employment, trade and distribution, where the economy greatly depends on the movement of yearly agricultural production. The large amount of trade are the export of agricultural products and the import of petroleum and industrial products, which, in turn, makes the economy of Pakistan very unstable.

The Government of Pakistan places emphasis upon the modernization and development of the mining and manufacturing industries to reform the country's economic structure. It is important for the country to promote the mining and manufacturing industries by making good use of its resources and to improve the balance of foreign currencies by domestically manufacturing industrial goods as substitutes for imports and more positively, manufacturing various products for exports. As a priority policy in this direction, the Government considers it vitally important to improve the scientific and technological level of Pakistan by increasing the number of well-trained researchers. The Government has intensified the policy of strengthening of the facilities of research field to improve the quality of research activities of the country.

Pakistan Council of Scientific and Industrial Research (PCSIR) was established in 1953 with aims to research and develop industrial technology especially for the industrialization with utilization of domestic mineral resources, agricultural products and other materials and to support and guide local industries technically. PCSIR, which now has eight laboratories and one training center with a staff totaling about 3,000 including 900 researchers, is the largest research and development institute in Pakistan. Lahore Laboratories as well as Karachi Laboratories are the oldest and the largest in scale among eight laboratories of PCSIR and are in the position to meet the national needs for research and development of science and technology of Pakistan.

In conformity to the objectives of PCSIR, Lahore Laboratories has been placing emphasis on the promotion of local industries and conducting research and development in response to regional industrial activities, covering researches for food industries, development of dyes and pigments for textile industries, technical research

for glass and ceramics industries, development of plant-based chemicals and improvement in ore beneficiation process for mineral resources. However, the research equipment in the Laboratories has become obsolete, making it difficult to pursue the diversified, specialized and advanced researches appropriate to the Laboratories. The present conditions of the Laboratories are not only lacking of introducing necessary new research equipment, but also far behind in the renewal program of the existing equipment, thus achievements of research work have not progressed as expected.

In view of such a background, the Government of Pakistan has requested the Government of Japan for a grant aid for provision of research equipment to the Lahore Laboratories. In response to the request, the Japanese Government decided to conduct a basic design study on the Project for Providing the Equipment for Lahore Laboratories, PCSIR (the Project) and sent a study team headed by Dr. Minori Sano, Senior Assistant to the Managing Director of Grant Aid Planning and Survey Department, Japan International Cooperation Agency (JICA), to Pakistan from August 18 to September 4, 1989. The study team has a series of discussions with the officials concerned in Pakistan and made field investigations at Lahore Laboratories to acquire information and data on the current research and development activities in Lahore Laboratories, the organization to carry out the Project, appropriateness of the Project as Japanese grant aid cooperation program and others, and verified demarcation of undertakings in the Project. After returning to Japan, the study team examined and evaluated the Project to select adequate equipment, estimate the project cost and develop a schedule for carrying out the project. The draft final report was thus prepared and its contents were explained by the study team dispatched to Pakistan from October 22 to November 1, 1989.

The original request by the Government of Pakistan was to provide 232 items of research equipment for 4 divisions (Food Technology and Fermentation, Applied Chemistry, Minerals and Metallurgy, and Glass and Ceramics) of the PCSIR Lahore Laboratories with the addition of the newly requested 133 items.

The request was evaluated in terms of research themes and adequate conformity of equipment to research program, technical level, maintenance system and other factors. The basic design study finally selected 152 items as necessary and adequate equipment as shown in the following table.

Number of Equipment by Division

Division	No. of Items	Major Equipment
Food Technology and Fermentation	62	Fermentators, Incubators, Water Baths, Rotary Type "KOJI" making Equipment, Amino Acid Analyzer, Fruit Hardness Testers, Spray Dryers, etc.
Applied Chemistry	59	GC-Mass Spectrometer, FT-NMR Spectrometer, Liquid Phase Chemical Reactors, FT-Infrared Spectrophotometer, Solvent Distillation Apparatus, Spectropolarimeter, Gas Chromatographs, etc.
Minerals and Metallurgy	15	Electron Probe X-ray Microanalyzer, ICP Emission Spectrometer, Induction Furnace, Universal Testing Machine, etc.
Glass and Ceramics	16	Heat Distortion Tester, Refractoriness Under Load Apparatus, Scanning Electron Microscope, Thermovision, Three-Zone Tubular Furnace, etc.
Total	152	

PCSIR will serve as the implementing agency of this Project on the Pakistan side. The Project cost is estimated approximately at 700 thousand Rupees (5 million Yen) for the Pakistani portion. The Project will take 13 months to complete after the conclusion of the Exchange of Notes between the two Governments through detailed design (2.5 months), tendering (1 month), manufacturing (5-6 months), transportation (1.5 months) to installation (2.5 months).

Maintenance and repair of the equipment to be supplied under the Project should be made adequately with that of the existing equipment. Therefore, the equipment needs to be managed by each department with periodical inspection and maintenance as well as timely replenishment of spare parts and consumables fully utilizing the function of workshops in Maintenance Division and warehouse keepers in Administration Division in the Laboratories. In addition to spare parts for two years for the new equipment, expected increases in costs for utilities, consumables, repair parts, and labor need to be included in the budget for the Lahore Laboratories. The annual maintenance cost in conjunction with the Project is estimated at about 5.5

million Rupees. PCSIR intends to allocate 10 million Rupees annually for the maintenance of the new equipment and the renewal of old facilities for the next five years from the 1990/91 fiscal year.

The Project is expected to bring various benefits as follows:

- Advancement of research and development activity in the scientific and technical fields in Pakistan;
- Contribution of the research achievements to improve and advance the manufacturing industries in Pakistan;
- Offering of places and opportunities for research activities to the young capable researchers and engineers being dispatched abroad;
- Promotion of the technical transfer from advanced countries and activation of the development of regional unique technology meeting the actual conditions in Pakistan.

The Lahore Laboratories is the largest core laboratory which places emphasis on practical applied researches in addition to basic researches. The implementation of the Project is considered very significant to improve and enhance research capabilities of the Lahore Laboratories and to widely use their achievements of research and development for improvement in technology in the industrial sectors of the country. The Project will play an important role in accelerating industrialization of the country, producing a significant economic and social benefits. Thus, it is believed the implementation of the Project is extremely suitable for Japanese grant aid co-operation, significance of which is great.

Pakistan side made a strong request for Japan's technical cooperation for dispatching Japanese experts to Pakistan and receiving Pakistani Counterpart in Japan in order to improve research and development capability of Lahore Laboratories, PCSIR. The study team recommends that favorable consideration will be given to this request for Japan's technical cooperation.

CONTENTS

APPENDICES

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

In the Islamic Republic of Pakistan (hereinafter referred to as "Pakistan"), agriculture accounts for the largest proportion of activities of industry, employment, trade and distribution, where the economy greatly depends on the movement of yearly agricultural production. To develop the overall economy of the country, it is important for the country to promote the mining and manufacturing industries by making good use of its resources and to improve the balance of foreign currencies by domestically manufacturing products as substitutes for imports and more positively, manufacturing goods for exports. The modernization and development of the mining and manufacturing industries have always been the major subjects for reform in the country's economic structure.

With a conception that improvement of the national technical level and cultivation of researchers are indispensable to effective promotion of the industrial development, Pakistan has been making efforts to expand and improve research and educational facilities and equipment. Especially, Pakistan Council of Scientific and Industrial Research (hereinafter referred to as "PCSIR"), which was established in 1953, several years after its independence, has been researching and developing science and technology to offer their research achievements to various industrial sectors of the country. PCSIR has been expanded and developed to have eight laboratories and a training center with 3,000 staff including 900 researchers. With economic growth and advancement of industrial activities in Pakistan, private and public companies have been expecting more and more of the role of PCSIR. Particularly, research and development activities have become increasingly varied, specialized and advanced in recent years, and it has become necessary also for the PCSIR's laboratories to renew and newly introduce research and experimental equipment.

Karachi Laboratories and Lahore Laboratories are the oldest and the largest in scale among eight laboratories of PCSIR and are in the position to meet the national needs for research and development of science and technology of Pakistan. However, the present conditions of the Laboratories are not only lacking of introducing necessary new research equipment, but also far behind in the renewal program of the existing equipment, thus achievements of research work have not progressed as expected. Spare parts are not easily procured due to the existing research equipment being obsolete models and some of the existing equipment not functional well.

Under these circumstances, PCSIR issued a "Five Year Plan of PCSIR for 1988-93" to expand and renew PCSIR's research equipment and facilities and to improve the quality of researches. Especially to improve research equipment in Lahore Laboratories, the PCSIR's integrated core laboratory, the Government of Pakistan made a request for grant aid cooperation to the Government of Japan.

In response to the request, the Japanese Government decided to conduct a basic design study on the project for providing the equipment for Lahore Laboratories, PCSIR (hereinafter referred to as "the Project") and sent a study team headed by Dr. Minori Sano, Senior Assistant to the Managing Director of Grant Aid Planning and Survey Department, Japan International Cooperation Agency (JICA), to Pakistan from August 18 to September 4, 1989. The study team had a series of discussions with the officials concerned in Pakistan and made field investigations at Lahore Laboratories to acquire information and data on the current research and development activities in Pakistan, the organization to carry out the Project, effects of the Project, appropriateness of the Project as Japanese grant aid cooperation program and others. In addition, the team also confirmed the organization for managing and maintaining the equipment, and locations, spaces and rooms to install the equipment. The formation of the study team and their schedule of the survey in Pakistan are shown in the appendices.

After returning to Japan, the study team examined and analyzed the results of field investigations and the collected data and clarified objectives and position of the Project for working out the scale of the equipment, contents of the equipment, estimation of Project cost and schedule for carrying out the Project.

The results of the basic design based on the above study are summarized in this report, titled, "Basic Design Study Report on the Project for Providing the Equipment for Lahore Laboratories, Pakistan Council of Scientific and Industrial Research in The Islamic Republic of Pakistan".

CHAPTER 2 BACKGROUND OF THE PROJECT

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2-1 Outline of Pakistan

2-1-1 Economy and Industry

(1) Economy

The Pakistan economy made a remarkable progress and development in the 1960s. However, since early 1970s the country faced many difficulties due to worsening international environment, trigered by the first oil crisis in 1973. The economy recovered from late 1970s to early 1980s and the target economic growth rate of 6.5% set for in the sixth five year plan (1983/84 to 1987/88) have been achieved. Gross national product (GNP) of Pakistan is shown in Table 2-1. Pakistan's GNP of 1987/88 was about 717 billion Rupees and GNP per capita of the same year was 6,252 Rupees. This figure is the highest in south western asian countries, 1.4 times of that of India and 2.5 times of that of Bangladesh. In case of Pakistan, deposits from emigrant workers which had been increased after the first oil crisis shared approximately 10% of GNP, however, the deposits decreased remarkably due to the recent economic recession in the middle east countries.

Table 2-1 Major Economic Indicators of Pakistan

(Unit: Million Rupees)

	1986/87		1987/88	
		Growth		Growth
GNP	644,638	9.5%	716,963	11.2%
Per capita GNP. Rps.	5,783	6.4%	6,252	8.1%
GDP for each sector		Share (%)		Share (%)
Agriculture	20,224	24.8	21,124	24.5
Mining	510	0.6	548	0.6
Manufacturing	15,991	19.6	17,201	20.0
Construction	4,512	5.5	4,820	5.6
Electricity - Gas	2,859	3.5	2,927	3.4
Transportation - Communication	5,960	7.3	6,322	7.3
Commercial	12,094	14.9	12,836	14.9
Bank - Insurance	2,458	3.0	2,508	2.9
Housing	2,876	3.5	3,028	3.5
Government - Defence	8,186	10.1	8,715	10.1
Services	5,757	7.1	6,137	7.1
Total	81,427	100.0	86,166	100.0

Source: Statistical yearbook of Pakistan 1988

(2) Trade

The export of primary products such as rice, cotton and crude leather shares approximately 34% of the total export amount of Pakistan. Export of vegitable, fruits and fish is also increasing lately. The major industrial products being exported are labour intensive light industry products such as cotton products (yarn, cloth and towel), carpets, garments, and leather products. Especially, three traditional export products of raw cotton, cotton yarn and cotton cloth occupy about one-third of export.

Regarding import, industrial raw materials such as petroleum, petroleum products, chemicals, fertilizer and steel products, share 45.5%, followed by 36.5% of capital goods such as machineries, electric machines and transportation machines, and 18% of consumable goods such as wheat, tea and edible oil. As a recent trend of the trade, import of industrial raw materials for consumable goods has been decreasing and import of capital goods and consumable goods has been increasing.

Until 1985/86, the U.S.A. had been the first and foremost importing country from Pakistan. However, in 1986/87, Japan imported 10.9% of the total, followed by the U.S.A. of 10.2% and U.K. of 7.2%. Traditionally the western industrialized countries have been importing cotton related products. Importing countries of these products are Japan sharing 16.3%, followed by the U.S.A. of 11.0%, West Germany of 7.5%, Kuwait of 7.4% and U.K. of 6.6%.

(3) Industries

- Agriculture

Pakistan has promoted industrialization after becoming the independent country, however, agriculture is still the central industry as shown in Table 2-1. Share of agriculture in GDP is 24.5% and percentage of employment for agricultural sector is about 50% of total workforce of the country. Most of agricultural area belongs to dry but well-irrigated area and concentrates in irrigated region of Punjab Province and Sind Province. Main farm products in these regions are wheat, cotton, rice and sugar cane, of which cotton and rice are traditionally important exporting farm products.

When harvest of such cash crop as cotton is damaged by harmful insects, the production of yarn and cloth for export will immediately be influenced. Other farm products include edible oil seeds, barley, beans and tabacco. In addition, stock breeding is also flourishing. Domestic animals have been used as horsepower for cultivation and as means of transportation of goods or industrial raw materials of leather and wool. Moreover, livestock aiming to produce meat, egg and dairy is also increasing.

- Manufacturing

The industries of Pakistan largely depend upon agriculture. Beginning with textile (cotton) industry which is the largest industry of the country, the industries of sugar, edible oil and fat, tabacco, jute, leather are all processing industries, utilizing agricultural raw materials or semi-products. These industries depend not only on domestic agricultural product market, but also on international agricultural markets and are not stable compared with other manufacturing industries.

- Mining

Pakistan is producing coal, oil, natural gas, iron ore, chromite, gypsum, lime and silica. In addition, it is confirmed that copper, manganese, boxite and mineral phosphate are recoverable on commercial basis. The government is particularly eager for exploitation and development of underground mineral resources as well as research and development of refining technology for these mine products.

2-1-2 National Development Plan

(1) The Seventh Five Year Plan

Succeeding to the 6th five year Plan, the Government of Pakistan worked out the 7th five year Plan for the national economic development.

As the successive policy from the 6th five year plan, the importance is attached to activation of private economic activities, cultivation of human resources and development of new technology.

Highlights of the 7th five year plan (1988/89 - 1992/93) are as follows:

. GDP growth rate during the 7th plan aims to 6.5% p.a.
. The total expenditure will be 642 billion Rupees, which is 138% of that of the 6th 5 year plan.
. The expenditure for public sector will be 350 billion Rupees and the expenditure of private sector will be 292 billion Rupees and the weight of private sector is increased.
. Expenditure by the Government for development plan is 90 billion Rupees and importance is attached to energy division, education division and population planning.
. Dependence on the foreign assistance will be decreased and the amount of foreign assistance will be controlled to 96 billion Rupees during the 7th plan, compared with 116 billion Rupees of foreign assistance during the 6th five year plan.
. In order to promote the export of agricultural products and control the import of food, it is planned to achieve 13% wheat surplus production, 71% of rice surplus, 17% of maize surplus by the end of the 7th plan, in addition to remarkable reduction in importation of edible oil.
. Import of crude oil will be restricted to 60% of the domestic demand.
. As a source of the fund for development of rural area, the local cess on land will be levied.
. In view of reduction of deposits of emigrant workers and increase of interest payment of foreign debt, the average growth rate of export will be set at 9.6% p.a. and that of import will be controlled to 4.6% p.a.
. Employment plan will be worked out on national scale in order to create job opportunities for 6 million people.

(2) Five Year Plan of PCSIR for 1988-1993

In line with favorable economic development of Pakistan, expectations to PCSIR from private and public sectors have been increased and contents of researches have become advanced. Due to the advanced contents of researches, renewal of obsolete research equipment, procurement of research equipment and upgrading of capability of researchers have become extremely important issues to PCSIR. Although PCSIR is managed and operated by

the budget allocated by the Government, it is not possible to procure necessary research equipment for their research activities due to the limited amount of the budget and PCSIR encountered to the situation that scheduled research activities are not fulfilled accordingly.

In view of the above situations and in unison with the national five year Plan, PCSIR worked out "Five Year Plan of PCSIR for 1988-1993".

Major points of five year Plan of PCSIR are as follows:

1) In this era when importance of science and technology has been increased more and more, PCSIR is to secure budget to make modernization of equipment and development of researchers possible. During the 6th five year Plan, PCSIR was provided only 34% of allocated budget amount (170 million Rupees out of allocation of 501 million Rupees). This subcritical amount barely covers maintenance work of the existing research equipment and facilities and very little was left for research projects or for purchase of new research equipment. In PCSIR's five year Plan, the financial layout has been worked out to be a total of 2,436 million Rupees to execute various plans such as:

   i) establishment of new laboratories
   ii) procurement of new research equipment
   iii) training of scientists and researchers
   iv) construction of housing facilities at various research centers

2) Especially, highly skilled and competent researchers form the background of an R&D organization and it is necessary to provide them not only excellent working conditions including good equipment and laboratory facilities, but also attractive service conditions comprising reasonable salary structure, a good career planning, housing and medical facilities. Under the present conditions, housing has become a major requirement and only practical solution of this problem is to construct housing complex in PCSIR campuses.

3) A sizable number of scientists and researchers trained in the late 1960s and 70s are now retiring from the first front every year. From viewpoints of continuation of research activities and activation of PCSIR, it is crucial issue to fill quickly with proper input and to cultivate young scientists and researchers.

With such crucial aspects in mind, PCSIR's five year Plan places its importance to renewal of research equipment, cultivation of young researchers and upgrading of research and living conditions of researchers.

2-2 Scientific and Technical Research and Development in Pakistan

Since the execution of the 6th five year Plan (from 1983/1984 to 1987/1988), the Government of Pakistan has placed their utmost emphasis on the advancement of science and technology, especially, execution of independent research program, and development of practical and applied technology meeting the national, social and environmental needs. The 7th five year Plan has succeeded the same basic philosophy. The Government has been taking a special financial measure to cultivate competent and capable researchers and engineers. In the latter two years of the 6th Plan, the Government sent 700 young researchers and engineers to western advanced countries of Europe, the U.S.A. and Australia at its own expense. In the 7th Plan, the Government also plans to dispatch a total of about 1,000 researchers and engineers to the advanced countries for their training and acquisition of degrees. The Government has already dispatched 300 persons in the first year of the 7th Plan. In the Western advanced countries, they study in a great variety of fields including medical science (especially, researches in cancer), biotechnology, micro-tissue, semiconductor physics, oceanography, aerospace, advanced communication technology and computer technology. This measure is based on the firm belief and conviction of the Government of Pakistan that it is impossible to industrialize the country without well-educated and -trained researchers and engineers. The Government plans to establish new laboratories related to researches in laser beams and optical fiber communications to assist in providing opportunities that the trainees sent abroad can work actively in Pakistan after their return to home country and conduct researches in their respective fields. It also plans to enrich the existing universities and national laboratories to prepare for their research and development activities and contribute to national scientific and technical development through daily research activities.

The Ministry of Science and Technology is working out plans for scientific and technical research and development. The Ministry, which became independent of the Ministry of Education only 17 years ago, is supervising great parts of science and technology with administrative guidance in Pakistan. Research and development institutions belonging to ministries including the Ministry of Industry, the Ministry of Communications, the Ministry of

Agriculture and the Ministry of Production which existed before the establishment of the Ministry of Science and Technology are engaged in research and development under the supervision and guidance of each ministry. Researches in atomic energy are managed by the Atomic Energy Commission under the direct control of the Prime Minister, due to their special characteristics.

The Ministry of Science and Technology has the following research institutions:

. Pakistan Science Foundation (subordinate institutions: Pakistan Scientific Information Centre, Technology Information Pilot System and National History Museum)
. Pakistan Council of Scientific and Industrial Research (which has 8 laboratories and one training center)
. Pakistan Medical Research Council (which has 13 medical research centers)
. Council for Works and Housing Research (which has National Building Research Institute)
. Pakistan Council of Appropriate Technology
. Pakistan Council of Research in Water Resources (which has Desertification Monitary Unit and Drainage Resolution Institute of Pakistan)
. National Center for Technology Transfer
. National Institute of Silicon Technology
. National Institute of Electronics
. National Institute of Power
. National Institute of Oceanography

As surmised from the names of the above research institutions, the Government of Pakistan intends to integrate scientific and technical research activities, with an exception of special researches such as atomic energy researches, into the Ministry of Science and Technology. Especially, research and development in new fields are now being concentrated at the Ministry.

The Ministry of Science and Technology, which was established in 1972, is not a large organization due to its short history. The Ministry, composed of a total of about 100 staffs including some 20 high civil officials and

other 20 high technical officials under secretary, with 50-60 officials who support daily works of senior staff, is efficiently directing scientific and technical administration which has become important more and more for rapid industrialization of the country.

2-3 Present Conditions of PCSIR

2-3-1 General Conditions of PCSIR

(1) History

PCSIR was established in 1953 with aims to research and develop industrial technology especially for the industrialization with utilization of domestic mineral resources, agricultural products and other materials and to support and guide local industries technically. In those days, the present competent authority, the Ministry of Science and Industry was not yet established, of which the predecessor was Department of Scientific and Industrial Research under the Ministry of Industry.
In conformity to the above objectives of PCSIR, laboratories were established in major cities and districts including Karachi, Lahore, Peshawar, Islamabad, Quetta and Hyderabad, reflecting the features of each region.

PCSIR, which now has 8 laboratories and one training center with a total of about 3,000 staffs including 900 researchers, is the largest research and development institute in Pakistan.

Although the competent authority of the Ministry of Science and Technology directs and supervises PCSIR, the supreme decision-making organ of PCSIR is the Council in substance. The ordinary council held twice a year settles important issues about PCSIR including research activities, research support system, working conditions of researchers and assistants and welfare system. The organization of PCSIR is shown in Figure 2-1.

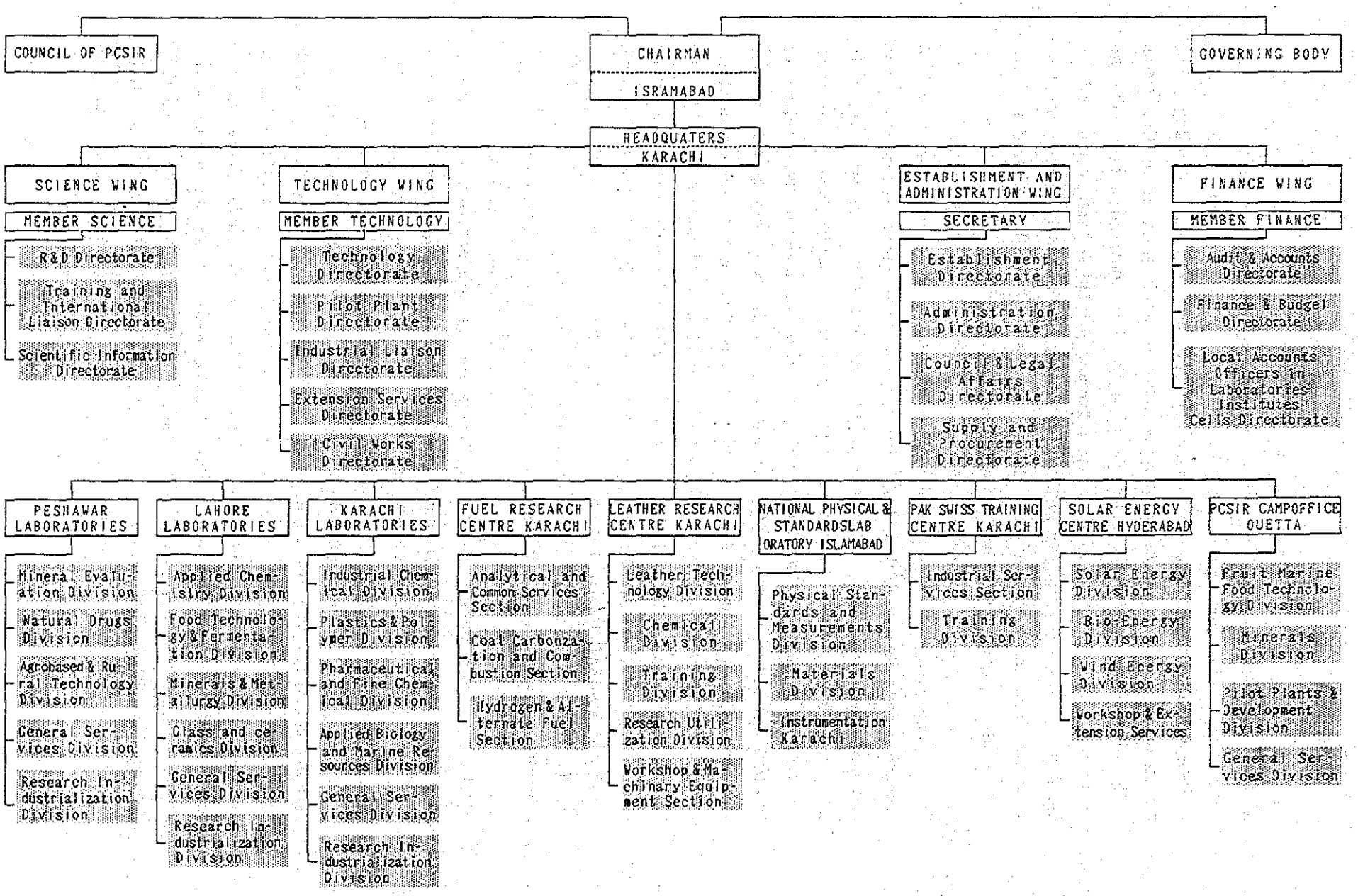

Figure 2-1 Organization of PCSIR

(2) PCSIR's Activities

PCSIR initially researched both basic science and applied technology, but has placed emphasis on researches on applied technology from the 1970s with an aim to contribute more directly to the industrial sectors of the country. Representatives of private companies have been nominated as members of the Council, and PCSIR's activities have been closely connecting with the business world in these days. At present, PCSIR's activities cover almost all of industrial fields in Pakistan.

PCSIR takes an active part not only in ordinary scientific and technical research and development but in training of high grade researchers and medium class engineers. Especially, PCSIR has been making efforts to cultivate high grade researchers in cooperation with other research institutions. Under the guidance and supervision of superior researchers of PCSIR's laboratories, about 400 persons have obtained master's degrees and 76 persons received doctorates. In view of vast expenses to obtain master's and doctor's degrees in foreign countries, PCSIR contributes much to the nation in this respect. PCSIR will place further stress on the training activities to reduce dependence on foreign countries in the field of high scientific and technical research.

(3) Relations with Foreign Countries

PCSIR has been making efforts to strengthen its collaboration with foreign institutions since it was founded. PCSIR has positively been involved in joint research and development and the exchange program of specialists among allies of Central Treaty Organization Scientific Coordination Board. As a part of the activities, Regional Training Centre on Mycotoxins was established within the estate of Karachi Laboratories. In addition, PCSIR made arrangement of collaboration with Denver Laboratory of the U.S.A. in 1979 to strengthen competence development of leading administrators and to intensify cooperative scientific research and development. Pak Swiss Training Centre, which was jointly established with the Swiss Government in Karachi in 1966, has been training talent in such fields of industrial electronics, optometry, precision machinery, instrumentation and dies and

mould design and fabrication to cope with the increasing demand of the industrial world. USAID provided research equipment to Fuel Research Centre in Karachi. Lahore Laboratories is promoting a project for improvement in textile machinery in cooperation with Canada. Malaysia participates in joint researches in palm oil. The expert sent by JICA has cooperated researches in leather treatment technology at Leather Research Centre-Karachi, staying there for a period of three years from May, 1981 to May, 1984.

Thus, PCSIR has been not only promoting cooperative relations with advanced countries including Europe and the U.S.A., but are quite eager to promote joint researches with developing countries.

2-3-2 Lahore Laboratories of PCSIR

(1) Outline of Lahore Laboratories

Lahore City is the provincial metropolis of Punjab, the center of administration of 60 million people, and the industrial, commercial, cultural and educational city with its long history. The City with a population of three million people is the second largest city next to Karachi in Pakistan, where Lahore Laboratories was established in 1954. Lahore Laboratories is the integrated and core laboratory among PCSIR together with Karachi Laboratories (established in 1953).

In conformity to the objectives of PCSIR, Lahore Laboratories has been putting emphasis on the promotion of local industries and conducting research and development in response to regional industrial activities, covering researches for food industries, development of dyes and pigments for textile industries, technical research for glass and ceramics industries, development of plant-based chemicals and improvement in ore beneficiation process for mineral resources. The Laboratories also takes an active part in reeducation of middle-class engineers of small-and medium-scale enterprises, quality control guidance in manufacturing processes for small-and medium-scale enterprises, and guidance and consultation for solving troubles encountered in manufacturing processes.

Lahore Laboratories, which is located in a quiet district, about five kilometers south of the center of Lahore City, has a site of 59 acres (about 24 hectare).

The Laboratories consists of four research divisions, that is, Food Technology & Fermentation Division, Applied Chemistry Division, Minerals & Metallurgy Division and Glass & Ceramics Division, and of three supporting divisions, Research Industrialization Division, General Services Division and Administration Division. The organization of Lahore Laboratories is illustrated in Figure 2-2.

The personnel structure of the laboratory is as follows:

Total employee: 569 (including 233 researchers)

Breakdown:		(Number of researchers)
Applied Chemistry	144	(76)
Food Technology & Fermentation	85	(53)
Minerals & Metallurgy	78	(43)
Glass & Ceramics	80	(30)
Research Industrialization	34	(21)
General Services	72	(10)
Administration, Accounting & Warehouse	76	

Many researchers received doctor's and master's degrees during their study in Europe, U.S.A. and Australia, which indicates high quality of researchers. Most of research subjects will reflect the trend of the times and meet the demand of the industrial sectors.

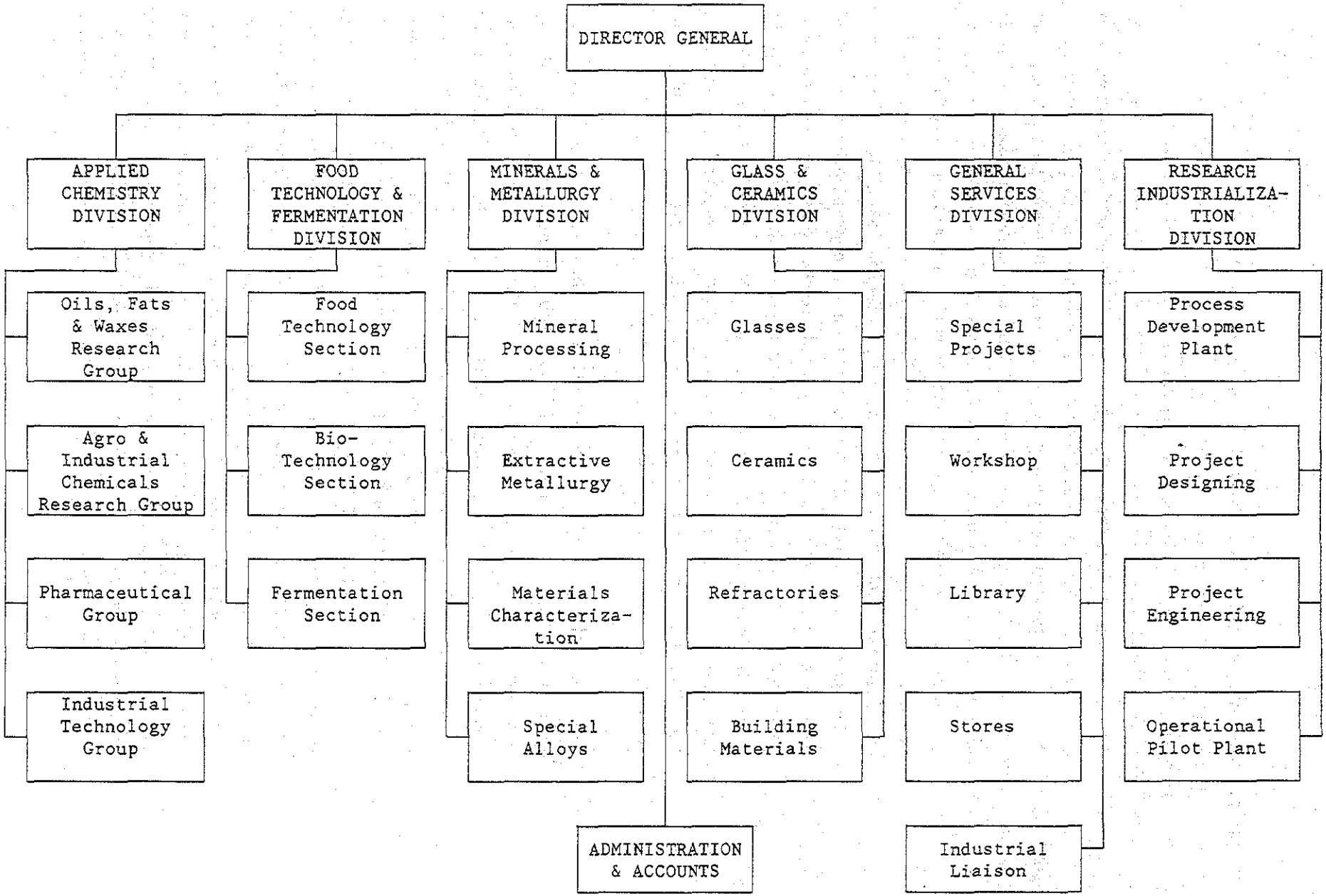

Figure 2-2 Organization of Lahore Laboratory

(2) Contents of Researches of Lahore Laboratories

1) Food Technology & Fermentation Division

The Food Field: Pakistan pays a very large amount for imported food every year, due to its large population and high birthrate. Therefore, it is an important research subject to preserve food from decay and deterioration caused by contamination of microorganisms in poor preservation. Especially, researches of microtoxins produced by microorganisms are actively pursued. Meanwhile, development of food production technology is also studied in response to the modernization of their traditional food life with the growth of national economy. Researchers are making efforts of research for concentrated juice, dried vegetables, powdered foods and instant foods, ahead of conventional preserved foods of bottled and canned foods, with an aim to cultivate local industries. They also have started studying healthy foods such as low-cholesterol and low-calory foods. Strongly interested in new foods for Pakistan including sprouted beans, they are going to start researches.

The Fermentation Field: The objective of this field is to manufacture high added-value products using microorganisms from agricultural products and wastes as raw materials. Pakistan has been sending many researchers to Czechoslovakia which has the highest fermentation technology in Eastern Europe, to reach the level of advanced countries. Except traditional industries such as daily products and vinegar, Pakistan is only producing alcohol as industrial raw materials and antibiotics (penicillin G). This is attributable to the fact that driving force of the industry did not work, due to little fermented foods in Pakistan and no alcoholic beverage industry at all, which established a basis of the fermentation technology in advanced countries. However, as there are many ferment products which are indispensable to process food closely related to the modernization of food life, this division will play a large part in the industry. At present, the division is making efforts to produce organic acid such as lactic acid and to develop technology to produce various hydrolizing enzymes of carbohydrate and protein

especially related to food processing. The Fermentation Division is also conducting researches to produce mashrooms by using wastes and to mass produce useful plants by using plant tissue (calus) culture techniques to which fermentation techniques are applicable, with an aim to obtain a footing in development of high bioengineering.

As mentioned above, under domestic conditions of Pakistan, Food Technology & Fermentation Division is conducting researches meeting domestic needs, maintaining a close connection with the industries.

Research theme and its contents are shown in Table 2-2.

Table 2-2 Food Technology and Fermentation Division

Fields	Subjects of research	Contents of research
Post harvest technologies	Extension of shelf life of fresh fruits	Standardization of handling during transportation Suitable techniques of packing Reduction of quality changes during storage Prevention against damage due to microorganisms
	Control of sweetening in Potato tubers during storage	Search of various factors affecting Potato sweetening Development of method for stabilizing Potato quality
	Reduction in post harvest losses in grains	Storage test using leaves, bark, and extract of plants indicating insecticidal activity
Food processing and packing	Production of ready to eat fruit bars	Development of simple, grass-root technology to produce shelf-stable fruit pieces and fruit bars
	Production of sprouted grains for human nutrition	Follow-up of nutrition changes during sprouting of grains Processing/incorporation of sprouted grains into diet for improved nutrition
	Preparation of low calorific diet for over weight people	Formulation and preparation of diet, chemical analysis of food, and biological and clinical evaluation of diet
	Studies on oat milling	Milling techniques for introducing oat into diet

Fields	Subjects of research	Contents of research
Food processing and packing	Production of low moisture/dried meat products	Comparison of drying methods and nutritional evaluation for various meat products
	Packing of food and food products	Development of packing techniques and materials
Food and feed quality assurance	Mycotoxins in food and feed	Detoxification of Aflatoxin contaminated commodities by chemical means and conducting trials on poultry
	Studies on minerals in food	Effects of contamination of heavy metals and deficiency of essential minerals in diet on human health
	Colouring matters in food	Fractionation and identification of colouring matters in food Monitor of colouring matters in Pakistani foods
Applied biochemistry	Industrial enzyme from animal tissue	Extraction and fractionation of Trypsin from animal pancreatic tissue Extraction of pepsin from animal paunch
	Protein concentrate and hydrolysate from meat/poultry industry by-products	Production of protein concentrates from feathers, skin, digestive tract and other offals Production of digestible proteolysates which can be used to enhance nutritive value of animal and poultry feed
	Production of lactic acid	Screening of microorganisms capable of producing lactic acid Studies on metabolic activities and symbiosis in isolated cultures

Fields	Subjects of research	Contents of research
Fermentation technology and biotechnology	Pullulanase by Bacillus species	Isolation, screening and identification of pullulanase producing Bacillus species Nutritional studies in shake flask culture
	Glucose oxidase by mould fermentation	Glucose oxidase production in shake flask culture using moulds such as Aspergillus and Penicillium species Isolation and purification of enzyme
	Pilot plant production of calcium gluconate	Optimization of gluconic acid fermentation in pilot plant Separation of calcium gluconate from fermented broth
	Development and maintenance of microbial cultures	Isolation and purification of microbial cultures of industrial importance from local habitate Lyophilization of potent cultures and establishment of routine check up method
	Production of Bacitracin by Bacillus lichenformis by submerged fermentation for poultry feed	Optimization of conditions for production of Bacitracin in stirred fermentor Improvement in isolation method of Bacitracin from fermented broth
	Ethanol from renewable biomass	Fermentation with sugar cane juice Production of cellulolytic enzymes Fermentation with bagasse hydrolyzed by cellulolytic enzyme

Fields	Subjects of research	Contents of research
Biomass utilization	Production of mushroom	Standardization of conditions for compost preparation in button mushroom production
	Integrated biogas technology	Biogas production with animal dung, poultry manure, municipal waste and wheat straw Biogas production with wild plants, Sarkanda, Dkawb and Kondser
	Biodegradation of recyclable agricultural wastes by Basidiosmycetes	Biodegradation of bagasse using Basidiomycetes belonging to different genus Conditions for optimal delignification of bagasse
	Utilization of fruits industry by-products and wastes	Utilization of fruit industry wastes into poultry feed Nutritional evaluation of feeds prepared from fruit industry waste
	Food and feed from sunflower seeds	Methods of effective utilization of sunflower seed
Plant tissue culture	Regeneration and clonal propagation of Pista vera plants by tissue culture	Micropropagation studies from juvenile/mature tissue Micropropagation by cell suspension culture technique
	Micropropagation of bulbons and cormous plants	Micropropagation by cell suspension culture technique

2) Applied Chemistry Division

Applied Chemistry Division has been carrying out research necessary for the development of chemical industry in Pakistan based on the government's development plans and also greatly contributing to the chemical industry in Punjab Province.

As Pakistani import of chemicals, medicine, dyes, and fertilizers still occupies about 24% of its total import, the development and industrialization of their substitutes and research and development of chemicals using domestic natural resources are urgently demanded. Therefore, the Division stresses the importance of the research which meets such demand. Also, the Division carries out various extension services to spread chemical technology, offers technical collaboration to chemical companies and provides the training courses to the graduate students, majoring chemistry in universities in Punjab Province. It carries out the chemical analysis of raw materials and products based on the requests from the chemical companies, thus playing an important role as a chemical analysis center in the region.

The Division has prepared about 400 reports in the past, about 200 processes are utilized in the chemical industry in Pakistan. It has acquired 35 patents in the chemical fields.

In this way the Division has achieved numerous successful results through its activities in various chemical fields and is expected to further expand its activities by the improvement of research equipment and facilities.

The research fields of the Division covers research activities for agricultural and industrial organic chemistry, oil and fat chemistry, plant chemistry, product development, quality control, pharmaceuticals, pilot plant experiments, etc.

Recent major research themes of the Division are shown in Table 2-3.

Table 2-3 Applied Chemistry Division

Fields	Subjects of research	Contents of research
Industrial organic chemicals	Development of dyes	Development works on dyes other than usage of benzideine (Dyes for cloths)
	Researches on the production of phenols	Production of phenols such as phenol, resorcinol and 2-naphthol from aromatic hydrocarbons (Those products are used for the production of dyes, resins, tanning materials, pharmaceuticals, etc.)
	Researches on parachloronitrobenzene	Researches on the reaction of parachloronitrobenzene and the production of delivatives, such as 2, 4-dinitrophenol from parachlonitrobenzene (Parachloronitrobenzene is applied to the production of dyes, pharmaceuticals and the products as intermediates.)
	Synthesis of paracetamol	Synthesis of paracetamol from nitrophemol(Single step synthesis of paracetamol shows economic advantages. This product is an important analgesic.)
	Studies for the production of detergent	Production of detergents by the separation of hydrocarbon of n-alkanes, reactions mono-chlorination of n-alkanes with benzene to produce alkyul-benzene. (Production of detergent from indigenous raw materials)
	Preparation of chemicals for tannin	Production of organic chemicals for tannin industry from such as phenols (Substitution of imported chemicals for tannin by the domestic products is planned. Leather is an important export commodity.)

Fields	Subjects of research	Contents of research
Mission oriented fundamental research	Researches on liquid crystals	Surveys on the materials showing the liquid crystalline behaviour. (Literature survey has been conducted due to the importance of applications.)
	Surveys on reactions of keto, ß-keto	Attempts to find optimum conditions for the formation of ketoes and ß-ketones by varying pH, temperature and concentration (Those products are of interest because of their therapeutic activity against certain groups of viruses, etc.)
	Studies of essential oils of umbelliferae family	Studies of antioxidant activity (Antioxidant activities of essential oils are comparable with those of the synthetic antioxidant)
	Studies for the production of oxalic acid	Pilot plant studies for the production of sodium oxide, diethyl oxalate, etc. from molasses, cane sugar, etc.
	Production of diethyl ether	Studies on the production of diethyl ether from the locally available ethyl alcohol. Process improvement and new catalyses development. (This product is an important solvent.)
	Studies of snakes and snake venoms	Ecological, biochemical and pharmacological studies of snakes and snake venoms
	Production of aroma chemicals	Indigenous production of aroma chemicals using terpin, etc.

Fields	Subjects of research	Contents of research
Catalysts and strategic chemicals	Production of guanidine nitrate	In case that permission is granted, installation of experimental production unit for guanidine nitrate, and test production (This product is used for the production of innersides, dyestuff, plastics, etc.)
	Production of hydrazine hydrate	Concentration of hydrazine and bench scale test
	Production of amino-guanidine sulphate	Preparation of feasibility study report and designing a semi pilot scale plant
	Production at sodium azide	The production of high purity sodium azide (The production will be scaled up after the qualification of sample sample.)
	Production of calcium rosinate	The works for the installation and standardization of calcium rosinate plant
	Production of sodium silicate based chemicals	Production of magnesium trisilicate, calcium & aluminum silicate, aluminum magnesium silicate
	Regeneration of nickel catalyst	Regeneration of nickel catalyst from the waste material (The regeneration of nuckel catalyst has been developed by wet method. The study for the production of nickel catalyst by dry method is planned.)
	Studies of catalysts for saponification	Studies of homogenous catalysts for saponification of the oils and fats
	Studies of adhesive	Study of reactions on the production of adhesives and resins using bis-phenols and urea (Study of bisphenols synthesis is also planned.)

Fields	Subjects of research	Contents of research
Catalysts and strategic chemicals	Studies of electric production of chemicals	Studies of production for chemicals produced electrolytically, such as caustic soda, chlorine, chlorates, etc. (Electrolytic cells will be fabricated for the production of sodium chlorate, etc.)
Plant Chemistry	Studies of acacia species	Evaluation of acacia species as a source of variable chemicals and forage (Lipid, proximate and protein analyses will be conducted.)
	Studies of myrsinacede family	Chemotherapeutic evaluation of the plant extacts of myrsine africana (The antibacterial studies and its comparison with the standard antibiotics are in progress.)
	Studies of essential oil of umbelliferae	Studies of essential oil of the species of the plant family umbelliferae on the analytical works and experimental cultivation
	Production of menthol	Development of indigenous production of menthol (Substitution of imported menthol by indigenous product)
	Surveys of essential oil resources	Surveys of essential oil extraction from various plants in Pakistan and physico-chemical evaluation (Essential oils are used in the perfume and flavour industries.)
	Studies of chemical composition of euphorbia species	Studies of analysis on chemical composition of various euphorbia species with the view to finding their applications due to possible potential crops for producing biomas and petroleum-like hydrocarbons

Fields	Subjects of research	Contents of research
Plant Chemistry	Studies of anti-microbial activity of essential oils	Studies of antimicrobial activities of essential oils isolated from various plants (Studies will be undertaken to identify the active constituents, mode of their activity and their toxicity)
	Screening studies of local flora as aromatic sources	Screening of local plants as the raw materials for the production of aromatic products
	Screening and evaluation of plants as a source of essential fatty acid	Cultivation of various oil bearing plant species and evaluation of plants as a source of essential fatty acid
	Studies of the production of oxalic acid	Development works for the production of oxalic acid from molasses, etc. (Pilot plant experiment stage)
Oils and fats	Exploitation of indigenous sources of oil and fats	Fundamental and applied research works on oils, fats and waxes produced from various plants families of e.g. umbelliferae, cucurbitaceae, etc.
	Studies of edible rice oil	Researches on extraction, refining, bleaching deodourization and hydrogenation of bran oil
	Development of oil seed processing technology	Development of oil seed processing technology suitable for the adoption at the village level (Machinery and equipment of oil seed processing are being studied.)

Fields	Subjects of research	Contents of research
Quality control and product development	Development of synthetic polymer and allied products	Researches on the development of PVC, melamine resin, nitrocellulose lacquers, rosin size, etc.
	Studies of quality control	Studies of methods for quality control such as standardization of analytical method such for pesticides and herbicides
	Research of industrial water conditioning	Develoment of pilot plant facility for treatment of water from various sources and evaluation of water from various springs of the country
	Quality control of edible oils	Quality control services by analysis and advice to private enterprizes on edible oils and their allied products
	Development of method for the estimation of nitrogen	Development of methods for the estimation of nitrogen in organic compounds by the use of tartaric acid and citric acid as reductant
	Studies of pure cane syrup	Surveys of cane syrup of good keeping quality taste and flavour
	Development of cosmetics, perfumes and flavours	Development works on shaving cream to establish the conditions for stabilishing the foaming parameters and reproducible appedrance, and on hair shampoo to be produced from coconut

3) Minerals and Metallurgy Division

The major mineral resources in Pakistan are nonmetallic minerals such as natural gas, limestones, coal, silica sand and gypsum, and metallic minerals such as iron ores, copper ores and chromite ores. First and foremost, Baluchistan Province is rich with metallic minerals. Iran and India, which are adjacent to Pakistan, have major mineral resources such as oil, coal and iron ores to be used for their industries, whereas Pakistan is not blessed with such mineral resources in terms of both quality and quantity of deposits. Natural gas, limestones and chromite ores are the only mineral resources currently used for its own industry throughout Pakistan. Especially, high quality chromite ores are exported and low quality chromite ores are used for refractories and they are at present the highest value added mineral resources in Pakistan. However, in the case of other major minerals such as copper ores and iron ores, they are still at the stage where their beneficiation technology is being studied on a pilot scale. Under these situations, what is required of Pakistan now is to develop mineral resources and substitute for imported resources for its economic development and to effectively use these resources for the promotion of its own industry.

Minerals and Metallurgy Division of Lahore Laboratories, established in 1956, has been carrying out research activities to offer technical support to the mineral and metallic industries, which are the basic industries for economic development in Pakistan. The research themes of the Division are extensive, ranging from basic research such as mineralogy, geochemistry and metallurgy to studies of beneficiation, casting, surface treatment and development of new products, of these studies the research results will directly be contributed to the domestic industries. The following are the specific activities carried out by the Division for industries and other research and development sectors.

a) Analysis and evaluation of ores

b) Development of mineral resources and feasibility studies of their commercialization

c) Operation plan for mining, beneficiation and refining of minerals, selection of minerals related equipment and facilities, and advice for maintenance of selected equipment

d) Development of a pilot plant for beneficiation and its demonstration operation

e) Planning of training programs or seminars for students, foreign students from middle east countries and the middle class engineers of industries in the field of minerals and metallurgy.

f) Provision of equipment and instruments necessary to take degrees or to carry out on-the-job training

Furthermore, the Division carries out the joint research projects with other research sectors, universities and companies.

Contents of researches and research theme of Minerals and Metallurgy Division are shown in Table 2-4.

Table 2-4 Minerals and Metallurgy Division

Fields	Subjects of research	Contents of research
Mineral beneficiation	Floatation	Development of selective flocculation /flotation process for low grade chromite ores
		Development of beneficiation process for low grade iron ore in the form of acceptable concentrate for the blast furnace
	Enrichment	Enrichment of lead and zinc based chemicals obtained from lead-zinc ore to the metallurgical grade which is suitable for the extraction of lead and zinc metals
	Extraction	Development of process and facilities to recover precious metals like gold, silver or platimum contained in iron ores
		Extraction of molybdenite during the enrichment of lead and zinc ore
Mineralogical/ geochemical studies	Characterization	Characterization of complex ores containing gold, silver, copper, lead, zinc and tungsten
	Utilization of industrial minerals	Characterization and utilization of magnesite, olivine, chrome, bauxite and dolomite
	Mineral based coatings	Development of mineral based corrosion resistant coatings
Extractive metallurgy	Extraction of lead metal	Development of recovery process for lead metal from minerals and industrial wastes

Fields	Subjects of research	Contents of research
Extractive metallurgy	Calcium and magnesium based chemicals from dolomite	Production of sulphate, chloride and flouride of calcium and magnesium from dolomite
Foundary technology and alloy development	Steel	Development of optimum deep hardening operation for case hardening of steel
	Mould	Development of binder system for mould and core
		Study on effective core making process
	Addition agent	Development of melting fluxes, grain refiners and degassing agents for aluminium and copper alloy melting
Electrochemical /surface treatment	Electrochemical colouring	Study on electrochemical colouring of stainless steel, aluminium and other metals
	Determination of ions	Development of effective methods for determination of gold, zinc, calcium nitrite, phenolphthalein and other trace elements in agricultural wastes
	Adsorption	Research on adsorption of gold, silver and copper metal on lead sulphide as a fundamental study of extractive metallurgy
	Solvent extraction	Study on solvent extraction of metal sulphides
	Electrolytic preparation	Electrolytic preparation of high purity potassium permanganate from pyrolusite

Fields	Subjects of research	Contents of research
Electrochemical /surface treatment	Electrolytic preparation	Preparation of basic chromium sulphate and sodium sulphate from chromite
		Development of appropriate electrolytic cell for sodium metal production
Utilization of minerals	Chemicals from minerals and wastes	Preparation of phosphoric acid and calcium phosphate from phosphate rock
		Preparation of chemicals like magnesium silicate, carbonate and milk of magnesia from magnesite
	Bio-leaching	Study on bio-leaching of sulphur from gypsum

4) Glass & Ceramics Division

Glass & Ceramics Division was established in 1960. The Division, which did not have sufficient research equipment nor researchers at the start, has been providing research equipment and training researchers in Pakistan as well as in foreign countries.

The Division has conducted the following research activities.

a) Evaluation and investigation of beneficiation technology of glass and ceramic materials

b) Development of production technology based on overseas predominant technology

c) Ad-Hoc research for quality control and solution of problems in manufacturing plants

d) Scientific and technical basic research in glass and ceramics

The results of these researches are utilized for advice and technical guidance for domestic industries, daily technical consultation and training of postgraduate students and engineers. To advise government agencies and universities is also an important task of the Division. Through such research and development, the Division published 2,000 reports, developed 60 processes and obtained more than 20 patents.

There are a few large companies and more than 1,000 small companies in the Pakistani ceramic industry. There are 26 large companies which produce more than 8 tons per day with 250-350 employees. Under the technical guidance of advanced countries with modern equipment introduced from overseas, these large companies' production efficiency and quality of products seem to be on the prime level.

EMCO, a typical insulator manufacturer, is located in an industrial area in the suburbs of Lahore and has a tile factory constructed in 1985 and

an electric insulator factory constructed around 1975. Its automatic tile production line introduced from Germany and electric insulation factory constructed under the guidance of Japanese manufacturer have intermediate quality as compared with those of Japanese ceramics companies. However, the rate of good quality products is low as 60%, which indicates that EMCO has problems in basic technology. These large companies always keep in contact with Lahore Laboratories.

The Division consists of five sections, namely, Glass Research Section, Ceramics Research Section, Refractory Research Section, Ceramic Material Research Section and Building Material Research Section, and has 30 researchers.

Research theme and the contents of researches of each section are shown in Table 2-5.

Table 2-5 Glass and Ceramics Division

Fields	Subjects of research	Contents of research
Glass	Development of signal glass	Development of colouring agents for colour glass for changing flue colour to green colour for traffic signal glass
	Protection glass for nuclear radiation	Development of zilconia as substitute of selium
	Form glasses for building materials	Development of insulating materials for buildings by sintering, foaming and molding of waste glass, chacoal and saw ducts
	Manufacturing process for borosilicate	Development of technology to prevent vaporization of boracic acid during glass resolution for production of chemical glass ware
	Semi-reduced manufacturing process for flint glass	Composition is $CaO.NaO.SiO_2$ development of reduced resolution method to use sodium sulphate as soda material
	Development of lead crystal glass manufacturing process	Development of technology to prevent vaporization of boracic acid and glass batch method
	Development of glass stirring refractory	Development of ring, thimbles and bars to be used for stirring of glass pot to prevent seeds ans striate during manufacturing process
	Experiment of phase separation of 96% silica glass	Production of quartz glass requires high temperature above 1,700°C. By the effect of phase separation, the glass produced at lower temperature will be acid treated to produce the glass containing 96% silica

Fields	Subjects of research	Contents of research
Ceramics	New ceramics	New research theme to develop building materials or functional materials by using oxide, nitride or boronide
	Bacteria filtration tube	Researches on ceramic filter composition, pore formation and molding methods and their application to chemical industry and pharaceutical industry
	Substitution of imported china clay	Plastic clay is imported. Swat china clay is intended to be used as substitution. Research is conducted to define mineralogy, rheolagy, casting and pyroplastic characteristics.
	Evaluation of Hunza clay	Chemical composition, physical properties and plastisities of Hunza clay are studied for utilization of industrial production.
	Development of sand lime bricks	Good results are obtained of calcium silicate bricks produced by sand collected from Mainwali and Ravi. Development is continued to improve quality and formation of xanotlite.
	Development of chemical porcelain	Various chemical bodies and glazes are developed to evaluate thermal shock resistance and chemical resistance properties. Development is continued to define compositions for chemical porcelain usable at higher temperature.
	Development of single coat enamel	Research of enamel glaze to evaluate properties of smelting frit, firing temperature, thermal expansion coefficient, capacity and acid resistant.

Fields	Subjects of research	Contents of research
Ceramics	Design, installation and operation of enamel kiln	To design and fabricate a kiln for efficient research work of enamel related study
	High temperature fuse	At present, development of 100 Ampere fuse has been completed. In future, fuse of 150 Amperes at 230 volts is developed.
	Development of high temperature electric insulating materials	It is planned to manufacture insulating materials domestically to substitute imported ones.
	Utilization of domestic pegmatite and geological study	Field survey for pegmatite has been completed and geochemical analysis is being carried out. Survey is planned for Gilgit, Hunza and Shigor valley regions.
	Research of basic refractories by Chillas Forsterite	This Forsterite is rich in magnesium and is developed to make refractories for steel industry.
Refractories	Development of ceramic fibres	Ceramic fibres are produced from refractory oxides using modern Sol-Gel technique.
	Mullite Refractories	Development is carried out for Mullite refractories which are excellent in fire proof, mechanical strength and resistance to corrosion.
	Dead-burning of Muslim bagh and Hazara magnesite	High temperature is required for dead-burning of magnesite. By adding iron, chrome or borocic acid, chromag Refractories can be developed at lower temperature.
	Insulating Refractories	To develop insulating refractories using domestic raw materials

Fields	Subjects of research	Contents of research
Refractories	Zirconium-Alumina-Silica (ZAS) Refractories	To develop a technology to domestically manufacture ZAS Refractories for glass melting furnace
	Beneficication for Zircon opacifier	Research for utilization and beneficication of glass and glaze opacifier
Raw materials for refractories	Mineral analysis	Researches of analytical methods of compositions in various minerals
	Pozzolanic activity of burnt clays	Evaluation for Pozzolanic activities of burnt clays and lime-amorphous silica
	Recovery of Titanium from high alumina clay	Evaluation of chemical recovery process of Titania from clays
Building materials	Lightweight aggregate	In order to meet increasing demant of lightweight aggregate, development is carried out by using slate, shale or local clays as raw materials.
	Research for Wollastonite	Wollastonite is used for production of ceramics, paint, paper, rubber and others, especially used for floor tile manufacturing to achieve high strength. It is studied to produce Wollastonite from rice husk ash, silica and limestone.
	Building materials from Magnesite cement	To develop building materials from magnesia cement, wood chip and agricultural wastes
	Refractory mortar for chemical industry	To study the production of acid proof mortar, air setting mortar, plastic mortar and castable materials from domestically available raw materials

Fields	Subjects of research	Contents of research
Building materials	Pre-fabricated gypsum based building materials	Pakistan has large deposits of gypsum, which are used for cement and refractory industries. To develop the gypsum for bricks and wall of building materials

(3) Existing Equipment

Major equipment of each division are as follows.

Food Technology and Fermentation Division

No.	Name of Equipment	Q'ty	Year of Installation	Origin
1	Digester	1	1975	BUCHI (Switzerland)
2	Peristalic Pump	1	1985	LKB BROMMA (Sweden)
3	Refrigerators	8	1965/85	PHILIPS(4) / UK (3) / West Germany(1)
4	Freeze Dryers	1	1983	LMIM (Hungary)
5	Ho-mogenizers	2	1976	Cento(1) / Unknown(1)
6	Distillation Apparatus	2	1980/85	Exelo Glass(1) / Gallenkamp(1)
7	Film Evaporator	1	1983	Gallenkamp (West Germany)
8	Cane Crusher	1	-	Unknown
9	Pulper	1	1976	News Bury (UK)
10	Deep Freezer	1	1980	FRIGIODAIRE G.M. (USA)
11	Refrigerated Centrifuge	1	1974	GE (USA)
12	Incubators	5	1976/80	Hesso(1) / West Germany(1) / China(1) / Unknown(2)
13	Fermentors	15	1971/80	E.ANCN-Italy(4) / Unknown(11)
14	Centrifuges	5	1983	SHARPLES-UK(4) / CEPA(1)
15	Flask Shaker	1	1981	Griffin & George (UK)
16	Spectrophotometer	1	1982	Japan
17	Atomic Absorption Spectrophotometer	1	1982	Japan

Applied Chemistry Division

No.	Name of Equipment	Q'ty	Year of Installation	Origin
1	Infrared Spectrophotometer	1	1980	Beckman (USA)
2	Infrared Spectrophotometer	1	1989	Hitachi (Japan)
3	Ultraviolet and Visible Spectrophotometer	1	1962	Beckman (USA)
4	Ultraviolet and Visible Spectrophotometer	1	1980	Hitachi (Japan) (Model: 100-20)
5	Ultraviolet and Visible Spectrophotometer	1	1981	Beckman (USA) (Model: 36)
6	Ultraviolet and Visible Spectrophotometer	1	1987	LKB
7	Spectronic	1	1986	Bausch & Lomb (USA)
8	NMR Spectrometer	1	1980	Hitachi (Japan) (Model:R-24B(60MHz))
9	Flame Photometer	1	n.a.	Carning (USA) (Model: EEL-100)
10	pH Meter	1	n.a.	Beckman (USA)
11	Color and Color Deferencemeter	1	1982	Lovibond (UK)
12	Gas Chromatograph	1	1970	n.a.
13	Gas Chromatograph	1	1978	Pye Unicam (Model: 204)
14	Gas Chromatograph	1	1980	Pye Unicam (Model: 104)
15	Gas Chromatograph	1	1988	Shimazu (Japan) (Model: GC-74G)
16	High Performance Liquid Chromatograph	1	n.a.	Beckman (USA)
17	Liquid Chromatograph	1	n.a.	MIM (Hungary)
18	High Performance Liquid Chromatograph	1	1984	Hitachi (Japan) (Model: 638-30)
19	Centrifuges and Ultracentrifuge	3	1977/83/83	Karl kolb/CEPA/Restch
20	Filter Press	1	1983	n.a.
21	Rotary Evaporator	1	1987	BUCHI (Switzerland)
22	Still	1	1983	n.a.
23	Autoclave	1	n.a.	Karl kolb
24	Mini Spray Dryer	1	1988	MRK
25	Ice Making Machine	1	1988	Howe

Minerals and Metallurgy Division

No.	Name of Equipment	Q'ty	Year of Installation	Origin
1	Optical Microscope	2	1976/n.a.	China / W. Germany
2	Spectrophotometer	2	1976/78	USA / Japan
3	Flame Photometer	2	1977/88	UK
4	Atomic Absorption Spectrometer	1	1976	Japan
5	pH Meter	4	1964/88	Italy
6	DTA/TGA	1	1986	West Germany
7	Infrared Moisture Meter	1	1986	Austria
8	Sulfur Determinator	1	1988	USA
9	Conductometer	1	1984	Italy
10	Polarograph Analyzer	1	1980	USA
11	Electronic Thickness Tester	1	1982	USA
12	Sand Muller/Mixer	1	1973	UK
13	Sieve Shaker	1	1970	UK
14	Mould Hardness Testing Meter	1	1986	Switzerland
15	Shell Mould Test Apparatus	1	1975	UK
16	Sand Refractoriness Testing Furnace	1	1972	Hungary
17	Vacuum Oven	1	1976	n.a.
18	Vacuum Pump	1	1987	China
19	Electric Oven	1	1988	West Germany

Glass and Ceramics Division

No.	Name of Equipment	Q'ty	Year of Installation	Origin
1	Electric Furnace	1	1970	Pakistan
2	Viscometer	1	1965	UK
3	Thermal Expansion Apparatus	1	1962	UK
4	Compression Testing Machine	1	1974	UK
5	DTA Assembly	1	1974	UK
6	Portable Hardness Tester	1	1982	Japan
7	Centrifuge	1	1967	Pakistan
8	Pulverizing Unit	1	1976	Pakistan
9	Low Temperature Furnace	1	1976	Pakistan
10	Kanthal Furnace	1	1976	Pakistan
11	Small Edge Runner Mill	1	1965	UK
12	Spectrophotometer	1	1967	UK
13	pH Meter	1	1983	USA
14	Continuous Pressure Filter	1	1976	Pakistan
15	Flame Photometer	1	1976	USA
16	Hydraulic Press	1	1982	Pakistan
17	Filter Press	1	1967	Pakistan
18	Crushing & Griding Unit	1	1967	Pakistan
19	Rotary Drum Vacuum Filter	1	1967	Pakistan
20	Rotary Furnace	1	1967	Pakistan
21	Extruder	1	1967	Pakistan

2-4 Background and Contents of the Request

2-4-1 Background of the Request

Agriculture accounts for high proportion of industry, employment and distribution of Pakistan. Agricultural production represents 25% of GDP in 1987/88 as shown in Table 2-1. However, as agricultural production is greatly influenced by weather conditions, it is difficult to keep a stable production level. The manufacturing industry has gradually been developing in recent years, which accounted for 20% of GDP in 1987/88. The industry has made possible self-supply of consumer goods to some degree. However, the nucleus of industry is light industry including textile and food processing industries, whereas high technical industry such as heavy chemical and electronic industries takes only a small part in industry in Pakistan.

It is vitally important for the national economic growth that the Government of Pakistan endeavors to develop industrial fields by utilizing domestic resources and to improve the balance of foreign currencies by strengthening the national industrial power mainly in the manufacturing industry and by domestically manufacturing substitutes for imports and products which can be exported in the near future. The modernization and development of the industrial sector are major subjects for a reform in the country's economic structure.

With a conception that improvement in the national technical level and training of researchers are indispensable to effective promotion of such industrial development, the Government of Pakistan has been making efforts to expand and improve research and educational equipment and facilities.

As a part of the activities, the Government of Pakistan has worked out the "Five year Plan of PCSIR for 1988-93" to expand and renew PCSIR's research facilities and to improve the quality of researchers. It is understood that the reasons for selecting Lahore Laboratories as the objective research institute to be applied for the project for providing research equipment are as follows:

1) Lahore Laboratories is working for research and development of unused natural resources set forth in the national economic 7th five year plan, namely, major projects for improvement of industrialization such as development of food and food industry, and development of utilization of mineral resources.

2) Lahore is conveniently located to secure natural resources. Lahore is cultural and research city, having Lahore Technical and Engineering University and Punjab University and other high educational institutes.

3) Lahore Laboratories has a number of buildings within its estate. The Laboratories is remodeling and re-constructing these buildings by obtaining budget from the Government in accordance with the priority of research contents and has a plenty of space to introduce new research equipment.

2-4-2 Contents of the Request

A total of 232 research equipment were requested to provide for Lahore Laboratories' four research divisions (Food Technology & Fermentation, Applied Chemistry, Minerals & Metallurgy and Glass & Ceramics). The contents cover various equipment and include many highly functional and advanced equipment. The following are the contents of the request by each research division.

(1) Food Technology & Fermentation Division

As the sum of imports such as wheat, tea and edible oil accounts for 12.2% of the total imports of Pakistan, self-supply of food is a pressing need of the country. Food Technology & Fermentation Division is investigating various preservation and processing methods, placing emphasis on the minimization of loss during processing and harvests and the utilization of surplus harvests for food. Requested equipment mainly include various physico-chemical equipment and analyzers which are used for basic and applied researches in food, fermentation and biological engineering. Various fermentors and incubators, which show characteristics of this research division, are also requested.

(2) Applied Chemistry Division

This division consists of research groups of agro and industrial chemicals, pharmaceuticals, oil fats and waxes, plant chemistry, industrial technology and quality control, and others. Therefore, equipment for organic analysis is chiefly requested, which includes functional equipment such as infrared spectrophotometers, GC-mass spectrometers and NMR spectrometers used mainly for researches in molecular structure of organic substances.

(3) Minerals & Metallurgy Division

Testing machinery for analysis of metallic structure, physical property tests and material tests are mainly requested. Analyzers used for metallurgical analysis, such as inductively coupled plasma emission spectrometer and atomic absorption spectrometer are also requested.

(4) Glass & Ceramics Division

Basic ceramic research equipment mainly including physical property testers and material testers are requested.

CHAPTER 3 CONTENTS OF THE PROJECT

CHAPTER 3 CONTENTS OF THE PROJECT

3-1 Objectives of the Project

The main objective of the Project for Providing Research Equipment is to carry out the following research plans with 1) renewal of the existing facilities and equipment and 2) installation of new equipment.

(1) Research to utilize domestic resources in industries

(2) Research to adopt foreign technology to Pakistan

(3) Development of new technology and products with the following objectives:

a) The most suitable utilization of natural resources
b) Substitution for import
c) Promotion of export
d) Increase in employment opportunities
e) Nationally requested technology
f) Promotion of village industries and prevention of depopulation

(4) Solution of problems in the industrial sector

(5) Consulting services related to new industrialization projects

(6) Joint research and development with industrial sectors

(7) Intensification of joint research with universities and cultivation of researchers

(8) Provision of research opportunities to senior researchers

3-2 Basic Policy for Selection of Equipment

In investigating reasonability of equipment requested by the Pakistani Government, the study team established a common basic policy for selection of equipment as follows. The equipment is selected in the light of the common recognition.

1) To coordinate the conformity of composition and required specification of requested equipment, by investigating contents of researches of each research division.

2) To select equipment suitable to the technical level of the Laboratories.

3) To confirm and adjust specification and quantity of equipment in view of contents of researches, the number of researchers, the scale of facilities, the existing equipment and the peripheral equipment.

4) To give priority to equipment which are indispensable to continuation of researches due to obsoleteness of the existing equipment.

5) To consider installation of new equipment necessary for researches meeting new needs of the domestic industries.

6) To select proper specifications of equipment, in case the equipment have exceeding functions unnecessary for research subjects.

7) To give priority to equipment which accords with objectives of researches and are frequently and widely utilized.

8) To select equipment which can be adequately maintained.

9) To avoid duplication of equipment which is planned to be supplied to other divisions.

(1) Food Technology & Fermentation Division

Research subjects of this Division are worked out in response to national demands and the new needs of the industries.

While the food section is researching for preservation, quality, safety and management of food and feed and processing of various agricultural products, the fermentation section is conducting researches in production of useful substances using microorganisms, fermentation production on the pilot plant scale and utilization of plant tissue culture. Therefore, a great variety of equipment are requested.

Equipment are classified into equipment for laboratories and equipment for pilot plant. In the food field, equipment have poor commonality, due to the variety of materials and the high specificity of each physical property. On the other hand, in the fermentation field, equipment features relatively rich commonality, despite of the variety of microorganisms utilized.

Equipment were selected in conformity with the following basic policy.

1) To give priority to substitutes for the existing obsolete equipment regarded as obstacles to the promotion of research theme.

2) To carefully investigate whether the installation of new equipment will make possible researches meeting research theme.

3) To avoid duplication of equipment which are planned to be introduced into other divisions..

4) To select proper kinds of equipment, in case the equipment have superior functions unnecessary for research subjects.

5) To select proper equipment which can be maintained and managed for proper use.

In accordance with the above policy, a part of the requested equipment is deleted and reduced redundant equipment to the proper quantity after discussion with leaders of each research theme.

(2) Applied Chemistry Division

The research in this Division covers a wide range of fields such as agricultural chemistry, industrial chemistry, oil and fat chemistry, plant chemistry, synthesis of medical drugs, industrialization technology, quality control and experiments on a pilot plant scale. It also functions as a chemical analysis center in the Punjab Province. Therefore, the various kinds of equipment are requested, but in selecting the equipment for the Division, the main consideration is the relations and importance between the research themes and the equipment necessary to such research. Also the following basic policies in giving the high priority among various kinds of requested equipment are considered.

1) Existing equipment which will suspend the research if it becomes obsolete.

2) Equipment, when newly introduced, will enable researchers to carry out the research which will meet the new needs of industries in Pakistan.

3) Equipment which meets the themes of the research, which is frequently used and is widely applied to.

4) Equipment which is required by the other Divisions, but most frequently used in the Applied Chemistry Division and which can be used jointly between divisions.

5) Equipment which can be maintained and controlled without difficulties.

6) Equipment which is installed in the other Divisions and is not expected often to be used in this Division is excluded.

Based on the above-mentioned basic principles, after the discussions with persons in charge of research themes and users of equipment, the priority of the importance on requested equipment is settled. In addition, the reasonable specifications are selected on the equipment which has too much sophisticated functions.

(3) Minerals and Metallurgy Division

The research activities in Mineral and Metallurgy Division covers a wide area ranging from the analysis and evaluation of minerals to the manufacturing of metal products. In view of the relations with the related industries and other research sectors in the country, the Division is required to function as a material research institute, an analyzing center or a product development center. These functions are indispensable for the implementation of each theme of research activities.

In view of the role and functions that the Division is required to possess, the following equipment must be improved for the Division, taking into consideration of the present situation of the research equipment.

(a) Equipment to prepare materials or specimens for testing or analyzing

(b) Equipment to test, analyze and monitor specimens

(c) Equipment to evaluate materials and specimens

To select the equipment and to investigate its specifications, the following items have also been taken into consideration besides the common basic policy.

1) The researchers must know well how to operate and maintain the equipment and also have the knowledge of its principal characteristics.

2) Utilities and consumables can be easily and continuously supplied.

3) The equipment should have necessary and sufficient functions semi-permanently and must not become obsolete or wear out in a short period of time.

4) The installing environment must be well arranged and the equipment must be used immediately after its installation.

(4) Glass & Ceramics Division

This Division, which was established in 1960, covers wide fields including glass, ceramics, refractories, ceramics materials and heavy claywares. Most of the existing equipment installed up to now are obsolete and unusable.

Contents of researches are classified as follows:

(a) Glass related research accompanying melting of raw materials

(b) Research of high temperature ceramics and refractories

(c) Research of heavy claywares sintered at low temperature

(d) Basic research with analysis using no heat reaction

According to characteristics of subjects, researches are divided into basic research, applied research, development research and measuring technology.

Equipment has been selected under the following policies.

1) Equipment indispensable to the execution of research in each laboratory

2) Equipment which needs to be renewed due to the obsoleteness

3) Equipment which are frequently used and useful for the promotion of research

4) Equipment which can be handled, maintained and managed without difficulty for the future.

5) Laboratories where the requested equipment are furnished should have enough and appropriate space for receiving equipment.

3-3 Study of Requested Equipment

3-3-1 Food Technology & Fermentation Division

This Division is one of the major divisions which were established with the foundation of Lahore Laboratories. At present, the Division has 53 researchers, the largest number next to Applied Chemistry Division, about half of which are senior researchers with doctorates.

Though it seems to have contributed mainly to training of researchers of domestic public institutions and industrial sectors, the Division, composed of seven research sections, is now putting stress on researches in line with the national policy and development researches meeting new needs of the industries.

(1) Research of Post Harvest Technologies

To prevent the loss or quality deterioration of stored food is an important research theme as Pakistan largely depends on imported food for its food supply. At present, researches have been carried out mainly on the quality control of harvested fruit and potatoes and the prevention of damages or contamination by insects or microorganisms. In the former case, temperature and respiration will affect the quality deterioration of food; and in the latter case, the temperature and humidity of the storing environment will affect damage or contamination by insects or microorganisms. The research level is low due to the lack of research equipment. If in this project any equipment is introduced to control the temperature and humidity of food storage environment and to promote the research related these factors, the causes of quality deterioration and damage from insects will be clarified and the methods of reducing quality deterioration and food loss will be developed.

Taking into consideration the above matters, major equipment selected are water bath incubator, as main equipment and electric moisture determination balance, vacuum drying oven, microscope and portable clean bench which are necessary for quality control.

(2) Research on food Processing and Packing

In this field a pilot plant is obsolete. However, the Division possesses conventional food processing equipment for dairy products, meat products, bottled or canned food and can offer highly advanced training programs. However, it does not have any research equipment necessary for the development of new types of food to meet new needs of food industry. At present, the research into the manufacture of fruit confectionery, low calorie food, low-moisture or dried food, bean sprouts and others is under way. However, the food in great demand in the industry such as condensed, dried or powdered food or instant food cannot be developed. Under these circumstances, in this project, selected equipment are compacting film evaporator, rotary vacuum evaporator, freeze dryer, mini spray dryer, fluid bed dryer and others as equipment to condense or dry food, and food cutter, vegetable dicer, soybean choppers, tomato crusher, electromagnetic labo micro pulverizer and others as experimental equipment to dice, pulverize or compress food materials.

(3) Food and Feed Quality Assurance

This field plays an important role to ensure the safety of food in people's eating habits by checking whether food or feed is contaminated by toxic substances produced by microorganisms or whether food coloring materials are toxic substances not allowed to be used for food. Not enough preparations have been done for new fields of research. In this project, major selected equipment are fundamental experiment research equipment such as electronic balance, cryoscope, and automatic diluter dispenser.

(4) Research on Applied Biochemistry

In this field, the main research objective is to recover the industrial enzymes and protein from the waste of animals such as feathers or internal organs disposed by the meat industry, condensed or hydrolyzed and to use as feed. Therefore, in this project, major selected equipment are refrigerated centrifuge, freeze dryer, slab gel electrophoresis apparatus, vacuum drying oven and others.

(5) Research into Fermentation Technology and Biotechnology

The number of researchers is the largest in this field among any other fields of the fermentation division. The development of production technology of new fermented products is under way. As the results of such research will greatly contribute to the food processing industry, a great expectation from the food industry is placed on this field.

Researchers have a strong intention to establish the fermentation production technology of solid and liquid culture and play a leading part in the industry. From this point of view, it is necessary to introduce pilot plant type equipment. However, the aerobic condition and agitation greatly affect the physiological activity of microorganisms in the fermentor where aerobic microorganisms are cultured. Therefore, unlike other processing machines, the size of a fermentor is not directly related to industrialization. For the industrialization of fermenting production, a fermentor must be equipped with instrumentation and control function in a scale suitable for the acquisition of improved technology and material balance of fermentation. Taking these matters into consideration in this project, major selected equipment are pilot plant equipment such as fermentors with a process control system (30 liters, 300 liters) and rotary type Koji making equipment, and analyzing equipment such as laboratory-sized air lift fermentor, jar fermentor, high speed amino acid analyzer, and quadrupole gas analyzer.

(6) Research into Biomass Utilization

In this field, researchers conduct research into the production of mushrooms, methane gas and feed using food industry waste or animal dung. Therefore, basic experimental equipment are selected.

(7) Research into Plant Tissue Culture

This field aims to speed up and increase the production and breeding of plants which usually take a longer period of time to grow and the production of virus free plants. Here, the tissue culture of pista vera, bulbous and cormous plants is carried out. However, its research level is still to be upgraded. Ultrasonic homogenizer is selected.

3-3-2 Applied Chemistry Division

The various types of equipment are requested by Applied Chemistry Division and they can be classified according to function as follows:

. Optical and spectrophotometric analyzers
. Electromagnetic analyzers
. Electro-chemical analyzers
. Separators and distillation apparatus
. Thermal analyzers
. Testing and physical properties measuring apparatus
. Chemical apparatus for general use
. Other chemical instruments

Many of the above-mentioned equipment can be used by other divisions, and they are required by the Division when it functions like as a chemical analysis center. Also, many of those are always required for the development, analysis and testing of chemicals even if the research themes change. The following are the results of the evaluation of each equipment according to its function.

(1) Optical and Spectrophotometric Analyzers

Optical and spectrophotometric analysis requires spectrophotometric analysis apparatus, and this analysis is an analytical method to identify substances, their molecular and atomic state and structure by detecting absorption or radiation of electromagnetic waves at specific spectrum. For wide range of electromagnetic waves, several different types of spectrophotometers are developed. The spectrophotometric analysis method is widely used because if requires very small amount of samples for relatively accurate analysis. This method is extremely important for the researchers in the chemical fields.

Although Applied Chemistry Division has four ultra-violet and visible spectrophotometers, two infrared spectrophotometers, one spectrophotometer and one flame spectrometer, these existing spectrophotometers except ultra-

violet and visible spectrometers and spectrophotometer are not sufficient in terms of function and number.

In this project new and high quality FT-infrared spectrophotometer and flame spectrometer will be introduced and fluorescencephotometer will newly be introduced for the efficient analysis of molecules of chemicals, analysis of molecule structures, determination of atomic elements and their quantitative analysis of chemicals produced or brought to the Laboratories.

(2) Electromagnetic Analyzers

The typical electromagnetic analyzers are nuclear magnetic resonance apparatus and mass spectrometer. The nuclear magnetic resonance apparatus works utilizing the property of resonance of an atomic nucleus in the magnetic field. It plays an important role in the identification of structure of substances. Recently, it is used to analyze the structure of organic chemical compounds and is also widely used in various fields such as polymer chemistry, biochemistry and medicine. The mass spectrometer is used with a gas chromatograph to separate substances and analyze the structure of separated substances, covering mainly the fields of organic compounds, biochemistry, pharmaceutics and medicine. The determination of molecules requires the results of analysis by the combination of an infrared spectrometer, a nuclear magnetic resonance apparatus and a mass spectrometer, which are indispensable for chemical analysis.

The 60 MHz nuclear magnetic resonance apparatus has been installed in the Division. However, capacity and resolution are not sufficient enough for advanced research works. Therefore, it is required to introduce nuclear magnetic resonance. And gas chromatograph mass spectrometer is also required for high precision analysis suitable to research themes planned in the Division.

(3) Electro-chemical Analyzers

The typical electro-chemical analyzers requested by the Division are polarograph, pH meter, ion meter and others. Though the polarograph is useful to analyze component elements, it was not ranked at high priority, judging from the results of discussion with researchers of the Division. Ion meter will be supplied as they are frequently used for general purposes.

(4) Separators and Distillation Apparatus

The separators and distillation apparatus requested by the Division are gas chromatograph, liquid chromatograph, electrophoresis apparatus and various distillation and extraction apparatuses. The gas chromatograph analysis is a quantitative analysis to separate a trace element in a solution by using gas as a medium. It is widely used and one of the most important analyzing methods in the field of analytical chemistry. Although there are four gas chromatographs equipped in the Division, the gas chromatograph with detectors requested will make the research activity to achieve wide range of high precision analysis of inorganic gas, organic compounds and other components. On the other hand, the liquid chromatograph is a method to separate a small amount of components in a state of liquid and is used for chemical substances which will become unstable when gasified or any substance with relatively large molecular weight. The liquid chromatographs will make possible a wide range of efficient separation and quantitative analyses of substances. The introduction of an electrophoresis apparatus will make possible the research into the basic chemical field where such experiment is carried out with snake poison currently by the Division. Furthermore, the introduction of various distillation and extraction apparatuses will make possible the developmental researches and process development of organic compounds.

(5) Thermal Analyzers

As the introduction of a thermal analyzer is planned in Minerals and Metallurgy Division and as it is not so often used in the Applied Chemistry Division, it is excluded.

(6) Testing and Physical Properties Measuring Apparatus

These measuring instruments consist of general purpose instruments including balance, thermometer and flowmeter, and spectropolarimeter, and color & color difference apparatus. Many of the instruments related to this field are mostly ones for traditional chemical analysis and measurement and many are geneal purpose instruments. They are frequently used and wear quickly. In this project the general purpose instruments will be reinforced by adding new ones. A spectropolarimeter will be introduced for analysis of photo isomer and color & color difference meter will be introduced mainly for analysis of colors of dyes.

(7) Chemical Apparatus for General Use

Typical examples of chemical apparatus for general use are dryer, incubator, stirrer, shaker, pulverizer, mixer, pump, distillation apparatus, centrifuge, autoclave, and others. For various kinds of chemical analyses, samples must undergo pretreatment such as condensation, dilution, distillation, mixing and separation. However, the existing equipment have great limitations in terms of quality and quantity to carry out analysis. These equipment will be reinforced in this project.

3-3-3 Minerals and Metallurgy Division

The equipment requested by this Division are mainly used to prepare specimens for testing and analyzing, to analyze a component and structure and to test mechanical properties of material. The study team has classified the requested equipment, discussed the purpose of each equipment and its compatibility with research themes and examined the appropriateness of the request.

(1) Microscopic Test

An optical microscope and an electron microscope are used for a microscopic test which is necessary for the separation of minerals and development of metallic materials. In the field of minerals and metallurgy research, the microscopic testing is the most fundamental method and even now the most reliable and precise inspection method due to the recent development of microscopic equipment.

There are two types of optical microscopes used in this field -- a metallurgical microscope which makes it possible to observe micro structure or color change under the scattered rays by an incident light, and a polarizing microscope which makes it possible to distinguish structure or observe the shape of a crystal by polarished light. Although some polarizing microscopes also have the functions of a metallurgical microscope; however, it is desirable to introduce both polarizing and metallurgical microscopes, because a single metallurgical microscope is a simple equipment and quite frequently used.

As the existing microscopes are obsolete and can hardly be used for research, new microscopes must be introduced and the basic functions of microscopic test must be reinforced.

An electron microscope has much higher resolution, compared to a optical microscope and is most useful for microscopic testing. The typical models are a transmission electron microscope (TEM) for thin film specimens and a scanning electron microscope (SEM) for lump-shaped specimens. In this

research field, SEM is more often used. As SEM can be used to observe extremely fine structure of crystals in three dimensions clearly, it is one of the indispensable equipment in the research of minerals, ceramics, metals and alloys. In this Lahore Laboratories it is desirable to introduce SEM as a common equipment shared by the Minerals and Metallurgy Division and the Glass and Ceramics Division.

In addition to the aboves, peripheral equipment of microscopes must be improved such as cutter, grinder and polisher to make specimens so that the microscopic equipment can be used in a most effective way.

(2) Instrumental Analysis

The analysis in this Division mainly consists of qualitative and quantitative chemical analysis of elements and thermal analysis to determine metal composition and properties. The Division has the existing research equipment such as spectrophotometer and electrolytic analyzer; however, they do not have sufficient functions, because some of them are analyzers for only particular elements or some of them are obsolete.

Introduction of an inductively coupled plasma emission analyzer (ICP) is effective as a metal element analyzer. The existing atomic absorption spectrometer analyzes only one element of one specimen, while ICP simultaneously analyzes multiple elements with simple pretreatment of a specimen in a short time. Therefore, analyzing functions will greatly be improved by introducing ICP.

An electron probe X-ray microanalyzer (EPMA) is desirable as a non-destructive analyzer of minerals, metals or ceramics. EPMA carries out qualitative and quantitative analyses of trace elements with the wave length and strength of characteristic X-rays radiated from the specimen by irradiating an electron probe to the specimen and can analyze elements ranging from beryllium (^{5}B) to uranium (^{92}U).

EPMA also detects a secondary electron radiated from the specimen and displays it as an image. The introduction of EPMA will improve the

research functions in the mineral, metallic and ceramic fields, which will result in not only the improvement of basic research but also the establishment of a research system to cope with the new industrial needs.

(3) Material Test

Material testing is indispensable in the research of metal. It is recommended to introduce general purpose equipment such as universal testing machine, impact testing machine, fatigue testing machine and hardness tester as necessary testing equipment for the analysis of basic properties of metals as well as for the development of new products. The Division has only special testing machines for casting, but no material testing machines for general use. Therefore, it is planned to introduce these material testing machines and measuring equipment to reinforce the research functions of the applied field of metals, thus to improve the function of the Division and meet the domestic industrial needs.

(4) Heating Furnace and Melting Furnace

An electric heating furnace is required for oxidization, deoxidization and property testing of minerals and metals. The existing heating furnace are obsolete, offering insufficient heating and temperature controlling functions; therefore, it is planned to introduce a muffle furnace with the functions of temperature control and ambient gas fluidization to renew a heating furnace. The heating element of the muffle furnace is silicon carbide (SiC) to raise the temperature upto 1,500°C.

Lahore Laboratories has no metal melting furnaces. At present, researchers are carrying out the research into casting mould, however, as any molten metal to be cast cannot be prepared, it is impossible to confirm the result of mould development in the Laboratories. A melting furnace is also indispensable to the refining of steel and nonferrous metals and to the research into alloys.

In particular, the research results of steel and alloy materials can be contributed directly to the needs of the new product development of

domestic industries. Therefore, it is planned to introduce a high frequency induction furnace to acquire a metal melting function. Melting will be atmospheric melting and the maximum capacity will be 50 kg equivalent of iron and the second furnace of 30 kg will be added for melting in small quantity of around 10 kg.

The specifications of the furnace will be such that, in the future, a vacuum furnace will be equipped to the induction generator which is a power source of the furnace. This generator can be shared by all the furnaces. It has been already confirmed that there is no problem concerning the place where furnaces will be installed and utilities such as electricity and water.

3-3-4 Glass and Ceramics Division

Though some of the existing equipment are obsolete, the equipment introduced at an early stage such as pulverizers for raw materials and molding machines are usable in ceramics research. The Division has few sufficient heaters such as electric furnace and has no high temperature furnace for ceramics sintering. In addition, there are few good measuring instruments, most of which seem to be unusable. Taking these matters into consideration, the study team has studied the requested equipment.

(1) Glass Research Section

This Section is conducting researches related to composition of various glass, improvement in quality and glass production technology. Equipment commonly used for these researches are to be provided, including glass melting furnace, tubular furnace, viscosity apparatus and heat distortion tester to measure physical properties at high temperature, and digital color measuring/difference calculating meter necessary for researches in glass colors.

(2) Ceramics Research Section

This Section is researching technology to utilize new ceramics, pottery, ceramic raw materials and other materials. It has no thermal high temperature sintering furnace, which is required to conduct these researches. As temperature of more than 1,600°C is necessary to sinter new ceramic materials, these kinds of researches are impossible without the high temperature furnace.

A thermobalance and differential thermal analyzer is required to measure behaviors of ceramic materials at high temperature (various thermal decomposition, crystal transformation, crystalization, thermal expansion, change in thermal gravity, etc.). Microscope and polishing machine are indispensable to make clear composition of ceramics.

Ceramic sintering temperature varies with materials, composition and atmosphere. Three-zone tubular furnace is suitable to determine the temperature precisely and promptly.

(3) Refractory Research Section

This Section is researching fire brick, speciality refractories, thermal insulating brick and other refractories. Thermal high temperature sintering furnace is very useful also in this section. Refractoriness is an important factor for refractories and action at high temperature also greatly influences quality. In other words, it is deformation caused by heat conduction and load at high temperature. Therefore, a high temperature thermal conductivity tester and a refractoriness under load apparatus are highly required.

(4) Ceramic Material Research Section

Duties of this Section include chemical and mineralogical analysis of various ceramic materials, measurement of various properties and development of material beneficiation technique.

Scanning electron microscope (SEM), which is commonly necessary in each research section, is widely used for analyses of micro-structure of materials, crystal state and defects of composition, measurement of distribution and concentration, etc. SEM is one of the most important equipment. Thermal analyzer is also necessary to identify raw materials.

(5) Heavy Ceramics Research Section

This Section is researching various heavy ceramic materials for building. Important factors for building materials are mechanical strength, weather proofing and thermal conductivity. Thermovision is used for evaluation and measurement of these properties. The equipment, which displays transition of thermal distribution in colors, is very useful to measure insulation property of building materials. In addition, universal material testing machine is used for measurement of mechanical strength of various materials.