JAPAN INTERNATIONAL COOPERATION AGENCY
MINISTRY OF UNIVERSITY AFFAIRS
THE KINGDOM OF THAILAND

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR EXPANSION OF THE FACULTY OF ENGINEERING AT THAMMASAT UNIVERSITY THE KINGDOM OF THAILAND

OCTOBER 1993

UNICO INTERNATIONAL CORPORATION

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a basic design study on the Project for Expansion of the Faculty of Engineering at Thammasat University and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Dr. Fumio Nishino Professor, Department of Civil Engineering, Faculty of Engineering of the University of Tokyo and constituted by members of UNICO International Corporation, from July 11 to July 28, 1993.

The team held discussions with the officials concerned of the Government of Thailand and conducted a field study at the study area. After the team returned to Japan, further studies were made, Then, a mission headed by Dr. Hiroshi Ito, Professor, Department of Mechanical Engineering, Nagaoka University of Technology, was sent to Thailand in order to discuss a draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the teams.

October 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

October 1993

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Expansion of the Faculty of Engineering at Thammasat University, the Kingdom of Thailand.

This study has been made by UNICO International Corporation, under a contract to JICA, during the period July 6, 1993 to October 29, 1993. In conducting the study, we examined the feasibility and rationale of the project with due consideration of the present situation of Thailand, and formulated the most appropriate basic design for the project under Japan's grant aid.

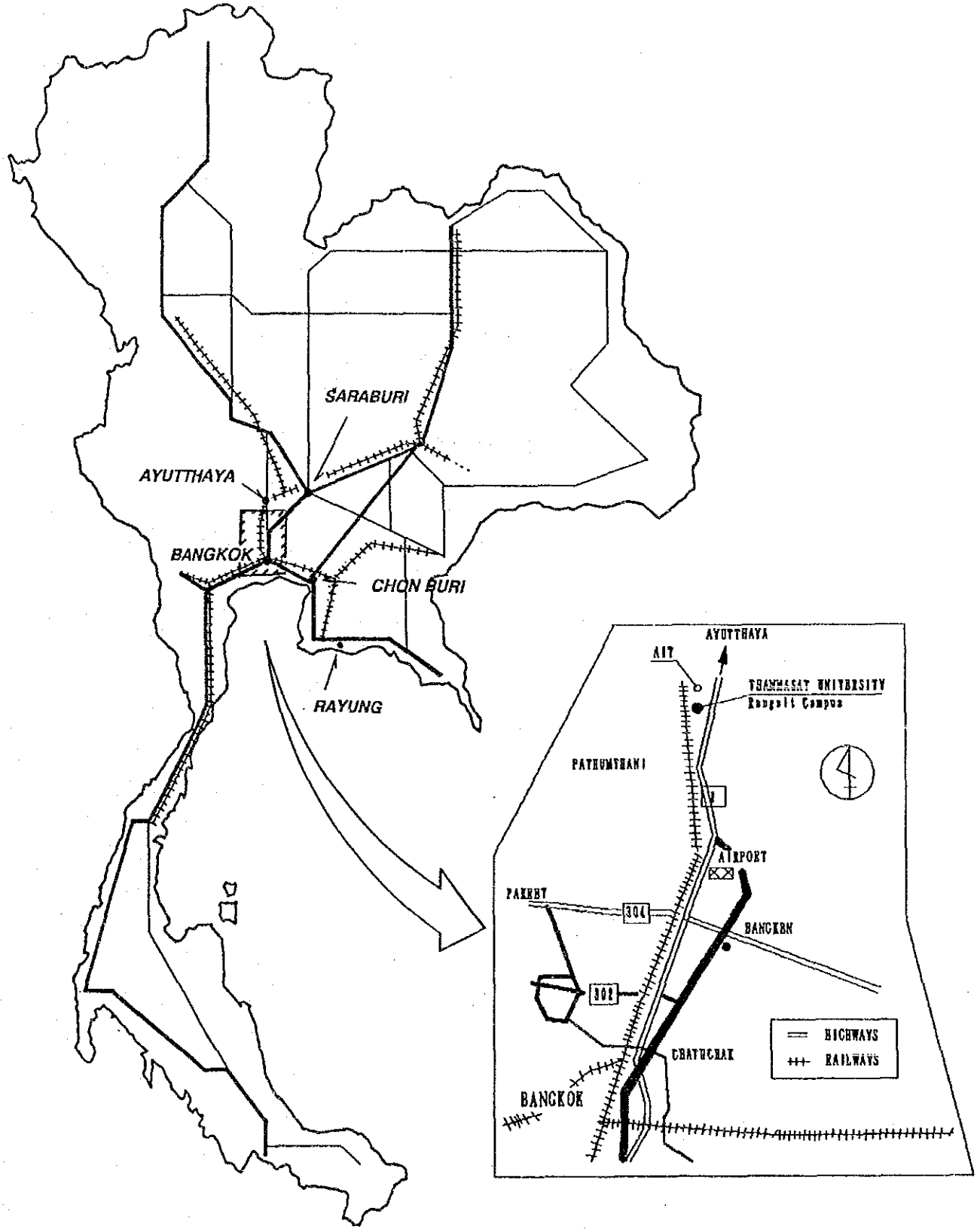
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA , the Ministry of Foreign Affairs and the Ministry of Education, Science and Culture. We also wish to express our gratitude to the officials concerned of the Thammasat University, Ministry of University Affairs, JICA Thailand Office and the Embassy of Japan in Thailand for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kiko Nagasawa
Project Manager,
Basic Design Study Mission on
the Project for Expansion of the Faculty of
Engineering at Thammasat University, Thailand
UNICO International Corporation

LOCATION OF THE PROJECT SITE



SUMMARY

SUMMARY

The economic policy of the Thai Government envisaged in the first to seventh 5-year economic and social development plans has been placing emphasis on the expansion of the social overhead capital leaving the industrial development at the hand of the private sector and has not pursued a rapid economic growth. The Government has been cautious for launching large scale industrial development projects and vigilant to the situation of financial balance and foreign debts. It has pursued modest industrialization centered on light industries possible within its technological capability and available capital, not a rapid industrial development as in other developing countries.

The economy has made great strides since the latter half of 1980s and the share of the industrial sector in the GDP has steadily increased. In 1989 the manufacturing and construction sector accounted for 32 % of the GDP against 15.2 % of the agricultural and fishery sector. During the period of the first three years of the sixth 5-year economic and social development plan (1987-1991) the growth rate reached as high as 11.7 % far exceeding the target rate of 5 %.

The per capita GNP reached US$ 1,600 in 1991 and Thailand is now a semiadvanced country. The fast development of the industrial sector brought by the rapid increase in private capital investment has caused a heavy demand for graduates from science and technology fields. Lack of engineers is now chronic. The number of students admitted to universities is limited and is not enough to meet the increasing demand for engineers caused by the rapid industrialization.

In order to make the higher education more responsive to the changing needs of the country, the government formulated " Thailand's Long-Term Plan for Higher Education (1990-2004)". In formulating the long-term plan the following trends were identified which higher education needs to take into account if it is to become more responsive to the changing needs of the country: demographic changes, increasing participation in the world community, continuing economic growth, progress of technology, urbanization, environment and natural resources, the labor market, the change of social environment.

The Plan projects changes in the Thai society for 15 years from 1990 and has two objectives: to enhance the dynamism and the effectiveness of the higher educational system and to adjust traditional ways of thinking and of performing university functions in order to meet the changing demands of the country. It makes policy recommendations to enhance the efficiency of the higher educational system and stipulates implementation goals during the seventh, eighth and ninth development plans.

During the period of the seventh five year plan the budget allocated for education will account for at least 22 % of the annual national budget, with higher education accounting for at least 15 % of the annual education budget.

Three to four thousand students graduate from engineering faculties every year while the demand for engineers amounts to about eight thousand every year. The seventh economic and social development plan intends to increase the graduates from engineering faculties by 15 % every year establishing new engineering faculties to fill the gap between the demand and supply. However, the gap is widening because the increase rate of demand is higher.

The development of human resources which is required of the industrialization is critically important to maintain stable economic growth, to develop natural resources, to raise the living standard and to improve the environment. The rapid industrialization of recent years with the sophistication and diversification of industrial structures has caused a chronic shortage of engineers and it is urgently needed to develop a educational system which can produce engineers of high caliber. The Government established in 1989 a Faculty of Engineering at the Thammasat University which has a prestigious history and tradition in social sciences and humanities. The Faculty of Engineering consists of the Department of Electrical Engineering, the Department of Industrial Engineering, the Department of Civil Engineering, the Department of Mechanical Engineering and the Department of Chemical Engineering.

The Japanese Government conducted Project Formulation Studies for Educational Sector in 1990, and confirmed that high priorities were placed on expansion of higher education and improvement of primary and secondary education. Afterwards the Thai Government requested the Japanese Government for a grant aid for the expansion of experimental equipment and a project-type technical cooperation in training of the teaching staff at the Faculty of Engineering of the Thammasat University.

Upon these requests, the Japan International Cooperation Agency (JICA) conducted a Basic Study and a Preliminary Study of the Project on Expansion for Faculty of Engineering, Thammasat University in 1992 to study the feasibility of a project-type technical cooperation. The JICA sent a mission to Thailand from 11 to 28 July 1993 to conduct a basic design study on the Project for Expansion of the Faculty of Engineering at Thammasat University. The mission studied the possibility of a grant aid, and confirmed the background of the request, details of the requested equipment, the implementation arrangement in Thailand, maintenance and management plans and the scope of the work. The mission visited institutions concerned and collected necessary information. The second JICA mission visited Thailand from 21 to 28 September 1993 to discuss the draft report of the basic design study with the Thammasat University and the Thai Government.

The results of the basic design study are summarized in the following.

(1) The Faculty of Engineering of the Thammasat University was established in August 1989. In 1990 the first batch of students was admitted in the Department of Electrical Engineering and the Department of Industrial Engineering. The Department of Civil Engineering began to admit students in 1991 and the Department of Chemical Engineering in 1993. The Department of Mechanical Engineering will admit the first batch of students in 1994. The number of students is 529 as of 1992. The total number of undergraduate students will be about 1,200 when all the five departments are fully completed with admission of 300 students each a year. The number of teaching staff is at present 38 and will be increased to 120 in the near future. Beside the regular full-time teachers, there are some part-time teachers from other universities.

The curriculum covers the standard subjects in the Thai engineering education. Some pieces of equipment have already been installed in part of the workshop buildings and are being used. A new building was completed recently. In June 1993 the Faculty moved into the new building. There are laboratories spacious enough to accommodate new equipment. Experimenta lequipment is expanding gradually which is purchased by the Government budget. However, even the equipment for student experiments is not enough and almost none for research.

(2) This project for expansion of equipment is a project for expansion of educational and research equipment necessary for education of students and for research by the teaching staff and senior students of the University. The departments which receive equipment are the five departments of the Faculty of Engineering which are to participate in the project-type technical cooperation. Equipment requested by the Faculty of Engineering is in principle in line with the scope of this project although in the course of time some pieces of equipment have been modified from the original request reflecting technological progress.

Based on these studies, an expansion project of the equipment necessary for the education and research at the Faculty of Engineering of the Thammasat University has been prepared. The outline of the project is as follows.

(1) Executing Agency: Faculty of Engineering, Thammasat University

(2) Plan of Activities: Education of undergraduate students and research by the teaching staff and senior students using the equipment provided through this project.

(3) Outline of Equipment:

Equipment planned is suitable for higher engineering education and for learning underlying principles of engineering. Experimental equipment for the departments has higher priority in selection than equipment of joint use. Criteria for selection of equipment are a balanced allocation among the departments, versatility, frequency of use and ease of use and maintenance.

(4) Installation of Equipment:

The equipment provided through this project will be installed in the workshop buildings and the main building of the Faculty of Engineering.

The equipment planned is listed in Table 1.

Table 1 Selected Equipment List

No.	Items	Q'ty
1.	**Electrical Engineering Department**	
1)	Equipment for Electromechanical Energy Conversion Laboratory (Three-Phase Squirrel-Cage Induction Motor Laboratory Set, DC Motor Laboratory Set, etc.)	1 lot
2)	Equipment for Electronics Laboratory (Prototype PCBs Production System, IC Design Software Package, Function Generators, etc.)	1 lot
3)	Equipment for Communication Laboratory (Signal Generators, Frequency counter, etc.)	1 lot
4)	Equipment for Instrumentation and Control System Laboratory (Experimental Process Unit, Robotic Unit, etc.)	1 lot
2.	**Industrial Engineering Department**	
1)	Equipment for CNC Laboratory (CNC Turning Center, CNC-EDM-Wire Cutting, etc.)	1 lot
2)	Equipment for CAD/CAM Laboratory (CAD/CAM System)	1 lot
3)	Equipment for Precision Laboratory (Measurement Data Processing Unit, Roundness Tester, etc.)	1 lot
3.	**Civil Engineering Dapartment**	
1)	Structural Loading System	1 lot
2)	Universal Testing Machine	1 lot
4.	**Mechanical Engineering Dapartment**	
1)	Eddy Current Dynamometer	1 lot
2)	Exhaust Gas Analyzer	1 lot
3)	Diesel Engine Fuel Pump Test Set	1 lot
4)	Internal Combustion Engine Test Bed	1 lot
5)	Steam Power Plant Test Set	1 lot
6)	Gas Turbine Plant Test Set	1 lot
7)	Pneumatic and Hydraulic Automatic Control System	1 lot
5.	**Chemical Engineering Department**	
1)	Equipment for Chemical Engineering Laboratory (Liquid-Liquid Extraction System, etc.)	1 lot
2)	Equipment for Analytical Laboratory (Glassware for Analytical Chemistry Laboratory)	1 lot
3)	Equipment for Organic Chemistry Laboratory (Glassware for organic Chemistry Laboratory)	1 lot
4)	Analytical Equipemnt (Scanning Electron Microscope, Gas Chromatograph, Thermal Analysis Instrument, etc.)	1 lot
6.	**Computers**	
1)	Personal Computers (for Electrical/Mechanical/Chemical Engg. Dept.)	1 lot

The cost of the work to be borne by the Thai side will be about 2.52 million Bahts. The detail design will take about three months and the equipment procurement and installation will take about nine months.

The following effects are expected when this project is realized by a Grant Aid of the Japanese Government.

(1) Many pieces of high performance equipment will be installed. These will make it possible to provide effective higher engineering education responsive to the sophistication and diversification of industries.

(2) Installation of equipment necessary for the teaching staff will help retain competent staff members who have a sense of duty and pride in education and research at the University. Consequently better education is expected.

(3) Installation of high performance equipment will enable the staff members to conduct various experiments and testing. This will help conduct research useful for the national economic development and provide technical support to other organizations.

The management and maintenance system of the project is evaluated as follows.

(1) The existing administrative system of the Faculty of Engineering will manage the project. The project is administered by a committee which is headed by the Assistant Dean for Administration and Head of Department of Civil Engineering and consists of Heads of other Departments and the faculty members. There is no problem with the organization and administration of the project.

(2) Head of a department is responsible for the daily operation and maintenance of equipment in his department. Teaching staff as well as technical staff is being increased. There will be no problem with the maintenance of equipment provided the laboratory staff are trained properly in the operation and maintenance work.

(3) The cost of operation and maintenance of equipment will be covered with the government budget which is the main source of the regular budget of the Faculty of Engineering. The Government budget is expected to increase largely (more than ten times that of 1993 after three years) as the equipment expands. Part of the rental of equipment from the Engineering English Programme will also be allotted to the Faculty of Engineering. Judging from these observations, the maintenance cost will be covered enough with the budget of the Faculty of Engineering.

The project is expected to produce the above mentioned effects and to raise the standard of engineering education in Thailand. It will contribute to the development of industries and economy of Thailand. These benefits will justify to implement this project by a Grant Aid of the Japanese Government.

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CHAPTER 1 INTRODUCTION

Chapter 1 Introduction

The economic policy of the Thai Government envisaged in the first to seventh 5-year economic and social development plans has been placing emphasis on expansion of the social overhead capital leaving the industrial development at the hand of the private sector and has not pursued a rapid economic growth. The Government has been cautious for launching large scale industrial development projects and vigilant to the situation of financial balance and foreign debts. It has pursued modest industrialization centered on light industries possible within its technological capability and available capital, not a rapid industrial development as in other developing countries.

The sixth 5-year economic and social development plan is assumed to have achieved its targets of stabilizing the economy and of improving the debt balance. The seventh 5-year economic and social development plan put an emphasis on the improvement and expansion of higher engineering education to remove obstacles to the social and economic development. Within this policy framework the Government established a faculty of engineering at the Thammasat University, which has a long history and tradition, to produce engineers of high caliber and requested the Japanese government for a grant aid to expand the educational and research facilities of the faculty.

Upon this request the Japanese government decided to conduct a basic design study on the Project for Expansion of the Faculty of Engineering at the Thammasat University. The Japan International Cooperation Agency (JICA) sent a basic study mission headed by Dr. Fumio Nishino, professor of the Department of Civil Engineering, the University of Tokyo to Thailand from 11 July to 28 July 1993 to study the background of the project, the details of the request and the present condition of the Faculty of Engineering.

The study mission had a series of discussions with the authorities concerned of this project in Thailand and visited the Faculty of Engineering of the Thammasat University and other institutions in Bangkok. The mission collected necessary information and studied the scope of the project, details of the equipment requested, the arrangement of the project implementation in

Thailand, maintenance and management plans and the scope of the work. Upon returning to Japan, the study team reviewed the propriety, optimum scale and management plan of the project and the effectiveness of assistance, and selected equipment to be provided through this project, estimated the total expenses and drew up an implementation plan in consultation with the authorities concerned.

Subsequently the JICA sent a study mission headed by Prof. Dr. Hiroshi Ito of Nagaoka University of Technology to Thailand from 21 to 28 September 1993 to explain and consult the Thai side on the draft report of the basic design study.

The report summarizes selection of equipment to be included in the basic design of the project, an implementation plan, a maintenance and management plan, evaluation of the project and suggestions. The constitution of the study mission, the itinerary, a list of persons interviewed, the minutes of discussions are appended at the end of the report (Appendix 1-4).

CHAPTER 2 BACKGROUND OF THE PROJECT

Chapter 2 Background of the Project

2.1 Economy and Social Development

2.1.1 Outline

The yearly economic growth rate of Thailand was about 7 % in 1960s and 1970s. In 1980s the economic growth slowed down as a result of the world recession. The growth rate of the GDP was 4.8 % in 1980, 4.1 % in 1982 and 3.5 % in 1985. However, the average rate in 1980s was maintained as high as at 7.9 %.

The economy has made great strides since the latter half of 1980s and the share of the industrial sector in the GDP has steadily increased. In 1989 the manufacturing and construction sector accounted for 32 % of the GDP against 15.2 % of the agricultural and fishery sector. During the period of the first three years of the sixth 5-year economic and social development plan (1987-1991) the growth rate reached as high as 11.7 % far exceeding the target rate of 5 %. The main cause of this high growth is attributed to the bigger growth of the export, investment and tourism than expected. The drop of oil price, the rise of the exchange rates on industrialized countries and the recovery of the prices of primary commodities have favored the growth of the Thai economy.

Although the growth rate slowed down a little in the ending period of the sixth 5-year plan, the Thai economy has grown and the business has expanded far more rapidly than expected during the period of the sixth plan. The high economic growth during the sixth plan period reduced the unemployment rate to 0.6 % and has resulted in almost full employment. The average yearly income doubled from 21,000 Bahts at the beginning of the sixth plan period to 41,000 Bahts at the end of the period. The direct capital investment from abroad grew steadily as in the previous period and the external reserve expanded to US$ 17 billion in the middle of 1991. The foreign liabilities decreased rapidly from 39 % to 34 % of the GDP.

The growth and stabilization of economy was maintained and the national finance was stabilized and strengthened by the cautious financial policy. However, at the same time factors to arrest the growth have surfaced as the structure of the world economy has changed. The first impediment factor is lack of the infrastructure and skilled labor. The second is the rapid rise of commodity prices. The third is the unequal distribution of income and of the benefit brought by the economic growth.

2.1.2 The Seventh Five Year Economic and Social Development Plan

The Seventh Five Year Economic and Social Development Plan covers the period between 1992 and 1996. The objectives of the Sixth Five Year Plan; 1) improvement of the balance of finance, 2) improvement of the foreign debt balance and 3) stabilization of economy were achieved. The Seventh Plan aims at building up the economic structure which may not be much affected by fluctuations of the world economy and at further growth and stabilization of its economy.

The three objectives of the Seventh Plan are:

1) To sustain economic expansion at an appropriate level with continuity anaad stability.

2) To redistribute income and decentralize development prosperity to the regions.

3) To improve the quality of life and protect natural resources and the environment.

In order to achieve these objectives, some quantitative guidelines have been set up. For instance, one of the guidelines for the quality of life and the environment is " the content of substances harmful to human health such as SO_2, CO, NO_2 in the atmosphere and lead in gasoline must be reduced to a certain extent which may not affect the health of people in the urban as well as rural areas ".

It is critically important to move ahead further with a programme to modify the structure of the industrial sector, the agricultural sector and the service and trade sector and to solve problems caused by the lack of infrastructure and energy in order to achieve 9 % of the economic growth maintaining the economic stability during the Seventh Five Year Economic and Social Development Plan. Development policies for individual industrial sectors are formulated from recognition that it is important to develop the financial, monetary and capital markets to help the stable economic growth and the development of science and technology.

"The development of human resources in science and technology " in the policy for the development of science and technology consists of the following programmes.

(1) To produce more engineers, scientists, experts and skilled workers who can cope with the changing world. To improve the existing science and technology programmes at the graduate courses by promoting more cooperation with the private sector. To train more students in the master and doctor courses at universities abroad in order to increase the university teachers and researchers.

(2) To promote the establishment of vocational training funds and vocational training facilities in specified fields and to give a high priority on holding training programmes in private sectors. To give incentives for the private sector to provide "on the job training ".

(3) To improve the work conditions of academics, especially those in research and development. One of the important objectives is to retain competent people in the government organizations providing them with better salaries and treatment including allowing professors of wide experiences and of qualification to conduct a contract research for the private sector.

" The development of the infrastructure and management system to advance science and technology " consists of the following programmes:

(1) To reorganize public institutions into those of more independence and flexibility so that the competent staff members who are recognized and respected by the private sector may find their institutions more attractive and stay in. To encourage research activities in educational institutions.

(2) To improve the activities of the public institutions placing emphasis on the formation of networks of public institutions, educational institutions and the private sector in order to apply the results of R & D for commercial purposes.

As seen from the above policy objectives, the Government recognizes the importance of training more engineers of high caliber and researchers to achieve the objectives of the Seventh Five Year Economic and Social Development Plan which are further development of industries and stable growth of economy.

2.2 Higher Education

In order to make higher education more responsive to the changing needs of the country, the Government formulated " Thailand's Long-Term Plan for Higher Education (1990-2004)". In formulating the long-term plan the following trends were identified which higher education needs to take into account if it is to become more responsive to the changing needs of the country: demographic changes, increasing participation in the world community, continuing economic growth, progress of technology, urbanization, environment and natural resources, the labor market, the change of social environment.

The Plan projects changes in the Thai society for 15 years from 1990 and has two objectives: to enhance the dynamism and the effectiveness of the higher educational system and to adjust traditional ways of thinking and of performing university functions in order to meet the changing demands of the country. It makes seven policy recommendations and stipulates implementation goals during the seventh, eighth and ninth development plans.

During the period of the seventh five year plan the budget allocated to education will account for at least 22 % of the annual national budget, with higher education accounting for at least 15 % of the annual education budget. At least 10 % of the budget of higher education will be allocated to research projects. The admission of students in science, medical science and agriculture is to be increased by more than 10 % and by more than 15 % in engineering every year.

unit: 100 milion Bahts

Fiscal Year	National Budget	Educational Budget	Educ. Budgt/ Natl. Budgt	Natl.Univ. Budgt	Natl.Univ.Bdgt/ Educ.Bdgt
1987	227,500	41,111.0	18.07%	5,353.00	13.20%
1988	243,500	42,860.7	18.01%	5,875.48	13.40%
1989	285,500	47,358.1	16.59%	6,630.50	14.00%
1990	335,000	59,962.1	17.90%	8,193.54	13.66%
1991	387,500	73,979.7	19.09%	10,510.79	14.21%

source: Ministry of University Affairs

There are three systems of universities.

(1) Government Closed System University

The admission into this type of university is limited. It is a comprehensive university which has postgraduate courses and conducts research. There are 19 universities, of which two are new universities that are autonomous and managed in a way of a private organization. Suranaree University of Technology which is in the north east region opened in 1993. Valailak University which is in the south region will be opened in 1995 or 1996. Other 17 universities are increasing their capacity of science and technology faculties setting up new faculties. The total number of students in this type of universities is about 200,000.

(2) Open University

There are two open universities which provide long distance education. The students major mainly in social sciences and humanities. More than 500,000 students are registered.

(3) Private University and College

There are 29 schools and the number of students is about 150,000.

In total there are about 85,000 students in higher educational institutions.

In the government universities as well as in private universities, the students majoring in social sciences and humanities are more than those in science and technology. Measures are being taken to increase the portion of science and engineering students, but the progress is slow due to the lack of teaching staff. At present the ratio of graduates from science and technology and health science to those from social sciences and humanities is 40 to 60. The Long-Term Plan for Higher Education envisages to reverse this ratio to 60 to 40 by the ending year of the Plan.

Three to four thousand students graduate from engineering faculties every year while the demand for engineers amount to about eight thousand every year. The Seventh Economic and Social Development Plan intends to increase the graduates from engineering faculties by 15 % every year establishing new engineering faculties to fill the gap between the demand and supply. However, the gap is widening because the increase rate of demand is higher. The next table shows the increase plan of engineering graduates drawn in 1989.

	1991	1992	1993	1994	1995	1996
1. Existing Faculty of Engineering						
1.1 National Univ. (8)	3,643	4,082	4,915	4,922	5,000	5,000
1.2 Private Univ. (6)	288	437	1,193	1,748	1,540	1,570
2. New Faculty of Engineering						
2.1 National Univ. (8)	-	29	50	205	452	480
2.2 Private Univ. (3)	-	70	135	135	175	180
Total	3,931	4,818	6,273	7,010	7,187	7,230

source: Ministry of University Affaris

In order to alleviate the lack of teaching staff the Ministry of University Affairs and the Ministry of Science, Technology and Environment created scholarships for engineering teachers. The grantee must work for a university after completion of study.

There are three schemes of entrance examination. The first is the joint entrance examination conducted by the operation committee set up by the Ministry of University Affairs. Government universities and private universities participate in this scheme. In 1992 there were 130,000 applicants and 40,000 passed the examination. Most of the successful candidates were from Bangkok. The second is the regional quota entrance examination to give more seats to candidates from the provinces. For instance Kohn Kaen University

allocates 50 % of the seats to the candidates from the eastern region and Prince of Songkla University allocates 50 % of the seats to the candidates from the southern region. The third scheme is the universities' special programmes. Talented students in science, arts or sports are admitted through the universities' special programmes.

More than 100 courses at national as well as private universities are given in English responding to the internationalization and globalization of Thai education. In order to promote exchange of students in the Asia and Pacific region, Thailand participates in " University Mobility in Asian Pacific Scheme" of APEC.

2.3 Faculty of Engineering, the Thammasat University

2.3.1 Thammasat University

(1) History

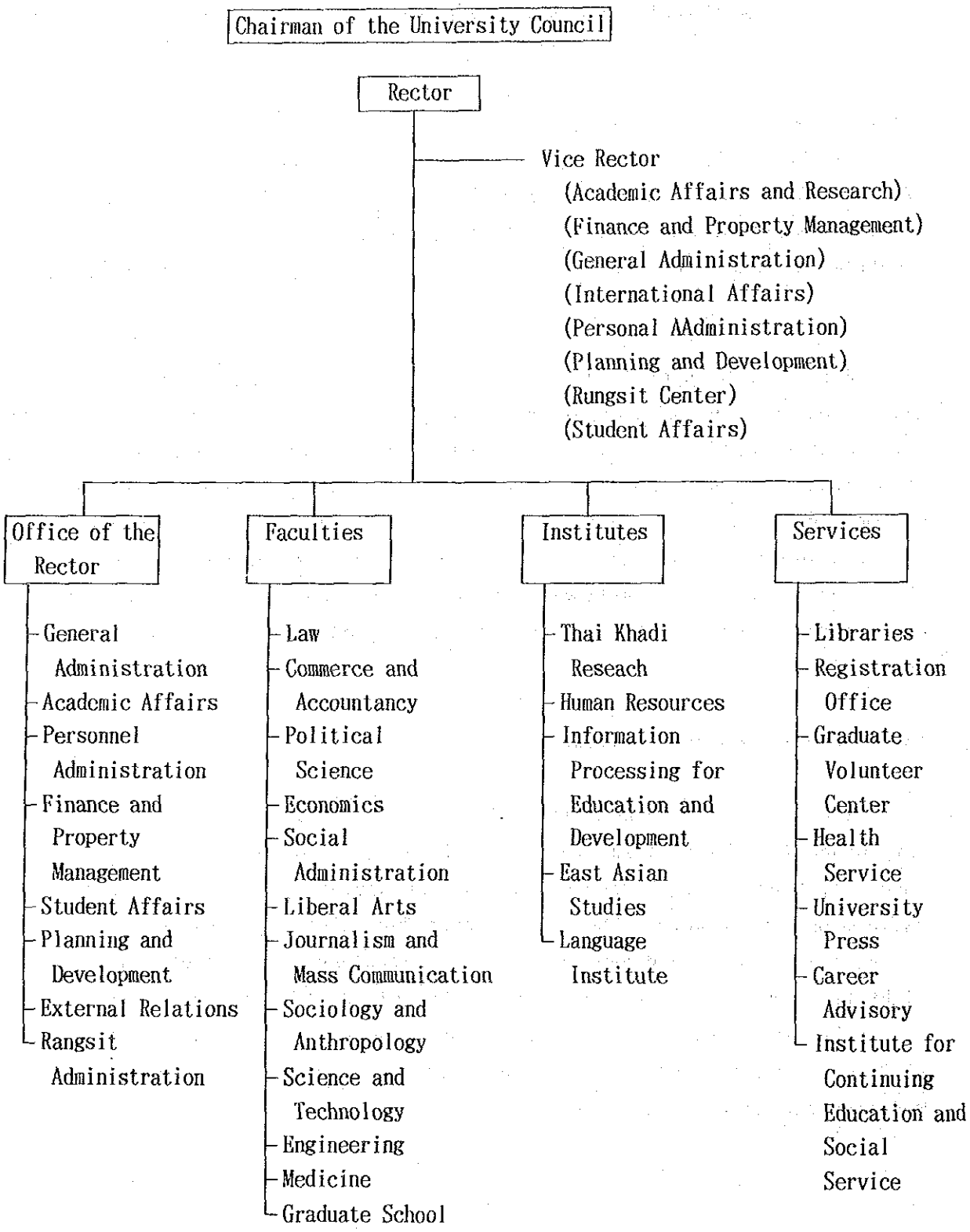
The Thammasat University was established in 1934 to provide education in law and political science. By 1949 four departments were established in social sciences and humanities. Afterwards a faculty of literature and other faculties were opened, and its reputation in social sciences has been built up.

With a purpose of producing graduates in science and technology, a faculty of science and technology was opened in 1986 in a new campus in Rangsit. Subsequently a faculty of engineering was opened in 1990 and a faculty of medicine in 1991. Now the Thammasat University has master's degree programmes in social sciences and humanities and a doctor's degree programme in business administration in addition to bachelor's degree programmes. It has also several research institutes such as Human Resources Institute. The University is one of the representative higher educational institutions in Thailand.

(2) Organization and Activities

The University is administered by the Rector under the Thammasat University Council. The organization of the University is shown in Figure 2.3.1. Under the Rector, eight Vice Rectors are in charge of eight administrative divisions respectively. There are eleven faculties, one graduate school, five research institutes and several other institutions. Of the eleven faculties, eight faculties of social sciences and humanities are housed in the old campus in Bangkok and three faculties of science and technology, namely the Faculty of Science and Technology, the Faculty of Engineering and the Faculty of Medicine are in the new campus in Rangsit.

Fig 2.3.1 ORGANIZATIONAL STRUCTURE:
THAMMASAT UNIVERSITY



The total number of teaching staff was 683 and the total staff numbered about 1,500 in 1990. About 11,700 of undergraduate students and about 640 of postgraduate students are registered. Graduates from the bachelor's degree programmes numbered about 2,300 in 1990. The number of teaching staff in a faculty is not always proportional to the number of students of the faculty. Assistant professors and lecturers number more than professors and associate professors. There are more female teachers than male teachers in the Faculty of Literature, the Faculty of Commerce and Accountancy, the Faculty of Journalism and Mass Communication, the Faculties of social sciences and the Faculty of Science and Technology. The ratio of female teachers to male teachers is 6 to 4 in the University.

In the Rangsit campus, there are a hospital (100 beds) of the Faculty of Medicine, Institute of East Asian Studies, Graduate Volunteer Center and Japanese Studies Programme beside the three faculties mentioned before. Student dormitories (for 650 students), staff's residences, a cafeteria and gymnasia are also housed in the Rangsit campus. These facilities are being expanded as the students and the staff increase.

The academic year of the university is divided into two semesters; the first semester (June to October) and the second semester (November to March). Most bachelor's degrees are obtained after four years of study. Some others are after five or six years of study. The Faculty of Engineering requires four years of study consisting of eight semesters. A master's degree is obtainable after two years of study and a doctor's degree usually requires at least three years of study after the master's degree.

(3) Engineering English Programme (EEP)

At the meeting of the Japan-Thailand Joint Committee on Trade and Economy held in Kobe, Japan in June 1989 the Federation of Thai Industries (FTI) requested the Federation of Economic Organizations, Japan for cooperation in the establishment of a new higher engineering institution in view that expansion of educational institutions to train engineers of high caliber is indispensable to the stable growth of Thai industries. At the Chiang Mai meeting of the said committee in 1990 the Federation of Economic Organizations, Japan

agreed to cooperate in this project. It was understood that funds of 1.4 billion yen would be raised (0.8 billion yen from the Federation of Economic Organizations, Japan and 0.6 billion yen from the Federation of Thai Industries). However, it turned out that it was difficult to establish a new engineering institution on this amount of funds. It was thought that the new institution should be attached to a prestigious university. This would attract more excellent students. Consultations between the establishment committee and the Thammasat University resulted in the start of the Engineering English Programme (EEP) in the Thammasat University.

The EEP is housed in the Rangsit campus of the Thammasat University and belongs to the University. However, it is independent and free from the Government restrictions in the recruit of students, the tuition fees, the appointment of teachers, the salaries of teaching staff etc. In general, the teachers of public universities are placed under the Government restrictions and their salaries are held down far low compared with those in the private sector. Because of this it is difficult for a new public institution to recruit competent teachers. The EEP is not placed under the Government restrictions and is expected to be able to recruit more easily competent teachers. It is noted that the EEP is independent of the Faculty of Engineering. The director of EEP is appointed by the Board of Trustees consisting of 12 members from the Thammasat University, the Federation of Thai Industries and the Federation of Economic Organizations, Japan. He is responsible for the administration and management of EEP. The EEP consists of five departments: electrical engineering, industrial engineering, civil engineering, mechanical engineering and chemical engineering. The department heads are full-time staff. Beside full-time professors, there are part-time professors. The part-time professors come from AIT, Chulalongkorn University and other famous universities. Admission of students started in 1992. At present there are about 270 students in the first and second year of the departments of electrical engineering, industrial engineering and civil engineering. Three hundred students will be admitted every year after all five departments are fully completed in 1995. The total number of undergraduate students of EEP will be 1,200.

The cost of facilities and the running cost of EEP are financed by the contributions from the private sector and the tuition fees. The EEP is financially independent of the Government. A plot of land was allocated to the EEP in the Rangsit campus. The construction of building started in 1993 at a site next to the buildings of the Faculty of Engineering. The construction and equipment costs will be covered with the contributions from the Federation of Thai Industries and the Federation of Economic Organizations, Japan. The salaries of teachers and the running cost will be covered with the tuition fees. The tuition fees are very high compared with those of public universities since the EEP is run without the Government budget. The EEP will use experimental equipment of the Faculty of Engineering when it is not in use by the Faculty. Twenty-five percent of the total tuition fees will be paid to the Thammasat University as the rental fee of the experimental equipment (60 % of the rental fee will be allocated to the Faculty of Engineering as a special budget apart from the regular budget).

2.3.2 Faculty of Engineering

(1) Organization and Management

(A) Purpose

In order to alleviate the severe shortage of engineers as a result of a rapid growth of industries, the Thammasat University established the Faculty of Engineering in August 1989. The Faculty consists of five departments: Department of Electrical Engineering, Department of Industrial Engineering, Department of Civil Engineering, Department of Mechanical Engineering and Department of Chemical Engineering. In 1990 the first batch of students was admitted to the Department of Electrical Engineering and to the Department of Industrial Engineering. The Department of Civil Engineering and the Department of Chemical Engineering began to admit students in 1991 and 1993 respectively. The Department of Mechanical Engineering will admit the first batch of students in 1994.

The objectives of the Faculty are as follows.

(Short-term objectives)

- To establish strong undergraduate educational programmes in engineering.
- To prepare students and faculty members for technical and professional careers in engineering.
- To bridge the gap between academics and the real world of product development and manufacturing.

(Medium and long term objectives)

- To establish a center of excellence in the fields of information technology and agro-industry.
- To fulfill its responsibility of a higher educational institution in terms of expertise and research.
- To build up technology transfer capability for the nation.

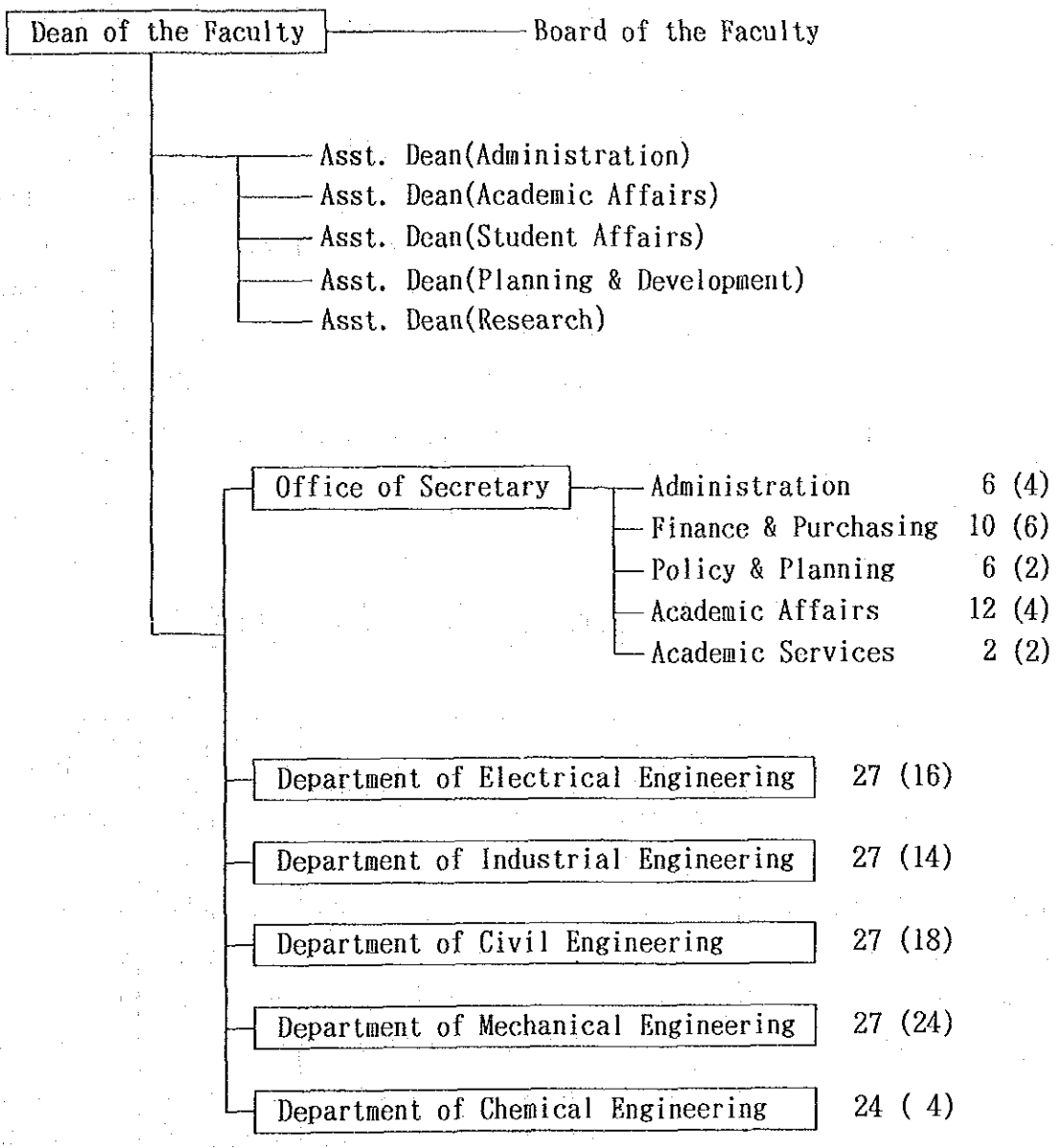
(B) Organization and Functions

Five Assistant Deans share responsibility in the administration and management of the Faculty under the supervision of the Dean. The Head of a department is selected among the teaching staff members of the department and supervises the department. The Office of Secretary is in charge of the administration (ref. Figure 2.3.2).

The number of students was 529 as of 1992 (ref. Table 2.3.1). The total number of undergraduate students will be about 1,200 when all the five departments are fully completed with admission of 300 students a year. Master courses will be set up in the future.

The number of posts in the Faculty is 89 in 1993. However, at present the Faculty members number 38 (ref. Table 2.3.2). The number of teaching staff varies with department. The Faculty is recruiting candidates to fill the vacant posts. However, it will take time to fill the available posts because university graduates from engineering departments are not enough in number to meet the demand from industries. The number of teaching staff is

Fig 2.3.2 Organization Chart of the Facuty of Engineering Thammasat University



Remarks

1. The number outside the parenthesis is the total positions available in the Faculty.
2. The number inside the parenthesis is the existing staff of the Faculty. This number includes both academic and non-academic staff.

Table 2.3.1 Number of Students in the Faculty of Engineering in 1992

Field of Study	First Year	Second Year	Third Year	Forth Year	Total
Electrical Engineering	40	47	44	47	178
Industrial Engineering	40	47	44	36	167
Civil Engineering	40	50	54	—	144
Chemical Engineering	40	—	—	—	40
Mechanical Engineering	—	—	—	—	—
Total	160*	144	142	83	529

* Actualy the first year students are still not chosen their department

Table 2.3.2 Number of Teaching Staff (1993)

Department	Current No. of Staff		Study Abroad	Total
	Prof., Assistant Prof.	Lecturer		
Electrical Engineering	—	6	5	11
Industrial Engineering	—	6(3)	3(1)	9(4)
Civil Engineering	1	11(3)	2	14(3)
Chemical Engineering	—	3	—	3
Mechanical Engineering	1(1)	—	—	1(1)
Total	2(1)	26(6)	10	38(8)

Remark ( ) : females

projected to be 24 in each department, the total being 120 when the number of students becomes 1,200 in the near future. At present many of the teachers are young and graduated from universities just a few years before. The majority of them are in the latter half of 20s and the first half of 30s. Therefore they lack experience in education and research. However, they are more active and flexible than old teachers. They have high potential capacities and are promising. In addition to the regular full-time teachers, a number of part-time teachers come from other universities, government organizations and private companies. Some departments utilize factories and other facilities near the University to provide their students with engineering practice and experiments.

At present the Faculty is in the process of building up its educational programme and concentrates its efforts on the education of undergraduate students, the expansion of facilities and equipment and the expansion of the teaching staff. It seems that the Faculty members cannot spare enough time for research activities. However, the Faculty will be engaged more actively in education and research as the expansion programme proceeds as scheduled. It is also expected to train engineers who are working in industries.

(C) Curriculum

The curriculum was prepared by the teaching staff of the Faculty of Engineering with reference to other universities' curricula and covers the standard subjects in the Thai engineering education. Students are required to take courses from the University's general education program in the first year. Lectures and experiments in basic sciences such as mathematics, physics and chemistry are given at the Faculty of Science and Technology. After the second year the lectures and experiments are given mostly at the Faculty of Engineering. As mentioned before, some departments give some of practice and experiments at factories and other facilities near the University.

(D) Management

The main building of the Faculty of Engineering was completed recently and the Faculty moved to the new building in June 1993. So the Faculty has

not yet been well organized. However, the staff members are working in close cooperation with each others and there is no sectionalism. All the staff members have a sense of responsibility and are energetic.

The regular budget is drafted by the Faculty and submitted to the Government through the Headquarters of the University for approval. The budget is divided into two sections: Non Academic Section and Academic Section. Each section is divided into three subsections: Salaries, Operations, and Equipment and Facilities.

(E) International Exchange Programmes

There are four exchange programmes which are going on or under consideration. These programmes are not always of the same nature.

a) Cooperation with the University of Nottingham, U.K.

Several programmes are in the pipeline. Such programmes as Staff Development Programme have started. Two staff members are participating in the PhD programme since the beginning of 1993. An MSc programme will start in 1995.

b) Transfer programme with the Illinois Institute of Technology

An agreement has been reached, but the programme has not yet started.

c) JICA's project-type technical cooperation

Consultation with JICA is under way.

d) Technical cooperation with CIDA, Canada

A programme to upgrade the capability of the Thammasat University in cooperation with the applied science division of the University of British Columbia. A project document has just been submitted. CIDA is considering this proposal.

(2) Department of Electrical Engineering

Electrical engineering is fundamental to many fields of high technology such as information technology, electronics design and the efficient use of energy. It is likely to be a growing area and to offer worthwhile careers to well qualified graduates. The Department provides the undergraduate students with courses in five major fields of electrical engineering : computers, communications, electronics, electric power, and instrumentation and control systems.

Experiments and practice given in this Department are as follows.

- Basic Electrical Engineering Laboratory
- Digital Circuit Design
- Electromechanical Energy Conversion
- Electric Circuit Laboratory
- Telecommunication Engineering Laboratory
- Instrumentation and Control Systems Laboratory

The present teaching staff numbers 11. However, five of them are now studying in U.S.A. and AIT. Ten-odd part-time teachers from other universities and institutions are giving some lectures and practice. Specialities of those teachers are electric installation, electric circuits, semiconductors, computers, telecommunications, instrumentation and control. They cover the fields which are just indispensable to the study of electrical engineering.

The undergraduate curriculum provides preparation in the basic electrical and physical sciences, electronics, computer science and engineering, information processing, control as well as humanities and social sciences. Many students apply for " Electrical Engineering Professional License " (EEPL) which is regarded by the students more important than the bachelor's degree. Since the EEPL is a qualification in practical business of electrical engineering, most of the engineering courses which applicants must take to apply for EEPL include practice and experiments. Accordingly equipment necessary for courses required to apply for EEPL needs to be provided. Experiments which can not be conducted at the University are conducted using the facili-

ties of other universities and private companies.

Equipment to conduct basic experiments of undergraduate students has been purchased by the Government budget. The Department is now equipped with oscilloscopes, measuring instruments such as current meters, power meters etc., D.C. and A.C. power sources, motors, some electronic devices, some controllers and so on. These pieces of equipment are installed in a workshop building. But still many pieces of equipment are required to learn electrical engineering. Equipment which is to be introduced newly for electric installation experiments, signal processing experiments, printed circuit board fabrication, telecommunications experiments, digital control experiments and so on will be installed in laboratories in the main building of the Faculty of Engineering.

(3) Department of Industrial Engineering

The Department of Industrial Engineering train industrial engineers whose work is to improve productivity. What is required of industrial engineers are understanding of the technology involved in manufacturing processes and the knowledge of management techniques. The curriculum offers two major areas: production engineering and engineering management. The graduates are working in the manufacturing industry, banks, hospitals, the transportation industry, the energy industry, the retail trade, the government offices, educational and research institutions, consultant business etc.

The experiments and practice given in this Department are as follows.

- Engineering Tools and Operations
- Tool Engineering
- Work Study
- Manufacturing Process and Technology
- Automation
- Basic Instrumentation
- Industrial Plant Design

The present number of teaching staff is 9, three of which are studying abroad (U.K. and U.S.A.). Ten-odd part-time teachers from public training institutions such as air pilot training schools, faculties of engineering of other universities and private companies are also teaching some subjects and give practice outside the campus.

The Department has already installed casting facilities, welding facilities, presses, lathes, milling cutters etc. It wants to have CNC machine tools which are widely used in Thai industries. Introduction of computers is only in its infancy. The Department plans to introduce CAD/CAM systems. Existing equipment is installed in the workshop building. The CNC machine tools and CAD/CAM systems which are planned to be introduced through this project will be installed in laboratories in the main building of the Faculty of Engineering.

(4) Department of Civil Engineering

Civil engineering is not only the engineering of structures but also the engineering for creating modern and convenient life and is concerned with environmental, social, political and economic welfare. The curriculum offers theoretical and practice courses in the planning, design, construction and management of civil works as well as environmental control. The Department aims at producing civil engineers with high academic and practical ability in the following professional fields:

1) Structural Engineering
2) Soil Engineering
3) Transportation Engineering
4) Surveying Engineering
5) Water Resources and Environmental Engineering

The undergraduate programme provides firstly studies in physical sciences, mathematics, humanities and social sciences, then proceeds to the fundamental aspects of civil engineering. The curriculum also provides a wide range of elective subjects suited to the student's goals of career. Thus the students are prepared to work effectively in any of the several branches of civil engineering.

Experiments and practice given in the Department are as follows:

- Fundamental of Civil Engineering
- Civil Engineering Laboratory
- Surveying
- Concrete Technology
- Soil Mechanics
- Highway Mechanics
- Hydraulic Engineering
- Environmental Engineering
- Traffic Engineering
- Civil Engineering Project

The present number of teaching staff is 14, two of which are studying abroad (U.K.). Additional two will join in the staff in the near future.

Equipment necessary for experiments of basic subjects has been installed which was financed from the Government budget. Equipment to be used by senior students and for research by the staff is necessary, especially for the experiments on structures. New equipment will be placed in the workshop building.

(5) Department of Mechanical Engineering

The major areas of study in the Department of Mechanical Engineering are energy utilization and the design of mechanical systems. Mechanical engineers are working in a wide range of industries. They are working in design, development, research, management and other related fields. The curriculum has been planned to give students a sound knowledge of basic sciences and engineering so that they can tackle not only current technical problems but also those that will arise in the technologies of the future.

Experiments and practice given in the Department are as follows:

- Basic Mechanical Engineering Laboratory
- Automatic Technology
- Mechanical Engineering Laboratory
- Mechanical/Machine Design
- Mechanical Engineering Project

The Department was to admit the first batch of students in 1991. However, students have not yet been admitted because of lack of teaching staff. The demand for mechanical engineers from industries is very high and it is difficult to employ mechanical engineers. The present number of teaching staff is one. But there are a few technicians. The Department has already installed a few pieces of equipment which were financed from the Government budget and is teaching basic subjects of mechanical engineering to the students of other Departments and mechanical engineering experiments to the students of the Department of Industrial Engineering. It is making efforts to expand equipment and the staff, and plans to admit the first batch of students in 1994.

Equipment for basic experiments of mechanical engineering has been installed which was financed from the Government budget. However, expansion of equipment for experiments in energy utilization, heat engineering and automatic technology is required. The workshop building is spacious enough to accommodate new equipment envisaged. The establishment of a practice facility of automobile engineering is under negotiation with Thai Isuzu Motor Co., Ltd. However, this facility will be placed in a partition separated from equipment to be installed through this project.

(6) Department of Chemical Engineering

The chemical industry in Thailand is growing rapidly. However, until recently only 6 universities have had a chemical engineering department and produced only about 300 graduates a year. There is a severe shortage of chemical engineers. Recently the Thammasat University and the Mahidol University opened a chemical engineering department in line with the expansion programme of faculty of engineering. The Department of Chemical Engineering of the Thammasat University admitted the first batch of 40 students in 1993.

The present number of teaching staff is 3 and their specialities are catalyst engineering, process control and heat transfer. There is one part-time lecturer. Two lecturers will join in the staff in 1994. In the future the number of staff is planned to become 19.

Experiments and practice given in the Department are as follows:

- Analytical Chemistry Laboratory
- Physical Chemistry Laboratory
- Organic Chemistry Laboratory
- Chemical Engineering Laboratory
- Chemical Engineering Project

In 1993 the first batch of students was admitted. Experiments in the first year are conducted at the Faculty of Science and Technology. At present there is no experimental equipment in the Department. Equipment for chemistry experiments such as shelves, a centrifuge etc. and equipment of chemical engineering experiments such as a boiler, electrical balances, an evaporator, a cooling tower etc. will be purchased using the 1994 Government budget. Some other pieces of equipment will be purchased from the 1995 Government budget. However, the Department is required to be equipped with more experimental instruments to conduct basic experiments in analytic chemistry, organic chemistry and chemical engineering. The Department wants to have these pieces of equipment as soon as possible.

The requested equipment is divided into two groups. Group I includes glassware for analytical chemistry experiments and organic chemistry experiments, and distillation units and dryers etc. which are used in the experiments of chemical engineering. These instruments are mainly for student experiments. Group II includes analytical instruments such as spectrophotometers, an electron microscope, chromatographs etc. These analytical instruments are necessary not only for the Department of Chemical Engineering but also for other departments such as the Department of Civil Engineering and the Department of Mechanical Engineering which do material analyses. A chemistry laboratory to conduct analytical and organic chemistry experiments, a chemical engineering laboratory and a project laboratory are prepared in the main building of the Faculty of Engineering.

2.4 Background and Outline of the Request

2.4.1 Background of the Request

The Thai economy achieved more than 10 % of the economic growth for three consecutive years since 1988 through the export oriented economic development. The per capita GNP reached US$ 1,600 in 1991 and Thailand is now a semi-advanced country. The fast development of the industrial sector brought by the rapid increase in private capital investment has caused heavy demand for graduates from science and technology fields. Lack of engineers is now chronic.

The Seventh Five Year Economic and Social Development Plan aims at building up a educational system which is responsive to the demand of labor market including extension of the period of compulsory education and improvement of science and technology education. The number of students admitted to universities is limited and is not enough to meet the increasing demand for engineers caused by the rapid industrialization. It is urgently needed to raise the level of production technology responding to the sophistication and diversification of industrial technology, to develop an educational system which will enhance research and development capabilities and to develop human resources.

At present there are 20 public universities and 25 private universities. The Thammasat University was founded in 1934 to teach social sciences and humanities. In 1990 the University established a Faculty of Engineering consisting of the Department of Electrical Engineering, the Department of Industrial Engineering, the Department of Civil Engineering, the Department of Mechanical Engineering and the Department of Chemical Engineering. In 1996 the total number of students of the Faculty of Engineering will be about 1,000 (it is scheduled to be 1,200 in the future) and the teaching staff will number about 100 (it will be about 120 in the future).

The Japanese Government sent an economic cooperation comprehensive survey mission led by Mr. Mikanagi in 1989 to Thailand upon a recommendation

of the Country Study for Development Assistance to the Kingdom of Thailand and conducted Project Formulation Studies for Educational Sector in 1990. It has been confirmed that high priorities have been placed on the expansion of higher education and the improvement of secondary education.

Afterwards the Thai Government requested the Japanese Government for a grant aid and a project-type technical cooperation in the expansion of experimental equipment and the training of teaching staff of the Faculty of Engineering of Thammasat University. Upon these requests, the Japanese Government conducted a Basic Study of the Project on Expansion for the Faculty of Engineering, Thammasat University in June 1992 and a Preliminary Study of the Project on Expansion for the Faculty of Engineering, Thammasat University in December 1992. Upon the results of these studies, this basic design study on a grant aid has been conducted

2.4.2 Outline of the Request

The request is outlined as follows.

(1) Objective

The objective of the requested project is to expand experimental and practice equipment necessary for education and research in line with the Project for Expansion of the Faculty of Engineering at Thammasat University.

(2) Executing Agency

The executing agency of this project is the Faculty of Engineering of Thammasat University.

(3) Activities of the Faculty of Engineering

Activities of the Faculty of Engineering are mainly education of the undergraduate students and research by the teaching staff and the senior students (master courses' students too in the future). Research requested from the Government organizations and private companies, and training of

engineers of these organizations are also conducted.

(4) Contents of the Request

The equipment requested by the Thai Government is the equipment necessary for the Faculty of Engineering of Thammasat University to conduct the above mentioned activities:

A. Equipment for experiments in the Department of Electrical Engineering

B. Equipment for experiments in the Department of Industrial Engineering

C. Equipment for experiments in the Department of Civil Engineering

D. Equipment for experiments in the Department of Mechanical Engineering

E. Equipment for experiments in the Department of Chemical Engineering

F. Equipment to be shared by all the Departments

These pieces of equipment are installed in the laboratories in the main building and the workshop buildings of the Faculty of Engineering. A list of the equipment is in Appendix-5 at the end of this report.

CHAPTER 3 OUTLINE OF THE PROJECT

Chapter 3 Outline of the Project

3.1 Objective

One of the objectives of the development programme of Thailand is to sustain economic expansion. In order to sustain economic expansion, it is urgently needed to restructure her industries and advance further the industrialization. Rapid industrialization caused by the recent increase in foreign (industrialized countries including Japan and neighboring countries) and domestic capital investment in Thai industries has made Thailand a newly industrialized country, but at the same time has led to a significant shortage of engineers and skilled labors. To develop further industries in Thailand it is indispensable to train more engineers of high standard. However, the present capacity of engineering education in higher educational institutions is not enough to produce sufficient number of engineers to meet the demand. One of the manpower development programmes of the Seventh Five Year Economic and Social Development Plan is to expand science and technology education and to create an educational system which will meet the demand of the changing labor market. The Government has taken several measures to expand higher education institutions of science and technology. In line with this policy, the Thammasat University, which has centered on education of social sciences and humanities, opened a faculty of engineering in 1989.

The objective of this project is to provide five departments of the newly established faculty of engineering of the Thammasat University, namely Department of Electrical Engineering, Department of Industrial Engineering, Department of Civil Engineering, Department of Mechanical Engineering and Department of Chemical Engineering with research and educational equipment needed for training engineers of high standard who are expected to contribute to the development of Thai industry.

3.2 Study and Examination on the Request

3.2.1 Justification of the Project and Study of the Request

The demand for engineers in Thailand is estimated to amount to about eight thousand every year. However, the number of graduates from engineering courses of higher education is estimated to be at most four thousand. To fill this gap between the demand and supply the Thai Government has made a plan to expand higher education of engineering. In line with this plan the Thammasat University opened a Faculty of Engineering. A project to provide educational and research equipment to the Faculty of Engineering of the Thammasat University is considered to be a necessary and justifiable project which can contribute to the development of Thai industries.

The Faculty of Engineering is projected to turn out 250 graduates from the five departments in 1998. Provision of educational and research equipment is expected to have the following effects.

1) The University will be able to offer a curriculum which reflects the technological level of the industry.
2) The University will be able to produce competent engineers who can increase competitive power of Thai industry in world markets.
3) The University will be able to conduct research which is requested from the government and industry.
4) The University will be able to retain competent staff members and to improve the quality of education.
5) To raise the educational and research level of the Faculty of Engineering of Thammasat University will stimulate other universities for better education of their own students and many universities will compete for better education.

3.2.2 Implementation and Operation

For the implementation of this project, an executive committee has been organized for which the Dean of the Faculty of Engineering is responsible. The Head of the Department of Civil Engineering is the committee chairman. The

Heads of other departments and some administrative officers are members of the committee. In July 1993 the Dean who had been the prime mover of this project moved to the Ministry of Science, Technology and Energy and is now helping the project as an adviser. At present the Acting Dean is responsible for the project.

Almost all staff members of the Faculty of Engineering are participating in the project and the responsibility of each member is clearly defined so that the project can be implemented smoothly through cooperation. The Ministry of University Affairs strongly supports this project. There will be no problems with the operation of the project.

3.2.3 Study of the Equipment Requested

The points which the study team considered as critical in the study of the requested equipment are as follows.

1) Equipment requested by the Faculty of Engineering is in principle in line with the plan of the original request. However, in the course of time some items of equipment have been modified reflecting the change of structures of the Faculty and the progress of technology. The study team considers that it is realistic and adequate to study equipment based on the consultation with the Faculty members at the time of this study.

2) Equipment requested to conduct experiments in engineering has priority over equipment requested as share use.

3) All departments will be equal in the allotment of amount of funds to purchase equipment. However, some adjustment will be made within a reasonable range whenever necessary.

4) Students are required to take some courses in order to apply for some professional licenses in Thailand. Inclusion of equipment which is used in these courses is taken into consideration. There are some compulsory subjects which are required to take in order to get the qualifications

of candidacy for national examinations. Some items of equipment are necessary for practicing these subjects. Provision of such equipment will meet the requirements from the Thai industries.

5) Criteria in the selection of equipment are reasonable price, versatility, frequency of use and cost-effectiveness. Equipment which is indispensable to the education of students and the research by teachers and senior students has priority in the selection. Equipment which is used in very special research or may be rarely used is excluded.

6) Equipment which will be used in education to meet the requirements of Thai industries will be selected. Engineers who can adapt themselves to the situation of Thai industries are in need. Equipment which helps practical education in the fields which are rapidly developing and demand many engineers will be selected. However, equipment which is useful in factories, but much too sophisticated or specialized to be used in education is given low priority.

7) In principle equipment made by Japanese manufacturers will be selected. However, in case that the equipment which is specialized for educational purposes and meets the performance requirements and the price of which is reasonable is not available in Japan, equipment manufactured in third countries will be considered. In view of the maintenance and after-sales service, local purchase will be considered for such items as personal computers.

The study of each item of equipment requested will be discussed as follows.

(1) Department of Electrical Engineering

1) Electromechanical Energy Conversion Laboratory

Requested items are such basic machines as motors and generators. All items are of small capacities (but not less than 1 kW) and useful to under-

stand the characteristic features of these types of machine. They include such conventional machines as induction motors, synchronous motors, DC motors, DC generators, transformers and power electronics machines such as inverters, solid state relays etc. These machines in combination of more than two or in single are connected to load (resistance which converts electric energy into heat energy). Students will learn how electric power, frequencies, voltage, electric currents, power factors will change in different combinations and how to control these machines. These machines are treated rather as energy conversion machines than as electromechanical machines. Efficient use of energy is the educational target in this laboratory.

Almost all items of requested equipment are motors and generators indispensable to experiments of electric machines and can be used in various kinds of experiment. They are useful for students to understand electric machines. Such small items as meters, switches and fuses are excluded since they are available locally and local purchase is preferred in view of their maintenance and operation. The amplidyne generator is excluded since it is an out-of-date machine which is no more in use. Introduction of power electronics machines such as inverters, SSRs etc. will change the antique look of electromechanical laboratory into a more modern and attractive looking laboratory.

2) Electronics Laboratory

Requested is basic equipment necessary to design, fabricate and test various electronic devices which use semiconductors and LSI. Equipment to fabricate small scale electronics circuits, especially CPU chips (microprocessors) is requested. It includes equipment for prototype production such as packages of software which is used on a personal computer, PCB prototype production systems, soldering stations etc., and measurement and testing instruments. Students can learn a series of processes starting with the design and ending with the evaluation of products using these instruments. These instruments are basic means to learn electronics subjects starting with "electronic circuits" ending with "project" in the curriculum. A course on the use of microprocessors will meet requirements from industries in the near future.

Such equipment necessary for the design of electronic circuits, simulation, PCB prototype production, soldering and measurement has been selected. A microprocessor-based development system can be constructed using such boards as A/Ds of the Signal Processing Laboratory and personal computers. So it was excluded from the list of requested equipment. Provision of LSIs and their accessories will enable them to fabricate development support systems by themselves. This Laboratory will be provided with equipment to fabricate electronic devices so that the laboratory may fabricate equipment which is not on sale at a market or special equipment which is difficult to be purchased because of a high price. Fabrication of electronic devices by themselves will help raise the academic level of the University.

3) Communication Laboratory

Equipment for microwave and millimeter wave communications and for data communications is requested. So far analog signal transmissions using such as AM or FM have been main means of telecommunications. However, they are recently being replaced with digital signal transmissions using such as PSK or QAM. The analog signal transmissions are shifting towards the use of higher frequency waves. In the digital signal transmissions the evaluation and measurement of the quality of transmission line is becoming more important. Request of equipment is made reflecting these trends.

Items requested for analog signal transmissions are a SSG, a RF vector network analyzer and packages of software to design high frequency circuits. A data communication test set and a bit error rate measurement instrument are requested for digital signal transmissions. These instruments are relatively sophisticated and used in senior student experiments and projects to be assigned in the final years. Electromagnetic compatibility (EMC) measurement equipment is useful for the staff members' research and is also used to meet requests from industries for measurement of EMC. A characteristic feature of this subject field is that students must learn not only basics but also sophisticated communication theories since the technological progress of telecommunications is quite rapid. For these reasons items requested range from basic to applications.

As referred to above, the communication technology is developing at a great speed. A new information network system, the integrated services digital network (ISDN) is expected to come up in the near future. In this circumstance special measurement instruments are coming up at a market one after another. However, they are usually short lived and replaced with another in turn. The list of requested equipment includes such special instruments. Most of them can be fabricated from personal computers and interfaces. Specialized instruments are often a black box and not suitable for education and research at a university. For these reasons, equipment which may be used only for special purposes has been excluded and only basic and versatile equipment has been selected. Such versatile instruments as a signal generator, analyzers (a network analyzer, and a bit error rate analyzer) etc. have been selected.

4) Instrumentation and Control System Laboratory

Equipment requested is equipment for instrumentation in a plant, digital signal processors and the related equipment, and measurement instruments. Automation of a factory is shifting from pneumatic controls to electronic controls. The electronic control process consists of measurement with sensors, operations with electrically controlled actuators and controls of these operations with microprocessors. This laboratory needs to teach the basic theories of measurement and control and an outline of actual instrumentation in a factory. Therefore they want to have equipment as similar as possible to one which is actually used in a factory.

Items requested are an experimental process unit of a chemical plant, a robotic unit, DSP boards and measurement instruments. Using these instruments students can learn theories and practice of instrumentation and control systems. These instruments will be used in "projects' in the final year too.

An electrically controlled process control system which is used in industry will be selected. The system consists of sensors, actuators and control systems. The sensors measure temperatures, levels, pressures and flow rates. The temperatures and flow rates are controlled. An arbitrary waveform generator and a FFT analyzer are also selected since they are instruments closely related to instrumentation.

For a study of the DSP (digital signal processor), a DSP board (experimental printed board equipped with a DSP and peripheral devices on a PCB) and DSP software packages are selected. They are instruments which employ new technologies in the digital signal processing to analyze and generate various signals.

(2) Department of Industrial Engineering

1) CNC Laboratory

CNC (computer numeric control) machine tools are being introduced in the machine work factories of machine parts as the technology becomes more sophisticated and the Thai industries more develop. While the operation of ordinary machine tools depends on the skills of workers, CNC machine tools require operation techniques particular to CNC machine tools in the preparation of tools, setting up of machining process and setting of workpieces. Requested equipment includes several kinds of CNC machine tools, a coordinate measuring machine and robots. These machines are important constituents of automated factories which manufacture machine parts with high precision. They are expensive. In selecting the machines to be provided it is necessary to take into consideration how widely and frequently they are used in factories in Thailand.

A machining center and a turning center are suitable for understanding and learning the production technology with CNC machine tools. So the highest priority is placed on these machines in the selection of equipment. There are two types of machining center: vertical and horizontal. When to machine heavy workpieces which require a longer preparation time, the horizontal type is more convenient since the workpiece can be set on a pallet. However, the horizontal type is more expensive than the vertical type. In view of the frequency and ease of use a vertical type machine will be selected. A turning center is used widely in machine work of various machine parts. The gantry robot requested will be excluded because this unit is used for mass production of machine parts in a factory. A university is not a mass production factory, and research into automation should be conducted in a different way. The EDM

wire cutting machine is widely and frequently used to produce metal molds or to cut workpieces in complicated shapes which are otherwise difficult to be machined. It will be included in the selection.

The EDM sink machine and the precision cylindrical grinder are different from the above mentioned machines in their use and require particular techniques in machining. In view of the frequency of use and the operation techniques of these two machines, they are considered to have low priority in the request and are excluded in the selection. The coordinate measuring machine is a useful machine to machine and measure three dimensional machine parts with high precision. However, precise measurement requires a thermostatic chamber and sophisticated techniques. It is excluded from the request since it will be not used as frequently as CNC machine tools. The articulate type robot plays an important role in the automation of machine factories in cooperation with CNC machines. However, in introducing robots into a factory, the relative economic value of robots must be calculated in comparison with the human labor costs. Although the labor costs are rising in Thailand, the rising rate is not so high to lead to wide use of robots. Its priority is low in the request. For these reasons it is excluded from the request list. As mentioned above, a vertical machining center is selected instead of a horizontal machining center.

2) CAD/CAM Laboratory

The CAD/CAM system, with the help of computers, designs, draws and analyze machine parts, simulates NC machining of designed parts and writes machining programs. As the performance of a small computer is becoming better, the image processing technology of workstations is developing and general purpose software is being widely used. The recent rapid progress of the performance of personal computers has made it possible to do the design and drawing of machine parts using software which runs on personal computers. A network consisting of workstations, personal computers and input-output devices, and software are requested. The CAD/CAM system is used to teach students the design and drawing with computers and to provide students with practice in CNC machining. The CAD/CAM technology will be widely used in the near future and the CAD/CAM system is considered to be necessary for the

Department. The system will be composed of the following components.

(Hardware)

- Workstations
- Personal computers
- Plotter
- Tape drive
- CD ROM drive
- Equipment for a network
- Laser printer

(Software)

- Software for workstations
- Software for personal computers

3) Precision Measurement Laboratory

In a precision machining factory, precision measuring technology is required as well as precision machining technology. In a mass production factory, the measuring technology which is necessary for the quality control of products (intermediate products) and the process management, and the knowledge of statistical analysis of data are required. The requested items are a measuring network which analyzes statistically data obtained by measuring products (intermediate products) produced in multiple processes and generates data necessary for the quality and process control; micrometers; gauges and a roundness tester.

Measuring instruments are indispensable in a machining factory. They are not expensive except very special ones. Arrangement of a network which processes statistically data obtained by measurement is different technology from the measuring technology. The networking complicates the measuring operation and costs much. A data processor is enough to learn the data processing techniques. Therefore a measurement data processing unit and measurement instruments with output terminals have been selected. Micrometers are excluded because most of them are for special measurement and not frequently used.

(3) Department of Civil Engineering

In recent years many high-rise buildings are being constructed in Bangkok. However, the load test of structures, the test of fatigue of structures by repeated loading or the shearing stress test is often neglected for the structures such as reinforced concrete pillars or reinforced concrete beams. While high-rise buildings are mushrooming in Bangkok, there are very few universities or research institutions which can undertake these tests for construction companies. In these circumstances, research into the structures of high-rise buildings and education of engineers in the structures of high-rise buildings are urgently needed. A hotel building in Nakhon Rathasima Province collapsed in August this year. It is said that the pillars of the building could not continue to support the weight of floors added to the building later. This incident has raised questions on the structures of high-rise buildings and the Government has instructed the authorities concerned to inspect major structures including high-rise buildings.

In the selection of equipment, the social needs have been taken into consideration. The requested equipment is divided into four categories: 1) equipment to conduct the fatigue test of the structures of buildings, 2) machines to test shearing, compressing, bending and tension of aggregates and parts of structures, and various grips for specimens to be used in these tests, 3) apparatus to test the stress characteristics of PC steel rods, concrete samples for compression test, test beams etc., 4) test specimens and temperature and humidity controllers to keep aggregates at constant temperatures and humidities. The social needs for the structural loading system of 1) is high and there are few institutions which have this system. It is considered to be significant that the Thammasat University has one. Equipment and software for earthquake analysis is not necessary because there are no big earthquakes in Thailand. Universal material testing machines in 3) are specialized equipment of high precision and are not used frequently. For these reasons the machines in 3) were excluded. Universal testing machines in 2) have been included. The temperature controllers in 4) were excluded because their installation entails considerable expenses.

(4) Department of Mechanical Engineering

The requested equipment is mainly for experiments in internal combustion engines, energy and heat engineering. Internal combustion engines are widely used as engines of agricultural machines, automobiles, ships etc. and are manufactured in Thailand too. Equipment related to internal combustion engines is an eddy current dynamometer which is used to measure the output of engines, an exhaust gas analyzer which analyses exhaust gases from engines, a diesel engine fuel pump test set which tests the performance of fuel injection pumps of diesel engines and an internal combustion engine test bed which is used to experiment the engine performance of diesel engine. These machines are necessary to conduct experiments to understand the underlying principles of the use and production of internal combustion engines. Therefore all of them will be selected.

Equipment for energy and heat engineering is a steam power plant test set consisting of a small boiler, a turbine and a generator, a gas turbine plant test set and a calorimeter for determining the capacity of air conditioning systems. The steam power plant test set is selected because it is useful for engineers who will work in a power plant or in any place related to the generation and use of energy to understand power plant systems. The gas turbine plant test set is also selected. The gas turbine plant is used in a place where there is no supply of electric power, It is useful for mechanical engineers to learn its principles and practice. The calorimeter is necessary for a manufacturer of air conditioning systems to test the performance of its products. However, it is a rather big and complicated system and is not suitable for research and education at a university. Therefore it was excluded from the request.

Beside the above mentioned items, a pneumatic control system and a hydraulic control system which control temperatures, pressures, flow rates, levels etc. are requested. These automatic control systems are widely used in factories and it is useful to learn their control characteristics. They are included in the selection.

(5) Department of Chemical Engineering

In the original application for the project, the Department requested only equipment for student experiments in chemical engineering such as a liquid-liquid extraction system, a fluid-solid extraction system, a chemical engineering process control test set, a continuous plate distillation unit and a batch plate packed distillation unit etc. Analytical instruments such as spectrophotometers, a scanning electron microscope etc. were requested from the Department of Civil Engineering for its Material Laboratory. Afterwards, the request for analytical instruments have been changed to that of the Department of Chemical Engineering.

The requested equipment is divided into two groups. The first group is equipment for chemical engineering experiments and mainly for student experiments. The second group of equipment is for student experiments as well as research by the teaching staff. This group is also necessary in other department of the Faculty.

The first group of equipment includes:

Glassware.....	Glassware for analytical chemistry laboratory, Glassware for organic chemistry laboratory.
Distillation units.....	Continuous plate distillation unit, Batch packed distillation unit.
Dryers.....	Drum dryer, Spray dryer.
Extraction systems.....	Liquid-liquid extraction system, Fluid-solid extraction system.
Reactors.....	Stirred liquid phase reaction unit, Fluidized-bed reactor, Fixed-bed reactor.
Others.....	Ball mill set, Stirrers set, Process control test set, Personal computers

The second group of equipment includes:

Atomic absorption spectrophotometer, Scanning electron microscope,
Thermal analysis instrument, UV-visible spectrophotometer,
Gas chromatograph, X-ray diffractometer,
X-ray fluorescence spectrometer, High performance liquid chromatograph,
Fourier transform infrared spectrophotmeter, Ion chromatograph.

1) First Group

The glassware for analytical chemistry laboratory and the glassware for organic chemistry laboratory are indispensable to analytical chemistry experiments and organic chemistry experiments respectively. At present the Department does not have any glassware and these items are "must" for these laboratories. The continuous plate distillation unit and the batch packed distillation unit are used in experiments in distillation in the chemical engineering laboratory III in the curriculum. The liquid-liquid extraction system is used in liquid-liquid extraction experiments of the chemical engineering laboratory III in the curriculum and the solid-liquid extraction system is used in solid-liquid extraction experiment of the chemical engineering laboratory III in the curriculum. The reactors are used in reactor experiments in the chemical engineering laboratory II and III in the curriculum. The ball mill set is used in the ball mill and sieve analysis of the chemical engineering laboratory I in the curriculum, the stirrers set in the mixing experiment of the chemical engineering laboratory I. The process control test set is used in the controlled evaporator experiments of the chemical engineering laboratory III.

As seen from the above, all the items are used in basic experiments of chemical engineering. However, it may be heavy burdens on the staff members to conduct all experiments prescribed in the curriculum since at present only three teaching staff are available. It will be more effective educationally to reduce the number of themes of experiment and to carry a fewer experiments thoroughly. Experiments on distillation, drying and extraction will be reduced to one each. The continuous plate distillation unit has been selected for experiments in distillation, the drum dryer for experiments in drying and

the liquid-liquid extraction system for experiments in extraction. All reactors requested were for liquid-liquid reactions. It will be better to include equipment for gas-solid reaction. Therefore a gas-solid catalytic reactor has been selected instead of the fixed-bed reactor. The process control test set is excluded from the request because the Department of Electrical Engineering has requested a similar set. While equipment of physical chemistry experiments will be purchased from the University budget, a vacuum-gas circulating absorption/reaction apparatus is not included in the purchasing list. It is recommended to include this apparatus in the request if possible.

2) Second Group

Equipment of the second group, analytical equipment, is mainly used for the research into catalysts by the staff members of the Department. In the past decade there has been a large expansion of the petrochemical industries in Thailand because the country is abundant in natural gas. However, methane which constitutes more than 70 % of the natural gas in Thailand is not effectively utilized because the research into catalysts to convert methane to something else valuable with low cost is lagged behind. The development of catalysts which suit to the natural conditions in Thailand is also necessary. For instance, the catalyst which is used for converting paraffins to olefins is fast deactivated because of a trace amount of mercury. Therefore the research into catalysts is quite important in Thailand. Furthermore this field is most suitable for a research theme of the staff members because they have been trained and have interests in this field.

Research into catalysts requires equipment for the preparation of catalysts, for the catalytic reactions, for the analysis of catalysts and for the characterization of catalysts. The equipment requested is mainly for the analysis and characterization of catalysts. Most items are those which are too expensive to be purchased from the University budget or to be used by other departments of the Faculty too. The scanning electron microscope is used to observe the surface structures of catalysts. The atomic absorption spectrophotometer and the X-ray fluorescence spectrometer are used for analyses of chemical components. The X-ray diffractometer is used for the structural analysis of the substance and the thermal analysis instrument for study-

ing property changes of a substance when it is treated with heat. The UV-visible spectrophotometer is used to study the photo absorbance of a substance in ultraviolet and visible ranges of light. The gas chromatograph is used to identify the composition of a gas or volatile liquid sample. The Fourier transform infrared spectrophotometer is recently in wide use for the analysis of structures of a substance. The high performance liquid chromatography (HPLC) is widely used in organic chemistry research and the ion chromatograph is mainly used in biochemistry and environmental engineering. However, these two are not so much used in the research into catalysts. As mentioned before these analytical instruments are widely used in other fields of engineering. For instance the scanning electron microscope is used to study the corrosion of steels and the crystallinity of cements in civil engineering. The gas chromatograph is used to study the composition of a flue gas from the combustion engine in mechanical engineering. Whenever the material analysis is required, these instruments are used. Of these instrument, the HPLC and the ion chromatograph are excluded from the request because they are not so much used in the research into catalysts. The X-ray diffractometer and the X-ray fluorescence spectrometer are also excluded because they will not be used for the time being. The atomic absorption spectrophotometer is widely used in chemical element analyses in chemistry and physics. However, the Fourier transform infrared spectrophotometer has been selected because analyses of organic compounds are more important in chemical engineering than element analyses.

(6) Equipment for Common Use

Equipment requested for common use is 1) an AV system for the auditorium of 150 seats, 2) equipment for a video library and 3) a mini bus of 25 seats. The AV system consists of microphones, tape recorders, mixers, amplifiers etc. If the auditorium is equipped with this kind of AV system, the auditorium will be able to be used for holding international conferences or lectures before a large audience. The video system library consists of a set of recorders and monitors and a set of video cameras and editing tools. With these facilities educational video tapes can be produced which show outdoor practice and procedures of experiment etc. Students can self-study viewing these video tapes.

The minibus will be used to transport students when they go to practice outside the campus or field surveys. At present the Faculty does not have a means to transport a group of students.

These facilities are to be used in common by all the departments and are quite helpful to increase the efficiency of education. However, at this stage of development of the Faculty of Engineering priority needs to be placed on equipping itself with experimental facilities rather than with those supporting facilities. The mini-bus is not acceptable because its use is not directly connected with education and research. For these reasons common use facilities have been excluded from the request list.

(7) Computers

The Faculty of Engineering has a five year plan to develop its computer system. The plan divides its computer use into four categories and each category has its expansion programme.

Category 1: Education and practice of students.
- Group 1: Education and practice of students of the Faculty of Engineering.
- Group 2: Practice of students of the Faculty of Engineering and other Faculties.

Category 2: Education and research of teaching staff.
Category 3: Preparation of office documents in administration.
Category 4: Experiments and project research.

So far computer facilities in Category 1 have been installed. Personal computers for the education and practice of the students of the Faculty of Engineering and workstations in common use for education and research have been installed.

Computers requested in this project for common use and for each department are classified as follows.

1) Personal computers and peripherals for common use (corresponding to the above mentioned Category 1).
2) Workstations and peripherals for common use.
3) Personal computers for the Department of Electrical Engineering, the Department of Civil Engineering, the Department of Mechanical Engineering and the Department of Chemical Engineering (corresponding to Category 2)
4) CAD/CAM systems of the Department of Industrial Engineering (included in Category 4)
5) Computers attached to some kind of laboratory equipment for data processing or setting of conditions (included in Category 4)

Computers of 1), 2) and 3) will be studied in this section. The Faculty has already 70 personal computers and 11 workstations (including new ones introduced in 1993) for education and practice of the undergraduate students as common facilities which were purchased from the Government budget. These facilities will be expanded whenever necessary within the limit of the budget. Inexpensive personal computers for students to practice are manufactured and sold all over the world. This type of computer should be purchased locally in view of the availability of maintenance services. For these reasons the personal computers of 1) and 2) which are facilities common to many students would be better purchased from the University budget and are excluded from this project. The personal computers requested in 3) for each department are for teaching staff members and senior students to use in research activities and of high grade. Nowadays research in science and technology can not be performed without computers. Without computers one can not design an experiment and can not analyze the result of experiment. Computer simulations combined with an experiment are quite useful and effective in obtaining results of the experiment. For these uses it is necessary to provide computers which can perform not only numerical calculations but also image processing and analyzes with sophisticated software. At present the Faculty does not have such computers. In these circumstances provision of some number of computers of the type mentioned above is considered to be necessary in the project. A printer must be provided with each computer.

3.2.4 Basic Policy of Implementation

The study team has confirmed the effect and feasibility of the project and also the capability of the Thai side to implement the project. We consider that the project is in line with the purpose of a Grant Aid and it is justified to implement the project by a Grant Aid of the Japanese Government for the reasons mentioned so far. Accordingly we examine the outline of the project and conceive a basic design of the project on the assumption that the project will be carried by a Grant Aid of the Japanese Government. However, part of the contents of the request will be revised as mentioned in Section 3.2.3 " Study of the Equipment Requested".

3.3 Project Description

3.3.1 Executing Agency and Operational Structure

(1) Executing Agency

The executing agency of the project is the Faculty of Engineering of the Thammasat University.

(2) Operational Structure

The operational structure of the project is the existing administrative system of the Faculty of Engineering of the Thammasat University. A project team has been formed which consists of the heads of the five departments and the assistant deans. The team leader is the Head of the Department of Civil Engineering. The Dean directs the Assistant Dean for Administration (who is also the Head of the Department of Civil Engineering) to carry the works such as foundation work, electric work, piping work etc.; to arrange the finance matters such as provision of the installation cost, maintenance fees etc.; to take charge of assets; and to employ staff members with assistance of the University Headquarters. Each department is responsible for the management, operation and maintenance of the equipment to be provided to the department. The staff member in charge of a laboratory is responsible for the management of the laboratory and the head of department supervises all laboratories of his department.

There are 18 staff members in the Office of Secretary (the number of posts is 36). The number of staff members of all the departments is 76 including 38 of teaching staff. The total posts available in the five departments are 136. These vacant posts will be filled gradually as the number of students increases and the equipment and facilities are expanded.

3.3.2 Location and Condition of Project Site

(1) Location

The Faculty of Engineering of the Thammasat University is in Rangsit in Pathumtanee Province, about 40 km north of Bangkok. In the campus there are the Faculty of Medicine, a hospital which has about 100 beds, the Faculty of Science and Technology, the Institute of East Asian Studies, the Administration Office of Rangsit Campus and some other offices. The campus also houses student dormitories and staff residences. The Engineering English Programme mentioned before is constructing its building next to the building of the Faculty of Engineering. The total area of Rangsit campus is about 390 hectares. The area allotted to the Faculty of Engineering is 32 hectares.

The map of the campus is shown in Figure 3.3.1.

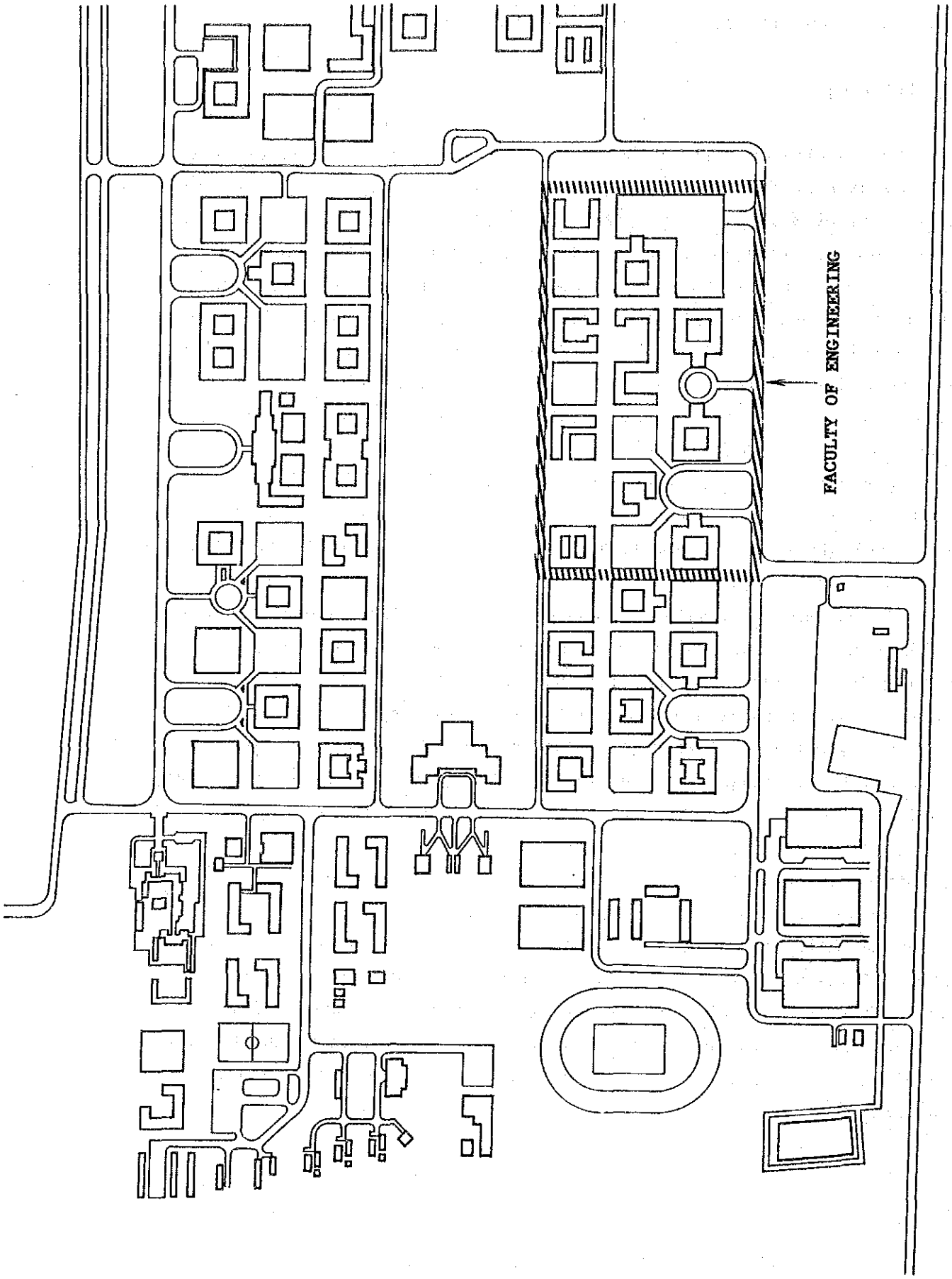
(2) Building

The buildings in which the equipment will be installed are the main building of the Faculty of Engineering and the workshop buildings. The main building has seven stories and the total floor area is about 30,000 m^2. There are three workshop buildings ; one for electrical engineering and industrial engineering, one for civil engineering and one for mechanical engineering. The workshop buildings have two stories. The floor area of each building is 2,600 m^2.

1) Structure of Building

The buildings are all of reinforced concrete. The main building has seven stories and the workshop buildings have two stories. The main building has 4 lifts (the maximum load is 700 kg and the front width is 1 m); two on the east side and two on the west side. There is no lift in the workshop buildings. The maximum allowable load of the floor in the main building is 0.4 tons/m^2.

Fig. 3.3.1 MAP OF FACULTY OF ENGINEERING



The main building of the Faculty of Engineering was completed in June 1993 and has just housed the Faculty. The workshop buildings were completed earlier and some pieces of equipment were already installed and are in use. The layout of the buildings is as follows.

Main Building 1st Floor: Chemical Engineering Laboratory, Electromechanical Energy Conversion Laboratory, CNC Laboratory.
2nd Floor: Dean's Office, Administrative Office, Chemical Engineering Laboratory, Computer Rooms.
3rd Floor: Lecture Rooms, Auditorium, Chemical Engineering Laboratory.
4th Floor: Staff Rooms, Library
5th Floor: Electrical Engineering Laboratory, Computer Rooms, Drawing Room.
6th Floor: Research Laboratories.
7th Floor: Conference Rooms, Seminar Rooms, Exhibition Room.
Workshop Building I : Industrial Engineering Laboratory (on the first floor), Electrical Engineering Laboratory (on the second floor).
Workshop Building II : Mechanical Engineering Laboratory.
Workshop Building III : Civil Engineering Laboratory.

Air conditioning facilities are not installed except in some rooms such as conference rooms.

(3) Infrastructure

1) Road

There are paved roads in the campus leading to the buildings of the Faculty of Engineering from the national highway. There are no such impediments as bridges to impede transportation of equipment. There is enough space for moving equipment around the buildings.

2) Electricity

Electricity is supplied by the Provincial Electricity Authority (PEA) and the voltage is dropped to 3-phase 380 V and 1-phase 220 V in the transformer room in the main building of the Faculty of Engineering. The voltage fluctuation is within 10 % of the nominal voltages. A power failure happens once a week during a period of frequent power failures.

3) Water Supply

Water is supplied from deep tube wells in the campus. The water level is 153 m deep. The water qualities are:

pH : 7.5
Turbidity : 0.8 NTU
Electric conductivity: 776 micro-siemens/cm (at 25°C)
Chemical constituents:

	mg/liter		mg/litre
Ca	31	SO_4	21
Mg	9.1	CO_3	0
Na	143	HCO_3	472
K	1.6	CO_2	24
Fe(soluted) -		NO_2	0.15
Fe(total)	0.16	NO_3	0.2
Mn(soluted)	0.17	F	0.0
Cu	0.0	Total solids	:488
Zn	0.05	Total hardness as $CaCO_3$	:122
Cl	22	Non carbonate hardness	: 0

source: Faculty of Engineering, Thammasat University

(4) Climate Conditions

The maximum temperatures, minimum temperatures, mean temperatures and relative humidities by month in Bangkok are shown in the following Table.

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temp. (°C)	Max.	32.0	32.7	33.7	34.9	34.0	33.1	32.7	32.5	32.3	32.0	31.6	31.3
	Min.	21.0	23.3	24.9	26.1	25.6	25.4	25.0	24.9	24.6	24.3	23.1	20.8
	Mean	25.9	27.4	28.7	29.7	29.2	28.7	28.3	28.1	27.8	27.6	26.9	25.6
Relative Humidity(%)		71	75	75	75	78	78	78	79	82	81	76	71

source: Climatology Division, Meteorological Department, Thailand

3.3.3 Outline of Equipment

The study of the equipment requested discussed in "3.2.3 Study of the equipment requested" has resulted in the selection of equipment outlined in the following.

(1) Department of Electrical Engineering

The equipment to be used in the courses required to apply for Electrical Engineering Professional License in Thailand (EEPL) and equipment for research by the teaching staff and for fabrication of teaching materials has been selected. It includes electrical equipment, communication equipment, measurement and control equipment, electronics equipment etc.

1) Electromechanical Energy Conversion Laboratory

Motors, generators and power electronics equipment such as inverters, SSRs have been selected. They are basic machines, and machines of the latest model which will be employed more effectively in the future.

2) Electronics Laboratory

Equipment necessary for fabricating electronic circuits has been selected. It includes equipment necessary for the design of circuits, for the design and fabrication of PCB, measurement instruments etc.

3) Communication Laboratory

Basic equipment for high frequency wave transmissions and for testing of transmission lines. Signal generators and several kinds of analyzers.

4) Instrumentation and Control System Laboratory

Instruments necessary for instrumentation of process control, and instruments necessary to study instrumentation such as an arbitrary waveform generator and a FFT analyzer. These instruments will help substantially the study and research of instrumentation.

Table 3.3.1 lists the items of equipment selected and the purposes of their use.

(2) Department of Industrial Engineering

CNC machines, precision measurement instruments and a CAD/CAM system (hardware and software) which are and will be in wide use in factories have been selected.

1) CNC Laboratory

CNC machine tools such as a CNC machining center, a CNC turning center and a EDM wire cutting machine have been selected.

2) CAD/CAM Laboratory

A CAD/CAM system has been selected which can do the design and drawing with computers (computer aided design) and simulate the cutting process of the designed machine parts. The system is constituted of workstations, personal computers, peripherals and CAD/CAM software.

3) Precision Measurement Laboratory

Several kinds of measuring instruments for precision measurement of length and diameters of workpieces, a data processing unit which processes measurement data, and a roundness tester.

Table 3.3.2 lists the items of equipment selected and the purposes of their use.

(3) Department of Civil Engineering

Equipment for experiments in structures has been selected. It includes a structure loading system and a material testing machine for aggregates and concrete.

Table 3.3.3 lists the items of equipment selected and the purposes of their use.

(4) Department of Mechanical Engineering

An eddy current dynamometer, an exhaust gas analyzer, a diesel engine fuel pump test set and an internal combustion engine test set have been selected for experiments in internal combustion engines. A steam power plant test set and a gas turbine plant test set have been selected for heat engineering. A pneumatic and hydraulic control system has been selected for automatic control experiments.

Table 3.3.4 lists the items of equipment selected and the purposes of their use.

(5) Department of Chemical Engineering

1) Analytical Chemistry Experiment

Sixty sets of glassware including desiccators, burettes, volumetric flasks etc. which are used in analytical chemistry experiments have been selected. Although the number of students in the second year is 40 at present, extra sets must be in reserve since glassware is fragile and easily broken.

2) Organic Chemistry Experiment

Sixty sets of standard glassware used in organic chemistry experiments. The number of sets is sixty for the same reason above. The glassware set is also used in experiments in vacuum distillation and fractional distillation.

3) Chemical Engineering Experiment

A continuous plate distillation unit in distillation experiments, a drum dryer for drying operations, and a liquid-liquid extraction system in extraction experiments have been selected. A fermenter system and a fluidized-bed reactor have been selected for chemical reaction operations. In experiments on gas-solid reactions, a gas-solid catalytic reactor has been selected. A stirrers set equipped with a control box which can measure rotation speeds and torque has been selected for the study of the effect of many factors in stirring. A ball mill set has been also selected to study the various effects of the ball mill.

4) Analytical Instruments

A scanning electron microscope to observe the surface characteristics of catalysts, a thermal analysis instrument to study property changes of a substance when it is treated with heat, and a UV-visible spectrophotometer to measure photo absorbance of a substance in ultraviolet and visible light ranges and a Fourier transform infrared spectrophotometer have been selected.. These instruments are mainly used for research into catalysts, but also for

material analyses in other fields of engineering as mentioned before. A gas chromatograph has also been selected because this is a very versatile instrument in chemical analyses.

Table 3.3.5 lists the items of equipment selected and the purposes of their use.

(6) Computers

Personal computers have been selected to be used in the Department of Electrical Engineering, the Department of Mechanical Engineering and the Department of Chemical Engineering.

Table 3.3.6 lists the items of equipment selected and the purposes of their use.

Table 3.3.1 Outline of the Selected Equipment for Elecrical Engineering Department

(1) Electrical Engineering Department

1) Electromechanical Energy Conversion Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
2.1.1	Three-Phase Squirrel-Cage Induction Motor Laboratory Set	To measure and study characteristics of such electric machines a motors, generators, transformers etc.
2.1.2	Three-Phase Slipring Induction Motor Laboratory Set	-ditto-
2.1.3	DC Motor Laboratory Set	-ditto-
2.1.4	DC Generator Laboratory Set	-ditto-
2.1.5	Single-Phase Motor Laboratory Set	-ditto-
2.1.6	Three-Phase Synchronous Motor Laboratory Set	-ditto-
2.1.7	Three-Phase Synchronous Generator Laboratory Set	-ditto-
2.1.8	Transformer Laboratory Set	-ditto-
2.1.10	Power Electronic Equipments	To measure and study characteristics of power electronics devices such as inverters and SSRs.
2.1.11	Connecting leads	To use in experiments of 2.1.1 - 2.1.10

(2) Electronics Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
2.1.1	IC Design Software Package	Software to design ICs. It is used to design ASICs and analogue ICs.
2.1.2	Circuit Schematic Simulation Software Packages	To simulate designed electronic circuits.
2.1.3	PCB Layout System Equipments for PCB fabrication	To design PCB layout for designed electronic circuits.
2.2.4	Prototype PCBs Production System	To produce a PCB pattern on a PCB. A machine uses milling process to produce copper routes on PCBs.
2.2.5	Soldering Station	To use to mount chips on or remove chips from PCBs.
2.2.6	Plotter	to output PCB patterns on paper.
2.2.7	Supporting Materials Equipments for Circuit Board Testing	Components to fabricate electronic circuits.
2.2.8	Digital Storage Oscilloscope	To test electronic circuits on PCBs observing signal waves.
2.2.9	Function Generator	To generate signals to test electronic circuits on PCBs.
2.2.10	Logic Analyzer	To use for time-domain analyses of digital circuits on PCBs.
2.2.11	Data Generator	To use for generating data patterns in digital circuit testing.

(3) Communication Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
2.3.1	Signal Generator	To generate test signals in radio frequency ranges.
2.3.2	RF Vector Network Analyzer	To measure amplitudes and phases of high frequency signals and analyze components of electronic circuits.
2.3.4	Frequency counter	To count frequencies.
2.3.5	High-frequency Analog Design Software Packages	To design high frequency circuits to be used in telecommunications.
2.3.6	EMC Measurement Systems	To measure the level of interference waves generated by electronic devices and to use to confirm that interference may not cause wrong action.
2.3.9	Bit Error Rate Analyzer	To analyze digital signals transmitted through communication channels.

(4) Instrumentation and Control System Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
2.4.1	Experimental process unit	To study a process control system of a chemical plant.
2.4.2	Robotic unit	To study actions and control systems of working robots.
2.4.3	General-purpose DSP board	To use for the analysis and synthesis of electric signals employing FFT.
2.4.4	Accessory boards	To use for the analogue-digital and the digital-analogue conversion.
2.4.5	DSP software package	Software for the analysis or synthesis of electric signals using DSP elements.
2.4.6	Arbitrary waveform generator	To generate arbitrary wave forms synthesizing signals and other time functions.
2.4.7	FFT Analyzer	To analyze electric signals using fast Fourier transform.

Table 3.3.2 Outline of the Selected Equipment for Industrial Engineering Department

(2) Industrial Engineering Department

1) Equipment for CNC Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
3.1.3	CNC TURNING CENTER	For external/internal cutting of cylindrical form work(part)with cutting tools
3.1.4	CNC-EDM-Wire Cutting	For EDM cutting a work which is difficult to cut with usual cutter with wire type electrode
3.1.8	CNC Vertical Machining Center	For various shaping/boring a work which is fixed on the table with various type cutting tools

2) Equipment for CAD/CAM Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
3.2	CAD/CAM System	For computer aided design, drawing and analysis, and processing(cutting) simulation of a designed work

3) Equipment for Precision Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
3.3.1	Measurement Data Processing Unit	For precise mesurement of processed work/ sample shape and dimension, and making process control data by statistical culculation of mesuring data
3.3.4	Roundness Tester	For measurement of roundness of a circuler form sample

Table 3.3.3 Outline of the Selected Equiopment for Civil Engineering Department

(3) Civil Engineering Department

No.	Items	Purpose for Usage (Related Curriculam)
4.1	Structural Loading System	For measurement strength of structure by testing bending, loading and compression stress or testing fatigue strength for repeating stress (CE-321, CE-322, CE-499, research of faculty staff and commission test from industry)
4.5	Universal Testing Machine	For measurement physical characteristics of construction materials by tensile, compression, bending and torsion test of the materials (CE-201, CE-221, CE-499)

Table 3.3.4 Outline of the Selected Equipment for Mechanical Engineering Department

(4) Mechanical Engineering Deparment

No.	Items	Purpose for Usage (Related Curriculam)
5.1	Eddy Current Dynamometer	For measurement engine output power
5.2	Exhaust Gas Analyzes	For quantitative analysis carbon oxides, nitrogen oxide, sulfur oxide in exhanst emission from engine
5.3	Diesel Engine Fule Pump Test Set	For measurement of characteristics of a diesel engine fuel pump
5.4	Internal Combustion Engine Test Bed	For experiment to learn various characteristics of a diese engine
5.5	Steam Power Plant Test Set Complete	For experiment to learn principle, operation, characteristics of steam power generation
5.6	Gas Turbine Plant Test Set Complete	For experiment to learn principle, operation, characteristics of gas turbin generation

No.	Items	Purpose for Usage (Related Curriculam)
5.7	Pneumatic and Hydraulic Automatic Control System	For experiment of automatic control for temperature, pressure, flow rate and leve, and to learn their control characteristic by setting value change

Table 3.3.5 Outline of the Selected Equipment for Chemical Engineering Department

(5) Chemical Engineering Department

(Group I)

1) Chemical Engineering Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
6.1.1	Liquid-Liquid Extraction System	The reciprocating-plate columns are suitable for processing mixtures with emulsifying tendencies. (AE 486 Chemical Engineering Laboratory III)
6.1.4	Continuous Plate Distillation Unit	Plate distillation is the most basic type distillation and is widely used in chemical industries. A distillation unit is equipment suitable for studying mass transfer. The continuous tpye is easy for students to get data. It also gives some concepts in scaling up to a pilot plant scale distillation unit. (AE 486 Chemical Engineering Laboratory III)
6.1.7	Stirred Liquid Phase Reaction Unit	To use in chemical reaction experiments. One of the most important industrial reactors is a stirred liquied phase reactor. This reactor is suitable for studying homogeneous and gas/liquid reactions. (AE 486 Chemical Engineering Laboratory III)
6.1.8	Fluidized-bed Ractor	There are some advantages in solid-catalyzed reactions in fluidized beds. To study fluidization and fluidized beds. (AE 486 Chemical Engineering Laboratory III)
6.1.9	Fixed-bed Reactor	To use in reaction engineering and catalysis. (AE 486 Chemical Engineering Laboratory III)
6.1.10	Stirrers Set	To study the effect of many factors in stirring such as type of propellers and stirring speed. (AE 384 Chemical Engineering Laboratory I)
6.1.11	Drum Dryer	To study the phenomena of drying process. It is used with the slurry or pastes. (AE 385 Chemical Engineering Laboratory II)

No.	Items	Purpose for Usage (Related Curriculam)
6.1.12	Ball Mill Set	To study the effct of various factors of ball mill unit, such as speed, pot size and ball size. (AE 384 Chemical Engineering Laboratory I)

2) Analytical Chemistry Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
6.1.13	Glassware for Analytical Chemistry Laboratory	To use in analytical chemistry experiments and physical chemistry experiments in the second year. (AE 281 Analytical Chemistry Laboratory, AE 282 Physical Chemistry Laboratory)

3) Organic chemistry Laboratory

No.	Items	Purpose for Usage (Related Curriculam)
6.1.14	Glassware for Organic Chemistry Laboratory 60 sets	To use mainly in organic chemistry experiments in the second year. It is also used in vacuum distillation or fractional distillation in chemical engineering. (AE 283 Organic Chemistry Laboratory, AE 486 Chemical Engineering Laboratory III)

(Group II)

Analytical Equipment

No.	Items	Purpose for Usage (Related Curriculam)
6.2.4	Scanning Electron Microscope	To study the surface of catalysts. (Research into catalysts)
6.2.6	Atomic Absorption Spectrophotometer	To study photo absorbance in ultraviolet and visible ranges of substances. (AE 281 Analytical Chemistry Laboratory, AE 282 Physical Chemistry Laboratory, AE 283 Organic Chemistry Laboratory, AE 486 Chemical Engineering Laboratory III, Research into Catalysts)
6.2.7	Gas Chromatograph	to identify the composition of gas or volatile liquid samples. (AE 281 Analytical Chmeistry Laboratory, AE 282 Physical Chemistry Laboratory, AE 283 Organic Chemistry Laboratory, AE 486 Chemical Engineering Laboratory III)
6.2.8	Thermal Analysis Instrument	To study property changes of a substance when it is treated with heat. It is also used to study phase transition of metals in industrial engineering. (Research into Catalysts)

No.	Items	Purpose for Usage (Related Curriculam)
6.2.10	Fourier-Transform Infrared Spectrophotometer	To use mainly to identify organic compounds. To study the change of skeleton of a catalyst. To measure the acidity of a catalyst. To analyze the amount of organic compunds in waste water in environmental engineering. (AE 281 Analytical Chemistry Laboratory, AE 283 Organic Chemistry Laboratory, AE 486 Chemical engineering Laboratory III, Research into Catalysts, Environmental Engineering)

Table 3.3.6 Outline of the Selected Equipement for Personal computers

(6) Personal Copmputers

No.	Items	Purpose for Usage (Related Curriculam)
7.1	Personal Computers (for Electrical Engg. Dep.)	For data analysis collected from various measuring equipment.
7.2	Personal computers (for Chemical Engg. Dep.)	For data analysis collected form various measuring equipment and ismulation work.
7.3	Personal Computers (for Chemical Engg. Dep.)	same a 7.1

3.3.4 Operation and Maintenance Plan

(1) Operation and Maintenance System

The Head of Department is responsible for the management and maintenance of equipment in his Department. Technicians are in charge of the maintenance of equipment in each department. The technicians are graduates from technical colleges of two years. The number of technicians is being increased. In view of the technical level of teaching staff and the nature of the equipment to be provided, there are not so many pieces of equipment which require special training in their handling at the manufacturers abroad. However, it will be necessary for all the staff members to be involved in the maintenance operation since there are not many staff members in all the departments. It is also necessary to establish a clearly defined management system in the Faculty for the maintenance of equipment.

In Bangkok there are branch offices or agents of manufacturers which supply parts and provide after-sales services such as inspections and maintenance. There will be no serious inconveniences concerning the after-sales service. There are not so many pieces of equipment which require special maintenance technique. However, it is necessary to assign a person in charge of maintenance to each piece of equipment and train him in the maintenance method by the manufacturer.

(2) Operation Costs and Sources of Funds

The budget of the Faculty of Engineering is divided into two categories: A) Non academic section and B) Academic section. The Non academic section is divided into three subsections: Salaries, Operations and Office Equipment and Building Facilities. The Academic section is divided into three subsections: Salaries, Operations and Teaching Equipment.

The Salaries mean personnel expenses. The Operations include expenses of printing and communication, honoraria, travel expenses, repair fees, expendable expenses etc. Utility expenses such as electricity and water are not

appropriated to the budget of the Faculty of Engineering, but to the budget of the University.

1) Personnel Expenses

The Faculty of Engineering has not yet been completed to its full capacity. The planned classes have not yet been filled with students up to the final year. There are still many vacant staff posts. The personnel expenses are earmarked in the budget every year. The 1994 budget for personnel expenses will be about 8 million Bahts. The equipment planned in this project is the equipment for the existing staff members to use. Therefore it is not necessary to increase the number of staff members for the operation and maintenance of equipment to be provided through this project. The University will continue to increase the staff according to its staff expansion plan until all the planned posts are filled. Personnel necessary to maintain equipment will expand as the staff expansion plan is realized as scheduled. Expansion of equipment through this project will not require, in itself, any additional increase in personnel expenses.

2) Operation and Maintenance Fees

Expenses which are required in relation to the equipment to be provided through this project are:

- Utility expenses (electricity, water etc.)
- Expenses of materials, chemicals, recording paper, ink ribbons ant other consumables.
- Repair fees and other expenses for maintenance.

These expenses are estimated as follows.

a) Electricity and water	36,000 Bahts
b) Materials, chemicals and consumables	464,000 Bahts
c) Maintenance fees	646,000 Bahts
Total	1,146,000 Bahts

3) Sources of Funds

The incomes of the University are;

a) Budget from the Government
b) University's own income

The Faculty of Engineering has not yet been completely established and is receiving a large amount of budget every year from the Government for its facilities and equipment. The budget to cover running expenses is also provided in a reasonable amount. The amount of the budget in the future is not definitely calculated since a yearly budget is compiled in the year just before that fiscal year. However, the Faculty projects the growth of the budget as shown in Table 3.3.7. based on the present trend. The Faculty at present does not have its own income. However, as mentioned in 2.3.1, it expects income of about 16.5 million Bahts a year coming from the rental which the Engineering English Programme pays for the use of the equipment of the Faculty. This money is not included in the regular budget of the Faculty. It can be used by the Faculty in a way it likes as long as the guideline of the Ministry of University Affairs is observed and can be used to cover part of the maintenance fee of equipment. Therefore the Faculty can afford the expense to maintain the equipment to be provided through this project and there will be no financial problem with the implementation of this project.

Table 3.3.7 Budget for Faculty of Engineering

(Fiscal Year : October - September)

(Unit : Bht)

Categories	1990	1991	1992	1993	1994	Prospects
1. Non Academic Section						
1.1 Salaries	237,600	445,100	529,500	471,000	N.A.	↗
1.2 Operation	70,000	200,000	500,000	600,000	N.A.	↗
1.3 Office Equipment and Building Facilities	220,400	678,700	376,600	950,000	N.A.	↗
Subtotal	528,000	1,323,800	1,406,100	2,021,000	2,250,000	
2. Academic Section						
2.1 Salaries	611,100	1,372,800	3,380,700	4,952,400	8,070,200	↗
2.2 Salaries for Part-time	–	–	–	–	1,080,000	↗
2.3 Operations	300,000	620,000	2,368,000	3,627,000	5,174,000	
- Personnel Services	–	110,000	1,134,000	1,791,000	2,152,000	↗
- Travelling, Repair of Equipment	–	10,000	234,000	366,000	450,000	↗
- Expendable Supplies	300,000	500,000	1,000,000	1,470,000	2,572,000	↗
2.4 Teaching Equipment	6,732,700	20,057,000	32,908,900	74,073,200	60,618,500	→
- Shared Equipment				6,112,000	6,800,000	
- Electrical Engineering			9,479,000	17,696,000	12,435,000	
- Industrial Engineering			10,337,300	17,034,500	12,363,000	
- Civil Engineering			9,412,300	12,150,700	13,032,500	
- Mechanical Engineering			1,680,300	21,080,000	2,320,000	
- Chemical Engineering					13,668,000	
Subtotal	7,643,800	22,049,800	36,657,600	82,652,600	74,942,700	
Total	8,171,800	23,373,600	38,063,700	84,673,600	77,192,700	

Source : Faculty of Engineering, the Tahmmasat University