No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE UP GRADATION OF PLASTICS TECHNOLOGY CENTRE
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

MARCH 2004

JAPAN INTERNATIONAL COOPERATION AGENCY
UNICO INTERNATIONAL CORPORATION

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Project for the Up Gradation of Plastics Technology Centre in the Islamic Republic of Pakistan and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team from October 6 to November 2, 2003.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft basic design, 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 Islamic Republic of Pakistan for their close cooperation extended to the teams.

March, 2004

Kunimitsu Yoshinaga
Vice President
Japan International Cooperation Agency

March, 2004

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Up Gradation of Plastics Technology Centre in the Islamic Republic of Pakistan.

This study was conducted by UNICO International Corporation, under a contract to JICA, during the period from October, 2003 to March, 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

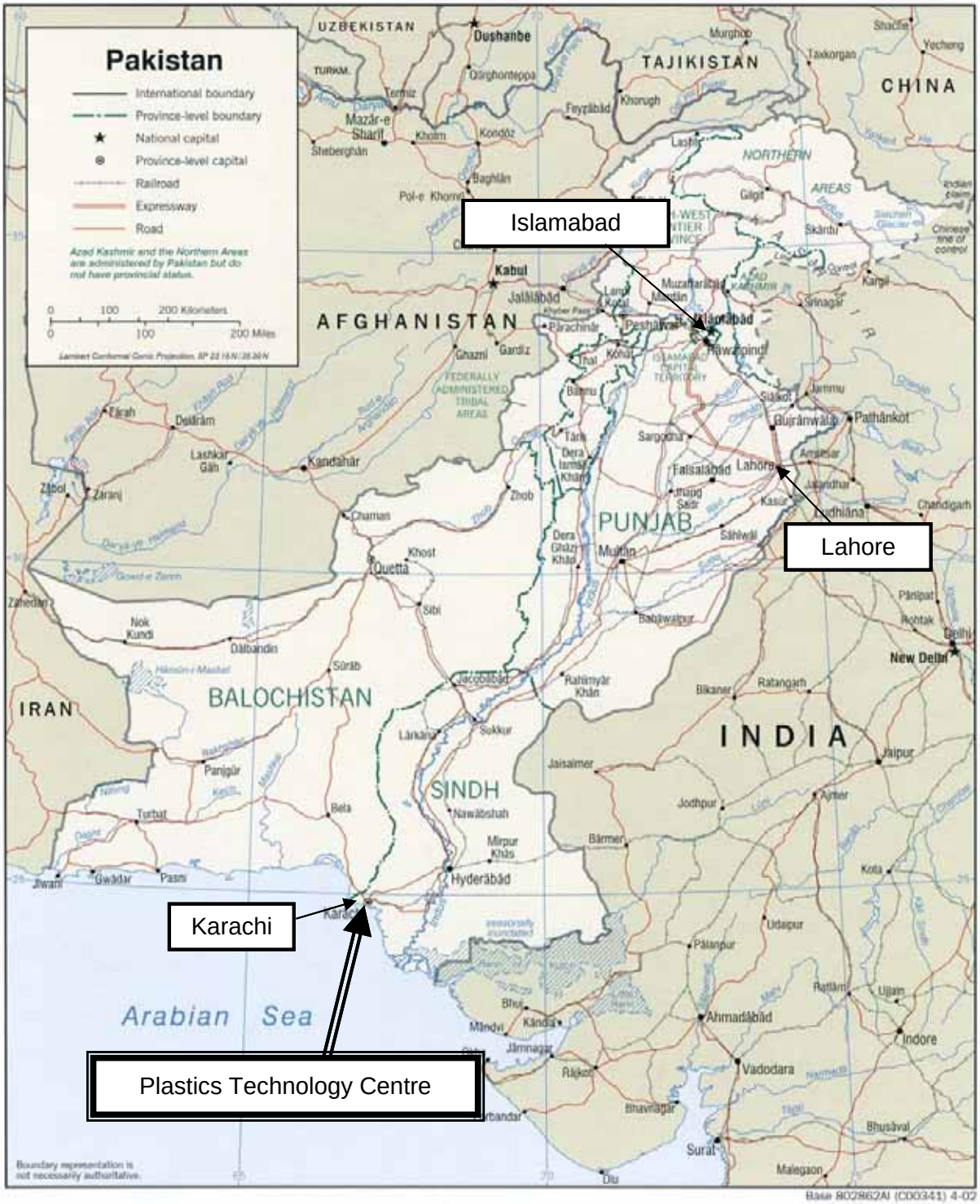
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Jun Ikeda
Project manager,
Basic design study team on
the Project for the Up Gradation of Plastics
Technology Centre in the Islamic Republic of Pakistan
UNICO International Corporation

Location Map

Islamic Republic of Pakistan



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Abbreviations

ACI	American Concrete Institute
ASTM	American Society Testing and Materials
A/P	Authorization to Pay
AVR	Automatic Voltage Regulator
B/A	Banking Arrangement
BS	British Standards
CAD	Computer Aided Design
DVD	Digital Video Disc
EDB	Engineering Development Board
E/N	Exchange of Notes
FCCCL	Federal Chemical & Ceramics Corporation Limited
GDP	Gross Domestic Product
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
OECD	Organization for Economic Cooperation and Development
PITAC	Pakistan Industrial Technical Assistance Centre
PJBF	Pakistan Japan Business Forum
PPMA	Pakistan Plastic Manufacturing Association
PS	Pakistan Standards
PSQCA	Pakistan Standards & Quality Control Authority
PTC	Plastics Technology Centre
PVC	Polyvinyl Chloride
SFDAC	Synthetic Fibre Development and Application Centre
SMEDA	Small & Medium Enterprise Development Authority
UNDP	United Nations Development Programme
UPVC	Unplasticized Polyvinyl Chloride

Summary

Summary

Since its separation and independence from India in 1947, the Islamic Republic of Pakistan (hereinafter referred to as Pakistan) has enjoyed a stable economic growth – an average annual real economic growth rate of 5 %. However, the economy plunged into recession in the 1990s, employment opportunities were not sufficiently provided, and the poverty group expanded largely in urban areas. In line with this, the Government of Pakistan drew up the National Development Plan to focus on a plan to reduce the unemployment rate, fostering of small and medium-sized enterprises, strengthening of supporting industries necessary for industrial development, and vitalization of agriculture. Despite this, due to a high population growth rate, an annual average of 3 percent, the national income per head has been in a downward trend in recent years; in 2000, approximately one third of the total population lived under the poverty line. To deal with this, the Poverty Reduction Strategy Paper was designed to aim at the expansion of employment opportunities through, for example, the expansion of agricultural production tand the vitalization of industries in terms of fostering of small and medium-sized enterprises and export promotion. Above all, the plastics industry which is linked to the production of various industrial products, including water supply and sewage systems, domestic articles, and automobile parts, plays an extremely vital role in the industrial development of the country, and at the same time has a potential effect on substantial job creation, and thus Pakistan has been actively striving for the strengthening of the plastics industry.

Nevertheless, although there are approximately 6,000 private firms in the plastics industry of Pakistan, small and medium-sized enterprises account for about 88 percent, which are not equipped with appropriate technologies and skills. Thus the industry is at an underdeveloped stage, obliging the country to depend on import products even for such products which are considered to be relatively easy to produce, such as pipes for water supply and sewage systems and irrigation systems, and construction materials. This situation also keeps the total number of workers in the industry remain as low as approximately 600,000. Plastics products are essential for all manufacturing sectors including home electric appliances and automobile parts, and in particular the demand for pipes for water supply and sewage systems and irrigation systems, and construction materials is expected to expand as a substituting material for asbestos pipes, so that it is urgent tasks to improve technology levels of plastics processing, and the subsequent expansion of the scale of the industry and job creation.

Established in 1988, the Plastics Technology Center located in Karachi has served as the sole public institutions in the field of plastics processing sector in the country. It provides technological guidance, product tests, and information about technologies to small and medium-sized enterprises, and also offers various educational and training courses including academic courses (bachelorship and diploma), short-term courses (for the improvement in technological levels), and basic courses (for beginners), and thus is promoting to enrich its functions as an institution for human resource development addressed to small and medium-sized enterprises. However, a preliminary survey found that there were quite a few pieces of broken or decrepit equipment at the

center, that the features of such equipment was inferior to that currently owned by private firms, and that there were few pieces of equipment (extruders / injection molding) able to manufacture PVC pipes and to test products that were in high demand among private firms. Thus, the survey concluded that currently the center could not satisfy requests from small and medium-sized firms sufficiently. On the other hand, the center promotes the strengthening of assistance for employment of people in the poverty group and workers in small and medium-sized enterprises as a major pillar of its activities. Thus, it is expected that the promotion of employment creation by reinforcing human resource development in this sector at the center will contribute to the governmental measures against poverty in Pakistan.

Under such circumstances, in order to improve PTC's technological level and its potential to train human resource, the Government of Pakistan requested the Government of Japan for grant aid cooperation which will supply various kinds of equipment satisfying market needs, including PVC pipe molding machines, mixers for materials, testing equipment for quality control, and recycling devices; and construct facilities to place such equipment.

Upon this request, the government of Japan conducted a preliminary survey in November 2002, gasped the overall picture of the request, confirmed the adequacy and necessity of the implementation of the project, and drew up points of concern at the time of conducting a Basic Design Study. Following the findings of the preliminary survey, the government of Japan decided to conduct a Basic Design Study, and entrusted the study to the Japan International Cooperation Agency (JICA), which dispatched the Basic Design Study Team to the country from October 6th to November 2nd, 2003. The study team held discussions with persons concerned and conducted a field survey and collected information related to the project in the study area.

Following an analysis in Japan which included examinations of the contents and scales of machines and facilities, and the estimation of costs for the project, a report to explain the summary of the Basic Design was drawn up. Based on the summary report, JICA dispatched a team to the site during February 10th–19th, 2004, and gave explanation to and had discussions with the Pakistani side. This was followed by an basic agreement with the government of Pakistan. The project summary finally proposed will be laid down as follows:

<Design policy concerning the selection of equipment, setting of the scales of facilities, and so on>

① Since the highly advanced, large-scale, mass-productive equipment used in large firms in Pakistan does not necessarily satisfy the purpose and the nature of the training at the PTC, equipment to be supplied under the project will be for acquisition of basic technologies currently required for small and medium-sized enterprises.

② In order to make effective use of the pieces of equipment currently possessed by the center, those which are broken or decrepit and thus fail to demonstrate their functions will continue to be used in introductory sessions prior to the official training so as to help trainees to understand the mechanisms of equipment, and for other purposes.

③ To comply with the purpose of the project, strengthening of the functions of PTC, the selection of equipment will be basically made in accordance with the main pillars of the existing activities which include training, technological assistance and product testing. At the same time, activities related to the recycling technologies that are to be reinforced at the center, and to product testing which can meet the ISO requirement, will be covered by the project.

④ To make effective use of the equipment currently possessed by the center, as stated in (2), the existing facilities where such equipment is installed will be used as it is. At the same time, new workshops will be built so as to accommodate new equipment to be procured. The project site will be situated in the courtyard of the premises of SFDAC adjacent to the center, so as to ensure necessary lengths for buildings where pipe manufacturing lines will be installed; to take into account the nature of education and training and flow lines.

The following is the project plan complying with the design policy described above:

<Project Plan>

(1) Number of trainees (per year)

Content of training	Past record (note) (The average between 1999 – 2002)	Planned capacity of course in FY 2009
Basic course		
3 month course	31 persons	60 persons
Short-term courses		
Plastics materials	The average number of trainees in each course is 10 persons, though some courses are unavailable in some years.	60 persons
Extruding		60 persons
Injection molding		60 persons
Thermal molding		20 persons
Blow molding		20 persons
Testing machines		60 persons
total	56 persons	280 persons
Grand total	87 persons	340 persons

(2) Number of commissioned tests (per year)

Past record (note) (The average between 1999 – 2002)	Planned number of tests in FY 2009
200 cases Tests for tensile strength (60 cases), tests for hardness (40 cases), and qualitative analysis of materials (20 cases), etc.	400 cases

Note: As reference, the annual average between 1999 and 2002 was adopted when the performance of the center has been stable throughout the year.

The following is the contents and scale of equipment and facilities, which have been determined in accordance with the frequencies of training courses and commissioned tests, described above, together with the contents of revised curriculum:

	Name of major equipment and room
Training equipment	mixers for materials, extruders (for PVC), cooling tanks, haul-off machines, cutting machines, Pipe belling machine, Granulator (for recycling purpose), injection molding machines (for PVC), thermal molding machines (for PE), and blow molding machines (for PET).
Testing equipment	Short-term and long-term hydrostatic testing baths, falling ball/weight Impact test equipment, Softening point test machine, universal testing machine, gas chromatograph, and digital hardness tester.
General supplementary equipment	Computers, printers, DVD players, digital video camera, tools for maintenance, and electric tools.
Workshops (work area)	Reinforced concrete structure; two-story; gross floor area – 1,432m^2 First floor: offices, practical training room, storage for raw materials, mixing room, storage for metal molds, and grinding room. Second floor: laboratory, computer room, and classroom for practical training.

Under the grant aid scheme of the government of Japan, the total construction schedule will be 19 months, with six months for detailed design and procedures related to tendering, and 13 months for the procurement of equipment and construction of workshop facilities. The total cost estimation required for this project is expected to be approximately 806 million yen (804 million yen to be borne by the Japanese side, and 1.94 million yen by the Pakistan side).

There is no problem, one can conclude, concerning the maintenance and operational system of the PTC and the cost in order to implement the project described above.

Where the maintenance and operational system of the PTC is concerned, (1) Most teaching staff members and engineers responsible for lectures and practical training have experiences for more than 10 years, and the majority are the holders of Master degrees or BS degrees. Also there are quite a few staff members who have been educated in the U.S. or the U.K. Thus, one can conclude that the theoretical potential of the center is quite excellent. (2) These teaching staff members and engineers have mutually cooperated with each other, so that the machines made more than 30 years ago are still in good conditions, and that other aspects of maintenance are well conducted such as oil filling and the clean workshop. Accordingly, the maintenance and operational system of the PTC can be considered to be well established. As for the aspects related to the cost, the new installation of equipment under this project will slightly increase the operational and maintenance cost, but the revision of the training courses and a likely increase in the number of commissioned tests will create new income sources. At the same time, the financial plan is sound enough to cover the costs with budges for existing training courses

and others. Therefore, there is no problem for the implementation of the project.

The implementation of the project is expected to have the following effects:

(1) Direct effects

* The number of persons out of work who will be able to acquire basic skills and knowledge of plastics processing at the basic course will increase from current 31 persons per year (the average of the previous four years as of 2002) to the target figure of the project, 60 persons per year (expected to be achieved in 2009).
* The number of engineers who will be able to acquire professional, practical skills and knowledge of at the short term courses will increase from current 56 persons per year (the average of the previous four years as of 2002) to the target figure of the project, 280 persons per year (expected to be achieved in 2009).
* The number of firm-commissioned tests will increase from the current 200 times per year (the average of the previous four years as of 2002) to the target figure of the project, 400 times per year (expected to be achieved in 2009)
* The renewal of existing outdated or decrepit machines will enable various training courses satisfying the needs of small and medium-sized enterprises.
* The diversification of types of machines will enable the provision of education and training courses concerning technologies which had been required by firms but failed to be offered so far.
* The establishment of a routine market survey scheme will lead to the development of training curriculum matching corporate needs and the provision of training courses and technological tests conforming to market trends.

(2) Indirect effects

* Expanding employment opportunities for graduates of the PTC who have received practical education and training sufficiently matching to the corporate needs at more than 6,000 plastics-related companies in Pakistan (of them, large firms account for 12 percent, as small and medium-sized firms 88 percent).
* Improving the qualities of Pakistani-made plastics products, and reducing the necessity for the dependence on import ready-made products. This will vitalize the plastics industry in Pakistan, ensuring a certain amount of employment.

Since this project is expected to have the effects stated above, it is reasonable, one can conclude, that the project will be implemented under the grant aid cooperation. However, for smooth and efficient implementation of the project, it is desirable that the Pakistan side should conduct market surveys on a regular basis, sufficiently grasp the corporate needs, and revise the contents of its training courses from time to time. At the same time, it seems necessary for the center to strengthen the cooperation and ties with the University of Karachi, the Technical Assistance Centre (PITAC), the Pakistan Plastics Manufacturing Association (PPMA) and other related organizations for the purpose of appropriately exchanging information about trends in the plastic industry, corporate needs, trends in related technologies and so on, so that the center will provide services of high quality.

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Chapter 1 Background of the Project

Chapter 1 Background of the Project

This project is one of the four projects that the Government of Pakistan formulated in accordance with proposals by the Pakistan-Japan Business Forum (PJBF), and to which the Pakistani-Japan summit meeting in March 2002 announced to give assistance. The initial purpose was to reinforce the functions of the Plastics Technology Centre (PTC), the sole public organization in Pakistan concerning plastics processing technologies, by providing, for example, learning equipment for basic technologies, raw materials, testing equipment for final products, and educational equipment involved in plastics molding process. However, a preliminary survey conducted in November 2002 found that there were quite a few pieces of broken or decrepit equipment at the centre, that the features of such equipment was inferior to that currently owned by private firms, and that there were very few pieces of equipment able to manufacture PVC pipes or to test products that are in high demand among private firms. Thus, the survey concluded that currently the centre could not satisfy requests from small and medium-sized firms sufficiently.

Under such circumstances, the Government of Pakistan came to request Japan for grant aid cooperation which will supply various kinds of equipment, including PVC pipe molding machines, mixers for materials, testing equipment for quality control, and recycling devices; and construct facilities to place such equipment.

Chapter 2 Contents of the Project

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2-1 Basic Concept of the Project

(1) Basic Concept of the Project

Pakistan has been suffering from an economic downturn, and there are not enough employment opportunities, incurring poverty being particularly widespread in urban areas. Thus the country has drawn up national development plans, Poverty Reduction Strategy Papers, and other plans, tackling the issue of job creation through, for example, human resource development, fostering of small and medium-sized enterprises, and strengthening of the supporting industries necessary for industrial development.

Among other industries, the plastics industry plays an essential role in the Pakistani economy, in that products of the industry are made wide use of for pipes for water supply and sewage systems, automobile parts, and other industrial products. Thus improvement of the quality and increased production of plastics products help the development of the economy, and Pakistan has accordingly been making active efforts to strengthen the industry. However, the fact that a majority of manufacturers in the plastics industry are small and medium-sized companies with a low level of technology hinders the Pakistani government's attempts to expand employment opportunities through import substitution policies and the promotion of export.

Under such circumstances this project, by providing various kinds of equipment together with a building to accommodate it for the Plastics Technology Centre (PTC), the sole public training institution for plastics processing technology, aims directly at improving the quality of various training courses and consulting services matched to market needs, and at upgrading the testing functions of the Centre to cope with increasingly diversified products. And ultimately, the project's target is to ensure that unemployed workers acquire enough basic skills to get employed and that engineers at small and medium-sized firms develop their specialities further so that they can contribute to the development of their companies.

The achievement of the targets described above will increase employment opportunities among unemployed persons who have acquired the skills at the PTC; help small and medium-sized firms advance their specialities, and improve their product quality; and thus enable them to manufacture products which can substitute for imported goods and can also be exported. All this will lead in turn to a bottom-up of processing technology among small and medium-sized enterprises as a whole, and vitalize the industry, so that the project will eventually contribute to securing employment and reducing poverty.

(2) Project Outline

In order to foster engineers and enable appropriate inspections for improvement of quality, which are required in the industry to realize the above objectives, this project aims at providing education and training concerning basic movement and structures of moulding methods, and improvement of product inspection for better quality, by means

of replacing decrepit plastic moulding machines and supplying test apparatuses and supplementary equipment for education to the sole educational and training institution in the country, the Plastic Technology Centre. This project covers procurement of equipment for practical training and testing which makes it possible to conduct education and training in the individual processes of extrusion, injection, blowing and thermoforming, and other general supplementary equipment which facilitates effective use of such equipment.

Apart from a role as an advanced educational institution with academic courses (four-year university), the PTC provides educational and training opportunities for engineers and inspection and technological assistance to small and medium industries. The operation of the centre is well established and the centre has solid accomplishments, but in order to make better use of equipment under this project, it is necessary to acquire the level of demand for engineers in the plastics moulding industry and the curriculum development based on the demand level, and to have the teaching staff of the PTC learn the manoeuvring and operational skills which realise full demonstration of functions of the equipment to be procured. In the past, through exchanges of opinions with the Pakistan Plastics Manufacturing Association (PPMA), technical seminars held at the Technical Assistance Centre (PITAC) and the Small & Medium Enterprise Development Authority (SMEDA), and communications with universities, the level of technologies demanded were grasped and the technological levels among teaching staff were improved to some extent. However, it is still necessary in the future that regular surveys should be conducted to monitor the level of demands mainly among companies belonging to the PPMA, those which the PTC has conducted education and training towards their engineers, and those which have received technological assistance or product inspections. At the same time, it is necessary to improve the technological level of teaching staff members for operating machines to be procured under the project. In line with this, the project will include specific schemes more than the simple installation of equipment.

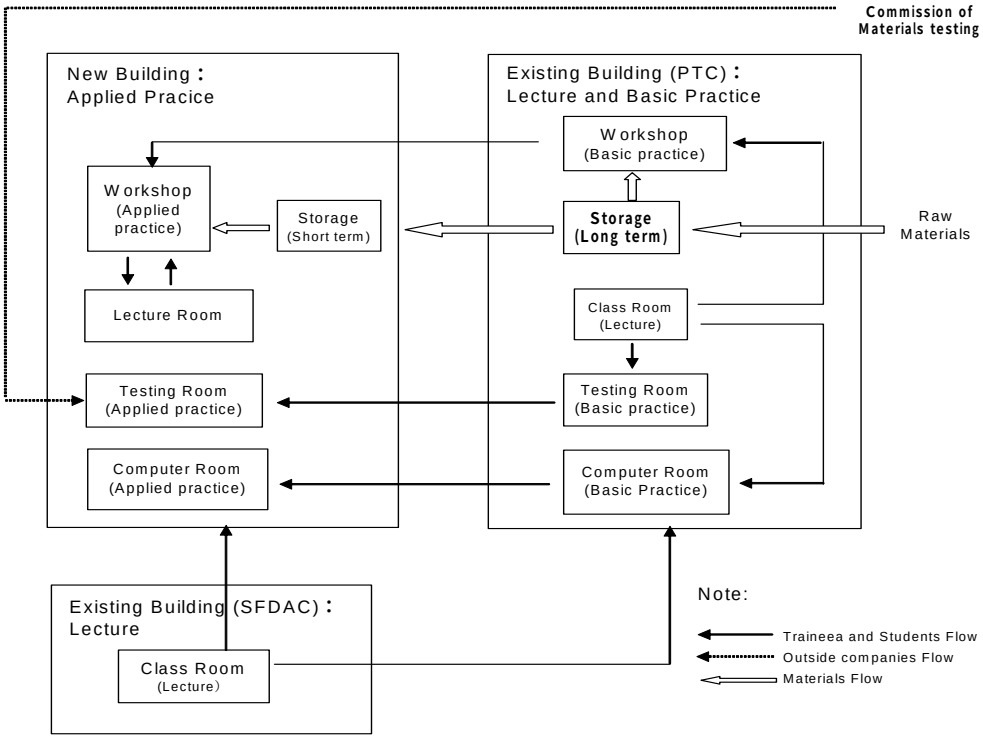
2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

Because of the nature of the PTC, as a training and educational institution, the specification of equipment to be procured will be satisfactory enough to meet training levels, not large-scale for mass production used in large companies in Pakistan. At the same time, equipment must satisfy the conditions for the acquisition of basic technologies used in small and medium industries. Also, in the light of the life span, equipment must be used longer enough to meet the market needs for some decades. As for plastics moulding machines, a basic machine is enough for the understanding of the basic structure of processing techniques, although there are various differences in terms of moulds and performance among product types and sizes. As for the PVC pipes, on the other hand, the target level of the training is to reach a definite technological level where trainees can manufacture products satisfying ISO, PS, or other industrial standards, so equipment to be procured must meet this technological level. Where testing equipment is concerned, because the facilities will play a role as the sole comprehensive plastics testing centre in Pakistan, equipment must be capable of testing a large number of products regulated under ISO, PS, or other industrial standards. For efficient use of the existing equipment and equipment to be procured, if the existing equipment is consistent with equipment to be procured in terms of the usage and function, the former will be taken advantage of under this project. However, if the former is out of order or excessively old and fails to demonstrate its function sufficiently, it will be used simply for pre-lessons about the mechanism of equipment prior to the actual practical training, or for the initial training concerning operation for beginners.

Figure 1 Summary of equipment plan



(i) Moulding Machine

The main moulding machines have been selected in and outside Pakistan, in the light of categories and production volume of plastic products, and the number of firms. The focus will be on moulding of thermo-plastics which account for approximately 90 percent of all plastics consumption. And the equipment to be procured will be for the main moulding methods: extrusion, injection, blowing and thermoforming.

Table 1 Moulding methods and distribution of companies

	Types of plastics		Proportion of products made in Pakistan	Distribution of plastics industry in Punjab	Distribution of plastics industry in Karachi	Distribution of moulding methods in Japan	Judgement
	Thermosetti-ng plastics	Thermo-plast ics					
Extrusion		○	○	○	○	○	○
Injection	○	○	○	○	○	○	○
Compression	○			○			×
Blowing		○	○		○	○	○
Thermoforming		○	○	○	○	○	○
Calendering		○					×
Tramsferring	○						×

Note:○ indicates a large production volume.

Of these, extrusion is particularly expected to be in higher demand on water supply and sewage system, building construction, agriculture and so on, and thus will be considered the basic technology, so that the PVC pipe extruder will be selected. As for injection moulding machine, the machine with joint will be selected so that quality products are still import from abroad but the product is essential for the infrastructure of water supply and sewage systems. Bottle will be selected for blowing and container will be selected for thermoforming because those goods are major products and basic shape in small-medium plastics industry .

(ii) Extruder

In the Pakistani market, the PVC pipes with 1” to 6” bore diameter are in high demand, and equipment to be procured will be selected so as to meet such market demand and to be usable for education and training. The equipment to be procured must be slow to wear, long-lasting, and easy to dismantle or assemble. It also has to be suitable for education and training so that trainees can easily understand the melting process of plastics and the machine structure. At the same time, equipment connected to the extruder will form the production line that ensures to manufacture products with quality high enough to meet ISO, PS, or other industrial standards. As for screw, the twin screw is considered the most common and consists of two types: parallel and conical types. The specifications of each screw will be determined in accordance with the compounding method, composition, quality required for products, productivity, and the purpose of use. By an international standard, the primary technology makes use of tin or low leaded stabilizer, and is the combination of a vacuum de-aeration unit with powder compound (for de-aeration of particles and evaporated air within plastics) and a screw with the movements to two opposite direction (for prevention of excessive cutting of the layer of screw flight). Both the parallel type and the conical type have advantages and disadvantages.

Special features of Parallel Type Extruder

1. Capable of handling a wide range of moulding materials
2. Easy to dismantle and assemble
3. Long life span with small resistance
4. Easy to confirm the resistance of the screw and the condition of melted plastics inside the cylinder

Special features of Conical Type Extruder

1. Screw types depend on moulding materials, and in some cases screw has to be changed depending on the materials.
2. Due to the complicated structure, it requires highly advanced maintenance skills.
3. Strong thrust bearing is capable of strong resistance, so there is no problem in the life span of the equipment.
4. Difficult to confirm the resistance of the screw and the condition of melted plastics inside the cylinder

Upon the comparison described above, together with the nature of the purpose, that is, mainly the training at the PTC, the parallel type extruder is to be adopted.

(iii) Pipe Manufacturing Line

Pipes extruded from the extruder take the form of cylinder but not accurate enough, remaining warm and soft. Those will be put into the precise shape by processing low-pressured vacuum calibration sleeves, and fixed into a certain size by cooling down gradually. Water is used for cooling and thus a water bath will be required. However, due to buoyant force, pipes with large diameters cannot be cooled down under the water, so that both the water spray cooling method and the water cooling method are to be used with the water spray bath, and also the natural water drop bath are to be used. The required length of the baths depends on the diameter of pipes and the volume; in the case of pipes with 2" to 6" diameter and the volume of 100kg per hour, the length of approximately 10 meters will be required for safe use. Cooled and fixed pipes require to be taken away at an appropriate speed in response to the speed of extrusion speed by the haul-off so as to avoid stagnation of products and maintain the stable shape of products. Pipes are cut into pieces of a certain length by a pipe cutter. The pipes are to be sold at the market for the purpose of raising money for their materials, so have to be approximately 6 meters long, which is commonly circulated in the market. Finally, a printer will be incorporated in the scope of the project in that the printing of manufacturer's name, size, lot numbers on pipes is one of the essential processes for manufacturing companies.

(Plan): Extruder→Mould→Vacuum calibration sleeves→Water bath→Haul off→
Printer→Pipe cutter

(iv) Injection Moulding Machine

The PVC pipe fittings are manufactured with the injection moulding machine, but the size and types of pipe fittings depend on the injection pressure, maximum plasticizing area, and injection area for moulded products, thus a single machine cannot afford various shapes of products. Therefore, various types of injection moulding machines

will be required for different shapes. While fittings of size 1” and 2” are producible with the small injection moulding machine (with clamping force of around 170t), the production of fittings of size 4” needs the medium-sized machine (with clamping force of around 450t).

Table 2 Relationship between mould and injection moulding machines

	Small Injection Moulding Machine (app. 170t)		Medium-sized Injection Moulding Machine (app. 450t)
Size	1”	2”	4”
Socket	Producible by pipe belling machines		
Elbow	○	○	○
Tees	○	○	○
Valve Socket	—	—	○
Reducer	—	—	○
Faucet	○	—	—

However, the medium-sized machine is unable to manufacture fittings of smaller sizes which the small machine can. Also, the production of larger products, 6”, requires a large injection moulding machine, which is out of scope of the education and training in question. Types of moulds will include elbow, tees, valve sockets, and reduces for the fittings of 4” which are in high demand in the ordinary markets and the market for pipe tees with different diameters. But at the same time, fittings of one and two inches are also to be covered. Accordingly, the mould will be selected. Sockets can be manufactured with pipe belling machines, so are not included in the project.

(v) Blow Moulding Machine

Blow moulding machines are used to manufacture bottle-shaped products and they consist of two types. One is the general blow moulding type whereby parison is extruded from the extruder, and turns into soft and tube-shaped. The parison is inserted into mould, and air is blown into it through a tube so that the parison is fitted into the mould from inside. The other is the stretching blow moulding type. In this method, a basis of the product is moulded first by the injection moulding method so that it takes the form like a test tube. The basis is inserted into mould with the central part of the injection moulding machine attached. Then air is quickly blown into the basis like a test tube. The blow moulding machine is exclusively used for bottle production on water bottle. Recently the demand of PET bottle is quickly increasing. Stretch blow moulding machine is selected because PET (polyethylene terephthalate) is soft and the machine is suitable for the soft materials.

(vi) Thermoforming Machine

Thermoforming machines are used to heat and soften sheets or films, so that the materials can be moulded into the right shape while they are soft. This type is suitable for the production of flat, thin trays, containers and so on. The machines consist of two types: the vacuum moulding whereby materials are fitted into the mould with the vacuum pressure; and the air pressure moulding whereby air pressure is used to fit materials into the mould. While the latter gains the higher pressure for moulding than the former and can create sharp forms of products, the latter

is applicable for various moulding methods, such as straight forming, drape forming, plug assisted forming, and so on. Also, the vacuum pressure method allows trainings for various kinds of equipment with the basic skills, so it will be adopted in this project.

(vii) Storage tank

Compound blended in the mixer is normally, if it is in a factory, delivered to a storage tank before putting into a moulding machine. However, it is necessary at the PTC for trainees to learn each process, so that compound in the mixer will be packed and stored in the storage tank before using in the next step. The use of a storage tank at this stage requires repacking when the compound is used later, which requires additional work and time. But a container can satisfy both the requirement for packing and storage tank, thus it enables to construct an efficient production process.

Factory: Mixer→Storage tank→Moulding machine

Proposal of the PTC: Mixer→Sacking→Storage tank→Sacking→Moulding machine

Plan: Mixer→Container→Moulding machine

(viii) Recycling

The recycling of waste materials and products within the PTC will be carried out by sorting out PVC and others. As for PVC, using a band saw and a crusher, waste materials and products are classified further. Sorted waste materials are extruded by the extruder for PVC, turned into pellet through a hot cut pelletizer, and kept in containers before reuse. Other materials are also classified further, with the use of the band saw and crusher, turned into pellet through a granulator, and kept in containers before reuse. At any case, it is not subject to the project that the PTC processes plastics wastes brought in from outside. However, in the light of the nature of the PTC, as a public institution, it is considered to be important to make the importance of recycling known to private companies. Hence, certain measures will be taken within the framework of soft components and reflected into the curriculum development.

Plan: PVC waste and products →Band saw→Crusher→Special Extruder→
Hot Cut Pelletizer→Container

Plan: Other waste and products →Band saw→Crusher→Granulator→Container

(ix) Incinerator

At the moment, incinerators which do not emit dioxin are all large plants, thus the project cannot afford to include incinerators. It may be possible to install at the PTC premises an incinerator designed for non-PVC materials (PVC is a sources of dioxin). However, unless a strict measure is taken for distinguishing types of waste materials, and strict management is conducted for the incinerator, the incinerator is likely to cause pollutions. As a result, an incinerator is not to be included in the project. Moreover, incineration does not help effective use of resources, and it is expected that waste materials should be reused as precious resource. It is important to pursue

methods other than incineration for the purpose of recycling, so that certain measures, together with recycling, will be taken within the framework of soft components and reflected into the curriculum development.

(x) Pipe manufacturing technologies

Because the pipe manufacturing technologies themselves are relatively simple, and because pipes are highly likely to be used further for water and electricity pipes, basic equipment will be procured for an existing training course. However, in cases like water pipes which need to bear a certain amount of pressure, it is necessary to understand the nature of liquid for the designing of pipes, which is too advanced to ensure necessary teaching staff members and is difficult to estimate the demand for it. Thus, the market survey will be conducted and its result will be reflected in the curriculum development.

(xi) Generator (covered by the construction work)

Due to the limitation of the supply of the commercial electricity, private electric generators are essential commodities in Pakistan. Currently, the existing premises are equipped with private generators, which are large enough to supply extra electricity to the equipment to be procured. Thus, a new private power generator will be installed. In particular, if the machine suddenly stops due to power failure, melted plastics during the process of producing PVC products will stagnate within the high-temperature moulding machine and mould itself, and the thermal decomposition will occur within a short time, likely to emit chlorine gas and dioxin. Since the gas leaks out of the moulding machine, it has a harmful impact on human bodies, as well as metal equipment within the premises (corrosion). To avoid such events, a generator will be installed, together with ventilators for evacuation of gas to outside.

(xii) Gantry crane

The volume of mould to be used for the moulding machines depends on the type of product. The maximum weight of mould under the project will be nearly 2t. A gantry crane may be installed within the workshop and be used to move mould from the mould storage to the moulding machines. However, the crane is fairly large, although it is not so frequently used. Also, it can be usable for a limited area. Thus, in order to put priority on the efficiency, a gantry crane will be installed in the mould storage alone, and a gate crane will be supplied to the workshop. The specification of the gate crane will be determined in the light of the width and height of the moulding machines, the location of trolley, and so on. Either way, it should be ensured that the one to be selected will be unlikely to fall down while moving.

Proposal of the PTC: Mould storage→ Crane→ Trolley→ Gantry Crane→ Moulding machine
Plan: Mould storage→ Crane→ Trolley→ Gate crane→ Moulding machine

(xiii) Chiller

In order to control the temperature of mould in the injection moulding machine, and to cool down the pipes extruded from the extruder, a large amount of water is used. For cooling down the pipes within a certain distance,

required water will be approximately 20 degrees Celsius at the nozzle, or 270 litters per minute in other cooling methods. Because the temperature exceeds 35 degrees Celsius in Karachi in summer, it has a negative impact on the product quality and equipment to use tap water directly. Hence, a circulation-type water cooling system will be installed. The system will also contribute to the cost reduction in that only a limited amount of water is used, while water is running and wasted at the moment.

(xiv) Quality Control and Testing Lab. Equipment

Because the PTC serves as the sole training and technology centre specialising in plastics, it receives orders for inspections from private companies and the PSQCA. However, the PTC is not so highly valued in that the scope of inspections is limited due to a limited variety of the existing equipment and that only some of the inspections can be conducted. As for the testing of plastics, on the other hand, it can handle a wide range of testing related to materials, moulded products, plastics, pigments, additives, and so on, and quality testing for moulded product. Testing equipment in high demand will be selected with an emphasis on plastic UPVC, not based on the types of moulding machines to be procured, the characteristics of staff members, and past experiences. In addition, Pakistan has been adopting the ISO, and thus inspections under the regulation of the ISO will be required in future. Thus, equipment to be procured will be in conformity with the regulations laid down by the ISO. Currently, the PS standards are applied to the testing of PVC pipes and fittings in Pakistan. The PS standards (PS3051) are in conformity with the British Standard 3505 the ISO 3633, the international standards for vinyl chloride and fittings.

Table 3 Equipment for testing and analysis for properties and components of plastics

Mechanical property test	Tension test
	Hardness test
	Stress test
	Puncture test
	Thickness and diameter gauging
Thermal property test	Quantification of water absorption of plastics, etc
	Thermal conductivity measurement
	Thermal stimulation measurement
Toxicology test for additives, heavy metals, etc.	Gas chromatography qualitative and quantitative analysis
	Toxicology test for components of plastics and products
Weather stress testing	Exposure test against ultra violet rays, light ray, ozone, etc.
Material science	Quality evaluation for materials and pigments, and test for molecular mass
Gauging of outer size of product	Mould prototype test
Optical test	Test for colour, turbidity, and lucidity of products
Others	For property test of plastics products under the condition of low temperature
	Distilled water machine for corrosion test

Table 4 Testing in terms of standards of PVC pipes

Testing item	Standards
Dimension test	PS3051, BS3505, ISO3633
Tensile test	ISO3633
Hydrostatic test	PS3051
Chemical resistance test	PS3051, ISO9852
Softening point test for VICAT	PS3051, ISO2570, ISO3633
Colour test for products	PS3051, ISO4422, BS3505
Impact test	PS3051, PS3051, BS3505, ISO4422
Flat test	PS3051, ISO3633, BS3505
Appearance test	

(xv) Training aids

It is said that 75 percent of all information is obtained visually, and thus visual equipment is effective particularly for education and training in a short term. In the past, pictures, illustrations, tables, panels and so on used to be commonly used, but since the emergence of the OHP, the projection of computer date and moving images has become common. While the PTC provides opportunities for basic education and training, it is effective for trainees to see actual production sites in factories in order to image a wide range of the technologies applied for plastics moulding. However, it is difficult to stop or move slowly the equipment in operation in factories for the sake of trainees. And the transportation of trainees to factories costs and takes a certain amount of time, so it is not suitable to conduct frequently during the short-term training courses, and the amount of information to be gained is limited. To deal with such problems, it is necessary to provide equipment which can record the scene in factories and enables trainees to watch the recording whenever they need to. For this purpose, DVD software or videotapes concerning the introduction of plastics moulding technologies are commercially available, but it is also important to use the recordings which teaching staff members record themselves at factories. Visual training materials are also effective for enlightening trainees concerning recycling and PVC pipes. Therefore, video player, TV, projector, digital video recorder, DVD player, and so on will be supplied under the project.

(xvi) Computer

The curriculum of the Basic Plastics Technology Courses and short-term courses includes computer courses, though skill levels vary extensively from simple typewriting to CAD manipulation. Although all the trainees enrolled in the Basic Plastics Technology Courses are assigned to receive computer courses, the gap of their skills and knowledge about computers is expected to be substantially wide. Under such circumstances, it may not be efficient to provide identical training programs to all trainees. Hence, the computers currently used in the PTC will be used for beginners, and those to be procured under the project for advanced trainees. Since the capacity of the Basic Plastics Technology Course is 30 persons and the PCT currently owns 15 computers, 15 computers will be procured under the project.

(xvii) Maintenance and other tools

Maintenance and other tools required for large equipment to be procured will be included as accessories, whereas

tools for repair and checking are not necessary. The tools to be procured are capable of simple repair and maintenance for electrical equipment, but are unable to deal with problems related to computers. Thus, general multi-purpose tools will be supplied as maintenance tools for mechanical equipment, and tools which can check on circuits and make simple adjustment will be supplied as tools for electrical equipment.

(2) Policies on natural conditions

The planned construction site of the PTC is located in the southern part of Karachi, Sindh province. The site is adjacent to a river, approximately 5 km away from the coastline, and falls into an arid region. It is in the scorching season particularly from June to August, and the daytime temperature can exceed 40 degrees Celsius and sometimes reach 50 degrees Celsius, but between December and February, the climate becomes as mild as spring in Japan. Thus, the natural conditions will be taken into account for the designing of the rooms of the buildings. There are very little natural disasters, with only several earthquakes under Magnitude 4 in the past. Hence, the designing of buildings does not require excessive measures for earthquakes or strong winds. The findings of ground surveys show that the earth 10 meters deep from the surface is sabulous silt, while plate loading tests conducted 2 meters deep showed that the allowable bearing capacity is expected to be 8 m/m^2; the ground is bearable for two-storied reinforced concrete buildings.

(3) Policies on social and economic conditions

Since the vast majority of people in Pakistan are Muslim, customs related to the religion such as the seniority rule, the system of patriarchy, and the differentiation between males and females are respected even in the educational system. So the plan will be designed with careful attention to such customs. Also, drinking and eating are restricted at daytime during Ramadan, so that the construction schedule will be drawn up in the light of the restricted opportunities for nutrition because the construction procedure, in particular outdoor construction work, may be less efficient during the fast. In 2004, the Ramadan commences in mid-October. As for construction, there are quite a few modern buildings in the centre of Karachi, and the existing premises of the PTC and the SFDAC do not take traditional appearances, so buildings to be constructed will not emphasis the Islamic taste. Since the site is near the coast, finishing, structure, fittings, and piping will be designed to be proof against salt injuries.

(4) Policies related to construction

Local construction companies pay attention to quality control; in order to respond to high temperatures in summer, they use ice cubes when mixing cement, give a rest after covering with cement, and so on. Also, the operation of construction machines is relatively easy. Thus the conditions for construction are well established. However, the construction will be carried out with special care for the following points.

(i) Ability, efficiency and skills of local construction workers will be well examined before the organizational

systems and the construction schedule are planned.

(ii) Because winds in summer contain sandblasts, places where dusts can pile up easily, such as the surface of basic formworks and concrete, will be thoroughly cleaned.

(iii) During construction, efforts will be made to prevent accidents and theft within and around the construction sites.

(iv) Since more than 90 percent of the population are Muslim, possible delay in construction work will be taken into account during Ramadan.

(v) Even during the construction of new buildings, the existing premises are being used. Thus the safety of teaching staff, trainees, and students must be secured. It is expected that construction vehicles and vehicles of persons who uses the facilities move in and out, so that traffic safety must be ensured and it will be necessary to take safety measures when carrying in and out materials and equipment.

(5) Policies related to procurement

Although there are many manufacturers of plastics moulding machines and their peripheral equipment in Japan, some of them do not export to Pakistan as their policy. At the same time, all cargos and technologies (with an exception of some items which are considered to be irrelevant to the development of weapons of mass destruction) are in principle subject to restrictions on export to Pakistan under the Catch All Control of the Japanese government. Restrictions on export do not necessarily mean the impossibility to export, but certain procedures may be required. Moreover, export of computer-related equipment (hardware and software) to Pakistan requires the permission of the U.S. government. Thus, as a condition of the tender, it will be stated that equipment suppliers are required to conduct such procedures, as well as the procedure to obtain permissions from the Japanese government.

The plastics moulding industry in Pakistan is classifiable into two groups: one which consists of a small number of companies supplying automobile parts and other to large companies, and the other which consists of a majority moulding daily commodities, domestic articles, and other things. Companies in the former group make use of advanced equipment, whereas those in the latter make use of second-hand equipment from within the country and abroad. Such used equipment, including mainly Japanese products, are widely spread in Karachi, so there are two maintenance companies which can handle with Japanese and other countries' products, regardless of the makes. Thus, the maintenance of Japanese products to be procured under this project will be secured by using such maintenance companies.

(6) Policies concerning the use of local companies

(i) Local contractors and construction materials

There are a number of local contractors in Pakistan, from small to large companies, and 4,500 firms are registered at the Technology Association of Pakistan. Upon making use of local contractors, their classifications should be confirmed, and contractors must be selected in the light of their business careers, equipment which they possess, and

their experiences in construction. Where the procurement of construction materials is concerned, individual local companies have their own strong ties with particular old trading companies and agencies, so that the selection of local companies has a substantial effect on the decision of materials to be procured. Accordingly, it should be borne in mind that human relationship, as well as the quality of products, is an important factor.

(ii) Effective use of local architectural design office

It is confirmed from personnel in the construction department of Karachi city that an application for confirmation is required from a local architectural design office in order to construct facilities of the PTC. At the same time, in order to supervise local construction companies, it is required to have a local architectural design office and a consultant, who are familiar with technical drawings and construction methods in the country, participate in the project. In this project, a Japanese design office will make use of a local architectural design office.

(7) Policies concerning operation and maintenance abilities of the institutions

Where the costs for operation and maintenance of the equipment to be procured are concerned, in its operational plan, the PTC has increased the allocation for education/training and technical services, so that the budget is formed in a reasonable manner. Even if the budget falls under the plan, the budget for the academic course can afford to cover the shortage, and the total budget of the PTC and the FSDAC can cover the costs. What is more, the Ministry of Industries and Production, the upper governmental body, has promised to compensate for possible shortage of funds, thus the costs for operation and maintenance are handsomely secured. The procurement of new equipment under the project not only increases the number of equipment types, but also updates the specifications of some of equipment from old-fashioned models to the modern standard models that are actually adopted among small and medium industries. However, because teaching staff members have exchanged information or communications with advanced plastics companies or universities abroad, or have been educated themselves abroad, so are capable of adopting new technologies, there will be no difficulty in the maintenance and operation of new equipment to be introduced.

(8) Policies concerning setting of grades of facilities, equipment, etc.

Since this project is to be conducted under the Japanese grant aid cooperation, luxurious decorations will be avoided as much as possible, and appearance and materials commonly used at the site will be used. The facilities will be built so as to secure room for equipment and education and training but also minimise the space. The grades of equipment will be set as to acquire practical technologies and basic skills required in small and medium industries. And new equipment will be selected in the light of the grade of equipment currently used in small and medium industries, and at the same time, equipment to be selected will be capable of standing long-term use and technology obsolescence.

(9) Policies concerning methods of construction / procurement and construction schedule

This project must be completed within a predetermined construction schedule. For this reason, the construction work of facilities and the procurement of materials and equipment beginning with the design of the project must be planned appropriately, and the construction plan of the facilities will be drawn in accordance with the following guidelines.

(i) The construction schedule will be planned in consideration of the schedule for the dismantlement of the existing gatehouse, approach roads, walls of the PTC, and so on.
(ii) Because the project will be under the supervision of the Ministry of Industries and Production, and under the commitment of the Ministry of Housing and Public Works for the sake of quality control of the facilities, it will be carried out under the scheme that can pass the construction examination set by Karachi City.
(iii) Construction work will be carried out in close cooperation with the Pakistani government.
(iv) The project should be designed in deference to the lifestyle in Pakistan, as well as the culture and tradition of the country.
(v) Construction methods will be determined in the light of circumstances at the site.
(vi) Equipment will be selected so that its spare parts can be obtained without difficulty at lowest possible cost, and that repair services are easily available.

The project mainly consists of the construction of buildings and the procurement of equipment actually used in factories. The schedule will take approximately 19 months in total, in that it includes the construction work, the delivery and installation work takes long time, and soft component is carried out after the installation of equipment.

2-2-2 Basic Plan

2-2-2-1 Basic Plan (Equipment Plan)

Of all above, the flowchart of the materials in the moulding process and necessary equipment are shown in Figure 2. Also, equipment which is requested but not mentioned above has been evaluated in accordance with the following criteria for adequacy and the criteria related to the existing equipment. Table 5 shows the list of such equipment, whereas Table 6 shows the results of evaluation concerning the main equipment.

[Criteria for adequacy evaluation]

A: Equipment should meet the need of small and medium industries in the plastics industry.

B: Equipment should be subject to the scope of the project and fall in the basic items required for the training courses, product testing, and technological assistant services.

C: Equipment should be easily handled for operation and maintenance.

D: There should be no overlap with the existing equipment.

E: Equipment should meet the standards of the ISO concerning plastics products.

[Criteria for evaluation of the current situation of the existing equipment]

A: Equipment which is out of order or decrepit; and cannot be used due to the unavailability of its manufacture because the model is extremely old, or due to the unavailability of spare parts. However, it can be still made use of as an educational material to explain the mechanism and structure of the equipment.

B: Equipment which can be used but fails to demonstrate its full functioning. However, it can be still usable as a material for the basic trainings of beginners.

C: Equipment which can be used and demonstrate its full functioning.

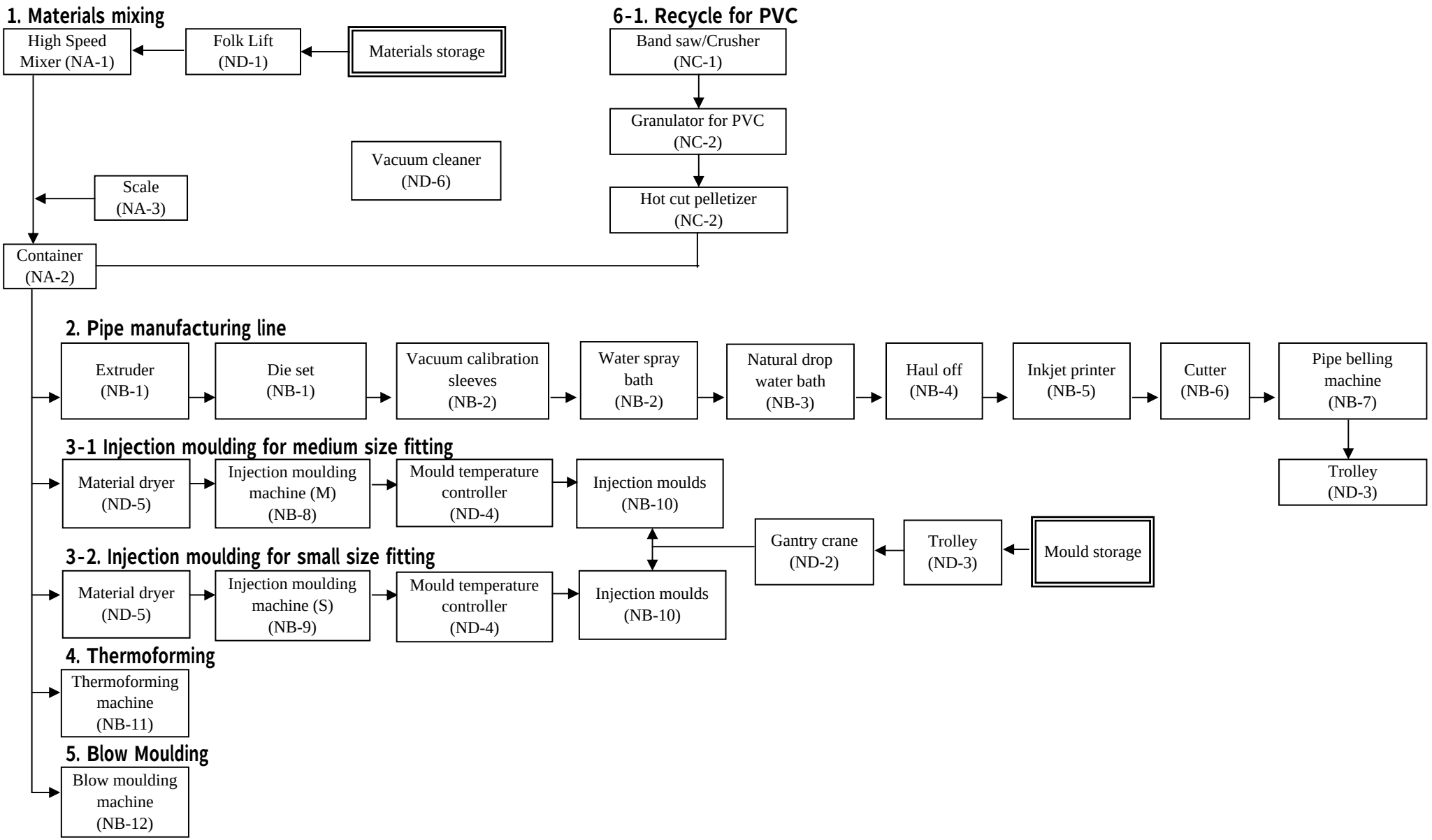


Figure 2 Outline of Processing

Table 5 Study result of the request

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
Plastics Manufacturing Equipment															
PM-1	High speed mixer with controls and chutes and valves. Pneumatic controls, Capacity 200 liter	Mixing polymers, additives, colorant, etc to make evenly blended materials	○	○	○	○				○	1			1 unit Small capability. To be used for basic training for beginners	1
PM-2	Storage tank, 1.5 ton for Pipe Compounds	Storing materials discharged from the mixer	○			○	○		To be changed to Plastic container	○	1				1
PM-3	Weighing Scale, 0-50 Kgs, 0-10Kgs, 0-1Kgs	Measuring the weights of materials, additives, etc.	○	○	○	○	○			○	1				1
PM-4	Folk Lift, 2 ton	Delivering materials from outside to storage or mixing room	○	○	○	○	○			○	1				1
PM-5	Extruder, Twin screw, parallel, Dosage feeder, Venting up to6" diameter pipes, counter rotation, 150Kgs/hour	Manufacturing pipes	○	○	○	○				○	1		1 unit 1988 (1965) To be used for basic training for beginners		1
PM-6	Extrusion Die head, up to 2- 6" dia with die trolley complete	Pulling away extruded pipes at a constant speed	○	○	○	○			Included in PM-5	×					0
PM-7	Bush & Pin for Pipe, Class D, 2, 3, 4, 6"	Metal patterns matching diameters of pipes	○	○	○	○		○	Included in PM-5	×	1		1 unit 1988 To be used for basic training for beginners		0
PM-8	Vacuum calibration sleeves, Vacuum sizer 2, 3, 4, 6"	Reducing pressure to make round pipes, and forming the dimension and shapes	○	○	○	○	○		Included in PM-9	×	1		1 unit 1988 To be used for basic training for beginners		0
PM-9	Water spray bath, for up to 6" dia pipe, 6m	Removing residual heat to stabilize the shape	○	○	○	○	○			○	1				1
PM-10	Natural drop water bath, for up to 6" dia pipe, 3m	Fixing the shape of pipes	○	○	○	○				○	1		1 unit 1988 To be used for basic training for beginners		1
PM-11	Haul Off, for up to 2-6" dia, with measuring and auto thickening device, 0-5m/min	Pulling away pipes at the same speed as extrusion to avoid congestion	○	○	○	○				○	1		1 unit 1988 To be used for basic training for beginners		1
PM-12	Inkjet Printer for pipes	Printing the name of manufacturer and specifications on pipes	○	○	○	○	○			○	1				1

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
PM-13	Cutter, up to 6" dia, with Chamfering option (disk cutter, 6m)	Cutting pipes into an appropriate length	○	○	○	○				○	1		1 unit 1988 To be used for basic training for beginners		1
PM-14	Pipe belling machine, Off line Tooling suitable for rubber ring joints up to 6" dia (RR)	Widening the diameter to make the end of pipes connectable	○	○	○	○	○			○	1				1
PM-15	Single Screw Extruder for small diameter with Palletizer for Olefin & PET material, 50Kgs/hour		○	○	○	○	○		Included in SF-2	×					0
PM-16	Injection moulding machine for UPVC (Hydraulic Type), Clamping force 450 Tons	Manufacturing joints for medium-sized diameter	○	○	○	○				○	1	1 unit 1990 To be used for basic training for beginners			1
PM-17	Injection moulding machine for PET & PC (Electric Type), Clamping force 150 Tons	Manufacturing joints for small diameter	○	○	○	○			Hydraulic type is selected.	○	1		1 unit 1988 To be used for basic training for beginners		1
PM-18	Specimen's mould & fabricate	Making components for test	○			○	○		It shall be made by hand tool.	×					0
PM-19	Hopper loader Floor Type, 150 Kgs/hour	Inserting raw materials into Injection moulding machine	○			○	○		It does not need due to manual operation.	×					0
PM-20	Injection Moulds for solvent type pressure fitting B.S.4346/B.S (EN) 2000 One each for: elbow, Tees, Valve Socket, Reducer, Reducing Tee, faucet fittings	Metal patterns for various joints	○	○	○	○	○	○	Selection of mould shall be limited.	○	1				1
Compounding Workshop															
C-1	Twin Screw Extruder, 50 Kgs/hour	Fusing PVC wastes and products again to make it usable again as raw	○	○	○	○	○		Single screw is selected.	○	1				1
C-2	Hot Cut Palletizer, 50 Kgs/hour	Cutting materials extruded by C-1 into the length of pallet	○	○	○	○	○		Included in C-1	×					0
C-3	Metal Detector	Detecting metals contained in pallet and removing them	○	○	○	○	○		Included in each processing machines	×					0
C-4	Vibrator Motor	Preventing the congestion of the PM-1 pipes	○	○	○	○	○		Included in PM-19. PM-19 is deleted.	×					0

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
Support Facility															
SF-1	Granulator for UPVC, Output 100 Kgs/hour, Cyclone, Dust collector, Grain 5-7mm	Fusing PVC wastes and products again to make it usable again as raw materials	○	○	○	○	○		To be changed to Band Saw and Crusher.	○	1				1
SF-2	Granulator for PET, PE, PP, Output 20 Kgs/hour, Cyclone, Dust collector	Fusing PET, PE, PP wastes and products again to make it usable again as raw materials	○	○	○	○			This machine does not work effectively because of necessity of much PET, PE, PP waste on operation.	○	1		1 unit 1990 To be used for basic training for beginners		1
SF-3	Storage tank for fittings compound, 200Kgs Capacity	Storing raw materials	○	○	○	○	○		Included in PM-2	×					0
SF-4	Crane Gantry (For Injection and Extruder) , 2ton	Used to move or fix the metal patterns	○	○		○	○		Included in Building	×					0
SF-5	Chain Block, 2 ton	Used to move or fix the metal patterns	○	○		○	○		To be changed to Gantry Crane	○	1				1
SF-6	Wooden Floor, 2x2m in Die/Mould Shop	Used to store or repair metal patterns	○	○		○	○		To be prepared by PTC	×					0
SF-7	350KVA Diesel/Furnace oil generator with fuel tank	Electrical power at the time of power failure	○	○		○	○		Included in Building	×					0
SF-8	150 KVA Diesel/Furnace oil generator with fuel tank	Electrical power at the time of power failure	○	○		○	○		Included in Building	×					0
SF-9	Air conditioner for laboratory	Keeping the temperature in the test room at a constant level	○	○		○	○		Included in Building	×					0
SF-10	Recycling Unit, 15 Kg/hr for PET	Recycling wastes and products	○	○	○	○	○		Included in SF-2	×					0
SF-11	Incinerator, double burner type, Small Unit	Incinerating wastes and products	○				○		It is quite difficult to remove dioxin.	×					0
SF-12	Compressor	Used for moulding machines	○	○	○	○	○		Included in each equipment	×					0
SF-13	Trolley, 1 ton, 6m	Used to deliver metal patterns, materials, products, etc.	○	○	○	○	○		It includes for mould moving and pipe moving.	○	1				1
SF-14	Chiller with temperature controller for pipe and fittings	Making coolant water for extruder and injection moulding machine	○	○	○	○	○		Included in Building	×					0
SF-15	Mould Temperature Controller	Heating mould before and during the moulding machine is used	○	○	○	○				○	1			1 unit 1991 Necessary for existing equipment	1
SF-16	Material Dryer, 110℃, 25Kgs, Vacuum	Drying raw materials before they are used	○	○	○	○	○			○	1				1
Additional		Cleaning scattered raw materials	○		○	○	○			○	1				1

Code No.	Original Name and Specifications of Equipment	Necessity Purpose of Use	Judgment	Relevance A	 B	 C	 D	 E	Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose A	 B	 C	Planned Quantity
Processing Machines															
P-1	Thermoforming Small Unit	Forming containers and cases	○	○	○	○				○	1		1 unit 1988 To be used for basic training for beginners		1
P-2	Sheet Forming with single screw extruder double type (Co-Extrusion), Small Unit	Used to mould sheets	○	○		○	○		It is not major.	×					0
P-3	Calendaring Machine, Small Unit	Used to process films and sheets	○	○		○	○		It is not major.	×					0
P-4	Blow moulding (stretch injection type), Small Unit	Used to mould bottles, etc.	○	○	○	○			It does not need special apparatus.	○	1	1 unit 1991 To be used for basic training for beginners			1
P-5	Compression Moulding	Used to mould thermosetting plastics	○			○			It is not major.	×			1 unit 1988 To be used for basic training for beginners		0
P-6	Vertical Injection Moulding Machine, 10-20 ton	Used for products containing different materials	○			○	○		It is not major.	×					0
Quality Control & Testing Lab. Equipment															
Q-1	Short term (1 hour) Hydrostatic testing bath, (20℃ test) 5 station type up to 12" dia	Short-term water pressure tests for PVC pipes: PS3051 ISO3633	○		○	○	○	○		○	1				1
Q-2	Long term Hydrostatic test, 20 - 60℃, one station type, Max. 6", L=1m	Long-term water pressure tests for PVC pipes: PS3051 ISO3633	○		○	○	○	○	Included in Q-1	×					0
Q-3	Methylene Chloride Test	Chemical resistance tests: PS3051, ISO9852	○			○	○	○	It does not need special apparatus.	×					0
Q-4	Glycerine test - Heat reversion test	Tests to observe heat resistance of PVC products	○			○	○		It does not need special apparatus.	×					0
Q-5	Falling ball/weight Impact test equipment, Auto control	Weight impact test for pipe joints: ISO3633, ISO4422, PS3501	○		○	○	○	○		○	1				1
Q-6	Softening point test machine, HDT/VICAT type	Testing softening points and magnitude of deformation due to heat: PS3051, ISO3633, ISO2507	○		○	○		○	Existing equipment is used for VICAT softing point. HDT alone will be installed.	○	1			1 unit 1989 To be used	1
Q-7	Fracture toughness test equipment, 3" to 6" dia	Measured with universal testing machine (Q15). Jigs for the measuring will be supplied: PS3051, ISO3633, PS3505	○			○	○	○	Included in Q-15	×					0

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
Q-8	Opacity test equipment	Testing opacity of PVC pipe joints: PS3051, BS3505, ISO4422	○		○	○	○	○		○	1				1
Q-9	Outside dia measurement gauges	Gauges measuring outside diameter: PS3051, ISO3633, BS3505	○		○	○	○	○	Included in Q-1	×					0
Q-10	Pipe wall thickness measurement gauges	Gauges measuring pipe wall thickness: PS3051, ISO3633,	○		○	○	○	○		○	1				1
Q-11	Groove dia and internal dia measurement gauges	Gauges measuring diameters of joints and pipe grooves: PS3051, ISO3633, BS3505	○		○	○	○	○		○	1				1
Q-12	Fittings internal dia measurement gauges sets	Gauges measuring internal diameters of joints: PS3051, ISO4422,	○		○	○	○	○		○	1				1
Q-13	Pipe Minimum and Maximum outside dia, measurement system	Gauges measuring minimum and maximum outside diameters of pipes: PS3051, BS3505, ISO3633	○		○	○	○	○		○	1				1
Q-14	Distillation Apparatus with demineralizer, 1.8 Lts/hr	Distillation apparatus with dimeneralizer: DIN19266	○		○	○	○	○		○	1				1
Q-15	Universal Testing Machine, 10 tons	Testing machines to measure stress, tension, compression, detachment, and bending: ISO3633, PS3051, PS3505	○		○	○		○		○	1			1 unit 1987 To be used for basic training for beginners	1
Q-16	Digital Hardness Tester: Shore A & D, Rockwell Hardness with Stand	Testing hardness of PVC pipe joints ASTM-D785	○		○	○			Existing equipment is used for hard rubber. Equipment measuring degrees of hardness of shore and rockwell will be supplied:	○	1		1 unit 1989 To be used for basic training for beginners		1
Q-17	Profile Measurement for Extrusion	Machine to observe the condition of inside of products manufactured by variant form extrusion	○		○	○	○		Special use	×					0
Q-18	Thickness Gauge	Gauges measuring thickness of sheets, etc.	○		○	○	○		Included in Q-41	×					0
Q-19	Circumference Measurement for Pipe	Machine measuring circumference of pipes	○		○	○	○			○	1				1
Q-20	Graves Tear Test	machine testing graves tear	○			○	○		Included in Q-15	×					0
Q-21	Water Extraction	Machine extracting materials melted when dipped in pure water	○			○	○		Equipment is not required in that glass containers are used for measuring.	×					0
Q-22	Water Vapor Transmission	Measuring device for water vapor transmission level taken from sample pieces	○		○	○	○			○	1				1

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
Q-23	Torque Tear	Machine measuring tearing strength: ASTM-D751B	○		○	○	○	○	Included in Q-15	×	1				0
Q-24	PPT Resistance	Testing bursting and tearing strength of sheets and films: ASTM－M2582	○			○	○	○	Included in Q-26	×					0
Q-25	Trapezoidal Tear	Testing bursting and tearing strength of thin sheets, etc: ASTM－M4533	○			○	○	○	Included in Q-15	×					0
Q-26	Puncture Resistance	Machine measuring bursting strength of packing film sheets: ASTM-M4833	○		○	○	○	○		○	1				1
Q-27	Humidity Chamber for Testing (Weather Stress Machine)	Humidity chamber for testing moulded products, etc.	○		○	○	○			○	1				1
Q-28	Freezer, Chest Type, -30℃	Freezer measuring physicality of sample pieces at low temperature	○		○	○	○			○	1				1
Q-29	3-D Measuring Machine (3-D MM)	Measuring 3-dimentions of product samples for making metal patterns on trial basis with CAD	○		○	○	○		Special use	×					0
Q-30	FTNIR with solid and liquid sample preparation accessories, software with DRS, ATR and IR	Machine analyzing identification, foreign substances, etc of resin	○		○	○	○			○	1				1
Q-31	Gas Chromatograph with accessories including software * Head Space Injector for GC * Molecular Sieve glass and SS columns for GC, 1/8" and 1/4" * Capillary columns for GC and GC-MS	Machine measuring infinitesimal impurities	○		○	○	○		Selection of columns shall be limited.	○	1				1
Q-32	Thermal conductivity detector	Machine measuring heat conductance of resin	○		○	○	○		Special use	×					0
Q-33	Thermal Analyzer, TGA & DSC	Machine measuring attributes of resin materials	○		○	○	○			○	1				1
Q-34	HPLC: * Octadecyl (RP column) for HPLC * Refractive Index detector for HPLC * Gel permeation columns for HPLC * Packed column injector for HPLC	Machine confirming impurities in materials and analyzing the fixed amount of additives, etc.	○		○	○	○		Selection of objectives shall be limited.	○	1				1
Q-35	Digital Impact Tester	Machine measuring impact tenacity (Charpy, Izod): ASTM-D1822, ISO13802	○		○	○	○	○		○	1				1
Q-36	Creep Tester, ISO-889	Creep tester for plastics products: ISO889, ISO4589	○		○	○	○	○		○	1				1

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
Q-37	Mullen Type Bursting Strength Tester, Up to 2000 Kpa	Tester for bursting strength and capacity to burst, etc.: ISO2785, ISO2759	○		○	○	○	○		○	1				1
Q-38	Oxygen Index Tester	Tester evaluating burning quality of polymer molecule such as plastics: ASTM-D2863, ISO4589	○		○	○	○	○		○	1				1
Q-39	Ozon Ageing Tester	Machine testing aging and deterioration of moulded products due to ozone: ASTM-D1149,	○		○	○	○	○		○	1				1
Q-40	Automatic Gas Permeability Tester	Permeability tester for oxygen and other gases: ASTM-D1434, ISO2558	○		○	○	○	○		○	1				1
Q-41	Digital Thickness Tester (Micrometer)	Thickness tester for film sheets, etc.	○		○	○	○			○	1				1
Q-42	Thermally Stimulated Current Tester	Observing activation of polymer molecule	×			○	○		Special use	×					0
Q-43	Ultrasonic Flaw Detector	Machine detecting flaws in soft PVC sheets, etc. during the process of ultrasonic adhesion	○		○	○	○			○	1				1
Second Plastic Processing															
S-1	Ultrasonic Welder with accessories (Gun)	Used to weld sheets, etc.	○		○	○	○			○	1				1
S-2	Plumbing Tools for 10 students (Several Types)	Used to connect pipes	○		○	○	○			○	1				1
S-3	Bending Machine	Bending pipes	○			○	○		Special use	×					0
S-4	Printing Machine for plastic packaging	Printing on plastics products	○			○	○		Included in PM-12	×					0
Plastic Design Laboratory															
PD-1	Computers Pentium 4 for Student	Training for operation of computer and software such as CAD	○	○	○	○				○	30			15 units To be used for basic training for beginners	15
PD-2	Pentium 4 for Teachers	For teaching staff	○		○	○				○	1				1
PD-3	UPS (Uninterrupted Power Supply)	Stabilizing power voltage, and supplying electricity in an emergency	○		○	○				○	1				1
PD-4	Laptop computer 4 with printer	For projectors	○		○	○	○			○	1				1
PD-5	Laser Printer, A4	For printing computer files	○	○		○				○	1				1
PD-6	Laser Printer, A3	For printing computer files	×	○	○	○	○		Included in PD-5	×					0
PD-7	Scanner, A3	Scanning documents and materials which will be used in class	○	○	○	○			Included in PD-5	×					0
PD-8	Plotter, A1	Outputting large drawings	×			○	○		Included in PD-5	×					0

Code No.	Original Name and Specifications of Equipment	Necessity	Judgment	Relevance					Study	Judgment	Necessary Quantity	Condition of Existing Equipment Q'ty, Installed year (production year), Purpose			Planned Quantity
		Purpose of Use		A	B	C	D	E				A	B	C	
PD-9	Server	Connecting each computer to printers and scanners for better efficiency	○	○	○	○				○	1				1
PD-10	Software:	For training of CAD	○	○	○	○				○	1				1
Training Aids															
T-1	Multimedia	Projector to connect computers	○		○	○	○			○	1				1
T-2	Video player and TV 32"	For playing videotapes	○		○	○	○			○	1				1
T-3	Digital Camera with zoom	Digital camera for still images	×		○	○	○		Included in T-4	×					0
T-4	Digital Camera with portable recorder	Digital video camera for moving and still images	○		○	○	○			○	1				1
T-5	Mobile stand for camera	Tripod stand for cameras	○		○	○	○		Included in T-4	×					0
T-6	DVD player with TV	For playing DVD media	○		○	○	○		Included in T-2	×					0
T-7	Projector for projection of samples	Projector to project sheets and actual substances	○		○	○	○		Included in T-1	×					0
T-8	Books, Journals, Videos and CD-Rom	Specialized books and ready-made media for education	○		○	○				○	1				1
T-9	Testing and Production Standards: JIS, ASTM, BSS, DIN, ISO, 1 each	ISO and other standards	○		○	○				○	1				1
T-10	Copy Machine, A3	Making source materials for practical works	○		○	○			Included in PD-5	×					0
Maintenance Equipment															
M-1	Tools for maintenance	For maintenance of equipment	○	○	○	○			To be selected general purpose tools	○	1				1
M-3	Multimeter	For maintenance of equipment	×	○	○	○			Included in M-7	×					0
M-4	Oscilloscope	For maintenance of equipment	×	○	○	○			Planned equipment does not need this equipment.	×					0
M-5	DC Generator	For maintenance of equipment	×	○	○	○			Planned equipment does not need this equipment.	×					0
M-6	IC Tester	For maintenance of equipment	×	○	○	○			Planned equipment does not need this equipment.	×					0
M-7	Circuit Tester	For maintenance of equipment	○	○	○	○				○	1				1
M-8	Revolution Counter	For maintenance of equipment	×		○	○	○		Planned equipment does not need this equipment.	×					0
M-9	Repairing instruments for computerized equipment	For maintenance of equipment	○	○		○			To be selected general purpose tools	○	1				1

Table 6 Major Equipment List

	Name of Equipment	Main Specification	Q'ty	Purpose of Use
1	High Speed Mixer	1.Law high speed mixer: 100L 2.Cooling tank：200L 3.Compressor: 3.5kW	1	Mixing polymers, additives, colorant, etc to make evenly blended materials
2	Forklift	1.Capacity Load：1000kg	1	Loading and unloading of materials, products in PTC
3	Extreder for pipe	1.Twin screw parallel vented extruder：output rate 100kg/hour	1	Manufacturing pipes
4	Die head and die	1.Mould size: 2inches, 4inches, 6inches	1	Jig for die and die sets
5	Water Spray Bath and vacuum calibration sleeves	1.Bath length：5m 2.Vacuum calibration sleeves	1	Removing residual heat to stabilize the shape
6	Natural Drop Water Bath	1.Bath length：5m	1	Fixing the shape of pipes
7	Haul-off	1.Caterpiller vertical type 2.Speed：Max.7m/min.	1	Pulling away pipes at the same speed as extrusion to avoid congestion
8	Printer for pipes	1.Inkjet type 2.Color: Black	1	Printing the name of manufacturer and specifications on pipes
9	Cutter for pipes	1.Diameter：13～200mm 2.Length：6m	1	Cutting pipes into an appropriate length
10	Pipe Belling Machine	1.TS Joint : 2inches, 4inches 2.RR Joint : 2inches, 4inches	1	Widening the diameter to make the end of pipes connectable
11	Injection Moulding Machine for medium size fitting	1.Hydraulic type 2.Clamping force：450t or more 3.Injection capacity：1,730g or more	1	Manufacturing joints for medium-sized diameter
12	Injection Moulding Machine for small size fitting	1.Hydraulic type 2.Clamping force：170t or more 3.Injection capacity：325g or more	1	Manufacturing joints for small diameter
13	Injection Moulds for fitting	1.Elbow 2.Tees 3.Valve socket 4.Reducer 5.faucet	1	Metal patterns for various joints
14	Thermoforming Machine	1.Sheet size：600x600mm 2.Depth：350mm	1	Forming containers and cases
15	Blow Moulding Machine	1.Stretch blow moulding 2.Mould：0.5L,1,5L	1	Used to mould bottles, etc.
16	Granulator for PVC	1.Single screw extruder：50kg/hour 2.Hot cut pelletizer	1	Fusing PVC wastes and products again to make it usable again as raw materials
17	Hot cut pelletizer	1. Side cut 2. Pellet cooler	1	Used for cutting of extruded pellet
18	Crusher	1. Number of cutting edge: 3 2.Motor: 11kW	1	Making PVC wastes usable again as raw materials
19	Gantry crane	1. Capacity: 2t 2. Chain block	1	Used to move or fix moulds
20	Mould Temperature Controller	1.Mould temp.：Max.90℃ 2.Mould weight：Max.2,000kg	1	Heating mould before the moulding machine and controlling temperature of mould are used
21	Material Dryer	1.Capacity：50kg/hour or more 2.Temperature：80～110℃	1	Drying raw materials before they are used
22	Short/Long term Hydrostatic testing bath	1.Test pipe length：1.0m 2.Test temp.：20±1.5℃	1	Short and long-term water pressure tests for PVC pipe.
23	Falling ball Impact testet	1.Falling distance：2.0m 2.Impact velocity：free 3.Mass of falling weight：5～20kg	1	Weight impact test for pipe joints

	Name of Equipment	Main Specification	Q'ty	Purpose of Use
24	HDT test equipment	1.Test temp.：Normal temp.～300℃ 2.No. of sample：3 3.Temp. step：2℃／min.	1	Testing softening points and magnitude of deformation due to heat
25	Opacity test equipment	1.Light source：Halogen lamp 2.Measuring range：380-780nm 3.Measuring area：6,10,30mm	1	Testing opacity of PVC pipe joints
26	Universal Testing Machine	1.Load：10kN 2.Test speed：0.0005-1000mm/min.	1	Testing machines to measure stress, tension, compression, detachment, and bending
27	Test piece making equipment	1. Plain cutter 2. V & U cutter	1	Making test piece for Universal Testing Machine
28	Digital Hardness Tester	1.Rockwell type hardness tester 2.Durometer	1	Testing hardness of PVC pipe joints
29	Water Vapor Transmission Measuring Equipment	1.Measuring range：5～70℃ 2.Controlled RH testing：50～90RH%	1	Measuring device for water vapor transmission level taken from sample pieces
30	Puncture Resistance tester	1.Punctur point：25mm	1	Machine measuring bursting strength of packing film sheets
31	Humidity Chamber for Testing (Weather meter)	1.Lamp：Xenon lamp 7.5kW 2.Standard irradiant：25-70W／	1	Humidity chamber for testing moulded products, etc.
32	FTIR (Fourier Transform Infra Red Spectrophotometer)	1.Main body 2.NIR kit 3.FIR kit	1	Machine analyzing identification, foreign substances, etc of resin
33	Gas Chromatograph	1.Main body 2.Columns	1	Machine measuring infinitesimal impurities
34	Thermal Analyzer TGA/DSC	1.Differencial Scanning Calorimeter 2.Automated cooling system	1	Machine measuring attributes of resin materials
35	HPLC (High Performance Liquid Chromatograph)	1.Solvent delivery unit 2.Degasser 3.Sample injector 4.Column oven	1	Machine confirming impurities in materials and analyzing the fixed amount of additives, etc.
36	Digital Impact Tester	1.Izot test：1-150kgf/cm2 2.Charpy test：10-150kgf/cm2	1	Machine measuring impact tenacity (Charpy, Izod)
37	Creep Tester	1.Load model：10-1000N 2.Load step：1N 3.Elongation：0-50mm	1	Creep tester for plastics products
38	Mullen Type Bursting Strength Tester	1.Bursting strength：Max.2000kPa 2.Liquid feed rate：95±5ml/min.	1	Tester for bursting strength and capacity to burst, etc.
39	Oxygen Index Tester	1.Flammable Column：75mm (Dia.) x450mm (H) 2.Oxygen Index setting：6-94%	1	Tester evaluating burning quality of polymer molecule such as plastics
40	Ozon Aging Tester	1.Chamber size：50x50x50cm 2.Ozon density：10-200pphm	1	Machine testing aging and deterioration of moulded products due to ozone
41	Automatic Gas Permeability Tester	1.Test piece：1 2.Measuring temp.：5-95℃	1	Permeability tester for oxygen and other gases
42	Ultrasonic Flaw Detector	1.Measuring range：20-10,000mm	1	Machine detecting flaws in soft PVC sheets, etc. during the process of ultrasonic adhesion
43	Ultrasonic Welder	1.Max.output：450W 2.Frequency：19.15kHz	1	Used to weld sheets, etc.
44	Software	1.Extrusion 2.Injection	1	Software for studying of mechanism and operation on Extrusion and Injection machine