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TRAINING OF ENGINEERS AND OPERATORS FOR NEW IRON AND STEEL OPERATIONS IN DEVELOPING COUNTRIES

by

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SUMMARY

Three levels of foreign engineering training programmes based on experience acquired over the past twenty-three years in Metallurgical Engineering are discussed. They are presented as possible guides for those persons who may become involved in making the decisions concerning the training of engineers and operators, who after their basic training, will be able to assume responsible positions in a new plant or perhaps an expanded steel industry in their home country. "Short Term, Combined University - In-Plant Group Training (Level "C") Programmes" are compared with "Government Promoted Training Programmes Within the Country" (Level "B") and "Regular University Academic Training Programmes" (B.S., M.S., Ph.D. programmes Level "A") where "spin-off" possibilities exist.

Illustrations of all three levels cite the advantages, depth, scope, and limitations of each type of programme. Some conclusions are presented along with recommendations concerning the use of short-term university programmes for engineering training supplemented with in-plant assignments and possible future graduate studies for outstanding students who complete this short-term programme. This paper outlines the critical need for simultaneous engineering educational training which should be coupled to parallel the growth of the new iron and steel operation in developing countries.

1. Engineer Training to Parallel Steel Plant Design and Construction Schedule

Whenever decisions are made to start building a new steel plant designed to apply modern technical practices in developing countries, considerable attention should be simultaneously focused on the parallel educational problem of training engineers and operators. To obtain efficient and economical operation of the iron and steelmaking facility, it will be necessary to replace the foreign engineers who have installed and operated the equipment while the "bugs are being ironed out" and the mill is tested for its designed capacity. Many steel plant executives believe that nothing equals "on-the-job training" for operating personnel, so a training programme poses several important questions:

a. What kind of training programme shall be adopted?

b. Who shall be selected for training?

c. When should the training programme start and terminate?

d. What will it cost?

2. Three Levels of Engineering Training May be Available

In terms of past experience, three basic levels of Metallurgical Engineering training will be reviewed. It should be noted here that this paper, which may possibly be used as a guide, is based upon the results obtained of training foreign students in Metallurgical Engineering at the University of Pittsburgh so that after their basic training in the United States, they would be prepared to assume responsible positions in new or expanded steel industries in their respective countries. Training programmes experienced at Pittsburgh may be classified in three levels for potential engineers and steel plant operators.

Level "A" Regular University Academic Training Programmes

a. Four Year Bachelor of Science Programme in Metallurgical Engineering

b. Three-Two Programme leading to two Bachelor of Science degrees. One B.S. degree from the student's home country (three years) plus an American university B.S. degree in Engineering after two additional years of study in the special field.

c. Advanced degree programmes for Master of Science or Doctoral degrees.

Level "B" Government Promoted Courses Within the Country

a. Universidad Tecni . Federico Santa Maria (Valparaiso, Chile) AID contract with University of Pittsburgh to train Doctoral candidates in Chemical and Electrical Engineering at UTFSM.

b. Universidad Tecnica del Estado (Santiago, Chile) AID contract with University of Pittsburgh to train technicians and workers at UTE.

c. Universidad Central (Quito, Ecuador) AID technical assistance programme with University of Pittsburgh.

Level "C" Short Term Combined University and In-Plant Training Programme

a. One year programme for the Latin American Trainees For Steel Industry (LATFSI)

Long-range planning objectives together with adequate timing suggest the adoption of university training programmes Levels "A" and "B" supplemented with in-plant or on-the-job experience; however, the short-term LATFSI programme (Level "C") was unique and produced excellent results with a group of students having heterogeneous backgrounds.

3. One Year LATFSI Programme at Pitt

The Latin American Trainees For Steel Industry programme will be described in detail, for excellent training results were obtained in a relatively short time. The programme was organised to consist of an orientation seminar of one month's duration in Buenos Aires followed by a one-year training programme in the Metallurgical Engineering Department of the University of Pittsburgh. The Pitt programme consisted of the following phases:

a. A two-month schedule of visitations to many plants; intensive classroom lectures on process metallurgy plus English instruction.

b. Regular trimester class programme in which the LATFSI students were integrated with Metallurgical graduate and undergraduate students, and intermittent special plant visitations.

c. Five month in-plant or on-the-job training experience and graduate research courses.

d. Closing seminar where LATFSI students discussed their in-plant training experiences.

The students attended the University on scholarships sponsored by the Organisation of American States (OAS) supplemented by grants from their companies or home governments. Very limited OAS funds and company grants made it necessary to employ an economic budget appreciably below the expenditures of the average American university student.

4. Student Selection Criteria

Student selection for the LATFSI programme was excellent considering the educational and economic backgrounds of the students, their age spectrum, their domestic status, their temperament, and their job responsibilities in their native countries. Six Latin American countries were represented by the group which included students from Argentina, Brasil, Chile, Colombia, Mexico, and Peru. The five Argentinian students worked for either Crisoldine, TAMET, Altos Hornos Zapla, Acindar or SOMISA. Their ages varied from 20 to 47 years. The two Brasilian students worked for Volta Redonda in hot strip mill operations and the open hearth shop. The Chilean student was employed in the blast furnace department at the CAP Huachipato plant. The three Colombian students worked for Acerias Paz del Rio in the foundry, the rolling mill, and Thomas converter shop. Three of the four Mexican students were recent graduates from either the Institute Politecnico Nacional or the National University of Mexico. These were sponsored by Banco de Mexico, while the fourth Mexican engineer worked for Tubos Acero de Mexico. Two of the three Peruvian engineers worked for SOGESA's Chimbote plant, while the third - a recent chemical engineering graduate was interested in refractories.

a. Since Metallurgical Engineering, according to our professional classification in North America, was not being taught in Latin America, at the time of the programme the students' educational background was quite broad and included Mechanical, Civil, Chemical, Electric, Naval, and Military engineers. All the students were able to read English for American texts were used extensively in the Latin American universities. However, their limited English comprehension and speaking ability necessitated a specialized English instruction period which was not anticipated when the programme was formulated. All but four of the eighteen students were married and had families. After the formal University courses and just prior to their in-plant training assignments, twelve of the wives and many of their children arrived in the States so that ultimately 48 persons were in the total LATFSI group.

b. Much to the surprise of the teaching staff, the LATFSI group with its heterogeneous background was fused into a highly competitive student body motivated by a great desire to learn "everything that was new" in steelmaking. They had extra "drive" to learn principles and technical information which they might later apply upon their return to their home countries.

5. <u>LATFSI Orientation Seminar in Buenos Aires</u>

The <u>LATFSI Orientation Seminar</u> was held May 4 to June 2, 1959 in Buenos Aires at the Facultad de Ingeneria to acquaint the students with Latin American steelmaking problems of obtaining raw materials, developing processes, and making steel products. The symposium programme was organized to include comprehensive lectures from Latin American Experts from various countries. A series of United Nations publications listed in Table 1 was distributed to each student and served as texts used extensively by the lectures.

<u>Table 1. - LATFSI Orientation Seminar Texts from the United Nations and Distributed to the Students</u>

a. <u>Problems of Steelmaking and Transforming Industries in Latin America,</u> Vol. I - Report of Sao Paulo Meeting, United Nations, N.Y. 1958, Sales No: 1957 II G. 6, Vol. I ($.75).

b. <u>A Study of the Iron and Steel Industry in Latin America,</u> Vol. I, Report on the Meeting of the Expert Working Group held at Bogota, United Nations N.Y. 1954, Sales No: 1954 II G.3, Vol. I ($1.25).

c. <u>A Study of the Iron and Steel Industry in Latin America</u>, Vol. II, Proceedings of the Expert Working Group held at Bogota, United Nations, Sales No: 1954 II G. 3, Vol. II ($4.50).

A summary of the seminar activities and digest of some of the remarks made by the experts follows in Table 2.

Table 2. - LATFSI Orientation Seminar Programme in Buenos Aires, May 4 - June 2, 1959

Speaker or Expert	Digest of Lecture
General Armando Martijena, Director, Fabricaciones Militares, Argentina	General Martijena discussed the importance of the Steel Industry in Latin America and how the LATFSI programme will be another aid for the solidification and growth of the steel industry in South America.
Dr. José A. Mora Secretary General, Organization of American States	Dr. Mora discussed the shortage of technical people in all branches of science and technology all over Latin America, and enumerated some of the problems of importing experienced technical labour and management.
Mr. Edwin Engel, Armco International Corporation, Buenos Aires, Argentina	Mr. Engel discussed the economics of the steel industry, capital investment, optimum plant size, integral plants, etc.
Mr. Thomas Fraser, formerly U.S. Bureau of Mines, Coal Consultant in South America	Mr. Fraser described the different types of coal known in Latin America, their coking ability, coal chemistry, coke manufacturing methods, etc.
Mr. Hector Canguilhem, Compania de Acero del Pacifico, Chile	Mr. Canguilhem lectured on steel-making processes and gave detailed explanations concerning equipment operations, blast furnace, low-shaft furnace, etc.
Dr. J. Alfred Berger Metallurgical Engineering Department, University of Pittsburgh	Dr. Berger described in detail the projected LATFSI programme at Pitt and presented a series of lectures on steelmaking processes.
General Macedo Soares e Silva Volta Redonda, Brasil	General Macedo Soares reviewed the total steel industry in South America from an economic viewpoint. He cited the conveniences and advantages which arise from having an industry in the home country rather than important products.

6. LATFSI Metallurgical Engineering Courses and Curriculum at Pitt

The LATFSI students registered for the following courses, shown in Table 3, many of which were especially formulated for the group. However, the grades obtained in all courses numbered in the 100 series carry credits which may be applied towards advanced degrees (Master of Science or Doctor of Philosophy), if the LATFSI students should elect to pursue graduate studies at the University of Pittsburgh or other accredited educational institutions.

Table 3. - LATFSI Metallurgical Course Registration or Curriculum

I. Intensive summer Metallurgical Engineering courses taken only by LATFSI students during July and August 1959.

Department	Title	Credits
Met. S41	General Blast Furnace Metallurgy	2
Met. S42	General Open Hearth Metallurgy	2
Met. S22	Metallography Laboratory	2
English XI	English as a Foreign Language	3
	Total Credits	9

II. Fall Trimester Metallurgical Engineering courses simultaneously taken by American students and LATFSI students (9/1/59-1/15/60)

Department	Title	Credits
Met. 4	Blast Furnace Technology	2
Met. 101*	Steel Plant Management	2
Met. 111*	Liquid Steel Controls - Bessemer and Acid Open Hearth	2
Met. 112*	Liquid Steel Controls - Basic Open Hearth - L.D.	2
Met. 75	Undergraduate Seminar	1
Met. 9	General Metallurgy for Engineers	2
Met. 22	Metallurgical Laboratory Operations and Quality Control	1
English X2	Practice in Spoken English	1
	Total Credits	13

III. LATFSI student course registration during in-plant training experience (1/16/60-6/1/60)

Department	Title	Credits
Met. 197*	Graduate Research Projects for M.S.	3
Met. 198*	Graduate Research Projects for M.S.	3
	Total Credits	6

* Courses and credits may be applied later to the M.S. degree programme.

7. **LATFSI Plant Visitations Integrated with Class Work**

Plant visitations were schedules to illustrate operations which were being discussed by their professors in the classroom. Table 4 briefly tabulates the plants visited by the LATFSI students before their in-plant training assignments.

Table 4. - Plant Visitations by LATFSI Students and Pitt Professors Via Chartered Bus.

	Plant and Location	Facilitary Visited
1.	Lockhart Iron and Steel (Pittsburgh)	Hand puddling furnaces, and modern steel warehouse
2.	J. & L. Steel Corporation (Pittsburgh Works)	Integrated steel plant - open hearth shop, blooming mill, strip mills
3.	Mackintosh-Hemphill Company (Pittsburgh Works)	Manufacture of large iron rolls in an air furnace
4.	Crucible Steel Company Research Laboratories (Pittsburgh)	Modern research laboratory for testing magnetic, stainless steels, alloy steels, and tool steels
5.	Weirton Steel Company (Weirton, W.Va.)	Integrated steel plant - coke ovens, sinter plant, blast furnaces, bessemers, open hearths, strip mills, electrolytic tin lines
6.	Heppenstall Company (Pittsburgh Works)	Acid open hearth furnaces - low alloy steel melting, forging operations, machine shop
7.	Superior Steel Company (Carnegie, Pa.)	Stainless steel rolling mills, unique processing equipment
8.	U.S. Steel Corporation (Monroeville, Pa.)	Applied Research Laboratory, complete facilities for testing modern steels and developing new products
9.	A.M. Byers Company (Ambridge, Pa.) (Pittsburgh Works)	Modern wrought iron and stainless steel producing plant, pipe skelp, pipe fabrication mills
10.	U.S. Bureau of Mines (Bruceton, Pa.)	Small experimental blast furnace and pilot plant
11.	Harbison-Walker Company (Pittsburgh)	Modern refractories testing and development laboratory
12.	Vulcan Mold Company (Latrobe, Pa.)	Ingot mold manufacturing by cupola iron melting
13.	Latrobe Steel Company (Latrobe, Pa.)	Electric arc furnace practice, vacuum arc melting furnace, complete tool steel mill
14.	Hiram Swank Sons (Johnstown, Pa.)	Refractories manufacturing plants

	Plant and Location	Facility Visited
15.	Climax Molybdenum Company (Langeloth, Pa.)	Molybdenum ferro-alloy producing plant
16.	United Engineering & Foundry Company (Pittsburgh)	Rolling mill and heavy equipment manufacturing
17.	Jessop Steel Company (Washington, Pa.)	Stainless and tool steel shop
18.	Babcock & Wilcox Company (Beaver Falls, Pa.)	Electric furnace and open hearth steels, seamless tubes, extruded metals
19.	J. & L. Steel Corporation (Aliquippa Works)	Integrated steel plant L.D. oxygen steel process
20.	U.S. Steel Corporation (Homestead, Pa.)	Large integrated plant - open hearths, large plate, structural mills, forge shop
21.	Atlas Steel (Welland, Ontario, Canada)	Continuous casting stainless and alloy steels
22.	Strategic Udy Pilot (Niagara Falls Plant, Canada)	Ore beneficiation - reduction plant

8. LATFSI Laboratory Instruction Programme

A special course (Met.E. 22) entitled "Metallography, Laboratory Practice and Quality Control" was inaugurated so that the LATFSI students could obtain experience in operating equipment in the various metallurgical department's laboratories. Steels of varying analyses were melted by the students in the 200 pound high-frequency induction furnace; cast into 25 pound ingots; hot rolled into strip or bar samples; machined into mechanical test specimens, then tested as shown in Table 5.

Table 5. - LATFSI Student Metallurgical Laboratory Quality Control Testing Operations

a. Hardness testing (Brinell, Rockwell "C", "B", "A", etc.)

b. Mechanical property tensile testing, impact testing, fatigue testing.

c. Metallographic specimen preparation and examination (mounting, polishing, etching, microscopic examination)

d. Macro examination (polishing, etching, evaluation).

e. Hot metal or liquid steel sampling.

f. Immersion thermocouple operation.

g. Optical pyrometry.

h. Slag pancake preparation.

i. Fracture testing steels.

j. Spark testing steels.

k. Carbometer and carbanalyzer operation.

l. X-ray powder diffraction analysis.

m. X-ray fluorescent sinter analysis.

n. Spectrographic analysis of steels.

9. LATFSI Five Month In-Plant or Job Training Experience

In-plant or on-the-job training assignments from January to June 1, 1960 were complicated by many factors, the most prevalent being the inability of the student's plant representatives to make the necessary arrangements. Initially, the persons responsible for the students theoretical training at the University were assured that, student in-plant training assignments would be handled by U.S. resident representatives of the Latin American Steel Companies through their affiliates, subsidiaries, equipment producers, or process licensers. The New York representative of the Brasilian National Steel Company was the only one who made in-plant training arrangements including transportation for his Brasilian students, which included visitations to Youngstown Sheet and Tube Company, Cleveland Works - Jones and Laughlin Steel Corporation, Fairless and Geneva Works - U.S. Steel Corporation, Kaiser Steel at Fontana, and the A.G. McKee Company - Cleveland. These excellent arrangements gave the Brazilian students an opportunity to obtain on-the-job observations of the steelmaking practices of prime interest to Volta Redonda. All the other students were placed in training programmes through the direct efforts of the Metallurgical Engineering staff and ultimately included the following assignments:

a. Ford Motor Company (Detroit)
Two Argentinian and two Mexican LATFSI students.

b. A.M. Byers Company (Pittsburgh and Ambridge Plants)
One Argentinian, one Mexican, and three Colombian LATFSI students.

c. Jessop Steel Company (Washington, Pa. and Green River, Kentucky Plants)
   Two Peruvian, one Argentinian, and one Mexican LATPSI students.

d. Republic Steel Corporation (Chicago)
   One Chilean, one Argentinian LATPSI students.

e. Harbison-Walker Refractories (Clearfield, Pa. plant and Pittsburgh Research Laboratory)
   One Peruvian student.

Some of the large participating companies had formal training programmes which included planned visitations to every department from the raw materials handling to the final product shipment. Other plants, after brief orientation programmes, placed the students on assignments directly concerned with his steelmaking speciality interests. For example, the Chilean student spent four months in blast furnace operations; an Argentinian student spent four months in the wire mill, while another spent three months in the rolling mills. Some idea of the scope of the in-plant training experiences may be obtained from Tabls 6 describing the condensed seminar and roundtabls symposium schedule presented for two weeks at the close of the programme.

Table 6. - Condensed Seminar and Round Table Discussion Programme on In-Plant Training experiences by the LATPSI Students

	Subject	LATPSI Student
1.	Carbon Steel Melting and Arc Furnace Practice at Jessop's Green River Works	Peruvian
2.	Stainless Steel and Tool Steel Melting Practices at Jessop's Washington Plant	Peruvian
3.	Jessop's Speciality Steels, Processing and Quality Control	Mexican
4.	Wrought Iron Manufacturing by Byers Process	Colombian
5.	Bessemer Operations for Producing Iron	Colombian
6.	Rolling Pipe Skelp and Special Products	Colombian
7.	Mill Maintenance Practices	Argentinian
8.	Electric Furnace Stainless Steel Arc Melting at Byers	Mexican
9.	Blast Furnace and Open Hearth Operations at Ford	Argentinian
10.	New Oxygen Open Hearth Practice at Ford	Argentinian

	<u>Subject</u>	<u>LATFSI Student</u>
11.	Blast Furnace Practices at Republic's Chicago Works	Chilean
12.	Open Hearth and L.D. Operations steelmaking	Brazilian
13.	Strip Mill Operations at Several Plants	Brazilian
14.	Rolling Mill Operations at Ford	Mexican
15.	Rolling Operations at Jessop	Argentinian
16.	Metal Fabrication and Car Assembly at Ford	Mexican
17.	Wire Mill Operations at Republic	Argentinian
18.	Metallurgical Refractory Manufacturing at Harbison Walker	Peruvian

10. <u>Instruction on Industrial Safety</u>

The importance of industrial plant safety practice was emphasized at regular intervals and during each plant inspection visit. At the beginning of the programme each student and instructor was provided with his personal hard hat (safety helmet) and blue furnace glasses. Safety goggles were always supplied when plant observations were made in eye hazard areas or in the laboratory machine shop and steel melting areas. Asbestos safety gloves, protective jackets and aprons were used in the laboratory when students melted steels, cast the ingots, and heat treated samples. The continual enforcement of safety regulations together with industrial safety movies were very worthwhile for none of the LATFSI students sustained any sifnificant injury or accident during the entire training programme.

11. <u>B.S. in Metallurgical Engineering Programme and Three-Two Training Programmes</u>

Other types of engineer training programmes warrant serious consideration for preparing mill operators, if four or five years are available for training the student. The standard nine trimester or eight semester regular University B.S. programme, requiring three to four years, provides an able student with a Bachelor of Science degree in Metallurgical Engineering which should be supplemented by on-the-job training by summer industrial plant practice between terms. A Three-Two plan exists (requiring a total of five years of study) in which the student, through prior University cooperative arrangements, takes <u>his basic sciences (mathematics, physics, chemistry, humanities, social sciences, and English) at a university in his native country</u> and then, for example, takes the last two junior and senior year's programme in Engineering at Pitt. Upon the completion of his studies at Pitt, the student then receives two Bachelor of Science in Engineering degrees (one from the university in his native country and one from the University of Pittsburgh). This Three-Two plan has been in existence for ten years with the University of the Andes at Bogota and more than 30 engineers have received two separate degrees. An early modification of this plan enabled a top operations official in the National Venezuelan Steel Company to obtain his B.S. in Metallurgical Engineering at the University of Pittsburgh, subsequently followed by additional graduate studies and on-the-job training in his home country.

12. <u>Master of Science and Ph.D. Advanced Degrees in Metallurgical Engineering for Operations and the Native University Teaching Profession</u>

Time and funds permitting, advanced degree graduate studies for the Master of Science in Metallurgical Engineering, or perhaps even the Doctor of Philosophy degrees, deserve serious engineer training consideration when research oriented mill operators and future plant executives are desired. Two Venezuelan students after having received the B.S. degree in Metallurgical Engineering from Rensselaer Polytechnic Institute spent two years in graduate studies toward the Master of Science degree in Metallurgical Engineering at the University of Pittsburgh and both have very responsible positions in the Venezuelan Steel Industry. A "spin-off" effort on the part of one of these men has produced a new type of steel product for Venezuela, thereby aiding his country's development as well as his own financial position. Both of these former graduate students also serve as part-time metallurgy professors at Universidad Central Venezuela, training students and future professional staff members. Thus, long-range educational planning efforts are producing the necessary educational results which are coupled directly to the parallel growth of steel producing facilities.

13. <u>Government Sponsored Engineering Training in Home Country and Cooperating American University</u>

In foreign countries where accredited universities are already established, two universities located in different countries might solicit governmental support for mutual contracts with one another which might start new engineering or other types of curricula in the home country, new graduate programmes, new professor training programmes, worker training programmes, and many other long and short-range objectives. For example, for the past three years AID has sponsored a contract between the Schools of Engineering and Mines and two separate Chilean Universities, Universidad Tecnica Federico Santa Maria (UTFSM) at Valparaiso and the Universidad Tecnica del Estado (UTE) which has eight campus sites located along Chile's 2300 mile length.

a. At Santa Maria, a team of Pitt professors and UTFSM professors have instituted a graduate doctoral programme in Chemical and Electrical Engineering within Chile. In April 1963, at the graduating ceremony, the first doctoral degree in Chemical Engineering in Chile was awarded while Chancellor Litchfield of the University of Pittsburgh awarded a Ph.D. in Electrical Engineering to a Santa Maria student who, under the sponsorship of the programme, completed the requirements for the Ph.D. degree at Pitt.

b. At the Universidad Tecnica del Estado in Santiago, the scope of the UTE-Pitt contract (sponsored by AID) covers objectives in which Pitt representatives are primarily engaged in technical assistance to cooperative worker training programmes. Some short-term advisers have assisted in curriculum planning for Metallurgical Engineering and new laboratory equipment design.

c. Several months ago, the University of Pittsburgh announced that it was conducting a technical assistance programme under an Alliance for Progress contract with the Agency for International Development (AID) at the Central University in Quito, Ecuador. During the initial phase of the programme, Civil and Chemical Engineering departments will be assisted. Other engineering technical assistance programmes involving student and teacher training instruction, under cooperative arrangements with the University of Pittsburgh, are also currently being investigated in other areas.

14. Conclusions Based on Past Engineer Training Experiences

As a result of the personal experiences gained during the past twenty-three years of training foreign and native Metallurgical Engineering students on three levels of experience, the following observations, comments, and conclusions are offered for consideration by those persons who must make decisions regarding the future training of engineers for operating positions when new steel operations are started in developing countries. After having been directly associated with foreign students primarily from Latin America (Venezuela, Chile, Argentina, Mexico, Brazil, Colombia, Peru, and Mexico, as well as a few graduate students from Canada, Hungary, France, and Sweden, together with several more from India, Turkey, China, and Japan) an unbiased evaluation of the academic records and performance seem to indicate that:

a. Two foreign graduate students in ten (approximately 20%) working on advanced degrees actually complete all the requirements (M.S. in Met.E., or Ph.D. degrees).

b. Eight foreign undergraduate students in ten (approximately 80%) generally complete the requirements for the Bachelor of Science degree in Metallurgical Engineering (B.S., Met.E.).

c. Students working on short-term engineering training programmes have the greatest possibility of completing the programme requirements. For example, eighteen foreign students (100%) or all the Latin American Trainees For Steel Industry (LATFSI students) completed the joint OAS-industry or foreign government sponsored training programme.

These data indicate that short-term specialized training programmes, involving groups of students, have better chances of completion than individual undergraduate and graduate students. These observations are based on the pre-programme assumption of good cooperation with industry in providing on-the-job or in-plant training opportunities for the students who should also have had a satisfactory achievement level or background in the comprehension, spoken and written language used at the educational institution. If these prerequisites had been achieved on the LATFSI students, it would have been possible to have shortened the programme to a period of seven or eight months duration. An adequate financial budget should include funds for tuition and fee charges, plant transportation charges, special professor instructional fees, books, laboratory supplies, stenographic note preparation, hospitalization, accident and illness insurance, safety clothing and accessories fee, an adequate housing allowance, and an emergency fund so that the campus programme co-ordinator can provide air transportation to the student in the event a death occurs in his immediate family. Prior budgetary arrangements on small details like those listed above can seriously affect the ultimate success of the programme.

18. <u>Recommendations for Advanced Educational Training After Short-Term Engineer Training Programmes</u>

After short-term training programmes are completed, a relative evaluation of the advanced study potential of the students should be obtained from the university professors who were directly responsible for the student's educational instruction and the personnel involved in their in-plant training programme. The superior engineering trainees might then be encouraged to complete a Master of Science programme or perhaps a Doctoral programme. It is readily understood that engineering training programmes vary considerably from country to country as well as within a given country not only in curriculum content, educational quality, time and cost requirements, and feasibility of in-plant training experiences from cooperating steel making industries. Yet in addition to the rewarding technical experiences and personal friendships that the student acquires during his training period, he unavoidably learns how the people in his host country live, what their cultural aspirations are, as well as the fundamental principles which they believe. These are the unscheduled intellectual by-products received in addition to technical engineering training which constantly is under dynamic evolution as it searches for the truthful acquisition, integration, and dissemination of knowledge required by developing countries.

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