PD-AAR-385

PURDUE UNIVERSITY
International Education and Research
International Programs in Agriculture

PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT

(Contract AID/NE-C-1701)

REPORT ON
SHORT-TERM STAFF ASSIGNMENT

Submitted by
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Department of Mechanical Engineering
Clemson University
Clemson, South Carolina

May 10 - June 21, 1985

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PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT

Report on Short-term Staff Assignment

INTRODUCTION

The Instituto Universitario da Beira Interior, hereafter IUBI, is a small educational institute located in Covilha, Portugal. The institute offers five-year degrees in textiles and management and has two-year preparation in mathematics, physics, and chemistry for students who transfer to upper divisions at other universities. A decision has been made to start a program in paper engineering which is in its second year and work toward four-year programs in mathematics and computer science is also proceeding.

Covilha is the heart of the wool processing industry which has a strong heritage in Portugal. There are dozens of weaving mills and fourteen dyeing and finishing mills in the city. Beginning in the early 1970's, energy consideration began to have serious economic impact on textile production worldwide and Portugal is no exception. Under the direction of Dr. Fiadeiro in the textile department, some important conservation measures were initiated, and further progress is desired.

The program, through AID at IUBI, has allowed some short-term advisors from the U.S.A. to communicate helpful ideas and information about a number of subjects to counterparts at IUBI. This report summarizes such a visit by the author to Covilha in the area of energy conservation in textiles.

RECOMMENDATIONS FOR RESEARCH

The following recommendations are general in nature and address programmatic concepts. A following section of this report gives some detailed projects and technical direction. Theoretical material of a detailed nature is separately transmitted to Dr. C. Goncalves and is not included herewith. Because of the directions of interest discovered at IUBI, the recommended effort has two divisions herein called "theoretical" and "industrial." Because the author's perception is limited in "theoretical" thermodynamics, that section will be brief and somewhat vague.

Theoretical Energy Conservation

The organization of an effort in theoretical energy conservation is built around the strengths of individuals and, therefore, must be loosely structured to promote flexibility. If the activity becomes more extensive, requiring a formal organization, it can be accommodated.

The resources are in the person of Dr. Avelino Morgado who has extensive training in physics. He could be assisted by some students from other universities who would choose Dr. Morgado to advise and lead their research. Also students performing the pedagogical examination needing a project and emphasis could also be employed. Consultation with the industrial effort to be described is also expected to occur naturally. Problems to address could be from the following incomplete list of topics:

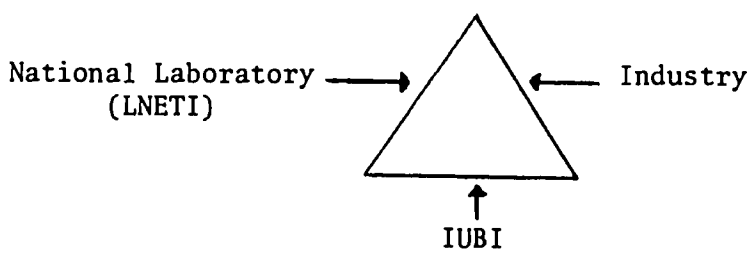
- Availability analysis and second law efficiency
- Evaluation of energy sources
- Employment of new technology
- Optimization using availability criteria

It is very possible that IUBI would be able to host an international meeting on availability. Since Portugal is such a lovely country and offers a delightful visit, it would be well for IUBI to receive recognition by hosting such an event.

Industrial Energy Conservation

A. Organization:

A three-sided organizational structure is already in place resulting from efforts at IUBI by Dr. Miguel Fiadeiro. This organization is sketched below:



The national laboratory has physical facilities (instrumentation, etc.) and the commission to help solve energy problems. Industry has experience and needs. IUBI has experience, training, interest, and judgement to design and execute conservation projects.

Within IUBI there should be some commissioning of an "energy group" with one person to be coordinator for the sake of ease of identification by persons outside of IUBI. The coordinator can be changed from time to time. The energy group can have assigned

members from the Physics and Textile Departments (and Paper in the future) according to need. The textile personnel know the processes, have industrial contacts, and have fifth-year students to do projects. The energy people and others in physics have a fundamental background and an interest in industrial energy conservation.

B. Resources:

There are several key resources needed to have an effective program in conservation: people, instruments, and commitment. It is assumed that cooperation by industry will be effective.

Key people are Dr. Miguel Fiadeiro and Dr. Carrilho Goncalves. Respectively, they are experts in dyeing and finishing and thermodynamics design and analysis. Their cooperation must be intimate and non-adversarial. I sense the correct type of mutual respect for these individuals to cooperate effectively. Their work must be multiplied by students hands or technicians. Students and research associates, such as Mr. Batuca who expects to perform a research project in conjunction with his pedagogical exam, are valuable assets to the program. Other assistants could be fifth-year students and graduate students from other Portuguese universities.

Graduate students from other Portuguese universities are particularly attractive individuals for consideration. One mechanism for involving such students is generally as follows. It is presumed that there are students, candidates for advanced degrees at Lisbon Technical University (IST), Coimbra, or Porto, which have definite interest in industrially directed research. Further, it has been reported to this author that the faculties of most of these institutions tend toward academic and away from industrial problems. I

have no way of evaluation of these impressions within the span of my visit, but accept them to formulate a plan of action. Prof. Dr. Goncalves should be of full academic stature at the named institutions, having completed his work at an excellent English university. When and if he chooses to make at least a tentative commitment to industrial involvement, he should become visible at each university by personal visits, presentation of seminars, reciprocal visits by respective faculty, and that he possibly be named Adjunct Professor. As an Adjunct Professor, he could direct the work of a student to receive a degree at the other school. One can easily imagine the many benefits from such a relationship.

In addition to the importance of people, industrial research will require the use of instrumentation not presently owned by IUBI. There are at least four mechanisms possible for providing instruments. These are:

- Equipment grants - NATO, etc.
- IUBI purchase or fabrication
- Cooperation with LNETI
- Purchase by an industrial cooperative

In all probability, these mechanisms except for IUBI direct acquisition will need to be handled through the previously mentioned "Energy Group." The giving of the name of the group insures the donor or lender of instruments that the group, not just IUBI, is responsible for the safety and productivity of the equipment. This does not imply that IUBI is irresponsible but rather that the smaller the organization it is more easily held accountable, and that the purpose of the gift or loan is more easily recalled.

C. Commitment by IUBI:

IUBI must be committed to the program. To so signify, it would be well to name the group, appoint a coordinator, designate participants, define goals and some near term objectives, print special letterhead stationery, and appoint a board of advisors from LNETI, industry, and other universities.

IUBI, from the highest level (Reitor) to the Department Head, must identify the profit of the activity and support its activity. The ways to do this are:

- remove hinderances and barriers as much as possible from the key personnel
- strengthen high level alliances with other agencies
- identify and provide a reward structure for individuals who contribute significantly

It is the opinion of the author that this last point is both crucial and difficult. To make a meaningful goal and reward structure takes great innovation and deliberate effort.

The author is confident that the Reitor can provide the leadership required in this demanding and delicate task. Particularly in this area can the Reitor use the Energy Conservation Program as a basis to strengthen his attempts to add graduate programs at IUBI. All advanced programs are based on research accomplishment. If the Reitor can produce one area in which IUBI sponsors advanced level work it would be an inspiration and example for other areas to follow. It is possible that the Energy Conservation Program could be such an example. Certainly a great deal of work would be required, but an early penetration could be very beneficial. To do it, there needs to be the conjunction of a jury, a school authorized to grant the degree,

and an outstanding candidate for the degree. I believe all three exist within the range of the energy conservation effort described herein.

PRIORITIES

The strategy appropriate for development of an effort in energy conservation is based on pragmatic reasoning. Items must be selected based on need for the item, availability of resources, and upon value continuing. At first, limited resources place restrictions on the problems to be addressed. When the program becomes more visible and successful, the energy group may request funds to add resources sufficient to address other problems. When other technology areas (Pulp and Paper, Fuel Production, etc.) are within the capability of the group to begin to work, these areas should be addressed.

A common structure for nearly every energy conservation program exists. Within its structure must lie these elements:

Process Studies -- The investigators must be thoroughly acquainted with the processes and the equipment used. The process must be broken into elements for analysis and comprehension of alternatives. These process studies allow economic evaluation of conservation measures and can form the basis for a management information system.

Conservation Projects -- Based on the process studies, conservation measures with alternative hardware or different procedure models may be constructed. The models may demand experimental

evidence for some of the details. An alternative design may be proposed and modeled resulting in a prediction of performance. The prediction allows a detailed economic evaluation for management review. After implementation, the results must be evaluated and documented.

Results and Utilization -- Widespread use for improvements will depend on communication of the results. Bulletins briefly summarize reports which cover the details of evaluation and are inexpensive to prepare. These bulletings lead to evaluation of the reports and eventually seminars and workshops will enlarge the communication. Larger conferences are appropriate for the group to host or organize.

Textile Area

The textile area is a good place to begin because projects are already in action and the proximity is excellent. There are a number of specific projects within textiles identified below. I believe the package drying study is especially good for IUBI.

- Immediate Projects with Presently Adequate Resources

  Enclosure of Barcas
  Heat exchanger for pressurizing loop in vertical autoclaves
  Some package drying studies
  Covering open tanks in horizontal autoclaves

- Projects Needing Moderate Additional Resources

  Package drying studies
  Continuous dryer studies
  Process studies on cotton

- Projects Needing Special Equipment

  Vapor compression in Vaporizador or Autoclave
  Control valves for cooling water reclaim
  Computer optimized control

Paper Area

- Needing Additional Resources

  Process Studies
  Evaporation Studies

- Needing Significant Resources

Other Areas

Involvement in other areas will be invited by industrial groups in need of help. The group must have a firm grip on objectives to prevent dilution of effort in nonproductive areas.

SCHEDULE

The schedules shown in Figures 1 and 2 (on pages 12 and 13) of activities proposed are based on an assumed size of the activity group. It is assumed that Dr. C. Goncalves is able to participate 33 percent of his effort, that Dr. M. Fiadeiro can participate 10 percent of his effort, that one student (post graduate) will participate at 50 percent effort and two (textile) students participate each at 25 percent effort.

Each project is more or less independent and the initial times shown for the projects may be considered arbitrary. Thus, all the projects shown in Figures 1 and 2 certainly do not want to be concurrent. Likewise, it is important to select some short-term projects

and some longer term projects to begin early to provide lead time for the longer ones and provide some immediate results to show interest.

ACTIVITY RECORD

Highlights of activities of the consultant are as follows:

1. Meetings with the staff at IUBI were held to educate the consultant. Discussions with the Reitor, Dr. Ferra of chemistry, Dr. A. Morgado, Dr. C. Goncalves, Mr. Gil, and Mr. Pacheco, all of physics, were instructive. I also met with Dr. Fiadeiro and viewed his laboratory.

2. Based on the meetings, I formulated an overview lecture of my anticipated activities and presented it. At this lecture, I announced a series of six seminars designed to address points in my "commission" (Appendix A).

3. I presented six seminars according to the announcement in Appendix B.

4. I visited a wool textile dyeing operation in Covilha which contains most of the equipment found in wool dyeing. This visit was analyzed and reviewed resulting in a number of specific projects.

5. I visited a cotton preparation and dyeing industry near Porto. I was able to advise Dr. Goncalves of findings relevant to cotton preparation for his use and future reference.

6. I visited Eng. Monteiro of Laboratorio Nacional de Engenharia Tecnologia Industrial in Lisbon to determine the amount and kind of support possible. He is willing and interested in continuing activities.

7. I contacted Dr. Albino Reis at Coimbra University. A planned seminar on Evaporation from Textiles had to be cancelled due to schedule problems.

8. I presented IUBI with books listed in Appendix D.

Enclosed as Appendix C are the daily notes of my activities.

AD HOC RECOMMENDATIONS

I was able to be a point of reference for Dr. C. Goncalves of the IUBI faculty with respect to the teaching of thermodynamics. He is a fine young professor who is challenging his students thoroughly and should be commended. We discussed curriculum and coverage, books to use, and common problems in teaching. I happened to bring, unintentionally, some teacher evaluation forms which we use at Clemson which he felt were good. In conjunction with our discussions were some thoughts for consideration presented here in the form of mild recommendations.

1. Teaching assignments should plan for repeated teaching of the same class to promote both quality and ease (efficiency) of the professor.

2. Make, at a very practical level, a set of learning tools for energy studies for textile and paper students. This could be some kind of applied thermo/heat transfer elective course or an abbreviated short course not for credit. This course can develop both the background and motivation for energy studies in the textile and paper students.

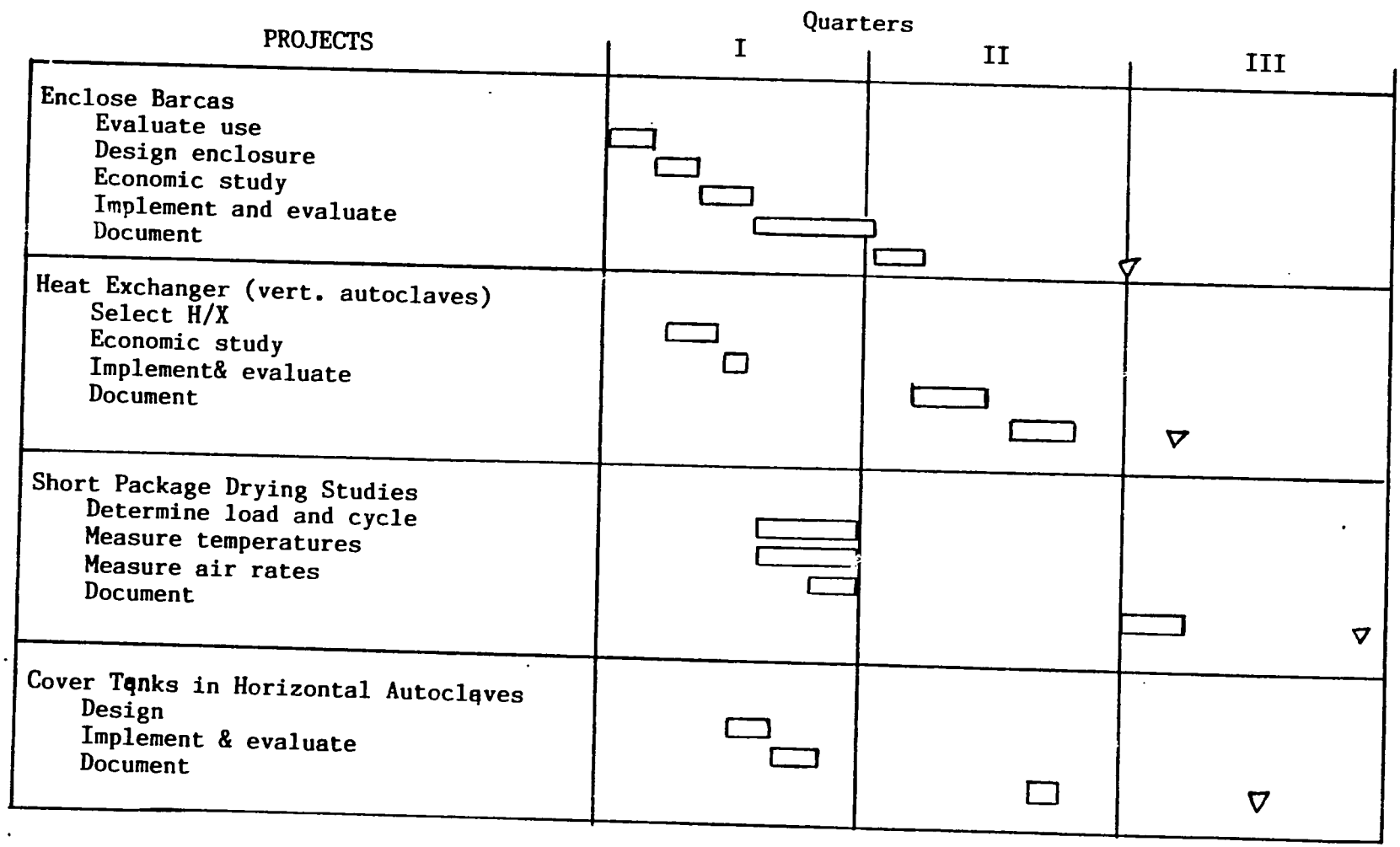


Figure 1. Schedule for Near-Term Projects

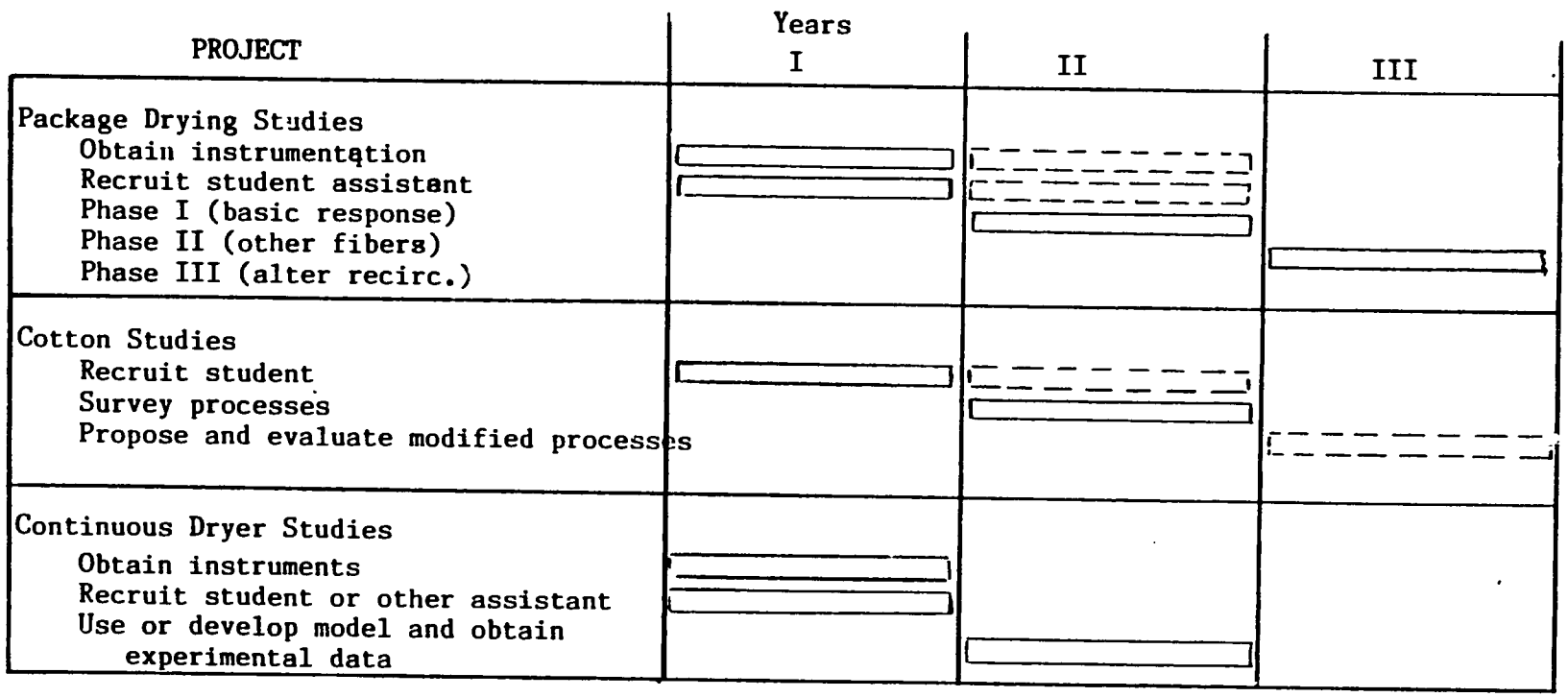


Figure 2. Schedules for Longer Term Projects

APPENDIX A

Consulting Commission

Instituto Universitário da Beira Interior

SCOPE OF WORK

SHORT TERM ADVISOR

NAME OF CONSULTANT: G. L. Gaddis

UNIVERSITY: Clemson University

ADRESS: Mechanical Engineering Depart. Clemson University, S.C. 29631

DATES OF SERVICE: May 10 - Juin 21

COUNTERPART: Doutor Eng9 Luis Carlos Carrilho Gonçalves

AREA OF CONTRACT TO BE SERVED: Energy Conservation - Audits of Energy - Industrial Energy Analysis

SCOPE OF SERVICE

- Information - Objectives

1. Evaporative processes in textile dyehouse industries. Techniques for inhibition of water evaporation.
2. Processes of textile fabrics drying with a decrease of available energy (exergy) consumption. Heat pumps applications.
3. Available energy (exergy) analysis as a measure of energy conservation. Economic implications. Optimization of energy consumption

- Formation - Objectives (Seminars)

1. Energy audits for thermal energy processes
2. Industrial energy analysis for textile industrics (raw materials, intermediate and final products).
3. Thermal energy storage systems.
4. Economic analysis of investments based on an energy analysis and on an exergetic analysis
5. Optimization of electrical energy consumption in industrial processes
6. Thermal insulation: products, techniques and applications of thermal insulants
7. Waste heat recovery

APPENDIX B

List of Seminars

SEMINAR NOTICE

SPEAKER: JOSEPH LEO GADDIS, PROFESSOR OF MECHANICAL ENGINEERING
CLEMSON UNIVERSITY, CLEMSON S.C.

A series of Seminars is planned to serve as a forum for discussion of methods in energy conservation.

These Seminars will be practical in nature with the intent of discovering how to save money by conserving energy.

LOCATION: SALA DE REUNIÕES

TIMES SUBJECT TO CHANGE

SUBJECTS:

1. EVAPORATION PROCESSES AND APPLICATION TO TEXTILES DIFFUSION AND HEAT TRANSFER IMPORTANCE OF AIR FLOW CONTROL PROCESSES IN INDUSTRY EVAPORATION MODELS	17 MAY - 16.00H
2. PROCESS MODELS FOR EVAPORATION FROM SHEETS EVAPORATION MODELS LIQUID DISTRIBUTION MODELS USE OF MODELS	21 MAY - 18.30H
3. SECOND LAW DEVICES HEAT EXCHANGERS HEAT PUMPS IMPLEMENTATION & ECONOMICS TOTAL ENERGY SYSTEMS	23 MAY - 18.30H
4. SECOND LAW AND AVAILABILITY ANALYSIS REVIEW OF PRINCIPLES SYSTEM OF SECOND LAW EFFICIENCIES	28 MAY - 18.30H
5. APPLICATION OF AVAILABILITY ANALYSIS TO INDUSTRIAL PROBLEMS	30 MAY - 18.30H
6. RESEARCH PLAN FOR CONSERVATION	04 JUNE - 18.30H

APPENDIX C

Daily Log

DAILY LOG

May 9 - June 21, 1985

May 9	Departed Clemson at 9:30 a.m.
May 10	Arrived Lisbon at 6:30 a.m. Met at airport by Jose Tomas. Met with Jose Luis Pinheiro and Luisa Gomes at USAID/Lisbon office. Drove to Covilha. Met with Rector Morgado and Joao Lisboa.
May 11, 12	Weekend
May 13	Established objectives; met with Luis Carrilho and Avelino Morgado to schedule seminars.
May 14	Worked half of the day on seminars. Discussed upcoming visit to U.S. of Luis Carrilho Goncalves.
May 15	Delivered seminar to 7 or 8 IUBI staff members. Decided classes would be held on Tuesdays and Thursdays from 2:00 - 6:30 p.m., except this week class will meet on Friday.
May 16	Prepared for Friday seminar. Took new office with Hassan Behery. Published schedule for seminars.
May 17	Delivered "Evaporation Processes and Application to Textiles" seminar. Met with Rector Morgado and the Rector from Evora, Ario Lobo Azevedo.
May 18, 19	Weekend
May 20	Prepared seminar on evaporation details for Tuesday. Met Fiadeiro to establish meeting for industrial visit.
May 21	Industrial visit set for Wednesday p.m. Continued to prepare for seminars. Prepared second evaporation seminar.
May 22	Planned seminars in a.m. In the afternoon, visited industrial plant with Fiadeiro and Carrilho.
May 23	Prepared seminars. Discussed travel with Carrilho. Delivered "Second Law Devices" seminar.
May 24	Studied and considered processes viewed. Carrilho provided process data.
May 25, 26	Weekend

May 27	Wrote notes for presentation. Worked on next two seminars. Books shipped from U.S. received in good condition.
May 28	Memo to Rector Morgado about books. Presented seminar to faculty and one student on Availability Analysis and Second Law Efficiency.
May 29	Studied Fiadeiro report and planned the next seminar.
May 30	Began to plan strategy for continuing involvement of IUBI with industrial people. Delivered Second Law seminar.
May 31	Continued to plan strategy for IUBI involvement. Plans to visit cotton factory. Reviewed machinery data.
June 1, 2	Weekend
June 3	Planned for possible visit to cotton factory on June 19 and visit to Coimbra at same time. Planned final seminar.
June 4	Delivered seminar to group. Planned coming visits to factories and Coimbra and possibly to Lisbon.
June 5	Spent the day with Rector Morgado (till 4:30 p.m.) on his plans. Confirmed meeting in Lisbon on June 11 and to Porto on June 19.
June 6	Portugal Holiday
June 7	Attended a meeting of IUBI's Scientific Council. Met with Fiadeiro on energy plan. Worked on details of plan.
June 8, 9	Weekend
June 10	Holiday, but travelled to Lisbon to meet tomorrow with energy men.
June 11	Meeting with Eng. Monteiro, Department of Conventional Energy, LNETI, Lisbon.
June 12	Returned to Covilha
June 13	Worked on end-of-tour report. Discussion with N. Raposo.
June 14	Worked on report. Began to outline problems with cotton.
June 15, 16	Weekend
June 17	Prepared notes on cotton preparation for Carrilho.

June 18	Prepared for seminar at Coimbra on Thursday. Assembled cotton data. Met with Carrilho in p.m.
June 19	Visited Riopele , a cotton mill near Porto, to observe cotton processing. Opportunities exist for work in several areas.
June 20	Meeting with Prof. A. Reis at Coimbra University cancelled at last minute due to Coimbra scheduling problems. Review with Carrilho.
June 21	Completed assignment and talked with Reitor Morgado about my findings.

APPENDIX D

Books Presented to IUBI

BOOKS PRESENTED TO IUBI

1. Title: Thermodynamics
   Author: Edward F. Obert and Richard A. Gagioli
   Publisher: McGraw-Hill Book Company, Inc.

2. Title: Thermodynamics for Engineers
   Author: SI Version, Jesse S. Doolittle, and Francis J. Hale
   Publisher: John Wiley & Sons

3. Title: Introduction to Thermodynamics
   Author: Richard E. Sonntag and Gordon J. Van Wylen
   Publisher: John Wiley & Sons, Inc.

4. Title: Basic Heat Transfer--Solutions Manual to Accompany
   Author: M. Ne Cati Ozisik
   Publisher McGraw-Hill Book Company

5. Title: Basic Heat Transfer
   Author: M. Ne Cati Ozisik
   Publisher: McGraw Hill Book Company

6. Title: Heat Transfer
   Author: J. P. Holman
   Publisher: McGraw-Hill Book Company

7. Title: Thermodynamics for Engineers
   Author: B. V. Karlekar
   Publisher: Prentice-Hall, Inc.

8. Title: Supplementary Problems for Thermodynamics
   Author: Gordon J. Van Wylen
   Publisher: John Wiley & Sons, Inc.

9. Title: Fundamentals of Classical Thermodynamics
   Author: SI Version, Gordon J. Van Wylen and Richard E. Sonntag
   Publisher: John Wiley and Sons, Inc.

10. Title: Elementary Fluid Mechanics
    Author: John K. Vennard and Robert L. Street
    Publisher: John Wiley & Sons, Inc.

11. Title: Solutions Manual to Accompany Thermodynamics for Engineers
    Author: SI Version, Jesse S. Doolittle and Francis J. Hale
    Publisher: John Wiley & Sons

12. Title: Engineering Thermodynamics with Applications
    Author: M. David Burghandt
    Publisher: Harper & Row

13. Title: Steam: Its Generation and Use
    Author: George Babcock and Stephen Wilcox
    Publisher: Babcock & Wilcox Company