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08269

Distr.
LIMITED

ID/WG. [illegible]
[illegible] September [illegible]

ENGLISH

United Nations Industrial Development Organization

[illegible] Consultation M[illegible]
[illegible] Fertilizer Indus[illegible]

[illegible] November [illegible]

[illegible]

MODEL FORM[illegible] CONTRACT FOR THE CONSTRUCTION OF A FERTILIZER PLANT AND GUIDELINES FOR THEIR USE

Training of personnel for start-up [illegible] operation of a new fertilizer plant*

prepared by

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CONTENTS

Preface

The First Consultation Meeting on the Fertilizer Industry considered a number of ways in which the construction and operation of new fertiliser plants built in developing countries could be improved.

UNIDO was requested to examine further "contract procedures" and to report the results of this examination to the Second Consultation Meeting. As a result of this examination, model forms of contract for the construction of a fertilizer plant have been prepared by UNIDO, along with guidelines for their use.

The training of personnel for the start up and operation of a new fertilizer plant is an important aspect of these model forms of contract. UNIDO therefore invited P.T. Pupuk Sriwidjaja (P.T. Pusri), Indonesia, to prepare a paper on this subject.

UNIDO is grateful for this contribution and hopes that it will facilitate greater understanding of the importance of training personnel in the successful operation of fertilizer plants.

Introduction

With the rapid increase in requirements for fertilizers, all manufacturers throughout the world must strive to optimize stream-days in their plants to the maximum extent possible in an effort to achieve the rated design production capacity. To achieve this goal it is essential that a well organized training program be conducted on a continuous basis for plant operating and maintenance personnel.

Prior to the start-up and operation of a new fertilizer plant training is required for plant operating and maintenance personnel and for all personnel who participate in supporting activities such as laboratory, logistics, accounting, marketing and distribution of fertilisers. Training is also required for management personnel. All new employees must be carefully trained and refresher training courses are required for all employees.

There are many opportunities for the Clients personnel to gain the transfer of technology from the contractors personnel throughout the design, engineering, procurement, plant erection, commissioning and plant start-up stages of a new fertilizer project. The Client should take full advantage of these opportunities.

The purpose of this paper is to stress the importance of the transfer of technology in the development of manpower and the training of personnel required to assure success in the start-up and operation of a new fertilizer plant.

Organization of Personnel

Usually the expansion of an existing fertilizer plant does not require a complete reorganization of the company. Only recruitment of additional operating and maintenance personnel, and personnel who participate in supporting activities is required. However, a new company embarking on a "grass roots" project will require the recruitment of top management personnel, managers and supervisors for the various departments, plant operating and maintenance personnel, and marketing and distribution personnel.

There are many variations of personnel organization charts used by large fertilizer plants throughout the world. Figure 1 shows in simplified form a typical organization chart for a large fertilizer manufacturing facility located in a developing country. The numbers shown in parenthesis under each plant unit operation represents the number of operating personnel usually assigned in a developing country to cover four rotating shifts.

In general, the number of operating personnel required for plants located in developing countries is 2.0 to 2.5 times the number required for plants operating in developed countries such as the United States, Japan and Western Europe. The primary reason for the larger number of operating personnel required in the developing countries is because the plant facilities are more extensive. For example, a fertilizer plant located in a developing country will usually require: (1) electric power generating facilities; (2) extensive natural gas purification and pretreatment facilities; (3) a booster compressor to increase and maintain the natural gas at the required pressure; and (4) an air separation plant to provide high purity nitrogen for use in blanketing catalyst during ammonia plant turnarounds.

In the developed countries a reliable supply of electric power is usually available from an outside source and therefore power generating facilities are not required. Also, natural gas pretreatment facilities and a booster compressor are not required because the gas is purified by the producer in the field and delivered to the plant-site at sufficient pressure to eliminate the need for additional compression. An air separation plant is not required because high purity bottled nitrogen is readily available from an outside source. Therefore, fertilizer plants located in the developed countries are far less extensive and consequently require fewer personnel for plant operations.

A trend which developed in the Western world during the past 20 years is Contract Maintenance. Many fertilizer plants in the United States maintain a relatively small Maintenance Department to perform preventative maintenance, emergency and routine type repairs required to keep the plant on-stream. For annual turnaround, arrangements are made with companies who specialize in Contract Maintenance to bring in a large crew of trained craftsmen to perform the work. In most of the developing countries Contract Maintenance service is not available and therefore fertilizer plants must maintain a large Maintenance Department capable of performing all types of maintenance work.

When recruiting management and key personnel for a new, "grass roots" fertilizer plant a strong effort should be made to employ people who have had previous experience in work similar to their new assignment. In most developing countries it is not possible to recruit operating and maintenance personnel who have had previous experience in fertilizer plant operations. However, there is usually an ample supply of graduates from technical high schools who, when properly trained, can satisfactorily meet the requirements for plant operating and maintenance personnel. Difficulties encountered in recruiting of qualified personnel very considerably from one country to another.

Recruiting of personnel for a new fertilizer plant can be performed in three stages. Top management personnel should be appointed as soon as possible after the decision has been made to embark on the project. Then, the department heads and key operating and maintenance personnel should be recruited immediately. Finally, one year before mechanical completion of the plant all operating and maintenance personnel, and personnel for all supporting activities should be recruited.

Personnel Training by Contractor

The obligation for training of the Clients personnel should be clearly defined in the contract with the General Contractor. The Contractors obligation should include: (1) training of Clients personnel in plant design, engineering and procurement in the Contractors office; (2) training of Clients maintenance personnel during the stages of plant-site civil works and the erection of plant equipment; (3) training of maintenance personnel in equipment vendors shops; (4) arrangements for field training of operating and maintenance personnel in operating plants; (5) intensive classroom training of Clients operating personnel by Contractors plant start-up operators.

A typical implementation schedule for construction of a large fertilizer plant is shown in Figure 2. This schedule shows the approximate date on which the various training obligations of the Contractor should begin.

As shown in Figure 2, the Clients key personnel should be assigned to the Contractors office soon after design, engineering and procurement activities begin. Soon after plant civil works and erection of plant equipment is started, the Client should assign appropriate craftsmen to work under the supervision of the Contractors personnel. Soon after procurement of equipment begins, the Clients key maintenance personnel should start training in the vendors shops where vital items of equipment such as centrifugal compressors, steam turbines, pumps, etc. are fabricated.

As shown in Figure 2, near the time erection of plant equipment and piping begins, the Contractors key plant start-up personnel should arrive at the plant-site and conduct an intensive two- to three-week training program for the Clients key operating personnel prior to departing for field training in an operating plant. The Contractors key plant start-up personnel should accompany the Clients personnel to the operating plant and actively participate in classroom and on-the-job training of Clients personnel.

Table I shows the minimum recommended number of personnel who should participate in field training for the start-up of a new ammonia-urea fertilizer plant and the minimum recommended training time for the various categories. Ammonia and urea plant operations are more complex than other types of fertilizer plants and therefore require more extensive training for operation and maintenance.

The contract between the Client and the General Contractor should include provisions whereby the Client at his discretion can retain the Contractors start-up operating personnel for a specified period of time after completion of a successful plant performance test. Or, as an alternative, the Client might prefer to arrange for a Management Contract with some operating company or the General Contractor for a specified period of time to assure that the plant continues to operate successfully and further advance training and manpower development.

Training Opportunities in the Developed Countries

Companies who manufacture fertilizers in the developed countries generally do not have personnel available to carry out formal classroom and on-the-job training programs for the start-up and operation of new plants in the developing countries. For example, in the United States a large ammonia plant is operated with five people per shift, one man operating the control board and four men in the field. These people do not have time available to perform training assignments.

The International Fertiliser Development Center (IFDC) and the Tennessee Valley Authority (TVA) located at Muscle Shoals, Alabama (USA) can provide excellent training in their laboratories and pilot plants. They can provide good training in agronomy and marketing and distribution of fertilisers. However, they do not have large-scale ammonia-urea plants required to provide on-the-job training.

Many universities and institutes in the developed countries offer short-term courses in management. Several accounting firms in various countries of the world can provide good training in accounting, auditing and finance.

Recently the Pullman-Kellogg Company of Houston, Texas (USA) organised a department named "World Wide Operations" which is designed to provide management, maintenance and operating services for plants located primarily in the developing countries. Mitsui Toatsu Chemicals, Inc. of Tokyo, Japan can offer a similar service.

Cooperation Among Developing Countries

There are now many modern large scale ammonia-urea fertiliser plants operating in the developing countries. Many new plants will be required in the future as requirements for fertilisers continue to increase. Personnel required to manage, operate and maintain these plants must be thoroughly trained to assure that the plants operate successfully. Probably the most logical solution to the problem of training personnel is for the fertilizer plants in the developing countries to cooperate by sharing their training facilities.

During the period 1974 to 1978, P. T. Pupuk Sriwidjaja (P. T. Pusri) completed three large ammonia-urea plants which increased urea production from 100,000 tons per year to over 1.5 million tons per year of installed capacity. Faced with the problem of training the large number of operating and maintenance personnel required for plant operations, a decision was made in 1975 to establish a Training Center at the Pusri plant-site in Palembang. The Training Center was established not only to provide training for Pusri personnel, but also to provide training for other fertilizer plants in Indonesia and other countries of the world.

A new building was constructed to house the Training Center which consisted of:

1. An auditorium with a seating capacity for about 100 trainees.
2. A large room where ammonia and urea plant models are located.
3. A classroom where plant control board simulators are located.
4. Six additional classrooms.
5. A library.
6. Offices for members of the training staff.

The Training Center is equipped with the following main items used to implement the training programs:

1. A Universal Process Trainer Carmody Simulator.
2. A Foxboro simulator for training of instrument maintenance trainees.
3. Models of ammonia and urea plants.
4. Overhead projectors for slides and film.
5. A movie camera and video tape closed circuit television.

After completion of classroom training, the trainees are transferred to the operating plants where they receive supervised on-the-job training.

on-the-job training is provided for both plant operating and plant maintenance trainees. Also, good facilities are available for classroom and on-the-job training of laboratory personnel.

Appendix A presents an outline of programs for classroom and on-the-job training for ammonia, urea and utility plant operations at the Pusri Training Center. Similar programs of training are available for plant maintenance personnel such as mechanics, electricians and instrumentation. Time requirements for completing classroom and on-the-job training in ammonia, urea and utility unit operations are shown in Table II.

As shown in Table II, the total time required for completion of classroom training in ammonia, urea and utility operations is 340 hours, equivalent to 42.5 eight-hour days. The total time for completion of on-the-job training in the operating plants is 135 days. Thus, the total time required for a trainee to complete classroom and on-the-job training for ammonia, urea and utility operations is 177.5 days. During 1976 and 1977, a total of 1,342 Pusri employees were trained at the Training Center.

Conclusions

To assure success in the start-up and operation of a new fertilizer plant it is exceedingly important to provide good training for the plant operating and maintenance personnel, and all personnel who participate in supporting activities for plant operations.

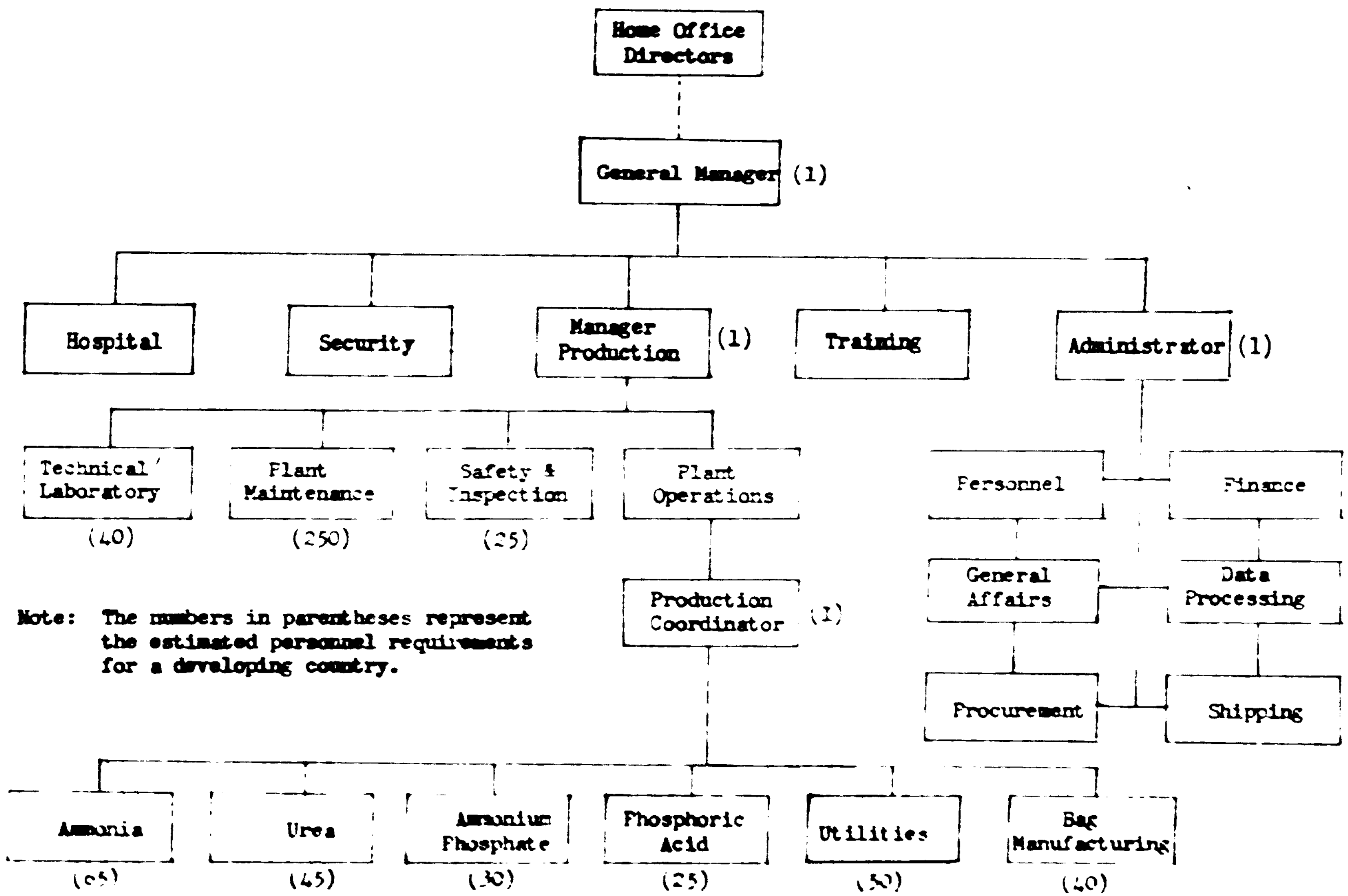
Full advantage should be taken of every opportunity to gain the transfer of technology from the General Contractors personnel throughout the design, engineering, procurement, plant erection, commissioning and plant start-up stages of the project.

There are many opportunities for the developing countries to cooperate by sharing training facilities and exchanging ideas on the solution to plant operating and maintenance problems.

The Training Center located at P. T. Pusri's large fertilizer manufacturing facility at Palembang Indonesia is available to assist fertilizer plants in other countries in training of their personnel. Pusri desires to cooperate by sharing the training facilities with fertilizer manufacturers in other developing countries and assisting in the start-up and operation of their plants.

Figure 1

SIMPLIFIED PERSONNEL ORGANIZATION CHART FOR A LARGE FERTILIZER PRODUCTION CENTER



Note: The numbers in parentheses represent the estimated personnel requirements for a developing country.

Figure 2: TYPICAL IMPLEMENTATION SCHEDULE FOR CONSTRUCTION OF A LARGE FERTILIZER PLANT

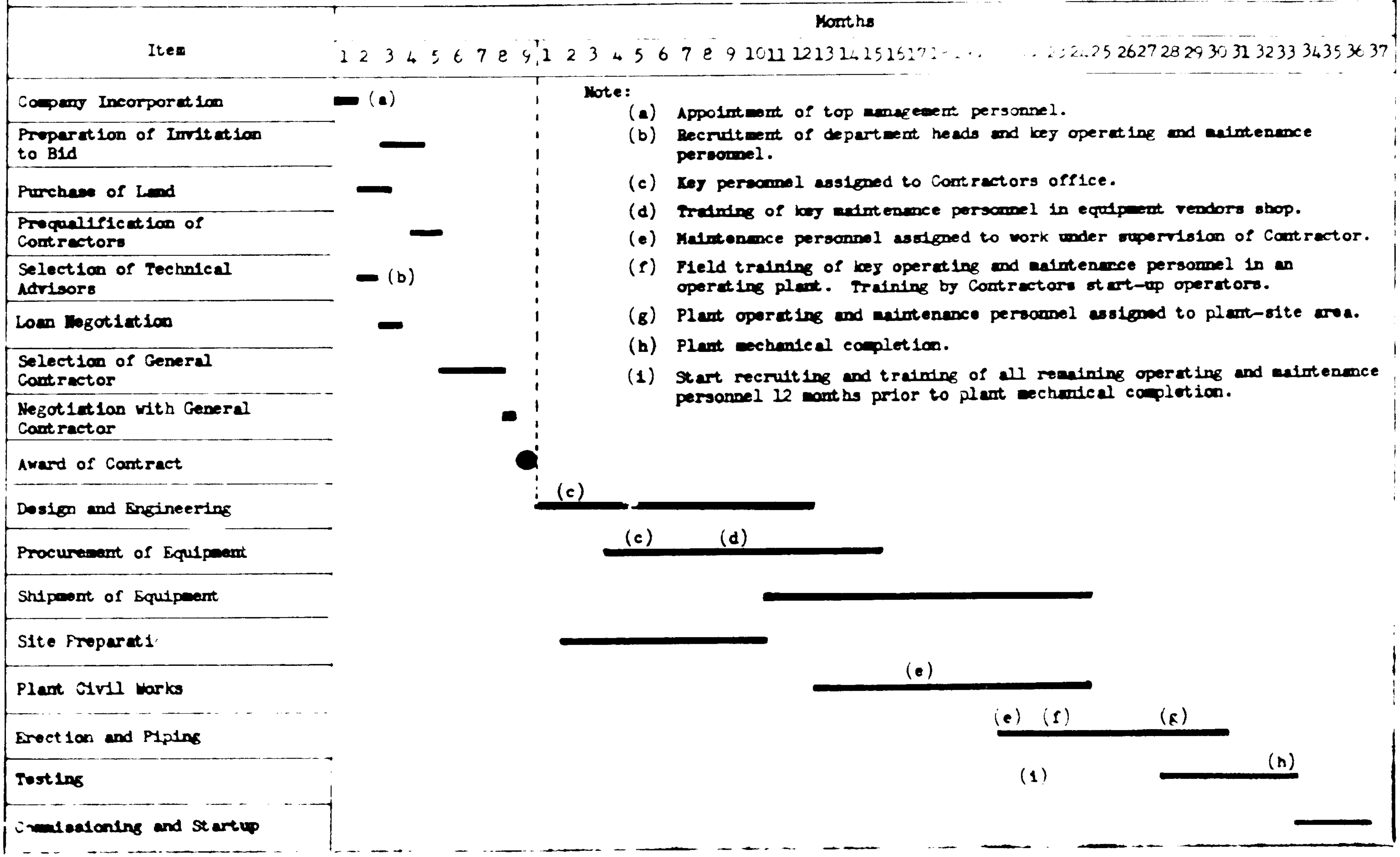


TABLE I

Suggested Minimum Number of Personnel Who Should Participate in Field Training Programs Prior to Start-up of a New Ammonia-Urea Fertilizer Plant[a]

Type of training[b]	Location of training[c]	Number of trainees	Training time,[d] weeks
	Operations		
Ammonia	Operating plant	15	16
Urea	Operating plant	15	16
Utilities	Operating plant	12	12
	Maintenance		
General	Operating plant	8	24
Machinery	Vendors shops	6	24
Instrument	Vendors shops	12	8
Instrument	Operating plant	12	12
	Other personnel		
Laboratory	Operating plant	3	12
Accounting	Operating plant	2	12

a. All trainees should be key personnel who can return to the plant site and train other plant personnel of lower grade who did not participate in field training abroad.

b. The training should consist of classroom and on-the-job.

c. The plant where operator training is conducted should be essentially the same design and capacity as the Clients plant.

d. This training does not include training obligations of the General Contractors start-up operating personnel.

TABLE II

TIME REQUIREMENTS FOR TRAINING IN AMMONIA, UREA AND UTILITY UNIT OPERATIONS

A. CLASSROOM TRAINING

Subject	Total training time, hours				
	Class-room	Field trips	Discussion	Response	Total
1. Ammonia unit operations	32	8	8	4	52
2. Urea unit operations	32	8	8	4	52
3. Utility operations	32	8	8	4	52
4. Heat exchange and plant equipment	24	8	8	4	44
5. Fluid flow, pipes, fittings, valves, pumps and compressors	24	8	8	4	44
6. Measuring equipment and automatic regulators, instrumentation	20	8	8	4	40
7. Starting and operation of engines, motors, turbines, pumps and compressors	12	4	4	2	22
8. Electric power techniques	12	4	4	2	22
9. Safety	8	4	-	-	12
Total hours[a]	196	60	56	28	340

B. ON-THE-JOB TRAINING

Unit operation	Training time, days
Ammonia	50
Urea	45
Utilities	40
Total days[a]	135

a. Total time required for a trainee to participate in all three subjects.

APPENDIX A

OUTLINE OF TRAINING PROGRAM FOR AMMONIA, UREA AND UTILITY OPERATIONS

Classroom Training

I. Ammonia Unit Operations

A. Block diagram of unit operations

B. Processes involved in each unit operation

1. Feed gas treating
2. Gas reforming
3. Synthesis gas production
4. Purification of synthesis gas
5. Refrigeration
6. Ammonia synthesis

C. Process flow diagram and instrumentation

D. Process equipment

1. Specifications
2. Design operating conditions
3. Materials of construction
4. Design operating temperatures and pressure

E. Centrifugal gas compressors

1. Feed gas
2. Air
3. Refrigeration
4. Synthesis gas

F. Specifications and operating conditions for catalysts

1. Sulfur removal
2. Primary reformer
3. Secondary reformer
4. High temperature shift
5. Low temperature shift
6. Methenator
7. Ammonia synthesis

APPENDIX A (Continued)

G. Chemistry and equilibrium reactions
H. Analytical control requirements and methods of analysis
I. Startup procedures
J. Shutdown procedures
   1. Normal
   2. Emergency

II. Urea Unit Operations

A. Block diagrams of unit operations
B. Processes involved in each unit operation
   1. Urea synthesis
      a. Reactor feed materials (ammonia, carbon dioxide and recycle carbamate solution)
      b. Reactor operation
      c. Carbamate decomposition (high pressure and low pressure decomposers)
      d. Gas separator
   2. Urea finishing
      a. Crystallizer and vacuum generator
      b. Centrifuge
      c. Urea dryer and pneumatic conveyor
      d. Urea melter and prilling operation
      e. Fluidizer cooler
      f. Conveyor system
C. Process flow diagram and instrumentation
D. Process equipment
   1. Specifications
   2. Design operating conditions
   3. Materials of construction
   4. Design operating temperature and pressure

APPENDIX A (Continued)

E. Pumps and compressors

1. Carbon dioxide
   a. Booster
   b. Reciprocating
2. Ammonia
3. Carbamate

F. Corrosion control

G. Chemistry and equilibrium reactions

H. Analytical control requirements and methods of analysis

I. Startup procedures

J. Shutdown procedures

1. Normal
2. Emergency

III. Utility Operations

A. Block diagrams of unit operations

B. Processes involved in each unit operation

1. Plant water supply
2. Water purification
   a. Coagulation
   b. Filtration
   c. Chlorination
   d. Ion exchangers
      1. Cation
      2. Anion
      3. Mixed bed
   e. Control of pH

C. Cooling towers

1. Corrosion and bacteriological control of recirculated cooling water.
2. Blowdown for control of suspended solids

APPENDIX A (Continued)

D. Gas turbine generators and waste heat boilers for electric power and steam production

E. Package unit boiler for production of steam

F. Plant and instrument air supply

G. Condensate stripper for cooling tower make-up water

H. Flow diagram and instrumentation

I. Equipment

   1. Specifications
   2. Design operating conditions
   3. Materials of construction
   4. Design operating temperature and pressure

J. Stand-by electric power generators

K. Startup and shutdown procedures

L. Emergency procedures

M. On-stream process analyzers

   1. Principal of operation
   2. Interpratation of results

N. Ammonia storage

   1. Instrumentation
   2. Precautionary measures

IV. Heat exchange and plant equipment

A. Heat exchangers, shell and tube

   1. Water cooled
   2. Ammonia cooled
   3. Process gas-liquid
   4. Condensers
   5. waste heat

B. Plant equipment

   1. Absorber towers
   2. Stripping columns

APPENDIX A (Continued)

3. Vessels
   a. High pressure
   b. Low pressure
4. Reactors
5. Ammonia storage
6. Prilling tower
7. Boilers
   a. High pressure steam (1500 psig.)
   b. Medium pressure steam (600 psig.)
8. Cooling tower

V. Fluid flow, pipes, fittings, valves, pumps and compressors

A. Pipelines
   1. Sizes
   2. Construction material
   3. Working pressure (ASA number)

B. Valves and fittings
   1. Various types and sizes
   2. Pressure rating
   3. Construction material

C. Pumps and compressors
   1. Centrifugal
   2. Reciprocating
   3. Plunger
   4. Rotary
   5. Operating problems
      a. Mechanical seals
      b. Stuffing box leakage
      c. Cavitation
      d. Overheating
      e. Bearing
      f. Impellers and rotors

APPENDIX A (Continued)

6. Effect of operating speed
7. Lubrication
8. Maintenance

VI. Measuring equipment and automatic regulators, instrumentation

A. Indicators
1. Temperature
2. Pressure
3. Flow
4. Speed

B. Indicator-controllers
1. Temperature
2. Pressure
3. Flow
4. Speed

C. Pneumatic controllers
D. Electronic controllers
E. Instrument maintenance
F. Orifice plates
G. Pilot tubes
H. Meters
1. Liquid
2. Gas

I. Manometer

VII. Starting and operation of engines, motors, turbines, pumps and compressors

A. Principal of operation
B. Startup procedures
C. Shutdown procedures
D. Emergency shutdown
E. Automatic equipment
F. Lubrication
G. Preventive maintenance
H. Standby equipment
I. Vibration monitors
J. Precautions

APPENDIX A (Continued)

VIII. Electric power techniques

A. Instruments

1. Ammeter
2. Voltmeter
3. Frequency meter
4. Kilowatt meter

B. Motors

1. Induction and direct stream
   a. Anatomy
   b. Performance
   c. Characteristics
   d. Operation
   e. Protection (overload relays, circuit breakers, etc.)

C. Electrical distribution

1. Loop network (grid)
   a. Circuit breakers
   b. Cables
   c. Transformers
   d. Panel
   e. Switch board
   f. 13.8 KV, 440 volt, 120 volt and direct current

D. Electrical drawings

1. Operation symbols
2. Mannual, automatic, interlock and components (timer, limit switch, flow switch, etc.)
3. On line diagram
4. Full diagram

IX. Safety

A. Personnel

1. Operating
2. Maintenance

B. Plant equipment

C. Safety hazards

APPENDIX A (Continued)

On-The-Job Training in the Operating Plants

I. Organization Structure

   A. Offsites

   B. Ammonia unit

   C. Urea unit

II. Operating Relationship Between Offsites, Ammonia and Urea Units

   A. Raw materials and feedstock

   B. Utility requirements

   C. Plant interconnections

   D. Responsibilities

III. Process Description, Flow Diagram, Operating Conditions and Controls

   A. Offsites operation

      1. General

      2. Electric power generation

      3. Water treatment

      4. Steam generation

      5. Natural gas metering stations

      6. Ammonia [illegible]

   B. Ammonia unit operation

      1. General

      2. Control [illegible]

      3. Feed gas treating

         a. [illegible]

         b. Dehydration

         c. Heavy hydrocarbon removal

         d. Carbon dioxide removal

      4. Gas reforming and carbon monoxide conversion

         a. Primary reformer

         b. Secondary reformer

         c. High temperature shift

         d. Low temperature shift

APPENDIX A (Continued)

5. Removal of carbon oxides
    a. Carbon Dioxide removal
    b. Final removal of carbon dioxide and carbon monoxide
6. Ammonia synthesis
7. Ammonia refrigeration
8. Rotating equipment
    a. Steam Turbines
    b. Motors
    c. Centrifugal compressors
    d. Centrifugal pumps
    e. Reciprocating pumps
9. Steam system
    a. High pressure steam
    b. Medium pressure steam
    c. Condensate return
10. Cooling tower operation
    a. Recirculating cooling water
    b. Water treatment
11. Plant startup
    a. Purging of equipment
    b. Precautions and safety measures
12. Plant shutdown
    a. Normal
    b. Emergency
13. Miscellaneous
    a. Steam balance
    b. Cooling water balance
    c. Replacement of catalysts

C. Urea unit operation
    1. General
    2. Control board
    3. Synthesis section

APPENDIX A (Continued)

4. Decomposition section
5. Recovery section, Nos. I and II
6. Crystallization and prilling section
7. Rotating equipment
    a. Steam turbines
    b. Motors
    c. Centrifugal compressors
    d. Centrifugal pumps
    e. Reciprocating compressors
    f. Reciprocating pumps
8. Steam system
    a. Medium pressure steam
    b. Low pressure steam
    c. Condensate return
9. Cooling tower operation
    a. Process cooling tower
    b. Recirculating cooling water
10. Startup
    a. Water run with air
    b. With aqueous ammonia run
    c. Without aqueous ammonia run
11. Normal shutdown
    a. For long period of time
    b. For short period of time
12. Emergency shutdown
    a. Electric power failure
    b. Steam failure
    c. Cooling water failure
    d. Instrument air failure
13. Miscellaneous
    a. Steam balance
    b. Cooling water balance
    c. Prilling test
    d. Draining of solution from reactor

APPENDIX A (Continued)

IV. Plant Safety

A. Rules and Regulations

B. Safety hazards

1. Operating personnel
2. Maintenance personnel

C. Safety equipment

1. Location
2. Use
3. Limitations
4. Maintenance

G - 7

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