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## IMPROVED TRAINING OF PROCESS WORKERS FOR THE SOUTH AFRICAN FERTILIZER INDUSTRY

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### RESUME

*La plupart des employés de l'industrie des engrais d'Afrique du Sud sont normalement recrutés localement autour de l'usine et ont habituellement reçu une éducation jusqu'à huit à douze ans de scolarité. Très peu d'entre eux ont des connaissances scientifiques et mathématiques suffisantes et ils ont ainsi une possibilité limitée de progresser dans des métiers exigeant des compétences techniques. Dans de nombreux cas, ceci résulte d'une absence d'opportunité plutôt que d'un manque d'aptitude et, pour corriger cela et améliorer la productivité dans l'industrie, l'industrie des engrais sud-africaine met ensemble en oeuvre des programmes d'enseignement et de formation pour son personnel. Ce programme vise à développer les connaissances des employés pour leur permettre de mieux comprendre les principes des procédés et du matériel utilisés pour la fabrication des engrais. Ce programme est également structuré pour fournir les bases nécessaires à une éducation technique complète.*

#### *Structure des programmes*

- *Positionnement de ce programme par rapport aux autres systèmes d'éducation et rôle de l'élévation du niveau des communautés désavantagées*
- *Procédure suivie pour déterminer le contenu nécessaire*
- *Collaboration entre l'industrie et le département d'éducation dans l'ensemble du programme*
- *Structuration des programmes par rapport aux exigences des collèges techniques pour les niveaux N1 à N6.*
- *Combinaison de l'offre éducative de la fabrication des engrais avec des sujets comme les mathématiques, la chimie et d'autres considérés comme une partie d'une éducation technique complète*

#### *Contenu de l'offre éducative en matière de fabrication des engrais*

- *Besoins en emplois et niveau d'éducation nécessaire selon les besoins*
- *Contenu détaillé des programmes pour atteindre les objectifs*
- *Progrès du projet*

#### *Calendrier prévu pour la mise en oeuvre du programme d'enseignement et de formation*



### 1. INTRODUCTION

The majority of workers in the fertilizer industry in South Africa are usually recruited from the local community around the factory and will generally be educated up to a level of eight to twelve years of formal education. Very few of these workers have adequate Science and Mathematics knowledge and are therefore limited in their ability to progress into jobs requiring technical know-how and skills. In many cases, this came about because of a lack of opportunity rather than a lack of ability and to correct this and enhance productivity in the industry, the fertilizer manufacturers in South Africa are jointly implementing an education and training programme for the benefit of their workers. This programme is aimed at developing the knowledge of workers to enable them to better understand the principles of the processes and equipment used for the manufacturing of fertilizers. The programme is also structured to provide the basic building blocks necessary for a full technical education.

## 2. EXPECTATIONS AND OBJECTIVES OF THE DIFFERENT ROLE PLAYERS

The different role players who are being affected by this training programme have different expectations and objectives for the programme. It was however felt that it would be possible to develop a training programme to satisfy all expectations and align the aims of the different role players into a common goal.

### EMPLOYERS IN THE FERTILIZER INDUSTRY

Fertilizer companies are striving to achieve higher productivity and better overall performance. In order to achieve this it is necessary for all workers to take full responsibility for their jobs from the effect of quality of raw materials through to knowing the requirements of customers. There is no place left for a worker who will only do a routine job and rely on supervision to take care of abnormal situations or on «experts» to tell him how to improve his work process. This can only be achieved if workers are trained to have adequate technical knowledge on the processes they control. Unlike artisans, process workers can not obtain qualifications applicable and recognised through industry, as training is process and industry specific. It was felt that the optimum solution would be to make sure that workers are equipped with the relevant skills in mathematics, chemistry and principles of plant operation. The applications of these skills can then be taught through a subject specific to the fertilizer industry.

### PROCESS WORKERS IN THE FERTILIZER INDUSTRY AND LABOUR UNIONS

Process workers gain experience and knowledge about equipment and processes but training done is aimed at specific plant flowsheets and operating procedures with no training in basic principles. Experience and knowledge gained this way is neither recognised by other employers nor fully applicable to the processes and does not enhance the value of these workers in the labour market. In addition, the worker never gets the opportunity to develop his technical skills and has limited opportunity to develop his career to the level of technician or plant management. In an environment where certain groups were disadvantaged the problem is more severe and imbalances can only be addressed by a bridging mechanism such as this training program.

### DEPARTMENT OF EDUCATION

The Department of Education as an arm of Central Government is aiming for an integrated approach to education and training. This will be achieved by the development and implementation of a «National Qualifications Framework». The objectives of the National Qualifications Framework are spelled out in the South African Qualifications Authority Act, Act No. 58 of 1995 as the following:

- «create an integrated national framework for learning achievements;
- facilitate access to, and mobility and progression within education, training and career paths;
- enhance quality of education and training;
- accelerate the redress of past unfair discrimination in education, training and employment opportunities; and thereby
- contribute to the full personal development of each learner and the social and economic development of the nation at large.»

Training programmes such as the one described here are very useful vehicles for involving the private sector to achieve most of these objectives.

## 3. THE PROCESS FOLLOWED TO DEVELOP THE TRAINING PROGRAM

### IDENTIFYING THE NEED

Indian Ocean Fertilizer is following a strategy of improving performance in all activities by encouraging and training employees to take full responsibility for their jobs and area of responsibility. The training of process workers was identified as a key element of the improvement process. Such training must teach the worker the basic principles of his job and equip him with the necessary skills to improve performance. In-house training does not teach basic mathematics and science and existing programs of formal education is not accessible to the targeted population consisting mainly of adult shift workers. A programme of basic education integrated with guidance in the application of theory was required. Similar programmes have been developed for other industries under guidance of the Department of Education and syllabi for subjects like mathematics, chemistry and plant operations theory already exist. Indian Ocean Fertilizer therefore

approached the Department of Education for assistance and an exploratory meeting was held on 17 March 1995. At this meeting it was agreed that responsibility for the development of the curriculum would be shared in the following way:

The Department of Education would be responsible for:

- facilitation and support
- leading the curriculum design process
- processing the final syllabi and synopses up to the approval of the Minister of Education

The industry would be responsible for:

- identification of all role players for the syllabus committee
- writing of concept syllabi and synopses
- translation and correct language usage (English and Afrikaans)
- typing of material
- all costs involved

The potential participants to the curriculum development process were identified and invited to join and a syllabus committee consisting of representatives from Trade Unions, Fertilizer Industry and the Department of Education were formed to develop the syllabus for a «National Diploma in Fertilizer Technology».

#### THE POSITION OF THIS PROGRAMME IN RELATION TO OTHER LEVELS OF EDUCATION

The complexity of the chemical processes used to make intermediate and final fertilizer products makes it necessary to have appropriately trained technicians appointed in certain positions. It would be all but impossible to train illiterate members of disadvantaged communities for these positions. This training and development program is therefore introduced at the lowest possible level, i.e. At a NQF level 2 equivalent to N1 or Standard 8 level which implies full literacy and numeracy or at least nine years of formal schooling.

#### MEETING THE REQUIREMENTS FOR INDIVIDUAL CAREER PATHS

The subject contents of instructional offerings are determined strictly according to the requirements of the job to be performed. The instructional programme (group of subjects/instructional offerings that are aimed at a specific occupation or a group of closely related occupations) must culminate in a rounded-off programme with different exit points. At achieving each exit point the student must be fully equipped to undergo practical training and then perform the tasks of the identified job.

It was decided to provide for two alternative paths in the career development of workers in the fertilizer industry. The one leg being a career in the production line and the other a career in the chemical laboratory. A worker must be able to transfer from the one leg to the other with the minimum of further training.

Table 1 shows the qualifications expected from a worker in order for him to perform the jobs of the different positions as indicated.

**Table 1 - Career Paths in the Fertilizer Industry**

<i>Level of Education</i>	<i>Production Line</i>	<i>Laboratory</i>
Illiterate/Literate	Unskilled Labourer	Laboratory Assistant
N1/N2 Certificate	Operator	Junior Analyst
N3/N4 Certificate	Process Controller	Analyst
N5/N6 Certificate	Supervisor	Senior Analyst/Supervisor
National N Diploma	Plant Manager	Laboratory Manager

The rest of this paper focuses only on the programme for production line workers.

## PROCEDURE TO DETERMINE THE CONTENTS OF THE INSTRUCTIONAL PROGRAMME

Vocational education requires a task analysis in order to select contents. The DACUM (Design A Curriculum) method, designed by the Ohio State University, was used to select the contents for the National Diploma in Fertilizer Technology. The DACUM was facilitated by an educationalist from the Department of Education. The process consisted of brainstorming sessions in which participants proposed topics to be included in the programme. The participants from the Department of Education were experienced educationalists, Trade Unions from the fertilizer industry participated and chemical engineers, chemists, mechanical engineers, trainers and workers represented the fertilizer industry. The topics (job functions or mental actions) were derived from the requirements of each of the identified jobs.

Topics were then grouped under common headings like quality management, process control, etc. and separated into the different levels of competency (in this case six levels from N1 through to N6). The different topics were formulated into outcome based learning objectives (the achievement which a learner must be able to accomplish before being considered competent). The learning objective must indicate an intellectual achievement, stipulate a condition and define a standard of achievement desired. A learning objective contains a verb which explains the intellectual achievement and determines the level of mental action required. Bloom's taxonomy categorises these verbs into different levels, i.e. knowledge, comprehension, application and ASE (analysis, synthesis and evaluation). As the level of learning increases the emphasis shifts from knowledge to application and ASE. The percentage of learning objectives in the ASE category will therefore increase from N1 through N6 while the opposite will be true for the knowledge category. Table 2 indicates the recommended cognitive levels for instructional offerings.

**Table 2 - Cognitive Levels for the Contents of Syllabi**

<i>Cognitive Levels</i>	<i>N1</i>	<i>N2</i>	<i>N3</i>	<i>N4</i>	<i>N5</i>	<i>N6</i>
1. Knowledge	60 %	50 %	40 %	40 %	30 %	20 %
2. Comprehension	20 %	20 %	20 %	20 %	20 %	20 %
3. Application	10 %	20 %	20 %	20 %	30 %	30 %
4. ASE	10 %	10 %	20 %	20 %	20 %	30 %

The learning objectives were developed to comply with the indicated objectives and then regrouped into independent modules. Each module being a grouping of related learning objectives associated with a specific job function. Table 3 is a summary of the modules developed for the instructional offering Fertilizer Manufacturing N1 & N2.

**Table 3 - Learning Content of the Instructional Offering Fertilizer Manufacturing N1 & N2**

<i>Module</i>	<i>Module Theme</i>	<i>Weighted Value N2</i>
1	Safety, Health and Environment	10 %
2	Human Resources	10 %
3	Chemical Processes	20 %
4	Equipment	25 %
5	Operation of Equipment	20 %
6	Total Quality Management	15 %

Each module has a weighted value which is an indication of:

- The percentage of the total content of the work which is covered by the module.
- The percentage of the time available for the instructional offering which is to be spent on the module.
- The percentage of the total marks of the examination which is to be allocated to the module.

#### **4. STRUCTURE AND CONTENTS OF INSTRUCTIONAL PROGRAMME IN FERTILIZER MANUFACTURING**

The most likely entrance level candidates are considered to be existing employees working as operators in fertilizer plants. With the introduction of the programme it is however expected that a number of workers currently filling higher level positions will also enter the programme at the N1 level. Any individual who wants to pursue a career as process worker in the fertilizer industry must also be able to complete his first nine years of formal schooling and enter this program at the N1 level.

#### **JOB FUNCTION AND THE LEVEL OF EDUCATION NECESSARY TO ACHIEVE THE REQUIRED LEVEL OF PERFORMANCE**

##### **Position of operator (Entrance Level - N1 & N2)**

The worker performing the duties of operator is considered to be the first level that can benefit from the training programme. This worker will perform some or all of the following activities:

- Receival and feeding of raw materials .
- Taking process measurements.
- Observing operations to detect conditions which may result in process upsets, equipment malfunction, safety hazards, uncontrolled releases of material and poor quality products.
- Switching of equipment.

In order to take full responsibility for these functions the worker must fully understand the following:

- Hazards of his/her work environment to his own health and safety.
- Potential impact of his/her activities on the health and safety of other people.
- The potential impact of his/her activities on the environment outside of the company boundaries.
- He/she is a member of a work team and that his/her interaction with other people will impact on the performance of the team.
- The influence of his/her activities (including mental action) on the production process and the quality of products.
- The influence of the quality of raw materials and intermediate products on the production process.

Such understanding can only be achieved through adequate knowledge of the underlying principles of the relevant chemical and physical processes. The teaching of these principles are covered by including the subjects mathematics, industrial chemistry and plant operations theory on the N1 and N2 level. The subject, «fertilizer manufacturing», focuses on the specific applications of the general subjects in the fertilizer manufacturing processes. Chemistry is for instance introduced by discussing the specific elements and chemical compounds encountered in the fertilizer industry. The basic principles of operation of equipment is illustrated by explaining the specific applications in the fertilizer manufacturing processes. The structure and contents of the programme is aimed at providing theoretical knowledge and explaining applications to support the practical skills required.

The contents of the N1 & N2 syllabi for the subject «Fertilizer Manufacturing» is reflected by the different modules included. (Table 3).

##### **Position of process controller (N3 & N4)**

The process controller has the responsibility of monitoring all the relevant parameters of a certain manufacturing process to ensure optimum results from this process. This is a complex task requiring the manipulation of input of raw materials, chemical reaction parameters, physical process parameters and the continuous evaluation and manipulation of mass and energy balances. Control procedures are often

complex and sometimes require fairly sophisticated mathematical calculations. Computers and computer control systems is nowadays a common tool of this worker.

Assuming full responsibility for this job requires extensive knowledge and understanding of the chemistry involved, the principles of flowsheets and mass and energy balances, operating principles of equipment and the principles and application of process control. The knowledge acquired on the N1 & N2 level must be supplemented by N3 & N4 level mathematics, chemistry and an existing instructional offering in production and quality control (see Table 4 for a summary of subject combinations). The new instructional offering in fertilizer manufacturing is again used to teach the application of knowledge in the specific field of fertilizer manufacturing. The process chemistry and control procedures used in the fertilizer industry is explained to demonstrate the practical application of theoretical knowledge. The contents of the syllabi for N3 & N4 fertilizer manufacturing is given in Table 5.

**Table 4 - Subject Combinations**

<b>N1, N2 &amp; N3</b>	Compulsory	Fertilizer Manufacturing Mathematics Industrial Chemistry
	Optional	Plant Operation Theory/Chemical Laboratory Technology
<b>N4 &amp; N5</b>	Compulsory	Fertilizer Manufacturing Supervisory Management Production and Quality Control
	Optional	Chemical Plant Operation/Chemistry
<b>N6</b>	Compulsory	Fertilizer Manufacturing Supervisory Management Production and Quality Control
	Optional	Chemical Plant Operation/Chemical Technology

**Table 5 - Syllabi for N3 & N4 Fertilizer Manufacturing**

<b>Module</b>	<b>Syllabus for N3</b>	<b>Syllabus for N4</b>
1	Health, Safety and Environment	Health, Safety and Environment
2	Human Resources	Process Chemistry
3	Process Calculations and Flowsheets	Sulphuric Acid Chemistry and Reactor Design
4	Transport of Material and Heat Transfer	Phosphoric Acid Chemistry and Reactor Design
5	Specific Process Chemistry	Granular Fertilizer Chemistry and Reactor Design
6	Process Control	Nitric Acid and Ammonium Nitrate Chemistry and Reactor Design
7	Total Quality Management	General Process Knowledge
8		Sulphuric and Phosphoric Acid Process Knowledge
9		Granulation, Nitric Acid and Ammonium Nitrate Process Knowledge
10		Process Control and Equipment
11		Super Phosphate Process Knowledge

## Supervisor and Plant Manager (N5 & N6)

Responsibilities of these positions develop beyond the operator and process controller positions into the fields of technical process troubleshooting and optimization. In addition these positions also take on a much wider managerial responsibility. Troubleshooting and optimization requires the ability to not only understand the relevant theoretical principles but also to apply these principles.

The subjects, supervisory management and production and quality control will satisfy the need for improved managerial skills. The high level of technical knowledge and skills needed for troubleshooting and process optimisation will come from the instructional offerings in fertilizer manufacturing and chemical plant operation. Table 6 is a summary of the contents of the syllabi for N5 & N6 fertilizer manufacturing.

**Table 6 - Syllabi for N5 & N6 Fertilizer Manufacturing**

<i>Module</i>	<i>Syllabus for N5</i>	<i>Syllabus for N6</i>
1	Health, Safety and Environment	Process Knowledge
2	Process Knowledge	Process Control
3	Process Control	Process Balances
4	Process Balances	Design

## DIPLOMA REQUIREMENTS

The issuing of a national diploma in Fertilizer Manufacturing will require the following:

- A minimum of twelve instructional offerings with a pass in at least three instructional offerings in each of the grades N4, N5 and N6, but with a maximum of five N4 instructional offerings.
- Passing the three compulsory instructional offerings at N6 level.
- The candidate must produce documentary proof of two years applicable practical experience at a fertilizer or sulphuric acid plant.

## 5. PROGRESS WITH THE DEVELOPMENT OF THE TRAINING PROGRAMME

### SYLLABUS DEVELOPMENT

The syllabus committee consisting of representatives from the Department of Education, Indian Ocean Fertilizer, Fedmis, Kynoch Fertilizer and the Trade Union UWUSA met for the first syllabus development workshop from 12-14 June 1995. The syllabus committee expanded during the subsequent four workshops to also include representatives from Omnia Fertilizers, SASOL Fertilizers and the Trade Union CWIU. At a final workshop held from 30 January to 1 February 1996 the last syllabi were finalized to have a full set of syllabi (N1 - N6) for the instructional offering in Fertilizer Manufacturing. During the same workshops other existing instructional offerings were selected to combine with those in Fertilizer Manufacturing to result in a fully developed draft for a National Diploma in Fertilizer Manufacturing.

### DEPARTMENT OF EDUCATION APPROVAL PROCESS FOR INSTRUCTIONAL OFFERINGS

The completed syllabi from the syllabus committee must go through a number of review and approval stages in the Department of Education before it can be approved by the Minister of Education.

The Minister of Education approved the syllabi for N1 & N2 Fertilizer Manufacturing in April 1996 and it is now possible to immediately implement the N1 & N2 levels of the Fertilizer Manufacturing instructional programme.

The syllabi for N3 to N6 is currently under revision and will be submitted for approval on completion of the revision process.

### IMPLEMENTATION OF THE INSTRUCTIONAL PROGRAMME

Successful implementation will depend on the eagerness of potential candidates and the extent to which the training program can be made «user friendly».



### **Institutions of tuition**

The training programme will be available for presentation through the Technical Colleges which are situated in many towns throughout South Africa. These Technical Colleges will present the subjects if a sufficient number of students indicate interest in the specific subject. The Technical College will appoint lecturers who will probably come from the fertilizer or related industries.

The biggest source of potential candidates will be the existing work force of fertilizer manufacturing facilities. The process workers from these plants work shifts which will make it impossible for them to fit in with the tuition rosters of Technical Colleges. For this reason it has been decided to pursue the option of distance tuition through the Technical College of South Africa. TECHNISA (Technical College of South Africa) has extensive experience in distance education and many similar instructional programmes have been implemented very successfully through TECHNISA. All other subjects incorporated into the Fertilizer Manufacturing Instructional programme, with the exception of chemical laboratory technology, have already been implemented to N3 level through TECHNISA. The only outstanding issue for implementation of the programme to N3 level is therefore the development of study material for N1, N2 and N3 Fertilizer Manufacturing.

### **DEVELOPMENT OF STUDY MATERIAL**

The study material is being developed to meet the requirements of distance education. TECHNISA is experienced in the development of such study material and has very clear guidelines for the development of such material. Study material is therefore being developed through TECHNISA with technical contents being supplied by experienced chemical engineers from the fertilizer industry. The quality of study material is of cardinal importance and must bridge the distance between tutor and student, must enable the learner to learn autonomously and must be attractive and challenging.

The development of study material will be funded by fertilizer companies participating in the development of the training programme and will also be available to other technical colleges. Such study material will certainly also enhance and standardise the quality of tuition at all institutions presenting the programme.

### **TARGET DATE FOR IMPLEMENTATION**

The target date for first tuition at the N1 level has been set for January 1997 with the N2 level being available by April 1997. The implementation dates for the N3 - N6 levels will be determined by demand.

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