The planning and establishment of the coal-beneficiation plant at Grootegeluk*

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SYNOPSIS

The Grootegeluk coal-beneficiation plant was erected in the Waterberg coalfield, near Ellisras in the Transvaal, to supply Iscor's steelworks with a predetermined tonnage of coking coal in accordance with strict quality requirements. This plant has to handle a high tonnage of raw coal, which is not easy to beneficiate, in order to produce $1,82 \times 10^6$ t of coal.

Extensive tests were conducted on borehole cores and a mass sample of coal obtained from the area. These tests were carried out on a laboratory and pilot-plant scale, and were aimed at the establishment of the most effective beneficiation methods and the choice of suitable equipment.

This led to the completion of a full set of design and manufacturing drawings that resulted in the project approach described in this paper.

SAMEVATTING

Die Grootegeluk-steenkoolveredelingsaanleg is in die Waterbergse steenkoolveld opgerig, naby Ellisras in Transvaal, ten einde 'n voorafbepaalde tonnemaat kookssteenkool volgens streng kwaliteitsvereistes aan Yskor se staalwerke te lewer. Hierdie aanleg moet 'n hoë tonnemaat ru-steenkool hanteer, wat moeilik is om te veredel en 'n produksie van $1,82 \times 10^6$ t kookssteenkool lewer.

Omvangryke toetswerk is uitgevoer op boorgatkerns en 'n massa-monster steenkool wat in die myngebied verkry is. Hierdie toetswerk is op laboratorium- en proefaanlegskaal gedoen en was gemik op die vasstelling van die mees doeltreffende veredelingsmetode en die keuse van geskikte toerusting.

Dit het gelei tot die voltooiing van volledige ontwerps- en vervaardigingstekeninge wat die projekbenadering wat in hierdie referaat beskryf word, moontlik gemaak het.

Introduction

The feasibility studies undertaken by the South African Iron and Steel Industrial Corporation Limited (Iscor) to consider all the parameters determined by its Planning Department indicated that a coal mine and beneficiation plant with a capacity of $1,82 \times 10^6$ t of coking coal per annum was a viable proposition in the Waterberg coalfield, near Ellisras in the Transvaal. This coalfield consists of a vast deposit of relatively low-yield coking and thermal (power-station) coal.

The beneficiation plant in the Grootegeluk Coal Project had to be designed to accommodate the following.

(1) Strict quality requirements are laid down by the Iscor steelworks.
(2) Selective mining, obviating the use of a large plant, is not possible.
(3) A large amount of near-gravity material is present in the plant feed, which demands very close control of the density of the medium and the equipment to achieve this.
(4) This mine has the potential to develop into one of Iscor's main suppliers of coal in the long-term and the planned annual tonnages are as follows:

Run-of-mine raw coal as plant feed		15×10^6
Coking coal		$1,82 \times 10^6$
Power-station coal:		
Middlings	$2,6 \times 10^6$	$3,5 \times 10^6$
Flotation tailings	$0,9 \times 10^6$	
Plant waste		10×10^6
Plant waste and crushed overburden		18×10^6.

The final coking-coal product is to have a size grading of less than 15 mm with an ash content of 10 per cent.

This paper deals mainly with the parameters that governed the design of the plant, the way in which these parameters were derived, and the project management required for the establishment of the beneficiation plant.

Research and Development

Although project management is the main subject of this paper, some detail of the plant layout must be included, as well as of the testwork that preceded the final layout and flow diagram.

The testwork, which started in 1974, was based on borehole and box-cut samples obtained from the site, and was conducted by Iscor's Research and Development Department and the Fuel Research Institute,

Crushing

As beneficiation costs, both capital and operational, increase rather dramatically with decreasing particle size of the material treated, and as the fine coking coal from Grootegeluk has a tendency to rapid ageing and a resultant deterioration in the coking properties, crushing systems were sought that would produce the minimum of fines.

Primary crushing. The Grootegeluk open-cast operation results in very large particles (plus 1 m) reaching the primary crushing stage as run-of-mine material. A primary crushing system was therefore required to handle these large lumps and reduce them to minus 150 mm, preferably in one stage, without the production of excessive fines. Extensive testwork led to the selection of a rotary breaker with the following features:

Reduction ratio	900 mm to 150 mm in one stage
Capacity	1250 t/h per breaker
Beneficiation	Hard shales arising as breaker rejects

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Secondary crushing. A crushing system was required to reduce the coarse coal product (between 150 and 15 mm) to a liberation size of between 15 and 10 mm with a minimum production of fine coal. Various crushing systems were tested (impact, double-roll, single-roll, and rolling-ring crushers operated singly and double stage in both closed and open circuits), and it was found that an impact crusher produces substantially more fines than a double-roll crusher, and that, the smaller the reduction ratio, the smaller the amount of fine material produced.

It was finally decided to employ a double-roll crusher as the first stage and a rolling-ring crusher as the second, with a screen between the two crushers. The rolling-ring second-stage crushing was selected to obviate closed-circuit crushing, which would have resulted in much higher capital costs. The use of two-stage crushing results in the reduction ratio per stage being limited to about 3. In this way the minimum of fines is produced.

Beneficiation of Plus 0,5 mm Material

Extensive tests were conducted on drill cores and on bulk samples (46 700 t) obtained from a box-cut mining operation. The tests were aimed at the determination of design parameters, as well as the selection of the best equipment. As Grootegeluk coal is difficult to beneficiate owing to a high percentage of near-gravity material in both the primary and secondary stages, the most efficient equipment had to be used.

Initially, the project team considered separate cycloning plants for low-density separation of the crushed product from the drum plant and the product from the primary cyclone plant. It was then suggested by Dutch State Mines that the two products could be treated together without a significant reduction in yield. After this had been confirmed in the Research and Process Development's pilot plant, this method was adopted since it led to a much simpler plant layout and operation, as well as to a lower capital cost.

Beneficiation of Minus 0,5 mm Material

Despite the selection of crushing systems that would produce a minimum amount of fines, the final coking product would still contain as much as 30 per cent minus 0,5 mm material. An effective means of beneficiation for this fraction had therefore to be found.

The following beneficiation processes were investigated:

(a) Deister concentrating tables
(b) water-only cyclones
(c) heavy-medium cyclones
(d) flotation.

The tests indicated that neither the Deister concentrating tables nor the water-only cyclones could produce a concentrate with an ash content of 10 per cent. Beneficiation by heavy-medium cyclone was feasible on pilot-plant scale, but, as this practice had not been proved on a commercial scale at that stage, it was decided that flotation would be employed.

Different types of flotation cells, as well as cells of different capacities, were tested, and it was finally decided to use seven 16 m^3 rougher cells and seven 3 m^3 cleaner cells per module designed so that the coarse particles would be kept in suspension without excessive turbulence in the cells. As the amount of air added in the process was found to be critical, a design using an external air supply, rather than a self-induced system, was chosen.

The following drying equipment was tested:

(i) dewatering screens
(ii) disc vacuum filters
(iii) drum vacuum filters
(iv) centrifuges.

The tests on different types of dewatering screens indicated very low capital and operating costs, but also unacceptably high percentages of moisture in the dewatered product, mainly because of the very stable froth in the concentrate. Owing to the high operating cost and the high percentage of moisture (more than 25 per cent) in the final product, it was decided that drum or disc vacuum filters should not be used.

Tests on a 900 mm diameter by 1800 mm long screen-bowl centrifuge at the plant of Iscor's Durban Navigation Collieries indicated that this type of drying yielded a very low percentage of moisture in the final product (12 to 16 per cent.) (Because of the high rail-transportation costs, the moisture content in the product plays a predominant role, and the reduced railage costs of the centrifuged product more than off-set the higher operating costs compared with the products of the dewatering screen and vacuum filter.)

Reactivity of the Coal

Tests on the Grootegeluk coal indicated its proneness to spontaneous combustion. Special attention had therefore to be given to the handling, not only of the coking coal and middlings products, but also of the waste product, which amounts to some 70 per cent of the plant feed (approximately 2100 t/h). When it is considered that some 20×10^6 t of middlings has to be stored before the power station that is to use it comes into operation, and that some 10×10^6 t of plant waste is produced annually, storage without spontaneous combustion becomes a major problem.

Stockpiles of power-station coal and plant waste are being built up initially as part of a large research project being undertaken by Iscor with the assistance of the University of the Witwatersrand, and these will be monitored in every detail before a final decision is taken on the method of storage to be used.

Coking

Coking tests were carried out in which Grootegeluk coking coal was used in different mixtures to establish the maximum amount of this coal that can be used to produce an acceptable coke. The outcome of these tests determined the capacity of the Grootegeluk coal mine.

All the testwork was done on relatively small samples (borehole cores and a bulk sample obtained from zones 11 and 10) representing the whole coal deposit. The final amount of Grootegeluk coal to be used in coking mixtures will be determined only when full-scale coking tests can be conducted.

Design Philosophy

The following basic requirements are essential for the successful completion of any large project.

Know-how.

The higher the level of in-house know-how, the more comprehensive can the requirements be stated by means of drawings and specifications, leading to a better end result.

Manpower.

A large and competent project team is essential in order to define all the requirements fully and to control the progress of the works financially and technically.

The project management functions include the following:

(1) plant design
(2) preparation and issue of tender enquiry documents (drawings, contractual and technical specifications, and standards)
(3) adjudication of tenders
(4) placing of contracts
(5) control according to financial, time, and technical bases
(6) cold and hot commissioning.

Generally speaking, the capital requirements are dictated by the desired technical standards to be achieved. The more tender competition available, the better the end result for the client. (An experienced project-management team is essential in determining the most competent contractor for the job.) Timeous completion can be achieved only if the necessary progress-control documentation has been employed and the controllers are available to measure the progress.

The Size of the Team

With regard to the time available for the project, decision-making parties should at an early stage determine the number of persons in the project-management team, the technical standard of the plant, and all the other factors involved.

The most efficient plant design is one that requires the minimum amount of finance over the full life span of the plant, i.e. the capital and operational costs combined. It is possible to build an 'inexpensive' plant from the viewpoint of capital that may, however, result in comparatively high maintenance costs.

Having the bare minimum number of project engineers may result in essential modifications at a later stage, which may prove fairly expensive, or in weak progress control, which may involve extra costs for late delivery.

It is therefore essential that all the requirements should be weighed carefully before a decision is taken as to the extent of the client's own involvement in a key project.

Turnkey Concept

The turnkey project is derived from the idea that, after a contractor has completed a building or a house from the grass roots to the roof and it is ready for occupation, the front door is locked and the keys handed to the client. In such a project, the client's responsibility amounts basically to the issuing of enquiry documents, adjudication of tenders, and control of progress and quality of construction, with the contractor responsible for the design, manufacture, supply, erection, and commissioning of the installations.

Iscor has often used this way of contracting on large industrial projects. Examples of these in recent years are the establishment of the Newcastle steelworks, the Sishen–Saldanha iron-ore project, and the railway line and extensions at the Vanderbijlpark steelworks.

This method is justifiable when manpower is not available for a full project team, or when the engineering know-how of specific processes or equipment is not available or forms part of a patented concept that determines the layout and/or functioning of the plant as a whole.

Iscor as the Principal Agent

Being the pricipal agent represented a major involvement by Iscor's technical staff with regard to

— the setting of technical standards
— financial control
— procurement of equipment
— control of delivery
— control of timeous plant erection
— commissioning.

The larger Iscor's involvement in the design and construction of the plant, the more the advantages that could be achieved with regard to improved plant layout, higher technical standards, lower maintenance costs, and higher production — in short, savings in money. The benefits that resulted from being the principal agent in the establishment of the Grootegeluk coal-beneficiation plant are elaborated in the next section.

Project Management at Grootegeluk

Contrary to the turnkey concept normally adopted by Iscor, it was decided that, for the Grootegeluk project, the management would be extended considerably to include the following functions as part of the team's responsibilities:

— complete plant design, including detailed drawings, before commencement of the erection
— acquisition of all process equipment, and its site storage and issuing to the erection contractors on a free-issue basis
— control of erection contractors to achieve set technical standards and design parameters
— control of the work in progress
— detailed financial control
— complete hot commissioning of the plant after the cold-commissioned plant had been handed over by the erection contractors
— acquisition of individual guarantees from all the suppliers and erectors with regard to their responsibilities.

In the planning and establishment of the Grootegeluk beneficiation plant, the following phases can be clearly distinguished.

Acquisition of Know-how

In launching the project on the Grootegeluk coal-beneficiation plant, it was first of all necessary to gather a skeleton staff with a ready knowledge of plant design, metallurgy, and project management. With Iscor's involvement in the beneficiation of iron ore, coal, zinc, and tin, and with expansion programmes nearing completion at its major centres, these people could be obtained from within the corporation. They determined the broad scope and parameters according to which the whole project was undertaken. Many visits were then paid to beneficiation plants that had been built in recent years in South Africa and elsewhere. Generous contributions were made by each and all.

The specific objective was the acquisition of the knowledge required for the design of a plant with a minimum of downtime, the highest possible availability that is economically justifiable, proper maintenance access to all plant equipment, and the highest possible metallurgical efficiency.

Expert advice was obtained from foreign companies having specialized knowledge on specific process designs and equipment capabilities including the following:

- A.S.V. Engineering, England (general plant layout)
- Dutch State Mines, Holland (layouts of heavy-medium cyclone plants and metallurgical flow)
- K.H.D. Germany (design of heavy-medium vessels)
- Jenicke and Johanson via Bateman Equipment (mass-flow concept in silos)
- Stephenson Adamson.

Iscor's Research and Development Department, Capital Buying Division, and Data Processing Services, as well as other internal departments, also rendered assistance. Important information based on beneficiation and operational experience was obtained from Iscor's mines at Sishen and Durnacol. This information was used in the improvement of standards for conveyor pulleys, wearing plates, screen design, etc.

Management Structure (Manpower)

In the beginning of 1975, the skeleton of the project-management team was structured by the appointment of a few senior people with the necessary experience and background from within Iscor. The following appointments were made: Mine Manager, Plant Manager, Project and Construction Manager, Plant Superintendent, and Chief Maintenance Engineer. They immediately started compiling the manpower structure that would be required for the plant during operational conditions. Simultaneously, a second manpower structure was drawn up to cope with the design and construction phase of the project.

The members of the necessary project-management team were then appointed to the positions that they would hold after the plant had been commissioned. Other personnel were included in the project organization without consideration of their status once the plant had been commissioned. (In this way a foreman would, for instance, become an inspector, a maintenance engineer would become a project engineer, etc.). Endeavours were made to accommodate as many of the eventual production personnel in the project organization as was practically possible.

To supplement the project team, other specialist project-management staff from other Iscor centres were seconded to the Grootegeluk Project team. Grootegeluk was fortunate in that a number of competent and experienced persons were available from centres such as Newcastle, Sishen–Saldanha, and Vanderbijlpark, where large extensions were being completed at the time. A few senior draughtsmen and electrical/electronic specialists were hired from outside Iscor on a two-year basis to supplement the team where necessary. The heart of the project-management team consisted of a group of project engineers, each individual being fully responsible for his allocated portion of the project.

The plant was divided into eight different areas of responsibilities:

(1) the primary breaking and screening plant
(2) the primary and secondary heavy-medium cyclone plant
(3) the heavy-medium vessel and froth-flotation plant
(4) the product-stacking and reclaiming plant
(5) the load-out station
(6) the waste-disposal system
(7) electrical
(8) procurement of process equipment.

These areas were allocated to individual project engineers, who had total responsibility in accordance with Iscor's policies and procedures with regard to

- plant design
- issuing of plant enquiry documents
- placing of contracts
- control of delivery and erection
- cold and hot commissioning.

Position charters were completed for each member of the team, defining each function fully.

It is interesting to note that Iscor traditionally splits the responsibilities of Project and Construction Engineers on large projects — the first being responsible for white-collar work, and the second for construction control on site. This method suffers from a division of responsibilities, often leading to a communication gap between the two parties. For Grootegeluk, this concept was changed, and a single person was responsible for both aspects.

The complete project-management team began working at Iscor's headquarters in Pretoria, and were transferred to Grootegeluk as soon as construction started on site. In this way, it was possible to maintain the original project responsibilities assigned to each member throughout the construction phase and plant commissioning.

Full use was also made of the many Iscor departments that could render expert services, including the

- Department of Research and Process Development
- specialized technical departments at other centres
- the Standardization Department
- the departments of the Consulting Civil Engineer, Consulting Metallurgist, and Mechnical and Electrical Consulting Engineer.

Appointment of Design Companies

Companies with the necessary background and knowledge were then appointed to design the plant in detail, completing all the necessary manufacturing and erection drawings in collaboration with the project team. This was supplemented by the simultaneous construction of large-scale (1:25) models. These models were constantly scanned to detect possible weaknesses of design or cluttered areas that might hamper the rapid replacement of units whenever necessary.

So that the designs could be completed, the specific equipment to be purchased, e.g. cyclones, flotation cells, centrifuges, and screens, had to be determined. During the design phase, the team had obtained a very good idea of alternative pieces of equipment, and even preferred manufacturers, that would be most suitable for the Grootegeluk plant. Open enquiries were nevertheless issued, and in some instances the team deviated from their original ideas.

Design of the Plant

The design of the plant was based on the following (Fig. 1).

(1) The incorporation of all the equipment that was decided on during the testwork. The choice of equipment was determined by the objective of the highest possible metallurgical efficiency.

(2) The establishment of a plant with the highest economically feasible availability. It was decided to design the plant on the basis of three to five parallel modules, incorporating 6-hour buffer-stock silos between the primary breaking and screening plants and the primary heavy-medium cyclone/heavy-medium vessel plants on the one hand, and the primary heavy-medium plants and the secondary heavy-medium cyclone plants on the other hand,

(3) The stockpiling of approximately one week's production in the product/waste stockpiles.

(4) The provision of sufficient access and handling facilities for maintenance.

The complete design involved about 32 000 drawings, which were produced in groups. The general-arrangement drawings showing the overall layout of the plant were supplemented by drawings showing details of the steelwork and the position of beams, columns, and other features of the steel construction, as well as by drawings showing civil work, water and electricity reticulation, and equipment in the plant.

Owing to the modular construction, each module being repeated five times and in some instances up to ten times, a relatively minor error in a drawing could be costly when components had to be remade and could result in construction delays. As the erection of the plant was scheduled for completion in 19 months, the elimination of these potential sources of delays was of major importance. As the planning of the plant progressed, models were built according to the drawings. In some instances, drawings were made only after aspects such as piping and cable runs had been finalized by the use of models.

A model reveals errors that are not so apparent on a drawing, and modifications can then be made to rectify these errors or to improve the design. The following are some examples of how the use of models was justified at Grootegeluk.

(a) The model showed that a large fabricated beam would seriously have restricted the stair access. The resulting change in design is estimated to have compensated for the cost of the model by eliminating the cost of fabrication of replacement beams and the expense of the delay in construction that would have been incurred.

(b) The model showed that an opening, required to allow access for a gantry crane to remove a unit of equipment for maintenance from its position several floors below, was blocked at one level by a reticulation pipeline; the drawings were modified to reroute the pipeline. The models were used extensively to determine the routings for pipelines and cable trays.

(c) The model showed that no support had been provided for the roof steelwork, although the drawings had been thoroughly checked.

(d) Because the plant is highly mechanized and will be manned by comparatively small numbers of operating personnel, figures scaled to a height of 1,6 m were used to represent people on the plant models to ensure that stairways, walkways, and access to equipment would be of optimum design for maintenance, access, and free movement.

Type of Tenders and Contractors

All in all, some fifty contracts had to be entered into between various erection contractors and equipment suppliers. A final date was set for completion to coincide with the commissioning of the railway line in July 1980. Working back from this date, a period of 3 weeks was allowed for the production of the first train load, 2 months for hot commissioning, 25 days for inclement weather (this figure was calculated from the average rainfall for that area), and a supply-and-erection period of 20 months, which included 1 month for cold commissioning. A period of approximately 4 months was therefore available for the negotiation of all the contracts. The overall programming was as shown in Table I.

TABLE I

OVERALL PROGRAMMING OF THE BENEFICIATION PLANT

Activity	1978 AMJJASOND / 1979 JFMAMJJASOND / 1980 JFMAMJJA
1. Negotiation of contracts	*********
2. Supply and erection of plant and equipment	************************************
3. Inclement weather	*
4. Cold commissioning	**
5. Hot commissioning	*****
6. First train production	**
7. First train departure	*

Purchase of Equipment

Table II lists all the equipment suppliers. The equipment marked with an asterisk was purchased on a turnkey basis, i.e. supply and erection. In these instances, Iscor regarded the installation of the equipment as a vital part of the supply in order to obtain a properly functioning plant. In some instances, Iscor was forced into installation agreements with suppliers in order to obtain the necessary process and quality guarantees.

In order to obtain the necessary equipment guarantees, all the contracts contained stipulations that the suppliers include the necessary amounts to cover supervision during the installation of equipment, cold commissioning, and hot commissioning, as well as the training of personnel.

Erection Contracts

A total of six erection contracts were entered into with the following companies:

- Bateman Engineering for the primary breaking and screening plant
- Project Engineering for the primary and secondary heavy-medium cyclone plant
- Genrec for the heavy-medium vessel and froth-flotation plants
- Roberts Construction for the stacking and reclaiming plant
- Bateman Engineering for the load-out station
- Project Engineering for the plant waste-disposal system.

Erection contracts included the supply of all civil materials, structural steel, painting, sheeting, and various small components of equipment that were not purchased direct by Iscor. This also incorporated the installation of all free-issue process equipment, as well as

TABLE II

SUPPLIERS OF EQUIPMENT

Supplier	Equipment
International Combustion Africa Ltd	Medium pumps
Salweir (Pty) Ltd	Water pumps and submersible pumps
Fraser & Chalmers Equipment (Pty) Ltd	Sump pumps (3 DTV)
Fraser & Chalmers Equipment (Pty) Ltd	Warman series A pumps for dirty water at silos
Amalgamated Power Engineering S.A. (Pty) Ltd	Pumps for paraffin, froth, and flocculent
Metering Systems (Pty) Ltd	Metering pumps
Humboldt Wedag S.A. (Pty) Ltd	Centrifuges and conditioners* Teska vessels*
Fraser & Chalmers Equipment (Pty) Ltd	Resonance screens, and USL and USK screens
	Magnetic separators
J. L. Clark Engineering (Pty) Ltd	Water filters
Samuel Osborn (SA) Ltd	Double-roll and roll-ring crushers
E. L. Bateman Equipment Ltd	Apron feeders*
E. L. Bateman Equipment Ltd	Flotation cells
E. L. Bateman Equipment Ltd	Thickener mechanisms*
E. L. Bateman Equipment Ltd	Hold-backs and flexible couplings
Hyflo Cape (Pty) Ltd	Hydrostatic drives
Surtees & Son (Pty) Ltd	Couplings and variable-speed couplings
Philip Hall (Pty) Ltd	Dewatering screens
Hansen Transmission (Pty) Ltd	Gearboxes
Stratford Engineering (Pty) Ltd	Dupar brakes
Delfos & Atlas Copco (Pty) Ltd	Compressors
Multotec Manufacturing (Pty) Ltd	Polyurethane screen panels
Mannesman S.A. Division of Demag Industrial Equipment (Pty) Ltd	O.T. cranes* and crawls
Schindler Lifts (S.A.) (Pty) Ltd	Man lift*
Dunlop Industrial Products (Pty) Ltd	Conveyor belting
G. E. C. Machines (Pty) Ltd	Electric motors
Siemens Ltd	Electric motors
Bosworth Steel Structures (Pty) Ltd	Conveyor pulleys
Skefko (Pty) Ltd	Anti-friction bearings
F. M. C. S.A. (Pty) Ltd	Conveyor idlers and pulleys
Bonar Long NTC (S.A.) (Pty) Ltd	Transformers
G. E. C. Power Distribution (Pty) Ltd	Switchgear
Herrmann Screens Manufacturing Co. (Pty) Ltd	Stainless-steel screen panels
Screenex Wire Weaving Manufacturers (Pty) Ltd	Polyurethane screen panels
Industrial Electrical Co. (Pty) Ltd	11 kV electrical distribution*
Lascon Lighting Industries (Pty) Ltd	Lighting
Windhoff Technik (Pty) Ltd	Locomotives*
Goodyear Tyre & Rubber Co. (S.A.) (Pty) Ltd	Conveyor belting
S.A. Scale Co. (Pty) Ltd	Scales
Virbramech (Pty) Ltd	Magnetite feeders
Cape Contracts (Pty) Ltd	Sandblasting, painting*
Metropolitan Power Services (Pty) Ltd	Central control desk*
P. J. Yelland & Co. (Pty) Ltd	Power-factor correcting equipment
A. T. W. Electrical (Pty) Ltd	Switchgear

* On a turnkey basis.

the cold commissioning of the plant itself.

From the above, it is clear that Iscor had the responsibility of delivering the correct free-issue equipment on time. Furthermore, three parties were involved in the cold commissioning, i.e. Iscor, the suppliers of equipment, and the erection contractor. Iscor therefore had the responsibility of co-ordinating all parties. As the erection contractors had nothing to do with the plant design, any errors during the design phase were excluded from their responsibilities.

Unfortunately, no stipulations with regard to responsibilities were incorporated in the design contracts with regard to 'consequential damages'. Iscor was therefore responsible for all the costs resulting from design errors, which amounted to a few hundred thousand rands. It is felt that any contracting firm that provides a design should accept responsibility (or at least partial responsibility) for the correctness of that design, specifically with regard to its correct functional operation.

The erection contractors were held responsible for the correct installation of process equipment in accordance with the suppliers' instructions and the normal guarantees applicable to the supply and erection of the items of equipment they supplied, e.g. crawls.

Commissioning

It was the responsibility of the erection contractors to install equipment and cold-commission the plant as a whole. A period of one month was allowed for this activity, and their responsibilities included the following:

(i) the proper installation and alignment of equipment in accordance with the suppliers' specifications

(ii) electrical no-load tests

(iii) the inspection, together with the equipment suppliers, of equipment under no-load running conditions

(iv) the commissioning of all pumps under full load conditions

(v) the achievement of water balance throughout the plant

(vi) the commissioning under full load conditions of all the equipment they had supplied and installed.

After the cold commissioning as described above had been completed, the plant was taken over by the project team, which had been augmented by additional members in the preceding months. This team now became the full-strength production team.

Two months were allowed for hot commissioning. During this time, the plant was commissioned fully, which included the following:

(1) full-load commissioning of the heavy-medium systems (15 in all) including automatic density control

(2) total operational control from the central control room

(3) running the plant in electrical-sequence operation

(4) taking the production of the individual plant module up to full capacity

(5) rectifying any technical and process errors.

The Beneficiation Process

The beneficiation plant is shown in Fig. 1.

Primary Breaking and Screening Plant

The plant consists of three parallel streams, each stream (module) consisting of a tip containing a grizzly, an apron feeder, a Bradford breaker, and ancillaries. The three breakers each feed the nominal minus 100 mm coal–shale — referred to as minus 150 mm material — onto a 1350 mm wide conveyor, which in turn feeds a Siebtechnik 3000 × 9000 mm screen, where the minus 15 mm material is screened out. Each of the two products is fed to a set of five silos designed for a storage capacity of 5 to 6 hours.

Primary and Secondary Cyclone Plant

The primary cyclone plant consists of five modules, each of which is fed by an 1800 mm wide belt feeder, which in turn feeds onto a 750 mm wide belt at a design capacity* of 285 t/h per module. Each of the feed conveyors feeds two desliming screens, each of which in turn feeds three cyclones. The float and sink products of each bank of three cyclones are fed onto one drain-and-rinse screen for the float product and one drain-and-rinse screen for the sink product. The two products are fed onto a common conveyor.

The secondary cyclone plant has virtually the same layout as the primary cyclone plant except that it has eight cyclones per module instead of six.

Heavy-medium Vessel Plant

As in the above plants, the heavy-medium vessel plant was designed in modules. It has five modules, each with a design capacity of 500 t/h.

Flotation Plant

All the minus 0,5 mm slurries are fed, via a launder, to two froth-flotation feed thickeners. The slurry is fed to a five-way distributor, from which each of the five flotation plant modules is fed.

The Loading-out Station

The loading-out station was designed to load continuously at up to 2000 t/h into block trains consisting of CCR1 trucks.

Conclusion

Some of the advantages and disadvantages of the method of project management adopted for the Grootegeluk project are as follows.

Advantages

(1) Perhaps the greatest advantage of the extended project-management approach adopted by Grootegeluk lies in the fact that the team, over a period of two years, became thoroughly acquainted with the plant, and was involved with the hot commissioning and production from the outset. Before the production phase, the operators were trained at other mining centres during the construction phases of the plants. They gained valuable experience during this training period, which was advantageously applied to Grootegeluk during the two months of hot commissioning of the plant.

* The design capacity for the whole plant is defined as the tonnage at which the plant is able to produce continuously. The average tonnage is that tonnage at which production will take place, including maintenance stops, etc.

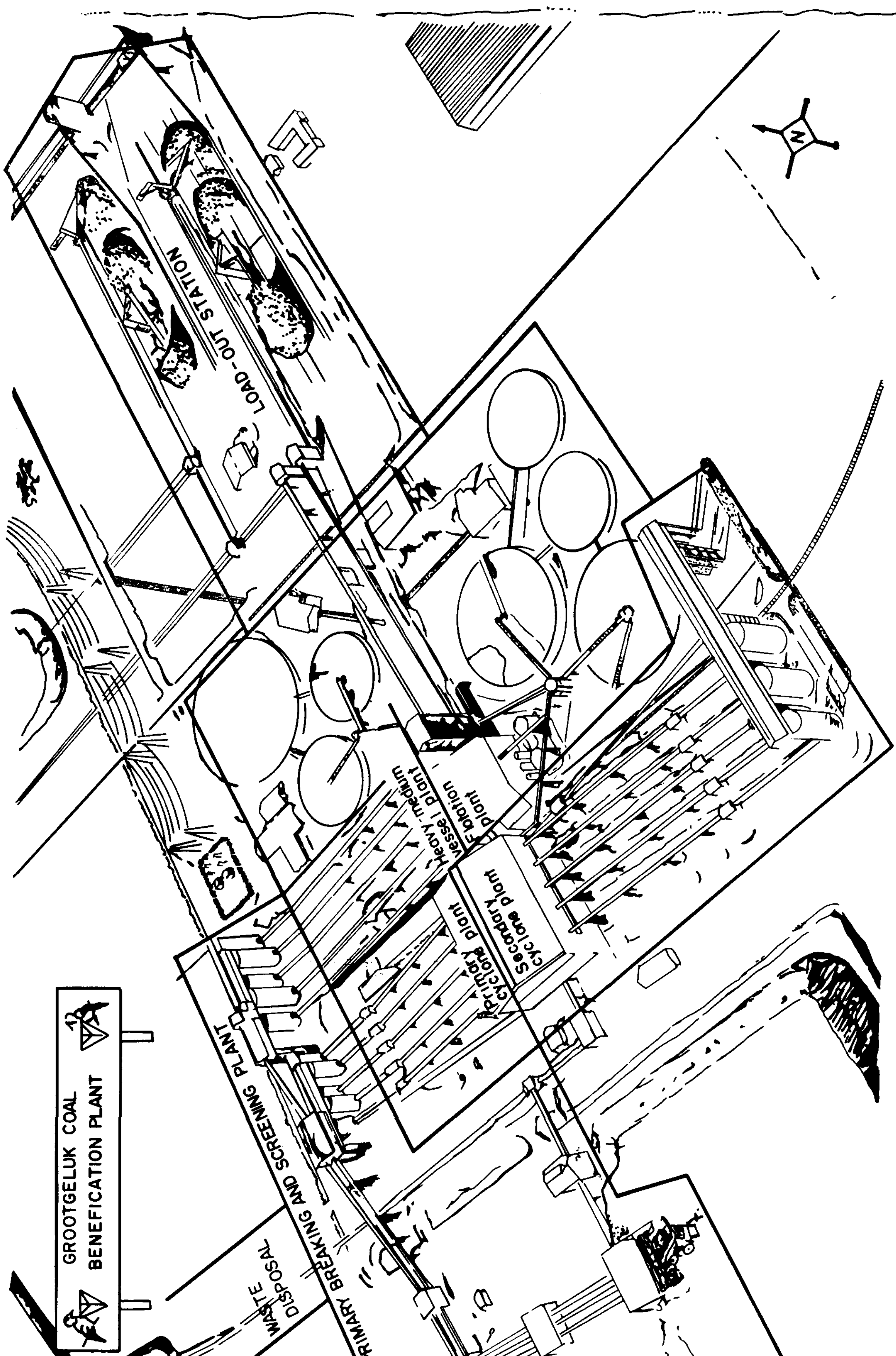

Fig. 1 — The coal-beneficiation plant at Grootegeluk

(2) Completion of the plant design (with detailed drawings) and the 'precedence' progress planning and scheduling networks for the plant as a whole before the contracts were placed allowed this project to be completed in accordance with Iscor's technical standards and exactly on time. When a contract is granted on a turnkey basis, too much is often left to the discretion of the tenderer with regard to technical standards and, being under the pressure of open-tender conditions, he tends to save money, thereby usually lowering the standards.

(3) Because the plant was fully defined (in terms of drawings and equipment) during the tender stage, a minimum of uncertainties remained. Therefore, the tenderers did not have to load their prices to allow for uncertainties.

(4) Iscor purchased, expedited, and stored most of the process equipment, which was issued to the erection contractors as and when required. This relieved the contractor of these duties, and the associated handling charges were saved.

(5) As all the design work had been completed beforehand, the adjudication of tenders could be done properly because the full extent of the enquiry was clear. Furthermore, a much larger force was available for tendering because no process guarantees had to be given by the erection contractors. This is an important factor: only a few major contractors in South Africa can undertake a turnkey job of this nature.

(6) Because of the above-mentioned advantages, a real money saving of 15 per cent on the project as a whole was achieved, completion was exactly on time, and, after the contracts had been entered into, the capital requirements were within 1 per cent of the budget, actually amounting to a saving of approximately one million rands.

Disadvantages

Being the principal agent, Iscor placed the following additional responsibilities on its management team:

(a) the correctness of all the design work and drawing details (layout, flow line, and detailed design), which implies that any error on a drawing resulting in a plant modification was for Iscor's cost;

(b) the purchase of equipment for free-issue supply to the contractor, which made Iscor responsible for the correctness and delivery in good time; furthermore, the necessary guarantees could be expected from the equipment supplier only if he was allowed to satisfy himself that his equipment was installed and commissioned correctly;

(c) using the above-mentioned method of order placing, Iscor had no option but to take full responsibility for the hot commissioning, which included the rectification of design errors.

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Pipe protection

BHRA Fluid Engineering will hold its fifth international conference on the Internal and External Protection of Pipes in Innsbruck, Austria, from 25th to 27th October, 1983. Offers of papers are invited.

The correct choice of both internal and external pipe coatings is vital to many industries, such as oil and gas production, refining and chemical processing, solids handling, water supply, and sewage disposal. Automated pipe-laying techniques, aggressive conditions, the movement of oil and gas at higher temperatures, and the need to transport large-particle slurries, such as coal, have created new technical demands. At the same time, the cost of inadequate pipe protection is correspondingly serious, repairs are likely to be very expensive, and lost production could lead to widespread environmental damage.

The Conference will cover recent developments in materials and new methods of combating corrosion and ereosion associated with the transport of solids, liquids and gases, in addition to state-of-the-art reviews and economic aspects of pipe protection. Offers of papers dealing with, or related to, the following are invited:

- pipeline materials
- coatings, wrappings, and linings
- transport of difficult and hazardous materials
- rehabilitation of gas, water, and sewer systems
- protection of joints
- submarine pipe protection including cathodic protection monitoring
- electrochemical aspects
- environmental aspects
- quality control
- applications and case histories.

An exhibition is also planned to allow manufacturers and users to display company literature and associated material.

Prospective authors are invited to submit titles and synopses as soon as possible. Further details are available from the Conference Organiser, 5th Pipe Protection, BHRA Fluid Engineering, Cranfield, Bedford, MK43 OAJ, England. Telephone (0234) 750422; telex 825059.