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A User's Evaluation of Feeder Performance

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BELTCON 5

CONTENTS

1. INTRODUCTION

This paper discusses an evaluation of various types of feeders employed on bulk coal handling installations on Eskom Power Stations. ESKOM, being a major operator of feeders on coal applications, have in recent years obtained wide experience on such feeder installations.

The paper commences with an overview of ESKOM's experience on general applications of vibratory, belt, plough, chain and rotary table feeders on coal plant, outlining various installations and some of the problems encountered. This is followed by a description of an investigation done on a 5500 ton mass flow silo/belt feeder installation at Lethabo Power Station. The coal flow in the silo and the improvements implemented on the belt feeder are then described.

A discussion of tests done at Kendal Power Station on a 750 ton capacity surge bin/belt feeder application follow. These tests were done to determine the belt feeder performance characteristics under varying load conditions, and to compare these with the theoretical design data. The performance of vibratory feeders on two similar surge bin applications is then described.

Finally, a general discussion on feeder selection for new coal plant applications is given.

2. GENERAL APPLICATIONS

Eskom operate numerous Power Station coal systems. The type of coal discharge feeders used are vibratory, belt, rotary plough, chain flight and rotary table feeders. The coal tonnage discharge rates vary from low quantities up to approximately 3000 tph.

The belt and vibratory feeders are normally utilized for the higher capacity discharge rates from silo/bin arrangements. The rotary plough feeders are used for large capacity discharge rates on long slot, large capacity bunker/staithe type arrangements. The coal feeders described in this paper are those installed by Eskom subsequent to 1960.

2.1 Vibratory Feeders

Eskom have vibratory feeders installed on various coal plant installations on Power Stations. The feeders include both the brute force and twin mass electro-mechanical types. The feeders operate with varying degrees of success. A general problem encountered is the inadequate control of feedrates under varying material characteristics and load conditions. These feeders do not always satisfactorily control the material flow under varying coal size consist and moisture contents, which lead to flooding, blockages and spillage. In addition, the vibrations on certain machines have led to high component failure rates which result in reduced plant availability and high maintenance costs. As the capital cost of vibratory feeders is usually lower than that for belt feeders, the full operating and maintenance costs are included in all economic evaluations done on such applications.

Twin Mass vibratory feeders with variable discharge rates up to 1 500 tph are operating on surge bins with capacities of approximately 1000 tons. Similar capacity brute force vibratory feeders have been retrofited and are operating on stockyard reclaim hoppers. These are being fed by mobile plant. The performance of the first mentioned installations is superior to those last mentioned. It is Eskom's preference to install a closed loop control system linked to a mass meter (situated downstream) for all vibratory feeder applications. This enables good control of the coal feed under varying coal bin discharge heights, material conditions and load variations.

2.2 Belt Feeders

In recent years ESKOM have installed numerous belt feeders on coal applications. These have been installed on coal bin/silo's with storage capacities varying from approximately 750 tons to 5500 tons. (See Table 1 for list of applications). The designs are mainly based upon Jenike & Johanson loading criteria with additional safety factors as thought necessary by Eskom. These criteria have proved to be satisfactory for normal running conditions.

Eskom required that the belt feeders must provide increasing drawout volume in the direction of belt travel to permit uniform discharge over the entire cross section of the bin outlet (ie to achieve mass flow discharge from the bin). This was achieved by providing a wedge interface between the bin outlet and feeder belt, diverging in the direction of feeder belt travel. Wherever possible continuous skirt plates are avoided in belt feeder design.

The feeders are equipped with either hydraulic or A C frequency controlled variable speed drives, both drive types having rendered satisfactory operation to date. The main selection criteria between the two drive types is normally based on economic considerations. The feeders have infinitely variable speed control and once they have been correctly commissioned and calibrated they operate satisfactorily with minimal maintenance and high availabilities. The feed rates can be set from low tonnages up to the maximum design capacity feedrates.

Under varying coal load and material conditions the belt feeders operated by Eskom on coal plant are generally performing well and have rendered good stability over the full operating range. (For vibratory feeders this stability is limited to a defined upper feed range). The preference is to incorporate a closed loop control system linked to a mass meter situated downstream of the feeder. This enables good control of the coal feedrate during unsteady material feed conditions, usually within 0,2 percent of the control set point.

TABLE 1 OVERVIEW OF COAL FEEDER APPLICATIONS AT THE LATER ESKOM POWER STATIONS

POWER STATION	APPLICATION	FEEDER TYPE	SILO/BIN STORAGE CAPACITY (TONS)	MAXIMUM FEEDRATE (TPH)	COMMENTS ON FEEDER OPERATION (APPLICABLE TO VARIABLE COAL CONDITIONS)
Tutuka	Mill Bins	Chain	900	80	Good
	Silo	Belt	4 500	1 050	Good
Lethabo	Mill Bins	Belt	900	100	Good
	Surge Bin	Vibrating	900	1 500	Fair
	Silos	Belt	5 500	1 050	Good
Kriel	Staithes	Clam shell gate	+70 000	± 1 000	Poor
	Reclaim tunnel	Gravity	±50	± 1 100	Poor
Matla	Staithes	Clam shell gate	50 000	± 1 000	Poor
	Staithes(Retrofit)	Rotary Plough	100 000	± 1 000	Good
	Reclaim tunnel	Gravity	± 50	± 1 100	Poor
Duvha	Staithes	Clam shell gate	150 000	± 1 000	Poor
	Reclaim tunnel	Vibrating	± 50tons	± 1 100	Poor
Matimba	Surge Bin	Belt	900	3 000	Good
	Silos	Belt	4 500	1 050	Good
Kendal	Surge	Vibrating	900	1 500	Fair/good
	Surge (Terrace)	Belt	750	1 050	Good
	Assize Bin	Belt	300	1 750	Good
	Mill Bins	Belt	900	80	Good

NOTE: Comments for performance is based on the following criteria:
Poor
Fair
Good
Excellent

Eskom are operating the following three types of belt feeder/idler frame configurations:

- Fixed belt feeder/idler frame (no movement relative to the bin discharge interface).

- Vertical spring supported belt feeder/idler frame (spring compensates for bin deflection). (See fig. 1).

- Adjustable belt feeder/idler frame (Adjustable idler frame with horizontal spring retention). This system compensates for bin deflection within a set range. (See fig. 2).

The performance on all three system types has been good. The main advantages of the last two mentioned systems is a reduction in start up torque and hence a reduction in the drive system power rating with associated cost savings. Although capital installation costs for the adjustable belt feeder idler frame are higher than for the fixed system, the life cycle costs, together with improved availability and maintainability, combined with lower power requirements, may be advantageous.

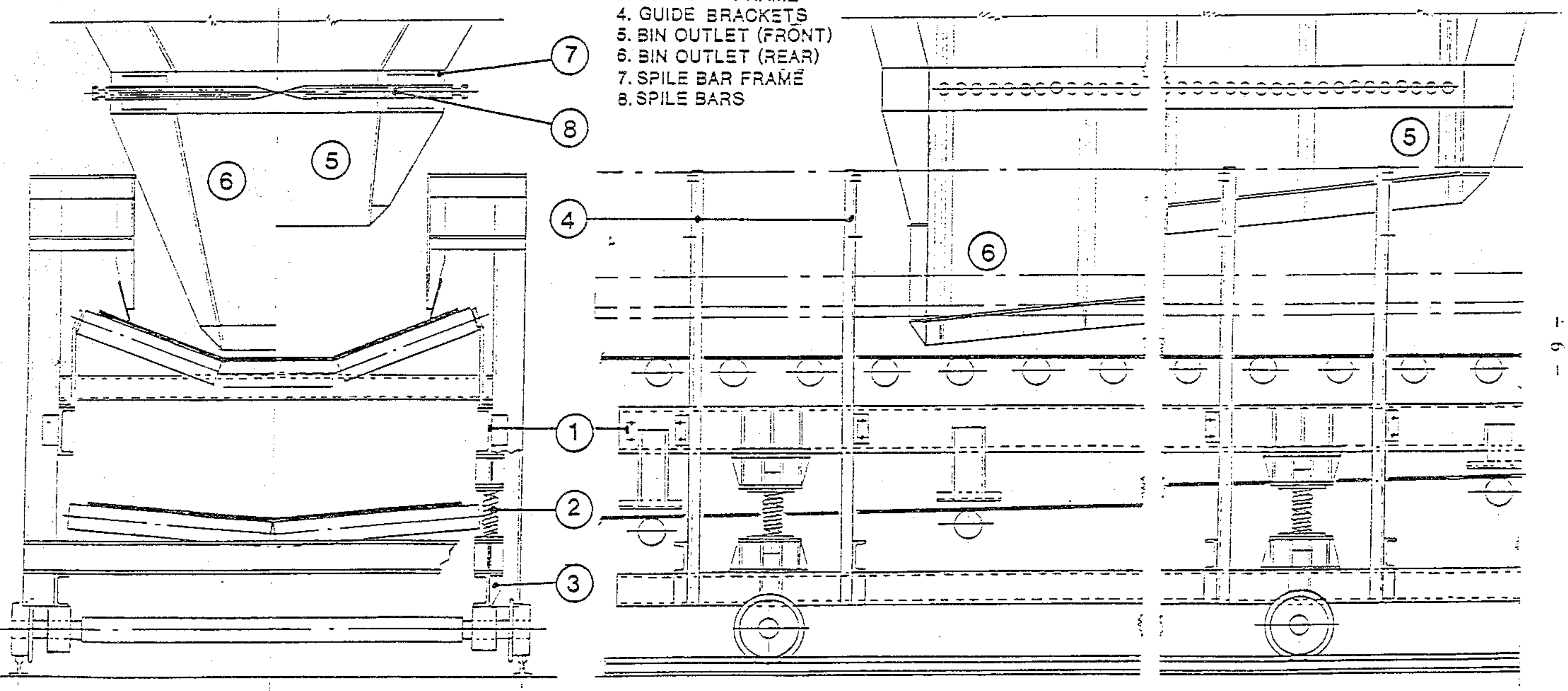
The general maintenance and wear on these feeders is minimal. The systems are readily maintained, the most technically advanced item of equipment being the drive system components.

Other than for potential material carry-over on the return section with resultant belt misalignment, Eskom's general experience with coal belt feeders is good.

BELT FEEDER TESTS

KEY:

1. IDLER FRAME
2. SPRING ASSEMBLIES
3. SUPPORT FRAME
4. GUIDE BRACKETS
5. BIN OUTLET (FRONT)
6. BIN OUTLET (REAR)
7. SPILE BAR FRAME
8. SPILE BARS

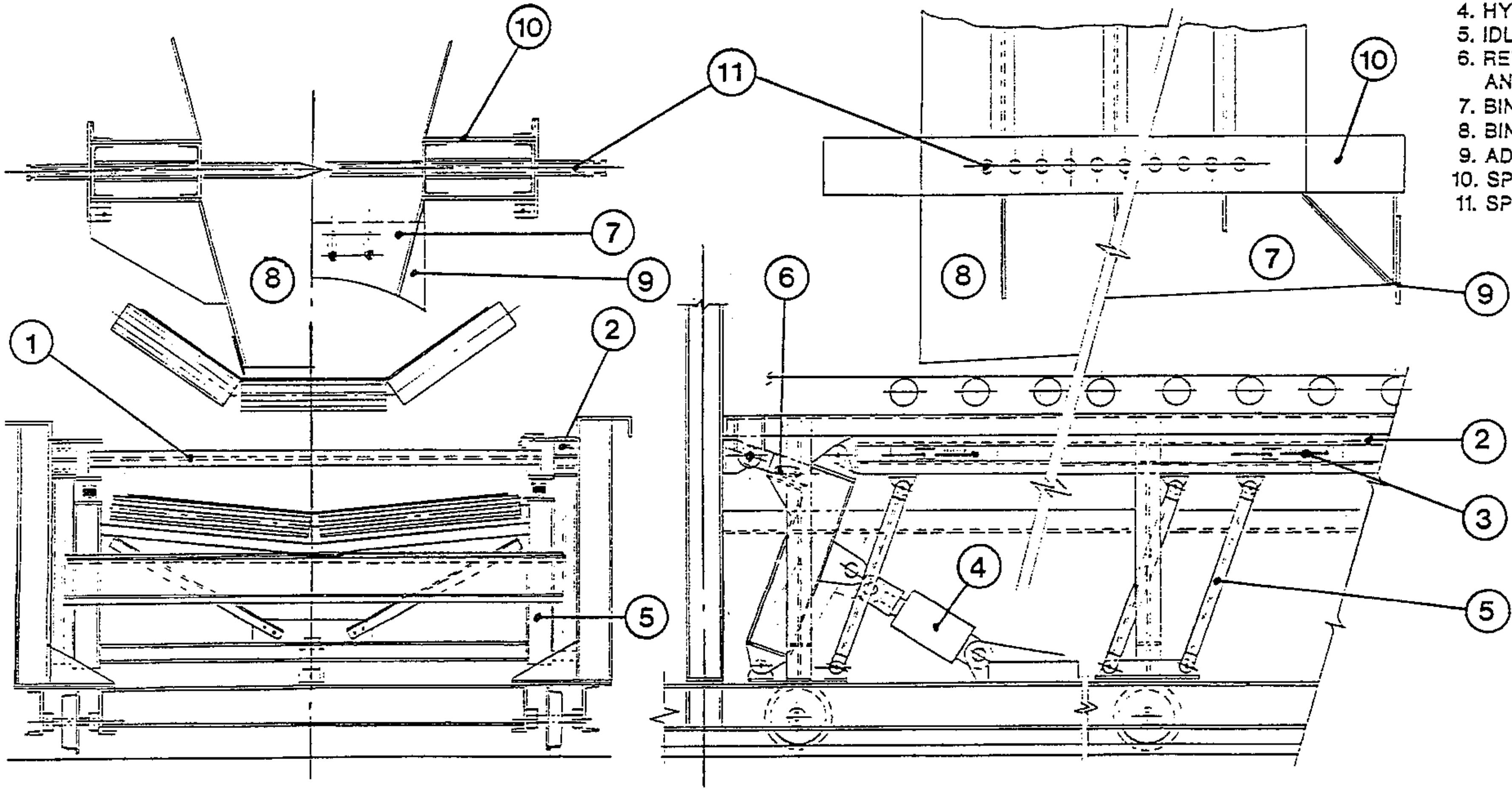


BELT FEEDER IDLER FRAME CONFIGURATION

VERTICAL SPRING SUPPORT

FIGURE 1

BELT FEEDER TESTS - KENDAL POWER STATION



BELT FEEDER IDLER FRAME CONFIGURATION

ADJUSTABLE IDLER FRAME SUPPORT

FIGURE 2

2.3 Chain Flight Feeders

ESKOM utilize volumetric chain flight feeders on coal Mill Bin discharge applications on numerous power stations. The feedrates vary from zero to approximately 100 tph. These operate satisfactorily under normal operating conditions. They are however susceptible to blockages by foreign objects which can lead to the bending and breaking of chains and chain flights. This can in turn lead to extensive downtime when clearing the system of these objects. This is especially true if the feed bins (approximate capacity ± 800 tons) are also contaminated with foreign objects which have been included in the coal supply. With the exception of the above, the chain feeders are operating satisfactorily on all such installations.

2.4 Rotary Table Feeders

Rotary table feeders are utilised on numerous power station's built in the 1960's. These are used to feed coal from the mill bin discharge to the mills. They perform fairly, under the varying coal conditions. When feeder problems do occur, they are mainly due to the coal transfer chute arrangement to the feeder and also from coal dust build-up around the table/seal mechanism. These table feeders are used on the older low tonnage feedrate applications and have largely been superceded by volumetric chain flight or belt feeders on new plant.

2.5 Rotary Plough Feeders

Rotary plough feeders are operating on the Matla Power Station Staith (bunker) system. Numerous coal hang-ups and blockages occurred on the earlier gravity type, clam-shell gate controlled discharge arrangement, especially with wet coal (in excess of 10% moisture). The rotary plough system has resulted in the elimination of these problems, and also in acceptable coal loading onto the reclaim belt below the staithes. A similar installation on Majuba Power Station will be installed with A C frequency controlled variable speed drives in contrast to the hydraulic drives employed at Matla. This is purely due to the economic advantages of the above. In addition the Majuba reclaim ploughs will employ a pivoted frame. This will permit reclamation from long slots situated on either side of the reclaim conveyor (see fig. 3).

MAJUBA STAITH RECLAIM TUNNEL

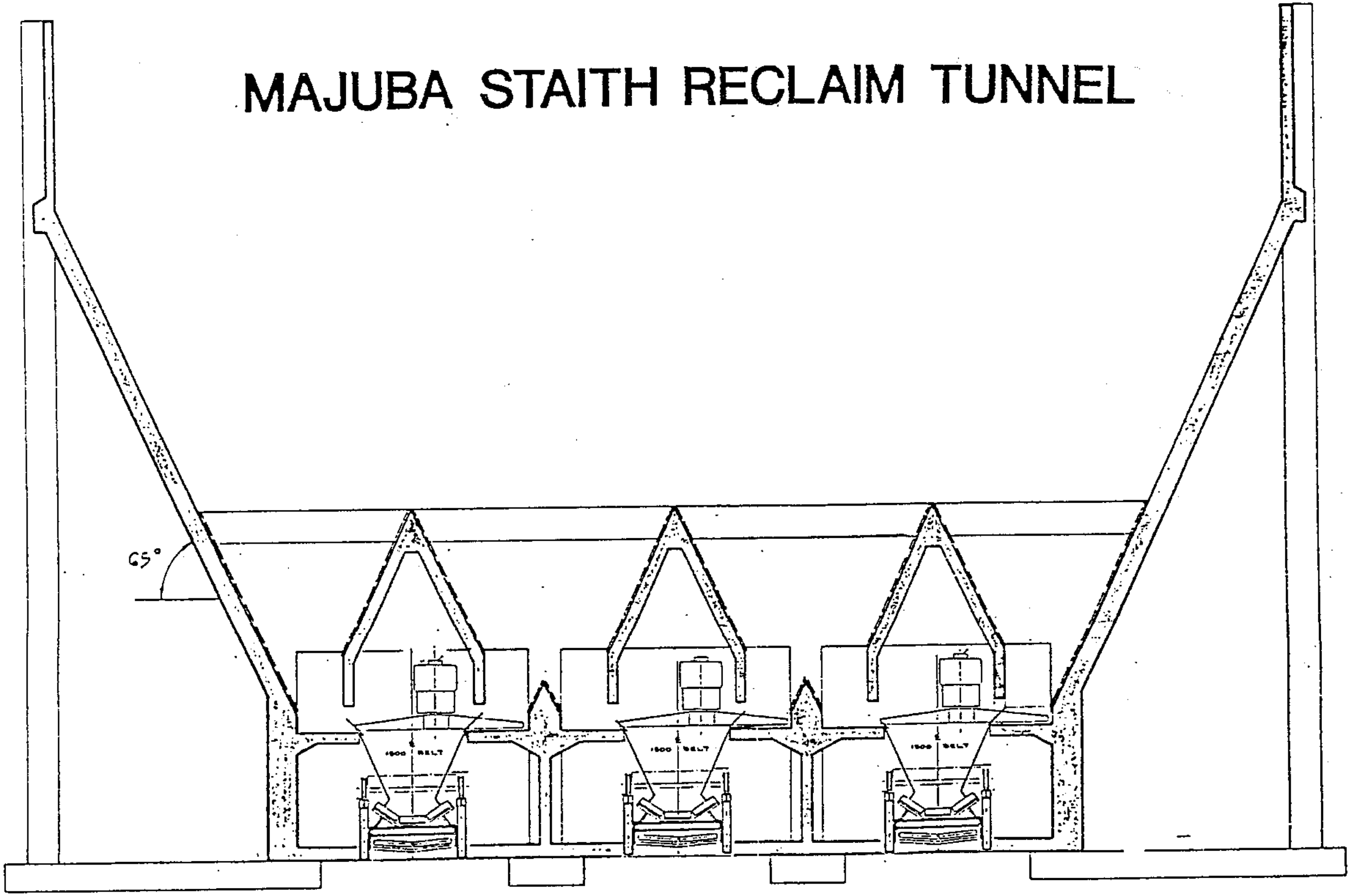


FIGURE 3.

The rotary plough is infinitely variable over the design speed range and can volumetrically control the coal feedrate. For operational purposes, it is more beneficial to control the mass feedrate. Eskom thus favour an adjustable closed loop control system, linked to a mass meter downstream of the rotary plough feeder. The plough feeders Eskom are using have variable feedrates varying from approximately 200 tph up to 1 500 tph.

A dust extraction/filter system can be installed on the plough feeders to reduce the dust burden to an acceptable level with additional cost implications. This however has not been found to be economically justifiable if the feedchute/skirting arrangement is correctly designed.

Eskom's experience with rotary plough feeders is good and Eskom are generally very positive regarding these feeders for slot reclaim applications.

3. BELT FEEDER AND COAL FLOW PERFORMANCE FOR A 5 500 TON SILO

The coal silo belt feeders installed at Lethabo Power Station below the 5500 ton unit silo's have a maximum design feedrate of 1050 tph. These feeders are driven by an infinitely variable speed hydraulic drive unit and have a fixed feeder idler frame. The feeders have been volumetrically calibrated and have been operating well for the past few years.

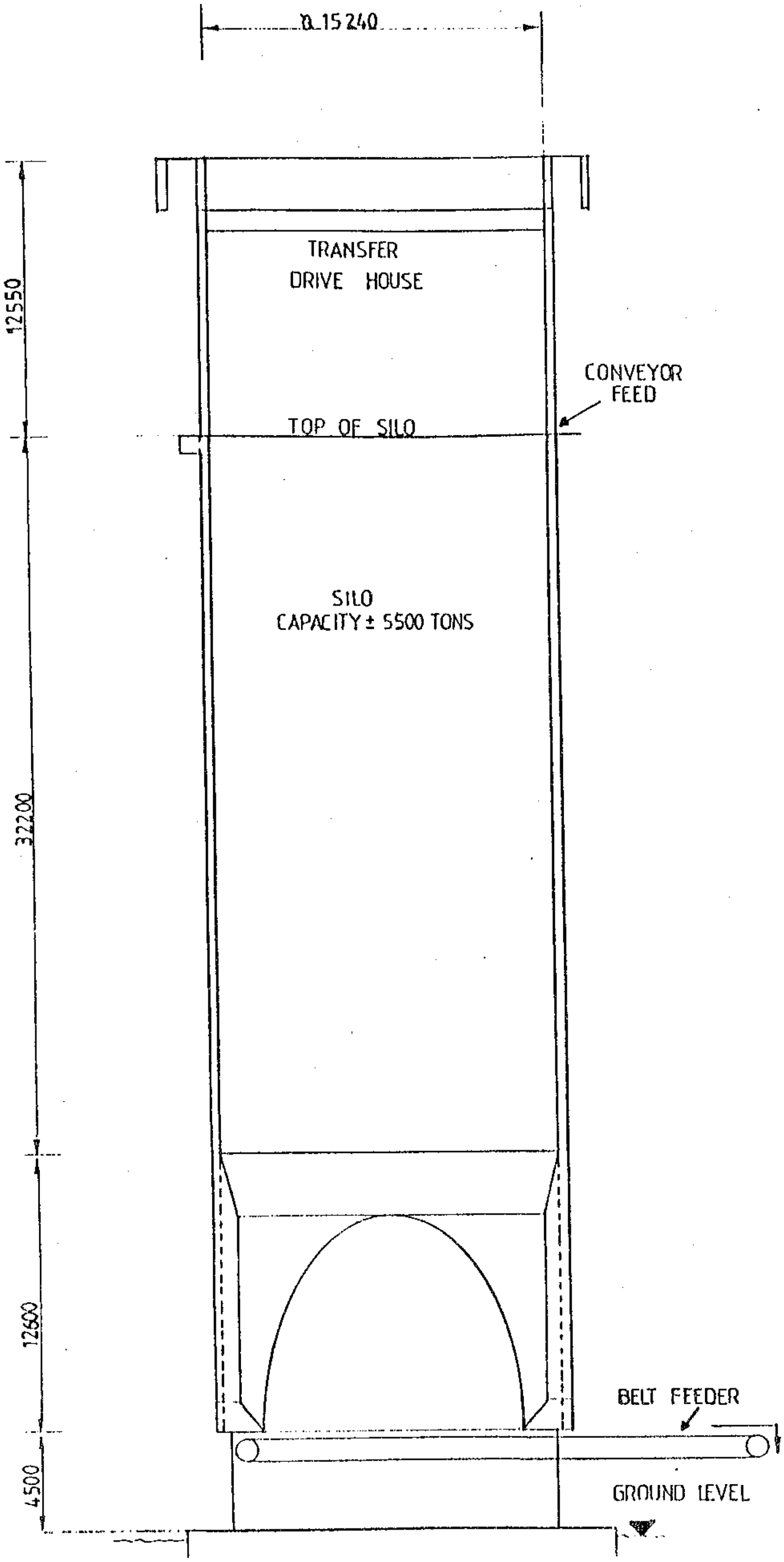
3.1 Observations and Testing.

The 5 500 ton coal silos on the Power Station terrace were vibrating noticeably. After brief inspections it was observed that the material flow along the feeder length was non-uniform. The flow at the rear end of the feeder was greater than that at the front end (discharge end), where the flow was almost stationary. It was assumed that this uneven flow did have some effect on the vibrations. In any event, the non-uniform flow pattern needed to be rectified.

In order to investigate the flow patterns, a silo (see figure 4) was filled to 88% of its maximum capacity. The belt feeder was then operated and the silo maintained the configuration as in figure 5 (Sketch 1), ie. a central cone configuration was maintained until the silo was approximately 38% full.

Thereafter, a small off centre crater developed (see fig. 5 sketches 2-4) towards the rear end of the feeder. This verified the non-uniform flow pattern as previously observed.

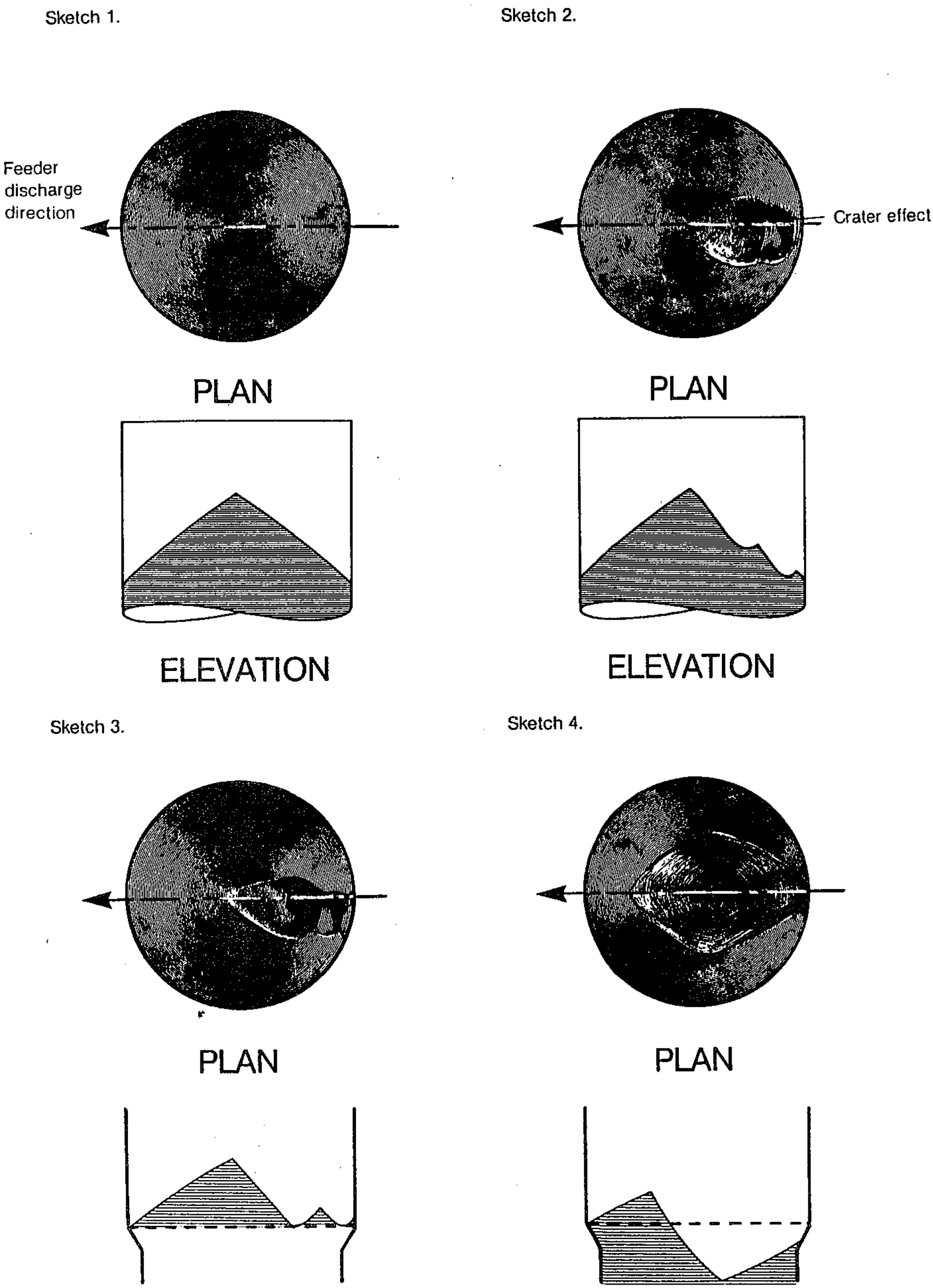
As the silo further emptied, the high coal flow rate towards the rear of the feeder became very noticeable (see fig. 5, sketch 5 & 6).



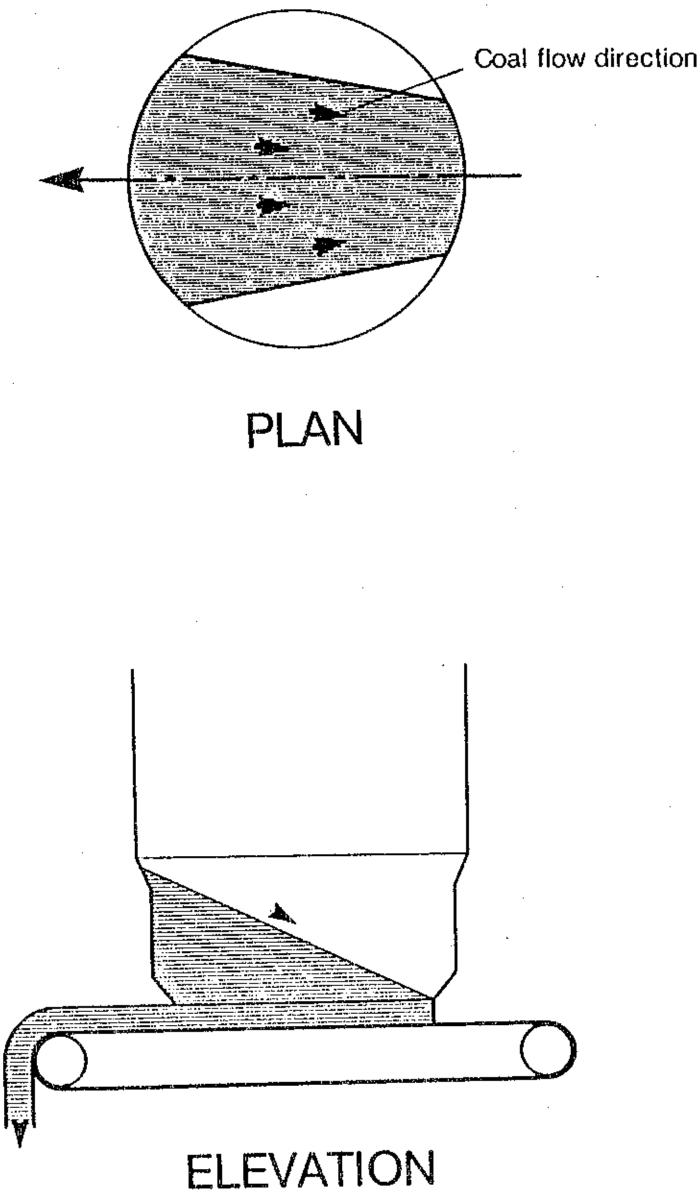
LETHABO COAL STORAGE SILO

FIG. 4

FIGURE 5 – COAL FLOW CHARACTERISTICS IN 5500 TON SILO AT LETHABO POWER STATION



Sketch 5.



Sketch 6.

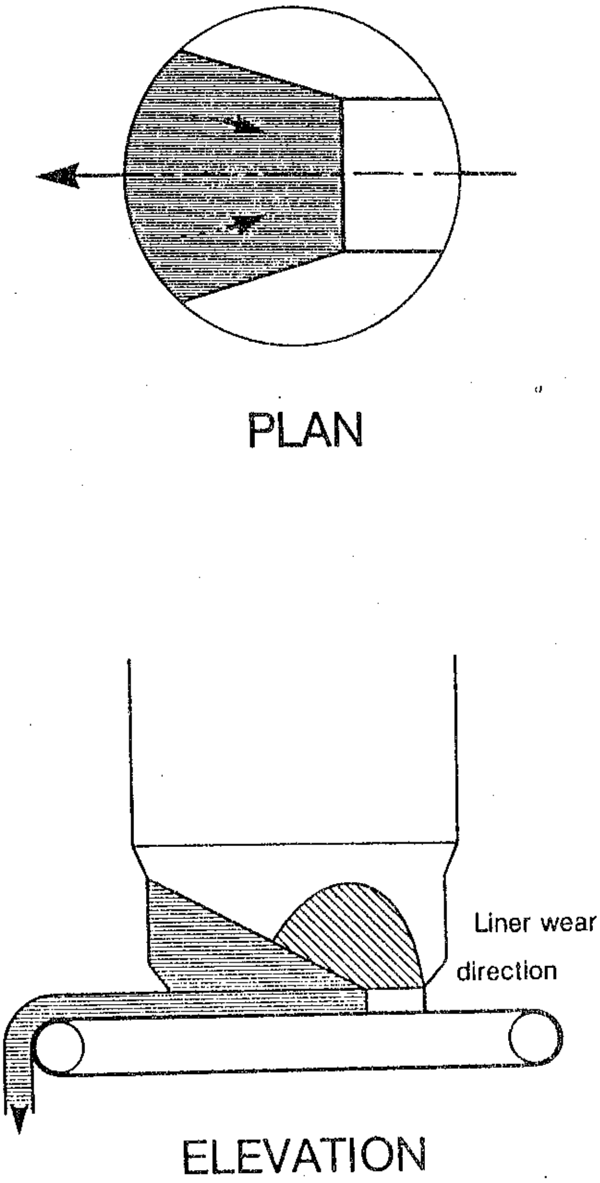


FIGURE 5

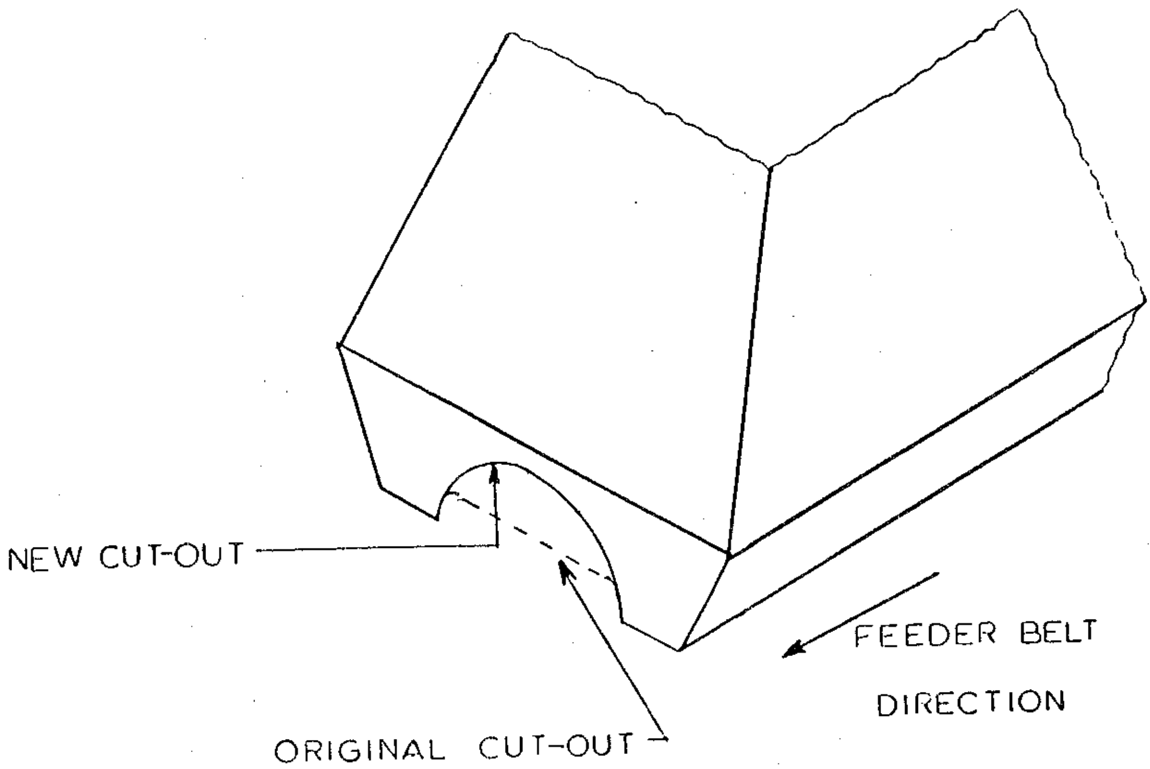
When the silo had completely emptied, large conglomerations of coal remained attached to the silo in the valleys (ie. feeder discharge end) of the silo. These conglomerations were then required to be manually removed. They had probably built up over a period as the result of a combination of high moisture, low coal flow rates and high coal pressures in this region. The flow pattern towards the rear of the belt feeder could easily be observed by the direction of the fine striations on the liners. (See fig 5, sketch 6). Because of the low flow rate experienced at the front end of the silo, the majority of coal was flowing at the rear end and causing excessive wear on the stainless steel liner plates.

3.2 Evaluation and Conclusions

In order to improve the flow pattern, the feeder skirt plates were adjusted, and dimensional checks and other minor adjustments were also done to the belt feeder. It is believed that these changes did not significantly effect the flow pattern.

The half moon cut-out area on the front nose section was then increased. This modification resulted in uniform flow across the belt feeder. (See figure 6). This item is thought to have most noticeably effected the flow pattern in the silo discharge area. This small modification has resulted in the feeder discharging evenly over the entire feeder discharge length and the flow patterns in the silo appear to be uniform.

The coal flow in the silo is now behaving in a full mass flow state.



BELT FEEDER FRONT NOSE CUT-OUT

FIGURE 6

4. BELT FEEDER PERFORMANCE

The basic Kendal Power Station terrace coal plant surge bin/belt feeder system consists of the following:

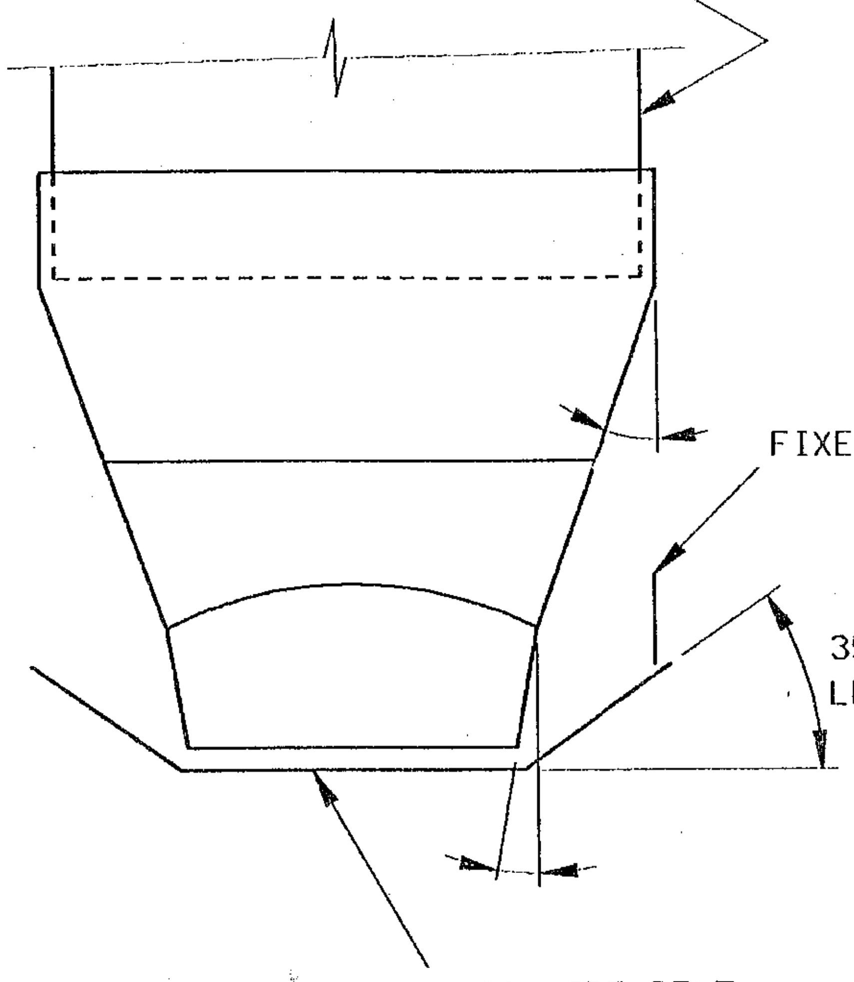
- A 750 ton capacity dual slot discharge mass flow bin.
- Two identical 1050 tph capacity variable speed belt feeders each complete with:
  - i) A dual motor/hydraulic pump drive system.
  - ii) A hydraulically operated idler frame retraction/adjustment facility.

The lowering device can be utilized to reduce the initial start up torque and also optimise the power/torque requirements. During the design phase of this project, an alternative system comprising an interface hopper located between the bin and belt feeder was considered. (See fig 7). It was suggested that the facility would have the same effect as the idler frame retraction facility ie. to reduce the start-up torque requirements. The hydraulic lowering device system, was the preferred option.

4.1 Tests and Observations

The tests done on the surge bin/belt feeder system can be summarised as follows:

- Measurement of the power consumption of the belt feeder with varying coal feedrates.
- Measurement of the performance of the belt feeder with various coal levels in the coal surge bins.
- Monitor the performance of the belt feeder in relation to the coal storage period in the surge bin.
- Measurement of the power consumption for two individual idler frame/surge hopper settings.



BELT FEEDER INTERFACE HOPPER

FIGURE 7

The coal level in the surge bin during the test period varied between 25-100 percent of the maximum level.

It was observed that the coal feedrate was not noticeably effected by the level of coal in the surge bin.

The coal flowrate was effectively controlled under all load and material conditions. The coal feeder belt responded in a positive manner to all the variable control settings over the full control speed range of the feeder ie from zero tph up to 1050 tph. The feeder performance was consistent and a steady feedrate was achieved even at low feedrate settings (0-200 tph). The power consumption for the feeder over the entire operating range was reduced for the case in which the idler frame/surge hopper setting was lowered. (See graph 1).

The installed belt feeder power and torque performance is adequate for normal operating conditions and also normal surge bin operating levels. The installed power/torque performance was inadequate for the condition in which the bin was filled from empty and then allowed to stand for an extended period. The idler frame was required to be lowered to start the belt feeder under this latter condition in accordance with the design philosophy.

4.2 Evaluation

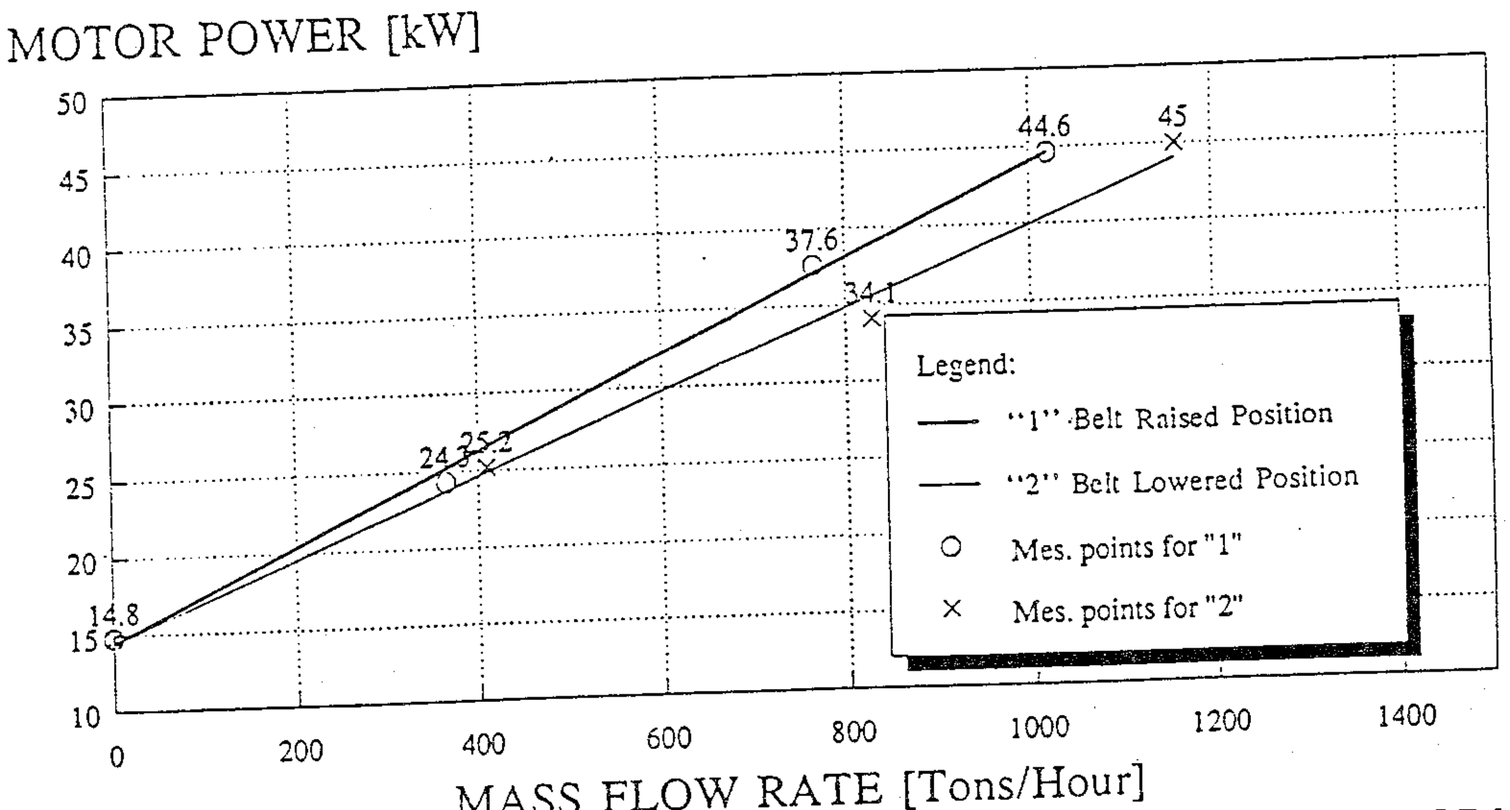
4.2.1 Power consumption related to the belt feeder coal feedrate.

The power consumption is directly proportional to the mass flow rate. (See graph 1). The coal level in the surge bin did effect the coal feedrate due to a change in coal density. This variation in density is compensated for by the closed loop control system.

BELT FEEDER TESTS - KENDAL POWER STATION
MOTOR POWER AS A FUNCTION OF MASS FLOW RATE

LINEAR APROX USING "LEAST SQUARE" METHOD

$$y1=A1x+B\ ,\ y2=A2x+B$$



GRAPH 1

"1"A1=2.960E-02 "2"A2=2.552E-02 B=14.445

4.2.2 Belt feeder performance related to the coal storage period/coal level in the bin.

The belt feeder operated satisfactorily under normal operating conditions. The installed drive torque proved inadequate to permit a start up after a seven hour consolidation period when the bin was filled from an empty state with the feeder stationary.

The theoretical torque requirement for this condition is 156 kN-m (Based on Arnold, MacLean and Roberts/Acknowledgements Item 6). Although the actual start-up torque could not be measured, it was in excess of the installed drive torque of 125 kN-m (see table 2). The hydraulically powered idler frame lowering device was initiated and belt feeder start up was readily achieved.

4.2.3 Effects of the retractable idler support frame on power consumption.

The power consumption measured under normal conditions (ie lowered frame setting) was lower than the power measured with the feeder retractable idler support frame in the raised test position. This trend was observed over the entire coal feed range. (See graph 1).

The belt feeder design was based upon Jenike and Johanson Inc. design load factors which were then increased in accordance with Eskom/Contractors experience. Table 2 highlights the actual measured performance data compared to the theoretical design data using various design procedures.

	DESIGN PROCEDURE	PREDICTED FEEDER LOAD FROM BIN (KN) Qi	Qf	ABSORBED POWER (KW) NORMAL FLOW (MAXIMUM RATING)	ABSORBED TORQUE (KNm) START-UP (NORMAL FLOW)	START-UP (FROM INITIALLY EMPTY CONDITION
1.0	Jenike & Johanson Inc.	F=1,8	F=1			
1.1	(Basic Theory) Normal Load = 18F + 34 Shear Load = 17,5F	66,4 31,5	52,0 17,5	16,5 kW	16,45	
1.2	Based on Design Report: Normal Load = 22F + 40 Shear Load = 23F	79,6	62,0	19,5	20,0	
1.3	Based on Eskom Specification Normal Load = 45F + 40 Shear Load = 50F	121,0	85,0	31,0	37,0	
2.0	Arnold McLean Roberts (where m = 0 for plain flow)	566	17,1	29,0		156
3.0	Bruff Excluding end effects	463	116	43,5	70,37	
4.0	Reisner	420	105	40,5	64,3	
5.0	From Test Results (Assuming drive efficiency of 65%)			26,8 (14,8 Actual 15,9 Theoretical under no load conditions)	-	> 125

Note: Absorbed power based on maximum capacity of 1050 Tons/hour at 0,5m/sec belt speed. Additional feeder power requirements are based on ISO 5048 design procedure other than for Item 2 (ie Arnold McLean Roberts).

TABLE 2

4.2.4 Belt feeder power consumption.

The specific power consumption at approximately 1050 tph is 40 watts/tph of coal, for the belt feeder. This power consumption is approximately ten times greater than for that measured on the two mass vibratory feeder at a similar feed capacity.

4.3 Conclusion

The belt feeder performance is good under varying material and load conditions. The feeder responds well over the total feed range ie. from 0 to 1050 tph.

The hydraulically powered adjustable idler retraction frame facility proved to be essential to assist in start-up after the bin was filled from an empty state and consolidation of coal has occurred. As this coal surge bin/feeder system is a critical plant item as regards the coal feed to the power station, the additional cost involved to improve availability/reliability is considered to be justified.

It is essential that the designer has a thorough understanding of the practical implications when using the various theoretical belt feeder load criteria during the design of such systems.

5. VIBRATORY FEEDER PERFORMANCE TESTS

On two very similar coal surge bin/vibratory discharge feeder applications, feed rate control problems were being experienced under varying coal and load conditions. Tests were done to evaluate the problem items and then to resolve them in order to enhance the performance of the system.

The vibratory feeder systems can be described generally as follows:

- Two ± 1000 ton capacity coal surge bins.
- Six dual mass vibratory feeders (Three per stream).
- Infinitely variable speed electro-mechanical vibratory feeders.
- Vibratory feeder design capacity is 0 to 1500 tph.
- A downstream mass meter interfaced with the feeder to provide a closed loop control system.
- Floor mounted feeder on coil spring isolating assembly.
- Vibratory feeder tray installed at 12,5 degrees downgrade. (See fig 8 for vibratory feeder configuration).

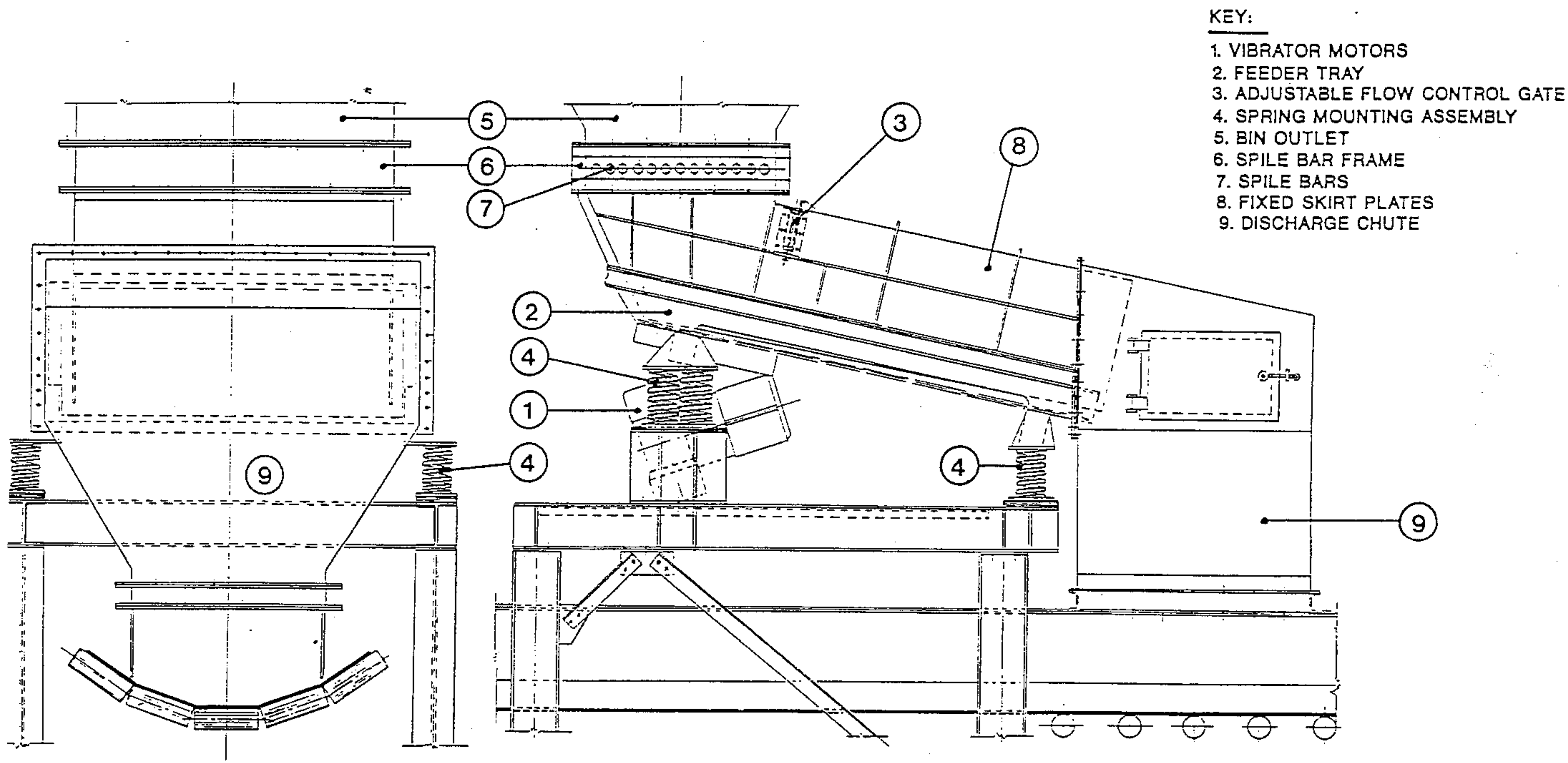
5.1 Tests and observations

Similar tests were done on both installations in order to optimise the systems. The tests were done to determine the actual feeder performance under varying load and material conditions.

The tests done on the feeder applications can be summarized as follows:

- Measurement of the mass flowrate as a function of the control set point. (This controls motor voltage and thus motor speed).
- Measurement of the mass flowrate as a function of the vibratory feeder tray displacement.
- Determine the effects of the hopper throat opening on the coal flow.

VIBRATING FEEDER TESTS - KENDAL POWER STATION



VIBRATING FEEDER CONFIGURATION

FIGURE 8

It was observed that the vibratory feeders on both surge bin applications were not performing to Eskom's requirements under the varying coal load and material conditions. Under extreme moist, dry and fine coal conditions, the feeders tend to flood. Under normal flow conditions (approximately 8% total moisture content), the feeder performance was generally satisfactory.

By installing an adjustable gate on the discharge hopper, the hopper throat opening can be varied. The installation of such a hopper throat control gate at Lethabo Power Station greatly improved the coal feed characteristics.

As the maximum coal particle size is approximately 32mm and the coal is normally moist with a fairly regularly shaped particle, the normally acceptable minimum hopper throat dimension of 2,5 times the maximum particle size could be easily achieved on this application. The reduction of the load on the feeder due to a reduced bin opening is also believed to have improved the control.

The coal feedrate is adjusted by altering the frequency (ie this is effected by varying the motor voltage). The control function was observed to be non-linear over the feedrate range (ie 0 - 1500 tph). The eccentric weights on the motor were increased, and the speed further reduced. This led to a further improvement in the control on the feeders even with varying material characteristics.

The coal level in the surge bin was maintained between 50 and 75 percent of the maximum bin level for the duration of the tests.

5.2 Evaluation

5.2.1 Set point (motor speed) related to the coal feedrate.

The control set point controls the motor speed via motor voltage. The control set point mass feedrate relationship is non-linear over the entire operating coal feedrate range (see graph 2). This control curve (ie voltage) can be approximated by a third order polynomial expression (see graph 3). As it is not required to operate in the lower feedrate range on this application, the control signal (ie 0-20mA) need only be used over the 300 to 1500 tph range. This greatly improves the controllability for this operating range and resulted in satisfactory material control for this application.

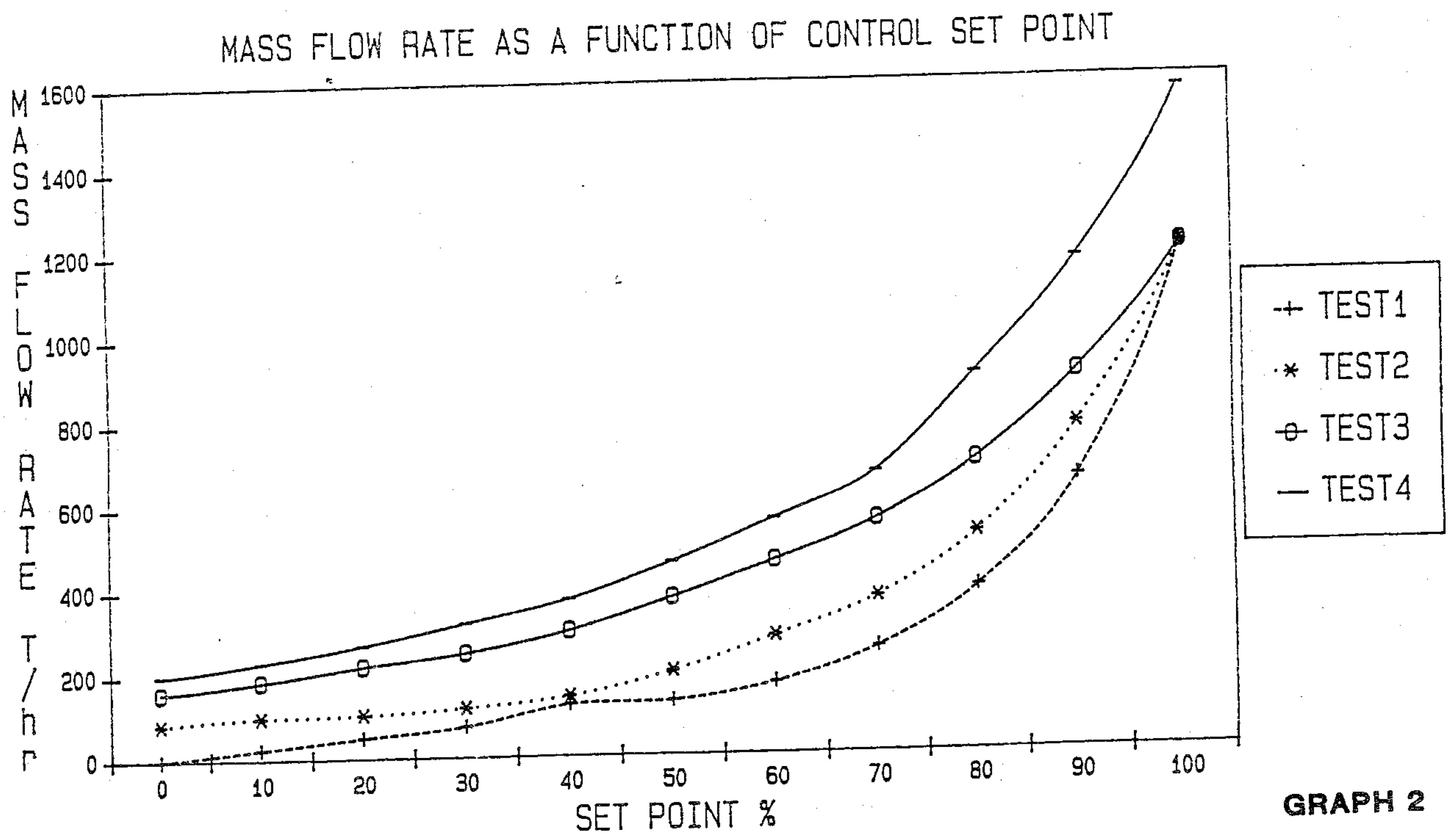
5.2.2 Vibratory feeder amplitude related to the coal feedrate.

Variations in tray displacement were related to the eccentric weight and frequency, ie:

First Test Range =	3,7kg mass per motor (7,4kg per vibratory feeder)
Second Test Range =	13,8kg mass per motor (27,6kg per vibratory feeder).

The feeder output control was optimised by employing a larger mass condition with a commensurate reduction in the motor speed control range. The latter reduced control range conversely increased the control increment and accuracy of the control set point. The relation between the mass feedrate and the tray displacement is illustrated in graph 4.

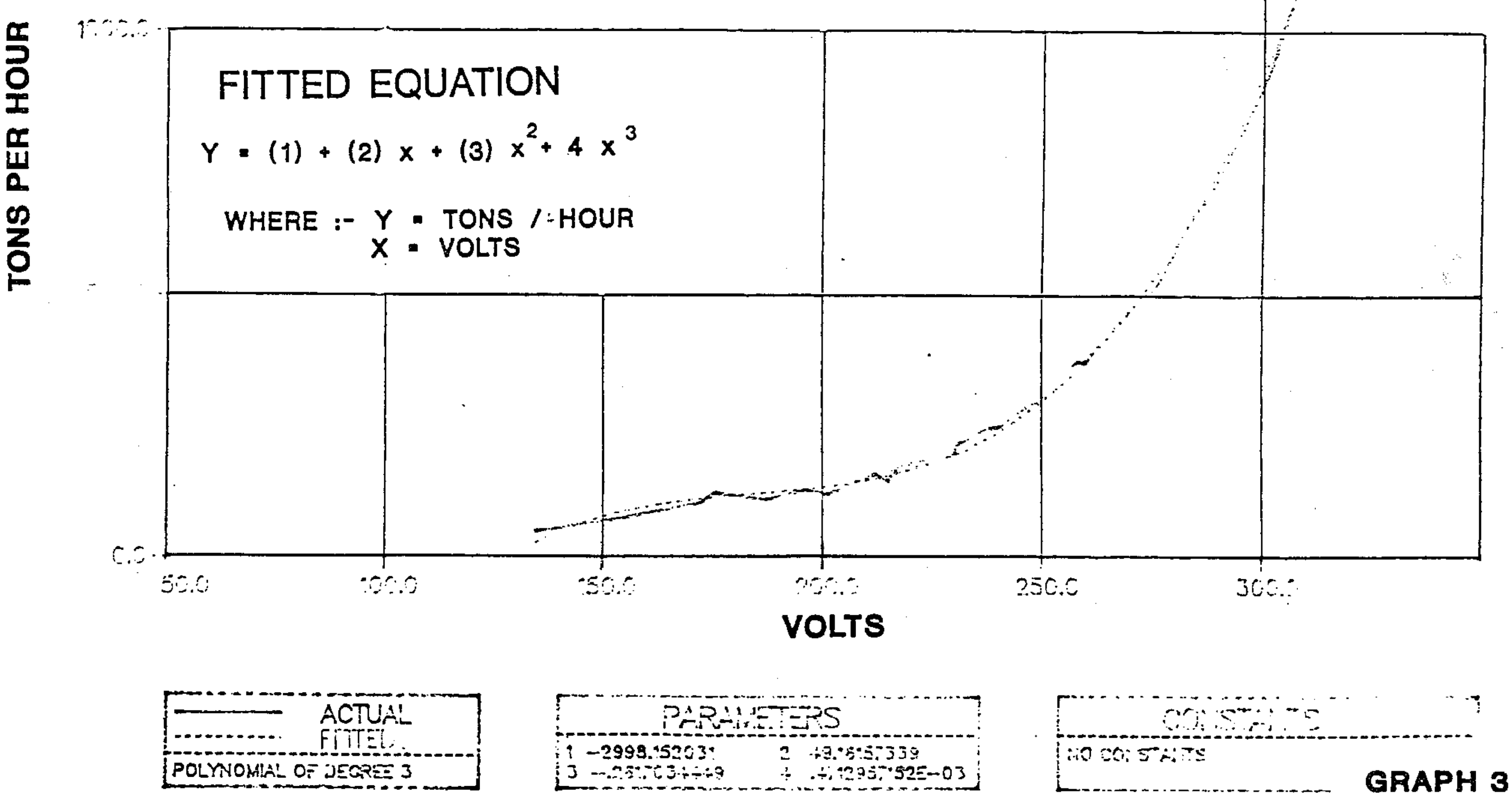
VIBRATING FEEDER TESTS - KENDAL POWER STATION



GRAPH 2

VIBRATING FEEDER TESTS - KENDAL POWER STATION

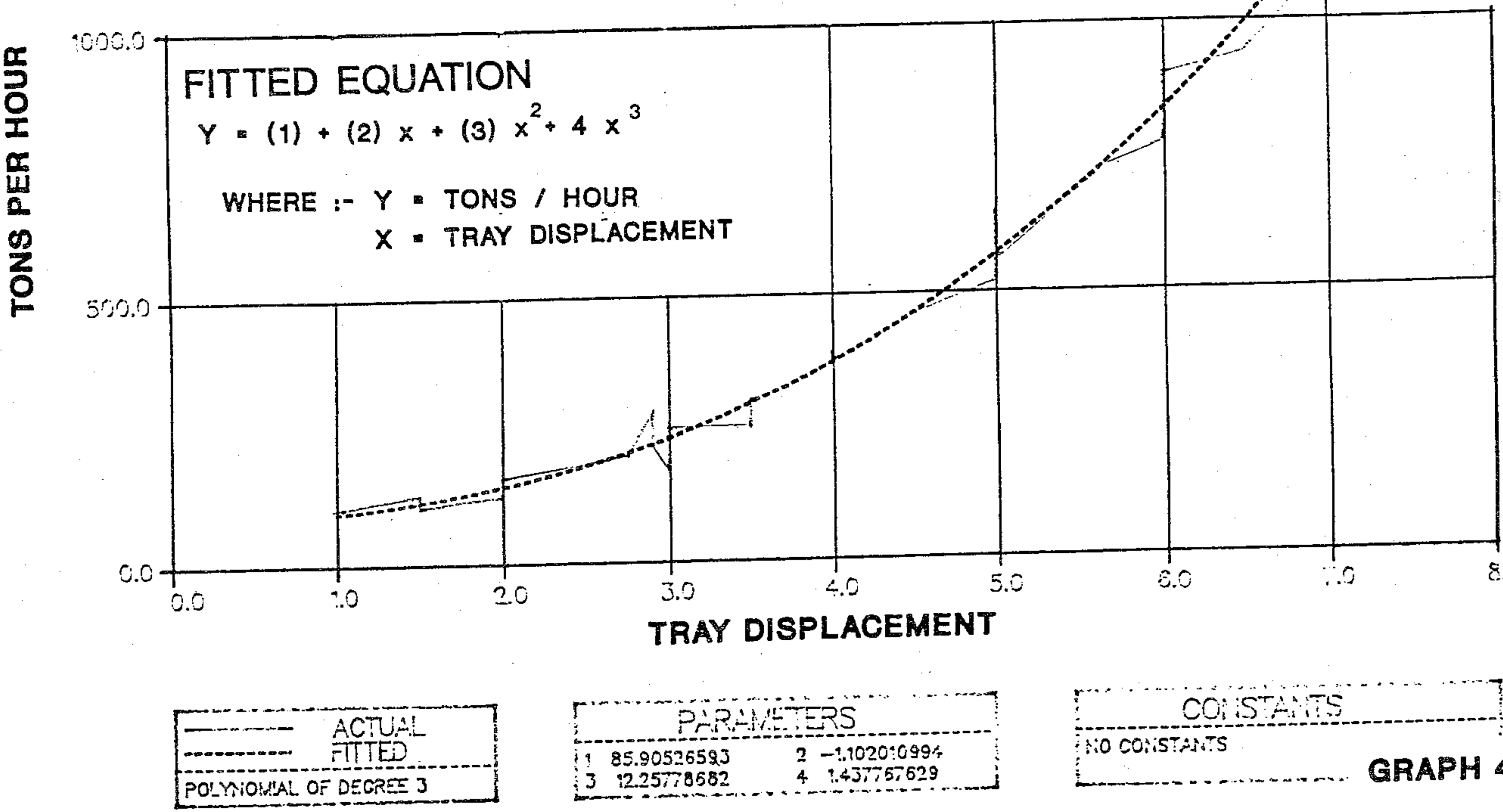
MASS FLOW AS A FUNCTION OF VOLTAGE - POLYNOMIAL APPOXIMATION



GRAPH 3

VIBRATING FEEDER TESTS - KENDAL POWER STATION

MASS FLOW AS A FUNCTION OF TRAY DISPLACEMENT
POLYNOMAL APPOXIMATION



GRAPH 4

5.2.3 Vibratory Feeder Power Consumption

The specific power consumption is approximately 3,5Watts/tph of coal at a 1200tph feedrate. This power consumption is approximately 10 times lower than that for the belt feeder application at a similar coal feedrate.

5.3 Conclusion

The vibratory feeder performance under varying load and coal conditions was improved as a result of the following:

- Limiting the control range. This was done by setting the operating range between 300 and 1500 tph (ie the unstable low tonnage feedrate range is eliminated).
- Reducing the vibrator motor speed and increasing the motor eccentric mass. This resulted in a larger tray displacement and improved feed control.
- Installing an adjustable gate on the hopper throat opening to control the coal carpet bed depth.

The measured specific power consumption for the vibratory feeder is approximately ten times lower than that for a similar belt feeder at similar feedrate capacities.

6. FEEDER SELECTION

Due to the ever increasing pressure to reduce costs, the designer is required to select the most 'fit for purpose' feeder installation.

It is the authors opinion that to select such a feeder installation, the designer is required to consider the entire system rather than just the feeder in isolation. The following items should be considered when selecting such a 'fit for purpose' feeder installation.

1. Operating and maintenance requirements.
2. Manpower skills available.
3. Varying coal feedrates and characteristics.
4. Plant availability, reliability and maintainability.
5. Entire coal system.
6. System life cycle costs.

Only once a full evaluation of all of the above has been done, can the correct coal feeder be selected. As the effects of coal starvation to the Power Station can be extremely costly, the justification for a particular coal feeder application must be based upon the criticality the feeder has on the Power Station performance and availability.

7. CONCLUSION

From the experience gained by Eskom over a number of years on various coal feeder plant applications, it has been found that the performance of belt feeders is more stable over a wider operating range than that for vibratory feeders. A more controlled material discharge feed can be maintained under varying coal loads and characteristics, and the operability is superior to vibratory feeders. However, each new feeder installation needs to be evaluated fully, in order to justify that the feeder type selected is both commercially and technically the most 'fit for purpose'.

It is important for the designer of such a system to fully understand the implications of applying the various theoretical design methods.

The results of performance tests done on coal silo belt feeder applications highlighted the following:

- Small variances in the feeder configuration can substantially improve the coal flow properties.
- Actual measured belt feeder power/torque requirements compare favourably with the various theoretical predictions under normal operating and flow conditions. It was also seen that the coal tonnage variation is linearly proportional to the power consumption.
- If an initially empty coal bin is filled and the coal allowed to consolidate, the actual initial start-up torque requirements increase substantially. This condition needs to be carefully considered by the designer.
- The actual measured start-up torque requirements are substantially reduced when lowering the belt feeder in relation to the discharge outlet. (ie utilizing a belt lowering device).

From the performance tests done on the coal bin/vibratory feeder applications the following can be concluded.

- It is desirable to have a facility to vary the coal bed depth on the vibratory feeder. This facility greatly improved the coal feed control.
- A reduction in vibration frequency with a simultaneous increase in the tray displacement improved the control of the coal feed.
- Control of the coal feed was further improved by limiting the control zone to the upper capacity range.

The measured specified power consumption for the twin mass vibratory feeder is approximately ten times lower than that for a belt feeder on a similar application, measured over a similar capacity range.

Each feeder application needs to be carefully considered in relation to the entire coal system, in order that the most "fit for purpose" system may be selected.

ACKNOWLEDGMENTS

1. 'Evaluation and Selection of feeding Equipment for Bulk Material' D K Reynolds - Bulk solids handling Vol 3, No 3 November 1983.

2. 'Vibrating feeders for stockpiling and Reclaim'. A Musschoot Coal Technology 1980.

3. Feeders for Bins and Hoppers - H Colijn and P J Carroll.

4. Materials Handling Handbook. - R A Kulwiec

5. ISO 5048 - Calculation of Operating Power and Tensile Forces in Belt Conveyors.

6. Storage and Flow of Solids - A W Jenike
Bulletin No. 123 of the Utah
Engineering Experiment Station

7. J & J Report No. 861481 - Eskom Kendal terrace coal handling plant.

8. Bulk Solids : Storage Flow and Handling. Arnold, McLean and Roberts.

9. Fives Cail Titaco - Kendal Belt Feeder Supplier.

10. Bulk Load (Pty) Ltd - Kendal Vibrating Feeder Supplier.

11. EID Rosherville - Assistance with Data Logging (Belt Feeder Tests)

12. Eskom Site Commissioning Staff - Kendal Assistance with Belt and Vibrating Feeder Tests.

13. A P Wiid - Testing done at Lethabo Power Station.

14. Jenike & Johanson Inc. - Report 16 October 1987.

15. Babcock Moxey - Lethabo belt feeder supplier.