A MACROSCOPIC DETERMINATION OF THE IMPACT OF LETHABO COAL QUALITY UPON THE OPTIMUM COMBUSTION AIR QUANTITY

Christoffel Philippus Storm

B.Eng (Mech) Hons. (Pretoria)

M.Eng (Mech) (PU for CHE)

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Mentor: Prof. J. P. van der Walt

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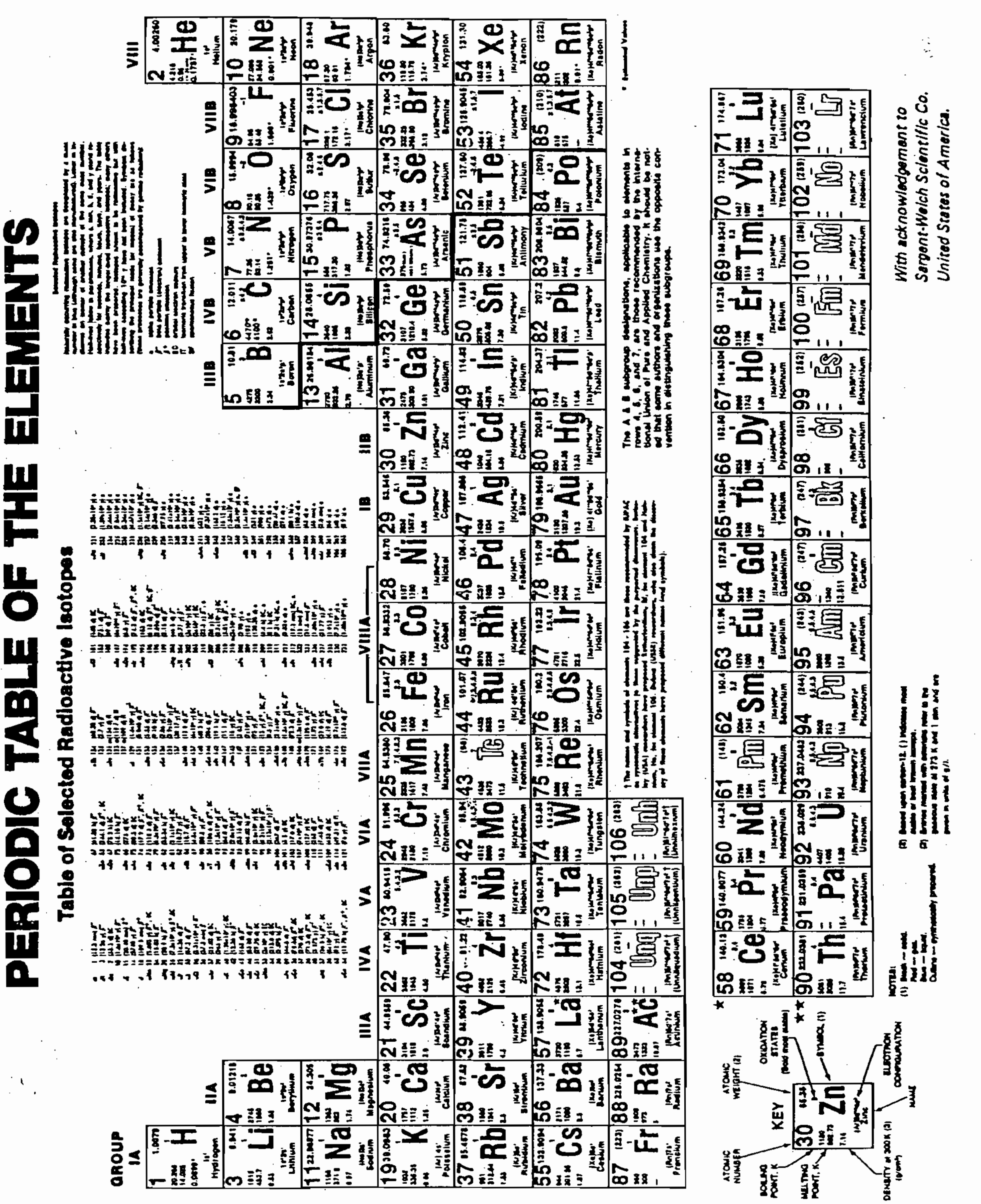
APPENDIX A
SAMPLE CALCULATIONS

Figure A.1: PERIODIC TABLE OF ELEMENTS



Similarly: $S + O_2 = SO_2$

(32) ---> 2(16) (64)

0,0055 --->0,0055 kg (0,0110)

and $2H_2 + O_2 = 2H_2O$

4(1) ---> 2(16) (36)

0,0263 --->0,2104 kg (0,2367)

The remaining components do not require oxygen, since they do not combust. The inherent oxygen should be subtracted: - 0,0893 kg

Thus, for every 1 kg of coal, 1.211 kg of oxygen is required. Since air contains 23,15 % oxygen (by mass):

For every 1 kg of coal, 5.233 kg of air is required.

During this operation the actual coal flow was 376.3 tons/h

= 104.5 kg/s

The stoichiometric air quantity is thus = <u>547,0 kg/s</u>

During the acceptance test, the measured total air flow was 746,0 kg/s. The excess air for this operation would then be 36,40%. This indicates the possible error discussed in the script, suggesting that the total air flow indication is not correct. This led to the investigation and method of calibration of the total air measuring aerofoil and the air flow calculation illustrated in Sample calculation A.2. The motivation for the above argument emanates from the existing formulae commonly used to obtain an approximate value for excess air from measured volumetric oxygen in flue gas:

$$\% \text{ Excess air} = \frac{\% O_2 \times 100}{20.95 - \% O_2}$$

From this formula the measured 3% O_2 would produce a figure of ± 17% excess air. Had the excess air been the more likely 17% the total air flow would be 640,0 kg/s.

Thus: Stoichiometric plus 17% excess air = 547,0 + 92,98

The exhaust gases due to 1 kg of coal:

CO_2 -	1,492
SO_2 -	0,011
H_2O -	0,237
Moisture in coal -	0,112
N_2 in coal -	0,009
	1,860 kg

But the total coal flow was 104,5 kg/s, thus the exhaust gases for 104,5 kg/s of coal:

CO_2 -	155,910
SO_2 -	1,150
H_2O -	24,740
Moisture in coal -	11,680
N_2 in coal -	0,962
	194,440 kg/s

The N_2 from the total air supplied (17% excess air included):

$$0{,}7686 \times 640{,}0 \text{ kg/s}$$

$$= 491{,}9 \text{ kg/s}$$

The O_2 from only the excess air supplied = $0{,}2315 \times 92.98$ kg/s

$$= 21{,}53 \text{ kg/s}$$

The atmospheric moisture in the combustion air supplied to the furnace (acceptance test values):

$$T_{wb} = 14{,}3\ ^\circ C$$

$$T_{db} = 28{,}3\ ^\circ C$$

Thus $\phi = 0{,}22$

(from Figure A.2: psychrometric chart at 1500 m altitude)

From saturation steam tables[18]:

$$P_s = 3845{,}8 \text{ Pa at } T = 28{,}3\ ^\circ C$$

$$\phi = P_w / P_s$$

(per definition)

thus $P_w = 846{,}1$ Pa

$$P_a = P_{atm} - P_w$$

$$= 85556 - 846{,}1$$

$$= 84709{,}9 \text{ Pa}$$

from $Pv = RT$:

$$v_a = RT/P$$

$$= 287{,}1 \times 301{,}45/84709{,}9$$

$$= 1{,}0217 \text{ m}^3/\text{kg}$$

From steam tables:

$$v_s = 36{,}142 \text{ m}^3/\text{kg}$$

$$\omega = \phi \times v_a / v_s \text{ (per definition)}$$

$$= 0{,}00622 \text{ kg}_{water}/\text{kg}_{air}$$

Thus, for 640,0 kg/s air flow, 3.98 kg/s of water vapour entered the furnace. This is to be added to the other moisture in coal. The total exhaust gases for 104,5 kg/s of coal & 17% excess air (this is the wet flue gas gravimetric analysis):

CO_2	155,90	-	21,95
SO_2	1,15	-	0,16
Moisture (in coal, in air, H_2 combustion)	40,39	-	5,69
N_2 (in coal, in air)	491,38	-	69,17
O2 (in excess air)	21,53	-	3,03
	710,36	kg/s	100,0%

The equivalent dry flue gas gravimetric analysis would be:

CO_2	155,91	-	23,27
SO_2	1,15	-	0,17
N_2 (in coal, in air)	491,38	-	73,34
O2 (in excess air)	21,53	-	3,21
	669,0	kg/s	100,0%

A.2: TOTAL AIR FLOW MEASURING AEROFOIL CALIBRATION

This example is numerically illustrated from measurements taken from an actual calibration exercise of the aerofoils prior to the main tests.

Manometer readings:

P_{stag} = -560 units

P_{stat} = -3500 units

Manometer fluid temperature reading:

T = 28 °C

Barometer reading:

P_{atm} = 86,48 kPa

Air temperature readings at duct intakes, 73 m level:

T_{db} = 30,8 + 273,15 = 303,9 K

T_{wb} = 14,0 + 273,15 = 287,2 K

Thus:

$$P_{stag} = -(560/5 - (0,0007 \times 560/5 \times (28 - 20))) = -111,4 \text{ Pa}$$

$$P_{stat} = -(3500/5 - (0,0007 \times 3500/5 \times (28 - 20))) = -696,1 \text{ Pa}$$

The factor 5 is for the 1:5 incline of the manometer, the other constants are for the temperature compensation of the manometric fluid, which has a reference at 20 °C. The negative sign means the duct is under suction. The absolute value of the total pressure is thus still greater than that of the static pressure.

Thus:

$$\begin{aligned} P_{dyn} &= P_{stagn} - P_{stat} \\ &= -111{,}4 - (-696{,}1) \\ &= 584{,}7 \text{ Pa} \end{aligned}$$

The value of the dynamic pressure has to be positive for the flow not to be in the reverse direction.

Relative humidity: At the T_{db} and T_{wb} values measured above, the relative humidity is read off the psychrometric chart, for 84.6 kPa and 1500 m.a.s.l. seen in Figure A.2.

$$\phi = 0{,}157 \quad \text{(or 15\%)}$$

Saturation pressure of water vapour at T_{db} (interpolated) from saturation steam tables[18]:

$$P_s = 4428{,}5 \text{ Pa}$$

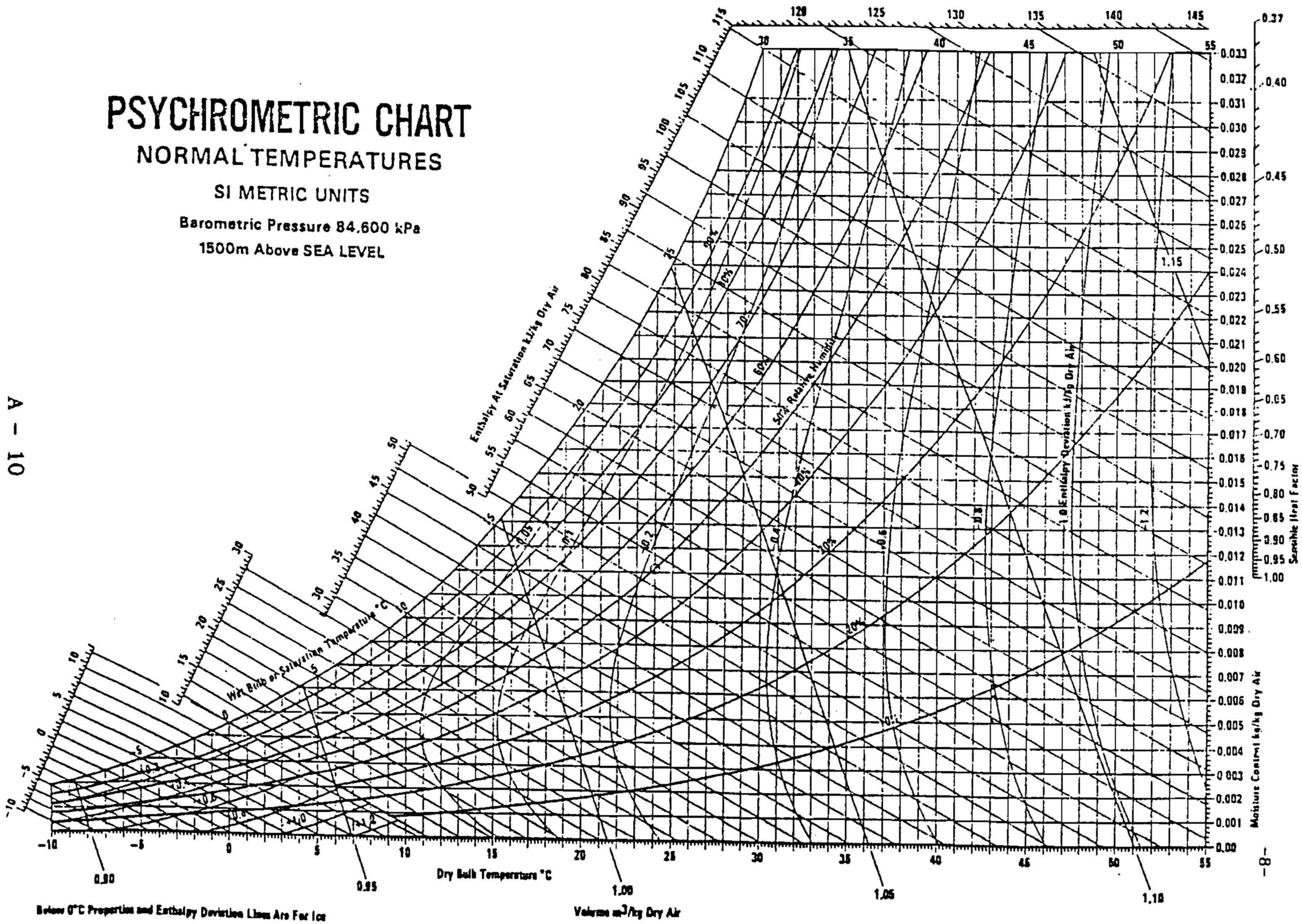


Figure A.2: PSYCHROMETRIC CHART FOR 1500 m.a.s.l.

Partial pressure of water vapour (from $\phi = P_w / P_s$, per definition):

$$P_w = \phi \times P_s$$
$$= 0,157 \times 4428,5$$
$$= 695,3 \text{ Pa}$$

Partial pressure of dry air:

$$P_{air} = P_{mixture} - P_w$$
$$= (P_{atm} + P_{stat}) - P_w$$
$$= (86480 - 696,1) - 695,3$$
$$= 85089 \text{ Pa}$$

Specific volume of dry air (from $Pv = RT$):

$$v_{air} = RT/P$$
$$= 287,1 \times 303,9 / 85089$$
$$= 1,025 \text{ m}^3/\text{kg}$$

Specific volume of water vapour, v_s (from steam tables[18] at T_{db}):

$$v_s = 31,72 \text{ m}^3/\text{kg}$$

$$\text{Absolute humidity } \infty = \phi \times v_{air} / v_s$$

$$= 0{,}157 \times 1{,}025 / 31{,}72$$

$$= 0{,}0051 \ kg_{water\ vapour} / kg_{air}$$

From the continuity equation:

mass flow = density x cross-sectional area x average velocity

and the equation for the velocity or dynamic pressure:

$$P_{dyn} = 1/2 \times \text{density} \times \text{velocity}^2$$

thus:

$$\text{velocity} = \sqrt{(2 \times P_{din} / \text{density})}$$

substituting this velocity in the continuity equation above, the theoretical mass flow (C_d factor not yet taken into account) of the mixture of air and water vapour (m_{mt}), becomes:

$$m_{mt} = A \times (\sqrt{(2 \times P_{dyn} / \text{density})}) \times \text{density}$$

$$m_{mt} = A \times (\sqrt{(2 \times P_{dyn} / \text{density})}) \times \sqrt{(\text{density})^2}$$

$$m_{mt} = A \times \sqrt{(2 \times P_{dyn} \times \text{density})}$$

since density = 1 / v, from Pv = RT, density = P/RT

Daltons law of partial pressures states:

$$P_{mixture} = P_{air} + P_{water\ vapour}$$

thus:

$m_{mt} = A \times \sqrt{(2 \times P_{dyn} \times (P_{air}/R_{air}T_{air} + P_w/R_wT_w))}$

$= 11.008x\sqrt{(2x584,7x(85089/(287.1x303,9) + 695,3/(461.5x303,9)))}$

$= 372,7$ kg/s

As said, this is the theoretical (ideal) mass flow, the C_d factor is not yet taken into account. A CFD study was performed on the whole duct including the aerofoil[19]. For this purpose, a C_d factor was determined.

From the graph in Figure A.3 at 372,7 kg/s mixture flow:

$$C_d = 0,833$$

Thus: The actual mass flow of the mixture:

$$m_m = m_{mt} \times C_d$$

$$= 372.7 \times 0,833$$

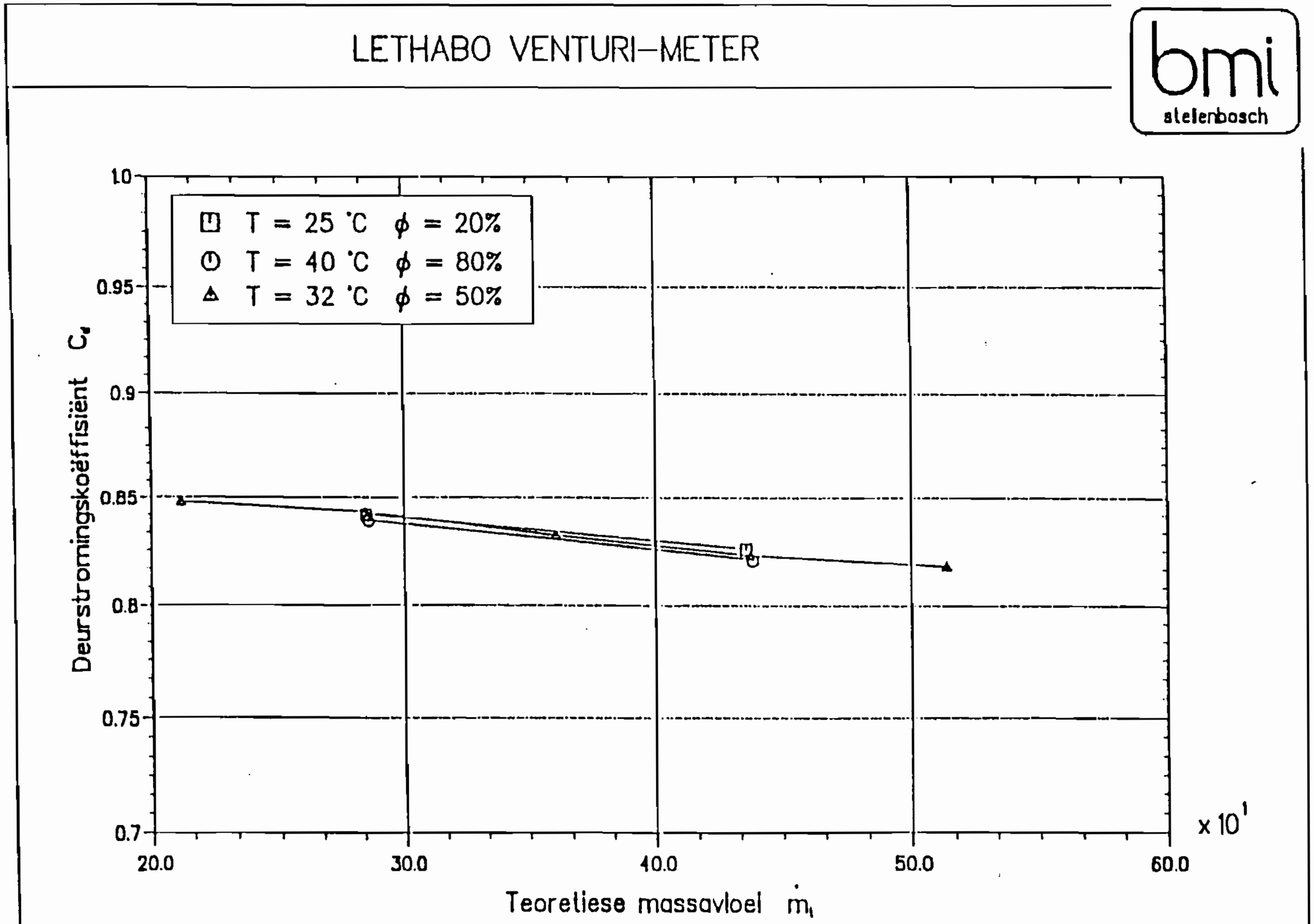
$$= 310,5 \text{ kg/s}$$

Mass flow of dry air only:

$$m_{air} = m_m /(1 + \infty)$$

$$= 310.5 / (1 + 0.00508)$$

$$= \underline{308,9 \text{ kg/s}}$$



Figuur 24: C_d as funksie van $\dot{m}_t$

Figure A.3: C_d FACTOR OF TOTAL AIR MEASURING AEROFOIL

At a required load and flow, the above exercise is done for the left and right hand side ducts of the boiler. The pressure differences versus the mass flow (corrected for temperature and humidity) are then given to C & I department for calibration of the indication.

The whole calculation and methodology above is written into a procedure[20] which is accepted, authorised and used at Lethabo Power Station as the method to determine the total air flow to the boiler and the calibration of these measuring aerofoils.

The above method was verified by means of separate tests, utilising a thermal anemometer (hot wire flow meter) and pitot tube traverses[21], which compared favourably on the estimated C_d factor.

A.3: AIR HEATER LEAKAGE COMPENSATION AND FLUE GAS PROPERTIES

A.3.1: Flue Gas properties

The flue gas analysis (% gravimetric) from sample calculation A.1 is taken as example. The significance of the difference between the volumetric vs. gravimetric percentage of a gas component of the flue gas is to be evaluated and other properties of the flue gas such as the molecular mass (M), polytropic expansion coefficient (n), specific heat capacities at constant pressure (cp) and constant volume (cp), as well as the specific gas constants (R) are also determined.

Wet flue gas analysis:

GAS	GRAV ANAL (kg/100kg)	MOLE MASS (kg/mole)	MOLES (/100kg)	VOL ANAL %mole	n	c_p kJ/kgK	c_v kJ/kgK	R kJ/kgK
CO_2	21,950	44	0,499	14,750	1,287	0,8457	0,6573	0,1884
SO_2	0,162	64	0,003	0,089	1,252	0,6448	0,5150	0,1298
H_2O	5,686	18	0,316	9,340	1,269	2,1800	1,7190	0,4615
N_2	69,170	28	2,470	73,020	1,399	1,0400	0,7436	0,2964
O_2	3,030	32	0,095	2,810	1,394	0,9182	0,6586	0,2596
	100,0	29,55	<---3,384	100,0	1,361	1,058	0,7771	0,2807

The flue gas properties are determined from the following thermodynamic relationships for a perfect gas:

$$n = c_p / c_v \quad \text{and} \quad R = c_p - c_v$$

The molecular mass of the wet flue gas: 1/3,384 x 100

$$M = 29,55 \text{ kg/mole}$$

Universal gas constant $\underline{R}$ = 8,314 kJ/moleK

The specific gas constant for wet flue gas:

$$R = 280,7 \text{ J/kgK}$$

The c_p value for wet flue gas:

$$c_p = 1,058 \text{ kJ/kgK}$$

The c_v value for wet flue gas:

$$c_v = 0,7771 \text{ kJ/kgK}$$

The polytropic expansion coefficient for wet flue gas:

$$n = 1,361$$

It should also be noted that the difference between the ratio gravimetric : volumetric for any gas component and the flue gas mixture is equal to the ratio of the molecular mass of the gas component : molecular mass of the total flue gas mixture.

Thus: to convert from volumetric (normally the mode the gas analysis instrument operates in) to gravimetric (normally the mode required in the calculations) multiply by the ratio $M_{gas}/M_{mixture}$.

In wet flue gas e.g. the ratio for oxygen of gravimetric : volumetric percentage is 3,030 : 2,807 = 1,08. The ratio of M_{oxygen} : $M_{mixture}$ is 31.998 : 29.55 = 1.08. This difference is also significant and should be taken into account in calculations.

Similarly, the dry flue gas analysis:

GAS	GRAV ANAL (kg/100kg)	MOLE MASS (kg/mole)	MOLES (/100kg)	VOL ANAL %mole	n	c_p kJ/kgK	c_v kJ/kgK	R kJ/kgK
CO_2	23,270	44	0,529	16,270	1,287	0,8457	0,6573	0,1884
SO_2	0,172	64	0,003	0,092	1,252	0,6448	0,5150	0,1298
N_2	73,340	28	2,619	80,560	1,399	1,0400	0,7436	0,2964
O_2	3,213	32	0,100	3,076	1,394	0,9182	0,6586	0,2596
	100,0	30,76	<---3,251	100,0	1,375	0,9902	0,7204	0,2703

The flue gas properties here are also determined from the following thermodynamic relationships for a perfect gas:

$$n = c_p / c_v \quad \text{and} \quad R = c_p - c_v$$

The molecular mass of the dry flue gas: 1/3,251 x 100

$$M = 30,76 \text{ kg/mole}$$

Universal gas constant $\underline{R}$ = 8,314 kJ/moleK

and the specific gas constant for dry flue gas:

$$R = 270,3 \text{ J/kgK}$$

Thus c_p for dry flue gas:

$$c_p = 0,9902 \text{ kJ/kgK}$$

Thus c_v for dry flue gas:

$$c_v = 0,7204 \text{ kJ/kgK}$$

Thus the polytropic expansion coefficient for dry flue gas:

$$n = 1,375$$

In the case of the dry flue gas too, it should be noted that the difference between the ratio gravimetric : volumetric for any gas component and the flue gas mixture is equal to the ratio of the molecular mass of the gas component : molecular mass of the total flue gas mixture.

Thus: to convert from volumetric to gravimetric for both wet and dry flue gas, multiply by the ratio $M_{gas}/M_{mixture}$. In dry flue gas e.g. the ratio for oxygen of gravimetric : volumetric percentage is 3,213 : 3,076 = 1,04. The ratio of M_{oxygen} : $M_{mixture}$ is 32.00 : 30.76 = 1.04. This difference is also significant and should be taken into account in calculations.

A.3.2: <u>Air in-leakage compensation on dfg temperature</u>

The air in-leakage via the air heater seals can have a deceiving effect on the dry flue gas loss calculation, since the back-end temperature will appear lower with higher leakage due to the dilution effect of the colder air leaking in. STEP calculates the actual dry flue gas loss according to:

$$Q = \dot{m} \times c_p \times (T_{out} - T_{in})$$

Although the mass flow of flue gas will increase due to the leakage, the STEP formula will not correctly be influenced, since the $O_2\%$ is normally not measured before and after the air heaters. Even if it is, as done correctly during these tests, the STEP formulae can not detect the additional mass flow, as calculated by the iterative methods discussed in Chapter 6. Therefore, a compensating formula had is to be derived:

Let $O_2\%$ (gravimetric) in flue gas before A/HTRS = x

Let $O_2\%$ (gravimetric) in flue gas after A/HTRS = z

$O_2\%$ (gravimetric) in air (leaking in via A/HTRS) = k

Leakage fraction (gravimetric) kg_{air}/kg_{gas} = y

Let the mass flow of flue gas before A/HTRS = G

Let the mass flow of flue gas after A/HTRS = M

Let the mass flow of air leaking into A/HTRS = L then: $$G + L = M$$

and $$G(x/100) + L(k/100) = M(z/100)$$

thus: $$xG + kL = zM$$

For L/G in terms of M:

$$L = \frac{zM - xG}{k}$$

$$L = \frac{zM - x(M - L)}{k}$$

$$L = \frac{zM - xM - xL}{k}$$

$$kL - xL = zM - xM$$

$$L(k - x) = M(z - x)$$

Thus: $$L = \frac{M(z - x)}{k - x}$$

$$G = \frac{zM - kL}{x}$$

$$G = \frac{zM - k(M - G)}{x}$$

$$G = \frac{zM - kM - kG}{x}$$

$$xG - kG = zM - kM$$

$$G(x - k) = M(z - k)$$

$$\text{Thus:} \quad G = \frac{M(z - k)}{x - k}$$

$$\text{Now:} \quad \frac{L}{G} = \frac{M(z - x)}{(k - x)} \times \frac{(x - k)}{M(z - k)}$$

$$\frac{L}{G} = \frac{(z - x)}{(k - x)} \times \frac{(k - x)}{(k - z)}$$

$$\frac{L}{G} = \frac{(z - x)}{(k - z)}$$

For L/M in terms of G:

$$L = \frac{zM - xG}{k}$$

$$L = \frac{z(G + L) - xG}{k}$$

$$L = \frac{zG + zL - xG}{k}$$

$$kL - zL = zG - xG$$

$$L(k - z) = G(z - x)$$

Thus: $$L = \frac{G(z - x)}{k - z}$$

$$M = \frac{xG - kL}{z}$$

$$M = \frac{xG + k(M - G)}{z}$$

$$M = \frac{xG + kM - kG}{z}$$

$$zM - kM = xG - kG$$

$$M(z - k) = G(x - k)$$

Thus: $$M = \frac{G(x - k)}{z - k}$$

Now: $$\frac{L}{M} = \frac{G(z - x)}{(k - z)} \times \frac{(z - k)}{G(x - k)}$$

$$\frac{L}{M} = \frac{(z - x)}{(k - z)} \times \frac{(k - z)}{(k - x)}$$

$$\frac{L}{M} = \frac{(z - x)}{(k - x)}$$

The above two formulae proved to be more accurate than the generally used formula by 1 - 2% :

$$\% \text{ Excess air} = \frac{O_2 \% \text{ after A/HTR} \times 100}{20{,}95 - O_2 \% \text{ after A/HTR}}$$

This is due to the fact that volumetric values for oxygen are used, but the excess air is normally required as a mass for calculations.

The amount of air in-leakage is now available as a fraction of the gas before or the mixture after the air heaters, as a function of the gravimetric O_2% before and after the air heaters. In both cases the value of k = 23.15. The advantage here is that the in-leakage will be available in kg/s, but an iterative method is necessary as discussed in A.3.4. Although the oxygen percentages are available as volumetric values (see Appendix B), the conversion to gravimetric is done as explained in A.3.1.

The primary reason for this calculation can now be pursued:

To calculate what the actual temperature of the flue gas would have been, had there been no air-in-leakage.

Heat given off by gas = heat absorbed by air

(This is not due to the heat exchange of the A/HTR between gas and air, but the gas on the A/HTR outlet and the in-leaking air.)

Let the final temperature after the air heaters of the mixture be T_f and let the air temperature before the air heaters be T_a, then:

$$m_g\ c_{pg}\ (T_g - T_f) = m_a\ c_{pa}\ (T_f - T_a)$$

$$m_g\ c_{pg}\ T_g - m_g\ c_{pg}\ T_f = m_a\ c_{pa}\ (T_f - T_a)$$

$$T_g = (m_a\ c_{pa}\ (T_f - T_a) + m_g\ c_{pg}\ T_f)\ /\ m_g\ c_{pg}$$

$$T_g = (m_a\ c_{pa}\ (T_f - T_a))\ /\ m_g\ c_{pg} + T_f$$

but $m_a/m_g = L/G$ (as above)

and $$L/G = \frac{(O_2\%_{after\ A/HTR} - O_2\%_{before\ A/HTR})}{(23{,}15 - O_2\%_{after\ A/HTR})}$$

Thus, if the O_2% (gravimetric) and temperature after the A/HTR, the O_2% (gravimetric) before the A/HTR and the FD inlet air temperature are known (c_{pg} = 0,9902 J/kgK is known from the tables above and c_{pa} = 1,004 J/kgK), the equation may be solved for T_g, i.e. what the temperature of the flue gas would have been had there been no air in-leakage (dilution). This value is used as input into the STEP after the dfg loss formula has been changed according to the above.

A.3.3 Theoretical air vs. Stoichiometric air

In the calculations of this project there is a need to distinguish between theoretical air and stoichiometric air for the sake of terminology and calculation. Stoichiometric air is defined here as the air quantity needed for combustion of the coal as calculated in Sample calculation A.1. from the chemical equations as basis. The accuracy thereof is dependant on the coal mass flow. This entity is normally the parameter that produces accuracy problems, not so much from the volumetric feeder side (Sample calculation A.5) as from the coal density and sample representativeness. The theory in Chapter 6 justifies a need for this air quantity to be equal to that calculated back from the oxygen and excess air side. The latter is very representative and the above formulae now enables a derivative thereof. It was shown above how these two formulae were derived:

$$\frac{L}{M} = \frac{(z - x)}{(k - x)}$$

and

$$\frac{L}{G} = \frac{(z - x)}{(k - z)}$$

The latter formula can now be used to derive an equation to determine the theoretical air if applied to the circumstances in the furnace immediately after combustion. If the air in-leakage (L) is seen as the excess air "leaking" into the theoretical air (G), the oxygen content "z" will be the resulting gravimetric percentage due to this amount of total combustion air. The oxygen content "x" will be the amount before the excess air was added, i.e. that corresponding to the theoretical air, which must be zero. The value k = 23.15 for the gravimetric percentage of oxygen in atmospheric air. The equation above then becomes:

$$\frac{\text{Excess air}}{\text{Theoretical air}} = \frac{z}{(23.15 - z)}$$

but: Theoretical air + Excess air = Combustion air

Thus: Excess air = Combustion air - Theoretical air

$$\frac{\text{Combustion air} - \text{Theoretical air}}{\text{Theoretical air}} = \frac{z}{(23.15 - z)}$$

$$\text{Combustion air} = \frac{z}{(23.15 - z)} \times (\text{Theoretical air}) + \text{Theoretical air}$$

$$\text{Combustion air} = \left(1 + \frac{z}{(23.15 - z)}\right) \times (\text{Theoretical air})$$

Thus:

$$\text{Theoretical air} = \frac{\text{Combustion air}}{\left(1 + \frac{z}{23.15 - z}\right)}$$

This equation can also be expressed as:

$$\text{Theoretical air} = \frac{\text{Total measured Air Flow - Air heater leakage}}{\left(1 + \dfrac{z}{23.15 - z}\right)}$$

The Combustion air also = Total measured Air Flow - Air heater leakage when Figure A.4 is viewed. The above equation is the one mentioned previously that produces more realistic values from which theoretical and excess air can be derived, than the approximate traditional equation below:

$$\%\ \text{Excess air} = \frac{O_2\ \%\ \text{after A/HTR} \times 100}{20{,}95 - O_2\ \%\ \text{after A/HTR}}$$

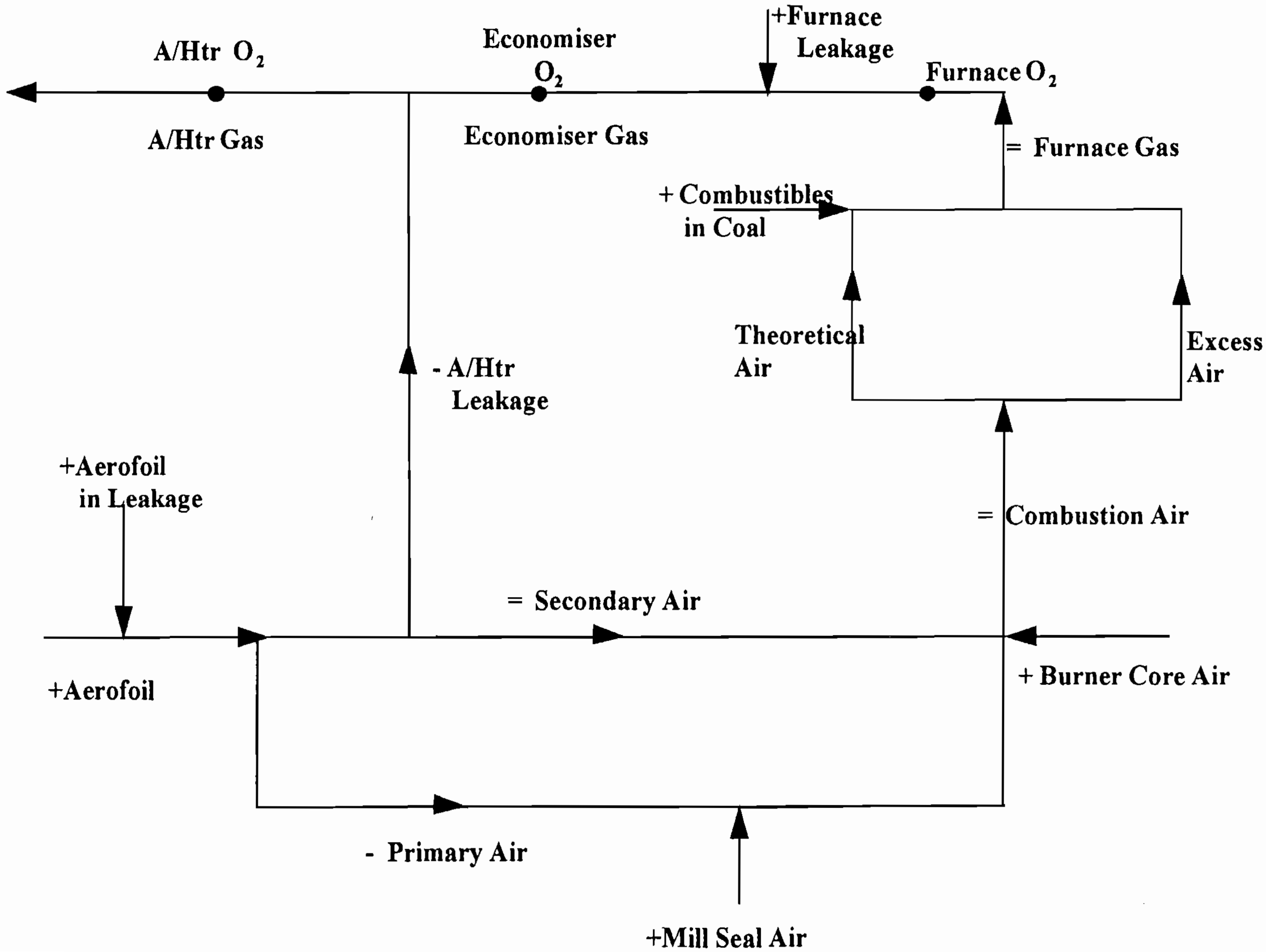


Figure A.4: AIR FLOW AND AIR HEATER LEAKAGE

A.3.4: <u>Air Heater Leakage iteration</u>

Air heater leakage is obtained from the formulae derived in A.3.2:

$$\frac{L}{M} = \frac{(z - x)}{(k - x)}$$

and

$$\frac{L}{G} = \frac{(z - x)}{(k - z)}$$

from which is derived (in A.3.3):

$$\text{Theoretical air} = \frac{\text{Combustion air}}{\left(1 + \frac{z}{23.15 - z}\right)}$$

and

$$\text{Theoretical air} = \frac{\text{Total measured Air Flow - Air heater leakage}}{\left(1 + \frac{z}{23.15 - z}\right)}$$

which can be verified from Figure A.4. It can be seen that since air heater leakage is at first part of combustion air and finally again part of air heater gas, an exact solution is not possible, but an iteration is required. The iteration logic can be followed from Figure A.4 and Table A.1 in the following sequential order below: (The parameters have alphabetical row numbers, those underscored are varying with iterations until the values have converged.)

- The total air flow measured by the aerofoils (Sample calculation A.2) Plus the in-leakage at the aerofoil casing is the first addition to the mass flow. The in-leakage is detected at the circumference of the rectangular joint between the steel casing of the aerofoil and the concrete of the duct. The flow rate is determined with a vane anemometer traverse, determining the average velocities through the areas and the measuring of the rectangular areas at different boiler loads. The minimum amounted to 1.8 kg/s and the maximum was 4.2 kg/s. A linear regression formula was derived to add the appropriate proportion of in-leakage to the aerofoil flow rate. For a specific test, this flow rate is a constant value, as indicated in row (a) of Table A.1.

- Next the primary air flow is subtracted in (b), just to be added again in (f), having no effect on the total.

- The air heater leakage is then subtracted in (c). It is calculated as indicated in Table A.1 by the formula based on:

$$\frac{L}{G} = \frac{(z - x)}{(23.15 - z)}$$

Table A.1: ITERATION FOR DETERMINING AIR HEATER LEAKAGE

	Parameter	Formula or type	Iteration 1	Iteration 2	Iteration 3
a	+ Aerofoil + in-leakage	Measured value (constant)	constant	constant	constant
b	*- Primary air*	Process value (constant)	constant	constant	constant
c	- A/HTR leakage	$o(s-p)/(23.15-s)$	0	$o_1(s_1-p_1)/(23.15-s_1)$	$o_2(s_2-p_2)/(23.15-s_2$
d	*= Secondary air*	a-b-c	do. (changing value)	do. (changing value)	do. (changing val
e	+ Mill seal air	Measured value (constant)	constant	constant	constant
f	*+ Primary air*	Process value (constant)	constant	constant	constant
g	+ Burner core air	Measured value (constant)	constant	constant	constant
h	Combustion air	a-c+e+g	do. (changing value)	do. (changing value)	do. (changing valu
i	Theoretical air	h/[1+m/(23.15-m)]	do. (changing value)	do. (changing value)	do. (changing valu
j	Excess air	h-i	do. (changing value)	do. (changing value)	do. (changing valu
k	+ Coal Combustibles	From dry-ash free coal	constant	constant	constant
l	Furnace gas	h+k	do. (changing value)	do. (changing value)	do. (changing valu
m	Furnace O_2	p-[n/l*(23.15-p)]	do. (changing value)	do. (changing value)	do. (changing valu
n	+ Furnace in-leakage	Pre-determined value	constant	constant	constant
o	Economiser gas	l+n	do. (changing value)	do. (changing value)	do. (changing valu
p	Economiser O_2	Measured value (constant)	constant	constant	constant
q	+ A/HTR leakage	$o(s-p)/(23.15-s)$	$o_1(s_1-p_1)/(23.15-s_1)$	$o_2(s_2-p_2)/(23.15-s_2)$	$o_3(s_3-p_3)/(23.15-s_3$
r	= A/HTR gas	o+q	do. (changing value)	do. (changing value)	do. (changing valu
s	A/HTR O_2	Measured value (constant)	constant	constant	constant

and utilising the economiser gas (o), the A/HTR O_2 (s) and the economiser O_2 (p).

- The secondary air (d) is the resulting flow thus far.

- The mill seal air (e) and burner core air (g) are pre-determined values. The burner core air in-leakage is a constant value (11.93 kg/s) irrespective of the load and the amount of mills in service, since it is only dependant on the differential pressure between atmosphere and furnace pressure, measured with a vane anemometer during testing. (The ID fans strive to maintain constant furnace pressure.) The seal air was tested by vane anemometer and pitot traverse with an average of 3.657 kg/s/mill in service.

- The balance then produces the combustion air (h), which varies as the A/HTR leakage changes with converging iterations.

- The combustion air comprises the theoretical (i) and excess (j) air. Theoretical air is obtained from the formula:

$$\text{Theoretical air} = \frac{\text{Combustion air}}{\left(1 + \dfrac{z}{23.15 - z}\right)}$$

and utilises the furnace O_2 (m) for the value of "z". The excess air (j) is simply the difference between the combustion and theoretical air.

- The coal combustibles (k), which adds to the gasses formed from the chemical equations, are simply the mass of the coal burnt for the test minus the moisture, hydrogen and ash.

- The addition of these coal combustibles to the combustion air amounts to the furnace gas (l).

- The furnace O_2 is back-solved from the above derived formula:

$$\frac{L}{G} = \frac{(z - x)}{(23.15 - z)}$$

where:

x = furnace O_2 (m)

L = furnace in-leakage (n)

G = Furnace gas (l)

z = economiser O_2 (p)

Take note that this value will be gravimetric and dry. See **Appendix B** for an explanation of which O_2 measurements are wet or dry, gravimetric or volumetric etc., by instrumentation and analysers. The gas component values are all transformed to dry gravimetric for calculations. The answers and results from iterations etc. will thus be the same.

- The furnace in-leakage (n) is pre-determined by the iterative calculation methods discussed in Chapter 6 and verified afterwards by practical tests involving pitot traverses to calculate gas and air flow differences. This value eventually amounted to a constant 35 kg/s, as can be seen in Appendices F, G and H.

- The economiser gas mass flow (o) is the sum of the furnace gas and furnace in-leakage.

- The economiser O_2 % is a volumetric wet measured value, transformed to gravimetric dry.

- The A/HTR leakage (q) again joins the gas stream and is calculated in the same way as in (c) above. The reason why it appears twice is to accomplish the iterative procedure explained below.

- The A/HTR gas (r) is the sum of the economiser gas (o) and the A/HTR leakage (q).

- The A/HTR O_2 is a volumetric wet measured value, converted to gravimetric dry for calculation.

The iteration operates as follows when the columns and specifically rows (c) and (q) in Table A.1 are viewed:

A value of zero is initially entered into row (c) of Iteration column 1 for the A/HTR leakage value. The above formulae will calculate a first iteration value for A/HTR leakage by going through the process explained above and place that value in row (q). All the other parameters that should change (underscored) will automatically be recalculated.

This first estimation for A/HTR leakage in row (q) column 1, will then be placed into row (c) of column 2, as a starting value by a macro written into the spreadsheet. The second iterative value for A/HTR leakage will then be calculated by the procedure and formulae described above in row (q), column 2.

This second estimation for A/HTR leakage in row (q) column 2, will then be placed into row (c) of column 3, as a starting value. The third iterative value for A/HTR leakage will then be calculated by the procedure and formulae and shown in row (q). The iteration is repeated until all the values, especially the A/HTR leakage have converged to an accepted degree of significant figures.

The answer of air heater leakage is now in terms of kg/s air flow, not as a fraction of the gas before or the mixture after the heater.

A.4: BOILER FEED WATER FLOW

This example uses the values for the H/550/28/9h00 test. The data is an extraction of the report: Feed water Flow rate calculations[23], specially compiled for these tests. (The amount of significant figures are as per digital instrument output. The final answer is rounded off to 5 significant figures.)

Determine the Static pressure working range:

Static output (averaged)	= 11.9695 mA
Static output zero	= 4.015 mA
Calibrated static output zero	= 4.003 mA

Thus,

Actual static output = 11.9695 + (4.003 - 4.015)

= 11.9575 mA

From calibration Table A.2, interpolate the actual static pressure:

Static pressure = (11.9575 - 11.5740) / (13.088 - 11.5740)

x (23481.57 - 19569.31) + 19569.31

= 20560.295 kPa

Thus,

Static pressure working range is between 19000 and 22000 kPa

Table A.2: CALIBRATION CERTIFICATE: GAUGE PRESSURE TRANSMITTER

NCS

ESKOM - TECHNOLOGY, RESEARCH AND INVESTIGATIONS

CERTIFICATE OF CALIBRATION No. : 0692P056
FOR A GAUGE PRESSURE TRANSMITTER

ESKOM

TRI REFERENCE No. : A1
TRI CALIBRATION No. : 19

MANUFACTURER & TYPE : Rosemount 1151GP
SERIAL NUMBER : 152686
INSTRUMENT RANGE : 0 to 41369 kPa

CALIBRATED FOR : ESKOM -T.R.I./ Performance & Metrology

CALIBRATION PROCEDURE : PC-02-02
REFERENCE EQUIPMENT : Budenberg 280D Pressure Balance S/N 9004
Fluke 8600A DMM S/N 2365133

DATE OF CALIBRATION : 29/06/92
LABORATORY TEMPERATURE : 21.7 °C

True Pressure (kPa)	Transmitter Output (mA)		
	Rising	Falling	Average
0.00	3.996	4.010	4.0030
3913.37	5.506	5.525	5.5155
7827.37	7.022	7.037	7.0295
11741.69	8.537	8.550	8.5435
15655.77	10.053	10.066	10.0595
19569.31	11.568	11.580	11.5740
23481.57	13.083	13.093	13.0880
27395.04	14.599	14.606	14.6025
31308.62	16.112	16.122	16.1170
35222.15	17.623	17.633	17.6280
39135.39	19.139	19.139	19.1390

UNCERTAINTY - The uncertainty of measurement is : ± 0.1 % FS
estimated for a confidence level of 95 % .

VALIDITY OF CERTIFICATE : 12 months

COMMENTS : Calibrated with diaphragm in a vertical plane.No load resistance applied.Excitation voltage = 24 VDC.

CALIBRATED BY : W De Vries

HEAD OF LABORATORY

CHECKED BY : M Mathieson

Determine the differential pressure:

Differential output (averaged) = 9.07731 mA

Differential output zero = 3.896 mA

For a static pressure of 19000 kPa:

Calibrated differential output zero = 4.012 mA

Thus:

Actual differential output = 9.07731 + (4.012 - 3.896)

= 9.19331 mA

From calibration Table A.3 interpolate actual differential pressure.

Actual differential pressure = (9.19331 - 7.5290) / (9.2865 - 7.5290)

x (59.88 - 39.92) + 39.92

= 58.8216 kPa

For a static pressure of 22000 kPa:

Calibrated differential output zero = 4.0105 mA

Thus:

Actual differential output = 9.07731 + (4.0105 - 3.896)

= 9.19181 mA

Table A.3: CALIBRATION TABLE: DIFFERENTIAL PRESSURE TRANSDUCER

Rec nr : 57 HP DIFFERENTIAL PRESSURE TRANSDUCER
Static pressure no. 3
DEVICE : DPHP12 NO. PTS : 10 STATIC PRESSURE: 19000 kPa

Number	Pressure kPa	mA output	mV output R=20 Ohms
1	0.00	4.0120	80.2400
2	19.96	5.7710	115.4200
3	39.92	7.5290	150.5800
4	59.88	9.2865	185.7300
5	79.84	11.0440	220.8800
6	99.80	12.8035	256.0700
7	119.76	14.5635	291.2700
8	139.71	16.3280	326.5600
9	159.67	18.0940	361.8800
10	179.63	19.8680	397.3600

Calibration table for differential pressure transducer at static pressure of 19000 kPa

Rec nr : 58 HP DIFFERENTIAL PRESSURE TRANSDUCER
Static pressure no. 4
DEVICE : DPHP12 NO. PTS : 10 STATIC PRESSURE: 22000 kPa

Number	Pressure kPa	mA output	mV output R=20 Ohms
1	0.00	4.0105	80.2100
2	19.96	5.7640	115.2800
3	39.92	7.5165	150.3300
4	59.88	9.2680	185.3600
5	79.84	11.0195	220.3900
6	99.80	12.7730	255.4600
7	119.76	14.5305	290.6100
8	139.71	16.2880	325.7600
9	159.67	18.0470	360.9400
10	179.63	19.8140	396.2800

Calibration table for differential pressure transducer at static pressure of 22000 kPa

From calibration Table A.3 interpolate actual differential pressure.

Actual differential pressure = (9.19181 - 7.5165) / (9.2680 - 7.5165)

x (59.88 - 39.92) + 39.92

= 59.0117 kPa

The next step is to interpolate to find the actual differential pressure at the calculated static pressure.

Differential pressure (H) = (20560.295 - 19000) / (22000 - 19000)

x (59.0117 - 58.8216) + 58.8216

= 58.92047 kPa

= 6008.2164 mm H_2O

Determine the feedwater density:

Feed water temperature = 155.7 °C

Static pressure = 20560.295 kPa

= 205.603 bar

From steam tables[18] interpolate specific volume for those conditions.

At 200 bar, the specific volume = (155.7 - 150) / (160 - 150)

x (0.0010886 - 0.0010779) + 0.001077

= 0.001083999 m^3/kg

At 210 bar, the specific volume = (155.7 - 150) / (160 - 150)

x (0.0010879 - 0.0010773) + 0.0010773

= 0.001199465 m^3/kg

Thus,

At 205.603 bar, the specific volume = (205.603 - 200) / (210 - 200)

x (0.001083342 - 0.001200744) + 0.001200744

= 0.0010836309 m^3/kg

Thus,

Feed water density = 1 / 0.0010836309

= 922.82345 kg/m^3

Calculate the feed water flow rate:

Feed water flow rate (Q) = $0.01252 \times c \times d_c \times E \times \sqrt{(H)} \times \sqrt{(density)}$

Where,

c = discharge coefficient (constant from m vs c graph, $4d^2/D^2$)

= 0.6063

$m = d^2 / D^2$

D = internal diameter of feed water pipe

= 422.191 mm

d = orifice internal diameter

= 280.007 mm

Temperature correction = $[1 + 0.0000126 \times (T - 20)]^2$

T = temperature at orifice (°C)

Corrected diameter, $d_c = d^2 \times$ temperature correction

$$E = 1 / \sqrt{(1 - m^2)}$$

$$= 1.11351$$

Feed water flow rate (Q) = $0.01252 \times 0.6063 \times (280{,}007)^2 \times (1 + 0.0000126 \times (155.7 - 20))^2 \times 1.11351 \times \sqrt{(6008.2146)} \times \sqrt{(922.8235)}$

= 1565812.26 kg/h

= <u>434.95 kg/s</u>

A.5: COAL VOLUMETRIC FEEDER INTEGRATOR

Table A.4 shows the feeder bar profile and the values in the table refer. The area of the feeder profile must first be determined:

profile area = Large rectangle - two small triangles

$$A = ((0,121 + 0,348 + 0,115) \times 0,1765) - (0,5 \times 0,065 \times 0,121)$$
$$- (0,5 \times 0,115 \times 0,0645)$$
$$A = 0,09544 \text{ m}^2$$

The 100% motor speed = 1260 rpm

Reduction gearbox ratio: 64,0 : 1

the feeder pulley speed = 19,6875 rpm

@ 40,21 % feeder speed, the feeder pulley speed = 7,916 rpm

For 23,75 minutes duration of test,

Tail pulley revolutions = 188

For area A, the swept volume = 15,22 m^3

Previous bulk density determination of coal = 1.0115 kg/m^3

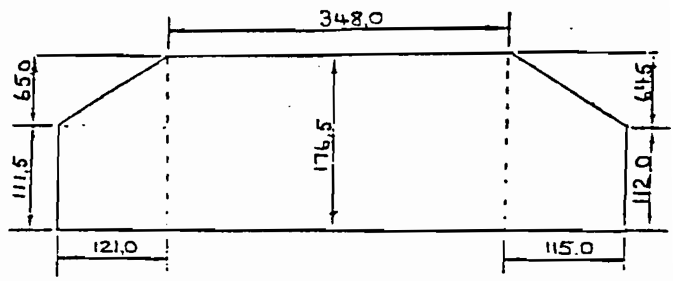
Mass = swept volume x density = 15,39 tons

Table A.4: COAL FEEDER CALIBRATION

CONSTANTS USED.

Feeder Bar Area = 0,09544 m^2
Drive Gear Ratio = 64,0:1
100% Speed = 1260 rpm.
Drive Pulley Dia. = 270 mm.
Belt Thickness = 10 mm.

FEEDER PROFILE.



LORRY TEST RESULTS.

TEST NO.	1.	2.	3.	4.	5.	TOTAL	AVERAGE.
Target Speed %	40	35	30	32,5	30		
Revs/Time %	40,21	35,97	29,96	32,50	30,10		
Tail Pulley Revs.	188	188	188	188	188		
Test Duration min.,	23,75	25,55	31,97	29,38	31,53		
Total Swept Vol m^3	15,79	15,79	15,79	15,79	15,79	78,95	
Bulk Density Kg/m^3	1011,5	1006,9	1015,4	1013,1	1008,7		1011,1
Vol x B/D Kg	15964,7	15895,4	16032,7	15996,4	15927,0		
Coal Mass.(Weighed) Kg.	17020,0	16700,0	17240,0	16720,0	16740,0	84420,0	
K1 (Based on Pulley Revs)	1,0661	1,0506	1,0753	1,0452	1,0510		1,0546
Coal Mass Flow Rate t/h.	43,00	37,97	32,46	34,15	31,86		
Stock Integrator Adv. m^3	16	16	17	16	16	81	
K2 (Mass/(B.Dx Int Vol)).	1,0517	1,0366	0,9987	1,0315	1,0992		1,0435
K3 (Mft/Speed % x B.D)	1,0572	1,0484	1,0670	1,0372	1,0493		1,0518

A.6: REVISED OSTWALD DIAGRAM FOR MAXIMUM THEORETICAL CO_2^{++}

According to sample calculation 1 it can be seen that CO_2 is one of the combustion products. The maximum percentage of CO_2 that can result from a combustion process is when the percentage excess air is zero and complete combustion takes place. This theoretical maximum amount of CO_2 is noted in an Ostwald diagram as CO_2^{++} (see Figure A.5). This percentage CO_2^{++} has a specific value for each coal analysis. It is generally calculated as follows[24]:

$$CO_2^{++}\ \% = \frac{20{,}95\ C \ + \ 0{,}1\ (H + S/8)}{C + 2{,}355\ (H + 0{,}16\ S + 0{,}04\ N)}$$

where the symbols have the same meaning as the elements participating in the combustion process and the constants are derived from the stoichiometric ratios of the same. When an actual amount of O_2 is measured in the flue gas, a corresponding amount of CO_2^{+} (called the Ostwald CO_2) can be derived from the graph and when an actual amount of CO_2 is measured, a corresponding amount of O_2^{+} (called the Ostwald O_2) can be derived. The trivial cases would produce the maximum CO_2^{++} at zero O_2 %, and 20.95 % O_2 (the volumetric percentage in air) would produce zero % CO_2.

There is always a fixed relationship between the percentages of O_2 and CO_2 in dry flue gas, even if excess air is present, relative to the

MODIFIED OSTWALD DIAGRAM

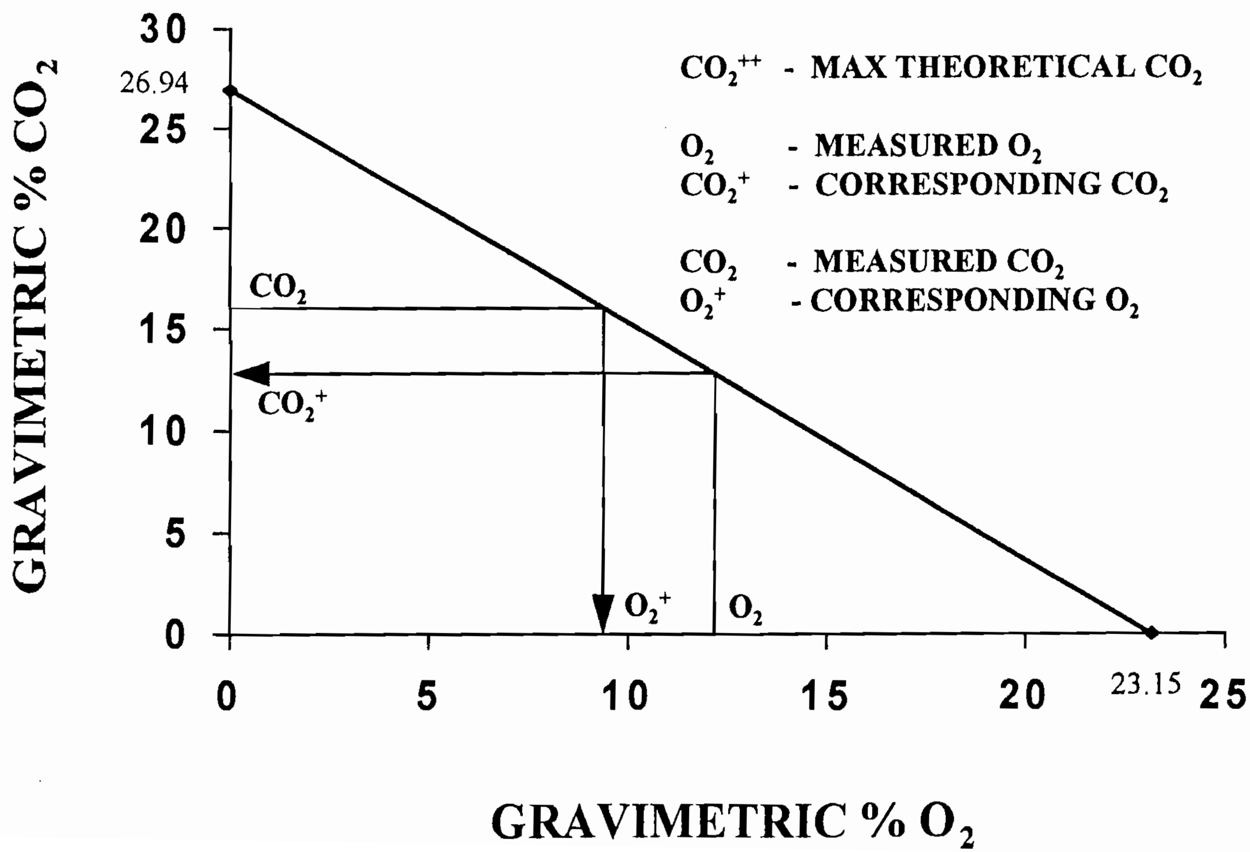


Figure A.5: CORRECTED OSTWALD DIAGRAM

percentage CO_2^{++}:

$$O_2^{+}\ \% = \frac{20,95\ (CO_2^{++} - CO_2)}{CO_2^{++}}$$

If the coal analysis is known and thus the percentage CO_2^{++}, the percentage CO_2 can be measured and thus the percentage O_2^{+} derived. This can be compared to the actual measured O_2 as a cross check of measurement accuracy and validity of testing.

Problems were encountered in reconciling the back-end gas analysis of the caravan with the mass-energy balance method devised in Chapter 6. It was discovered that the inaccuracies of the generally used Ostwald diagram was one of the main deficiencies. Practically the deficiencies presented as: the derived CO_2^{+} from the actual back-end measured O_2 values by the caravan's analysers failed to correspond to the actual measured CO_2 by the caravan to an acceptable level, and vice versa. The specific reasons being that volumetric gas percentages derived from the Ostwald diagram were used in gravimetric gas balance formulae. It was therefore proposed to derive an Ostwald diagram on a dry gravimetric basis.

From the basic combustion equations as in Sample calculation 1:

$$C + O_2 = CO_2$$

$$(12) \longrightarrow 2(16) \quad (44)$$

$$S + O_2 = SO_2$$

$$(32) \longrightarrow 2(16) \quad (64)$$

$$2H_2 + O_2 = 2H_2O$$

$$4(1) \longrightarrow 2(16) \quad (36)$$

the total dry ash free gas mass:

= CO_2 + SO_2 (dry gasses formed)

+ nitrogen in air from oxygen needed for combustion

+ nitrogen in coal

$$= (44/12 \times C + 64/12 \times S)$$
$$+ (32/12 \times C + 32/4 \times H + S - O_2) \times 76.86/23.15$$
$$+ N_2$$

the maximum theoretical CO_2:

$$= (44/12 \times C + 64/12 \times S)$$

for a coal analysis of: C - 38%, S - 0.5%, H - 2.5%, O_2 - 6%, N_2 - 3%, the maximum theoretical CO_2 = 1.393 kg and total dry gas = 5.279 kg.

The CO_2^{++} = 26.388 %

The clean air O_2 on the graph is then 23.15 % (instead of the 20.95 volumetric).

The y = mx + c of this gravimetrical graph amounts to:

$$CO_2^{+} = CO_2^{++}(1 - O_2/23.15)$$

The conversion of volumetric to gravimetric percentage is done according to the method in Sample calculation A.3.1. In the actual test calculations the carbon in the above combustion equations were reduced by the unburned carbon in ash and the more accurate molecular masses (Figure A.1) to more significant figures were used. An actual test example illustrated the following difference between the old and revised Ostwald diagrams:

Actual measured volumetric dry O_2 % = 5.6 (by caravan analyser)

= 5.973 % gravimetric dry

From the above formula, the corresponding CO_2^{+} = 19.579% (gravimetric)

Back calculated: = 13.349% (volumetric)

The caravan analyser measured: actual CO_2 = 13.2% (volumetric)

The old volumetric Ostwald diagram and formula produced:

$$CO_2^{+} = 13.9\ \%$$

which is less accurate than the above 13.349 produced by the revised gravimetric diagram.

A.7: BACK-END GAS ANALYSIS AND MASS FLOW RECONCILIATION

The back-end gas analysis from the caravan facility was identified and utilised as a powerful tool to serve as one link in the energy and mass balance technique described in Chapter 6. The variance between the theoretical complete (Sample calculation A.1) and practical incomplete combustion also required an iteration to determine the dry flue gas mass flow more accurately. All this will be explained below by using the S/630/5.5/15h30 test as a sample calculation.

The gas components are displayed in the first column of Table A.5. Column (a) contains the volumetric percentages as measured by the caravan facility. The NO_x, SO_2 and CO is measured in ppm, but converted to percentage, which is displayed. The N_2 is determined by difference.

Column (b) contains the molecular mass of each component, as determined from Table A.1. Column (c) contains the product of (a) and (b) where the sum total divided by 100 gives the molecular mass of the flue gas. Column (d) produces the gravimetric percentage per 100 kg of flue gas, by dividing the value in (c) by the molecular mass of the mixture.

To obtain the gravimetrical fraction of the gas component as a percentage of a 100 kg of coal, the amount of CO_2 for complete

Table A.5: BACK-END GAS ANALYSIS

Gas component	(a) Measured Analysis Volumetric % (= mole %)	(b) Molecular mass kg/mole	(c = a x b) kg/100 mole	(d = c/b*100) Gravimetric % kg/100kg gas	(e) Gravimetric % kg/100kg coal THEORETICAL	(f) Gravimetric % kg/100kg coal PRACTICAL
N_2	80.774	28.013	2262.731	73.607	455.522	448.492
O_2	3.013	31.999	96.414	3.136	19.410	19.110
NO_x	.063	46.006	2.912	.095	.586	.376
SO_2	.102	64.059	6.533	.213	1.315	1.295
CO	.047	28.010	1.328	.043	.267	.263
CO_2	16.000	44.010	704.160	22.906	141.762	139.572
Flue gas	100.000	Mixture =	30.741	100.000	618.859	609.109

combustion is determined first:

$$C \quad + \quad O_2 \quad = \quad CO_2$$

$$12.011 \quad 2(15.9994) \quad 44.010$$

The coal analysis for this test has 38.689 % carbon on an as received basis. For a 100 kg of coal burnt,

38.689 x 44.010/12.011 = 141.762 kg of CO_2 is produced.

This is the maximum theoretical amount of CO_2 that is produced.

Thus, if 22.907 % of a gas component = 141.762 kg, then 100 % of the total gas = 141.762/.22907 = 618.859 kg of the total dry flue gas for each 100 kg of coal. The other gas components' quantities can now be determined if the percentage of the component in (d) of the total in (e) is taken.

If the practical case is to be evaluated, where incomplete combustion takes place, the following chemical equations are valid:

$$2C + O_2 = 2CO$$

24.022	31.999	56.019

$$2CO + O_2 = 2CO_2$$

44.010	31.999	88.018

The above equations can be used to indicate incomplete combustion. The unburnt carbon is firstly subtracted from the carbon in the first equation, then the CO measured at the back-end (unburnt gas) is subtracted in the second equation. Both these entities reduce the possible amount of CO_2 and thus the total amount of flue gas that can be formed, since less carbon directly combusts into CO_2.

From the above equations the amount of CO formed is calculated by:

$$CO = (ppm\ CO/1000000x100) \ x\ (28.013/M_{mixture}) \ x\ (flue\ gas/100\ kg\ coal)$$

the resulting CO_2 can now be calculated by:

$$CO_2 = 88.019/56.019 \times [\ 56.019/24.022 \times (C - C_{unburnt} \times ash\% /100) - CO_{(as\ above)}]$$

with this new value of CO_2, a new value of flue gas is determined as above. This requires an iteration as in Table A.6:

Table A.6: <u>ITERATION FOR FLUE GAS, CO AND CO_2</u>

Parameter	Formula	Iteration 1	Iteration 2	Iteration 3
CO	as above	0	= f(flue gas$_{(1)}$)	= f(flue gas$_{(2)}$)
CO_2	as above	= f($CO_{(1)}$)	= f($CO_{(2)}$)	= f($CO_{(3)}$)
flue gas	as above	= f($CO_{2(1)}$)	= f($CO_{2(2)}$)	= f($CO_{2(3)}$)

Firstly, the CO is calculated as a function of the flue gas in the previous column (iteration). Then the CO_2 is calculated as a function of the CO in the same column (iteration). The flue gas is then calculated as a function of the CO_2 in the same iteration, all according to the formulae derived above. Iteration 1 is started by entering zero CO formed. The resulting CO_2 and flue gas will be equal to the theoretical amount. The iteration is then repeated until the values converge.

These final values can be seen in column (f) of Table A.5. It can be seen that the differences are not negligible. The resulting flue gas e.g. differs from the theoretical with almost 10 kg/100 kg coal. This is necessary for the degree of accuracy needed especially to distinguish between the tests with high vs low excess air (producing high and low unburnt carbon and CO).

A.8: CALCULATED CALORIFIC VALUE OF COAL

The calorific value (CV) of coal has always been a topic of contention. It has a significant impact on the accuracy of the thermal efficiency calculation caused by the sensitivity due to its relatively small amount of significant figures. The general simplified equation for overall thermal efficiency is (if no fuel oil is used):

$$\eta_{overall} = \frac{\text{Electrical units sent out (USO)}}{\text{coal mass flow} \times \text{CV}}$$

The USO has a relatively large amount of significant figures, even if measured in MWh, and the measuring instrumentation (CT and VT) is relatively very accurate and reliable. The amount of significant figures in the coal mass flow is also favourable, as well as the mass flow when a high quality load cell mass meter is used under the conveyor belt. Accurate mass flow becomes a more difficult task when a volumetric feeder is used, more in the determination of an accurate and representative density of coal. This problem is discussed in the calculation methods in Chapter 6. Even so, the biggest problem regarding accuracy and representativeness remains the CV.

The representivety is firstly a problem. This can largely be overcome by an accurate coal scanner which is able to cater for the characteristics of the components of the specific coal range. This aspect is discussed in Chapter 7. After the representivety comes the issue of the bomb calorimeter. During the calculation phases discussed in Chapter 6, it was found that the CV values produced by the bomb calorimeters, from three different laboratories involved, differed on average and trend values to such an extent that unrealistic efficiencies emanated in various cases. The calculated efficiencies also exhibited such a great variance on successive reduced air flow tests that no optimum can be derived, hence the curves displaying a jagged pattern.

After contemplation and literature survey on this issue[14,25] the following arguments can be offered:

- The bomb calorimeter is an artificially ignited closed system process, not representing the actual case in the burner accurately, which would be closer represented by a flow process combustion chamber type testing method.

- It is stated[25] that the bomb is actually only suitable for testing of substances less volatile than fuel oil. This would render virtually only the carbon as a separate substance suitable for testing in a bomb regarding this argument, but rule out all volatiles and the coal as a whole.

- The bomb measures GCV since the latent energy of the moisture is recovered in the process over time. The combustion process and heat transfer in the furnace and gas passes would be closer represented by a NCV since only a portion of the super heat of the moisture is recovered, but no latent heat.

- The combustion in the bomb is a constant volume process while in the burner and furnace it would more closely be represented by a constant pressure process, thus NCV_p rather than GCV_v.

- The time consumed by ignition and combustion in the bomb is different to that in the burner and furnace, since it is triggered by an electric spark in the bomb but the ignition in the burner results from sustained exothermic heat transfer.

- Combustion in the bomb takes place under a different pressure and an artificial O_2 atmosphere as opposed to the atmospheric air supply in the furnace.

- The bensoic tablet used for calibrating the bomb has a CV value roughly double that of the range of coal burnt at Lethabo, making the calibration less accurate.

The above assists in the motivation to compile a CV calculation method that would produce more consistent, representative and realistic values of CV for the tests. Each coal sample is divided into four parts. These four parts were intended for:

- Moisture analysis
- CV determination by bomb calorimeter
- Ultimate analysis with an infra-red spectrograph
- Referee sample for future reference

The elemental analysis of the sample proved a lot more representative and realistic than the comparative values of CV determined by the bomb. It was therefore decided to derive a Dulong type formula where the specific CV value of an element was weighted with the percentage of the element in the ultimate analysis to produce an overall CV for the sample. (See Gill[14] Chapter 8, p303 - 306 and BS 1016[26] part 16.)

The general formula (also used in Chapter 4 and accompanying appendices C, D and E) for converting air dried to as fired CV is:

$$CV_{as\ fired} = CV_{air\ dried} \times \frac{(100 - \text{Total moisture})}{(100 - \text{Inherent moisture})}$$

The Dulong type formula used to calculate the CV of the coal from the separate CV's of its constituents is:

$$CV_{as\ fired} = \frac{(C \times 33.82) + (H \times 143.050) + (S \times 9.304)}{100}$$

where 33.82, 143.050 and 9.304 are the GCV_v values tested separately for the elements of Carbon, Hydrogen and Sulphur respectively, under the conditions of Gross CV, constant volume process. The reason for doing this is to utilise the more realistic values of the ultimate analysis of the coal as opposed to the direct bomb CV. The value for carbon used is the total carbon, including that in volatiles, but excluding the carbonates (in ash and CO_2 gaseous form), also supplied by the analysis. There is a value of 121.840 MJ/kg available for the NCV_p of hydrogen, but no equivalent values for carbon and sulphur.

This formula differs from the similar one in Gill[14] in that the inherent oxygen in coal is not subtracted from the hydrogen (first divided by 8) since the way the ultimate analysis is done for these tests directly contains the free hydrogen available for combustion, and not that also contained in crystalline water.

This value of GCV_v is then converted to NCV_p by means of the formula given in BS 1016[26]:

$$NCV_p = GCV_v - (0.212 \times H) - (0.024 \times (\text{Total moisture} + 0.1 \times \text{Ash})) - (0.0008 \times O_2)$$

The equivalent formula in Gill differs in the factor that is multiplied by the O_2 % (0.0007 instead of 0.0008). This results in a very small difference in the final answer, but 0.0008 is preferred since Gill mentions approximations introduced into his formula for the average inherent oxygen content of UK coal.

Concerning the representativeness of a specific parameter, it was found that even while the coal ordered and actually received varied in a narrow band of less than 2 MJ/kg per quality type, the individual tests showed a greater variance. The same holds for the ultimate analysis percentages of the elements. This is due to the fact that the qualities and analysis of the mass of coal supplied was given as averages of greater masses, while the sampling at the feeders during testing was less representative.

By means of experimentation in the calculation method of Chapter 6 it was found that by using the actual test value of an entity (percentage of an element, etc.) on a one to one basis, the curve of efficiencies with varying excess air (coal quality and load kept constant), had a sharper peak, showing the much wanted apex or optimum easier. Some tests however, showed a too jagged image with this criteria. If the average value of all the tests for the day of a parameter of the coal quality is used, the value seems more in line with the trend of the large batch of coal received. The curve is then smoother, showing evidence of more representivety regarding a macroscopic approach, but often lacking the forming of an apex, being too smooth.

The mentioned experimentation showed that the best of both the above extremes produced the most favourable results. This was achieved by biasing the daily average value of a parameter with a weighting of 50% towards the specific test value.

A.9: MOISTURE IN FLUE GAS

Since all the calculations involving gasses (Chapters 4, 6 and 7, as well as accompanying appendices) are based on dry ash free principles, it was necessary to calculate the moisture in flue gas. For each and every test this calculation was done in the spreadsheets of Appendices F, G and H.

- The first moisture component entering the flue gas comes from the air supplied for combustion:

Atmospheric air moisture = ∞ x (Total aerofoil air + in-leakages)

where ∞ = $kg_{water\ vapour}$ / kg_{air} from the value as per Appendix A.2. The total aerofoil air plus the in-leakages (core air, mill seal air and aerofoil casing leakage) as per Appendix A.3.4 are used instead of the iterated combustion air. The reason for this was that the moisture in flue gas was needed where most of the flue gas measurements and analysis are made. That is where the air heater leakage has again joined up to the main stream of gas flow. The value will be accurate for A/HTR and ID discharge, with a small error at the economiser outlet.

- The moisture in coal on an as fired basis also enters the flue gas:

Total moisture in coal = coal mass flow x total moisture %

- The moisture resulting from the combustion of hydrogen:

Moisture from combustion = mass flow of coal x % hydrogen in coal (as received basis) / 100 x 8.937

The factor 8.937 comes from the amount of water resulting from the combustion of the amount of hydrogen in the coal analysis:

$$2H_2 + O_2 = 2H_2O$$

$$4(1.0079) + 2(15.9994) \quad (36.030)$$

$$4.032 + 2(15.9994) \quad (36.030)$$

$$\text{i.e. } 36.030 / 4.032 = 8.937$$

- The moisture originating from the ash hopper:

Moisture from Ash hopper = 5 - (mass flow of coal x ash % / 100 x 0.073 x 0.401)

The total make-up water to the ash hopper is a measured average of 300 litres / minute (= 5 kg/s) and consists of:

- Potable water to the sealing trough

- Secondary CW to the hopper
- Potable water to the quenching sprays

The moisture in the bottom ash removed by the submerged scraper conveyor (SSC) must be subtracted from this figure. That is the moisture (40.1 % average as analysed by the laboratory) in the bottom ash component (7.3 %) of the total ash in the coal. The remainder of the water evaporates and rises into the flue gas.

- The fly ash contains crystalline water despite the high temperatures that it is subjected to prior to being sampled in the sampling matrix. This moisture can also be picked up in the sampler which is much cooler than the flue gas due to the fly ash being hydroscopic to an extent. The laboratory detects an average of 14.2 % moisture in fly ash during the unburnt carbon-in-ash analysis. (During the precipitator efficiency tests the fly ash : bottom ash ratio was determined as 92.7 : 7.3 %). This moisture value has to be subtracted from the above sum total:

Moisture in fly ash = coal mass flow x ash % /100 x 0.927 x 0.142

The table below contains actual test values at 630 MW, high air flow. The values in brackets indicate the approximate percentage of the specific moisture component of the dry flue gas.

Table A.7: Moisture in flue gas

Moisture origin	Low grade	Spec grade	High grade
+ Atmospheric air moisture	4.07 (10.7)	3.98 (10.1)	4.53 (12.1)
+ Total moisture in coal	8.39 (22.1)	8.42 (22.3)	10.34 (27.6)
+ Moisture from combustion	22.01 (57.9)	22.58 (57.4)	19.92 (53.1)
+ Moisture from Ash hopper	3.60 (9.5)	3.70 (9.4)	4.23 (11.3)
- Moisture in fly ash	6.39	5.92	3.51
Total moisture in flue gas	31.67	32.80	31.26
Flue gas-Moist. corr. fact.	0.957	0.954	0.956
Average correction factor	0.958	0.953	0.954

The Flue gas moisture correction factor =

1 - (total moisture in gas / (ID Dfg + total moisture in gas))

It can be seen that the average moisture correction factor does not differ much between coal qualities and indicates that the moisture is approximately 5 % of the gas and thus not negligible. The moisture from combustion is highest and averages approximately 56%, followed by the moisture in coal (at ± 24%), followed by moisture in air (± 11%), followed by moisture from the ash hopper (at ± 9%). The tests were performed during a month of May in the Southern hemisphere presenting very dry air (ϕ = 15%). Also, the lower loads are characterised by higher A/F ratios. It can thus be said that during the summer months with relative humidities in excess of 80 % at times and especially at lower loads, the fraction of moisture from combustion air increases with the other sources decreasing proportionally. A trial calculation showed that the moisture from air exceeds the fraction of moisture from coal at times such as these.

APPENDIX B
BACK-END OXYGEN AND TEMPERATURE MONITORING

APPENDIX B: OXYGEN AND TEMPERATURE BACK-END MONITORING

B.1: ECONOMISER OUTLET OXYGEN CORRECTIONS

It was decided that for the degree of accuracy needed in these tests the percentage O_2 volumetric correction factor was to be determined each day prior to testing. The reading was considered adequate and representative due to the sixteen point sampling matrix (Figure 3.30) that covered the duct area evenly and was tuned for isokinetic operational mode. The Zirconium type cell that is utilised at this sampling point measures the wet volumetric portion of oxygen in total flue gas and no moisture drier incorporated.

The calibrations of the oxygen analysers is done with a portable Otox type oxygen analyser that is calibrated[22] in clean air and thereafter with specially prepared test gas containing 3 % O_2. These instruments measure the dry volumetric percentage oxygen in flue gas, since they are fitted with silicon driers. The correction factor would then automatically incorporate the wet to dry correction factor and double compensation would be avoided.

The weighting factors required to distinguish between the amount of left and right hand duct gas flow in order to obtain the total values of oxygen in flue gas at the economiser outlet are obtained from the traverse results as described in B.2 below.

B.2: AIR HEATER OUTLET SAMPLING POINTS

Concerning the oxygen and temperature measuring points at the air heater outlet, the following is of importance:

- The measuring should be done after the primary duct has rejoined the secondary to take the total heat exchange into account.

- Due to the geometry of the ducting it is only practically feasible to measure at the precipitator inlets where the ducts had split into four.

- The following point concerns the determination of the most representative measuring point in each of the four ducts by evaluating the results of a traverse done over sixteen points in each duct. The right hand inner duct is an exception however, since a support beam bars the entrance to the porthole at sampling position no. 3 vertically. No traverse is done in that plane as the zero figures indicate in Table B.3 and Figure B.3.

- The objective is also to determine the weight factor for each duct for calculating the oxygen and temperature of the total flow (all four ducts combined) as well as a derived weighting factor for the left and right-hand side.

The following tabular (Table B.1 through to Table B.4) and graphical presentations (Figure B.1 through to Figure B.4) for each of the four ducts show the determination of the measuring points and the weighting factors:

- The matrix position.
- Stagnation pressure.
- Static pressure.
- Dynamic pressure: difference between stagnation and static pressure.
- Temperature measurement with thermo-couple.
- A velocity weight factor:

$$\text{From} \quad P_{dyn} = 0{,}5 \times \text{density} \times V^2$$

$$V \text{ is proportional to } \sqrt{(P_{dyn})}$$

To obtain a numerically convenient number it is multiplied by 100 afterwards.

- The last column is then temperature weighted with this velocity-proportional value, which is proportional to the flow.

- The average of both the velocity weight factor and the weighted temperature values are then compared to the graphical presentation of the same and the most representative measuring point for both temperature and oxygen (i.e. where the main stream of flow occurs, mostly at the point with highest velocity) can judgementally be allocated. The bold dot in the figure indicates that point. The measuring probes are then positioned at that matrix position indicated by the bold dot on each duct.

The Otox oxygen analysers mentioned in Section B.1 above are utilised here. The values obtained here is thus dry volumetric.

B.3: ID FAN OUTLET SAMPLING POINTS

The oxygen content of the flue gas after the precipitators and the ID fans too are measured by the specially equipped mobile gas analysis caravan. These instruments incorporate gas coolers (cooling the gas to an equivalent of -10 °C dew point), equivalent to total moisture removal. The value obtained can thus also be considered as dry volumetric. Calibration is done with specially prepared test gas in a laboratory beforehand.

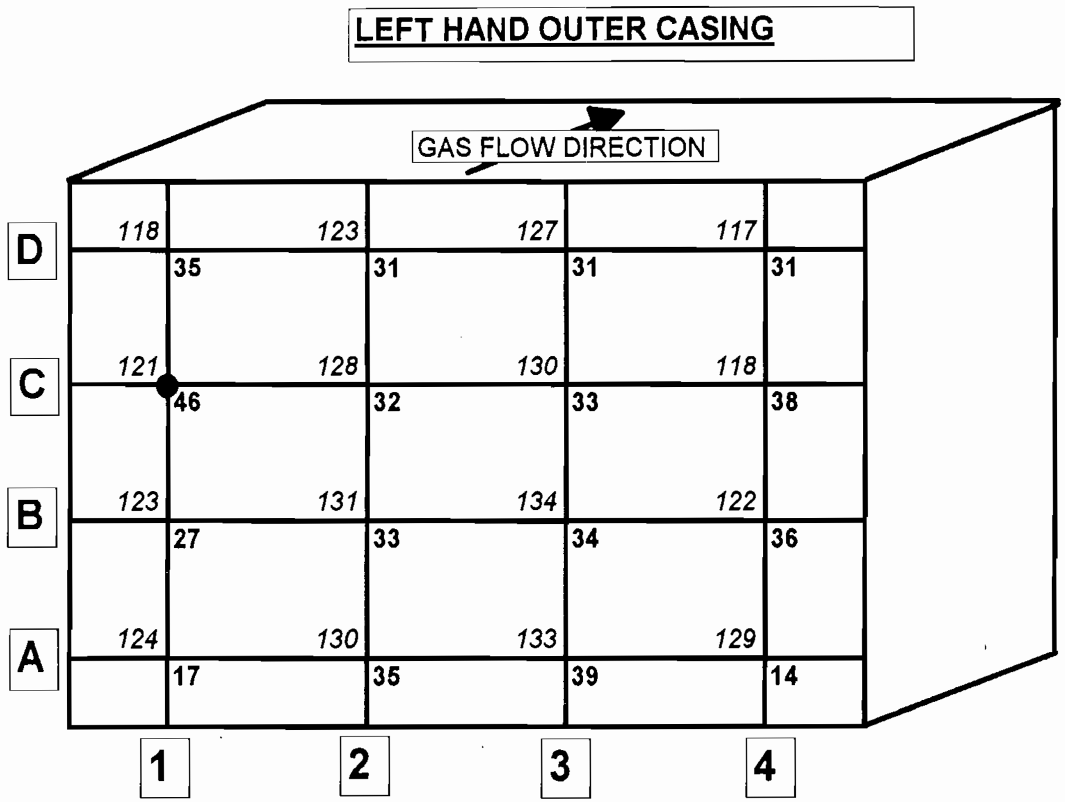
The weighting factors used (for left and right hand flow) to determine the total values of oxygen in flue gas at this point are also obtained from the weighting factor in the traverse results as described in B.2 above.

Table B.1: LEFT HAND OUTER GAS DUCT TRAVERSE

LH OUTER

Matrix	Pstag	Pstat	Pdyn	Temp	V-fact	V-factxT
A1	-1.75	-1.78	.03	124.30	17.32	2152.94
A2	-1.66	-1.78	.13	130.30	35.50	4625.19
A3	-1.54	-1.69	.16	133.10	39.50	5257.03
A4	-1.64	-1.66	.02	128.80	14.14	1821.51
B1	-1.70	-1.78	.08	122.50	27.39	3354.80
B2	-1.68	-1.79	.11	131.10	33.17	4348.10
B3	-1.67	-1.55	-.12	134.10	34.21	4586.93
B4	-1.59	-1.72	.13	122.40	36.06	4413.19
C1	-1.53	-1.74	.21	121.10	45.83	5549.50
C2	-1.66	-1.76	.10	127.60	31.62	4035.07
C3	-1.60	-1.71	.11	130.30	32.71	4262.22
C4	-1.53	-1.67	.15	117.60	38.21	4493.49
D1	-1.72	-1.84	.13	117.80	35.36	4164.86
D2	-1.67	-1.77	.09	122.90	30.66	3768.04
D3	-1.63	-1.73	.09	127.00	30.66	3893.75
D4	-1.63	-1.73	.10	116.50	31.14	3628.37
SUM	-26.19	-27.69	1.50	2007.40	513.46	64354.98
AVERAGE	-1.64	-1.73	.09	125.46	30.65	125.34

See overleaf for graphical view of above table



LEGEND:
TEMPERATURES °C
VELOCITY WEIGHT FACTORS

TEST MEASURING POINT: C1
VELOCITY WEIGHT FACTOR: 31

Figure B.1: LEFT HAND OUTER GAS DUCT TRAVERSE

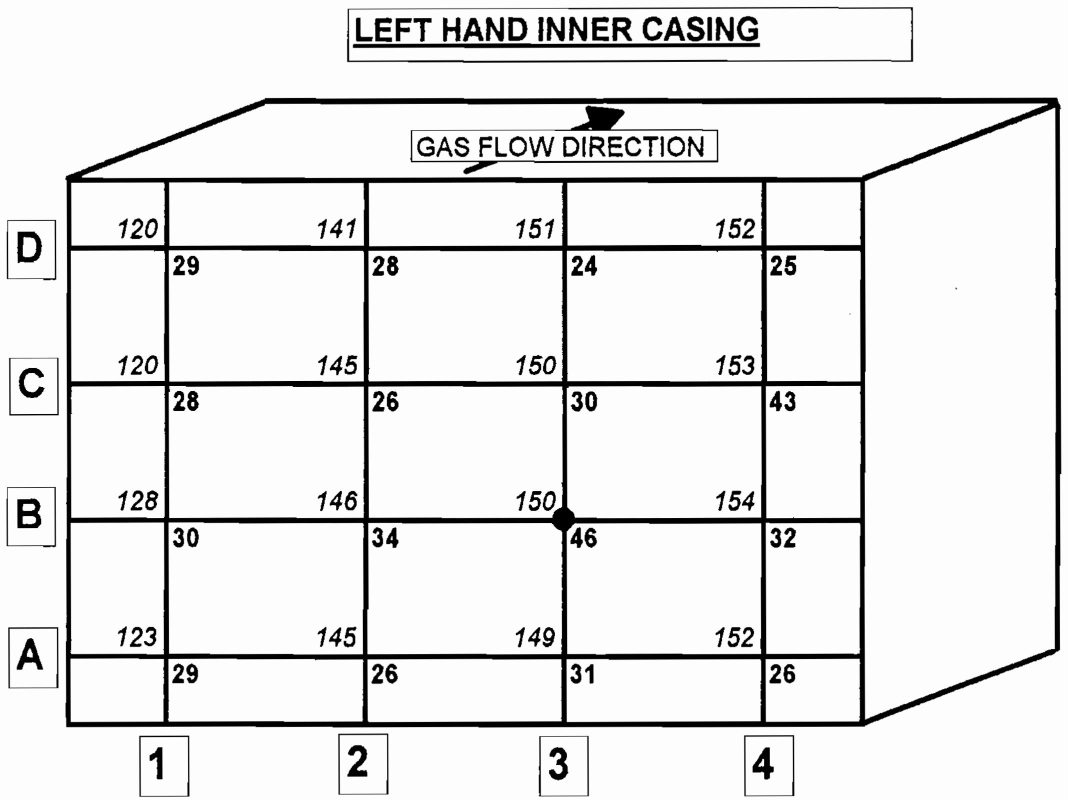
Table B.2: LEFT HAND INNER GAS DUCT TRAVERSE

LH INNER

Matrix	Pstag	Pstat	Pdyn	Temp	V-fact	V-factxT
A1	-1.59	-1.67	.09	123.10	29.33	3610.00
A2	-1.61	-1.68	.07	144.80	25.88	3748.06
A3	-1.53	-1.63	.10	149.10	31.30	4667.57
A4	-1.59	-1.66	.07	151.70	26.46	4013.60
B1	-1.55	-1.64	.09	127.60	30.50	3891.28
B2	-1.55	-1.66	.11	146.20	33.62	4914.58
B3	-1.45	-1.67	.21	149.80	46.26	6929.77
B4	-1.53	-1.64	.10	153.50	31.94	4902.40
C1	-1.63	-1.71	.08	120.10	27.75	3332.64
C2	-1.58	-1.65	.07	145.00	26.46	3836.34
C3	-1.58	-1.67	.09	150.00	30	4500
C4	-1.49	-1.67	.19	153.00	43.01	6580.78
D1	-1.66	-1.74	.08	120.30	28.81	3465.81
D2	-1.57	-1.64	.08	141.30	27.57	3895.37
D3	-1.61	-1.67	.06	151.40	24.49	3708.53
D4	-1.60	-1.66	.06	152.10	25.10	3817.68
SUM	-25.11	-26.66	1.55	2279.00	488.47	69814.40
AVERAGE	-1.57	-1.67	.10	142.44	31.09	142.92

See overleaf for graphical view of above table

Figure B.2: **LEFT HAND INNER GAS DUCT TRAVERSE**



LEGEND:
TEMPERATURES °C
VELOCITY WEIGHT FACTORS

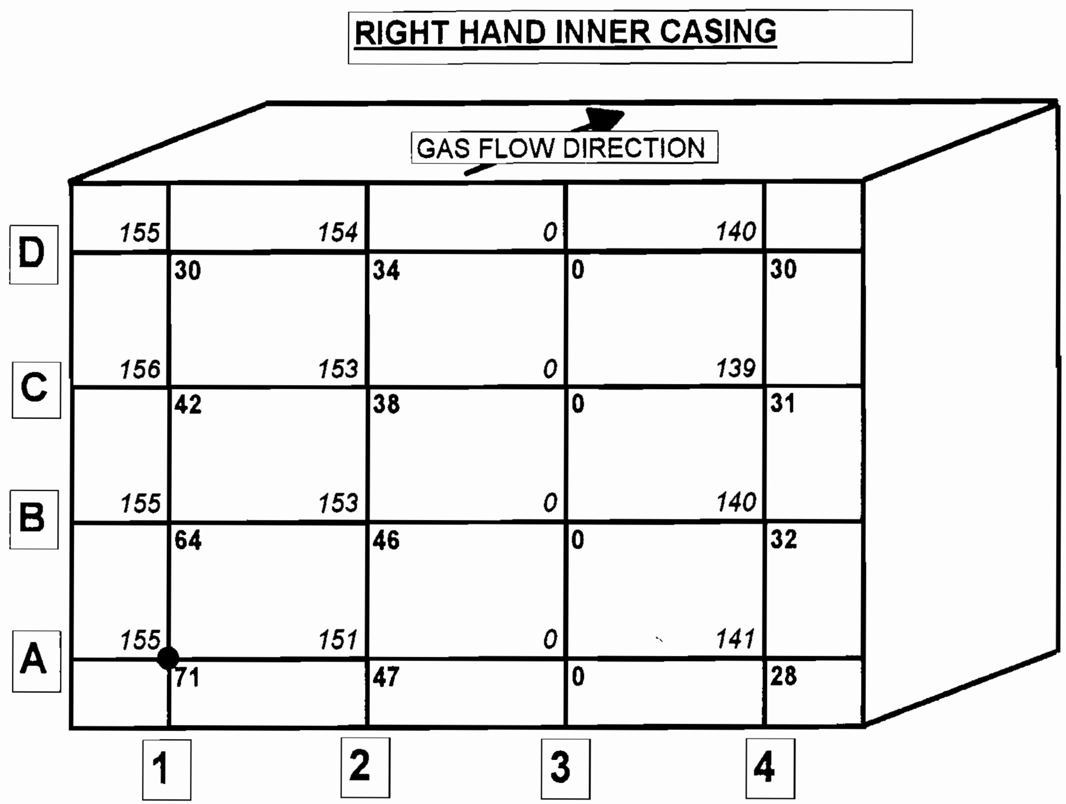
TEST MEASURING POINT: B3
VELOCITY WEIGHT FACTOR: 31

Table B.3: RIGHT HAND INNER GAS DUCT TRAVERSE

RH INNER

Matrix	Pstag	Pstat	Pdyn	Temp	V-fact	V-factxT
A1	-1.45	-1.96	.51	155.20	71.20	11050.85
A2	-1.69	-1.92	.23	150.80	47.43	7153.07
A3						
A4	-1.82	-1.90	.08	140.60	27.93	3926.74
B1	-1.49	-1.91	.41	155.40	64.34	9998.88
B2	-1.73	-1.94	.22	152.70	46.37	7080.41
B3						
B4	-1.87	-1.97	.10	139.90	31.62	4424.03
C1	-1.79	-1.96	.18	155.60	42.19	6564.77
C2	-1.84	-1.98	.15	153.10	38.08	5829.87
C3						
C4	-1.86	-1.95	.10	139.10	31.30	4354.52
D1	-1.93	-2.02	.09	155.20	30.33	4707.45
D2	-1.87	-1.98	.12	154.20	34.35	5296.94
D3						
D4	-1.89	-1.98	.09	140.10	30	4203
SUM	-21.20	-23.46	2.26	1791.90	495.16	74590.53
AVERAGE	-1.77	-1.96	.19	149.33	43.40	150.64

See overleaf for graphical view of above table



LEGEND:
TEMPERATURES °C
VELOCITY WEIGHT FACTORS

TEST MEASURING POINT: A1
VELOCITY WEIGHT FACTOR: 43

Figure B.3: RIGHT HAND INNER GAS DUCT TRAVERSE

Table B.4: RIGHT HAND OUTER GAS DUCT TRAVERSE

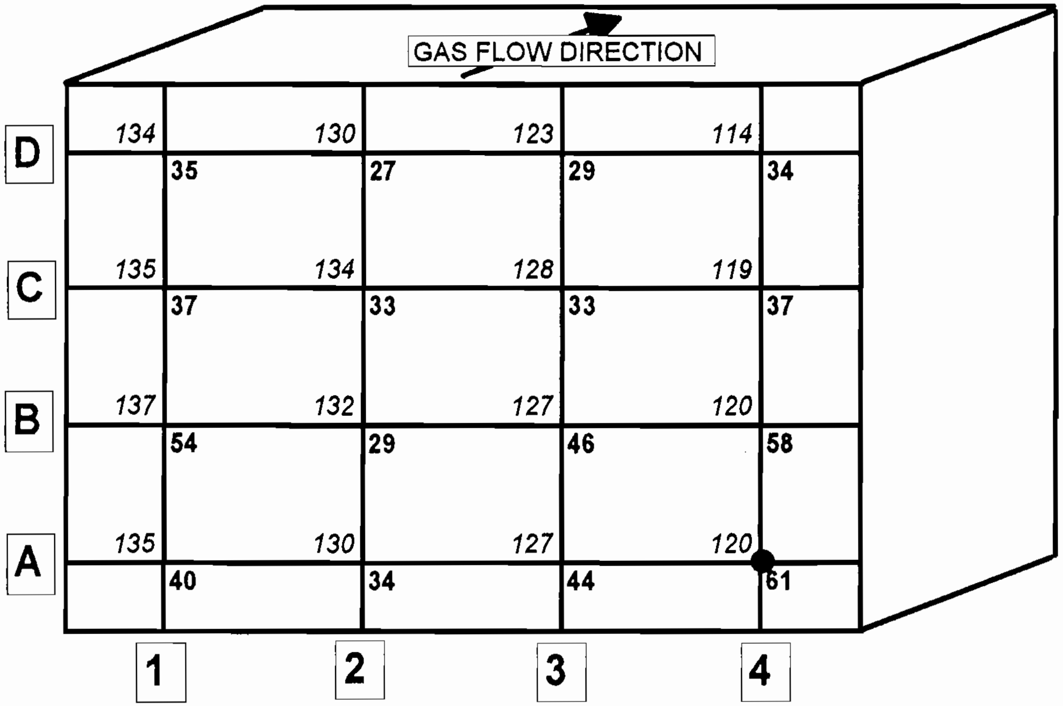
RH OUTER

Matrix	Pstag	Pstat	Pdyn	Temp	V-fact	V-factxT
A1	-1.80	-1.96	.16	134.80	40	5392
A2	-1.88	-1.99	.11	130.20	33.62	4376.73
A3	-1.89	-2.09	.20	127.00	44.38	5636.85
A4	-1.92	-2.29	.37	120.40	61.07	7353.28
B1	-1.74	-2.03	.29	136.70	53.67	7336.09
B2	-1.90	-1.99	.08	132.20	28.64	3785.63
B3	-1.88	-2.09	.21	126.60	45.61	5773.85
B4	-1.99	-2.33	.34	120.30	58.05	6983.62
C1	-1.86	-2.00	.14	134.90	36.74	4956.54
C2	-1.90	-2.01	.11	133.60	32.71	4370.17
C3	-1.99	-2.10	.11	127.70	33.17	4235.33
C4	-2.21	-2.34	.14	119.30	36.74	4383.36
D1	-1.87	-2.00	.13	134.15	35.36	4742.92
D2	-1.93	-2.00	.07	130.40	27.02	3523.21
D3	-1.98	-2.07	.09	123.40	29.50	3639.78
D4	-2.24	-2.36	.12	113.90	34.21	3895.98
SUM	-30.98	-33.62	2.65	2045.55	630.47	80385.35
AVERAGE	-1.94	-2.10	.17	127.85	40.67	127.50

See overleaf for graphical view of above table

Figure B.4: RIGHT HAND OUTER GAS DUCT TRAVERSE

RIGHT HAND OUTER CASING



LEGEND:
TEMPERATURES °C
VELOCITY WEIGHT FACTORS

TEST MEASURING POINT: A4
VELOCITY WEIGHT FACTOR: 41

APPENDIX C
LOW GRADE COAL LIMITS

APPENDIX C: LOW GRADE COAL LIMITS

The determination of the characteristic values for the selection of the low grade coal were done first, by means of iterative calculating spreadsheets. The objective here was to test coal with as low as possible quality that could safely be burnt in the Lethabo furnaces without loss of ignition. The consecutive columns in the applicable spreadsheets (Table C.1, Table C.2 and Table C.3) contain the following values or formulae: (See nomenclature for explanation of abbreviations or list of symbols.)

LOAD [%]

Five equal increments of load to be tested were entered over the span from the selected maximum to minimum loads.

USO [MW] = LOAD % / 100 x 593

593 MW is the nominal design MCR USO.

UNITS GENERATED [MW] = USO + 25

25 MW is the approximate nominal auxiliary electrical power consumption for one unit. This is not exactly true for all loads since certain auxiliary plant consume power directly proportional to the unit load (fans etc.). There are however other auxiliary power consumers that consume constant load (mills, CW pumps, lubricating and jacking oil pumps, etc.). The above approximation is adequate for this exercise since only an indication of UG is needed for

operational purposes during testing, but USO is used in calculations.

EFFICIENCY [%]

Only monthly averages and seasonal trends of overall thermal efficiency values were available from STEP history for the calculations in these spreadsheets. Accurate values for a specific unit (vs. the whole station), steady load (vs. AGC), overall efficiencies per load for the whole unit (vs. boiler or turbine separately) etc. were not known at that point in time. Many of these were intended to be determined in this project.

BOILER LOAD [MW] = USO / EFFICIENCY x 100

MILLS i/s

The anticipated (some cases hypothetical) number of mills i/s were entered at each load. Where the number of mills was entered more than once, it was to cater for various combinations of mill biasing.

MILLS BIASED

Often, one or two of the top mills are biased down to reduce the chances of metal temperature excursions, or a bottom mill can be biased up to improve evaporation. The remainder of the mills should make up the load difference to achieve the initial load set-point. The effect of biasing was brought into these calculations on each mill combination.

NOMINAL LOAD PER MILL [MW] = BOILER LOAD [MW] / AMOUNT OF MILLS IN SERVICE

LOAD PER MILL BIASED DOWN (-) [MW] = NOMINAL LOAD PER MILL [MW] x 0.967

Tests were carried out prior to the main tests on the unit to ascertain the amount of mill load change (PA flow and feeder speed) due to a certain degree of biasing. The maximum percentage biasing available on these units range between 35 - 60 % (an unbiased or nominal mill setting is 50%). The maximum bias that would be applied to a mill during operation resulted in a load reduction of 3.3% (corresponding to a 35% down bias). This implies that the mill will be operating at 96.7% of its load setting.

From experience with Lethabo coal, it is too low a burner load that poses a danger in terms of loss of ignition during the combustion of low grade coal. Therefore the biasing up (+) of mills will be considered only at the calculation of the high grade coal qualities.

NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] = NOMINAL LOAD PER MILL [MW] / 6

Six burners are served by one mill. This would be the load per burner when equal distribution of PA flow, pf flow and pf size occurs. (The ideal case, not found in practice.)

LOAD PER BURNER OF A DOWN BIASED MILL (-) WITH NORMAL DISTRIBUTION AMONGST BURNERS [MW] = LOAD OF A DOWN BIASED MILL [MW] / 6

Results of tests performed at Lethabo on Units 1 and 3 were used to determine an order of magnitude for any mal-distribution of pf amongst burners for these furnaces[12]. These furnaces performed very well since the worst figures obtained for leanest and richest running burners compared very favourably to other furnaces in general. These figures amounted to -5,308 and +6,153 percent deviation from the average respectively, resulting in the factors for multiplying the nominal distribution burner loads below.

NOMINAL LOAD PER BURNER WITH LEAN MALDISTRIBUTION (-) [MW] = NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] x 0.94692

LOAD PER BURNER OF A MILL BIASED DOWN (-) AND WITH LEAN MALDISTRIBUTION (-) [MW] = LOAD PER BURNER OF A MILL BIASED DOWN (-) AND WITH NORMAL DISTRIBUTION [MW] x 0.94692

PERCENTAGE BURNER LOAD (-) = LOAD PER BURNER BIASED DOWN (-) AND WITH LEAN MALDISTRIBUTION (-) [MW] / 56 x 100

The nominal load per burner for the Lethabo furnaces are 56 MW, based on 5 mills i/s at MCR.

PF FINENESS, % PASSING THROUGH A 75 μm SIEVE = -0.94523 x PA FLOW + 107.55111

The unit 1 mill performance since day one (with seasoned and established ball charge) was plotted as a scatter graph of pf fineness (percentage passing through a 75 μm sieve) as a function of PA flow (kg/s) (see Figure 4.1). A linear regression of these points produced a $y = mx + c$ graph with values as above. This method was used to obtain a forecast of what the pf fineness would be at a certain PA flow. The pf fineness as variable was to be eliminated as much as possible in these tests, as explained in chapter 4.1.

PA FLOW [kg/s]

A base minimum value of PA flow (± 20 kg/s), within the mill operating range, is entered was all the rows of this column as the independent variable from which this automatic iteration was started. For a given PA flow, a percentage feeder speed is calculated from $y = mx + c$ (see figure 4.2):

PA = % feeder speed x 0.28571 +17 1429

Then for this percentage feeder speed a coal flow is calculated also from a linear regression $y = mx + c$ (see figure 4.3):

% feeder speed = Coal flow x 0.9302

For this coal flow a nominal mill load [MW] can be calculated for a certain CV [MJ/kg]:

Coal flow [kg/s] x CV [MJ/kg] = mill load [MW]

Decreasing values of coal CV is then entered alternatively into the iteration formula automatically (this iteration column is not shown on the spreadsheet) and each time the PA flow will be increased in small increments of 0.01 up to a value where all the equations below are satisfied, with corresponding pf fineness. Extremes of burner loads etc. is also calculated automatically as in the equations of the columns above. The limiting factors are too high heat release per burner for the high CV coal and too low burner load resulting in loss of ignition for the low CV coal, where "NO GO" is flagged in the appropriate columns below where these limits are exceeded. Feasible combinations of mills in service for all coal qualities and loads can then be chosen where the expected pf fineness is as constant as possible, thus eliminating it as a variable, as much as is practically possible.

LOWER CV NOMINAL AS FIRED [MJ/kg]

= MILL LOAD [MW] / ((PA FLOW - 17.1429) / 0.26577 x 2 x 3.6)

This y = mx + c type equation is derived from the combined equations of figures 4.2 and 4.3 (see PA FLOW and the iteration explanation above). The numerator 2 in the above equation is to obtain the flow for both feeders and the 3.6 is to convert tons/h to kg/s.

INHERENT MOISTURE [%] = -0.4074 x NOMINAL CV AS FIRED + 10.796

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

TOTAL MOISTURE [%] = -0.8888 x NOMINAL CV AS FIRED + 23.555

Also, only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

LOWER CV NOMINAL AIR DRIED [MJ/kg]

= LOWER CV NOMINAL AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)

Standard formula.

LOWER CV LIMIT AIR DRIED [MJ/kg] = IF BURNER LOAD % < 50%, "NO GO"

IF BURNER LOAD % < 70%, 15 MJ/kg

IF BURNER LOAD % < 100%, 14.5 MJ/kg

IF BURNER LOAD % < 125%, 13.5 MJ/kg

The first three criteria are taken from the Burner Stability diagram (Figure 4.4). It emanates from the Lean Coal tests[3]. It prescribes that a Lethabo burner should never be operated below 50% load in order to maintain ignition, or only below 70% load if the coal CV is 15 MJ/kg or above (with the corresponding HIV minimum value, see below), etc. The 125% burner load is the maximum burner load permissible, obtained from the supplier, for the purposes of these tests.

LOWER HIV LIMIT [%] = IF BURNER LOAD % < 50%, "NO GO"

IF BURNER LOAD % < 70%, 22 %

IF BURNER LOAD % < 100%, 21 %

IF BURNER LOAD % < 125%, 19 %

Similar to the minimum permissible CV vs. burner load as above, this criteria is also taken from the Burner Stability diagram (Figure 4.4), emanating from the Lean Coal tests[3].

LOWER VOLATILE LIMIT AIR DRIED [%] = LOWER HIV LIMIT AIR DRIED [%] x 0.146 + 15.308

This value is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of HIV. This is not always true for Lethabo coal, since certain volatiles are inert (as discussed in Chapter 4.1). This is only done to obtain an approximate value for this parameter for the purposes of coal ordering.

LOWER VOLATILE LIMIT AS FIRED [%] = LOWER VOLATILE LIMIT AIR DRIED [%] x (100 - TOTAL MOISTURE) / (100 - INHERENT MOISTURE)

Standard formula.

LOWER CV AIR DRIED CRITERIA = IF THE LOWER CV NOMINAL AIR DRIED ≥ LOWER AIR DRIED CV LIMIT, PRINT THAT VALUE OF CV, OTHERWISE "NO GO"

Table C.1: ITERATION FOR LOWEST POSSIBLE LIMIT OF COAL QUALITY

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL -BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER -BIASED DISTR	MW /BURNER NOMINAL -MALDISTR	MW /BURNER -BIASED -MALDISTR	% BURNER LOAD (-)	Pf FIN %<75µm	PA FLOW /MILL kg/s LOWER CV	LOWER CV NOMINAL AS FIRED MJ/kg	LOWER INHERENT MOISTURE %	LOWER TOTAL MOISTURE NOMINAL	LOWER CV NOMINAL AIRDRIED MJ/kg	LOWER CV LIMIT AIRDRIED MJ/kg	LOWER HIV LIMIT AIRDRIED MJ/kg	LOWER VOL LIMIT AIRDRIED %	LOWER VOL LIMIT AS FIRED %	LOWER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	278	48	46	45	44	79%	82	27.30	13.54	5.3	11.5	14.50	14.5	21	18.37	17.16	NO GO
102	605	630	35.06	1725	5	1	345	334	58	56	54	53	95%	80	29.33	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
102	605	630	35.06	1725	5	2	345	334	58	56	54	53	95%	80	29.33	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
102	605	630	35.06	1725	4	1	431	417	72	70	68	66	119%	77	32.38	13.54	5.3	11.5	14.50	13.5	19	18.08	16.89	14.50
102	605	630	35.06	1725	4	2	431	417	72	70	68	66	119%	77	32.38	13.54	5.3	11.5	14.50	13.5	19	18.08	16.89	14.50
89	525	550	35.25	1489	6	2	248	240	41	40	39	38	68%	83	25.91	13.54	5.3	11.5	14.50	15.0	22	18.52	17.30	NO GO
89	525	550	35.25	1489	5	1	298	288	50	48	47	45	82%	81	27.66	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
89	525	550	35.25	1489	5	2	298	288	50	48	47	45	82%	81	27.66	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
89	525	550	35.25	1489	4	1	372	360	62	60	59	57	102%	79	30.29	13.55	5.3	11.5	14.50	13.5	19	18.08	16.89	14.50
89	525	550	35.25	1489	4	2	372	360	62	60	59	57	102%	79	30.29	13.55	5.3	11.5	14.50	13.5	19	18.08	16.89	14.50
80	475	500	35.37	1343	6	2	224	216	37	36	35	34	62%	84	25.05	13.54	5.3	11.5	14.50	15.0	22	18.52	17.30	NO GO
80	475	500	35.37	1343	5	1	269	260	45	43	42	41	74%	82	26.63	13.54	5.3	11.5	14.50	14.5	21	18.37	17.16	NO GO
80	475	500	35.37	1343	5	2	269	260	45	43	42	41	74%	82	26.63	13.54	5.3	11.5	14.50	14.5	21	18.37	17.16	NO GO
80	475	500	35.37	1343	4	1	336	325	56	54	53	51	92%	80	29.00	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
80	475	500	35.37	1343	4	2	336	325	56	54	53	51	92%	80	29.00	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
72	425	450	35.40	1201	6	2	200	194	33	32	32	31	55%	85	24.21	13.55	5.3	11.5	14.50	15.0	22	18.52	17.30	NO GO
72	425	450	35.40	1201	5	1	240	232	40	39	38	37	66%	83	25.63	13.53	5.3	11.5	14.49	15.0	22	18.52	17.30	NO GO
72	425	450	35.40	1201	5	2	240	232	40	39	38	37	66%	83	25.63	13.53	5.3	11.5	14.49	15.0	22	18.52	17.30	NO GO
72	425	450	35.40	1201	4	1	300	290	50	48	47	46	83%	81	27.74	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
72	425	450	35.40	1201	4	2	300	290	50	48	47	46	83%	81	27.74	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50
72	425	450	35.40	1201	3	1	400	387	67	65	63	61	110%	78	31.28	13.54	5.3	11.5	14.50	13.5	19	18.08	16.89	14.50
63	375	400	35.33	1062	6	2	177	171	29	29	28	27	49%	85	23.39	13.55	5.3	11.5	14.50	NO GO	NO GO	#VALUE!	#VALUE!	#N/A!
63	375	400	35.33	1062	5	1	212	205	35	34	34	32	58%	84	24.64	13.55	5.3	11.5	14.50	15.0	22	18.52	17.30	NO GO
63	375	400	35.33	1062	5	2	212	205	35	34	34	32	58%	84	24.64	13.55	5.3	11.5	14.50	15.0	22	18.52	17.30	NO GO
63	375	400	35.33	1062	4	1	265	257	44	43	42	41	73%	82	26.52	13.54	5.3	11.5	14.49	14.5	21	18.37	17.16	NO GO
63	375	400	35.33	1062	4	2	265	257	44	43	42	41	73%	82	26.52	13.54	5.3	11.5	14.49	14.5	21	18.37	17.16	NO GO
63	375	400	35.33	1062	3	1	354	342	59	57	56	54	97%	80	29.64	13.55	5.3	11.5	14.50	14.5	21	18.37	17.16	14.50

Table C.2: ITERATION FOR LOWER LIMIT OF COAL TO BE ORDERED

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL -BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER -BIASED DISTR	MW /BURNER NOMINAL -MALDISTR	MW /BURNER -BIASED -MALDISTR	% BURNER LOAD (-)	Pf FIN %<75µm	PA FLOW /MILL kg/s LOWER CV	LOWER CV NOMINAL AS FIRED MJ/kg	LOWER INHERENT MOISTURE %	LOWER TOTAL MOISTURE NOMINAL	LOWER CV NOMINAL AIRDRIED MJ/kg	LOWER CV LIMIT AIRDRIED MJ/kg	LOWER HIV LIMIT AIRDRIED MJ/kg	LOWER VOL LIMIT AIRDRIED %	LOWER VOL LIMIT AS FIRED *%	LOWER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	278	48	46	45	44	79%	82	26.71	14.38	4.9	10.8	15.320	14.5	21	18.37	17.25	15.32
102	605	630	35.06	1725	5	1	345	334	58	56	54	53	95%	80	28.63	14.37	4.9	10.8	15.31	14.5	21	18.37	17.25	15.31
102	605	630	35.06	1725	5	2	345	334	58	56	54	53	95%	80	28.63	14.37	4.9	10.8	15.31	14.5	21	18.37	17.25	15.31
102	605	630	35.06	1725	4	1	431	417	72	70	68	66	119%	78	31.49	14.38	4.9	10.8	15.32	13.5	19	18.08	16.97	15.32
102	605	630	35.06	1725	4	2	431	417	72	70	68	66	119%	78	31.49	14.38	4.9	10.8	15.32	13.5	19	18.08	16.97	15.32
89	525	550	35.25	1489	6	2	248	240	41	40	39	38	68%	84	25.40	14.38	4.9	10.8	15.32	15.0	22	18.52	17.38	15.32
89	525	550	35.25	1489	5	1	298	288	50	48	47	45	82%	82	27.06	14.37	4.9	10.8	15.31	14.5	21	18.37	17.24	15.31
89	525	550	35.25	1489	5	2	298	288	50	48	47	45	82%	82	27.06	14.37	4.9	10.8	15.31	14.5	21	18.37	17.24	15.31
89	525	550	35.25	1489	4	1	372	360	62	60	59	57	102%	80	29.53	14.38	4.9	10.8	15.32	13.5	19	18.08	16.97	15.32
89	525	550	35.25	1489	4	2	372	360	62	60	59	57	102%	80	29.53	14.38	4.9	10.8	15.32	13.5	19	18.08	16.97	15.32
80	475	500	35.37	1343	6	2	224	216	37	36	35	34	62%	84	24.59	14.38	4.9	10.8	15.32	15.0	22	18.52	17.38	15.32
80	475	500	35.37	1343	5	1	269	260	45	43	42	41	74%	83	26.08	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
80	475	500	35.37	1343	5	2	269	260	45	43	42	41	74%	83	26.08	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
80	475	500	35.37	1343	4	1	336	325	56	54	53	51	92%	81	28.31	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
80	475	500	35.37	1343	4	2	336	325	56	54	53	51	92%	81	28.31	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
72	425	450	35.40	1201	6	2	200	194	33	32	32	31	55%	85	23.80	14.38	4.9	10.8	15.32	15.0	22	18.52	17.38	15.32
72	425	450	35.40	1201	5	1	240	232	40	39	38	37	66%	84	25.13	14.38	4.9	10.8	15.32	15.0	22	18.52	17.38	15.32
72	425	450	35.40	1201	5	2	240	232	40	39	38	37	66%	84	25.13	14.38	4.9	10.8	15.32	15.0	22	18.52	17.38	15.32
72	425	450	35.40	1201	4	1	300	290	50	48	47	46	83%	82	27.13	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
72	425	450	35.40	1201	4	2	300	290	50	48	47	46	83%	82	27.13	14.38	4.9	10.8	15.32	14.5	21	18.37	17.25	15.32
72	425	450	35.40	1201	3	1	400	387	67	65	63	61	110%	79	30.46	14.38	4.9	10.8	15.32	13.5	19	18.08	16.97	15.32
63	375	400	35.33	1062	6	2	177	171	29	29	28	27	49%	86	23.03	14.38	4.9	10.8	15.32	NO GO	NO GO	#VALUE!	#VALUE!	#N/A!
63	375	400	35.33	1062	5	1	212	205	35	34	34	32	58%	85	24.21	14.37	4.9	10.8	15.31	15.0	22	18.52	17.38	15.31
63	375	400	35.33	1062	5	2	212	205	35	34	34	32	58%	85	24.21	14.37	4.9	10.8	15.31	15.0	22	18.52	17.38	15.31
63	375	400	35.33	1062	4	1	265	257	44	43	42	41	73%	83	25.98	14.37	4.9	10.8	15.31	14.5	21	18.37	17.24	15.31
63	375	400	35.33	1062	4	2	265	257	44	43	42	41	73%	83	25.98	14.37	4.9	10.8	15.31	14.5	21	18.37	17.24	15.31
63	375	400	35.33	1062	3	1	354	342	59	57	56	54	97%	80	28.92	14.37	4.9	10.8	15.31	14.5	21	18.37	17.25	15.31

Table C.3: <u>ITERATION FOR LOWER LIMIT OF ACTUAL TEST COAL</u>

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL -BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER -BIASED DISTR	MW /BURNER NOMINAL -MALDISTR	MW /BURNER -BIASED -MALDISTR	% BURNER LOAD (-)	Pf FIN %<75μm	PA FLOW /MILL kg/s LOWER CV	LOWER CV NOMINAL AS FIRED MJ/kg	LOWER INHERENT MOISTURE %	LOWER TOTAL MOISTURE NOMINAL	LOWER CV NOMINAL AIRDRIED MJ/kg	LOWER CV LIMIT AIRDRIED MJ/kg	LOWER HIV LIMIT AIRDRIED MJ/kg	LOWER VOL LIMIT AIRDRIED %	LOWER VOL LIMIT AS FIRED *%	LOWER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	278	48	46	45	44	79%	82	26.55	14.62	3.2	8.4	15.462	14.5	21	18.37	17.38	15.46
102	605	630	35.06	1725	5	1	345	334	58	56	54	53	95%	81	28.43	14.63	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
102	605	630	35.06	1725	5	2	345	334	58	56	54	53	95%	81	28.43	14.63	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
102	605	630	35.06	1725	4	1	431	417	72	70	68	66	119%	78	31.25	14.63	3.2	8.4	15.47	13.5	19	18.08	17.10	15.47
102	605	630	35.06	1725	4	2	431	417	72	70	68	66	119%	78	31.25	14.63	3.2	8.4	15.47	13.5	19	18.08	17.10	15.47
89	525	550	35.25	1489	6	2	248	240	41	40	39	38	68%	84	25.26	14.63	3.2	8.4	15.47	15.0	22	18.52	17.52	15.47
89	525	550	35.25	1489	5	1	298	288	50	48	47	45	82%	82	26.89	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
89	525	550	35.25	1489	5	2	298	288	50	48	47	45	82%	82	26.89	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
89	525	550	35.25	1489	4	1	372	360	62	60	59	57	102%	80	29.32	14.63	3.2	8.4	15.47	13.5	19	18.08	17.10	15.47
89	525	550	35.25	1489	4	2	372	360	62	60	59	57	102%	80	29.32	14.63	3.2	8.4	15.47	13.5	19	18.08	17.10	15.47
80	475	500	35.37	1343	6	2	224	216	37	36	35	34	62%	84	24.47	14.61	3.2	8.4	15.45	15.0	22	18.52	17.52	15.45
80	475	500	35.37	1343	5	1	269	260	45	43	42	41	74%	83	25.93	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
80	475	500	35.37	1343	5	2	269	260	45	43	42	41	74%	83	25.93	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
80	475	500	35.37	1343	4	1	336	325	56	54	53	51	92%	81	28.13	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
80	475	500	35.37	1343	4	2	336	325	56	54	53	51	92%	81	28.13	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
72	425	450	35.40	1201	6	2	200	194	33	32	32	31	55%	85	23.69	14.62	3.2	8.4	15.46	15.0	22	18.52	17.52	15.46
72	425	450	35.40	1201	5	1	240	232	40	39	38	37	66%	84	25.00	14.62	3.2	8.4	15.46	15.0	22	18.52	17.52	15.46
72	425	450	35.40	1201	5	2	240	232	40	39	38	37	66%	84	25.00	14.62	3.2	8.4	15.46	15.0	22	18.52	17.52	15.46
72	425	450	35.40	1201	4	1	300	290	50	48	47	46	83%	82	26.96	14.63	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
72	425	450	35.40	1201	4	2	300	290	50	48	47	46	83%	82	26.96	14.63	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46
72	425	450	35.40	1201	3	1	400	387	67	65	63	61	110%	79	30.23	14.63	3.2	8.4	15.47	13.5	19	18.08	17.10	15.47
63	375	400	35.33	1062	6	2	177	171	29	29	28	27	49%	86	22.93	14.63	3.2	8.4	15.46	NO GO	NO GO	#VALUE!	#VALUE!	#N/A!
63	375	400	35.33	1062	5	1	212	205	35	34	34	32	58%	85	24.09	14.62	3.2	8.4	15.46	15.0	22	18.52	17.52	15.46
63	375	400	35.33	1062	5	2	212	205	35	34	34	32	58%	85	24.09	14.62	3.2	8.4	15.46	15.0	22	18.52	17.52	15.46
63	375	400	35.33	1062	4	1	265	257	44	43	42	41	73%	83	25.83	14.61	3.2	8.4	15.45	14.5	21	18.37	17.38	15.45
63	375	400	35.33	1062	4	2	265	257	44	43	42	41	73%	83	25.83	14.61	3.2	8.4	15.45	14.5	21	18.37	17.38	15.45
63	375	400	35.33	1062	3	1	354	342	59	57	56	54	97%	80	28.72	14.62	3.2	8.4	15.46	14.5	21	18.37	17.38	15.46

APPENDIX D
HIGH GRADE COAL LIMITS

APPENDIX D: HIGH GRADE COAL LIMITS

The determination of the characteristic values for the selection of the high grade coal were done after that of the low grade coal, also by means of iterative calculating spreadsheets. The anticipation here was to test coal with as high as possible quality that could safely be burnt in the Lethabo furnaces without burner damage or exceeding the heat transfer per unit area of the furnace wall. The consecutive columns in the applicable spreadsheets (Table D.1, Table D.2 and Table D.3) contain the following values or formulae: (See nomenclature for explanation of abbreviations or list of symbols.)

LOAD [%]

Five equal increments of load to be tested were entered over the span from the selected maximum to minimum loads.

USO [MW] = LOAD % / 100 x 593

593 MW is the nominal design MCR USO.

UNITS GENERATED [MW] = USO + 25

25 MW is the approximate nominal auxiliary electrical power consumption for one unit. This is not exactly true for all loads since certain auxiliary plant consume power directly proportional to the unit load (feedpumps, fans etc.). There are however other auxiliary power consumers that consume constant load (mills, CW pumps,

lubricating and jacking oil pumps, etc.). The above approximation is adequate for this exercise since only an indication of UG is needed for operational purposes during testing, but USO is used in further calculations here.

EFFICIENCY [%]

Only monthly averages and seasonal trends of overall thermal efficiency values were available from STEP history for the calculations in these spreadsheets. Accurate values for a specific unit (vs. the whole station), steady load (vs. AGC), overall efficiencies per load for the whole unit (vs. boiler or turbine separately) etc. were not known at that point in time. Many of these were intended to be determined in this project.

BOILER LOAD [MW] = USO / EFFICIENCY x 100

MILLS i/s

The anticipated (some cases hypothetical) number of mills i/s were entered at each load. Where the number of mills was entered more than once, it was to cater for various combinations of mill biasing (see below).

MILLS BIASED

Often, one or two of the top mills are biased down to reduce the chances of metal temperature excursions, or a bottom mill can be biased up to improve evaporation. The remainder of the mills should make up the load difference to achieve the initial load set-point. The effect of biasing was brought into these calculations on each mill combination.

NOMINAL LOAD PER MILL [MW] = BOILER LOAD [MW] / AMOUNT OF MILLS IN SERVICE

Tests were carried out prior to the main tests on the unit to ascertain the amount of mill load change (PA flow and feeder speed) due to a certain degree of biasing. The maximum percentage biasing available on these units range between 35 - 60 % (an unbiased or nominal mill setting is 50%). The maximum bias that would be applied to a mill during operation resulted in a load reduction of 3.3% (corresponding to a 35% down bias). This implies that the mill will be operating at 96.7% of its load setting.

From experience with Lethabo coal, it is too low a burner load that poses a danger in terms of loss of ignition during the combustion of low grade coal. Therefore the biasing up (+) of mills will be considered only at the calculation of the high grade coal qualities.

LOAD PER MILL BIASED UP (+) [MW] = (BOILER LOAD - LOAD PER MILL BIASED DOWN x AMOUNT OF MILLS BIASED DOWN) / (MILLS i/s - AMOUNT OF MILLS BIASED DOWN)

The above simply calculates the resulting load of the remainder of the mills that would automatically pick up load due to the load reduction of the mills biased down. This has also been verified by testing.

NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] = NOMINAL LOAD PER MILL [MW] / 6

Six burners are served by one mill. This would be the load per burner when equal distribution of PA flow, pf flow and pf size occurs. (The ideal case, not found in practice.)

LOAD PER BURNER OF AN UP BIASED MILL (+) WITH NORMAL DISTRIBUTION AMONGST BURNERS [MW] = LOAD OF AN UP BIASED MILL [MW] / 6

Results of tests performed at Lethabo on Units 1 and 3 were used to determine an order of magnitude for any mal-distribution of pf amongst burners for these furnaces[12]. These furnaces performed very well since the worst figures obtained for leanest and richest running burners compared very favourably to other furnaces in general. These figures amounted to -5,308 and +6,153 percent deviation from the average respectively, resulting in the factors for multiplying the nominal distribution burner loads below.

NOMINAL LOAD PER BURNER WITH RICH MALDISTRIBUTION (+) [MW] = NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] x 1.06153

LOAD PER BURNER OF A MILL BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] = LOAD PER BURNER OF A MILL BIASED UP (+) AND WITH NORMAL DISTRIBUTION [MW] x 1.06153

PERCENTAGE BURNER LOAD (+) = LOAD PER BURNER BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] / 56 x 100

The nominal load per burner for the Lethabo furnaces are 56 MW, based on 5 mills i/s at MCR.

PF FINENESS, % PASSING THROUGH A 75 μm SIEVE = -0.94523 x PA FLOW + 107.55111

The unit 1 mill performance since day one (with seasoned and established ball charge) was plotted as a scatter graph of pf fineness (percentage passing through a 75 μm sieve) as a function of PA flow (kg/s) (see Figure 4.1). A linear regression of these points produced a $y = mx + c$ graph with values as above. This method was used to obtain a forecast of what the pf fineness would be at a certain PA flow. The pf fineness as variable was to be eliminated as much as possible in these tests, as explained in chapter 4.1.

PA FLOW [kg/s]

A base minimum value of PA flow (± 20 kg/s), within the mill operating range, was entered in all the rows of this column as the independent variable from which this automatic iteration was started. For a given PA flow, a percentage feeder speed is calculated from $y = mx + c$

(see figure 4.2)

PA = % feeder speed x 0.28571 +17 1429

Then for this percentage feeder speed a coal flow is calculated also from a linear regression $y = mx + c$ (see figure 4.3)

% feeder speed = Coal flow x 0.9302

For this coal flow a nominal mill load [MW] can be calculated for a certain CV [MJ/kg]

Coal flow [kg/s] x CV [MJ/kg] = mill load [MW]

Decreasing values of coal CV is then entered alternatively into the iteration formula automatically (this iteration column is not shown on the spreadsheet) and each time the PA flow will be increased in small increments of 0.01 up to a value where all the equations below are satisfied, with corresponding pf fineness. Extremes of burner loads etc. is also calculated automatically as in the equations of the columns above. The limiting factors are too high heat release per burner for the high CV coal and too low burner load resulting in loss of ignition for the low CV coal, where "NO GO" is flagged in the appropriate columns below where these limits are exceeded. Feasible combinations of mills in service for all coal qualities and loads can then be chosen where the expected pf fineness is as constant as possible, thus eliminating it as a variable, as much as is practically possible.

UPPER CV NOMINAL AS FIRED [MJ/kg]

= MILL LOAD [MW] / ((PA FLOW - 17.1429) / 0.26577 x 2 x 3.6)

This y = mx + c type equation is derived from the combined equations of figures 4.2 and 4.3 (see PA FLOW and the iteration explanation above). The numerator 2 in the above equation is to obtain the flow for both feeders and the 3.6 is to convert tons/h to kg/s.

UPPER CV LIMIT AS FIRED [MJ/kg] = UPPER CV NOMINAL AS FIRED [MJ/kg] / LOAD PER BURNER BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] x 56 (nominal burner load) x 1.25

In the above equation the nominal CV is simply scaled up by the ratio of the richest possible burner load to the nominal burner load and the maximum percentage of overload (125%) permitted in a burner (estimated by the supplier after discussion) to obtain the maximum corresponding CV that could be tolerated by this combination of mills, load etc.

INHERENT MOISTURE [%] = -0.4074 x NOMINAL CV AS FIRED + 10.796

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

TOTAL MOISTURE [%] = -0.8888 x NOMINAL CV AS FIRED + 23.555

Also, only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

UPPER CV NOMINAL AIR DRIED [MJ/kg]
= UPPER CV NOMINAL AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)
Standard formula.

NOMINAL AIR DRIED HIV [%] = 3 x AIR DRIED CV - 23
This is a linear relationship obtained from the Burner stability diagram (Figure 4.4) to forecast HIV from air dried CV.

NOMINAL VOLATILES AIR DRIED [%] = NOMINAL AIR DRIED HIV [%] x 0.146 + 15.308
This value is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of HIV. This is not always true for Lethabo coal, since certain volatiles are inert (as discussed in Chapter 4.1). This is only done to obtain an approximate value for this parameter for the purposes of coal ordering.

UPPER CV LIMIT AIR DRIED [MJ/kg] = UPPER CV LIMIT AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)
Standard formula.

UPPER CV AIR DRIED CRITERIA := IF THE UPPER CV AIR DRIED LIMIT > NOMINAL UPPER AIR DRIED CV BY MORE THAN A 0.5 MARGIN (safety factor), PRINT THAT VALUE OF CV, OTHERWISE "NO GO"

Table D.1: ITERATION FOR HIGHEST POSSIBLE LIMIT OF COAL QUALITY

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL +BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER +BIASED DISTR	MW /BURNER NOMINAL +MALDISTR	MW /BURNER +BIASED +MALDISTR	% BURNER LOAD (+)	Pf FIN %<75μm	PA FLOW /MILL kg/s UPPER CV	UPPER CV NOMINAL AS FIRED MJ/kg	UPPER CV LIMIT AS FIRED MJ/kg	UPPER INHERENT MOISTURE %	UPPER TOTAL MOISTURE NOMINAL	UPPER CV NOMINAL AIRDRIED MJ/kg	UPPER HIV NOMINAL AIRDRIED %	UPPER VOL NOMINAL AIRDRIED %	UPPER CV LIMIT AIRDRIED MJ/kg	UPPER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	292	48	49	51	52	93%	84	24.56	18.55	24.86	3.2	7.1	19.31	34.94	20.41	25.88	19.31
102	605	630	35.06	1725	5	1	345	348	58	58	61	62	111%	83	26.05	18.53	20.87	3.2	7.1	19.30	34.90	20.40	21.73	19.30
102	605	630	35.06	1725	5	2	345	353	58	59	61	62	113%	83	26.05	18.53	20.59	3.2	7.1	19.30	34.90	20.40	21.44	19.30
102	605	630	35.06	1725	4	1	431	436	72	73	76	77	139%	81	28.27	18.55	16.66	3.2	7.1	19.31	34.93	20.41	17.35	NO GO
102	605	630	35.06	1725	4	2	431	446	72	74	76	79	142%	81	28.27	18.55	16.30	3.2	7.1	19.31	34.93	20.41	16.98	NO GO
89	525	550	35.25	1489	6	2	248	252	41	42	44	45	81%	85	23.55	18.53	28.77	3.2	7.1	19.30	34.90	20.40	29.96	19.30
89	525	550	35.25	1489	5	1	298	300	50	50	53	53	96%	84	24.83	18.54	24.18	3.2	7.1	19.30	34.91	20.40	25.18	19.30
89	525	550	35.25	1489	5	2	298	304	50	51	53	54	97%	84	24.83	18.54	23.85	3.2	7.1	19.30	34.91	20.40	24.84	19.30
89	525	550	35.25	1489	4	1	372	376	62	63	66	67	120%	82	26.75	18.54	19.29	3.2	7.1	19.31	34.92	20.41	20.09	19.31
89	525	550	35.25	1489	4	2	372	385	62	64	66	68	123%	82	26.75	18.54	18.88	3.2	7.1	19.31	34.92	20.41	19.66	19.31
80	475	500	35.37	1343	6	2	224	228	37	38	40	40	73%	86	22.92	18.53	31.91	3.2	7.1	19.30	34.90	20.40	33.23	19.30
80	475	500	35.37	1343	5	1	269	271	45	45	48	48	86%	85	24.07	18.55	26.83	3.2	7.1	19.31	34.94	20.41	27.94	19.31
80	475	500	35.37	1343	5	2	269	274	45	46	48	49	88%	85	24.07	18.55	26.47	3.2	7.1	19.31	34.94	20.41	27.56	19.31
80	475	500	35.37	1343	4	1	336	339	56	57	59	60	108%	83	25.81	18.53	21.39	3.2	7.1	19.30	34.89	20.40	22.27	19.30
80	475	500	35.37	1343	4	2	336	347	56	58	59	61	111%	83	25.81	18.53	20.93	3.2	7.1	19.30	34.89	20.40	21.80	19.30
72	425	450	35.40	1201	6	2	200	203	33	34	35	36	65%	86	22.31	18.53	35.68	3.2	7.1	19.29	34.88	20.40	37.15	19.29
72	425	450	35.40	1201	5	1	240	242	40	40	42	43	77%	85	23.34	18.54	29.99	3.2	7.1	19.30	34.90	20.40	31.23	19.30
72	425	450	35.40	1201	5	2	240	245	40	41	42	43	78%	85	23.34	18.54	29.59	3.2	7.1	19.30	34.90	20.40	30.81	19.30
72	425	450	35.40	1201	4	1	300	303	50	51	53	54	97%	84	24.89	18.53	23.93	3.2	7.1	19.30	34.90	20.40	24.91	19.30
72	425	450	35.40	1201	4	2	300	310	50	52	53	55	99%	84	24.89	18.53	23.42	3.2	7.1	19.30	34.90	20.40	24.38	19.30
72	425	450	35.40	1201	3	1	400	407	67	68	71	72	130%	82	27.47	18.54	17.85	3.2	7.1	19.30	34.91	20.41	18.59	NO GO
63	375	400	35.33	1062	6	2	177	180	29	30	31	32	57%	87	21.71	18.53	40.37	3.2	7.1	19.30	34.89	20.40	42.03	19.30
63	375	400	35.33	1062	5	1	212	214	35	36	38	38	68%	86	22.62	18.54	33.93	3.2	7.1	19.31	34.93	20.41	35.33	19.31
63	375	400	35.33	1062	5	2	212	217	35	36	38	38	69%	86	22.62	18.54	33.48	3.2	7.1	19.31	34.93	20.41	34.86	19.31
63	375	400	35.33	1062	4	1	265	268	44	45	47	47	86%	85	23.99	18.54	27.07	3.2	7.1	19.31	34.92	20.41	28.19	19.31
63	375	400	35.33	1062	4	2	265	274	44	46	47	49	87%	85	23.99	18.54	26.49	3.2	7.1	19.31	34.92	20.41	27.59	19.31
63	375	400	35.33	1062	3	1	354	360	59	60	63	64	115%	83	26.27	18.55	20.20	3.2	7.1	19.31	34.93	20.41	21.03	19.31

Table D.2: ITERATION FOR HIGH LIMIT OF COAL TO BE ORDERED

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL +BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER +BIASED DISTR	MW /BURNER NOMINAL +MALDISTR	MW /BURNER +BIASED +MALDISTR	% BURNER LOAD (+)	Pf FIN %<75µm	PA FLOW /MILL kg/s UPPER CV	UPPER CV NOMINAL AS FIRED MJ/kg	UPPER CV LIMIT AS FIRED MJ/kg	UPPER INHERENT MOISTURE %	UPPER TOTAL MOISTURE NOMINAL	UPPER CV NOMINAL AIRDRIED MJ/kg	UPPER HIV NOMINAL AIRDRIED %	UPPER VOL NOMINAL AIRDRIED %	UPPER CV LIMIT AIRDRIED MJ/kg	UPPER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	292	48	49	51	52	93%	84	24.91	17.71	23.74	3.6	7.8	18.52	32.57	20.06	23.46	18.52
102	605	630	35.06	1725	5	1	345	348	58	58	61	62	111%	83	26.47	17.70	19.93	3.6	7.8	18.51	32.54	20.06	20.41	18.51
102	605	630	35.06	1725	5	2	345	353	58	59	61	62	113%	83	26.47	17.70	19.66	3.6	7.8	18.51	32.54	20.06	20.18	18.51
102	605	630	35.06	1725	4	1	431	436	72	73	76	77	139%	80	28.80	17.70	15.90	3.6	7.8	18.52	32.55	20.06	16.93	NO GO
102	605	630	35.06	1725	4	2	431	446	72	74	76	79	142%	80	28.80	17.70	15.56	3.6	7.8	18.52	32.55	20.06	16.62	NO GO
89	525	550	35.25	1489	6	2	248	252	41	42	44	45	81%	85	23.85	17.70	27.49	3.6	7.8	18.52	32.55	20.06	26.27	18.52
89	525	550	35.25	1489	5	1	298	300	50	50	53	53	96%	84	25.19	17.71	23.10	3.6	7.8	18.52	32.56	20.06	22.96	18.52
89	525	550	35.25	1489	5	2	298	304	50	51	53	54	97%	84	25.19	17.71	22.79	3.6	7.8	18.52	32.56	20.06	22.72	18.52
89	525	550	35.25	1489	4	1	372	376	62	63	66	67	120%	82	27.20	17.71	18.43	3.6	7.8	18.52	32.57	20.06	19.14	18.52
89	525	550	35.25	1489	4	2	372	385	62	64	66	68	123%	82	27.20	17.71	18.04	3.6	7.8	18.52	32.57	20.06	18.81	18.52
80	475	500	35.37	1343	6	2	224	228	37	38	40	40	73%	86	23.19	17.71	30.49	3.6	7.8	18.52	32.56	20.06	28.39	18.52
80	475	500	35.37	1343	5	1	269	271	45	45	48	48	86%	84	24.40	17.71	25.61	3.6	7.8	18.52	32.56	20.06	24.89	18.52
80	475	500	35.37	1343	5	2	269	274	45	46	48	49	88%	84	24.40	17.71	25.27	3.6	7.8	18.52	32.56	20.06	24.63	18.52
80	475	500	35.37	1343	4	1	336	339	56	57	59	60	108%	83	26.21	17.71	20.44	3.6	7.8	18.53	32.58	20.06	20.83	18.53
80	475	500	35.37	1343	4	2	336	347	56	58	59	61	111%	83	26.21	17.71	20.01	3.6	7.8	18.53	32.58	20.06	20.47	18.53
72	425	450	35.40	1201	6	2	200	203	33	34	35	36	65%	86	22.55	17.70	34.09	3.6	7.8	18.52	32.55	20.06	30.79	18.52
72	425	450	35.40	1201	5	1	240	242	40	40	42	43	77%	85	23.63	17.71	28.65	3.6	7.8	18.52	32.56	20.06	27.11	18.52
72	425	450	35.40	1201	5	2	240	245	40	41	42	43	78%	85	23.63	17.71	28.27	3.6	7.8	18.52	32.56	20.06	26.83	18.52
72	425	450	35.40	1201	4	1	300	303	50	51	53	54	97%	84	25.25	17.71	22.86	3.6	7.8	18.52	32.57	20.06	22.78	18.52
72	425	450	35.40	1201	4	2	300	310	50	52	53	55	99%	84	25.25	17.71	22.38	3.6	7.8	18.52	32.57	20.06	22.40	18.52
72	425	450	35.40	1201	3	1	400	407	67	68	71	72	130%	81	27.95	17.72	17.06	3.6	7.8	18.53	32.59	20.07	17.96	NO GO
63	375	400	35.33	1062	6	2	177	180	29	30	31	32	57%	87	22	17.43	37.96	3.7	8.1	18.25	31.76	19.95	33.18	18.25
63	375	400	35.33	1062	5	1	212	214	35	36	38	38	68%	86	22.88	17.70	32.40	3.6	7.8	18.52	32.55	20.06	29.68	18.52
63	375	400	35.33	1062	5	2	212	217	35	36	38	38	69%	86	22.88	17.70	31.96	3.6	7.8	18.52	32.55	20.06	29.39	18.52
63	375	400	35.33	1062	4	1	265	268	44	45	47	47	86%	85	24.31	17.71	25.86	3.6	7.8	18.53	32.58	20.07	25.08	18.53
63	375	400	35.33	1062	4	2	265	274	44	46	47	49	87%	85	24.31	17.71	25.31	3.6	7.8	18.53	32.58	20.07	24.67	18.53
63	375	400	35.33	1062	3	1	354	360	59	60	63	64	115%	82	26.70	17.71	19.29	3.6	7.8	18.53	32.58	20.06	19.87	18.53

Table D.3: ITERATION FOR HIGH LIMIT OF ACTUAL TEST COAL

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL +BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER +BIASED DISTR	MW /BURNER NOMINAL +MALDISTR	MW /BURNER +BIASED +MALDISTR	% BURNER LOAD (+)	Pf FIN %<75μm	PA FLOW /MILL kg/s UPPER CV	UPPER CV NOMINAL AS FIRED MJ/kg	UPPER CV LIMIT AS FIRED MJ/kg	UPPER INHERENT MOISTURE %	UPPER TOTAL MOISTURE NOMINAL	UPPER CV NOMINAL AIRDRIED MJ/kg	UPPER HIV NOMINAL AIRDRIED %	UPPER VOL NOMINAL AIRDRIED %	UPPER CV LIMIT AIRDRIED MJ/kg	UPPER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	292	48	49	51	52	93%	84	25.18	17.12	22.94	5.9	12.6	18.43	32.29	20.02	22.29	18.43
102	605	630	35.06	1725	5	1	345	348	58	58	61	62	111%	82	26.78	17.13	19.29	5.9	12.6	18.44	32.33	20.03	19.39	18.44
102	605	630	35.06	1725	5	2	345	353	58	59	61	62	113%	82	26.78	17.13	19.03	5.9	12.6	18.44	32.33	20.03	19.18	18.44
102	605	630	35.06	1725	4	1	431	436	72	73	76	77	139%	80	29.19	17.13	15.39	5.9	12.6	18.44	32.33	20.03	16.07	NO GO
102	605	630	35.06	1725	4	2	431	446	72	74	76	79	142%	80	29.19	17.13	15.06	5.9	12.6	18.44	32.33	20.03	15.77	NO GO
89	525	550	35.25	1489	6	2	248	252	41	42	44	45	81%	85	24.08	17.12	26.58	5.9	12.6	18.43	32.29	20.02	24.99	18.43
89	525	550	35.25	1489	5	1	298	300	50	50	53	53	96%	83	25.46	17.13	22.35	5.9	12.6	18.45	32.34	20.03	21.83	18.45
89	525	550	35.25	1489	5	2	298	304	50	51	53	54	97%	83	25.46	17.13	22.05	5.9	12.6	18.45	32.34	20.03	21.60	18.45
89	525	550	35.25	1489	4	1	372	376	62	63	66	67	120%	82	27.54	17.13	17.83	5.9	12.6	18.44	32.33	20.03	18.18	18.44
89	525	550	35.25	1489	4	2	372	385	62	64	66	68	123%	82	27.54	17.13	17.45	5.9	12.6	18.44	32.33	20.03	17.86	NO GO
80	475	500	35.37	1343	6	2	224	228	37	38	40	40	73%	85	23.40	17.11	29.46	5.9	12.6	18.42	32.27	20.02	27.01	18.42
80	475	500	35.37	1343	5	1	269	271	45	45	48	48	86%	84	24.65	17.12	24.76	5.9	12.6	18.43	32.28	20.02	23.66	18.43
80	475	500	35.37	1343	5	2	269	274	45	46	48	49	88%	84	24.65	17.12	24.43	5.9	12.6	18.43	32.28	20.02	23.42	18.43
80	475	500	35.37	1343	4	1	336	339	56	57	59	60	108%	82	26.52	17.13	19.77	5.9	12.6	18.44	32.32	20.03	19.79	18.44
80	475	500	35.37	1343	4	2	336	347	56	58	59	61	111%	82	26.52	17.13	19.35	5.9	12.6	18.44	32.32	20.03	19.44	18.44
72	425	450	35.40	1201	6	2	200	203	33	34	35	36	65%	86	22.73	17.13	33.00	5.9	12.6	18.45	32.34	20.03	29.36	18.45
72	425	450	35.40	1201	5	1	240	242	40	40	42	43	77%	85	23.85	17.13	27.71	5.9	12.6	18.44	32.32	20.03	25.80	18.44
72	425	450	35.40	1201	5	2	240	245	40	41	42	43	78%	85	23.85	17.13	27.34	5.9	12.6	18.44	32.32	20.03	25.54	18.44
72	425	450	35.40	1201	4	1	300	303	50	51	53	54	97%	83	25.53	17.12	22.10	5.9	12.6	18.43	32.30	20.02	21.64	18.43
72	425	450	35.40	1201	4	2	300	310	50	52	53	55	99%	83	25.53	17.12	21.63	5.9	12.6	18.43	32.30	20.02	21.27	18.43
72	425	450	35.40	1201	3	1	400	407	67	68	71	72	130%	81	28.32	17.13	16.49	5.9	12.6	18.44	32.33	20.03	17.04	NO GO
63	375	400	35.33	1062	6	2	177	180	29	30	31	32	57%	87	22.09	17.11	37.27	5.9	12.6	18.42	32.26	20.02	32.00	18.42
63	375	400	35.33	1062	5	1	212	214	35	36	38	38	68%	86	23.07	17.14	31.36	5.9	12.6	18.45	32.35	20.03	28.29	18.45
63	375	400	35.33	1062	5	2	212	217	35	36	38	38	69%	86	23.07	17.14	30.94	5.9	12.6	18.45	32.35	20.03	28.01	18.45
63	375	400	35.33	1062	4	1	265	268	44	45	47	47	86%	84	24.56	17.12	24.99	5.9	12.6	18.43	32.29	20.02	23.84	18.43
63	375	400	35.33	1062	4	2	265	274	44	46	47	49	87%	84	24.56	17.12	24.46	5.9	12.6	18.43	32.29	20.02	23.44	18.43
63	375	400	35.33	1062	3	1	354	360	59	60	63	64	115%	82	27.03	17.12	18.65	5.9	12.6	18.43	32.30	20.02	18.86	18.43

APPENDIX E
INTERMEDIATE GRADE COAL SELECTION

APPENDIX E: INTERMEDIATE GRADE COAL SELECTION

The determination of the characteristic values for the selection of the intermediate (called "spec." grade) coal to be ordered were done finally. No extremes (as in the lowest or highest possible) were of course calculated, since it was simply positioned midway between the low and high grade extremes according to CV value, as explained in Chapter 4.1. The iterative calculating spreadsheets were only used to check whether the actual test coal received would not exceed any of the limits according to the low and high criteria (as in Appendix C and D respectively) and to obtain similar guidelines for mill configurations (Table E.2 and Table E.1 respectively).

The following formulae are common to both the low and high criteria (Table E1 and E2). The consecutive columns in the applicable spreadsheets contain the following values or formulae: (See nomenclature for explanation of abbreviations or list of symbols.)

LOAD [%]

Five equal increments of load to be tested were entered over the span from the selected maximum to minimum loads.

USO [MW] = LOAD % / 100 x 593

593 MW is the nominal design MCR USO.

UNITS GENERATED [MW] = USO + 25

25 MW is the approximate nominal auxiliary electrical power consumption for one unit. This is not exactly true for all loads since certain auxiliary plant consume power directly proportional to the unit load (feed pumps, fans etc.). There are however other auxiliary power consumers that consume constant load (mills, CW pumps, lubricating and jacking oil pumps, etc.). The above approximation is adequate for this exercise since only an indication of UG is needed for operational purposes during testing, but USO is used in further calculations here.

EFFICIENCY [%]

Only monthly averages and seasonal trends of overall thermal efficiency values were available from STEP history for the calculations in these spreadsheets. Accurate values for a specific unit (vs. the whole station), steady load (vs. AGC), overall efficiencies per load for the whole unit (vs. boiler or turbine separately) etc. were not known at that point in time. Many of these were intended to be determined in this project.

BOILER LOAD [MW] = USO / EFFICIENCY x 100

MILLS i/s

The anticipated (some cases hypothetical) number of mills i/s were entered at each load. Where the number of mills was entered more than once, it was to cater for various combinations of mill biasing (see below).

MILLS BIASED

Often, one or two of the top mills are biased down to reduce the chances of metal temperature excursions, or a bottom mill can be biased up to improve evaporation. The remainder of the mills should make up the load difference to achieve the initial load set-point. The effect of biasing was brought into these calculations on each mill combination.

NOMINAL LOAD PER MILL [MW] = BOILER LOAD [MW] / AMOUNT OF MILLS IN SERVICE

LOAD PER MILL BIASED DOWN (-) [MW] = NOMINAL LOAD PER MILL [MW] x 0.967

(As in Table E2, Lower limit)

Tests were carried out prior to the main tests on the unit to ascertain the amount of mill load change (PA flow and feeder speed) due to a certain degree of biasing. The maximum percentage biasing available on these units range between 35 - 60 % (an unbiased or nominal mill setting is 50%). The maximum bias that would be applied to a mill during operation resulted in a load reduction of 3.3% (corresponding to a 35% down bias). This implies that the mill will be operating at 96.7% of its load setting.

From experience with Lethabo coal, it is too low a burner load that poses a danger in terms of loss of ignition during the combustion of low grade coal. Therefore the biasing up (+) of mills will be considered only at the calculation of the high grade coal qualities.

LOAD PER MILL BIASED UP (+) [MW] = (BOILER LOAD - LOAD PER MILL BIASED DOWN x AMOUNT OF MILLS BIASED DOWN) / (MILLS i/s - AMOUNT OF MILLS BIASED DOWN)
(As in Table E1, Higher limit).

The above simply calculates the resulting load of the remainder of the mills that would automatically pick up load due to the load reduction of the mills biased down. This has also been verified by testing.

NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] = NOMINAL LOAD PER MILL [MW] / 6
Six burners are served by one mill. This would be the load per burner when equal distribution of PA flow, pf flow and pf size occurs. (The ideal case, not found in practice.)

LOAD PER BURNER OF A DOWN BIASED MILL (-) WITH NORMAL DISTRIBUTION AMONGST BURNERS [MW] = LOAD OF A DOWN BIASED MILL [MW] / 6
(As in Table E2, Lower limit)

LOAD PER BURNER OF AN UP BIASED MILL (+) WITH NORMAL DISTRIBUTION AMONGST BURNERS [MW] = LOAD OF AN UP BIASED MILL [MW] / 6

(As in Table E1, Higher limit)

Results of tests performed at Lethabo on Units 1 and 3 were used to determine an order of magnitude for any mal-distribution of pf amongst burners for these furnaces[12]. These furnaces performed very well since the worst figures obtained for leanest and richest running burners compared very favourably to other furnaces in general. These figures amounted to -5,308 and +6,153 percent deviation from the average respectively, resulting in the factors for multiplying the nominal distribution burner loads below.

NOMINAL LOAD PER BURNER WITH LEAN MALDISTRIBUTION (-) [MW] = NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] x 0.94692

(As in Table E2, Lower limit)

NOMINAL LOAD PER BURNER WITH RICH MALDISTRIBUTION (+) [MW] = NOMINAL LOAD PER BURNER WITH NORMAL DISTRIBUTION [MW] x 1.06153

(As in Table E1, Higher limit)

LOAD PER BURNER OF A MILL BIASED DOWN (-) AND WITH LEAN MALDISTRIBUTION (-) [MW] = LOAD PER BURNER OF A MILL BIASED DOWN (-) AND WITH NORMAL DISTRIBUTION [MW] x 0.94692

(As in Table E2, Lower limit)

LOAD PER BURNER OF A MILL BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] = LOAD PER BURNER OF A MILL BIASED UP (+) AND WITH NORMAL DISTRIBUTION [MW] x 1.06153

(As in Table E1, Higher limit)

PERCENTAGE BURNER LOAD (+) = LOAD PER BURNER BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] / 56 x 100

(As in Table E1, Higher limit)

PERCENTAGE BURNER LOAD (-) = LOAD PER BURNER BIASED DOWN (-) AND WITH LEAN MALDISTRIBUTION (-) [MW] / 56 x 100

(As in Table E2, Lower limit)

The nominal load per burner for the Lethabo furnaces are 56 MW, based on 5 mills i/s at MCR.

PF FINENESS, % PASSING THROUGH A 75 µm SIEVE = -0.94523 x PA FLOW + 107.55111

The unit 1 mill performance since day one (with seasoned and established ball charge) was plotted as a scatter graph of pf fineness (percentage passing through a 75 µm sieve) as a function of PA flow (kg/s) (see Figure 4.1). A linear regression of these points produced a y = mx + c graph with values as above. This method was used to obtain a forecast of what the pf fineness would be at a certain PA flow. The pf fineness as variable was to be eliminated as much as possible in these tests, as explained in chapter 4.1.

PA FLOW [kg/s]

A base minimum value of PA flow (± 20 kg/s), within the mill operating range, was entered in all the rows of this column as the independent variable from which this automatic iteration was started. For a given PA flow, a percentage feeder speed is calculated from $y = mx + c$ (see figure 4.2)

$$PA = \%\ feeder\ speed \times 0.28571 + 17\ 1429$$

Then for this percentage feeder speed a coal flow is calculated also from a linear regression $y = mx + c$ (see figure 4.3)

$$\%\ feeder\ speed = Coal\ flow \times 0.9302$$

For this coal flow a nominal mill load [MW] can be calculated for a certain CV [MJ/kg]

$$Coal\ flow\ [kg/s] \times CV\ [MJ/kg] = mill\ load\ [MW]$$

Decreasing values of coal CV is then entered alternatively into the iteration formula automatically (this iteration column is not shown on the spreadsheet) and each time the PA flow will be increased in small increments of 0.01 up to a value where all the equations below are satisfied, with corresponding pf fineness. Extremes of burner loads etc. is also calculated automatically as in the equations of the columns above. The limiting factors are too high heat release per burner for the high CV coal and too low burner load resulting in loss of ignition for the low CV coal, where "NO GO" is flagged in the appropriate columns below where these limits are exceeded. Feasible combinations of mills in service for all coal qualities and loads can then be chosen where the expected pf fineness is as constant as possible, thus eliminating it as a variable, as much as is practically possible.

The following formulae apply to the high grade coal criteria only (Table E1):

UPPER CV NOMINAL AS FIRED [MJ/kg]
= MILL LOAD [MW] / ((PA FLOW - 17.1429) / 0.26577 x 2 x 3.6)
This equation is obtained from the y = mx + c type equations derived from the combined equations of figures 4.2 and 4.3 (see PA FLOW and the iteration explanation below). The 2 is to obtain the flow for both feeders and the 3.6 is to convert tons/h to kg/s.

UPPER CV LIMIT AS FIRED [MJ/kg] = UPPER CV NOMINAL AS FIRED [MJ/kg] / LOAD PER BURNER BIASED UP (+) AND WITH RICH MALDISTRIBUTION (+) [MW] x 56 (nominal burner load) x 1.25
In the above equation the nominal CV is simply scaled up by the ratio of the richest possible burner load to the nominal burner load and the

maximum percentage of overload (125%) permitted in a burner (estimated by the supplier after discussion) to obtain the maximum corresponding CV that could be tolerated by this combination of mills, load etc.

UPPER INHERENT MOISTURE [%] = -0.4074 x NOMINAL CV AS FIRED + 10.796

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

UPPER TOTAL MOISTURE [%] = -0.8888 x NOMINAL CV AS FIRED + 23.555

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

UPPER CV NOMINAL AIR DRIED [MJ/kg]

= UPPER CV NOMINAL AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)

Standard formula.

NOMINAL AIR DRIED HIV [%] = 3 x AIR DRIED CV - 23

This is a linear relationship obtained from the Burner stability diagram (Figure 4.4) to forecast HIV from air dried CV.

NOMINAL VOLATILES AIR DRIED [%] = NOMINAL AIR DRIED HIV [%] x 0.146 + 15.308

This value is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of HIV. This is not always true for Lethabo coal, since certain volatiles are inert (as discussed in Chapter 4.1). This is only done to obtain an approximate value for this parameter for the purposes of coal ordering.

UPPER CV LIMIT AIR DRIED [MJ/kg] = UPPER CV LIMIT AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)
Standard formula.

UPPER CV AIR DRIED CRITERIA := IF THE UPPER CV AIR DRIED LIMIT > NOMINAL UPPER AIR DRIED CV BY MORE THAN A 0.5 MARGIN (safety factor), PRINT THAT VALUE OF CV, OTHERWISE "NO GO"

The following formulae apply to the low grade coal criteria only (Table E2):

LOWER CV NOMINAL AS FIRED [MJ/kg]
= MILL LOAD [MW] / ((PA FLOW - 17.1429) / 0.26577 x 2 x 3.6)
This equation is obtained from the y = mx + c type equations derived from the combined equations of figures 4.2 and 4.3 (see PA FLOW and the iteration explanation below). The 2 is to obtain the flow for both feeders and the 3.6 is to convert tons/h to kg/s.

LOWER INHERENT MOISTURE [%] = -0.4074 x NOMINAL CV AS FIRED + 10.796

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

LOWER TOTAL MOISTURE [%] = -0.8888 x NOMINAL CV AS FIRED + 23.555

Only an indication of this value is needed. It is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of CV.

LOWER CV NOMINAL AIR DRIED [MJ/kg]

= LOWER CV NOMINAL AS FIRED [MJ/kg] x (100 - INHERENT MOISTURE) / (100 - TOTAL MOISTURE)

Standard formula.

LOWER CV LIMIT AIR DRIED [MJ/kg] = IF BURNER LOAD % < 50%, "NO GO"
IF BURNER LOAD % < 70%, 15 MJ/kg
IF BURNER LOAD % < 100%, 14.5 MJ/kg
IF BURNER LOAD % < 125%, 13.5 MJ/kg

The first three criteria are taken from the Burner Stability diagram (Figure 4.4). It emanates from the Lean Coal tests[3]. It prescribes that a Lethabo burner should never be operated below 50% load in order to maintain ignition, or only below 70% load if the coal CV is 15

MJ/kg or above (with the corresponding HIV minimum value, see below), etc. The 125% burner load is the maximum burner load permissible, obtained from the supplier, for the purposes of these tests.

LOWER HIV LIMIT [%] = IF BURNER LOAD % < 50%, "NO GO"
IF BURNER LOAD % < 70%, 22 %
IF BURNER LOAD % < 100%, 21 %
IF BURNER LOAD % < 125%, 19 %

Similar to the minimum permissible CV vs. burner load as above, this criteria is also taken from the Burner Stability diagram (Figure 4.4), emanating from the Lean Coal tests[3].

LOWER VOLATILE LIMIT AIR DRIED [%] = LOWER HIV LIMIT AIR DRIED [%] x 0.146 + 15.308

This value is determined from an average obtained from Lethabo coal statistics and expressed in a linear relationship as a function of HIV. This is not always true for Lethabo coal, since certain volatiles are inert (as discussed in Chapter 4.1). This is only done to obtain an approximate value for this parameter for the purposes of coal ordering.

LOWER VOLATILE LIMIT AS FIRED [%] = LOWER VOLATILE LIMIT AIR DRIED [%] x (100 - TOTAL MOISTURE) / (100 - INHERENT MOISTURE)

Standard formula.

LOWER CV AIR DRIED CRITERIA := IF THE LOWER CV NOMINAL AIR DRIED $\geq$ LOWER AIR DRIED CV LIMIT, PRINT THAT VALUE OF CV, OTHERWISE "NO GO"

Table E.1: ITERATION FOR THE HIGHER LIMIT OF THE ACTUAL SPEC GRADE TEST COAL

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL +BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER +BIASED DISTR	MW /BURNER NOMINAL +MALDISTR	MW /BURNER +BIASED +MALDISTR	% BURNER LOAD (+)	Pf FIN %<75µm	PA FLOW /MILL kg/s UPPER CV	UPPER CV NOMINAL AS FIRED MJ/kg	UPPER CV LIMIT AS FIRED MJ/kg	UPPER INHERENT MOISTURE %	UPPER TOTAL MOISTURE NOMINAL	UPPER CV NOMINAL AIRDRIED MJ/kg	UPPER HIV NOMINAL AIRDRIED %	UPPER VOL NOMINAL AIRDRIED %	UPPER CV LIMIT AIRDRIED MJ/kg	UPPER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	292	48	49	51	52	93%	83	26.33	14.97	20.07	3.9	10.7	16.12	25.35	19.01	20.46	16.12
102	605	630	35.06	1725	5	1	345	348	58	58	61	62	111%	81	28.16	14.98	16.87	3.9	10.7	16.13	25.38	19.01	17.74	16.13
102	605	630	35.06	1725	5	2	345	353	58	59	61	62	113%	81	28.16	14.98	16.64	3.9	10.7	16.13	25.38	19.01	17.54	16.13
102	605	630	35.06	1725	4	1	431	436	72	73	76	77	139%	78	30.92	14.98	13.45	3.9	10.7	16.12	25.36	19.01	14.63	NO GO
102	605	630	35.06	1725	4	2	431	446	72	74	76	79	142%	78	30.92	14.98	13.17	3.9	10.7	16.12	25.36	19.01	14.36	NO GO
89	525	550	35.25	1489	6	2	248	252	41	42	44	45	81%	84	25.07	14.98	23.26	3.9	10.7	16.12	25.37	19.01	23.02	16.12
89	525	550	35.25	1489	5	1	298	300	50	50	53	53	96%	82	26.66	14.97	19.53	3.9	10.7	16.12	25.35	19.01	20.02	16.12
89	525	550	35.25	1489	5	2	298	304	50	51	53	54	97%	82	26.66	14.97	19.27	3.9	10.7	16.12	25.35	19.01	19.80	16.12
89	525	550	35.25	1489	4	1	372	376	62	63	66	67	120%	80	29.03	14.98	15.59	3.9	10.7	16.13	25.38	19.01	16.60	16.13
89	525	550	35.25	1489	4	2	372	385	62	64	66	68	123%	80	29.03	14.98	15.26	3.9	10.7	16.13	25.38	19.01	16.30	16.13
80	475	500	35.37	1343	6	2	224	228	37	38	40	40	73%	85	24.29	14.98	25.79	3.9	10.7	16.13	25.38	19.01	24.96	16.13
80	475	500	35.37	1343	5	1	269	271	45	45	48	48	86%	83	25.72	14.98	21.67	3.9	10.7	16.12	25.37	19.01	21.77	16.12
80	475	500	35.37	1343	5	2	269	274	45	46	48	49	88%	83	25.72	14.98	21.38	3.9	10.7	16.12	25.37	19.01	21.53	16.12
80	475	500	35.37	1343	4	1	336	339	56	57	59	60	108%	81	27.87	14.97	17.28	3.9	10.7	16.12	25.35	19.01	18.10	16.12
80	475	500	35.37	1343	4	2	336	347	56	58	59	61	111%	81	27.87	14.97	16.91	3.9	10.7	16.12	25.35	19.01	17.77	16.12
72	425	450	35.40	1201	6	2	200	203	33	34	35	36	65%	85	23.54	14.96	28.82	3.9	10.7	16.11	25.32	19.00	27.15	16.11
72	425	450	35.40	1201	5	1	240	242	40	40	42	43	77%	84	24.81	14.98	24.24	3.9	10.7	16.13	25.38	19.01	23.78	16.13
72	425	450	35.40	1201	5	2	240	245	40	41	42	43	78%	84	24.81	14.98	23.92	3.9	10.7	16.13	25.38	19.01	23.53	16.13
72	425	450	35.40	1201	4	1	300	303	50	51	53	54	97%	82	26.73	14.98	19.33	3.9	10.7	16.12	25.36	19.01	19.85	16.12
72	425	450	35.40	1201	4	2	300	310	50	52	53	55	99%	82	26.73	14.98	18.92	3.9	10.7	16.12	25.36	19.01	19.51	16.12
72	425	450	35.40	1201	3	1	400	407	67	68	71	72	130%	79	29.92	14.98	14.43	3.9	10.7	16.13	25.38	19.01	15.54	NO GO
63	375	400	35.33	1062	6	2	177	180	29	30	31	32	57%	86	22.80	14.96	32.59	3.9	10.7	16.10	25.31	19.00	29.72	16.10
63	375	400	35.33	1062	5	1	212	214	35	36	38	38	68%	85	23.93	14.96	27.38	3.9	10.7	16.11	25.32	19.01	26.12	16.11
63	375	400	35.33	1062	5	2	212	217	35	36	38	38	69%	85	23.93	14.96	27.02	3.9	10.7	16.11	25.32	19.01	25.86	16.11
63	375	400	35.33	1062	4	1	265	268	44	45	47	47	86%	83	25.62	14.98	21.87	3.9	10.7	16.12	25.36	19.01	21.93	16.12
63	375	400	35.33	1062	4	2	265	274	44	46	47	49	87%	83	25.62	14.98	21.40	3.9	10.7	16.12	25.36	19.01	21.55	16.12
63	375	400	35.33	1062	3	1	354	360	59	60	63	64	115%	81	28.44	14.98	16.32	3.9	10.7	16.13	25.39	19.01	17.25	16.13

Table E.2: ITERATION FOR THE LOWER LIMIT OF THE ACTUAL SPEC GRADE TEST COAL

LOAD %	USO MW	UNITS GEN MW	EFFICIENCY %	BLR LOAD MW	MILLS I/S	MILLS BIASED	LOAD /MILL NOMINAL MW	LOAD /MILL -BIASED MW	MW /BURNER NOMINAL DISTR	MW /BURNER -BIASED DISTR	MW /BURNER NOMINAL -MALDISTR	MW /BURNER -BIASED -MALDISTR	% BURNER LOAD (-)	Pf FIN %<75µm	PA FLOW /MILL kg/s LOWER CV	LOWER CV NOMINAL AS FIRED MJ/kg	LOWER INHERENT MOISTURE %	LOWER TOTAL MOISTURE NOMINAL	LOWER CV NOMINAL AIRDRIED MJ/kg	LOWER CV LIMIT AIRDRIED MJ/kg	LOWER HIV LIMIT AIRDRIED MJ/kg	LOWER VOL LIMIT AIRDRIED %	LOWER VOL LIMIT AS FIRED *%	LOWER CV AIRDRIED CRITERIA
102	605	630	35.06	1725	6	2	288	278	48	46	45	44	79%	83	26.33	14.97	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
102	605	630	35.06	1725	5	1	345	334	58	56	54	53	95%	81	28.16	14.98	3.9	10.7	16.13	14.5	21	18.37	17.07	16.13
102	605	630	35.06	1725	5	2	345	334	58	56	54	53	95%	81	28.16	14.98	3.9	10.7	16.13	14.5	21	18.37	17.07	16.13
102	605	630	35.06	1725	4	1	431	417	72	70	68	66	119%	78	30.92	14.98	3.9	10.7	16.12	13.5	19	18.08	16.80	16.12
102	605	630	35.06	1725	4	2	431	417	72	70	68	66	119%	78	30.92	14.98	3.9	10.7	16.12	13.5	19	18.08	16.80	16.12
89	525	550	35.25	1489	6	2	248	240	41	40	39	38	68%	84	25.07	14.98	3.9	10.7	16.12	15.0	22	18.52	17.21	16.12
89	525	550	35.25	1489	5	1	298	288	50	48	47	45	82%	82	26.66	14.97	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
89	525	550	35.25	1489	5	2	298	288	50	48	47	45	82%	82	26.66	14.97	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
89	525	550	35.25	1489	4	1	372	360	62	60	59	57	102%	80	29.03	14.98	3.9	10.7	16.13	13.5	19	18.08	16.80	16.13
89	525	550	35.25	1489	4	2	372	360	62	60	59	57	102%	80	29.03	14.98	3.9	10.7	16.13	13.5	19	18.08	16.80	16.13
80	475	500	35.37	1343	6	2	224	216	37	36	35	34	62%	85	24.29	14.98	3.9	10.7	16.13	15.0	22	18.52	17.21	16.13
80	475	500	35.37	1343	5	1	269	260	45	43	42	41	74%	83	25.72	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
80	475	500	35.37	1343	5	2	269	260	45	43	42	41	74%	83	25.72	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
80	475	500	35.37	1343	4	1	336	325	56	54	53	51	92%	81	27.87	14.97	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
80	475	500	35.37	1343	4	2	336	325	56	54	53	51	92%	81	27.87	14.97	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
72	425	450	35.40	1201	6	2	200	194	33	32	32	31	55%	85	23.54	14.96	3.9	10.7	16.11	15.0	22	18.52	17.21	16.11
72	425	450	35.40	1201	5	1	240	232	40	39	38	37	66%	84	24.81	14.98	3.9	10.7	16.13	15.0	22	18.52	17.21	16.13
72	425	450	35.40	1201	5	2	240	232	40	39	38	37	66%	84	24.81	14.98	3.9	10.7	16.13	15.0	22	18.52	17.21	16.13
72	425	450	35.40	1201	4	1	300	290	50	48	47	46	83%	82	26.73	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
72	425	450	35.40	1201	4	2	300	290	50	48	47	46	83%	82	26.73	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
72	425	450	35.40	1201	3	1	400	387	67	65	63	61	110%	79	29.92	14.98	3.9	10.7	16.13	13.5	19	18.08	16.80	16.13
63	375	400	35.33	1062	6	2	177	171	29	29	28	27	49%	86	22.80	14.96	3.9	10.7	16.10	NO GO	NO GO	#VALUE!	#VALUE!	#N/A!
63	375	400	35.33	1062	5	1	212	205	35	34	34	32	58%	85	23.93	14.96	3.9	10.7	16.11	15.0	22	18.52	17.21	16.11
63	375	400	35.33	1062	5	2	212	205	35	34	34	32	58%	85	23.93	14.96	3.9	10.7	16.11	15.0	22	18.52	17.21	16.11
63	375	400	35.33	1062	4	1	265	257	44	43	42	41	73%	83	25.62	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
63	375	400	35.33	1062	4	2	265	257	44	43	42	41	73%	83	25.62	14.98	3.9	10.7	16.12	14.5	21	18.37	17.07	16.12
63	375	400	35.33	1062	3	1	354	342	59	57	56	54	97%	81	28.44	14.98	3.9	10.7	16.13	14.5	21	18.37	17.07	16.13

APPENDIX F
TEST DATA : LOW GRADE COAL

APPENDIX F: LOW GRADE COAL TEST DATA

Table F.1: LOW GRADE COAL 630 MW TESTS

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	3.279	2.833	2.675	2.182	1.770	1.064
O2 A/HTR OUTL AVG DRY	% vol	4.714	4.173	3.902	3.385	2.841	1.245
O2 ID DISCHARGE AVG	% vol	5.003	4.596	4.428	4.015	3.621	3.022
O2 ECON DRY	% vol	3.204	2.843	2.629	2.267	1.895	.966
O2 ID DISCHARGE DRY	% vol	4.983	4.453	4.131	3.555	2.926	1.145
CO2 ID AVG DRY	% vol	13.326	13.847	14.061	14.452	14.988	16.351
CO2 (THEORETIC MAX)	% mass	26.968	26.975	26.970	26.876	27.020	26.935
CO2 (OSTWALD) DRY	% vol	14.392	14.884	15.168	15.626	16.281	17.829
O2 (OSTWALD)	% vol	6.241	5.677	5.438	4.946	4.450	2.891
SO2 ID AVG DRY	ppm	835.452	876.107	903.621	932.936	965.298	1036.890
NOx ID AVG DRY	ppm	634.962	647.810	644.342	678.583	691.418	661.170
CO (CODEL) AVG DRY	ppm	22.346	28.445	17.796	23.286	18.577	165.914
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	840.970	841.010	841.250	841.510	841.850	842.100
AMBIENT TEMPERATURE	°C	20.140	20.350	19.750	18.700	16.450	15.430
RELATIVE HUMIDITY	%	34.275	31.290	30.330	31.110	34.940	33.265

Table F.1: <u>LOW GRADE COAL 630 MW TESTS</u> (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
DEWPOINT TEMPERATURE	°C	-25.015	-24.600	-24.460	-24.625	-25.460	-25.580
FD AIR INLET T.(Tdb)	°C	34.381	34.328	33.842	33.356	32.650	31.944
A/HTR GAS OUTLET AVG	°C	146.170	147.332	147.685	148.289	149.063	150.751
NO-LEAK A/HTR OUTL T.	°C	156.085	155.872	155.789	155.264	154.859	152.353
DRY FLUEGAS HEAT LOSS	MW	89.538	87.098	85.975	83.577	81.506	74.326
ID DISCHARGE TEMP AVG	°C	137.430	138.420	138.708	138.398	138.212	138.461
OPACITY	%	34.494	32.061	30.775	29.639	27.114	24.862
MOISTURE ATMOSPHERIC	kg/s	4.553	4.418	4.339	4.204	4.065	3.719
MOISTURE (COAL)	kg/s	8.248	8.649	7.944	8.147	8.385	9.054
MOISTURE (COMBUSTION)	kg/s	21.934	21.554	21.779	21.354	22.011	21.161
MOISTURE (HOPPER)	kg/s	3.734	3.713	3.758	3.700	3.599	3.531
MOISTURE TO FLY-ASH	kg/s	5.776	5.874	5.669	5.934	6.394	6.704
NETT MOISTURE	kg/s	32.692	32.461	32.151	31.471	31.666	30.760
AIR FLOW A.FOIL TOTAL	kg/s	596.884	584.087	572.858	556.608	534.936	513.731
AIR FLOW TOTAL	kg/s	648.917	629.711	618.326	599.019	579.218	529.745
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	21.942	21.942	21.942	21.942	21.942	21.942
AIR HTR LEAKAGE	kg/s	59.059	49.603	46.153	38.636	31.146	8.082
ESP AIR LEAKAGE	kg/s	40.383	37.679	36.041	33.289	30.653	23.626
COMBUSTION AIR	kg/s	589.858	580.108	572.173	560.383	548.072	521.663
THEORETICAL AIR	kg/s	531.404	533.260	532.252	531.641	530.366	529.479
STOICHIOM. AIR	kg/s	531.410	533.262	532.263	531.644	530.366	529.479
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000

Table F.1: LOW GRADE COAL 630 MW TESTS (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
CALCULATED FURNACE O2	% mass	2.294	1.870	1.615	1.187	.748	-.347
EXCESS AIR	kg/s	58.454	46.848	39.921	28.741	17.706	-7.816
ECON GAS(DAF)	kg/s	675.142	665.487	657.368	645.436	634.293	607.700
FURNACE GAS DRY	kg/s	640.142	630.487	622.368	610.436	599.293	572.700
TOTAL A/HTR GAS(DAF)	kg/s	735.701	716.589	705.020	685.572	666.939	617.282
ID GAS (DAF)	kg/s	776.084	754.268	741.062	718.862	697.592	640.908
ID GAS (CHEM. ANAL.)	kg/s	774.590	752.770	739.573	717.364	696.091	639.408
ID GAS (BALANCE TECH)	kg/s	776.099	754.272	741.089	718.869	697.589	640.910

VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION

THEORETICAL CO2	kg/100kg	144.308	143.858	145.996	143.565	139.717	137.817
BACK-END N2	kg/100kg	553.378	531.431	531.663	508.602	476.584	429.446
BACK-END O2	kg/100kg	38.627	33.152	30.722	25.236	19.446	6.823
BACK-END NOx	kg/100kg	.462	.452	.449	.452	.431	.369
BACK-END SO2	kg/100kg	1.297	1.306	1.345	1.326	1.284	1.237
BACK-END CO	kg/100kg	.015	.019	.012	.014	.011	.087
BACK-END CO2	kg/100kg	142.084	141.778	143.835	141.114	136.991	134.017
TOTAL GAS	kg/100kg	735.861	708.137	708.027	676.744	634.746	571.979
MOLE MASS (mixture)	kJ/kmolK	3037.481	3043.853	3046.078	3050.148	3056.342	3071.305

COAL QUANTITY AND QUALITY

COAL VOLUME FLOW	m3/h	384.420	382.271	384.800	383.526	381.013	379.435
COAL DENSITY	TON/m3	.988	1.003	.979	.997	1.038	1.063
COAL MASS FLOW	kg/s	105.468	106.515	104.670	106.225	109.901	112.051

Table F.1: <u>LOW GRADE COAL 630 MW TESTS</u> (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	3.900	4.000	3.700	4.100	3.700	3.600
ASH	%	43.400	43.800	42.900	44.100	46.100	47.700
VOLATILE MATTER	%	16.000	15.400	15.900	15.600	14.600	14.300
FIXED CARBON(BY DIFF)	%	36.700	36.800	37.500	36.200	35.600	34.400
CARBON	%	41.630	41.470	42.570	41.050	39.010	38.160
HYDROGEN	%	2.430	2.370	2.430	2.340	2.340	2.220
NITROGEN	%	.820	.900	.940	.880	.700	.830
TOTAL SULPHUR	%	.530	.470	.440	.870	.570	.540
CARBONATE (CO2)	%	1.730	1.180	1.280	1.190	1.060	1.170
OXYGEN (BY DIFF)	%	5.560	5.810	5.740	5.470	6.520	5.780
GROSS CV	MJ/kg	15.570	15.620	15.930	15.320	14.860	14.400
SURFACE MOISTURE	%	4.080	4.290	4.040	3.720	4.080	4.650
INHERENT MOISTURE	%	3.740	3.830	3.550	3.950	3.550	3.430
TOTAL MOISTURE	%	7.820	8.120	7.590	7.670	7.630	8.080
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	7.820	8.120	7.590	7.670	7.630	8.080
ASH (BY DIFF)	%	42.213	42.324	42.164	42.958	43.516	44.189
VOLATILE MATTER	%	15.322	14.713	15.234	14.996	13.982	13.611
FIXED CARBON(BY DIFF)	%	34.645	34.843	35.012	34.376	34.872	34.120
CARBON	%	39.384	39.261	39.845	39.181	38.131	37.613
HYDROGEN	%	2.290	2.259	2.291	2.252	2.247	2.183
NITROGEN	%	.785	.860	.901	.846	.670	.790
TOTAL SULPHUR	%	.527	.497	.484	.691	.546	.530

Table F.1: LOW GRADE COAL 630 MW TESTS (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
CARBONATE (CO2)	%	1.657	1.127	1.226	1.144	1.015	1.114
OXYGEN	%	5.324	5.551	5.500	5.258	6.244	5.502
GCVv (AS RECD, BOMB)	MJ/kg	14.935	14.950	15.287	14.750	14.254	13.731
GCVv (DAILY AVERAGE)	MJ/kg	14.651	14.651	14.651	14.651	14.651	14.651
GCVv (BIAS.DAILY AVE)	MJ/kg	14.793	14.800	14.969	14.700	14.452	14.191
NCVp (CALCed, DULONG)	MJ/kg	15.866	15.776	16.024	15.768	15.393	15.126
HEAT IN VOLATILES	%	21.545	21.177	22.539	21.178	17.258	15.960
CARBON IN DUST	%	1.400	1.300	1.400	1.600	1.700	2.300
CARBON IN ROUGH ASH	%	1.400	1.300	.900	.500	1.400	1.500
MEAN CARBON IN ASH	%	1.400	1.300	1.364	1.521	1.678	2.242
MILLING PLANT							
NUMBER OF MILLS I/S	#	6.000	6.000	6.000	6.000	6.000	6.000
MILL CONFIGURATION	#	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF
PF FINENESS (%<75µm)	%	81.240	76.070	81.600	78.830	73.230	81.610
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	13.568	13.405	12.579	12.356	11.431	10.343
FEED FLOW (ORIFICE)	kg/s	491.901	494.552	492.444	495.055	494.364	494.547
TOTAL FEED FLOW	kg/s	505.469	507.957	505.023	507.411	505.795	504.890
MAIN STEAM TEMP.	°C	540.967	539.800	538.568	537.580	537.730	539.174
REHEAT STEAM TEMP.	°C	535.600	535.696	535.629	535.666	535.767	535.800
FINAL FEEDW. TEMP.	°C	245.210	245.169	244.950	244.581	244.412	244.037

Table F.1: LOW GRADE COAL 630 MW TESTS (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	20.906	21.112	20.994	20.450	19.756	18.496
CW OUTLET TEMP.(T2)	°C	36.263	36.521	36.239	35.757	34.890	33.545
CONDENSATE TEMP.	°C	39.926	40.157	39.890	39.418	38.564	37.345
BACKPRESS. (AVERAGE)	kPa	5.267	5.338	5.294	5.122	4.871	4.494
CW PUMPS I/S (WEST)	#	4.000	4.000	4.000	4.000	4.000	4.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	628.726	629.270	625.900	628.450	625.547	624.586
UNIT CONSUMPTION	MW	26.085	25.883	25.742	25.465	25.207	25.056
REACTIVE LOAD	MVAR	186.613	193.918	178.622	202.580	190.417	208.800
WORKS POWER / USO	%	4.328	4.290	4.289	4.223	4.199	4.179
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	38.259	37.893	37.509	38.486	38.324	38.967
EFF. GCVv (DAILY AVE)	%	39.001	38.665	39.136	38.745	37.285	36.520
EFF. GCVv(DAILY BIAS)	%	38.626	38.275	38.306	38.615	37.798	37.704
EFF. NCVp (CALCed)	%	36.013	35.907	35.782	36.001	35.488	35.373
STEP FACTOR	%	98.930	99.104	99.179	99.217	99.171	99.082
TOTAL ACCOUNTED LOSS	%	1.070	.897	.821	.782	.830	.918
UNACCOUNTED LOSSES	%	.000	-.000	.000	.001	-.001	.000
STEP LOSSES							
CARBON IN REFUSE	%	.251	.159	.210	.370	.565	.877
DRY FLUE GAS	%	.328	.276	.132	-.046	-.150	-.323

Table F.1: LOW GRADE COAL 630 MW TESTS (Monday, 2nd May 1994)

PARAMETER	UNITS	630/20.0/14h00	630/17.5/15h30	630/15.0/16h30	630/12.5/17h30	630/10.0/18h45	630/7.50/20h00
H2 & FUEL MOISTURE	%	.007	.012	.001	-.008	-.004	.003
MAIN STEAM TEMP.	%	-.112	-.096	-.075	-.057	-.060	-.086
REHEAT STEAM TEMP.	%	-.014	-.017	-.015	-.016	-.018	-.019
CONDENSER BACKPRESS.	%	-.171	-.172	-.166	-.166	-.162	-.148
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.004	-.002	-.003	.011	.009	.017
WORKS POWER	%	-.109	-.158	-.156	-.200	-.246	-.296

Table F.2: <u>LOW GRADE COAL 550 MW TESTS</u> (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	4.074	3.859	3.320	2.823	2.161	1.220
O2 A/HTR OUTL AVG DRY	% vol	5.060	4.682	4.343	3.933	3.253	2.243
O2 ID DISCHARGE AVG	% vol	6.001	5.818	5.228	4.775	4.101	3.269
O2 ECON DRY	% vol	4.187	3.726	3.328	2.830	2.128	1.259
O2 ID DISCHARGE DRY	% vol	5.538	5.106	4.726	4.215	3.442	2.399
CO2 ID AVG DRY	% vol	12.975	13.439	13.763	13.847	14.564	15.588
CO2 (THEORETIC MAX)	% mass	26.742	27.046	27.113	26.710	26.945	27.070
CO2 (OSTWALD) DRY	% vol	13.784	14.343	14.726	14.933	15.771	16.808
O2 (OSTWALD)	% vol	6.502	6.171	5.857	5.510	4.867	3.833
SO2 ID AVG DRY	ppm	826.153	841.938	889.668	920.400	959.972	1052.994
NOx ID AVG DRY	ppm	659.567	686.384	731.108	740.096	730.284	644.039
CO (CODEL) AVG DRY	ppm	13.559	7.858	30.481	15.417	22.211	313.694
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	843.950	843.870	843.820	843.390	842.760	842.440
AMBIENT TEMPERATURE	°C	8.895	12.380	15.195	18.140	19.600	19.910
RELATIVE HUMIDITY	%	43.100	52.245	33.040	24.750	22.095	22.190
DEWPOINT TEMPERATURE	°C	-31.300	-31.360	-31.190	-30.325	-29.100	-28.895
FD AIR INLET T.(Tdb)	°C	25.339	28.150	30.982	33.521	35.086	35.591

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
A/HTR GAS OUTLET AVG	°C	140.914	143.350	145.786	149.092	152.280	155.822
NO-LEAK A/HTR OUTL T.	°C	146.969	149.798	152.470	156.243	159.378	161.840
DRY FLUEGAS HEAT LOSS	MW	80.408	78.934	77.375	76.170	74.316	72.377
ID DISCHARGE TEMP AVG	°C	129.604	130.469	131.338	133.813	135.477	137.838
OPACITY	%	30.528	28.981	27.806	26.196	23.543	20.788
MOISTURE ATMOSPHERIC	kg/s	4.081	3.981	3.894	3.786	3.633	3.444
MOISTURE (COAL)	kg/s	8.115	8.412	8.580	8.339	8.229	8.678
MOISTURE (COMBUSTION)	kg/s	19.088	19.774	19.295	18.884	18.566	19.173
MOISTURE (HOPPER)	kg/s	3.841	3.840	3.804	3.654	3.723	3.791
MOISTURE TO FLY-ASH	kg/s	5.290	5.293	5.460	6.143	5.826	5.520
NETT MOISTURE	kg/s	29.834	30.715	30.113	28.519	28.325	29.566
AIR FLOW A.FOIL TOTAL	kg/s	543.455	541.434	509.376	499.939	477.325	452.501
AIR FLOW TOTAL	kg/s	581.508	567.180	554.795	539.328	517.497	490.468
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	21.942	21.942	21.942	21.942	21.942	21.942
AIR HTR LEAKAGE	kg/s	32.409	33.869	34.506	35.607	33.621	26.896
ESP AIR LEAKAGE	kg/s	39.860	37.971	36.118	33.610	30.090	26.282
COMBUSTION AIR	kg/s	549.099	533.311	520.289	503.721	483.877	463.572
THEORETICAL AIR	kg/s	470.621	469.753	468.970	466.977	466.231	467.257
STOICHIOM. AIR	kg/s	470.621	469.753	468.970	466.977	466.231	467.257
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	3.309	2.759	2.283	1.689	.844	-.184
EXCESS AIR	kg/s	78.478	63.558	51.319	36.744	17.645	-3.686

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
ECON GAS(DAF)	kg/s	627.183	613.503	600.888	583.567	562.791	544.887
FURNACE GAS DRY	kg/s	592.183	578.503	565.888	548.567	527.791	509.887
TOTAL A/HTR GAS(DAF)	kg/s	661.091	648.872	636.894	620.675	597.912	573.283
ID GAS (DAF)	kg/s	700.952	686.842	673.012	654.285	628.002	599.565
ID GAS (CHEM. ANAL.)	kg/s	699.452	685.342	671.512	652.785	626.503	598.065
ID GAS (BALANCE TECH)	kg/s	700.952	686.842	673.012	654.284	628.004	599.567
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	140.781	139.493	137.744	130.961	135.949	137.553
BACK-END N2	kg/100kg	556.582	532.799	514.452	487.866	480.932	451.666
BACK-END O2	kg/100kg	43.292	38.226	34.141	28.725	23.109	15.127
BACK-END NOx	kg/100kg	.483	.482	.495	.473	.460	.381
BACK-END SO2	kg/100kg	1.293	1.262	1.287	1.256	1.290	1.329
BACK-END CO	kg/100kg	.009	.005	.019	.009	.013	.173
BACK-END CO2	kg/100kg	139.488	138.367	136.746	129.792	134.493	135.205
TOTAL GAS	kg/100kg	741.147	711.140	687.140	648.121	640.297	603.882
MOLE MASS (mixture)	kJ/kmolK	3034.044	3039.812	3043.657	3043.075	3051.613	3064.152
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	324.500	325.035	320.420	329.812	324.054	324.566
COAL DENSITY	TON/m3	1.049	1.070	1.100	1.102	1.090	1.101
COAL MASS FLOW	kg/s	94.577	96.583	97.944	100.951	98.080	99.285

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6^{th} May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	2.600	2.700	2.900	2.400	2.400	2.600
ASH	%	45.300	44.400	45.100	49.200	48.100	45.100
VOLATILE MATTER	%	14.600	14.700	14.300	14.500	14.100	14.400
FIXED CARBON(BY DIFF)	%	37.500	38.200	37.700	33.900	35.400	37.900
CARBON	%	42.080	41.350	40.270	36.300	39.260	40.270
HYDROGEN	%	2.410	2.446	2.350	2.230	2.260	2.310
NITROGEN	%	.690	.800	.750	.610	.650	.700
TOTAL SULPHUR	%	.880	.440	.530	2.120	.470	.850
CARBONATE (CO2)	%	1.050	1.010	1.060	1.110	1.070	1.140
OXYGEN (BY DIFF)	%	4.990	6.840	7.040	6.030	5.790	7.030
GROSS CV	MJ/kg	15.610	15.980	15.690	13.790	14.610	15.840
SURFACE MOISTURE	%	6.140	6.180	6.030	6.000	6.140	6.300
INHERENT MOISTURE	%	2.440	2.530	2.730	2.260	2.250	2.440
TOTAL MOISTURE	%	8.580	8.710	8.760	8.260	8.390	8.740
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	8.580	8.710	8.760	8.260	8.390	8.740
ASH (BY DIFF)	%	43.643	42.260	42.488	45.176	44.683	42.437
VOLATILE MATTER	%	13.681	13.768	13.414	13.610	13.214	13.470
FIXED CARBON(BY DIFF)	%	34.095	35.262	35.338	32.954	33.713	35.353
CARBON	%	38.422	38.070	37.593	35.742	37.103	37.540
HYDROGEN	%	2.223	2.239	2.196	2.140	2.153	2.174
NITROGEN	%	.647	.749	.704	.573	.609	.655
TOTAL SULPHUR	%	.826	.619	.662	1.408	.634	.811
CARBONATE (CO2)	%	.984	.946	.994	1.042	1.003	1.066

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
OXYGEN	%	4.676	6.406	6.604	5.660	5.426	6.576
GCVv (AS RECD, BOMB)	MJ/kg	14.652	14.993	14.743	12.962	13.713	14.841
GCVv (DAILY AVERAGE)	MJ/kg	14.317	14.317	14.317	14.317	14.317	14.317
GCVv (BIAS.DAILY AVE)	MJ/kg	14.485	14.655	14.530	13.640	14.015	14.579
NCVp (CALCed, DULONG)	MJ/kg	15.465	15.346	15.134	14.516	14.917	15.104
HEAT IN VOLATILES	%	21.298	20.459	18.936	14.017	16.857	19.440
CARBON IN DUST	%	.800	.700	.600	.700	.900	1.400
CARBON IN ROUGH ASH	%	.500	.700	.600	.400	.300	.200
MEAN CARBON IN ASH	%	.778	.700	.600	.678	.857	1.314
MILLING PLANT							
NUMBER OF MILLS I/S	#	6.000	6.000	6.000	6.000	6.000	6.000
MILL CONFIGURATION	#	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF
PF FINENESS (%<75μm)	%	80.440	80.380	83.790	82.430	83.940	82.870
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	13.628	12.484	11.825	10.946	8.959	6.553
FEED FLOW (ORIFICE)	kg/s	423.305	427.617	426.643	429.750	433.978	439.118
TOTAL FEED FLOW	kg/s	436.933	440.101	438.468	440.696	442.937	445.671
MAIN STEAM TEMP.	°C	541.668	539.595	538.714	537.939	537.086	538.396
REHEAT STEAM TEMP.	°C	535.800	535.555	535.473	535.609	535.261	535.209
FINAL FEEDW. TEMP.	°C	238.300	238.300	238.300	238.300	238.279	237.763

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	12.858	11.198	14.781	16.895	18.075	18.567
CW OUTLET TEMP.(T2)	°C	29.860	28.154	31.718	34.268	35.075	35.504
CONDENSATE TEMP.	°C	31.988	30.420	33.955	33.991	37.336	37.093
BACKPRESS. (AVERAGE)	kPa	3.414	3.086	3.837	4.386	4.698	4.824
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	550.333	550.417	550.267	550.467	551.067	550.467
UNIT CONSUMPTION	MW	25.217	25.173	24.993	24.735	24.541	24.405
REACTIVE LOAD	MVAR	189.588	181.965	195.304	208.240	194.854	192.613
WORKS POWER / USO	%	4.802	4.793	4.758	4.705	4.661	4.639
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	37.895	36.272	36.376	40.177	39.147	35.701
EFF. GCVv (DAILY AVE)	%	38.780	37.983	37.458	36.374	37.495	37.007
EFF. GCVv(DAILY BIAS)	%	38.333	37.108	36.909	38.181	38.303	36.342
EFF. NCVp (CALCed)	%	35.902	35.438	35.438	35.877	35.987	35.080
STEP FACTOR	%	99.081	99.176	99.199	99.218	99.119	98.945
TOTAL ACCOUNTED LOSS	%	.919	.823	.801	.782	.881	1.055
UNACCOUNTED LOSSES	%	-.000	.000	.000	.000	.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	-.080	-.089	-.130	-.138	.030	.379
DRY FLUE GAS	%	.165	.113	.085	.096	-.010	-.115
H2 & FUEL MOISTURE	%	-.007	-.000	.009	.020	.026	.036

Table F.2: LOW GRADE COAL 550 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	550/27.0/09h15	550/24.0/08h00	550/21.00/10h1	550/17.5/11h15	550/14.0/12h30	550/10/13h30
MAIN STEAM TEMP.	%	-.120	-.093	-.078	-.064	-.047	-.072
REHEAT STEAM TEMP.	%	-.019	-.013	-.011	-.015	-.006	-.005
CONDENSER BACKPRESS.	%	.014	-.013	.022	.038	.044	.045
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.010	-.010	-.010	-.010	-.008	.004
WORKS POWER	%	.081	.033	.020	-.039	-.042	-.112

Table F.3: LOW GRADE COAL 500 MW TESTS (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	4.447	4.077	3.542	3.432	3.058	2.177
O2 A/HTR OUTL AVG DRY	% vol	5.431	5.096	4.729	4.405	4.127	2.862
O2 ID DISCHARGE AVG	% vol	6.421	6.001	5.569	5.401	5.062	4.263
O2 ECON DRY	% vol	4.378	4.045	3.666	3.399	3.125	2.120
O2 ID DISCHARGE DRY	% vol	5.995	5.618	5.174	4.833	4.487	3.055
CO2 ID AVG DRY	% vol	12.802	13.084	13.371	13.564	13.917	15.069
CO2 (THEORETIC MAX)	% mass	27.002	27.007	27.007	26.823	27.076	27.167
CO2 (OSTWALD) DRY	% vol	13.525	13.866	14.261	14.461	14.918	16.271
O2 (OSTWALD)	% vol	6.847	6.540	6.223	5.898	5.666	4.464
SO2 ID AVG DRY	ppm	783.861	811.449	850.551	845.456	890.199	973.374
NOx ID AVG DRY	ppm	639.169	647.191	650.253	677.618	676.560	619.472
CO (CODEL) AVG DRY	ppm	20.090	21.265	17.001	23.175	20.836	33.063
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	844.100	843.370	843.220	843.200	843.280	843.610
AMBIENT TEMPERATURE	°C	16.190	17.660	18.430	19.280	19.435	17.260
RELATIVE HUMIDITY	%	25.925	23.500	23.315	20.650	20.235	23.205
DEWPOINT TEMPERATURE	°C	-29.310	-28.945	-28.600	-28.450	-28.640	-28.505
FD AIR INLET T.(Tdb)	°C	30.967	32.651	33.762	34.298	34.612	33.514

Table F.3: LOW GRADE COAL 500 MW TESTS (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
A/HTR GAS OUTLET AVG	°C	134.452	136.769	139.086	141.376	144.010	147.103
NO-LEAK A/HTR OUTL T.	°C	141.142	143.346	145.664	147.585	150.216	151.541
DRY FLUEGAS HEAT LOSS	MW	69.259	68.229	67.341	66.984	67.223	64.190
ID DISCHARGE TEMP AVG	°C	126.714	127.990	128.851	130.073	132.860	135.072
OPACITY	%	28.683	27.296	23.927	24.890	38.895	22.062
MOISTURE ATMOSPHERIC	kg/s	3.867	3.779	3.679	3.609	3.536	3.271
MOISTURE (COAL)	kg/s	7.439	7.705	7.477	7.218	7.000	6.754
MOISTURE (COMBUSTION)	kg/s	16.693	16.321	16.430	16.597	17.070	16.886
MOISTURE (HOPPER)	kg/s	3.974	3.953	3.948	4.005	4.041	4.012
MOISTURE TO FLY-ASH	kg/s	4.684	4.780	4.801	4.542	4.378	4.508
NETT MOISTURE	kg/s	27.288	26.978	26.732	26.887	27.268	26.416
AIR FLOW A.FOIL TOTAL	kg/s	517.426	506.154	489.939	478.238	462.855	446.253
AIR FLOW TOTAL	kg/s	550.931	538.376	524.068	514.017	503.663	465.786
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	18.285	18.285	18.285	18.285	18.285	18.285
AIR HTR LEAKAGE	kg/s	37.587	36.064	34.828	31.906	30.731	20.123
ESP AIR LEAKAGE	kg/s	40.097	38.141	35.814	34.137	32.576	26.570
COMBUSTION AIR	kg/s	513.344	502.312	489.240	482.111	472.932	445.663
THEORETICAL AIR	kg/s	436.854	436.182	434.561	434.905	433.468	431.906
STOICHIOM. AIR	kg/s	436.854	436.182	434.561	434.905	433.468	431.906
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	3.449	3.048	2.587	2.267	1.932	.715
EXCESS AIR	kg/s	76.490	66.130	54.679	47.206	39.463	13.757

Table F.3: LOW GRADE COAL 500 MW TESTS (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
ECON GAS(DAF)	kg/s	589.543	578.805	565.455	557.870	549.261	522.233
FURNACE GAS DRY	kg/s	554.543	543.805	530.455	522.870	514.261	487.233
TOTAL A/HTR GAS(DAF)	kg/s	628.629	616.370	601.783	591.276	581.492	543.856
ID GAS (DAF)	kg/s	668.727	654.511	637.597	625.413	614.068	570.426
ID GAS (CHEM. ANAL.)	kg/s	667.227	653.011	636.097	623.913	612.568	568.926
ID GAS (BALANCE TECH)	kg/s	668.726	654.511	637.597	625.412	614.068	570.427
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	145.647	143.760	143.676	145.937	148.064	147.212
BACK-END N2	kg/100kg	581.530	562.876	551.556	553.269	547.477	503.818
BACK-END O2	kg/100kg	49.126	44.513	40.095	37.502	34.461	21.519
BACK-END NOx	kg/100kg	.491	.481	.473	.493	.487	.409
BACK-END SO2	kg/100kg	1.286	1.287	1.319	1.313	1.369	1.372
BACK-END CO	kg/100kg	.014	.015	.012	.016	.014	.020
BACK-END CO2	kg/100kg	144.290	142.576	142.511	144.753	146.984	145.971
TOTAL GAS	kg/100kg	776.737	751.747	735.965	737.346	730.791	673.110
MOLE MASS (mixture)	kJ/kmolK	3032.939	3036.048	3039.019	3040.728	3045.156	3058.173
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	313.089	314.023	312.675	309.313	309.169	305.792
COAL DENSITY	TON/m3	.990	.998	.997	.987	.978	.998
COAL MASS FLOW	kg/s	86.094	87.065	86.634	84.819	84.028	84.745

Table F.3: <u>LOW GRADE COAL 500 MW TESTS</u> (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	4.600	4.600	4.600	4.500	4.200	4.400
ASH	%	43.200	43.700	44.000	42.500	41.400	42.000
VOLATILE MATTER	%	15.800	15.100	15.700	15.400	16.300	15.700
FIXED CARBON(BY DIFF)	%	36.400	36.600	35.700	37.600	38.100	37.900
CARBON	%	41.570	40.590	40.440	41.720	42.980	42.230
HYDROGEN	%	2.270	2.200	2.220	2.290	2.380	2.320
NITROGEN	%	.990	.940	.950	.910	1.050	.850
TOTAL SULPHUR	%	.690	1.080	.910	1.700	.630	.550
CARBONATE (CO2)	%	.990	1.040	1.210	1.050	1.260	1.110
OXYGEN (BY DIFF)	%	5.690	5.850	5.670	5.330	6.100	6.540
GROSS CV	MJ/kg	15.220	15.150	14.900	15.680	16.120	15.820
SURFACE MOISTURE	%	4.230	4.450	4.200	4.200	4.310	3.730
INHERENT MOISTURE	%	4.410	4.400	4.410	4.310	4.020	4.240
TOTAL MOISTURE	%	8.640	8.850	8.630	8.510	8.330	7.970
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	8.640	8.850	8.630	8.510	8.330	7.970
ASH (BY DIFF)	%	41.333	41.353	41.645	41.251	40.258	40.772
VOLATILE MATTER	%	15.101	14.397	15.007	14.724	15.568	15.088
FIXED CARBON(BY DIFF)	%	34.927	35.400	34.718	35.515	35.844	36.169
CARBON	%	39.749	39.234	39.211	39.829	40.409	40.177
HYDROGEN	%	2.175	2.139	2.151	2.185	2.227	2.205
NITROGEN	%	.946	.896	.908	.870	1.003	.817
TOTAL SULPHUR	%	.773	.958	.878	1.256	.744	.707
CARBONATE (CO2)	%	.946	.992	1.157	1.004	1.203	1.067

Table F.3: <u>LOW GRADE COAL 500 MW TESTS</u> (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
OXYGEN	%	5.438	5.578	5.420	5.096	5.826	6.285
GCVv (AS RECD, BOMB)	MJ/kg	14.575	14.475	14.271	15.022	15.425	15.229
GCVv (DAILY AVERAGE)	MJ/kg	14.833	14.833	14.833	14.833	14.833	14.833
GCVv (BIAS.DAILY AVE)	MJ/kg	14.704	14.654	14.552	14.927	15.129	15.031
NCVp (CALCed, DULONG)	MJ/kg	15.854	15.648	15.653	15.942	16.148	16.046
HEAT IN VOLATILES	%	18.958	17.292	17.722	20.041	21.411	19.678
CARBON IN DUST	%	.800	.700	.700	.700	.700	.800
CARBON IN ROUGH ASH	%	1.600	1.300	1.100	1.300	.600	.600
MEAN CARBON IN ASH	%	.858	.743	.729	.743	.693	.786
MILLING PLANT							
NUMBER OF MILLS I/S	#	5.000	5.000	5.000	5.000	5.000	5.000
MILL CONFIGURATION	#	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF
PF FINENESS (%<75µm)	%	81.000	83.760	73.350	84.030	83.960	
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	10.206	9.583	8.575	8.870	8.181	5.788
FEED FLOW (ORIFICE)	kg/s	394.773	394.455	394.375	394.312	393.317	394.731
TOTAL FEED FLOW	kg/s	404.979	404.038	402.950	403.182	401.498	400.519
MAIN STEAM TEMP.	°C	535.357	535.404	535.404	535.452	537.295	538.809
REHEAT STEAM TEMP.	°C	534.717	534.139	534.578	534.626	536.550	535.635
FINAL FEEDW. TEMP.	°C	233.842	233.555	233.233	233.365	233.223	232.609

Table F.3: LOW GRADE COAL 500 MW TESTS (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	15.626	16.720	17.493	18.033	18.241	18.107
CW OUTLET TEMP.(T2)	°C	31.095	32.482	33.265	33.719	33.914	33.568
CONDENSATE TEMP.	°C	31.537	32.743	33.369	34.413	33.976	33.640
BACKPRESS. (AVERAGE)	kPa	3.587	3.940	4.143	4.260	4.320	4.226
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	503.609	500.874	498.439	498.704	497.817	495.296
UNIT CONSUMPTION	MW	23.287	23.146	22.966	22.915	22.799	22.519
REACTIVE LOAD	MVAR	189.335	202.100	223.090	200.704	201.703	239.461
WORKS POWER / USO	%	4.848	4.845	4.830	4.816	4.800	4.763
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	38.277	37.907	38.459	37.342	36.649	36.632
EFF. GCVv (DAILY AVE)	%	37.613	36.992	37.001	37.818	38.112	37.611
EFF. GCVv(DAILY BIAS)	%	37.942	37.444	37.716	37.579	37.366	37.115
EFF. NCVp (CALCed)	%	35.189	35.065	35.063	35.187	35.009	34.767
STEP FACTOR	%	99.043	99.134	99.147	99.219	99.096	99.010
TOTAL ACCOUNTED LOSS	%	.957	.866	.853	.781	.904	.990
UNACCOUNTED LOSSES	%	.000	.000	.000	-.000	.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	.166	.083	.072	-.052	.149	.439
DRY FLUE GAS	%	.056	.055	.044	.070	.073	-.124
H2 & FUEL MOISTURE	%	-.020	-.006	-.003	.006	.008	.013

Table F.3: LOW GRADE COAL 500 MW TESTS (Wednesday, 4th May 1994)

PARAMETER	UNITS	500/29.0/11h45	500/26.0/13h15	500/23.5/14h15	500/20.75/15h1	500/18.0/16h15	500/12.0/17h30
MAIN STEAM TEMP.	%	-.009	-.010	-.010	-.011	-.051	-.080
REHEAT STEAM TEMP.	%	.007	.021	.010	.009	-.037	-.015
CONDENSER BACKPRESS.	%	.009	.041	.054	.053	.058	.047
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.014	-.014	-.012	-.015	-.013	-.003
WORKS POWER	%	-.134	-.200	-.198	-.173	-.177	-.182

Table F.4: <u>LOW GRADE COAL 450 MW TESTS</u> (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
FLUE GAS ANALYSIS							
02 ECON AVERAGE	% vol	4.873	4.765	4.361	3.834	3.113	2.531
02 A/HTR OUTL AVG DRY	% vol	5.913	5.716	5.183	4.459	4.101	3.383
02 ID DISCHARGE AVG	% vol	6.980	6.732	6.408	5.873	5.202	4.693
02 ECON DRY	% vol	5.006	4.791	4.243	3.550	3.239	2.648
02 ID DISCHARGE DRY	% vol	6.525	6.298	5.688	4.857	4.462	3.645
C02 ID AVG DRY	% vol	12.182	12.401	12.834	13.493	13.749	14.297
C02 (THEORETIC MAX)	% mass	26.683	26.809	26.806	26.912	26.799	26.668
C02 (OSTWALD) DRY	% vol	12.874	13.142	13.681	14.483	14.770	15.417
02 (OSTWALD)	% vol	7.351	7.177	6.695	6.028	5.676	4.982
S02 ID AVG DRY	ppm	828.468	821.871	831.928	879.525	929.278	968.283
NOx ID AVG DRY	ppm	559.681	571.337	602.723	620.805	631.121	615.018
CO (CODEL) AVG DRY	ppm	24.372	22.396	30.383	20.139	23.507	16.937
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	845.350	844.800	843.870	843.590	843.350	843.440
AMBIENT TEMPERATURE	°C	16.240	17.875	19.605	20.100	20.040	19.530
RELATIVE HUMIDITY	%	27.860	24.260	21.330	20.225	19.470	20.185
DEWPOINT TEMPERATURE	°C	-29.920	-29.590	-28.460	-28.405	-28.510	-28.490
FD AIR INLET T.(Tdb)	°C	31.461	32.831	33.872	34.151	33.196	32.240

Table F.4: LOW GRADE COAL 450 MW TESTS (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
A/HTR GAS OUTLET AVG	°C	132.809	134.554	141.459	144.512	147.188	149.315
NO-LEAK A/HTR OUTL T.	°C	138.641	140.446	147.582	150.316	152.752	153.989
DRY FLUEGAS HEAT LOSS	MW	63.370	62.858	64.299	62.923	63.438	61.996
ID DISCHARGE TEMP AVG	°C	123.907	123.868	127.963	131.029	131.514	133.266
OPACITY	%	27.783	26.413	26.354	23.263	22.631	21.156
MOISTURE ATMOSPHERIC	kg/s	3.639	3.587	3.456	3.290	3.215	3.074
MOISTURE (COAL)	kg/s	7.032	6.992	7.068	6.983	7.355	7.848
MOISTURE (COMBUSTION)	kg/s	16.203	15.848	15.759	15.515	14.927	14.309
MOISTURE (HOPPER)	kg/s	3.962	3.954	3.993	4.028	4.001	3.943
MOISTURE TO FLY-ASH	kg/s	4.738	4.775	4.597	4.437	4.561	4.822
NETT MOISTURE	kg/s	26.098	25.606	25.678	25.378	24.936	24.351
AIR FLOW A.FOIL TOTAL	kg/s	489.752	479.246	459.154	439.069	425.382	411.826
AIR FLOW TOTAL	kg/s	518.287	510.924	492.148	468.451	457.793	437.586
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	18.285	18.285	18.285	18.285	18.285	18.285
AIR HTR LEAKAGE	kg/s	31.673	31.479	29.972	26.633	24.299	19.230
ESP AIR LEAKAGE	kg/s	40.548	39.343	36.202	32.192	30.329	26.721
COMBUSTION AIR	kg/s	486.615	479.445	462.177	441.818	433.494	418.356
THEORETICAL AIR	kg/s	400.428	399.986	398.936	397.596	397.247	396.532
STOICHIOM. AIR	kg/s	400.428	399.986	398.936	397.596	397.247	396.531
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.100	3.837	3.168	2.317	1.936	1.208
EXCESS AIR	kg/s	86.187	79.459	63.241	44.222	36.247	21.824

Table F.4: <u>LOW GRADE COAL 450 MW TESTS</u> (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
ECON GAS(DAF)	kg/s	558.073	551.119	533.993	513.536	504.814	488.480
FURNACE GAS DRY	kg/s	523.073	516.119	498.993	478.536	469.814	453.480
TOTAL A/HTR GAS(DAF)	kg/s	591.246	584.098	565.464	541.670	530.613	509.210
ID GAS (DAF)	kg/s	631.793	623.441	601.667	573.862	560.941	535.931
ID GAS (CHEM. ANAL.)	kg/s	630.293	621.941	600.167	572.362	559.441	534.431
ID GAS (BALANCE TECH)	kg/s	631.793	623.441	601.666	573.863	560.943	535.940
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	138.683	138.766	139.644	141.571	139.928	137.915
BACK-END N2	kg/100kg	583.965	573.780	559.635	541.267	525.072	498.035
BACK-END O2	kg/100kg	53.632	50.859	44.709	36.848	32.788	25.322
BACK-END NOx	kg/100kg	.431	.433	.444	.442	.435	.401
BACK-END SO2	kg/100kg	1.363	1.329	1.309	1.336	1.367	1.347
BACK-END CO	kg/100kg	.018	.016	.021	.013	.015	.010
BACK-END CO2	kg/100kg	137.718	137.743	138.734	140.785	138.936	136.597
TOTAL GAS	kg/100kg	777.127	764.159	744.852	720.692	698.613	661.711
MOLE MASS (mixture)	kJ/kmolK	3025.278	3027.865	3032.390	3039.798	3042.499	3048.159
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	273.297	267.576	270.115	267.548	279.790	276.725
COAL DENSITY	TON/m3	1.071	1.098	1.077	1.071	1.033	1.054
COAL MASS FLOW	kg/s	81.299	81.585	80.777	79.627	80.294	80.993

Table F.4: LOW GRADE COAL 450 MW TESTS (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	3.100	3.000	3.200	3.100	3.700	4.300
ASH	%	47.000	47.200	45.900	45.000	45.800	48.000
VOLATILE MATTER	%	13.600	13.300	14.800	14.400	13.400	12.000
FIXED CARBON(BY DIFF)	%	36.300	36.500	34.100	37.500	37.100	35.700
CARBON	%	40.010	40.060	40.570	41.740	40.720	39.550
HYDROGEN	%	2.370	2.310	2.320	2.320	2.210	2.100
NITROGEN	%	.960	.960	.970	1.010	1.000	.960
TOTAL SULPHUR	%	.960	.600	.940	.560	.960	.720
CARBONATE (CO2)	%	1.130	1.230	1.400	1.480	1.360	1.190
OXYGEN (BY DIFF)	%	4.470	4.640	4.700	4.790	4.250	3.180
GROSS CV	MJ/kg	15.010	14.940	14.990	15.500	15.370	14.430
SURFACE MOISTURE	%	5.730	5.740	5.730	5.850	5.670	5.630
INHERENT MOISTURE	%	2.920	2.830	3.020	2.920	3.490	4.060
TOTAL MOISTURE	%	8.650	8.570	8.750	8.770	9.160	9.690
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	8.650	8.570	8.750	8.770	9.160	9.690
ASH (BY DIFF)	%	44.321	44.323	43.513	42.958	43.498	44.886
VOLATILE MATTER	%	12.797	12.514	13.926	13.532	12.613	11.296
FIXED CARBON(BY DIFF)	%	34.232	34.593	33.812	34.740	34.730	34.128
CARBON	%	37.849	37.872	38.111	38.637	38.189	37.639
HYDROGEN	%	2.184	2.155	2.160	2.159	2.109	2.057
NITROGEN	%	.903	.903	.913	.949	.941	.904
TOTAL SULPHUR	%	.823	.654	.814	.635	.823	.711
CARBONATE (CO2)	%	1.063	1.157	1.317	1.391	1.280	1.120

Table F.4: LOW GRADE COAL 450 MW TESTS (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
OXYGEN	%	4.206	4.366	4.422	4.501	4.000	2.993
GCVv (AS RECD, BOMB)	MJ/kg	14.150	14.082	14.131	14.593	14.499	13.617
GCVv (DAILY AVERAGE)	MJ/kg	14.179	14.179	14.179	14.179	14.179	14.179
GCVv (BIAS.DAILY AVE)	MJ/kg	14.164	14.130	14.155	14.386	14.339	13.898
NCVp (CALCed, DULONG)	MJ/kg	15.221	15.180	15.279	15.439	15.234	14.960
HEAT IN VOLATILES	%	18.185	16.920	19.075	19.489	18.988	15.239
CARBON IN DUST	%	.600	.500	.500	.500	.600	.800
CARBON IN ROUGH ASH	%	.000	1.800	.900	.000	.400	.400
MEAN CARBON IN ASH	%	.557	.594	.529	.464	.586	.771
MILLING PLANT							
NUMBER OF MILLS I/S	#	5.000	5.000	5.000	5.000	5.000	5.000
MILL CONFIGURATION	#	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF
PF FINENESS (%<75μm)	%	83.330	83.490	84.530	83.150	82.620	85.040
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	9.912	9.672	9.419	8.654	7.170	5.842
FEED FLOW (ORIFICE)	kg/s	351.090	349.140	348.011	347.522	358.178	357.416
TOTAL FEED FLOW	kg/s	361.002	358.812	357.430	356.176	365.348	363.258
MAIN STEAM TEMP.	°C	534.386	534.430	536.620	535.978	537.100	541.178
REHEAT STEAM TEMP.	°C	535.264	534.313	535.369	535.217	535.030	535.008
FINAL FEEDW. TEMP.	°C	228.436	228.137	227.981	227.630	228.541	228.150

Table F.4: <u>LOW GRADE COAL 450 MW TESTS</u> (Thursday, 5^{th} May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	16.230	17.288	18.473	18.624	18.902	18.781
CW OUTLET TEMP.(T2)	°C	31.123	31.939	33.138	32.922	33.254	32.864
CONDENSATE TEMP.	°C	30.633	31.717	32.627	32.553	32.415	32.702
BACKPRESS. (AVERAGE)	kPa	3.564	3.763	4.050	4.009	4.109	4.014
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	448.979	445.165	444.548	440.895	451.786	450.646
UNIT CONSUMPTION	MW	22.840	22.733	22.613	22.420	22.387	22.205
REACTIVE LOAD	MVAR	146.265	144.052	156.013	162.226	160.645	157.675
WORKS POWER / USO	%	5.360	5.381	5.359	5.358	5.214	5.183
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	37.043	36.769	36.966	36.014	36.885	38.847
EFF. GCVv (DAILY AVE)	%	36.969	36.518	36.841	37.066	37.718	37.309
EFF. GCVv(DAILY BIAS)	%	37.006	36.643	36.903	36.532	37.297	38.062
EFF. NCVp (CALCed)	%	34.438	34.110	34.187	34.039	35.105	35.361
STEP FACTOR	%	99.072	99.261	99.150	99.218		
TOTAL ACCOUNTED LOSS	%	.928	.739	.850	.781		
UNACCOUNTED LOSSES	%	.000	.000	.000	.001		
STEP LOSSES							
CARBON IN REFUSE	%	-.093	-.328	-.298	-.222		
DRY FLUE GAS	%	-.093	-.111	.079	-.062		
H2 & FUEL MOISTURE	%	-.017	-.012	.005	.017		

Table F.4: LOW GRADE COAL 450 MW TESTS (Thursday, 5th May 1994)

PARAMETER	UNITS	450/30.0/10h45	450/27.0/11h45	450/23.0/13h30	450/20.0/14h30	450/16.0/15h30	450/12.5/16.30
MAIN STEAM TEMP.	%	.015	.014	-.037	-.023		
REHEAT STEAM TEMP.	%	-.006	.016	-.009	-.005		
CONDENSER BACKPRESS.	%	.068	.069	.080	.066		
TURB. DETERIORATION	%	.894	.894	.894	.894		
FINAL FEEDWATER TEMP.	%	-.017	-.020	-.017	-.018		
WORKS POWER	%	.177	.215	.153	.134		

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	5.029	4.657	4.122	3.559	3.101	2.552
O2 A/HTR OUTL AVG DRY	% vol	5.643	5.218	4.705	4.035	3.564	3.030
O2 ID DISCHARGE AVG	% vol	7.023	6.618	6.159	5.704	5.339	4.850
O2 ECON DRY	% vol	5.087	4.632	4.113	3.483	3.068	2.637
O2 ID DISCHARGE DRY	% vol	6.400	5.914	5.320	4.539	3.988	3.377
CO2 ID AVG DRY	% vol	12.279	12.721	13.085	13.718	14.126	14.665
CO2 (THEORETIC MAX)	% mass	26.714	26.880	26.745	26.867	26.884	26.988
CO2 (OSTWALD) DRY	% vol	12.999	13.522	13.975	14.741	15.243	15.859
O2 (OSTWALD)	% vol	7.259	6.863	6.379	5.752	5.311	4.786
SO2 ID AVG DRY	ppm	787.118	821.889	856.572	883.825	923.293	970.744
NOx ID AVG DRY	ppm	545.382	562.955	583.610	582.550	561.348	507.861
CO (CODEL) AVG DRY	ppm	21.586	19.128	21.762	29.378	24.945	54.127
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	842.290	842.540	842.850	843.000	843.190	843.310
AMBIENT TEMPERATURE	°C	20.360	19.885	17.680	16.260	15.530	14.170
RELATIVE HUMIDITY	%	21.365	22.005	25.825	26.410	27.050	29.340
DEWPOINT TEMPERATURE	°C	-28.745	-28.880	-29.135	-29.785	-29.925	-30.190
FD AIR INLET T.(Tdb)	°C	36.049	36.228	36.006	35.387	34.582	33.796

Table F.5: <u>LOW GRADE COAL 400 MW TESTS</u> (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
A/HTR GAS OUTLET AVG	°C	133.018	135.243	136.499	138.101	138.933	141.252
NO-LEAK A/HTR OUTL T.	°C	136.384	138.761	139.993	141.297	141.776	143.501
DRY FLUEGAS HEAT LOSS	MW	53.735	53.485	52.521	51.496	50.853	50.615
ID DISCHARGE TEMP AVG	°C	130.752	128.998	129.664	130.878	131.596	131.474
OPACITY	%	25.459	22.970	21.843	19.942	18.901	17.859
MOISTURE ATMOSPHERIC	kg/s	3.263	3.166	3.056	2.922	2.833	2.741
MOISTURE (COAL)	kg/s	5.931	6.057	6.089	5.709	6.141	5.868
MOISTURE (COMBUSTION)	kg/s	15.158	15.396	14.847	14.743	14.854	14.941
MOISTURE (HOPPER)	kg/s	4.159	4.173	4.025	4.125	4.080	4.159
MOISTURE TO FLY-ASH	kg/s	3.840	3.775	4.452	3.993	4.198	3.838
NETT MOISTURE	kg/s	24.670	25.017	23.565	23.505	23.711	23.872
AIR FLOW A.FOIL TOTAL	kg/s	441.222	419.049	405.230	389.492	378.576	365.992
AIR FLOW TOTAL	kg/s	464.666	450.819	435.051	415.857	403.249	390.131
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	14.628	14.628	14.628	14.628	14.628	14.628
AIR HTR LEAKAGE	kg/s	17.681	17.606	16.694	14.434	12.374	9.303
ESP AIR LEAKAGE	kg/s	42.168	39.308	35.905	32.032	29.603	26.925
COMBUSTION AIR	kg/s	446.985	433.213	418.357	401.423	390.875	380.827
THEORETICAL AIR	kg/s	368.074	367.298	366.325	365.065	364.142	363.604
STOICHIOM. AIR	kg/s	368.074	367.298	366.324	365.064	364.142	363.603
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.087	3.522	2.879	2.097	1.583	1.047
EXCESS AIR	kg/s	78.911	65.915	52.032	36.359	26.733	17.223

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
ECON GAS(DAF)	kg/s	516.372	502.527	486.881	470.290	460.529	450.567
FURNACE GAS DRY	kg/s	481.372	467.527	451.881	435.290	425.529	415.567
TOTAL A/HTR GAS(DAF)	kg/s	535.553	521.633	505.076	486.224	474.403	461.371
ID GAS (DAF)	kg/s	577.721	560.941	540.981	518.256	504.005	488.296
ID GAS (CHEM. ANAL.)	kg/s	576.222	559.441	539.480	516.755	502.505	486.795
ID GAS (BALANCE TECH)	kg/s	577.720	560.940	540.983	518.261	504.005	488.302

VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
THEORETICAL CO2	kg/100kg	145.247	146.572	139.204	144.795	140.830	145.699
BACK-END N2	kg/100kg	605.416	590.846	548.359	542.964	512.547	510.326
BACK-END O2	kg/100kg	54.516	49.141	40.912	34.506	28.570	24.062
BACK-END NOx	kg/100kg	.436	.439	.421	.415	.377	.339
BACK-END SO2	kg/100kg	1.342	1.367	1.319	1.345	1.324	1.385
BACK-END CO	kg/100kg	.016	.014	.015	.020	.016	.034
BACK-END CO2	kg/100kg	143.851	145.377	138.404	143.416	139.169	143.725
TOTAL GAS	kg/100kg	805.577	787.184	729.429	722.666	682.002	679.871
MOLE MASS (mixture)	kJ/kmolK	3026.177	3031.444	3035.031	3042.142	3046.613	3052.952

COAL QUANTITY AND QUALITY

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
COAL VOLUME FLOW	m3/h	240.491	238.545	240.996	241.806	239.879	245.698
COAL DENSITY	TON/m3	1.074	1.075	1.108	1.068	1.109	1.052
COAL MASS FLOW	kg/s	71.715	71.259	74.165	71.715	73.901	71.823

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	2.400	2.500	2.200	2.100	2.300	2.300
ASH	%	43.300	42.900	48.600	45.000	46.000	43.200
VOLATILE MATTER	%	14.900	14.500	14.200	14.900	14.400	14.400
FIXED CARBON(BY DIFF)	%	39.400	40.100	35.000	38.000	37.300	40.100
CARBON	%	42.680	43.520	39.220	42.400	40.170	42.940
HYDROGEN	%	2.520	2.580	2.390	2.450	2.400	2.480
NITROGEN	%	.770	.820	.690	.780	.650	.720
TOTAL SULPHUR	%	1.560	.510	.580	.470	1.000	.610
CARBONATE (CO2)	%	1.150	1.110	1.020	1.180	1.050	1.090
OXYGEN (BY DIFF)	%	5.760	6.120	5.300	5.620	6.430	6.660
GROSS CV	MJ/kg	15.750	16.730	14.650	16.010	15.430	16.680
SURFACE MOISTURE	%	6.010	6.150	6.150	5.990	6.150	6.010
INHERENT MOISTURE	%	2.260	2.350	2.060	1.970	2.160	2.160
TOTAL MOISTURE	%	8.270	8.500	8.210	7.960	8.310	8.170
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	8.270	8.500	8.210	7.960	8.310	8.170
ASH (BY DIFF)	%	41.439	40.979	44.309	42.507	42.515	41.139
VOLATILE MATTER	%	13.984	13.587	13.308	13.990	13.495	13.515
FIXED CARBON(BY DIFF)	%	36.307	36.934	34.172	35.543	35.680	37.176
CARBON	%	39.640	40.002	37.991	39.517	38.435	39.764
HYDROGEN	%	2.341	2.367	2.278	2.308	2.283	2.322
NITROGEN	%	.723	.768	.647	.732	.609	.676
TOTAL SULPHUR	%	1.102	.609	.641	.590	.838	.656
CARBONATE (CO2)	%	1.079	1.040	.956	1.108	.984	1.023

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
OXYGEN	%	5.406	5.735	4.967	5.277	6.026	6.251
GCVv (AS RECD, BOMB)	MJ/kg	14.803	15.700	13.750	15.052	14.481	15.678
GCVv (DAILY AVERAGE)	MJ/kg	14.757	14.757	14.757	14.757	14.757	14.757
GCVv (BIAS.DAILY AVE)	MJ/kg	14.780	15.229	14.253	14.904	14.619	15.217
NCVp (CALCed, DULONG)	MJ/kg	16.059	16.163	15.377	15.935	15.552	16.039
HEAT IN VOLATILES	%	17.050	20.442	15.947	20.137	16.669	19.805
CARBON IN DUST	%	.800	.700	.400	.800	1.000	1.200
CARBON IN ROUGH ASH	%	1.900	1.500	1.200	1.400	1.400	1.900
MEAN CARBON IN ASH	%	.879	.758	.458	.843	1.029	1.250
MILLING PLANT							
NUMBER OF MILLS I/S	#	4.000	4.000	4.000	4.000	4.000	4.000
MILL CONFIGURATION	#	BCDE	BCDE	BCDE	BCDE	BCDE	BCDE
PF FINENESS (%<75µm)	%	78.390	81.480	79.250	83.820	80.580	81.290
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	7.282	6.779	6.331	6.306	6.313	6.273
FEED FLOW (ORIFICE)	kg/s	316.446	317.819	319.556	322.341	324.556	325.449
TOTAL FEED FLOW	kg/s	323.728	324.598	325.887	328.647	330.869	331.722
MAIN STEAM TEMP.	°C	536.361	536.371	536.217	536.409	536.274	537.422
REHEAT STEAM TEMP.	°C	535.357	534.979	534.913	526.783	517.974	514.887
FINAL FEEDW. TEMP.	°C	222.637	222.650	222.650	222.350	222.350	222.298

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	19.340	19.398	18.861	18.520	17.889	17.364
CW OUTLET TEMP.(T2)	°C	32.055	32.072	31.500	31.176	30.512	29.944
CONDENSATE TEMP.	°C	31.483	31.535	31.074	30.774	30.120	29.714
BACKPRESS. (AVERAGE)	kPa	3.745	3.763	3.616	3.547	3.399	3.269
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	399.860	399.790	400.610	399.900	399.900	399.709
UNIT CONSUMPTION	MW	20.717	20.553	20.412	20.327	20.195	20.134
REACTIVE LOAD	MVAR	142.695	166.956	181.078	215.568	184.404	179.504
WORKS POWER / USO	%	5.464	5.420	5.369	5.355	5.318	5.304
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	35.715	33.897	37.283	35.164	35.482	33.709
EFF. GCVv (DAILY AVE)	%	35.825	36.064	34.738	35.866	34.817	35.813
EFF. GCVv(DAILY BIAS)	%	35.770	34.947	35.966	35.512	35.146	34.729
EFF. NCVp (CALCed)	%	32.921	32.928	33.338	33.215	33.038	32.951
STEP FACTOR	%	98.756	98.922	99.218	99.211	98.986	98.787
TOTAL ACCOUNTED LOSS	%	1.244	1.078	.782	.789	1.014	1.213
UNACCOUNTED LOSSES	%	.000	.000	-.000	.000	.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	.300	.230	.130	.082	.258	.474
DRY FLUE GAS	%	.097	.033	-.120	-.254	-.364	-.375
H2 & FUEL MOISTURE	%	.005	.014	.009	.003	.007	.019

Table F.5: LOW GRADE COAL 400 MW TESTS (Friday, 6th May 1994)

PARAMETER	UNITS	400/37.0/15h45	400/32.5/16h45	400/28.0/17h45	400/24.0/18h45	400/19.0/19h45	400/15.0/20h45
MAIN STEAM TEMP.	%	-.031	-.032	-.028	-.032	-.029	-.054
REHEAT STEAM TEMP.	%	-.009	.001	.002	.197	.409	.483
CONDENSER BACKPRESS.	%	.022	.024	.015	.018	.015	.010
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	.005	.004	.007	.015	.015	.016
WORKS POWER	%	-.038	-.090	-.126	-.133	-.191	-.254

APPENDIX G
TEST DATA : SPEC GRADE COAL

APPENDIX G: SPEC GRADE COAL TEST DATA

Table G.1: SPEC GRADE COAL 630 MW TESTS

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	3.990	3.458	2.899	2.148	1.550	1.165
O2 A/HTR OUTL AVG DRY	% vol	5.168	4.719	4.112	3.395	2.731	2.293
O2 ID DISCHARGE AVG	% vol	5.641	5.198	4.624	3.944	3.367	3.013
O2 ECON DRY	% vol	4.016	3.496	2.834	2.098	1.506	1.261
O2 ID DISCHARGE DRY	% vol	5.605	5.091	4.396	3.551	2.813	2.492
CO2 ID AVG DRY	% vol	13.034	13.383	13.870	14.449	14.940	15.583
CO2 (THEORETIC MAX)	% mass	26.887	26.857	26.834	26.838	26.692	26.910
CO2 (OSTWALD) DRY	% vol	13.811	14.251	14.856	15.607	16.171	16.631
O2 (OSTWALD)	% vol	6.524	6.120	5.566	4.925	4.282	3.732
SO2 ID AVG DRY	ppm	840.447	860.675	897.393	947.743	991.453	1019.755
NOx ID AVG DRY	ppm	746.364	760.743	758.608	724.078	679.693	632.989
CO (CODEL) AVG DRY	ppm	34.183	24.016	20.759	26.618	114.434	471.914
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	846.310	845.370	844.835	844.680	844.800	844.660
AMBIENT TEMPERATURE	°C	16.605	18.390	18.915	19.030	18.460	18.025
RELATIVE HUMIDITY	%	36.665	35.510	31.605	28.770	33.005	31.990

Table G.1: <u>SPEC GRADE COAL 630 MW TESTS</u> (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
DEWPOINT TEMPERATURE	°C	-29.460	-29.910	-29.240	-29.115	-29.225	-29.425
FD AIR INLET T.(Tdb)	°C	31.517	33.295	33.985	33.950	34.080	33.950
A/HTR GAS OUTLET AVG	°C	143.105	145.107	147.258	149.258	151.109	152.104
NO-LEAK A/HTR OUTL T.	°C	150.866	153.136	155.451	157.382	158.611	158.324
DRY FLUEGAS HEAT LOSS	MW	89.380	87.391	85.522	83.442	81.415	80.439
ID DISCHARGE TEMP AVG	°C	133.650	133.901	135.104	136.075	137.038	137.027
OPACITY	%	34.856	32.147	29.225	26.526	24.097	23.572
MOISTURE ATMOSPHERIC	kg/s	4.640	4.502	4.327	4.132	3.976	3.911
MOISTURE (COAL)	kg/s	8.118	8.568	8.053	7.705	8.422	8.369
MOISTURE (COMBUSTION)	kg/s	22.857	23.323	22.776	23.501	22.583	23.537
MOISTURE (HOPPER)	kg/s	3.711	3.711	3.769	3.757	3.702	3.728
MOISTURE TO FLY-ASH	kg/s	5.881	5.884	5.619	5.674	5.924	5.807
NETT MOISTURE	kg/s	33.446	34.220	33.306	33.421	32.759	33.738
AIR FLOW A.FOIL TOTAL	kg/s	612.022	590.797	571.212	550.394	519.222	507.920
AIR FLOW TOTAL	kg/s	661.335	641.677	616.675	588.855	566.489	557.254
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	21.942	21.942	21.942	21.942	21.942	21.942
AIR HTR LEAKAGE	kg/s	47.974	48.133	46.783	43.827	38.786	31.845
ESP AIR LEAKAGE	kg/s	42.250	39.467	35.908	31.937	28.789	27.795
COMBUSTION AIR	kg/s	613.360	593.544	569.892	545.028	527.702	525.409
THEORETICAL AIR	kg/s	527.588	526.266	524.551	522.188	521.500	525.508
STOICHIOM. AIR	kg/s	527.594	526.266	524.550	522.188	521.500	525.508
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000

Table G.1: SPEC GRADE COAL 630 MW TESTS (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
CALCULATED FURNACE O2	% mass	3.237	2.624	1.842	.970	.272	-.004
EXCESS AIR	kg/s	85.772	67.278	45.342	22.840	6.203	-.099
ECON GAS(DAF)	kg/s	699.421	679.591	655.798	630.690	613.484	613.399
FURNACE GAS DRY	kg/s	664.421	644.591	620.798	595.690	578.484	578.399
TOTAL A/HTR GAS(DAF)	kg/s	748.896	729.224	704.081	676.017	653.770	646.744
ID GAS (DAF)	kg/s	791.146	768.691	739.989	707.954	682.559	674.539
ID GAS (CHEM. ANAL.)	kg/s	789.652	767.191	738.489	706.454	681.059	673.039
ID GAS (BALANCE TECH)	kg/s	791.134	768.681	739.996	707.956	682.559	674.539

VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION

THEORETICAL CO2	kg/100kg	141.760	140.769	142.665	142.614	139.589	141.634
BACK-END N2	kg/100kg	557.212	540.314	530.399	509.635	481.783	465.383
BACK-END O2	kg/100kg	43.933	38.620	32.651	25.261	18.866	16.214
BACK-END NOx	kg/100kg	.549	.541	.528	.483	.427	.386
BACK-END SO2	kg/100kg	1.319	1.307	1.334	1.350	1.331	1.328
BACK-END CO	kg/100kg	.023	.016	.013	.017	.067	.269
BACK-END CO2	kg/100kg	140.524	139.629	141.691	141.378	137.787	139.433
TOTAL GAS	kg/100kg	743.559	720.428	706.617	678.124	640.262	623.012
MOLE MASS (mixture)	kJ/kmolK	3035.328	3038.936	3044.078	3050.158	3055.213	3064.317

COAL QUANTITY AND QUALITY

COAL VOLUME FLOW	m3/h	443.010	434.677	433.448	426.521	431.244	431.104
COAL DENSITY	TON/m3	.865	.884	.870	.881	.890	.904
COAL MASS FLOW	kg/s	106.398	106.698	104.724	104.399	106.606	108.271

Table G.1: SPEC GRADE COAL 630 MW TESTS (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	3.700	3.900	3.800	3.800	3.400	3.800
ASH	%	43.800	43.800	42.500	42.900	44.300	42.500
VOLATILE MATTER	%	17.800	17.600	17.700	18.700	17.800	18.600
FIXED CARBON(BY DIFF)	%	34.700	34.700	36.000	34.600	34.500	35.100
CARBON	%	40.470	40.000	40.970	40.800	39.470	40.400
HYDROGEN	%	2.510	2.560	2.540	2.620	2.490	2.540
NITROGEN	%	.910	.830	.890	.920	.860	.860
TOTAL SULPHUR	%	.520	.660	1.090	.680	1.550	.940
CARBONATE (CO2)	%	.600	.500	.590	.620	.720	.730
OXYGEN (BY DIFF)	%	7.490	7.750	7.620	7.660	7.210	8.230
GROSS CV	MJ/kg	14.880	14.720	15.260	15.120	14.730	15.130
SURFACE MOISTURE	%	4.080	4.290	4.040	3.720	4.650	4.080
INHERENT MOISTURE	%	3.550	3.740	3.650	3.660	3.250	3.650
TOTAL MOISTURE	%	7.630	8.030	7.690	7.380	7.900	7.730
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	7.630	8.030	7.690	7.380	7.900	7.730
ASH (BY DIFF)	%	41.961	41.688	41.266	41.617	42.063	40.895
VOLATILE MATTER	%	17.047	16.816	16.958	17.978	16.944	17.812
FIXED CARBON(BY DIFF)	%	33.362	33.467	34.086	33.026	33.093	33.563
CARBON	%	38.689	38.418	38.936	38.922	38.096	38.654
HYDROGEN	%	2.419	2.440	2.434	2.476	2.402	2.433
NITROGEN	%	.872	.793	.853	.884	.819	.824
TOTAL SULPHUR	%	.683	.749	.956	.760	1.171	.884

Table G.1: <u>SPEC GRADE COAL 630 MW TESTS</u> (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
CARBONATE (CO2)	%	.575	.478	.565	.596	.685	.699
OXYGEN	%	7.173	7.405	7.300	7.364	6.863	7.881
GCVv (AS RECD, BOMB)	MJ/kg	14.251	14.087	14.643	14.557	14.044	14.512
GCVv (DAILY AVERAGE)	MJ/kg	14.349	14.349	14.349	14.349	14.349	14.349
GCVv (BIAS.DAILY AVE)	MJ/kg	14.300	14.218	14.496	14.453	14.196	14.430
NCVp (CALCed, DULONG)	MJ/kg	15.806	15.737	15.933	15.969	15.624	15.830
HEAT IN VOLATILES	%	20.823	19.655	21.274	23.274	20.307	21.782
CARBON IN DUST	%	.700	.700	.600	.800	1.100	1.200
CARBON IN ROUGH ASH	%	1.500	.800	.700	.400	.800	.700
MEAN CARBON IN ASH	%	.758	.707	.607	.771	1.078	1.164
MILLING PLANT							
NUMBER OF MILLS I/S	#	6.000	6.000	6.000	6.000	6.000	6.000
MILL CONFIGURATION	#	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF
PF FINENESS (%<75μm)	%	73.150	73.350	75.970	74.660	78.440	74.030
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	14.005	14.147	13.035	12.089	11.259	10.346
FEED FLOW (ORIFICE)	kg/s	488.507	490.931	492.423	494.689	497.406	497.898
TOTAL FEED FLOW	kg/s	502.512	505.078	505.458	506.778	508.665	508.244
MAIN STEAM TEMP.	°C	535.380	533.947	534.247	534.387	534.213	534.400
REHEAT STEAM TEMP.	°C	535.400	535.600	535.106	535.603	535.500	535.800
FINAL FEEDW. TEMP.	°C	245.150	245.150	245.150	244.850	244.506	244.520

Table G.1: SPEC GRADE COAL 630 MW TESTS (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	16.221	17.514	18.052	18.441	17.658	18.005
CW OUTLET TEMP.(T2)	°C	35.283	36.599	37.014	37.042	36.648	36.851
CONDENSATE TEMP.	°C	38.983	40.271	40.644	40.770	40.280	40.563
BACKPRESS. (AVERAGE)	kPa	4.941	5.252	5.351	5.423	5.270	5.327
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	627.448	627.743	627.630	627.400	627.543	627.400
UNIT CONSUMPTION	MW	26.196	25.876	25.548	25.360	25.165	25.044
REACTIVE LOAD	MVAR	246.465	224.285	230.113	218.320	198.143	222.090
WORKS POWER / USO	%	4.357	4.299	4.243	4.212	4.178	4.158
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	39.654	40.042	39.263	39.614	40.235	38.337
EFF. GCVv (DAILY AVE)	%	39.382	39.312	40.067	40.189	39.379	38.772
EFF. GCVv(DAILY BIAS)	%	39.518	39.674	39.661	39.899	39.802	38.553
EFF. NCVp (CALCed)	%	35.752	35.844	36.084	36.112	36.165	35.145
STEP FACTOR	%	98.942	99.015	99.009	99.059	99.218	98.987
TOTAL ACCOUNTED LOSS	%	1.058	.985	.990	.941	.782	1.013
UNACCOUNTED LOSSES	%	.001	.000	.001	.000	-.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	-.124	-.119	-.039	-.071	-.020	.268
DRY FLUE GAS	%	.234	.178	.119	.075	-.053	-.090

Table G.1: SPEC GRADE COAL 630 MW TESTS (Monday, 9th May 1994)

PARAMETER	UNITS	630/23.5/11h00	630/19.5/12h30	630/15.0/13h30	630/10.0/14h30	630/08.0/16h45	630/05.5/15h30
H2 & FUEL MOISTURE	%	-.033	-.025	-.015	-.008	-.004	-.005
MAIN STEAM TEMP.	%	-.009	.026	.019	.015	.019	.015
REHEAT STEAM TEMP.	%	-.010	-.014	-.003	-.014	-.012	-.019
CONDENSER BACKPRESS.	%	.040	.037	.029	.021	.034	.028
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.005	-.004	-.005	.002	.011	.010
WORKS POWER	%	.070	.012	-.009	.025	-.088	-.088

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	4.447	3.791	3.315	2.708	2.530	1.210
O2 A/HTR OUTL AVG DRY	% vol	5.773	5.300	4.775	4.043	3.998	2.394
O2 ID DISCHARGE AVG	% vol	6.139	5.582	5.235	4.535	4.529	3.211
O2 ECON DRY	% vol	4.438	3.879	3.310	2.575	2.514	1.284
O2 ID DISCHARGE DRY	% vol	6.308	5.764	5.164	4.328	4.260	2.645
CO2 ID AVG DRY	% vol	12.447	12.914	13.309	13.960	13.938	15.499
CO2 (THEORETIC MAX)	% mass	26.839	27.006	26.932	26.997	26.907	26.935
CO2 (OSTWALD) DRY	% vol	13.152	13.729	14.223	15.011	15.014	16.513
O2 (OSTWALD)	% vol	7.145	6.725	6.245	5.568	5.534	3.843
SO2 ID AVG DRY	ppm	809.521	843.570	860.388	909.816	904.073	1018.809
NOx ID AVG DRY	ppm	698.047	716.109	727.589	723.261	747.836	628.383
CO (CODEL) AVG DRY	ppm	32.320	32.395	28.001	25.350	22.325	500.546
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	844.095	843.990	844.090	844.330	842.760	845.010
AMBIENT TEMPERATURE	°C	20.610	20.885	20.780	20.040	15.280	12.900
RELATIVE HUMIDITY	%	24.900	24.750	24.675	25.900	22.095	43.515
DEWPOINT TEMPERATURE	°C	-29.745	-29.245	-29.295	-29.170	-29.100	-30.285
FD AIR INLET T.(Tdb)	°C	33.723	34.360	34.526	34.720	34.720	34.526

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
A/HTR GAS OUTLET AVG	°C	142.506	143.726	145.156	148.008	148.507	151.994
NO-LEAK A/HTR OUTL T.	°C	151.629	153.190	154.710	157.382	158.007	158.683
DRY FLUEGAS HEAT LOSS	MW	80.084	78.429	76.832	75.244	75.248	70.566
ID DISCHARGE TEMP AVG	°C	132.059	134.702	134.360	134.497	137.036	136.305
OPACITY	%	32.486	28.981	28.766	24.907	24.471	20.864
MOISTURE ATMOSPHERIC	kg/s	4.200	4.060	3.918	3.735	3.720	3.413
MOISTURE (COAL)	kg/s	10.489	10.471	10.689	10.468	9.915	10.582
MOISTURE (COMBUSTION)	kg/s	19.674	20.137	19.510	19.605	19.573	19.945
MOISTURE (HOPPER)	kg/s	3.894	3.969	3.882	3.992	3.962	3.949
MOISTURE TO FLY-ASH	kg/s	5.048	4.705	5.101	4.603	4.738	4.796
NETT MOISTURE	kg/s	33.209	33.932	32.899	33.197	32.432	33.092
AIR FLOW A.FOIL TOTAL	kg/s	572.254	550.762	534.846	510.920	511.182	465.356
AIR FLOW TOTAL	kg/s	598.439	578.523	558.241	532.052	529.858	486.032
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	21.942	21.942	21.942	21.942	21.942	21.942
AIR HTR LEAKAGE	kg/s	51.771	51.782	50.055	46.171	46.316	30.142
ESP AIR LEAKAGE	kg/s	42.663	39.693	36.488	32.488	32.013	25.521
COMBUSTION AIR	kg/s	546.668	526.742	508.185	485.881	483.543	455.890
THEORETICAL AIR	kg/s	461.761	460.204	458.986	457.388	456.774	459.440
STOICHIOM. AIR	kg/s	461.761	460.204	458.987	457.388	456.774	459.440
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	3.596	2.924	2.241	1.358	1.282	-.180
EXCESS AIR	kg/s	84.907	66.538	49.199	28.493	26.768	-3.550

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
ECON GAS(DAF)	kg/s	625.943	606.731	587.731	565.747	562.531	536.721
FURNACE GAS DRY	kg/s	590.943	571.731	552.731	530.747	527.531	501.721
TOTAL A/HTR GAS(DAF)	kg/s	679.214	660.013	639.286	613.418	610.347	568.363
ID GAS (DAF)	kg/s	721.877	699.706	675.775	645.906	642.360	593.883
ID GAS (CHEM. ANAL.)	kg/s	720.378	698.206	674.275	644.406	640.859	592.383
ID GAS (BALANCE TECH)	kg/s	721.877	699.706	675.775	645.906	642.359	593.883
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	138.062	140.527	137.101	140.934	140.825	140.040
BACK-END N2	kg/100kg	568.856	558.855	529.804	520.728	521.141	464.231
BACK-END O2	kg/100kg	50.546	45.339	38.407	31.568	31.065	17.178
BACK-END NOx	kg/100kg	.525	.528	.507	.495	.511	.383
BACK-END SO2	kg/100kg	1.299	1.328	1.281	1.329	1.320	1.325
BACK-END CO	kg/100kg	.023	.022	.018	.016	.014	.285
BACK-END CO2	kg/100kg	137.172	139.701	136.149	140.044	139.788	138.458
TOTAL GAS	kg/100kg	758.420	745.773	706.167	694.179	693.839	621.859
MOLE MASS (mixture)	kJ/kmolK	3028.608	3034.046	3038.035	3045.285	3044.653	3063.576
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	393.180	378.019	378.438	376.432	382.480	368.509
COAL DENSITY	TON/m3	.871	.894	.910	.890	.871	.933
COAL MASS FLOW	kg/s	95.182	93.823	95.696	93.046	92.581	95.501

Table G.2: <u>SPEC GRADE COAL 550 MW TESTS</u> (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	4.100	4.100	4.100	4.300	4.400	4.400
ASH	%	43.500	41.200	43.800	40.600	41.700	41.100
VOLATILE MATTER	%	17.400	18.400	17.900	18.400	17.800	18.600
FIXED CARBON(BY DIFF)	%	35.000	36.300	34.200	36.700	36.100	35.900
CARBON	%	40.280	41.800	39.780	42.000	41.630	41.350
HYDROGEN	%	2.500	2.600	2.470	2.550	2.540	2.520
NITROGEN	%	.940	.980	1.000	1.150	1.000	1.060
TOTAL SULPHUR	%	.900	.580	.670	.760	.720	.950
CARBONATE (CO2)	%	.660	.740	.690	.710	.760	.800
OXYGEN (BY DIFF)	%	7.120	8.000	7.480	7.930	7.250	7.820
GROSS CV	MJ/kg	15.140	15.750	14.810	16.000	15.550	15.640
SURFACE MOISTURE	%	7.200	7.340	7.350	7.240	6.580	6.970
INHERENT MOISTURE	%	3.820	3.820	3.820	4.010	4.130	4.110
TOTAL MOISTURE	%	11.020	11.160	11.170	11.250	10.710	11.080
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	11.020	11.160	11.170	11.250	10.710	11.080
ASH (BY DIFF)	%	40.136	38.516	39.969	38.180	39.422	38.591
VOLATILE MATTER	%	16.097	16.996	16.532	17.012	16.578	17.248
FIXED CARBON(BY DIFF)	%	32.747	33.328	32.329	33.557	33.290	33.081
CARBON	%	37.679	38.352	37.417	38.463	38.433	38.219
HYDROGEN	%	2.328	2.372	2.312	2.350	2.354	2.340
NITROGEN	%	.870	.905	.924	1.063	.931	.983
TOTAL SULPHUR	%	.770	.621	.663	.705	.689	.794
CARBONATE (CO2)	%	.611	.684	.637	.656	.708	.742

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
OXYGEN	%	6.587	7.389	6.908	7.332	6.752	7.252
GCVv (AS RECD, BOMB)	MJ/kg	14.048	14.591	13.718	14.838	14.524	14.547
GCVv (DAILY AVERAGE)	MJ/kg	14.378	14.378	14.378	14.378	14.378	14.378
GCVv (BIAS.DAILY AVE)	MJ/kg	14.213	14.484	14.048	14.608	14.451	14.462
NCVp (CALCed, DULONG)	MJ/kg	15.285	15.553	15.164	15.570	15.574	15.486
HEAT IN VOLATILES	%	21.161	22.748	20.298	23.513	22.481	23.091
CARBON IN DUST	%	.500	.500	.600	.600	.700	.800
CARBON IN ROUGH ASH	%	1.300	1.000	.700	.500	.400	.500
MEAN CARBON IN ASH	%	.558	.536	.607	.593	.678	.778
MILLING PLANT							
NUMBER OF MILLS I/S	#	6.000	6.000	6.000	6.000	6.000	6.000
MILL CONFIGURATION	#	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF	ABCDEF
PF FINENESS (%<75µm)	%	74.530	74.200	75.370	74.220	74.790	73.890
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	13.499	11.910	11.663	10.827	11.350	8.697
FEED FLOW (ORIFICE)	kg/s	431.778	434.557	434.865	435.742	433.978	439.118
TOTAL FEED FLOW	kg/s	445.277	446.467	446.528	446.569	445.328	447.815
MAIN STEAM TEMP.	°C	535.126	535.363	535.500	535.500	534.418	535.165
REHEAT STEAM TEMP.	°C	532.168	532.100	532.100	532.100	532.098	532.243
FINAL FEEDW. TEMP.	°C	238.750	238.026	238.456	238.446	238.188	237.900

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	19.037	19.370	19.475	19.420	17.200	16.520
CW OUTLET TEMP.(T2)	°C	35.975	36.261	36.382	36.161	33.954	33.730
CONDENSATE TEMP.	°C	37.397	38.010	37.551	37.965	35.403	34.827
BACKPRESS. (AVERAGE)	kPa	4.962	5.055	4.995	5.033	4.470	4.232
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	549.330	548.930	549.800	549.000	549.270	549.534
UNIT CONSUMPTION	MW	25.322	25.105	25.019	24.720	24.745	24.409
REACTIVE LOAD	MVAR	152.150	166.560	176.288	143.038	154.550	160.832
WORKS POWER / USO	%	4.832	4.793	4.767	4.715	4.718	4.648
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	39.191	38.265	39.975	37.974	39.010	37.799
EFF. GCVv (DAILY AVE)	%	38.291	38.832	38.142	39.191	39.406	38.245
EFF. GCVv(DAILY BIAS)	%	38.736	38.547	39.037	38.573	39.207	38.020
EFF. NCVp (CALCed)	%	36.018	35.898	36.164	36.189	36.379	35.507
STEP FACTOR	%	98.582	98.713	98.818	98.849	99.219	98.934
TOTAL ACCOUNTED LOSS	%	1.418	1.287	1.182	1.151	.782	1.066
UNACCOUNTED LOSSES	%	-.000	-.000	-.000	-.000	-.001	.000
STEP LOSSES							
CARBON IN REFUSE	%	-.149	-.187	-.145	-.096	-.227	.098
DRY FLUE GAS	%	.501	.379	.282	.235	-.043	-.037
H2 & FUEL MOISTURE	%	.005	.001	.008	.020	.008	.017

Table G.2: SPEC GRADE COAL 550 MW TESTS (Wednesday, 11th May 1994)

PARAMETER	UNITS	550/30.0/13h45	550/26.0/14h45	550/22.0/15h45	550/18.0/16h45	550/14.0/20h45	550/10/21h45
MAIN STEAM TEMP.	%	-.003	-.009	-.012	-.012	.014	-.004
REHEAT STEAM TEMP.	%	.068	.070	.070	.070	.070	.066
CONDENSER BACKPRESS.	%	.052	.055	.032	.046	.043	.025
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.023	-.006	-.015	-.017	-.010	-.002
WORKS POWER	%	.073	.090	.069	.010	.032	.007

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	4.818	4.306	3.807	3.095	2.730	1.800
O2 A/HTR OUTL AVG DRY	% vol	5.884	5.604	5.136	4.423	3.950	3.149
O2 ID DISCHARGE AVG	% vol	6.694	6.211	5.771	5.061	4.675	3.910
O2 ECON DRY	% vol	4.749	4.389	3.862	3.080	2.583	1.893
O2 ID DISCHARGE DRY	% vol	6.442	6.110	5.593	4.772	4.205	3.359
CO2 ID AVG DRY	% vol	12.418	12.592	12.937	13.648	13.966	14.637
CO2 (THEORETIC MAX)	% mass	26.993	26.900	26.796	27.022	26.907	26.780
CO2 (OSTWALD) DRY	% vol	13.114	13.359	13.764	14.628	15.063	15.750
O2 (OSTWALD)	% vol	7.263	7.018	6.575	5.926	5.503	4.681
SO2 ID AVG DRY	ppm	771.356	806.175	836.714	891.017	924.274	995.971
NOx ID AVG DRY	ppm	723.427	712.347	689.748	664.474	651.936	557.237
CO (CODEL) AVG DRY	ppm	12.503	28.849	40.072	29.484	38.605	186.061
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	846.200	845.825	845.190	844.455	844.090	844.035
AMBIENT TEMPERATURE	°C	12.280	17.205	18.395	19.395	19.395	19.703
RELATIVE HUMIDITY	%	61.255	34.260	30.410	27.935	27.210	26.520
DEWPOINT TEMPERATURE	°C	-31.455	-29.775	-29.465	-29.200	-29.055	-29.008
FD AIR INLET T.(Tdb)	°C	27.536	32.495	33.538	33.811	34.214	34.508

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
A/HTR GAS OUTLET AVG	°C	130.774	135.715	137.490	140.073	141.436	145.101
NO-LEAK A/HTR OUTL T.	°C	138.184	143.511	145.477	148.299	149.657	152.541
DRY FLUEGAS HEAT LOSS	MW	69.957	68.855	67.529	66.314	64.989	63.819
ID DISCHARGE TEMP AVG	°C	118.154	121.306	124.726	127.615	128.870	131.026
OPACITY	%	22.145	24.981	23.680	25.838	22.059	18.941
MOISTURE ATMOSPHERIC	kg/s	3.889	3.809	3.693	3.520	3.410	3.257
MOISTURE (COAL)	kg/s	10.586	9.991	10.172	9.984	10.387	10.323
MOISTURE (COMBUSTION)	kg/s	18.589	18.533	18.285	18.368	18.185	18.541
MOISTURE (HOPPER)	kg/s	3.955	3.932	3.870	4.019	3.955	3.969
MOISTURE TO FLY-ASH	kg/s	4.769	4.875	5.159	4.478	4.771	4.707
NETT MOISTURE	kg/s	32.249	31.390	30.860	31.412	31.167	31.383
AIR FLOW A.FOIL TOTAL	kg/s	526.865	519.254	501.895	484.359	460.985	447.511
AIR FLOW TOTAL	kg/s	554.082	542.710	526.051	501.329	485.601	463.776
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	18.285	18.285	18.285	18.285	18.285	18.285
AIR HTR LEAKAGE	kg/s	41.700	42.893	42.388	40.979	39.473	33.549
ESP AIR LEAKAGE	kg/s	40.675	38.756	36.050	32.213	29.617	26.064
COMBUSTION AIR	kg/s	512.382	499.817	483.662	460.351	446.128	430.228
THEORETICAL AIR	kg/s	426.677	425.617	425.157	423.542	422.121	422.602
STOICHIOM. AIR	kg/s	426.677	425.617	425.157	423.542	422.121	422.601
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	3.872	3.437	2.800	1.851	1.246	.410
EXCESS AIR	kg/s	85.705	74.199	58.505	36.808	24.006	7.626

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
ECON GAS(DAF)	kg/s	589.046	575.830	559.378	536.740	521.979	505.637
FURNACE GAS DRY	kg/s	554.046	540.830	524.378	501.740	486.979	470.637
TOTAL A/HTR GAS(DAF)	kg/s	632.246	620.223	603.266	579.218	562.952	540.686
ID GAS (DAF)	kg/s	672.921	658.979	639.316	611.431	592.569	566.750
ID GAS (CHEM. ANAL.)	kg/s	671.421	657.479	637.816	609.931	591.069	565.250
ID GAS (BALANCE TECH)	kg/s	672.921	658.979	639.316	611.431	592.569	566.750
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	134.637	134.362	131.837	137.579	134.457	135.558
BACK-END N2	kg/100kg	555.747	548.227	523.824	519.328	496.762	478.271
BACK-END O2	kg/100kg	50.491	47.154	41.154	34.766	29.214	22.424
BACK-END NOx	kg/100kg	.532	.516	.476	.454	.425	.349
BACK-END SO2	kg/100kg	1.210	1.246	1.233	1.300	1.286	1.331
BACK-END CO	kg/100kg	.009	.019	.026	.019	.023	.109
BACK-END CO2	kg/100kg	133.871	133.653	130.936	136.761	133.464	134.401
TOTAL GAS	kg/100kg	741.860	730.815	697.647	692.628	661.175	636.885
MOLE MASS (mixture)	kJ/kmolK	3028.550	3030.130	3033.703	3041.992	3044.936	3052.537
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	353.085	353.013	352.095	351.212	347.344	352.125
COAL DENSITY	TON/m3	.925	.920	.937	.905	.929	.910
COAL MASS FLOW	kg/s	90.707	90.170	91.639	88.277	89.624	88.988

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	4.000	3.600	3.500	3.500	3.300	3.600
ASH	%	43.500	44.600	46.500	42.000	44.300	43.900
VOLATILE MATTER	%	18.200	18.200	17.700	18.200	17.900	18.500
FIXED CARBON(BY DIFF)	%	34.300	33.600	32.300	36.300	34.500	34.000
CARBON	%	40.030	39.750	38.300	41.810	40.160	40.710
HYDROGEN	%	2.500	2.500	2.430	2.540	2.490	2.550
NITROGEN	%	.990	1.010	1.010	1.040	1.050	1.030
TOTAL SULPHUR	%	.550	.580	.790	.570	.660	.720
CARBONATE (CO2)	%	.610	.760	.600	.690	.780	.670
OXYGEN (BY DIFF)	%	7.820	7.200	6.870	7.850	7.260	6.820
GROSS CV	MJ/kg	15.010	15.000	14.440	15.820	15.130	15.390
SURFACE MOISTURE	%	7.970	7.740	7.860	8.070	8.550	8.290
INHERENT MOISTURE	%	3.700	3.340	3.240	3.240	3.040	3.310
TOTAL MOISTURE	%	11.670	11.080	11.100	11.310	11.590	11.600
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	11.670	11.080	11.100	11.310	11.590	11.600
ASH (BY DIFF)	%	40.104	41.140	42.207	39.494	40.548	40.678
VOLATILE MATTER	%	16.694	16.743	16.262	16.682	16.322	16.914
FIXED CARBON(BY DIFF)	%	31.532	31.037	30.431	32.514	31.540	30.808
CARBON	%	36.745	36.670	35.981	37.548	36.696	36.996
HYDROGEN	%	2.293	2.296	2.263	2.310	2.282	2.312
NITROGEN	%	.908	.929	.928	.953	.957	.942
TOTAL SULPHUR	%	.548	.562	.658	.557	.596	.625
CARBONATE (CO2)	%	.560	.699	.551	.632	.711	.613

Table G.3: <u>SPEC GRADE COAL 500 MW TESTS</u> (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
OXYGEN	%	7.173	6.623	6.312	7.195	6.620	6.235
GCVv (AS RECD, BOMB)	MJ/kg	13.811	13.836	13.303	14.540	13.833	14.113
GCVv (DAILY AVERAGE)	MJ/kg	13.906	13.906	13.906	13.906	13.906	13.906
GCVv (BIAS.DAILY AVE)	MJ/kg	13.858	13.871	13.604	14.223	13.869	14.009
NCVp (CALCed, DULONG)	MJ/kg	14.890	14.882	14.614	15.194	14.865	15.006
HEAT IN VOLATILES	%	22.784	24.135	22.635	24.371	22.887	26.171
CARBON IN DUST	%	.450	.400	.500	.500	.600	.650
CARBON IN ROUGH ASH	%	1.000	.800	1.000	.800	.900	.500
MEAN CARBON IN ASH	%	.490	.429	.536	.522	.622	.639
MILLING PLANT							
NUMBER OF MILLS I/S	#	5.000	5.000	5.000	5.000	5.000	5.000
MILL CONFIGURATION	#	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF
PF FINENESS (%<75µm)	%	76.880	78.430	75.150	75.810	78.860	75.180
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	10.402	9.865	9.162	8.324	8.276	6.481
FEED FLOW (ORIFICE)	kg/s	394.773	394.455	394.375	394.312	393.317	394.731
TOTAL FEED FLOW	kg/s	405.175	404.320	403.537	402.636	401.593	401.212
MAIN STEAM TEMP.	°C	534.900	535.050	536.100	534.900	535.500	536.100
REHEAT STEAM TEMP.	°C	535.500	535.500	535.600	535.500	534.400	535.500
FINAL FEEDW. TEMP.	°C	233.200	233.800	233.650	233.307	233.200	233.200

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	13.775	16.762	17.718	18.355	18.638	18.720
CW OUTLET TEMP.(T2)	°C	29.125	32.072	32.940	33.804	34.030	33.823
CONDENSATE TEMP.	°C	32.331	35.255	36.262	35.866	34.844	35.898
BACKPRESS. (AVERAGE)	kPa	3.207	3.877	4.103	4.299	4.359	4.184
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	499.900	500.000	500.000	500.000	499.906	500.100
UNIT CONSUMPTION	MW	23.173	22.906	22.833	22.579	22.502	22.316
REACTIVE LOAD	MVAR	150.638	151.877	131.653	153.271	147.235	143.144
WORKS POWER / USO	%	4.861	4.801	4.785	4.729	4.713	4.671
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	38.055	38.241	39.143	37.196	38.508	38.044
EFF. GCVv (DAILY AVE)	%	37.795	38.049	37.445	38.892	38.306	38.610
EFF. GCVv(DAILY BIAS)	%	37.924	38.145	38.275	38.025	38.407	38.325
EFF. NCVp (CALCed)	%	35.297	35.553	35.630	35.595	35.834	35.779
STEP FACTOR	%	99.046	99.177	99.189	99.169	99.218	99.025
TOTAL ACCOUNTED LOSS	%	.954	.823	.811	.831	.782	.975
UNACCOUNTED LOSSES	%	.000	-.000	.000	.000	-.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	-.040	-.168	-.079	-.017	-.019	.147
DRY FLUE GAS	%	.248	.230	.155	.121	.078	.178
H2 & FUEL MOISTURE	%	-.026	-.018	-.009	.006	.011	.043

Table G.3: SPEC GRADE COAL 500 MW TESTS (Tuesday, 10th May 1994)

PARAMETER	UNITS	500/31.0/09h15	500/26.5/11h00	500/23.5/12h00	500/19.0/13h15	500/16.0/14h15	500/11.0/15h30
MAIN STEAM TEMP.	%	.002	-.001	-.026	.002	-.012	-.012
REHEAT STEAM TEMP.	%	-.012	-.012	-.014	-.012	.014	.014
CONDENSER BACKPRESS.	%	.012	.025	.028	.040	.038	-.012
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.007	-.022	-.019	-.009	-.007	-.006
WORKS POWER	%	-.118	-.106	-.120	-.194	-.216	-.272

Table G.4: SPEC GRADE COAL 450 MW TESTS (Friday, 13th May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	5.364	4.887	3.901	3.190	3.297	3.419
O2 A/HTR OUTL AVG DRY	% vol	6.345	5.856	5.450	4.771	4.386	3.907
O2 ID DISCHARGE AVG	% vol	7.128	6.697	5.898	5.783	5.213	4.896
O2 ECON DRY	% vol	5.507	4.866	4.293	3.559	3.140	2.623
O2 ID DISCHARGE DRY	% vol	6.980	6.429	5.911	5.188	4.753	4.178
CO2 ID AVG DRY	% vol	12.034	12.463	12.593	13.396	13.768	14.182
CO2 (THEORETIC MAX)	% mass	27.077	27.122	26.791	27.171	27.237	27.276
CO2 (OSTWALD) DRY	% vol	12.670	13.189	13.466	14.336	14.770	15.309
O2 (OSTWALD)	% vol	7.727	7.282	6.949	6.289	5.924	5.495
SO2 ID AVG DRY	ppm	654.321	677.557	732.706	748.890	772.428	792.430
NOx ID AVG DRY	ppm	706.060	708.218	667.564	664.406	646.358	612.576
CO (CODEL) AVG DRY	ppm	15.922	24.364	42.161	42.967	54.304	17.043
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	847.450	847.105	845.290	845.480	845.660	843.440
AMBIENT TEMPERATURE	°C	12.885	16.010	19.900	19.390	18.750	18.110
RELATIVE HUMIDITY	%	62.180	42.435	22.135	22.400	23.105	20.185
DEWPOINT TEMPERATURE	°C	-30.620	-30.290	-29.685	-29.790	-29.685	-28.490
FD AIR INLET T.(Tdb)	°C	28.672	30.909	34.464	34.406	33.940	32.359

Table G.4: <u>SPEC GRADE COAL 450 MW TESTS</u> (Friday, 13th May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
A/HTR GAS OUTLET AVG	°C	127.189	130.421	129.418	133.169	134.409	136.936
NO-LEAK A/HTR OUTL T.	°C	132.578	136.641	136.185	140.220	141.607	144.438
DRY FLUEGAS HEAT LOSS	MW	61.966	61.174	57.108	57.367	57.100	57.851
ID DISCHARGE TEMP AVG	°C	121.257	122.565	126.741	128.337	128.435	122.565
OPACITY	%	23.428	22.365	22.385	21.491	18.578	19.283
MOISTURE ATMOSPHERIC	kg/s	3.657	3.532	3.421	3.278	3.196	3.096
MOISTURE (COAL)	kg/s	9.657	9.384	8.823	8.747	9.012	9.116
MOISTURE (COMBUSTION)	kg/s	17.287	17.060	19.402	16.364	16.115	15.997
MOISTURE (HOPPER)	kg/s	4.091	4.047	4.119	4.117	4.129	4.111
MOISTURE TO FLY-ASH	kg/s	4.148	4.351	4.019	4.028	3.977	4.058
NETT MOISTURE	kg/s	30.544	29.672	31.747	28.478	28.475	28.261
AIR FLOW A.FOIL TOTAL	kg/s	498.758	484.791	457.482	449.804	436.946	425.145
AIR FLOW TOTAL	kg/s	520.931	503.116	487.184	466.773	455.111	440.726
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	18.285	18.285	18.285	18.285	18.285	18.285
AIR HTR LEAKAGE	kg/s	30.449	33.510	36.771	35.562	34.900	34.004
ESP AIR LEAKAGE	kg/s	41.410	38.411	35.520	32.273	30.282	27.893
COMBUSTION AIR	kg/s	490.482	469.605	450.413	431.211	420.210	406.722
THEORETICAL AIR	kg/s	391.288	390.466	388.145	388.319	387.760	386.481
STOICHIOM. AIR	kg/s	391.288	390.466	388.145	388.319	387.760	386.481
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.682	3.901	3.200	2.303	1.788	1.152
EXCESS AIR	kg/s	99.195	79.139	62.268	42.892	32.451	20.241

Table G.4: SPEC GRADE COAL 450 MW TESTS (Friday, 13th May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
ECON GAS(DAF)	kg/s	564.414	543.558	523.143	505.088	493.937	480.659
FURNACE GAS DRY	kg/s	529.414	508.558	488.143	470.088	458.937	445.659
TOTAL A/HTR GAS(DAF)	kg/s	596.363	578.569	561.414	542.150	530.338	516.163
ID GAS (DAF)	kg/s	637.773	616.980	596.934	574.422	560.620	544.056
ID GAS (CHEM. ANAL.)	kg/s	636.273	615.480	595.434	572.923	559.120	542.556
ID GAS (BALANCE TECH)	kg/s	637.773	616.980	596.932	574.424	560.623	544.061
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	136.804	135.307	138.104	139.030	139.768	138.378
BACK-END N2	kg/100kg	582.152	557.309	565.016	534.263	522.536	503.407
BACK-END O2	kg/100kg	57.410	50.551	46.895	38.957	34.880	29.483
BACK-END NOx	kg/100kg	.545	.522	.497	.468	.445	.405
BACK-END SO2	kg/100kg	1.077	1.066	1.164	1.126	1.135	1.119
BACK-END CO	kg/100kg	.011	.017	.029	.028	.035	.011
BACK-END CO2	kg/100kg	136.139	134.774	137.403	138.356	138.968	137.624
TOTAL GAS	kg/100kg	777.334	744.239	751.004	713.198	697.999	672.049
MOLE MASS (mixture)	kJ/kmolK	3024.135	3028.882	3029.078	3039.111	3043.403	3047.799
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	313.247	309.959	308.446	306.197	307.157	303.719
COAL DENSITY	TON/m3	.943	.963	.928	.947	.941	.960
COAL MASS FLOW	kg/s	82.046	82.901	79.484	80.542	80.319	80.955

Table G.4: <u>SPEC GRADE COAL 450 MW TESTS</u> (Friday, 13^{th} May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	4.900	4.800	4.600	5.400	5.800	5.600
ASH	%	41.500	42.900	41.300	40.400	40.000	40.600
VOLATILE MATTER	%	18.700	18.500	18.800	18.900	18.800	18.600
FIXED CARBON(BY DIFF)	%	34.900	33.800	35.300	35.300	35.400	35.200
CARBON	%	40.060	39.010	40.630	40.720	41.150	40.450
HYDROGEN	%	2.550	2.480	2.940	2.420	2.390	2.360
NITROGEN	%	1.060	1.040	1.060	1.140	1.020	1.060
TOTAL SULPHUR	%	.650	.500	.560	.680	.420	.470
CARBONATE (CO2)	%	.840	.800	.910	.930	.880	.800
OXYGEN (BY DIFF)	%	8.440	8.470	8.000	8.310	8.340	8.660
GROSS CV	MJ/kg	15.100	14.560	15.300	15.280	15.320	15.170
SURFACE MOISTURE	%	7.200	6.830	6.790	5.750	5.730	5.980
INHERENT MOISTURE	%	4.570	4.490	4.310	5.110	5.490	5.280
TOTAL MOISTURE	%	11.770	11.320	11.100	10.860	11.220	11.260
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	11.770	11.320	11.100	10.860	11.220	11.260
ASH (BY DIFF)	%	38.423	39.365	38.889	38.558	38.264	38.361
VOLATILE MATTER	%	17.289	17.177	17.466	17.755	17.660	17.426
FIXED CARBON(BY DIFF)	%	32.518	32.138	32.545	32.828	32.855	32.953
CARBON	%	37.336	36.928	37.691	37.944	38.145	37.766
HYDROGEN	%	2.356	2.328	2.542	2.313	2.299	2.282
NITROGEN	%	.980	.966	.985	1.071	.958	.993
TOTAL SULPHUR	%	.555	.487	.515	.574	.452	.475
CARBONATE (CO2)	%	.777	.743	.845	.874	.827	.749

Table G.4: SPEC GRADE COAL 450 MW TESTS (Friday, 13^{th} May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
OXYGEN	%	7.803	7.864	7.432	7.806	7.834	8.113
GCVv (AS RECD, BOMB)	MJ/kg	14.009	13.563	14.258	14.398	14.439	14.260
GCVv (DAILY AVERAGE)	MJ/kg	14.154	14.154	14.154	14.154	14.154	14.154
GCVv (BIAS.DAILY AVE)	MJ/kg	14.082	13.859	14.206	14.276	14.296	14.207
NCVp (CALCed, DULONG)	MJ/kg	15.168	14.999	15.527	15.345	15.377	15.229
HEAT IN VOLATILES	%	21.498	19.860	22.801	22.890	23.041	21.849
CARBON IN DUST	%	.400	.300	.400	.400	.500	.500
CARBON IN ROUGH ASH	%	.900	.700	.900	.700	.600	.500
MEAN CARBON IN ASH	%	.436	.329	.436	.422	.507	.500
MILLING PLANT							
NUMBER OF MILLS I/S	#	5.000	5.000	5.000	5.000	5.000	5.000
MILL CONFIGURATION	#	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF
PF FINENESS (%<75µm)	%	81.950	83.200	82.140	83.730	82.330	81.950
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	9.973	9.247	7.807	7.442	7.383	6.652
FEED FLOW (ORIFICE)	kg/s	335.503	337.605	341.404	339.304	339.159	339.979
TOTAL FEED FLOW	kg/s	345.476	346.852	349.211	346.746	346.542	346.631
MAIN STEAM TEMP.	°C	536.600	536.600	536.767	536.400	536.583	536.229
REHEAT STEAM TEMP.	°C	535.500	534.400	534.400	534.400	534.400	534.371
FINAL FEEDW. TEMP.	°C	228.300	228.300	228.250	228.300	228.300	228.307

Table G.4: SPEC GRADE COAL 450 MW TESTS (Friday, 13th May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	14.932	16.415	19.191	19.166	19.015	18.760
CW OUTLET TEMP.(T2)	°C	28.769	30.235	32.814	32.894	32.573	32.404
CONDENSATE TEMP.	°C	28.643	29.822	32.368	32.478	32.415	32.105
BACKPRESS. (AVERAGE)	kPa	3.068	3.365	4.013	4.027	3.931	3.550
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	449.200	449.709	449.267	449.067	449.267	449.010
UNIT CONSUMPTION	MW	23.039	22.764	22.529	22.485	22.389	22.194
REACTIVE LOAD	MVAR	257.050	247.014	206.983	231.783	232.900	235.573
WORKS POWER / USO	%	5.406	5.332	5.279	5.271	5.245	5.200
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	37.077	37.972	37.656	36.785	36.810	36.971
EFF. GCVv (DAILY AVE)	%	36.696	36.385	37.930	37.419	37.549	37.248
EFF. GCVv(DAILY BIAS)	%	36.886	37.161	37.793	37.099	37.176	37.109
EFF. NCVp (CALCed)	%	34.244	34.337	34.577	34.514	34.563	34.620
STEP FACTOR	%	98.822	99.011	99.084	99.144	99.219	98.952
TOTAL ACCOUNTED LOSS	%	1.178	.989	.916	.856	.781	1.048
UNACCOUNTED LOSSES	%	.000	.000	.000	-.000	-.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	-.033	-.077	-.060	-.089	-.013	.212
DRY FLUE GAS	%	.348	.176	.084	.016	-.052	.064
H2 & FUEL MOISTURE	%	-.019	-.020	-.017	-.010	-.006	.022

Table G.4: SPEC GRADE COAL 450 MW TESTS (Friday, 13th May 1994)

PARAMETER	UNITS	450/28.5/09h00	450/25.5/11h00	450/22.5/15h45	450/19.5/16h45	450/16.5/17h45	450/12.5/19h00
MAIN STEAM TEMP.	%	-.037	-.037	-.040	-.032	-.036	-.028
REHEAT STEAM TEMP.	%	-.012	.014	.014	.014	.014	.015
CONDENSER BACKPRESS.	%	.006	.007	.016	.021	.005	-.079
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.013	-.011	-.011	-.013	-.012	-.013
WORKS POWER	%	.043	.042	.036	.054	-.014	-.040

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12th May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
FLUE GAS ANALYSIS						
O2 ECON AVERAGE	% vol	5.340	4.728	3.896	3.143	2.708
O2 A/HTR OUTL AVG DRY	% vol	5.809	5.456	4.893	4.214	3.604
O2 ID DISCHARGE AVG	% vol	7.131	6.561	5.982	5.358	4.913
O2 ECON DRY	% vol	5.219	4.736	4.061	3.229	2.570
O2 ID DISCHARGE DRY	% vol	6.556	6.143	5.519	4.699	3.989
CO2 ID AVG DRY	% vol	12.191	12.533	13.047	13.614	14.223
CO2 (THEORETIC MAX)	% mass	26.733	26.847	26.889	26.908	27.059
CO2 (OSTWALD) DRY	% vol	12.872	13.299	13.882	14.621	15.351
O2 (OSTWALD)	% vol	7.368	7.051	6.508	5.891	5.316
SO2 ID AVG DRY	ppm	754.616	791.517	819.905	859.577	884.108
NOx ID AVG DRY	ppm	635.339	622.555	589.221	525.525	502.282
CO (CODEL) AVG DRY	ppm	21.324	31.986	28.961	49.026	91.066
AIR & FLUE GAS PROPERTIES						
BAROMETRIC PRESSURE	mbar	846.035	845.905	845.155	844.685	844.560
AMBIENT TEMPERATURE	°C	11.870	17.900	20.245	20.525	20.770
RELATIVE HUMIDITY	%	52.600	32.745	25.165	24.590	23.425
DEWPOINT TEMPERATURE	°C	-31.520	-30.790	-30.395	-29.770	-29.280
FD AIR INLET T.(Tdb)	°C	27.448	33.563	34.366	35.095	35.260

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12^{th} May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
A/HTR GAS OUTLET AVG	°C	127.418	129.834	133.536	136.582	138.651
NO-LEAK A/HTR OUTL T.	°C	131.138	134.105	138.439	142.282	144.530
DRY FLUEGAS HEAT LOSS	MW	54.884	52.095	52.253	51.686	51.066
ID DISCHARGE TEMP AVG	°C	126.775	118.641	121.967	123.554	116.301
OPACITY	%	22.338	19.025	19.385	16.962	17.783
MOISTURE ATMOSPHERIC	kg/s	3.219	3.138	3.025	2.887	2.777
MOISTURE (COAL)	kg/s	8.984	8.833	8.945	8.805	8.701
MOISTURE (COMBUSTION)	kg/s	15.486	15.882	15.337	15.532	15.483
MOISTURE (HOPPER)	kg/s	4.160	4.188	4.151	4.178	4.226
MOISTURE TO FLY-ASH	kg/s	3.835	3.708	3.874	3.752	3.531
NETT MOISTURE	kg/s	28.012	28.333	27.585	27.650	27.657
AIR FLOW A.FOIL TOTAL	kg/s	444.760	433.545	416.182	395.329	394.987
AIR FLOW TOTAL	kg/s	458.288	446.776	430.701	410.898	395.191
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	14.628	14.628	14.628	14.628	14.628
AIR HTR LEAKAGE	kg/s	18.688	21.655	23.275	25.231	24.737
ESP AIR LEAKAGE	kg/s	40.884	38.592	35.290	31.206	28.152
COMBUSTION AIR	kg/s	439.600	425.121	407.426	385.667	370.454
THEORETICAL AIR	kg/s	359.489	358.608	358.352	356.454	355.485
STOICHIOM. AIR	kg/s	359.489	358.608	358.352	356.454	355.485
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.219	3.622	2.788	1.754	.935
EXCESS AIR	kg/s	80.111	66.514	49.075	29.213	14.969

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12th May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
ECON GAS(DAF)	kg/s	509.118	494.994	477.304	455.474	441.104
FURNACE GAS DRY	kg/s	474.118	459.994	442.304	420.474	406.104
TOTAL A/HTR GAS(DAF)	kg/s	529.306	518.148	502.079	482.205	467.341
ID GAS (DAF)	kg/s	570.191	556.740	537.369	513.411	495.492
ID GAS (CHEM. ANAL.)	kg/s	568.691	555.240	535.869	511.911	493.992
ID GAS (BALANCE TECH)	kg/s	570.190	556.739	537.369	513.411	495.495
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION						
THEORETICAL CO2	kg/100kg	137.015	138.473	137.088	138.228	140.196
BACK-END N2	kg/100kg	575.849	566.378	538.610	521.663	506.739
BACK-END O2	kg/100kg	53.170	48.955	41.774	34.342	28.282
BACK-END NOx	kg/100kg	.483	.465	.418	.360	.334
BACK-END SO2	kg/100kg	1.225	1.263	1.242	1.258	1.255
BACK-END CO	kg/100kg	.015	.022	.019	.031	.057
BACK-END CO2	kg/100kg	135.972	137.379	135.816	136.830	138.691
TOTAL GAS	kg/100kg	766.715	754.463	717.880	694.484	675.357
MOLE MASS (mixture)	kJ/kmolK	3025.297	3029.258	3035.090	3041.019	3048.005
COAL QUANTITY AND QUALITY						
COAL VOLUME FLOW	m3/h	285.709	289.635	288.769	284.623	290.875
COAL DENSITY	TON/m3	.937	.917	.933	.935	.908
COAL MASS FLOW	kg/s	74.368	73.793	74.855	73.927	73.368

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12th May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)						
INHERENT MOISTURE	%	3.700	3.800	3.900	4.000	4.000
ASH	%	43.000	41.800	43.000	42.100	39.900
VOLATILE MATTER	%	18.300	18.700	17.900	18.800	19.600
FIXED CARBON(BY DIFF)	%	35.000	35.700	35.200	35.100	36.500
CARBON	%	40.630	41.410	40.530	41.150	42.300
HYDROGEN	%	2.560	2.640	2.510	2.570	2.580
NITROGEN	%	.940	1.050	.840	.870	1.060
TOTAL SULPHUR	%	1.290	.840	.910	.790	.760
CARBONATE (CO2)	%	.760	.810	.530	.690	.800
OXYGEN (BY DIFF)	%	7.120	7.650	7.780	7.830	8.600
GROSS CV	MJ/kg	15.280	15.540	15.100	15.400	16.160
SURFACE MOISTURE	%	8.680	8.470	8.350	8.210	8.160
INHERENT MOISTURE	%	3.400	3.500	3.600	3.700	3.700
TOTAL MOISTURE	%	12.080	11.970	11.950	11.910	11.860
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)						
TOTAL MOISTURE	%	12.080	11.970	11.950	11.910	11.860
ASH (BY DIFF)	%	39.164	38.393	39.135	38.656	37.194
VOLATILE MATTER	%	16.656	17.059	16.350	17.197	17.939
FIXED CARBON(BY DIFF)	%	32.100	32.578	32.566	32.236	33.007
CARBON	%	37.394	37.792	37.414	37.725	38.262
HYDROGEN	%	2.340	2.380	2.322	2.351	2.356
NITROGEN	%	.856	.958	.767	.796	.970
TOTAL SULPHUR	%	.994	.790	.823	.768	.755
CARBONATE (CO2)	%	.692	.739	.484	.631	.732

Table G.5: <u>SPEC GRADE COAL 400 MW TESTS</u> (Thursday, 12th May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
OXYGEN	%	6.480	6.979	7.106	7.162	7.871
GCVv (AS RECD, BOMB)	MJ/kg	13.950	14.220	13.835	14.131	14.837
GCVv (DAILY AVERAGE)	MJ/kg	14.195	14.195	14.195	14.195	14.195
GCVv (BIAS.DAILY AVE)	MJ/kg	14.073	14.207	14.015	14.163	14.516
NCVp (CALCed, DULONG)	MJ/kg	15.202	15.369	15.172	15.310	15.501
HEAT IN VOLATILES	%	22.180	22.520	20.393	22.849	24.762
CARBON IN DUST	%	.600	.700	.800	.900	1.000
CARBON IN ROUGH ASH	%	1.800	1.100	1.400	1.300	1.200
MEAN CARBON IN ASH	%	.686	.729	.843	.929	1.014
MILLING PLANT						
NUMBER OF MILLS I/S	#	4.000	4.000	4.000	4.000	4.000
MILL CONFIGURATION	#	BCDE	BCDE	BCDE	BCDE	BCDE
PF FINENESS (%<75μm)	%	76.600	77.250	78.410	76.760	75.700
WORKING FLUID CONDITIONS						
REHEATER SPRAY FLOW	kg/s	6.772	6.322	6.256	6.160	6.060
FEED FLOW (ORIFICE)	kg/s	316.446	317.819	319.556	322.341	324.556
TOTAL FEED FLOW	kg/s	323.218	324.141	325.812	328.501	330.616
MAIN STEAM TEMP.	°C	535.775	535.720	536.325	536.325	535.775
REHEAT STEAM TEMP.	°C	532.375	532.100	530.901	525.200	515.275
FINAL FEEDW. TEMP.	°C	222.450	222.467	222.450	222.450	222.507

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12^{th} May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
CONDENSER PERFORMANCE						
CW INLET TEMP.(T1)	°C	13.860	17.930	18.800	19.310	19.541
CW OUTLET TEMP.(T2)	°C	25.431	30.555	31.261	31.905	32.111
CONDENSATE TEMP.	°C	25.266	29.788	30.910	31.308	31.490
BACKPRESS. (AVERAGE)	kPa	2.356	3.413	3.540	3.701	3.762
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS						
UNITS GENERATED	MW	401.460	401.164	401.387	401.456	401.679
UNIT CONSUMPTION	MW	20.818	20.634	20.425	20.339	20.185
REACTIVE LOAD	MVAR	203.670	188.459	175.830	164.300	163.768
WORKS POWER / USO	%	5.469	5.422	5.361	5.337	5.291
STEP OUTPUT PARAMETERS						
EFF. GCVv (BOMB)	%	36.690	36.263	36.786	36.482	35.046
EFF. GCVv (DAILY AVE)	%	36.058	36.329	35.854	36.319	36.631
EFF. GCVv(DAILY BIAS)	%	36.371	36.296	36.314	36.400	35.821
EFF. NCVp (CALCed)	%	33.670	33.553	33.543	33.673	33.544
STEP FACTOR	%	99.062	99.102	99.118	99.218	98.768
TOTAL ACCOUNTED LOSS	%	.938	.897	.882	.782	1.232
UNACCOUNTED LOSSES	%	.000	.000	-.000	-.000	-.000
STEP LOSSES						
CARBON IN REFUSE	%	.147	.178	.220	.191	.456
DRY FLUE GAS	%	.050	-.034	-.066	-.293	-.283
H2 & FUEL MOISTURE	%	-.036	-.029	-.002	-.015	-.005

Table G.5: SPEC GRADE COAL 400 MW TESTS (Thursday, 12th May 1994)

PARAMETER	UNITS	400/34.0/09h00	400/30.0/11h15	400/26.0/13h00	400/22.0/14h00	400/18.0/15h00
MAIN STEAM TEMP.	%	-.018	-.017	-.031	-.031	-.018
REHEAT STEAM TEMP.	%	.063	.070	.098	.235	.473
CONDENSER BACKPRESS.	%	-.053	.014	-.004	.009	.011
TURB. DETERIORATION	%	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	.017	.015	.016	.017	.016
WORKS POWER	%	-.126	-.194	-.246	-.226	-.313

APPENDIX H
TEST DATA : HIGH GRADE COAL

APPENDIX H: HIGH GRADE COAL TEST DATA

Table H.1: HIGH GRADE COAL 630 MW TESTS

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	3.706	3.521	2.667	2.463	1.905	1.400
O2 A/HTR OUTL AVG DRY	% vol	5.469	5.084	4.557	3.979	3.345	2.578
O2 ID DISCHARGE AVG	% vol	5.980	5.550	4.880	4.460	3.970	3.460
O2 ECON DRY	% vol	3.738	3.411	2.859	2.335	1.872	1.448
O2 ID DISCHARGE DRY	% vol	5.794	5.419	4.775	4.102	3.458	2.842
CO2 ID AVG DRY	% vol	13.082	13.457	13.961	14.421	15.023	15.960
CO2 (THEORETIC MAX)	% mass	27.566	27.559	27.724	27.669	27.633	27.713
CO2 (OSTWALD) DRY	% vol	13.994	14.344	15.025	15.611	16.194	16.858
O2 (OSTWALD)	% vol	6.848	6.444	5.997	5.471	4.807	3.875
SO2 ID AVG DRY	ppm	375.791	377.529	398.428	414.728	443.948	558.548
NOx ID AVG DRY	ppm	801.541	723.323	707.089	666.887	619.534	558.548
CO (CODEL) AVG DRY	ppm	22.672	20.957	26.670	28.726	48.534	726.661
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	845.580	844.900	844.560	844.440	844.520	844.700
AMBIENT TEMPERATURE	°C	15.820	16.895	17.070	17.070	17.150	16.320
RELATIVE HUMIDITY	%	44.410	39.015	37.695	37.455	34.410	33.820

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
DEWPOINT TEMPERATURE	°C	-30.260	-29.805	-29.590	-29.860	-30.290	-30.040
FD AIR INLET T.(Tdb)	°C	30.557	31.565	32.000	31.849	31.929	31.099
A/HTR GAS OUTLET AVG	°C	132.437	133.652	135.773	138.841	140.757	142.541
NO-LEAK A/HTR OUTL T.	°C	143.281	143.892	145.996	148.702	149.415	149.042
DRY FLUEGAS HEAT LOSS	MW	82.556	80.685	79.242	78.575	76.612	75.086
ID DISCHARGE TEMP AVG	°C	125.592	128.097	129.448	132.801	133.019	132.982
OPACITY	%	30.372	26.838	24.477	22.736	23.281	21.750
MOISTURE ATMOSPHERIC	kg/s	4.526	4.427	4.261	4.104	3.965	3.837
MOISTURE (COAL)	kg/s	10.335	10.409	11.109	9.980	11.147	11.347
MOISTURE (COMBUSTION)	kg/s	19.920	19.695	18.693	19.394	18.376	19.316
MOISTURE (HOPPER)	kg/s	4.229	4.262	4.259	4.277	4.265	4.289
MOISTURE TO FLY-ASH	kg/s	3.518	3.370	3.384	3.300	3.354	3.247
NETT MOISTURE	kg/s	35.492	35.423	34.938	34.456	34.399	35.542
AIR FLOW A.FOIL TOTAL	kg/s	618.486	603.629	583.837	563.406	545.758	526.628
AIR FLOW TOTAL	kg/s	645.032	630.995	607.274	584.782	564.857	546.644
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	18.285	18.285	18.285	18.285	18.285	18.285
AIR HTR LEAKAGE	kg/s	69.433	64.529	61.422	55.903	47.331	34.554
ESP AIR LEAKAGE	kg/s	39.912	37.922	34.641	31.429	28.553	26.363
COMBUSTION AIR	kg/s	575.599	566.466	545.851	528.879	517.526	512.090
THEORETICAL AIR	kg/s	504.299	505.738	502.855	501.449	502.900	508.329
STOICHIOM. AIR	kg/s	504.299	505.738	502.855	501.449	502.899	508.329
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
CALCULATED FURNACE 02	% mass	2.868	2.482	1.824	1.201	.654	.170
EXCESS AIR	kg/s	71.300	60.728	42.996	27.430	14.627	3.761
ECON GAS(DAF)	kg/s	661.440	652.279	632.203	615.019	603.269	600.574
FURNACE GAS DRY	kg/s	626.440	617.279	597.203	580.019	568.269	565.574
TOTAL A/HTR GAS(DAF)	kg/s	732.374	718.308	695.126	672.423	652.100	636.628
ID GAS (DAF)	kg/s	772.286	756.229	729.767	703.851	680.652	662.992
ID GAS (CHEM. ANAL.)	kg/s	770.786	754.730	728.267	702.351	679.152	661.491
ID GAS (BALANCE TECH)	kg/s	772.287	756.238	729.762	703.853	680.650	662.991

VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION

THEORETICAL CO2	kg/100kg	163.230	165.160	163.557	165.457	164.614	165.871
BACK-END N2	kg/100kg	641.348	631.382	603.663	592.425	565.704	531.266
BACK-END 02	kg/100kg	52.405	48.241	40.578	34.116	27.446	21.289
BACK-END NOx	kg/100kg	.680	.604	.563	.520	.461	.392
BACK-END SO2	kg/100kg	.680	.673	.678	.691	.705	.838
BACK-END CO	kg/100kg	.018	.016	.020	.021	.034	.476
BACK-END CO2	kg/100kg	162.728	164.766	163.166	164.954	164.010	164.423
TOTAL GAS	kg/100kg	857.859	845.683	808.667	792.727	758.361	718.685
MOLE MASS (mixture)	kJ/kmolK	3035.186	3039.670	3045.253	3049.965	3057.130	3070.057

COAL QUANTITY AND QUALITY

COAL VOLUME FLOW	m3/h	337.981	332.837	329.829	329.053	327.373	335.088
COAL DENSITY	TON/m3	.959	.967	.985	.971	.987	.991
COAL MASS FLOW	kg/s	90.025	89.423	90.243	88.789	89.753	92.251

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	6.300	6.400	7.300	5.900	7.100	6.800
ASH	%	31.500	30.400	30.200	30.000	30.200	28.500
VOLATILE MATTER	%	20.600	20.900	20.600	21.200	20.700	21.600
FIXED CARBON(BY DIFF)	%	41.600	42.300	41.900	42.900	42.000	43.100
CARBON	%	46.910	48.070	47.060	48.270	47.840	48.660
HYDROGEN	%	2.630	2.620	2.460	2.600	2.440	2.500
NITROGEN	%	1.290	1.350	1.320	1.360	1.300	1.520
TOTAL SULPHUR	%	.440	.500	.380	.450	.570	.420
CARBONATE (CO2)	%	2.100	1.580	2.100	2.130	1.540	2.210
OXYGEN (BY DIFF)	%	8.830	9.080	9.180	9.290	9.010	9.390
GROSS CV	MJ/kg	17.750	18.210	18.060	18.510	18.160	18.690
SURFACE MOISTURE	%	5.510	5.580	5.380	5.660	5.700	5.880
INHERENT MOISTURE	%	5.970	6.060	6.930	5.580	6.720	6.420
TOTAL MOISTURE	%	11.480	11.640	12.310	11.240	12.420	12.300
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	11.480	11.640	12.310	11.240	12.420	12.300
ASH (BY DIFF)	%	29.612	29.110	28.432	28.746	28.704	27.356
VOLATILE MATTER	%	19.393	19.659	19.409	19.929	19.435	20.243
FIXED CARBON(BY DIFF)	%	39.515	39.591	39.849	40.085	39.441	40.101
CARBON	%	44.548	45.075	44.637	45.156	44.926	45.269
HYDROGEN	%	2.433	2.427	2.354	2.417	2.340	2.366
NITROGEN	%	1.214	1.270	1.244	1.278	1.221	1.424
TOTAL SULPHUR	%	.423	.451	.395	.428	.484	.413

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
CARBONATE (CO2)	%	1.977	1.486	1.979	2.002	1.446	2.071
OXYGEN	%	8.313	8.541	8.649	8.733	8.459	8.800
GCVv (AS RECD, BOMB)	MJ/kg	16.710	17.191	17.084	17.460	17.120	17.587
GCVv (DAILY AVERAGE)	MJ/kg	17.192	17.192	17.192	17.192	17.192	17.192
GCVv (BIAS.DAILY AVE)	MJ/kg	16.951	17.191	17.138	17.326	17.156	17.389
NCVp (CALCed, DULONG)	MJ/kg	17.716	17.887	17.630	17.911	17.717	17.864
HEAT IN VOLATILES	%	20.023	22.110	21.114	22.354	22.087	22.886
CARBON IN DUST	%	.400	.300	.300	.400	.500	.700
CARBON IN ROUGH ASH	%	.400	.400	.400	.500	.300	.100
MEAN CARBON IN ASH	%	.400	.307	.307	.407	.486	.657
MILLING PLANT							
NUMBER OF MILLS I/S	#	5.000	5.000	5.000	5.000	5.000	5.000
MILL CONFIGURATION	#	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF	BCDEF
PF FINENESS (%<75µm)	%	83.380	81.850	82.250	83.910	83.360	81.980
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	11.469	9.955	9.092	8.989	7.248	7.102
FEED FLOW (ORIFICE)	kg/s	493.076	496.569	499.051	498.754	501.496	502.726
TOTAL FEED FLOW	kg/s	504.545	506.524	508.143	507.743	508.744	509.828
MAIN STEAM TEMP.	°C	535.080	534.300	534.943	535.500	534.950	534.325
REHEAT STEAM TEMP.	°C	534.400	534.557	534.714	535.200	534.750	534.100
FINAL FEEDW. TEMP.	°C	244.500	244.200	244.500	244.250	244.250	244.250

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	15.886	16.610	16.850	16.730	16.790	17.080
CW OUTLET TEMP.(T2)	°C	33.939	34.585	34.834	34.660	34.650	34.870
CONDENSATE TEMP.	°C	37.650	38.397	38.511	38.430	38.376	38.620
BACKPRESS. (AVERAGE)	kPa	4.509	4.688	4.747	4.697	4.688	4.753
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	626.387	626.258	626.329	626.483	626.588	626.791
UNIT CONSUMPTION	MW	24.360	24.176	23.858	23.698	23.500	23.310
REACTIVE LOAD	MVAR	248.075	263.121	269.825	278.217	259.179	253.426
WORKS POWER / USO	%	4.046	4.015	3.960	3.931	3.897	3.863
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	40.020	39.167	39.078	38.884	39.249	37.196
EFF. GCVv (DAILY AVE)	%	38.898	39.164	38.833	39.489	39.085	38.052
EFF. GCVv(DAILY BIAS)	%	39.451	39.165	38.955	39.184	39.167	37.619
EFF. NCVp (CALCed)	%	37.746	37.641	37.867	37.905	37.927	36.621
STEP FACTOR	%	98.891	98.969	99.162	99.225	99.218	98.972
TOTAL ACCOUNTED LOSS	%	1.109	1.031	.838	.775	.781	1.028
UNACCOUNTED LOSSES	%	-.001	.000	.000	.000	.000	-.000
STEP LOSSES							
CARBON IN REFUSE	%	.025	.003	-.074	.064	.032	.301
DRY FLUE GAS	%	.066	.005	.005	-.225	-.109	-.109

Table H.1: HIGH GRADE COAL 630 MW TESTS (Monday, 16th May 1994)

PARAMETER	UNITS	630/21.0/11h45	630/18.0/13h15	630/15.0/14h15	630/11.0/15h15	630/08.0/16h15	630/05.0/17h15
H2 & FUEL MOISTURE	%	-.053	-.052	-.041	-.050	-.034	-.023
MAIN STEAM TEMP.	%	-.002	.017	.001	-.012	.001	.017
REHEAT STEAM TEMP.	%	.014	.011	.007	-.005	.006	.022
CONDENSER BACKPRESS.	%	-.019	-.021	-.022	-.026	-.030	-.033
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	.009	.016	.008	.015	.015	.016
WORKS POWER	%	.175	.158	.058	.119	.006	-.056

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
FLUE GAS ANALYSIS							
02 ECON AVERAGE	% vol	4.443	4.240	4.132	3.198	2.555	2.157
02 A/HTR OUTL AVG DRY	% vol	6.076	5.635	5.042	4.701	4.017	3.106
02 ID DISCHARGE AVG	% vol	6.366	5.985	5.600	4.891	4.261	3.611
02 ECON DRY	% vol	4.535	4.114	3.535	3.187	2.638	2.120
02 ID DISCHARGE DRY	% vol	6.546	6.085	5.419	4.995	4.272	3.540
CO2 ID AVG DRY	% vol	12.617	13.055	13.534	13.822	14.461	15.482
CO2 (THEORETIC MAX)	% mass	27.706	27.767	27.691	27.725	27.707	27.649
CO2 (OSTWALD) DRY	% vol	13.384	13.848	14.422	14.828	15.494	16.182
02 (OSTWALD)	% vol	7.427	6.995	6.440	6.150	5.459	4.346
SO2 ID AVG DRY	ppm	392.924	415.793	449.555	475.053	503.343	537.189
NOx ID AVG DRY	ppm	872.746	841.487	786.671	728.223	639.066	543.605
CO (CODEL) AVG DRY	ppm	6.486	28.182	32.761	31.320	107.207	766.942
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	846.900	846.830	846.350	845.730	845.200	845.030
AMBIENT TEMPERATURE	°C	10.020	13.870	15.280	16.275	16.670	16.830
RELATIVE HUMIDITY	%	62.930	48.170	42.645	39.415	35.890	35.110
DEWPOINT TEMPERATURE	°C	-30.930	-30.910	-30.370	-30.170	-30.120	-29.860
FD AIR INLET T.(Tdb)	°C	25.342	28.409	30.332	31.204	31.661	32.089

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
A/HTR GAS OUTLET AVG	°C	118.551	124.869	127.109	131.546	132.951	134.126
NO-LEAK A/HTR OUTL T.	°C	127.737	133.979	135.829	140.440	140.796	139.474
DRY FLUEGAS HEAT LOSS	MW	68.187	68.620	66.169	67.001	64.616	61.609
ID DISCHARGE TEMP AVG	°C	119.164	121.951	123.520	124.960	126.536	126.390
OPACITY	%	26.953	24.894	23.514	22.266	21.094	20.571
MOISTURE ATMOSPHERIC	kg/s	4.102	3.986	3.828	3.733	3.582	3.440
MOISTURE (COAL)	kg/s	9.647	10.234	10.092	10.071	10.040	10.346
MOISTURE (COMBUSTION)	kg/s	16.853	16.644	16.210	16.052	15.854	16.382
MOISTURE (HOPPER)	kg/s	4.418	4.384	4.403	4.380	4.416	4.368
MOISTURE TO FLY-ASH	kg/s	2.656	2.812	2.726	2.829	2.663	2.887
NETT MOISTURE	kg/s	32.364	32.436	31.807	31.407	31.229	31.649
AIR FLOW A.FOIL TOTAL	kg/s	567.250	551.584	525.426	509.352	498.314	473.235
AIR FLOW TOTAL	kg/s	584.462	567.984	545.351	531.716	510.208	489.963
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	14.628	14.628	14.628	14.628	14.628	14.628
AIR HTR LEAKAGE	kg/s	58.859	55.256	51.068	49.188	41.906	28.127
ESP AIR LEAKAGE	kg/s	40.608	38.144	34.621	32.478	29.187	26.348
COMBUSTION AIR	kg/s	525.602	512.728	494.283	482.528	468.301	461.836
THEORETICAL AIR	kg/s	442.468	442.819	441.774	440.076	440.440	446.399
STOICHIOM. AIR	kg/s	442.469	442.819	441.774	440.076	440.440	446.399
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	3.662	3.156	2.459	2.037	1.377	.774
EXCESS AIR	kg/s	83.134	69.909	52.509	42.452	27.861	15.437

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
ECON GAS(DAF)	kg/s	605.565	593.239	574.641	562.668	548.664	544.086
FURNACE GAS DRY	kg/s	570.565	558.239	539.641	527.668	513.664	509.086
TOTAL A/HTR GAS(DAF)	kg/s	665.924	649.995	627.209	613.355	592.070	573.713
ID GAS (DAF)	kg/s	706.532	688.139	661.829	645.833	621.257	600.061
ID GAS (CHEM. ANAL.)	kg/s	705.032	686.639	660.329	644.333	619.757	598.561
ID GAS (BALANCE TECH)	kg/s	706.535	688.139	661.830	645.833	621.257	600.062
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	167.832	165.115	165.806	164.814	166.878	165.291
BACK-END N2	kg/100kg	681.843	648.649	629.586	613.738	594.116	543.901
BACK-END O2	kg/100kg	63.173	55.851	48.158	43.202	35.732	27.222
BACK-END NOx	kg/100kg	.790	.724	.656	.591	.501	.392
BACK-END SO2	kg/100kg	.759	.764	.800	.823	.843	.827
BACK-END CO	kg/100kg	.005	.023	.025	.024	.078	.516
BACK-END CO2	kg/100kg	167.464	164.790	165.432	164.421	166.348	163.747
TOTAL GAS	kg/100kg	914.034	870.801	844.658	822.798	797.619	736.605
MOLE MASS (mixture)	kJ/kmolK	3030.824	3036.061	3041.182	3044.185	3051.604	3065.125
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	301.716	298.786	300.786	299.293	298.284	299.857
COAL DENSITY	TON/m3	.922	.952	.938	.944	.940	.978
COAL MASS FLOW	kg/s	77.298	79.024	78.355	78.492	77.889	81.463

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	6.400	6.600	6.700	6.700	7.100	6.900
ASH	%	28.000	29.100	28.400	29.400	27.800	28.800
VOLATILE MATTER	%	22.000	21.400	21.700	21.600	21.800	21.800
FIXED CARBON(BY DIFF)	%	43.600	42.900	43.200	42.300	43.300	42.500
CARBON	%	49.740	48.320	48.630	48.020	49.060	48.120
HYDROGEN	%	2.620	2.540	2.490	2.460	2.440	2.410
NITROGEN	%	1.440	1.490	1.650	1.840	2.110	2.440
TOTAL SULPHUR	%	.440	.390	.890	.420	.510	.440
CARBONATE (CO2)	%	2.130	1.860	1.860	2.130	1.970	2.100
OXYGEN (BY DIFF)	%	9.230	9.700	9.380	9.030	9.010	8.790
GROSS CV	MJ/kg	18.910	18.450	18.670	18.260	18.790	18.520
SURFACE MOISTURE	%	6.470	6.770	6.590	6.540	6.210	6.200
INHERENT MOISTURE	%	6.010	6.180	6.290	6.290	6.680	6.500
TOTAL MOISTURE	%	12.480	12.950	12.880	12.830	12.890	12.700
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	12.480	12.950	12.880	12.830	12.890	12.700
ASH (BY DIFF)	%	26.972	27.119	26.914	27.357	26.570	27.012
VOLATILE MATTER	%	20.486	19.856	20.174	20.093	20.349	20.354
FIXED CARBON(BY DIFF)	%	40.062	40.075	40.032	39.720	40.190	39.933
CARBON	%	45.804	45.063	45.251	44.980	45.544	45.111
HYDROGEN	%	2.380	2.339	2.318	2.305	2.299	2.286
NITROGEN	%	1.341	1.382	1.534	1.712	1.970	2.278
TOTAL SULPHUR	%	.445	.421	.653	.435	.478	.445
CARBONATE (CO2)	%	1.983	1.726	1.729	1.981	1.839	1.961

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
OXYGEN	%	8.595	9.000	8.720	8.400	8.410	8.207
GCVv (AS RECD, BOMB)	MJ/kg	17.682	17.196	17.433	17.060	17.619	17.366
GCVv (DAILY AVERAGE)	MJ/kg	17.393	17.393	17.393	17.393	17.393	17.393
GCVv (BIAS.DAILY AVE)	MJ/kg	17.537	17.294	17.413	17.226	17.506	17.379
NCVp (CALCed, DULONG)	MJ/kg	18.062	17.746	17.809	17.681	17.869	17.707
HEAT IN VOLATILES	%	23.372	21.182	22.339	21.259	22.853	22.232
CARBON IN DUST	%	.300	.200	.250	.300	.350	.700
CARBON IN ROUGH ASH	%	.600	.900	.900	.500	.700	.700
MEAN CARBON IN ASH	%	.322	.250	.297	.314	.375	.700
MILLING PLANT							
NUMBER OF MILLS I/S	#	4.000	4.000	4.000	4.000	4.000	4.000
MILL CONFIGURATION	#	BCDE	BCDE	BCDE	BCDE	BCDE	BCDE
PF FINENESS (%<75μm)	%	82.260	82.170	80.200	80.950	81.840	81.060
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	9.445	8.463	7.769	6.423	5.896	5.722
FEED FLOW (ORIFICE)	kg/s	434.948	437.854	439.153	439.790	442.199	442.498
TOTAL FEED FLOW	kg/s	444.393	446.317	446.922	446.213	448.095	448.220
MAIN STEAM TEMP.	°C	534.600	533.971	534.600	534.286	533.814	534.443
REHEAT STEAM TEMP.	°C	535.800	534.760	534.917	534.729	532.771	533.585
FINAL FEEDW. TEMP.	°C	237.850	237.350	237.350	237.350	237.350	237.336

Table H.2: HIGH GRADE COAL 550 MW TESTS (Tuesday, 17th May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	11.865	13.994	15.300	16.260	16.380	16.380
CW OUTLET TEMP.(T2)	°C	27.984	29.933	31.181	32.027	32.160	31.996
CONDENSATE TEMP.	°C	29.395	31.002	32.372	33.271	33.616	33.586
BACKPRESS. (AVERAGE)	kPa	3.273	3.403	3.687	3.814	3.914	4.036
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	550.160	550.053	550.835	550.800	550.393	550.291
UNIT CONSUMPTION	MW	22.042	21.986	21.679	21.470	21.377	21.310
REACTIVE LOAD	MVAR	304.450	274.730	241.030	254.850	239.824	255.070
WORKS POWER / USO	%	4.174	4.163	4.097	4.056	4.041	4.029
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	38.640	38.861	38.738	39.529	38.549	37.392
EFF. GCVv (DAILY AVE)	%	39.282	38.421	38.829	38.773	39.050	37.335
EFF. GCVv(DAILY BIAS)	%	38.958	38.640	38.783	39.147	38.798	37.363
EFF. NCVp (CALCed)	%	37.827	37.655	37.922	38.141	38.009	36.672
STEP FACTOR	%	98.877	99.048	99.080	99.170	99.218	99.209
TOTAL ACCOUNTED LOSS	%	1.123	.952	.920	.829	.782	.791
UNACCOUNTED LOSSES	%	.000	.000	.000	.001	.000	.000
STEP LOSSES							
CARBON IN REFUSE	%	.213	.134	.156	.160	.209	.319
DRY FLUE GAS	%	.141	.075	.092	.029	-.118	-.202
H2 & FUEL MOISTURE	%	-.059	-.053	-.038	-.035	-.039	-.037

Table H.2: <u>HIGH GRADE COAL 550 MW TESTS</u> (Tuesday, 17^{th} May 1994)

PARAMETER	UNITS	550/28.0/09h00	550/24.5/10.15	550/21.0/11h15	550/17.0/12h15	550/13.5/13h30	550/10.0/14h30
MAIN STEAM TEMP.	%	.010	.026	.010	.018	.030	.014
REHEAT STEAM TEMP.	%	-.019	.006	.002	.007	.053	.034
CONDENSER BACKPRESS.	%	.018	-.026	-.030	-.049	-.035	-.010
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	.001	.014	.016	.016	.015	.015
WORKS POWER	%	-.077	-.119	-.183	-.211	-.228	-.235

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	4.945	4.594	3.960	3.460	2.840	2.007
O2 A/HTR OUTL AVG DRY	% vol	6.687	6.267	5.634	5.044	4.348	3.460
O2 ID DISCHARGE AVG	% vol	7.030	6.613	5.957	5.382	4.638	3.992
O2 ECON DRY	% vol	5.023	4.609	3.910	3.361	2.755	2.149
O2 ID DISCHARGE DRY	% vol	7.202	6.773	6.011	5.357	4.575	3.720
CO2 ID AVG DRY	% vol	11.938	12.335	12.808	13.365	13.896	14.848
CO2 (THEORETIC MAX)	% mass	27.498	27.516	27.452	27.524	27.366	27.447
CO2 (OSTWALD) DRY	% vol	12.664	13.073	13.729	14.369	14.993	15.849
O2 (OSTWALD)	% vol	8.043	7.626	7.078	6.519	5.851	4.881
SO2 ID AVG DRY	ppm	344.227	358.020	385.748	418.979	456.577	504.247
NOx ID AVG DRY	ppm	860.044	834.161	770.810	725.018	646.182	532.840
CO (CODEL) AVG DRY	ppm	12.964	25.699	20.214	19.356	43.344	385.314
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	847.310	846.905	845.740	845.440	845.360	845.450
AMBIENT TEMPERATURE	°C	11.310	14.405	16.700	17.430	17.690	17.550
RELATIVE HUMIDITY	%	57.180	44.220	32.395	29.210	28.295	28.485
DEWPOINT TEMPERATURE	°C	-31.010	-30.350	-30.150	-29.389	-29.560	-29.730
FD AIR INLET T.(Tdb)	°C	27.052	29.587	32.316	32.898	32.926	32.954

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
A/HTR GAS OUTLET AVG	°C	123.172	127.130	130.472	131.685	133.313	134.896
NO-LEAK A/HTR OUTL T.	°C	133.857	137.622	141.001	141.641	142.489	142.162
DRY FLUEGAS HEAT LOSS	MW	68.483	67.657	65.171	63.058	61.035	58.531
ID DISCHARGE TEMP AVG	°C	117.224	119.071	122.430	124.841	125.955	126.716
OPACITY	%	27.700	26.631	24.840	23.070	21.624	21.036
MOISTURE ATMOSPHERIC	kg/s	3.957	3.850	3.670	3.528	3.371	3.215
MOISTURE (COAL)	kg/s	9.484	9.405	9.121	9.450	9.276	9.428
MOISTURE (COMBUSTION)	kg/s	15.214	15.500	15.886	15.893	15.626	16.405
MOISTURE (HOPPER)	kg/s	4.406	4.416	4.462	4.479	4.435	4.459
MOISTURE TO FLY-ASH	kg/s	2.710	2.663	2.454	2.378	2.580	2.471
NETT MOISTURE	kg/s	30.352	30.508	30.686	30.972	30.128	31.035
AIR FLOW A.FOIL TOTAL	kg/s	547.447	529.131	514.389	489.527	467.003	443.633
AIR FLOW TOTAL	kg/s	563.826	548.571	522.739	502.510	480.141	457.778
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	14.628	14.628	14.628	14.628	14.628	14.628
AIR HTR LEAKAGE	kg/s	63.202	59.921	57.222	52.292	45.945	35.105
ESP AIR LEAKAGE	kg/s	42.102	39.718	35.470	32.319	28.680	25.310
COMBUSTION AIR	kg/s	500.624	488.650	465.517	450.218	434.196	422.674
THEORETICAL AIR	kg/s	410.546	411.295	408.994	408.554	407.883	410.345
STOICHIOM. AIR	kg/s	410.546	411.295	408.994	408.554	407.883	410.345
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.165	3.665	2.811	2.142	1.403	.675
EXCESS AIR	kg/s	90.078	77.355	56.523	41.665	26.313	12.328

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
ECON GAS(DAF)	kg/s	576.488	564.830	540.910	526.090	509.635	499.354
FURNACE GAS DRY	kg/s	541.488	529.830	505.910	491.090	474.635	464.354
TOTAL A/HTR GAS(DAF)	kg/s	641.190	626.251	599.632	579.881	557.080	535.959
ID GAS (DAF)	kg/s	683.292	665.968	635.102	612.200	585.760	561.268
ID GAS (CHEM. ANAL.)	kg/s	681.792	664.468	633.602	610.700	584.260	559.769
ID GAS (BALANCE TECH)	kg/s	683.292	665.968	635.102	612.200	585.759	561.266
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	164.241	164.980	167.971	167.983	165.412	167.332
BACK-END N2	kg/100kg	705.757	686.459	675.388	648.202	615.621	579.410
BACK-END O2	kg/100kg	71.911	65.753	57.203	48.874	39.519	30.290
BACK-END NOx	kg/100kg	.805	.759	.688	.620	.523	.407
BACK-END SO2	kg/100kg	.688	.696	.735	.765	.789	.822
BACK-END CO	kg/100kg	.011	.022	.017	.015	.033	.275
BACK-END CO2	kg/100kg	163.947	164.701	167.647	167.690	165.086	166.273
TOTAL GAS	kg/100kg	943.121	918.390	901.678	866.168	821.572	777.476
MOLE MASS (mixture)	kJ/kmolK	3022.393	3027.077	3031.690	3038.103	3043.613	3055.581
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	275.298	273.334	272.713	270.028	269.343	270.614
COAL DENSITY	TON/m3	.947	.955	.930	.942	.953	.960
COAL MASS FLOW	kg/s	72.450	72.515	70.436	70.679	71.297	72.191

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	6.100	5.800	5.900	6.100	5.700	5.700
ASH	%	30.800	30.300	28.700	27.800	29.900	28.300
VOLATILE MATTER	%	21.500	21.300	21.600	22.100	21.400	21.900
FIXED CARBON(BY DIFF)	%	41.600	42.600	43.800	44.000	43.000	44.100
CARBON	%	48.030	48.550	50.260	50.420	48.880	50.050
HYDROGEN	%	2.550	2.600	2.740	2.740	2.670	2.770
NITROGEN	%	1.360	1.360	1.280	1.370	1.280	1.350
TOTAL SULPHUR	%	.540	.560	.450	.420	1.130	.700
CARBONATE (CO2)	%	2.330	1.930	2.300	2.100	1.970	1.950
OXYGEN (BY DIFF)	%	8.290	8.900	8.370	9.050	8.470	9.180
GROSS CV	MJ/kg	17.800	18.140	18.760	18.970	18.350	18.820
SURFACE MOISTURE	%	7.410	7.580	7.460	7.710	7.720	7.770
INHERENT MOISTURE	%	5.680	5.390	5.490	5.660	5.290	5.290
TOTAL MOISTURE	%	13.090	12.970	12.950	13.370	13.010	13.060
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	13.090	12.970	12.950	13.370	13.010	13.060
ASH (BY DIFF)	%	28.101	27.815	27.210	26.314	27.814	26.701
VOLATILE MATTER	%	19.811	19.593	19.895	20.294	19.656	20.103
FIXED CARBON(BY DIFF)	%	38.998	39.622	39.945	40.022	39.520	40.136
CARBON	%	44.824	45.026	45.842	45.845	45.144	45.668
HYDROGEN	%	2.406	2.427	2.493	2.489	2.458	2.503
NITROGEN	%	1.253	1.251	1.179	1.258	1.176	1.239
TOTAL SULPHUR	%	.540	.549	.498	.484	.810	.612
CARBONATE (CO2)	%	2.147	1.775	2.118	1.928	1.809	1.790

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
OXYGEN	%	7.639	8.187	7.709	8.310	7.780	8.427
GCVv (AS RECD, BOMB)	MJ/kg	16.475	16.759	17.354	17.501	16.928	17.351
GCVv (DAILY AVERAGE)	MJ/kg	17.061	17.061	17.061	17.061	17.061	17.061
GCVv (BIAS.DAILY AVE)	MJ/kg	16.768	16.910	17.208	17.281	16.994	17.206
NCVp (CALCed, DULONG)	MJ/kg	17.754	17.852	18.206	18.193	17.952	18.167
HEAT IN VOLATILES	%	19.944	20.044	22.155	22.661	21.041	21.770
CARBON IN DUST	%	.200	.100	.200	.200	.200	.600
CARBON IN ROUGH ASH	%	.600	1.500	1.000	.700	.600	.600
MEAN CARBON IN ASH	%	.229	.201	.258	.236	.229	.600
MILLING PLANT							
NUMBER OF MILLS I/S	#	4.000	4.000	4.000	4.000	4.000	4.000
MILL CONFIGURATION	#	BCDE	BCDE	BCDE	BCDE	BCDE	BCDE
PF FINENESS (%<75μm)	%	81.760	85.200	85.190	85.820	84.690	85.090
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	8.897	8.013	7.387	7.015	6.066	5.890
FEED FLOW (ORIFICE)	kg/s	398.495	401.367	403.083	404.717	405.847	408.054
TOTAL FEED FLOW	kg/s	407.392	409.379	410.470	411.732	411.913	413.944
MAIN STEAM TEMP.	°C	537.029	536.400	536.400	537.500	537.500	537.500
REHEAT STEAM TEMP.	°C	537.500	537.500	537.029	537.500	536.557	535.700
FINAL FEEDW. TEMP.	°C	234.000	233.450	233.450	233.450	233.450	233.450

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	12.587	14.384	16.380	16.731	16.960	17.080
CW OUTLET TEMP.(T2)	°C	27.584	29.444	31.409	31.678	31.904	32.008
CONDENSATE TEMP.	°C	27.930	30.761	31.763	32.080	32.137	32.284
BACKPRESS. (AVERAGE)	kPa	2.889	3.271	3.659	3.729	3.784	3.814
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	505.874	506.139	506.010	506.070	506.070	506.285
UNIT CONSUMPTION	MW	21.792	21.614	21.421	21.181	20.993	20.841
REACTIVE LOAD	MVAR	225.000	226.817	239.970	220.235	194.183	222.660
WORKS POWER / USO	%	4.502	4.461	4.420	4.368	4.328	4.293
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	40.556	39.869	39.643	39.200	40.192	38.755
EFF. GCVv (DAILY AVE)	%	39.162	39.163	40.324	40.210	39.877	39.413
EFF. GCVv(DAILY BIAS)	%	39.847	39.513	39.981	39.698	40.034	39.081
EFF. NCVp (CALCed)	%	37.634	37.429	37.789	37.710	37.898	37.015
STEP FACTOR	%	98.943	99.065	99.140	99.206	99.218	99.150
TOTAL ACCOUNTED LOSS	%	1.057	.935	.860	.794	.782	.850
UNACCOUNTED LOSSES	%	.000	.000	.000	.000	-.000	.001
STEP LOSSES							
CARBON IN REFUSE	%	-.039	-.106	-.034	.063	.075	.303
DRY FLUE GAS	%	.357	.282	.156	.095	.046	-.093
H2 & FUEL MOISTURE	%	-.042	-.038	-.034	-.028	-.021	-.020

Table H.3: HIGH GRADE COAL 500 MW TESTS (Wednesday, 18th May 1994)

PARAMETER	UNITS	500/32.0/10h00	500/28.0/11h00	500/24.0/13h00	500/19.5/14h00	500/15.0/15h00	500/11.0/16h00
MAIN STEAM TEMP.	%	-.046	-.032	-.032	-.055	-.055	-.055
REHEAT STEAM TEMP.	%	-.060	-.060	-.049	-.060	-.037	-.017
CONDENSER BACKPRESS.	%	-.015	-.009	-.016	-.019	-.019	-.019
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.012	.004	.003	.003	.003	.004
WORKS POWER	%	.020	.001	-.028	-.100	-.105	-.148

Table H.4: HIGH GRADE COAL 450 MW TESTS (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
FLUE GAS ANALYSIS							
02 ECON AVERAGE	% vol	5.354	5.104	4.567	4.024	3.302	2.415
02 A/HTR OUTL AVG DRY	% vol	6.963	6.213	5.866	5.172	4.669	3.644
02 ID DISCHARGE AVG	% vol	7.558	6.979	6.426	5.860	5.208	4.313
02 ECON DRY	% vol	6.145	5.094	4.673	3.894	3.273	2.479
02 ID DISCHARGE DRY	% vol	7.646	6.761	6.380	5.615	4.965	4.040
C02 ID AVG DRY	% vol	11.854	12.478	12.798	13.441	13.850	14.969
C02 (THEORETIC MAX)	% mass	27.633	27.664	27.683	27.719	27.761	27.765
C02 (OSTWALD) DRY	% vol	12.343	13.167	13.531	14.260	14.875	15.774
02 (OSTWALD)	% vol	8.209	7.554	7.223	6.556	6.140	4.963
S02 ID AVG DRY	ppm	307.067	344.493	371.746	407.140	454.273	509.317
NOx ID AVG DRY	ppm	820.920	786.758	749.676	701.469	613.096	488.799
CO (CODEL) AVG DRY	ppm	16.740	25.557	29.695	51.719	51.341	444.028
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	846.590	846.345	845.875	845.180	844.690	844.470
AMBIENT TEMPERATURE	°C	11.980	14.490	15.875	16.760	17.460	17.845
RELATIVE HUMIDITY	%	49.790	39.715	34.440	29.980	28.365	27.565
DEWPOINT TEMPERATURE	°C	-31.300	-31.430	-30.900	-30.980	-30.650	-30.095
FD AIR INLET T.(Tdb)	°C	27.612	29.880	31.509	31.883	32.797	33.102

Table H.4: <u>HIGH GRADE COAL 450 MW TESTS</u> (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
A/HTR GAS OUTLET AVG	°C	123.729	126.606	128.854	130.828	133.321	136.688
NO-LEAK A/HTR OUTL T.	°C	129.075	133.596	136.179	138.451	141.517	143.306
DRY FLUEGAS HEAT LOSS	MW	60.363	58.623	57.944	56.680	55.934	54.339
ID DISCHARGE TEMP AVG	°C	118.524	118.441	119.357	121.614	122.773	124.607
OPACITY	%	28.067	26.059	23.507	22.097	21.363	20.020
MOISTURE ATMOSPHERIC	kg/s	3.657	3.451	3.369	3.216	3.095	2.939
MOISTURE (COAL)	kg/s	8.206	8.256	7.974	8.105	7.980	8.758
MOISTURE (COMBUSTION)	kg/s	13.972	13.652	13.722	13.614	13.231	13.211
MOISTURE (HOPPER)	kg/s	4.465	4.473	4.436	4.490	4.473	4.477
MOISTURE TO FLY-ASH	kg/s	2.440	2.406	2.576	2.326	2.407	2.388
NETT MOISTURE	kg/s	27.860	27.426	26.924	27.100	26.372	26.997
AIR FLOW A.FOIL TOTAL	kg/s	509.664	487.781	467.241	446.476	430.212	405.855
AIR FLOW TOTAL	kg/s	520.876	491.503	479.742	457.969	440.594	418.378
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	14.628	14.628	14.628	14.628	14.628	14.628
AIR HTR LEAKAGE	kg/s	30.863	37.505	38.141	37.453	38.179	29.137
ESP AIR LEAKAGE	kg/s	41.168	36.162	34.200	30.540	27.609	24.002
COMBUSTION AIR	kg/s	490.013	453.998	441.601	420.516	402.415	389.241
THEORETICAL AIR	kg/s	375.690	373.301	372.952	372.521	369.881	373.938
STOICHIOM. AIR	kg/s	375.690	373.301	372.952	372.521	369.881	373.938
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	5.401	4.115	3.599	2.642	1.872	.910
EXCESS AIR	kg/s	114.323	80.697	68.649	47.996	32.534	15.303

Table H.4: HIGH GRADE COAL 450 MW TESTS (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
ECON GAS(DAF)	kg/s	562.563	526.217	513.941	492.913	474.800	462.440
FURNACE GAS DRY	kg/s	527.563	491.217	478.941	457.913	439.800	427.440
TOTAL A/HTR GAS(DAF)	kg/s	594.926	565.223	553.583	531.866	514.479	493.077
ID GAS (DAF)	kg/s	636.094	601.384	587.783	562.405	542.088	517.079
ID GAS (CHEM. ANAL.)	kg/s	634.594	599.884	586.283	560.905	540.588	515.579
ID GAS (BALANCE TECH)	kg/s	636.093	601.384	587.782	562.405	542.089	517.088
VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION							
THEORETICAL CO2	kg/100kg	166.617	166.932	165.005	168.179	166.456	167.194
BACK-END N2	kg/100kg	717.223	684.470	661.048	642.831	619.269	572.198
BACK-END O2	kg/100kg	77.923	65.549	59.690	51.014	43.322	32.664
BACK-END NOx	kg/100kg	.785	.715	.658	.598	.502	.371
BACK-END SO2	kg/100kg	.627	.669	.696	.740	.793	.824
BACK-END CO	kg/100kg	.015	.022	.024	.041	.039	.314
BACK-END CO2	kg/100kg	166.167	166.390	164.681	167.942	166.205	166.443
TOTAL GAS	kg/100kg	962.739	917.815	886.798	863.166	830.131	772.814
MOLE MASS (mixture)	kJ/kmolK	3022.679	3029.265	3032.944	3040.305	3044.409	3058.795
COAL QUANTITY AND QUALITY							
COAL VOLUME FLOW	m3/h	243.902	243.328	240.025	241.694	240.268	241.034
COAL DENSITY	TON/m3	.975	.969	.994	.970	.978	.999
COAL MASS FLOW	kg/s	66.071	65.523	66.281	65.156	65.302	66.910

Table H.4: <u>HIGH GRADE COAL 450 MW TESTS</u> (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	6.000	6.300	5.800	6.000	5.900	6.400
ASH	%	30.200	30.000	31.700	29.200	30.100	29.300
VOLATILE MATTER	%	21.500	21.300	20.800	21.200	21.600	21.200
FIXED CARBON(BY DIFF)	%	42.300	42.400	41.700	43.600	42.400	43.100
CARBON	%	48.970	49.110	47.900	49.900	48.810	49.500
HYDROGEN	%	2.550	2.510	2.490	2.520	2.440	2.390
NITROGEN	%	1.270	1.200	1.170	1.190	1.200	1.130
TOTAL SULPHUR	%	.540	.410	.380	.440	.520	.490
CARBONATE (CO2)	%	1.690	2.050	1.830	1.670	2.250	1.660
OXYGEN (BY DIFF)	%	8.780	8.420	8.730	9.080	8.780	9.130
GROSS CV	MJ/kg	18.170	18.130	17.790	18.600	18.270	18.380
SURFACE MOISTURE	%	6.800	6.700	6.590	6.820	6.690	7.110
INHERENT MOISTURE	%	5.620	5.900	5.440	5.620	5.530	5.980
TOTAL MOISTURE	%	12.420	12.600	12.030	12.440	12.220	13.090
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	12.420	12.600	12.030	12.440	12.220	13.090
ASH (BY DIFF)	%	28.412	28.279	29.322	27.844	28.245	27.563
VOLATILE MATTER	%	19.951	19.783	19.350	19.668	20.070	19.597
FIXED CARBON(BY DIFF)	%	39.217	39.337	39.297	40.048	39.465	39.750
CARBON	%	45.473	45.558	45.033	45.899	45.428	45.630
HYDROGEN	%	2.336	2.318	2.311	2.321	2.286	2.257
NITROGEN	%	1.178	1.115	1.088	1.104	1.115	1.045
TOTAL SULPHUR	%	.466	.405	.392	.419	.457	.441
CARBONATE (CO2)	%	1.568	1.904	1.702	1.549	2.091	1.534

Table H.4: HIGH GRADE COAL 450 MW TESTS (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
OXYGEN	%	8.147	7.820	8.122	8.424	8.158	8.440
GCVv (AS RECD, BOMB)	MJ/kg	16.929	16.911	16.613	17.326	17.043	17.066
GCVv (DAILY AVERAGE)	MJ/kg	16.981	16.981	16.981	16.981	16.981	16.981
GCVv (BIAS.DAILY AVE)	MJ/kg	16.955	16.946	16.797	17.154	17.012	17.024
NCVp (CALCed, DULONG)	MJ/kg	17.895	17.894	17.716	18.018	17.824	17.836
HEAT IN VOLATILES	%	21.654	21.330	20.003	21.825	21.686	21.227
CARBON IN DUST	%	.400	.400	.200	.100	.100	.200
CARBON IN ROUGH ASH	%		1.100	.600	.500	.700	.400
MEAN CARBON IN ASH	%	.371	.450	.229	.129	.143	.214
MILLING PLANT							
NUMBER OF MILLS I/S	#	4.000	4.000	4.000	4.000	4.000	4.000
MILL CONFIGURATION	#	BCDE	BCDE	BCDE	BCDE	BCDE	BCDE
PF FINENESS (%<75µm)	%	87.230	85.400	86.020	86.340	86.970	85.870
WORKING FLUID CONDITIONS		.000	.000	.000	.000	.000	.000
REHEATER SPRAY FLOW	kg/s	8.065	7.540	6.981	5.929	5.737	5.451
FEED FLOW (ORIFICE)	kg/s	351.853	354.868	359.254	359.881	360.412	365.750
TOTAL FEED FLOW	kg/s	359.918	362.408	366.235	365.810	366.149	371.201
MAIN STEAM TEMP.	°C	537.800	537.800	537.800	537.800	537.800	537.800
REHEAT STEAM TEMP.	°C	537.500	537.456	537.500	536.400	538.774	530.700
FINAL FEEDW. TEMP.	°C	228.150	227.850	227.550	227.550	227.550	227.550

Table H.4: <u>HIGH GRADE COAL 450 MW TESTS</u> (Thursday, 19th May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	12.790	14.502	15.708	16.359	16.589	17.110
CW OUTLET TEMP.(T2)	°C	26.306	27.971	29.266	29.804	30.020	30.574
CONDENSATE TEMP.	°C	26.311	27.572	29.085	29.526	31.222	30.287
BACKPRESS. (AVERAGE)	kPa	2.559	2.878	3.125	3.237	3.294	3.422
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	449.235	449.070	449.078	449.575	449.418	448.426
UNIT CONSUMPTION	MW	21.144	21.090	20.889	20.748	20.510	20.330
REACTIVE LOAD	MVAR	180.030	174.533	172.134	185.565	188.770	180.182
WORKS POWER / USO	%	4.939	4.928	4.878	4.838	4.782	4.749
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	38.273	38.624	38.885	37.987	38.539	37.490
EFF. GCVv (DAILY AVE)	%	38.155	38.464	38.043	38.757	38.678	37.677
EFF. GCVv(DAILY BIAS)	%	38.214	38.544	38.459	38.368	38.608	37.583
EFF. NCVp (CALCed)	%	36.207	36.503	36.464	36.527	36.849	35.871
STEP FACTOR	%	98.722	98.833	98.934	99.113	99.218	98.976
TOTAL ACCOUNTED LOSS	%	1.277	1.166	1.066	.887	.782	1.024
UNACCOUNTED LOSSES	%	.001	.000	.000	-.000	-.000	-.000
STEP LOSSES							
CARBON IN REFUSE	%	.103	.092	-.050	-.089	-.061	.185
DRY FLUE GAS	%	.345	.242	.235	.154	.101	.012
H2 & FUEL MOISTURE	%	-.059	-.042	-.032	-.024	-.015	-.006

Table H.4: HIGH GRADE COAL 450 MW TESTS (Thursday, 19^{th} May 1994)

PARAMETER	UNITS	450/33.0/09h45	450/29.0/10h45	450/25.0/11h45	450/20.5/12h45	450/16.5/13h45	450/12.5/15h00
MAIN STEAM TEMP.	%	-.061	-.061	-.061	-.061	-.061	-.061
REHEAT STEAM TEMP.	%	-.060	-.059	-.060	-.034	-.091	.103
CONDENSER BACKPRESS.	%	-.020	-.019	-.015	-.021	-.019	-.014
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	-.008	.001	.010	.012	.011	.008
WORKS POWER	%	.143	.118	.145	.055	.023	-.096

Table H.5: <u>HIGH GRADE COAL 400 MW TESTS</u> (Friday, 20th May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
FLUE GAS ANALYSIS							
O2 ECON AVERAGE	% vol	5.500	5.464	5.046	4.587	3.838	3.261
O2 A/HTR OUTL AVG DRY	% vol	6.643	6.374	5.804	5.281	4.632	3.807
O2 ID DISCHARGE AVG	% vol	7.415	7.112	6.585	6.100	5.436	4.862
O2 ECON DRY	% vol	5.362	4.975	4.358	3.791	3.169	2.565
O2 ID DISCHARGE DRY	% vol	7.387	7.023	6.381	5.746	4.986	4.127
CO2 ID AVG DRY	% vol	11.957	12.149	12.664	13.153	13.742	14.553
CO2 (THEORETIC MAX)	% mass	27.613	27.608	27.619	27.725	27.739	27.698
CO2 (OSTWALD) DRY	% vol	12.564	12.888	13.486	14.125	14.835	15.621
O2 (OSTWALD)	% vol	8.086	7.875	7.329	6.862	6.240	5.355
SO2 ID AVG DRY	ppm	341.353	367.733	410.941	443.314	481.851	504.959
NOx ID AVG DRY	ppm	782.577	755.646	704.374	641.851	554.422	472.904
CO (CODEL) AVG DRY	ppm	12.947	5.376	11.395	9.127	28.548	272.252
AIR & FLUE GAS PROPERTIES							
BAROMETRIC PRESSURE	mbar	845.485	845.120	845.030	844.915	844.990	845.160
AMBIENT TEMPERATURE	°C	8.310	7.395	7.040	6.650	6.520	6.015
RELATIVE HUMIDITY	%	52.220	55.225	55.615	57.070	56.950	60.905
DEWPOINT TEMPERATURE	°C	-31.310	-31.815	-31.940	-31.880	-31.830	-31.950
FD AIR INLET T.(Tdb)	°C	28.406	27.231	27.235	27.096	25.957	25.232

Table H.5: HIGH GRADE COAL 400 MW TESTS (Friday, 20th May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
A/HTR GAS OUTLET AVG	°C	121.939	121.567	122.933	126.141	126.887	126.125
NO-LEAK A/HTR OUTL T.	°C	129.915	130.194	131.633	135.111	135.501	133.078
DRY FLUEGAS HEAT LOSS	MW	53.775	53.337	52.210	52.289	51.047	48.277
ID DISCHARGE TEMP AVG	°C	122.926	120.439	118.984	119.244	120.900	121.038
OPACITY	%	26.459	24.879	21.939	22.243	19.940	19.529
MOISTURE ATMOSPHERIC	kg/s	3.226	3.147	3.022	2.907	2.781	2.651
MOISTURE (COAL)	kg/s	7.558	7.415	7.491	7.582	7.557	7.545
MOISTURE (COMBUSTION)	kg/s	12.870	12.362	12.367	12.144	11.872	12.087
MOISTURE (HOPPER)	kg/s	4.542	4.512	4.536	4.530	4.534	4.543
MOISTURE TO FLY-ASH	kg/s	2.092	2.226	2.117	2.143	2.125	2.085
NETT MOISTURE	kg/s	26.102	25.211	25.300	25.020	24.619	24.741
AIR FLOW A.FOIL TOTAL	kg/s	454.599	443.480	427.243	412.320	393.375	372.440
AIR FLOW TOTAL	kg/s	459.353	448.126	430.227	413.784	395.724	377.165
CORE AIR FLOW	kg/s	11.930	11.930	11.930	11.930	11.930	11.930
SEAL AIR FLOW	kg/s	10.971	10.971	10.971	10.971	10.971	10.971
AIR HTR LEAKAGE	kg/s	40.979	42.732	41.025	39.572	36.062	28.395
ESP AIR LEAKAGE	kg/s	40.977	38.565	34.885	31.594	27.876	24.105
COMBUSTION AIR	kg/s	418.374	405.393	389.202	374.212	359.662	348.770
THEORETICAL AIR	kg/s	340.253	338.225	337.679	336.191	335.277	336.448
STOICHIOM. AIR	kg/s	340.253	338.225	337.679	336.191	335.277	336.448
FURNACE LEAKAGE	kg/s	35.000	35.000	35.000	35.000	35.000	35.000
CALCULATED FURNACE O2	% mass	4.323	3.836	3.065	2.352	1.570	.818
EXCESS AIR	kg/s	78.121	67.168	51.523	38.021	24.385	12.322

Table H.5: HIGH GRADE COAL 400 MW TESTS (Friday, 20th May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
ECON GAS(DAF)	kg/s	487.278	473.786	457.583	443.020	428.435	417.754
FURNACE GAS DRY	kg/s	452.278	438.786	422.583	408.020	393.435	382.754
TOTAL A/HTR GAS(DAF)	kg/s	529.757	518.018	500.108	484.091	465.997	447.648
ID GAS (DAF)	kg/s	570.734	556.583	534.992	515.685	493.873	471.754
ID GAS (CHEM. ANAL.)	kg/s	569.234	555.083	533.492	514.185	492.373	470.254
ID GAS (BALANCE TECH)	kg/s	570.732	556.582	534.991	515.684	493.874	471.752

VOLUMETRIC - GRAVIMETRIC BACK-END GAS RECONCILIATION

THEORETICAL CO2	kg/100kg	168.240	166.581	168.044	166.693	167.046	168.353
BACK-END N2	kg/100kg	720.224	703.523	681.954	652.031	626.026	595.070
BACK-END O2	kg/100kg	75.450	69.922	61.487	52.838	43.930	34.552
BACK-END NOx	kg/100kg	.750	.705	.636	.553	.458	.371
BACK-END SO2	kg/100kg	.698	.733	.793	.816	.850	.846
BACK-END CO	kg/100kg	.012	.005	.010	.007	.022	.200
BACK-END CO2	kg/100kg	167.978	166.360	167.827	166.358	166.523	167.561
TOTAL GAS	kg/100kg	965.111	941.248	912.706	872.604	837.809	798.599
MOLE MASS (mixture)	kJ/kmolK	3023.404	3025.115	3030.935	3036.337	3042.857	3052.465

COAL QUANTITY AND QUALITY

COAL VOLUME FLOW	m3/h	219.408	221.842	221.018	222.354	223.031	223.021
COAL DENSITY	TON/m3	.970	.960	.955	.957	.951	.954
COAL MASS FLOW	kg/s	59.136	59.132	58.616	59.097	58.948	59.072

Table H.5: HIGH GRADE COAL 400 MW TESTS (Friday, 20^{th} May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
PROXIMATE AND ULTIMATE ANALYSIS (AIR DRIED)							
INHERENT MOISTURE	%	6.200	5.800	6.200	6.000	6.400	6.300
ASH	%	29.000	30.900	29.600	29.800	29.500	28.900
VOLATILE MATTER	%	21.600	21.000	21.300	21.500	21.500	21.900
FIXED CARBON(BY DIFF)	%	43.200	42.300	42.900	42.700	42.600	42.900
CARBON	%	49.810	48.900	49.700	49.030	49.030	49.820
HYDROGEN	%	2.630	2.530	2.550	2.490	2.430	2.470
NITROGEN	%	1.210	1.180	1.190	1.180	1.180	1.170
TOTAL SULPHUR	%	.540	.410	.430	.470	.520	.510
CARBONATE (CO2)	%	1.650	2.170	2.030	2.290	2.330	2.420
OXYGEN (BY DIFF)	%	8.960	8.110	8.300	8.740	8.610	8.410
GROSS CV	MJ/kg	18.530	18.150	18.470	18.320	18.270	18.400
SURFACE MOISTURE	%	6.980	7.130	6.990	7.230	6.830	6.830
INHERENT MOISTURE	%	5.800	5.410	5.790	5.600	5.990	5.900
TOTAL MOISTURE	%	12.780	12.540	12.780	12.830	12.820	12.773
PROXIMATE AND ULTIMATE ANALYSIS (AS RECEIVED)							
TOTAL MOISTURE	%	12.780	12.540	12.780	12.830	12.820	12.773
ASH (BY DIFF)	%	27.506	28.655	27.926	27.648	27.596	27.389
VOLATILE MATTER	%	19.999	19.417	19.720	19.853	19.938	20.300
FIXED CARBON(BY DIFF)	%	39.715	39.388	39.574	39.668	39.646	39.538
CARBON	%	45.915	45.463	45.862	45.493	45.590	45.946
HYDROGEN	%	2.382	2.334	2.345	2.314	2.292	2.310
NITROGEN	%	1.120	1.091	1.102	1.090	1.094	1.085
TOTAL SULPHUR	%	.472	.412	.421	.439	.463	.459
CARBONATE (CO2)	%	1.528	2.006	1.879	2.115	2.161	2.243

Table H.5: HIGH GRADE COAL 400 MW TESTS (Friday, 20th May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
OXYGEN	%	8.296	7.499	7.684	8.071	7.984	7.796
GCVv (AS RECD, BOMB)	MJ/kg	17.230	16.851	17.174	16.989	17.017	17.129
GCVv (DAILY AVERAGE)	MJ/kg	17.065	17.065	17.065	17.065	17.065	17.065
GCVv (BIAS.DAILY AVE)	MJ/kg	17.148	16.958	17.120	17.027	17.041	17.097
NCVp (CALCed, DULONG)	MJ/kg	18.096	17.883	18.027	17.866	17.873	18.017
HEAT IN VOLATILES	%	22.047	20.950	22.070	21.032	21.206	21.935
CARBON IN DUST	%	.100	.100	.100	.300	.400	.400
CARBON IN ROUGH ASH	%	1.500	1.000	.900		1.000	.900
MEAN CARBON IN ASH	%	.201	.165	.158	.278	.443	.436
MILLING PLANT							
NUMBER OF MILLS I/S	#	3.000	3.000	3.000	3.000	3.000	3.000
MILL CONFIGURATION	#	BCD	BCD	BCD	BCD	BCD	BCD
PF FINENESS (%<75µm)	%	79.970	75.570	81.590	81.260	80.230	83.350
WORKING FLUID CONDITIONS							
REHEATER SPRAY FLOW	kg/s	6.421	6.454	6.373	6.380	6.332	6.389
FEED FLOW (ORIFICE)	kg/s	323.823	322.931	320.359	321.278	326.079	324.495
TOTAL FEED FLOW	kg/s	330.244	329.385	326.732	327.658	332.411	330.884
MAIN STEAM TEMP.	°C	538.324	538.400	538.400	537.771	537.800	538.139
REHEAT STEAM TEMP.	°C	535.000	533.576	531.800	528.881	521.088	515.135
FINAL FEEDW. TEMP.	°C	222.050	222.040	222.050	222.050	222.275	222.008

Table H.5: <u>HIGH GRADE COAL 400 MW TESTS</u> (Friday, 20^{th} May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
CONDENSER PERFORMANCE							
CW INLET TEMP.(T1)	°C	13.085	12.397	12.509	11.969	11.158	10.375
CW OUTLET TEMP.(T2)	°C	25.107	24.380	24.482	24.003	23.264	22.438
CONDENSATE TEMP.	°C	25.150	24.366	24.420	24.096	23.346	22.623
BACKPRESS. (AVERAGE)	kPa	2.297	2.173	2.204	2.112	1.990	1.868
CW PUMPS I/S (WEST)	#	3.000	3.000	3.000	3.000	3.000	3.000
ELECTRICAL PARAMETERS							
UNITS GENERATED	MW	399.564	401.843	401.843	400.286	400.188	400.152
UNIT CONSUMPTION	MW	17.540	17.532	17.438	17.280	17.164	17.086
REACTIVE LOAD	MVAR	212.530	215.400	224.859	234.196	234.196	229.895
WORKS POWER / USO	%	4.591	4.562	4.536	4.512	4.481	4.460
STEP OUTPUT PARAMETERS							
EFF. GCVv (BOMB)	%	37.493	38.568	38.185	38.148	38.183	37.858
EFF. GCVv (DAILY AVE)	%	37.855	38.085	38.430	37.978	38.076	38.000
EFF. GCVv(DAILY BIAS)	%	37.673	38.325	38.307	38.063	38.129	37.929
EFF. NCVp (CALCed)	%	35.699	36.343	36.378	36.275	36.353	35.991
STEP FACTOR	%	99.007	99.094	99.200	99.217	99.193	99.005
TOTAL ACCOUNTED LOSS	%	.993	.906	.800	.782	.807	.995
UNACCOUNTED LOSSES	%	.000	.000	.000	.001	.001	.000
STEP LOSSES							
CARBON IN REFUSE	%	.131	.043	.043	.073	.178	.350
DRY FLUE GAS	%	.381	.347	.231	.178	-.013	-.115
H2 & FUEL MOISTURE	%	-.032	-.025	-.023	-.015	-.021	-.020

Table H.5: HIGH GRADE COAL 400 MW TESTS (Friday, 20th May 1994)

PARAMETER	UNITS	400/37.0/00h00	400/32.5/00h50	400/27.5/01h45	400/23.5/02h35	400/18.0/03h45	400/14.0/05h00
MAIN STEAM TEMP.	%	-.071	-.072	-.072	-.061	-.061	-.068
REHEAT STEAM TEMP.	%	.000	.034	.077	.147	.334	.477
CONDENSER BACKPRESS.	%	-.034	-.039	-.036	-.046	-.071	-.094
TURB. DETERIORATION	%	.894	.894	.894	.894	.894	.894
FINAL FEEDWATER TEMP.	%	.024	.033	.032	.027	.018	.028
WORKS POWER	%	-.299	-.308	-.347	-.415	-.451	-.457

APPENDIX I
STEP PROGRAM PHILOSOPHY AND CUSTOMISATION

APPENDIX I: STEP PROGRAM CUSTOMISATION

I.1 INTRODUCTION

The purpose of these notes is to give a brief summary of the background and philosophy applicable to the STEP system as well as identified shortcomings and methods adopted to address these.

STEP is the abbreviation for Station Thermal Efficiency Performance program that basically comprises a mathematical model of the power station and the generating units within. The system was developed in Great Britain for the then Central Electricity Generating Board (CEGB) and was introduced into ESKOM in the early 1970's to optimise efficiency by reducing energy losses as far as possible. At the time, efficiencies were typically about 27%, due in part to the vintage of the plant design and in cases poor operating and maintenance practises.

I.2 PHILOSOPHY ON TARGETS AND CORRECTION FACTORS

The decision to construct a power generating plant of a specific rating depends on the projected growth in demand for electricity and the availability of sufficient quantities of water and fuel of suitable quality.

I.2.1 Design considerations, criteria and constraints:

The overall cycle efficiency is generally set by the steam conditions specified to conform to the design standard adopted. Scientific and engineering principles form the basis of the design, against a background of economics, for example, according to Laws of Thermodynamics:

- Energy cannot be created or destroyed but only converted from one form to another.
- Heat machines can only operate where some heat is rejected to a sink.

Available Technology and Plant characteristics:

- Temperatures, pressures and mass flows.
- Configuration of plant, i.e., number of turbine cylinders, drum or Benson type boiler, etc.
- Cooling methods for the condenser, generator stator and rotor etc.
- Feed pump type and configuration.
- Mill type and configuration.
- Design efficiencies of components (fans, pumps, motors and heat exchangers).

It is thus accepted that the Rankine cycle process will reject heat to atmosphere via flue gas, cooling towers and radiation. In addition, the plant will use some electricity within itself, lose water and have an impact on the environment. These losses vary in magnitude primarily relative to load, and the STEP system makes it possible to ste appropriate targets.

In view of the above, the normal output energy of the modern power plants in ESKOM is about 36% of the input. The question is whether this output ratio is optimum or not for given circumstances and whether the Station has control over any adverse condition or not.

It is clear that a certain magnitude of loss is inevitable, therefore a target must be set for this, such that when controllable conditions deviate from the optimum, a STEP loss equal to (Actual - Target) may be calculated and corrective action taken as soon as possible.

I.2.2 Controllable factors:

Factors that affect the output or efficiency of the plant but can be corrected by:

I.2.2.1 Immediate intervention by the operator, control system and other automatic responses to ensure:

- Combustion air flow kept at optimum (affects Flue Gas, Carbon in Ash and Works Power Losses).
- Batching of coal qualities, i.e. kept constant in a range enabling optimising of the unit for that specific range of quality.
- Coal reclaimed from driest patches in the coal stockyard.
- Boiler balance (Fan and mill bias).

- Flows and temperatures controlled to an even temperature profile and heat transfer per component as per design, avoid cycling of mills / fans / feedwater.

- Correct Steam Temperature and Reheater Spray water settings (working fluid mass flow rate).

- Possible washing of LP turbine last stage blades avoided i.e. isentropic deterioration due to too low Reheat Steam Temperature and/or condenser back pressure.

- Boiler pressure correct (working fluid mass flow rate).

- Optimum number of CW pumps in service (Cooling water mass flow rate and condenser back pressure optimised against Works power).

- Water/steam loss reduced (closed drain valves, tight gland seals, etc.).

- HP/IP cylinder by-passes shut.

- Water chemical quality controlled (silica deposits avoided in turbine, boiler heat transfer not adversely affected).

- Prevention of unnecessary usage of EFP's, wrong mill combinations, unnecessary running of unloaded conveyors, etc. (Works power reduction).

- Unit Board voltages controlled at maximum.

- Equalised sharing of reactive load amongst units.

- Reduction in lost start-up heat due to unnecessary (forced) outages / starts minimised.

I.2.2.2 Routines, maintenance and optimisation actions to get plant up to spec. by:

- Effective and selective sootblowing (air heater, economiser, furnace, front, then rear gas pass, air heater).
- Minimising air in-leakages (inspection doors, ash hopper seal etc.)
- Setting air heater seals for minimum leakage and ensuring packs clear of obstruction.
- Optimising mill performance (for ball tube mills especially the grinding media level and size distribution, trunnion division plate settings, boiler balancing).
- Ensuring even PA/Pf distribution to burners.
- Evaluating PF fineness test results and exercise corrective actions (classifier vane settings, etc.).
- Correct burner swirl generator settings.
- Undamaged burners.
- Damper stroke checking.
- Ensuring casing/ducting free of leaks and clear of obstructions.
- Reducing water/steam loss by repairing leaks, passing valves.
- Demineralised water consumption testing.
- Feed heater effectiveness testing.
- Condenser tube cleanliness.
- Boiler Feed Pump condenser cleaning.
- Condenser vacuum decay testing.
- Turbine cylinder and control valve maintenance (cleaning deposits).
- Cleaning CW system (screens and water boxes).
- Cooling Tower spray nozzle cleaning, etc.

- Having production planned for optimum load and minimised shutdowns (cold reserve, etc.).
- Regular mass meter and other instrument calibration.
- Ensuring measuring point representativeness.
- Accurate coal accounting and regular coal stock surveys, etc.

I.2.2.3 Refurbishment when necessary of: Air heater packs, turbine blading, condenser tubing, mill liners, etc.

I.2.2.4 Identification of possible enhancement and design modifications e.g.: Sliding pressure control, changing heat transfer areas, alternative fuel, etc.

I.2.3 Uncontrollable factors:

Some factors impacting on the plant are deemed not to be within control of the Station. These are generally Transmission System related and/or external or environmental aspects. To isolate the parameters which can be controlled by the Station (indicated by the STEP losses), the Target Efficiency needs to be corrected for these as well as for the effects of the target losses, such as:

- Load demand (assuming that Trading and Bidding strategy of the Station to compete for load as well as the availability of plant has no effect).
- Reactive power demand.

- It is assumed that there is no control over the following: The availability of sufficient quantity of coal, and coal quality different from design (volatile and ash content, CV, total moisture)

- Atmospheric conditions worse than design (cooling water inlet temperature (assuming cooling tower performance fixed), air inlet temperature, relative humidity).

- Availability of a sufficient quantity of raw water (drought periods affecting load).

- More stringent emission limits than designed for (affecting load).

- Start-up heat following essential planned outages.

I.3 STEP SYSTEM ATTRIBUTES

I.3.1 Sliding targets:

Any component of plant is designed for a specific output that should be achievable under given circumstances (load, ambient conditions etc.). In practice, conditions deviate from design due to atmospheric or other factors and to determine whether the plant performs at its best for those conditions, the design value is corrected for the variance in conditions to set a Target and the Actual compared against that.

I.3.2 Reconciliation of Direct and Indirect sides:

Although the targets are derived from separate boiler and turbine design and/or acceptance data, the method forces evaluation of the overall energy conversion cycle. This approach ensures increased accuracy due the proper analysis of results in explaining the unaccounted STEP loss. This method is therefore superior to others that simply accept values indicated by the indirect (or losses) method.

I.3.3 Historical data, trends, and overall station indicators:

The system lends itself to storing of statistics for reporting purposes. It also facilitates easy analysis of operational data even if it may be suspect in terms of absolute values due to the exposing of trends. It also enables the summation of unit data to arrive at a single Station Performance Indicator and other supporting station data that in its turn enables comparison of differently rated Power Stations at a corporate level.

I.4 THE STEP MECHANISM

The ratio of actual to target efficiency is called the STEP factor and is an indication of how well the unit has performed under given circumstances. A poor STEP factor should coincide with a high STEP loss that is the cue for corrective action. If none of the STEP losses are large but the unaccounted loss is, this is an indication of a measurement or calculation error. See Figure I.1 for a diagrammatic representation.

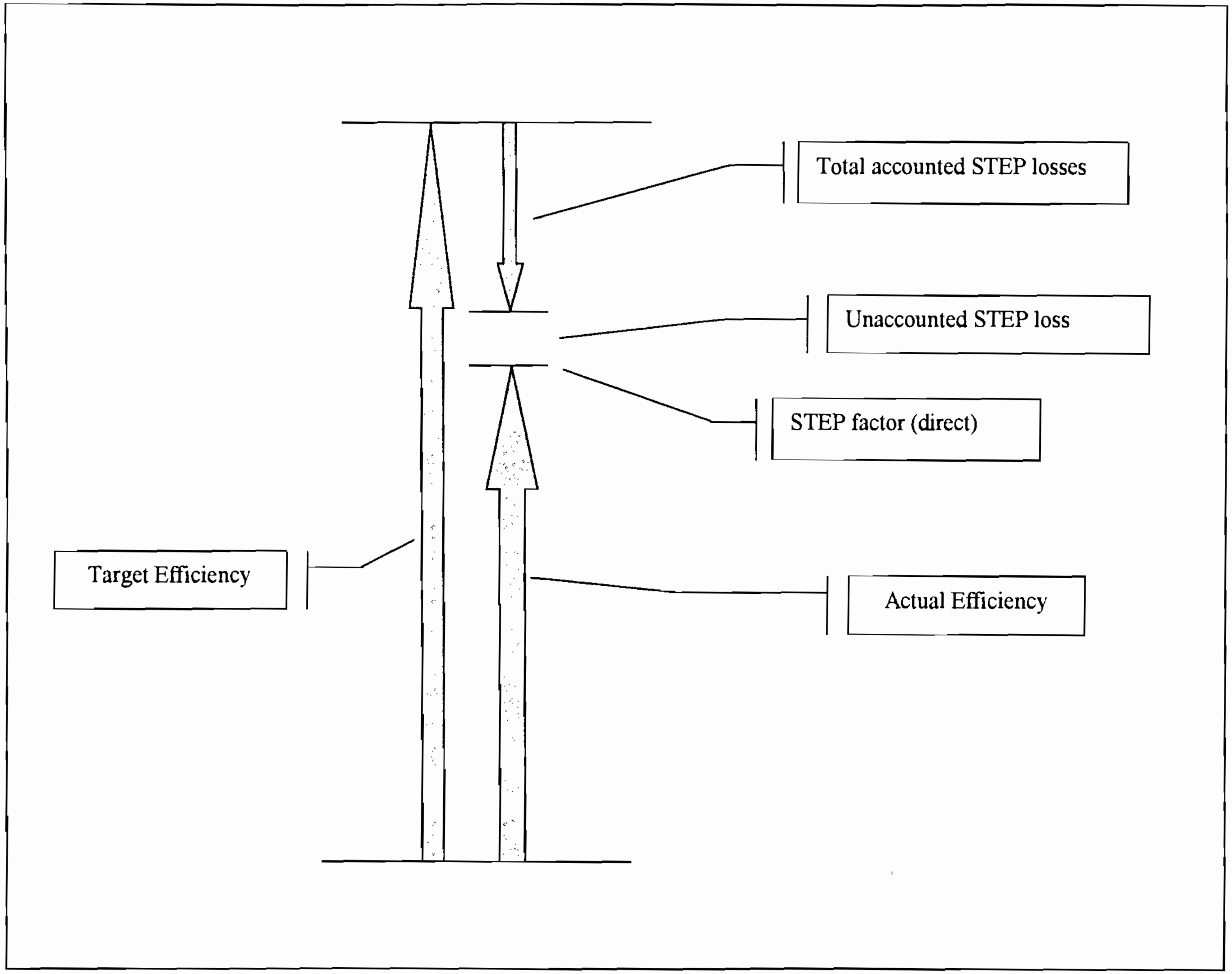


Figure I.1: DIAGRAM of STEP MECHANISM

Correction factors and targets are typically calculated by substituting a parameter (often load %) into a polynomial equation. These polynomial equations are of the 4th degree and to prevent unnecessary complexity, the values of coefficients are not shown in this document.

In order to clarify concepts underlying the mechanism, the following is a breakdown of basic formulae as it was used in STEP prior to the modifications that are explained within the body of this document.

I.4.1 STEP factor formulae:

STEP factor = Actual efficiency / Target efficiency

Actual efficiency = (Energy Sent Out) / (Coal Burnt x CV)

Target efficiency = Inverse of (Optimum Heat rate x Correction factors).

The purpose of the correction factors is to adjust the optimum for the deviation of conditions from ideal (design). The expression "heat rate" is the inverse of efficiency and this convention is used in some calculations in STEP.

Optimum Heat rate = the heat rate attainable under ideal (design) conditions. Boiler load Correction factor: The boiler is physically dimensioned for full load and therefore the the dynamics for heat transfer by radiation and convection as well as excess air requirement for optimum combustion varies greatly with load and so does the accompanying efficiency.

Turbine load Correction factor: Turbine stage inlet/exhaust blade angles are designed for a specific rate of mass flow. When mass flow varies due to change in load, steam velocities and angles deviate from design and this result in a loss of isentropic efficiency. The partial closing of control valves also results in a throttling loss. The turbine is therefore less efficient on loads below design load, which is normally full load.

Boiler Fuel Correction factor: When boiler fuel deviates from design (normally getting worse), it implies increased materials handling (coal, air, ash), poorer combustion etc., and the overall performance of the unit is thus greatly influenced by the fuel quality (confirmed by EPRI research[34]).

Condenser Back pressure Correction factor: Cycle efficiency is largely affected by condenser Back pressure and the target efficiency must therefore be corrected for variations in target Back pressure, which in turn is affected by CW inlet temperature and load. The convention is to assume CW flow to be constant at design.

Power Factor Correction factor: The transmission system requires reactive power for voltage control purposes and this demand impacts on the I^2R heat loss of the generator.

Works Power Correction factor: The Works Power consumption of a unit (in MW) has a large fixed component and therefore the Works Power as a percentage of energy sent out increases sharply towards lower loads, impacting negatively on the overall efficiency.

Demineralised Water Make-up Correction factor: As with Works Power loss, the absolute heat loss due to water/steam leaks is rather constant for various loads due to constant temperature and pressure in the cycle and therefore this loss as a percentage of energy sent out increases sharply towards lower loads, impacting negatively on the overall efficiency.

I.4.2 Total Accounted STEP losses:

Total accounted STEP losses = Total Boiler + Total Turbine + Unit STEP losses.

STEP loss (in general) = Actual loss - target loss

Actual loss = energy loss / input energy x 100

Target loss = Minimum loss (the loss @ maximum efficiency) corrected for deviation of conditions from ideal (design).

Where the parameter is not energy but a pressure or temperature, the difference between actual and target is directly related to a STEP loss percentage by means of a polynomial equation.

Total Boiler STEP losses = Carbon in refuse + Dry Flue Gas + Fuel Moisture + Mill Rejects + Radiation STEP losses.

There is no Mill rejects loss associated with tube mills and therefore this loss is not considered. Also, since radiation is not measured due to it being assumed a constant value, the actual loss equals the target loss and the STEP loss in this case is therefore constant on zero.

Step Factor Carbon in Refuse Loss = Actual - Target Carbon in Refuse Loss.

Actual = (Ash x Carbon in Ash) / (100 - Carbon in Ash) x CV of Carbon/ CV of Coal.

Target = f(Load) from polynomial x Ash / Ash_{std} x CV_{std} / CV of Coal, where:

Ash = Ash % in coal.

Carbon in Ash = Mean % Carbon in refuse.

CV of Coal = CV of Coal as received.

Step Factor Dry Flue Gas Loss = Actual - Target Dry Flue Gas Loss

Actual = dfg x c_p x (Gas Outlet T - Air Inlet T) x 100 / (CV of Coal x 1000), where:

dfg = dfc/100 x ((Carbon$_{total}$ - c_u) + Sulphur/1.83)

dfc = (11 x CO_2 + 8 x O_2 + 7 x (100 - (O_2+CO_2))) / (3 x CO_2)

c_u = Ash x Carbon in Ash / (100 - Carbon in Ash),

c_p = Specific Heat of Flue Gas

Gas Outlet T = Mean Air heater Gas Outlet Temperature.

Air Inlet T = Mean FD Fan Air Inlet Temperature

CO_2 = Mean Air heater Outlet CO_2 %

O_2 = Mean Air heater Gas Outlet O_2 %

Carbon$_{total}$ = Total Carbon % in Coal

Sulphur = Sulphur % in Coal

Target = f(Load) from polynomial x (Carbon$_{total}$ - c_u + Sulphur/1.83) /(Std Carbon$_{total}$ - tc_u + Sulphur$_{std}$/1.83) x CV$_{std}$/CV of Coal, where:

tc_u = (Target Carbon in Ash Loss x CV$_{std}$/(Ash / Ash$_{std}$ x CV$_{std}$ / CV of Coal x CV of Carbon)

Std Carbon$_{total}$ = total Carbon % in Standard Fuel

Sulphur$_{std}$ = Sulphur % in Standard Fuel

CV$_{std}$ = CV of Standard Fuel

Radiation Loss = Radiation Loss Constant / (Load x f(load) from polynomial)

Step Factor H_2 And Fuel Moisture Loss = Actual - Target H_2 and Fuel Moisture Loss

Actual = ((Total Moisture + (9 x H_2)) / CV of Coal) x (H_2 Loss constant A +(((Gas Outlet T/2)-(Air Inlet T)/H_2 Loss constant B)), where:

Total Moisture = Total Moisture % in Coal

H_2 = Hydrogen % in Coal

H_2 = [KH1 + 100 / (100 - Total Moisture) x [(KH2 x CV of Coal) + (KH3 x Volatiles) + (KH4 x Ash)]] x 1/(100 / (100 - Total Moisture))

Target = f(Load) from polynomial + Correction Factor

Correction Factor = Target H_2 + H_2O in Fuel Correction Factor = Heat Loss per kg Moisture In Gas x ((Total Moisture + 9 x H_2)/CV of Coal - ($Moist_{std}$ + 9 x Std H_2)/CV_{std})

$Moist_{std}$ = Moisture % in Standard Fuel

Std H_2 = Hydrogen % in Standard Fuel

Total Turbine STEP losses = Main steam + Reheat steam + Final Feed Water Temperature + Condenser Back pressure + Turbine Deterioration STEP losses.

These losses are not calculated as a percentage of the energy. The variance of temperature or pressure from target is referred back to a polynomial which relates it directly to a STEP loss. The turbine deterioration loss is obtained from the most recent turbine cylinder efficiency test which is referred back to the original acceptance test efficiency.

Unit STEP losses = Works Power (WP) + Demineralised Water Make-up STEP losses.

STEP factor Works Power loss = Actual WP % of USO - WP Target % of USO

WP Target = minimum WP % x f(load) from polynomial

STEP factor make-up loss = (Actual - Target Make-Up Loss) x Make-Up Heat Ratio (0.00817)

Actual = (1 - (Make-Up Heat Ratio x Make-Up % of Water Evaporated @ MCR)) / (1- Make-Up Heat Ratio)

Target = Make-Up % of Water Evaporated @ MCR x f(load) from polynomial x Make-Up Correction Factor, where:

Make-Up Correction Factor = (1 - Make-Up Heat Ratio x Make-Up % of Water Evaporated @ MCR) / (1- Make-Up Heat Ratio x Make-Up % of Water Evaporated @ MCR x f(load) from polynomial)

I.4.3 Unaccounted STEP loss:

Unaccounted STEP loss = 100 % - STEP factor (direct) - Total accounted losses

I.4.4 STEP factor (indirect):

STEP factor (indirect) = 100% - Total accounted losses

I.5 STEP SYSTEM SHORTCOMINGS

I.5.1 Average of targets vs. target of averages:

The off-line STEP system calculates the averages for relevant parameters (load from energy sent out during the operating hours recorded). Due to the most prominent targets being a function of load and forming a polynomial curve rather than a straight line, it follows that where a unit operates more often at either full load or at approximately 60% load, the daily target will be derived incorrectly from the average load (close to 80%). An on-line system will eliminate this particular shortcoming by calculating targets continuously and the periodical value will then be calculated as the average of the targets as opposed to the target based on the average load as with the off-line system.

I.5.2 On-line Coal and Ash analysis:

One of the biggest drawbacks is the delay of up to four days for analyses of coal and ash. This prevents STEP from being available in time for immediate corrective actions. The solution would be to implement on-line coal and ash analysers.

I.5.3 STEP is not modelling (mass/energy balance):

Although it is the ideal to have a mass / energy balance calculated for a plant, this is not practical due to the amount of data which must be handled simultaneously on a real time basis per time unit including storage for history purposes. On a Pareto basis, STEP produces practical results that can be used for optimising whilst it requires the bare minimum of input data. There is however scope with current technology for automation, thereby increasing the number of input parameters and enhancing the quality of results and also the timeousness thereof.

I.6 CUSTOMISATION OF THE STEP SYSTEM

I.6.1 Discrepancies:

At Lethabo the following discrepancies existed from commissioning and since it was not clear what corrective actions were indicated, these were included in the reasons for performance testing:

- Dry Flue Gas (Dfg) and Carbon in Ash STEP losses never showed the "see-saw" effect of countering each other.
- Dfg showed a too high loss at low loads.

- A seasonal trend in the Dfg where the loss was higher during winter times.

- Works Power loss was always high and only during the Unit 1 tests in 1994 with the High grade coal, did the STEP loss calculate normal (actual compared to "old" target), proving that coal quality impacts on works power consumption if only due to reduced milling power.

I.6.2 Modifications:

The Unit 1 test data, which evaluated the whole unit (and not only the boiler or turbine separately), were used to update and modify the STEP targets. These test results indicated optimum efficiencies over a range of loads (100 % to 60 %) for three different coal qualities. Some important points to note are the following:

- The values of the different parameters from the tests used for the calculation of polynomials were not the lowest but occurred where the unit yielded the best efficiency for a specific air flow per load, i.e. for each loss target that loss value that coincided with the lowest combined total loss.
- Parameters used to derive equations for STEP targets were taken from Spec. coal tests at the above optimum points.
- In general, STEP loss = Actual loss - Target loss. Since the unit was assumed to be operating at its maximum possible performance at the Spec. optima points using Spec. coal, the calculated STEP loss is set equal to zero and therefore the Target loss = Actual loss.

Since the Target formula = polynomial x correction factor, it follows that the polynomial = actual / correction factor. The equations and correction factors were then calculated such that the average STEP loss tended towards zero for the 15 optimum points with the Spec. coal as first priority (see Figure 6.34).

- Tests were conducted between full load and approximately 60% load since this represents the normal operating range. For the calculation of polynomials, values outside of the range has been estimated to expand to the full range.

New inputs required from the ultimate coal analysis:

Total Carbon (excluding Carbonates)

Hydrogen

Oxygen in coal (by difference)

Nitrogen

Carbonates

New inputs required from plant measurements:

CO in Flue Gas (optional for very accurate calculations)

Air heater Outlet O_2

The CV of coal would then be calculated by the STEP program (see motivations and calculation in Appendix A.8)

The Heat in Volatiles would also be calculated as follows:

$HIV = (CV - Carbon_{fixed}/100 \times CV_{carbon})/CV \times 100$

Standard Fuel Qualities:

CV of Standard Fuel	MJ/kg	15.659
Moisture in Standard Fuel	%	9.300
Ash in Standard Fuel	%	40.301
Volatile content in Standard Fuel	%	17.363
Carbon in Standard Fuel	%	38.474
Hydrogen In Standard Fuel	%	2.398
Sulphur in Standard Fuel	%	0.550

The above differ from previous values obtained during the Acceptance test and are based on the average of the Spec. coal used in the Unit 1 tests (May 1994) corrected to a Total Moisture of 9.3 % (corresponding to a 2 year average of STEP data).

Radiation Loss: The previous formula was replaced by:

f(Load) from a polynomial

Target Carbon in Refuse Loss: The previous formula was replaced by:

(Ash x Target C in Ash)/(100-Target C in Ash) x CV_{carbon}/CV x Volatiles adjustment factor x Volatiles Weighting Factor, where:

Target C in Ash = f(Load) from a polynomial

Volatiles adjustment factor = f(volatiles) from a polynomial

Volatiles Weighting Factor = 1.1

Actual Dry Flue Gas Loss: The previous formula was replaced by:

$((100/23.15 \times (31.999/12.011 \times (C_{total} - Ash \times C\ in\ Ash/100)+7.936 \times H_2 - O_2\ coal+0.998 \times S))/100 \times (1 + O_2\ econ \times 3199.9/3050 / (23.15- O_2\ econ \times 3199.9/3050)) + ((C_{total} - Ash \times C\ in\ Ash/100 -(CO(ppm)/10000 \times 28.01/30.5 \times 56.021/24.022 \times C_{total} \times 87.998/56.021)) + S + N_2 + Carbonates)/100) \times 0.9902 \times (T_{no-leak}\ A/HTR\ outlet - T_{FDinlet}) / (CV \times 1000) \times 100$

$T_{no-leak}\ A/HTR\ outlet = (3199.9/3050 \times (O_2\ A/HTR - O_2\ econ) /(23.15 - 3199.9/3050 \times O_2\ A/HTR)) \times ((T_{A/HTR\ outlet} - T_{FDinlet}) \times 1.004 /c_p)+T_{A/HTR\ outlet}$

Target Dry Flue Gas Loss: The previous formula was replaced by:

$((100/23.15 \times (31.999/12.011 \times (C_{total} - Ash \times Target\ C\ in\ Ash/100) + 7.936 \times H_2 - O_2\ coal + 0.998 \times S))/100 \times (1 + Target\ O_2\ econ \times Target\ O_2\ adjustment\ factor \times 3199.9/3050 / (23.15- Target\ O_2\ econ \times Target\ O_2\ adjustment\ factor \times 3199.9/3050)) + ((C_{total} - Ash \times Target\ C\ in\ Ash/100 - (CO(ppm)/10000 \times 28.01/30.5 \times 56.021/24.022 \times C_{total} \times 87.998/56.021)) + S + N_2 + Carbonates)/100) \times 0.9902 \times (Target\ T_{no-leak}\ A/HTR\ outlet - T_{FDinlet})/(CV \times 1000) \times 100$

Target C in Ash = f(Load) from a polynomial

Target O_2 econ: = f(Load) from a polynomial

Target $T_{no-leak}$ A/HTR outlet = f(Load) from a polynomial

Target O2 adjustment factor = (1 - weighting factor x (1 - $Volatiles_{std}$ / Volatiles)) x (1 - weighting factor x (1 - Std C_{total}/))

Volatiles weighting factor = 1.5

Carbon weighting factor = 1

Target H_2 and Fuel Moisture Loss: The previous formula was replaced by: (moisture + 9 x H_2) / CV x (H_2 loss constant A + (Target T_{out}/2 - $T_{FDinlet}$) / H_2 loss constant B)

Target Works Power: The previous formula was replaced by:

Minimum WP x f(Load) from a polynomial x CV adjustment factor

CV adjustment factor = (1 - weighting factor x (1 - CV_{std}/CV))

CV weighting factor = 0.63

Target Heat Rate (HR): The previous formula was replaced by:

HR_{opt} x Radiation correction factor (cf) x Boiler load cf x Boiler Fuel cf x Power factor cf x WP cf x BP cf x Turbine load

Optimum sent out heat rate = 2.729 (efficiency = 36.65 %)

Note regarding the Optimum Sent Out Heat Rate:

Even with Turbine deterioration excluded for all units, back-calculations from the derived unit STEP factors indicated that the next best unit would not exceed the STEP factor of Unit

1, resulting in unit STEP factors exceeding 100 %.

Radiation Correction factor (new item):

(100 + Radiation loss %) / (100 + Spec. radiation loss % @ 90 % load)

Spec. Radiation Loss @ 90% load = 0.841

Boiler Load Correction Factor = f(Load) from a polynomial

Boiler Fuel Correction Factor: The previous formula was replaced by:

(1 - weighting factor x (1 - CV_{std}/CV)) x (1 - weighting factor x (1 - $Volatiles_{std}$/Volatiles)) x HIV cf

CV weighting factor = 0.327

Volatiles weighting factor = 0.0438

HIV cf (new item) = (HIV - 26.032)/362 + 1.00459

Heat in Volatiles (standard) = 26.032

Works Power Correction Factor: The previous formula was replaced by:

(100 + WP target)/(100 + WP_{std} loss @ 90 % load)

WP_{std} loss @ 90 % load = 4.401

Turbine Load Correction Factor: The previous formula was replaced by: f(Load) from a polynomial

I.6.3 Fine tuning of the process:

- To ensure integrity of the unaccounted loss, for any sliding of the target for a specific loss, correcting of the Optimum heat rate must also be done.
- Optimum heat rate and minimum loss should slide for an uncontrollable factor but not for a controllable factor (Appendix I.2.2 and I.2.3).
- Due to the interrelated nature of the losses it is necessary to evaluate the targets and correction factors as a package and in sequence starting with the most independent parameters.

Methodology to determine the Correction Factors:
In order to determine/calculate the targets, the following methodology was followed: the 90 sets of data were put into a spreadsheet and STEP parameters calculated in order to facilitate simultaneous graphic evaluation of results of all tests. This was a five-tier process where the spreadsheets advanced from Revision (Rev.) A to E.

Revision A:
With the Optimum Sent Out Efficiency set at the original 38.24%, the average unaccounted STEP loss of the 15 optimum tests was 4.989%. It was thus clear that the original Optimum Sent Out Efficiency was not realistic and had to be re-evaluated in view of efficiencies calculated from the tests.

- In order for the average unaccounted loss to be zero, the Optimum Efficiency had to be set at 36.318%.

- The Optimum Efficiency was then set at 36.648% which was in close correspondence to the efficiency calculated by means of the direct side gas balance technique for the Spec. grade 550 MW test (as explained in Chapter 6.1). This was also confirmed by using 1996 STEP history to back-calculate ensuring that no unrealistic gains would arise with the Optimum Efficiency set as above. The above was done with the average unaccounted loss at 0.894% in order to establish what the efficiency would be in the case where the Turbine Deterioration is reset to zero following turbine maintenance and reblading, from the 0.894% at the time of testing. At this point, the average total Accounted STEP loss for the 15 optimum points was 0.782% (= Turbine deterioration).

Revision B:

- The criteria for determining equations and correction factors were that for all loads and coal qualities at the 15 optima, the STEP factors, total accounted and unaccounted loss must be equal and the STEP loss zero (except for turbine deterioration). This was done by profiling Carbon in Ash, Oxygen (economiser), Gas outlet temperatures and carbon content of coal in a coherent manner by first getting the total accounted loss of individual tests to 0.782%. Thereafter the individual unaccounted losses were changed to zero by adjusting coal flow via density depending on trends with moisture and efficiencies as calculated by the back-end gas balance technique (Chapter 6.1). The resultant STEP factors were calculated as 99.218%.

- The contribution of the Boiler Fuel Correction Factor, and Actual and Target efficiencies did not converge at this point, i.e. seemed lacking of yet another correction factor.

Revisions C, D and E:

- With individual test STEP factors equal to 99.218%, the total accounted loss equal to 0.782% and the unaccounted loss equal to 0 at the 15 optima, the accounted losses of the remaining tests were profiled according to original calculated efficiencies, again by adjusting the previous parameters in a coherent manner. (The justification for this "profiling" comes from trending individual parameters against the large sets of related data).

- The "missing" correction factor was found to be satisfied by a Heat in Volatiles factor that correlated to the trend of moisture versus density with up to 82%.

In the process of minimising the variance between maximum and minimum values of unaccounted loss, the various components of the Boiler Fuel correction factor were determined as well as the weighting factors thereof. The final step was to trim the Heat in Volatiles factor by considering the following questions:

- Should O_2 be included in active volatiles,
- Is the $Carbon_{total}$: H_2 or $Carbon_{fix}$: $Volatiles_{total}$ important?

The conclusion was that for Lethabo coal, $Carbon_{fix}$: $Volatiles_{total}$ is most prominent to characterise Lethabo coal (see **Figures 6.29** to 6.33, Chapter 6.4).

APPENDIX J
PULVERISED FUEL SAMPLING RESULTS

APPENDIX J: EVALUATION OF MILL PERFORMANCE

SECTION 1:

PRE-TEST MILL OPTIMISATION

PF FINENESS TESTS AT 28 kg/s PRIMARY AIR FLOW

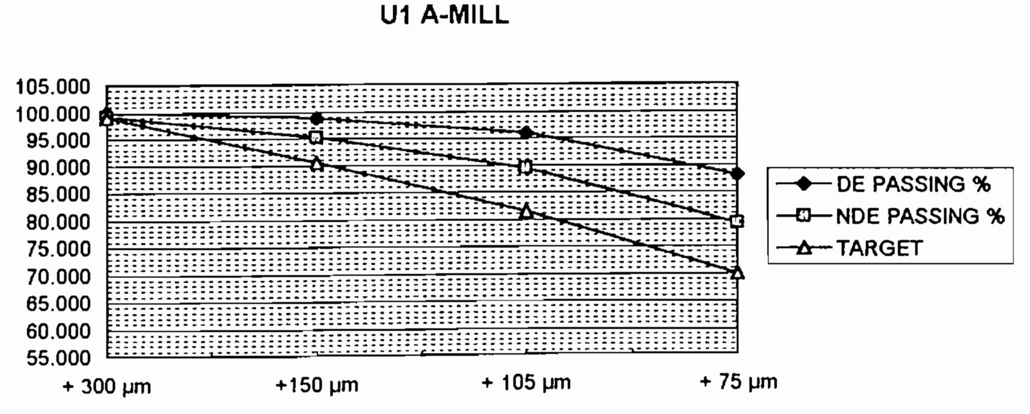
MILLS A, B, C, D and E

DRIVE and NON-DRIVE ENDS

PRE AIRFLOW MILL TEST SHEET

DATE: 13 / 04 / 94 **MILL:** U1 A

GENERATOR LOAD	617	MW				
	DE	NDE				
PA FLOW	27.890	27.890	Kg/sec			
FEEDER SPEED	35.660	35.680	%			
CLASSIFIER OUTLET TEMP	79.750	79.750	°C			
BYPASS DAMPER POS	21.290	21.300	%			
SAMPLE MOISTURE	4.000	3.590	%			
SAMPLE WEIGHT	527.390	758.910	gr			
DE	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm	- 75 μm	SAMPLE
RETAIN GRAMS	0.02	0.51	1.34	3.59	40.03	45.49
RETAINED %	0.044	1.121	2.946	7.892	87.997	
PASSING %	99.956	98.835	95.889	87.997		
NDE	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm	- 75 μm	SAMPLE
RETAIN GRAMS	0.42	2.23	3.13	5.57	43.11	54.46
RETAINED %	0.771	4.095	5.747	10.228	79.159	
PASSING %	99.229	95.134	89.387	79.159		
	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm		
DE PASSING %	99.956	98.835	95.889	87.997		
NDE PASSING %	99.229	95.134	89.387	79.159		
TARGET	99	90.5	81.5	70		



PRE AIRFLOW MILL TEST SHEET

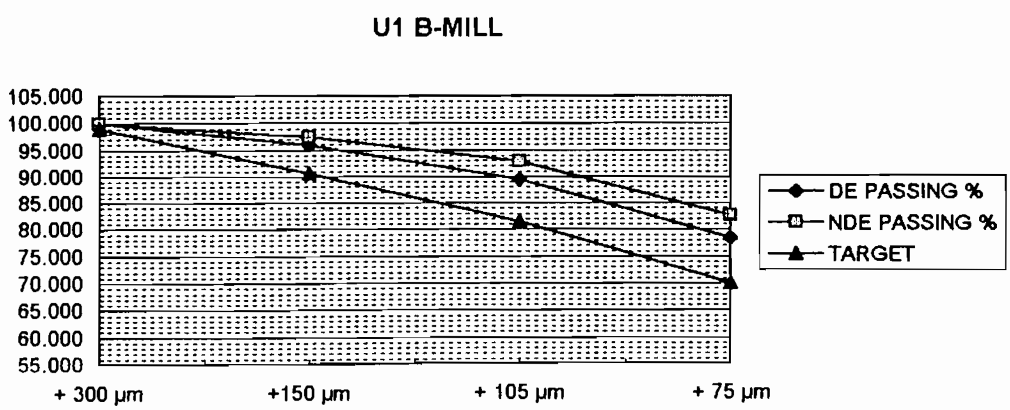
DATE: 13 /04 /94 **MILL:** U1 B

GENERATOR LOAD	618	MW	
	DE	NDE	
PA FLOW	27.930	27.930	Kg/sec
FEEDER SPEED	36.420	36.400	%
CLASSIFIER OUTLET TEMP	81.700	82.230	°C
BYPASS DAMPER POS	20.810	20.750	%
SAMPLE MOISTURE	3.560	2.890	%
SAMPLE WEIGHT	809.930	752.720	gr

DE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.04	2.44	3.81	6.65	46.76	59.70
RETAINED %	0.067	4.087	6.382	11.139	78.325	
PASSING %	99.933	95.846	89.464	78.325		

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.12	1.29	2.6	5.62	45.86	55.49
RETAINED %	0.216	2.325	4.686	10.128	82.646	
PASSING %	99.784	97.459	92.773	82.646		

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
DE PASSING %	99.933	95.846	89.464	78.325
NDE PASSING %	99.784	97.459	92.773	82.646
TARGET	99	90.5	81.5	70



PRE AIRFLOW MILL TEST SHEET

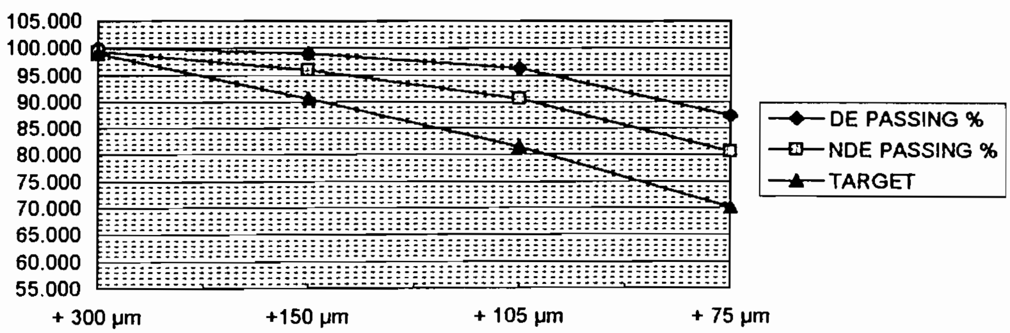
DATE: 13 /04 /94 **MILL:** U1 C

GENERATOR LOAD	571	MW			
	DE	NDE			
PA FLOW	28.060	28.060	Kg/sec		
FEEDER SPEED	35.610	36.120	%		
CLASSIFIER OUTLET TEMP	82.370	80.130	°C		
BYPASS DAMPER POS	20.120	20.930	%		
SAMPLE MOISTURE	4.180	3.620	%		
SAMPLE WEIGHT	519.260	661.090	gr		

DE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.01	0.53	1.4	4.73	45.65	52.32
RETAINED %	0.019	1.013	2.676	9.041	87.252	
PASSING %	99.981	98.968	96.292	87.252		
NDE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.38	1.86	2.9	5.36	43.5	54.00
RETAINED %	0.704	3.444	5.370	9.926	80.556	
PASSING %	99.296	95.852	90.481	80.556		

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
DE PASSING %	99.981	98.968	96.292	87.252
NDE PASSING %	99.296	95.852	90.481	80.556
TARGET	99	90.5	81.5	70

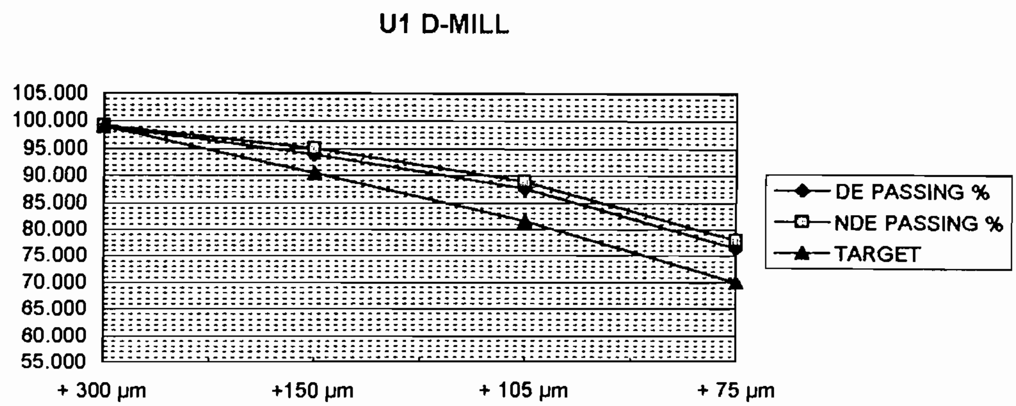
U1 C-MILL



PRE AIRFLOW MILL TEST SHEET

DATE: 13 /04 /94 **MILL:** U1 D

GENERATOR LOAD	618	MW				
	DE	NDE				
PA FLOW	28.050	28.050	Kg/sec			
FEEDER SPEED	39.470	39.610	%			
CLASSIFIER OUTLET TEMP	78.470	76.550	°C			
BYPASS DAMPER POS	20.330	20.150	%			
SAMPLE MOISTURE	4.240	3.830	%			
SAMPLE WEIGHT	800.860	710.09	gr			
DE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.61	2.64	3.33	5.9	40.56	53.04
RETAINED %	1.150	4.977	6.278	11.124	76.471	
PASSING %	98.850	93.873	87.594	76.471		
NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.42	2.16	3.07	5.63	40	51.28
RETAINED %	0.819	4.212	5.987	10.979	78.003	
PASSING %	99.181	94.969	88.982	78.003		
	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm		
DE PASSING %	98.850	93.873	87.594	76.471		
NDE PASSING %	99.181	94.969	88.982	78.003		
TARGET	99	90.5	81.5	70		



PRE AIRFLOW MILL TEST SHEET

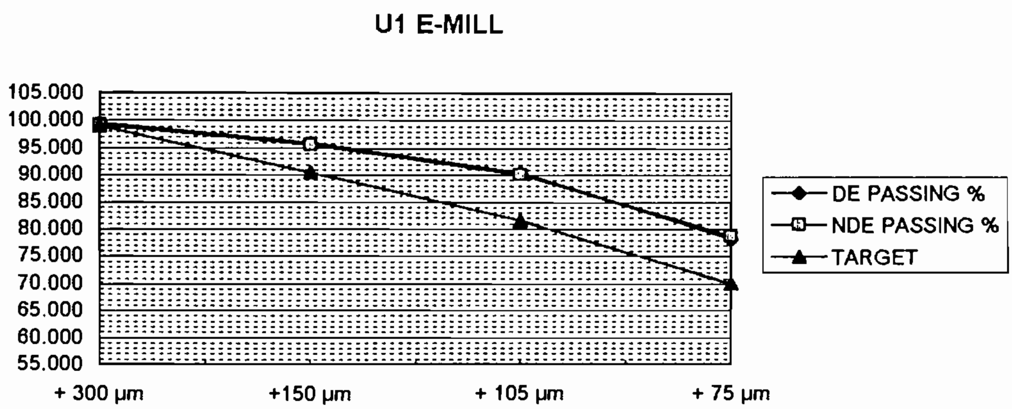
DATE: 13 /04 /94 **MILL:** U1 E

GENERATOR LOAD	618	MW	
	DE	NDE	
PA FLOW	28.000	28.000	Kg/sec
FEEDER SPEED	35.960	39.340	%
CLASSIFIER OUTLET TEMP	80.220	79.200	°C
BYPASS DAMPER POS	20.560	20.810	%
SAMPLE MOISTURE	3.840	3.470	%
SAMPLE WEIGHT	632.480	803.240	gr

DE	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm	- 75 μm	SAMPLE
RETAIN GRAMS	0.29	1.83	2.95	6.36	40.97	52.40
RETAINED %	0.553	3.492	5.630	12.137	78.187	
PASSING %	99.447	95.954	90.324	78.187		

NDE	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm	- 75 μm	SAMPLE
RETAIN GRAMS	0.46	2.07	3.02	6.43	44.13	56.11
RETAINED %	0.820	3.689	5.382	11.460	78.649	
PASSING %	99.180	95.491	90.109	78.649		

	+ 300 μm	+150 μm	+ 105 μm	+ 75 μm
DE PASSING %	99.447	95.954	90.324	78.187
NDE PASSING %	99.180	95.491	90.109	78.649
TARGET	99	90.5	81.5	70



SECTION 2:

PRE-TEST MILL OPTIMISATION

PF FINENESS TESTS AT 24 - 32 kg/s PRIMARY AIR FLOW

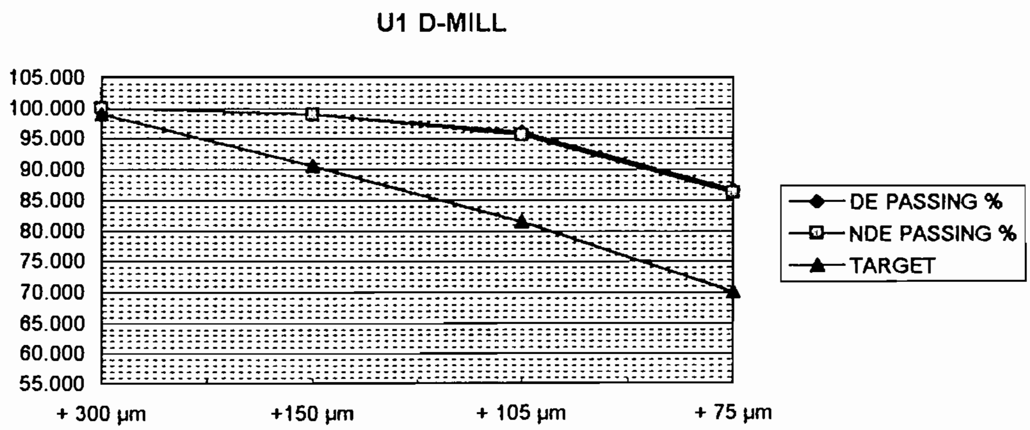
D MILL

DRIVE and NON-DRIVE ENDS

PRE AIRFLOW MILL TEST SHEET

DATE: 20/ 04 /94 **MILL: 1-D**

GENERATOR LOAD	**612**	**MW**				
	DE	**NDE**				
PA FLOW	24.010	24.010	**Kg/sec**			
FEEDER SPEED	28.350	28.510	**%**			
CLASSIFIER OUTLET TEMP	90.560	85.740	**°C**			
BYPASS DAMPER POS	39.650	39.380	**%**			
SAMPLE WEIGHT	431.750	415.930	**gr**			
DE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.03	0.55	1.73	5.42	50.49	58.22
RETAINED %	0.052	0.945	2.971	9.310	86.723	
PASSING %	99.948	99.004	96.032	86.723		
NDE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.02	0.57	1.87	5.27	48.31	56.04
RETAINED %	0.036	1.017	3.337	9.404	86.206	
PASSING %	99.964	98.947	95.610	86.206		
	+ 300 µm	**+150 µm**	**+ 105 µm**	**+ 75 µm**		
DE PASSING %	99.948	99.004	96.032	86.723		
NDE PASSING %	99.964	98.947	95.610	86.206		
TARGET	99	90.5	81.5	70		



PRE AIRFLOW MILL TEST SHEET

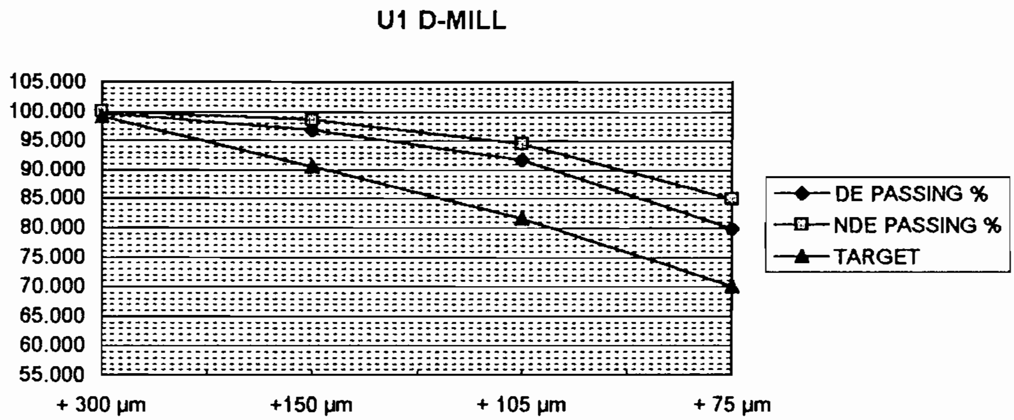
DATE: 20/ 04 /94 **MILL:** 1-D

GENERATOR LOAD	587	MW	
	DE	NDE	
PA FLOW	26.130	26.130	Kg/sec
FEEDER SPEED	34.080	33.950	%
CLASSIFIER OUTLET TEMP	81.410	79.220	°C
BYPASS DAMPER POS	27.750	27.470	%
SAMPLE WEIGHT	608.530	579.360	gr

DE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.21	1.61	2.91	6.8	45.43	56.96
RETAINED %	0.369	2.827	5.109	11.938	79.758	
PASSING %	99.631	96.805	91.696	79.758		

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAIN GRAMS	0.06	0.77	2.39	5.53	49.19	57.94
RETAINED %	0.104	1.329	4.125	9.544	84.898	
PASSING %	99.896	98.567	94.443	84.898		

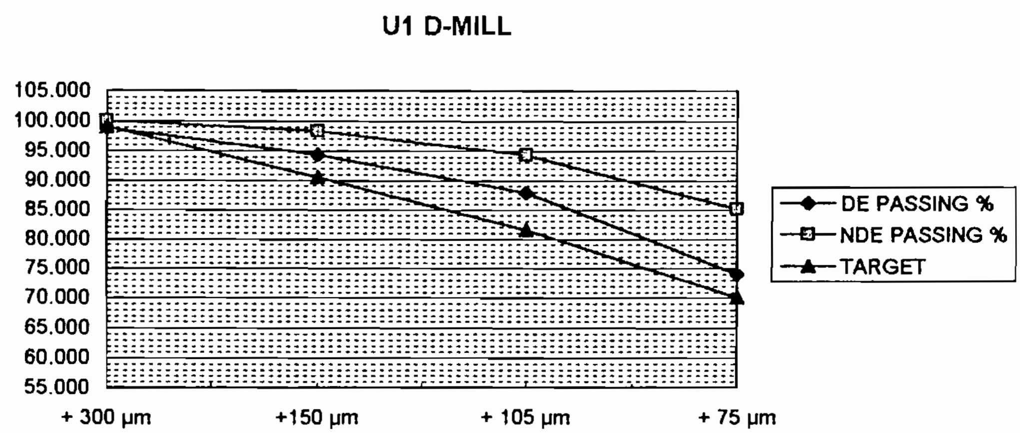
	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
DE PASSING %	99.631	96.805	91.696	79.758
NDE PASSING %	99.896	98.567	94.443	84.898
TARGET	99	90.5	81.5	70



PRE AIRFLOW MILL TEST SHEET

DATE: 20/ 04 /94 **MILL:** 1-D

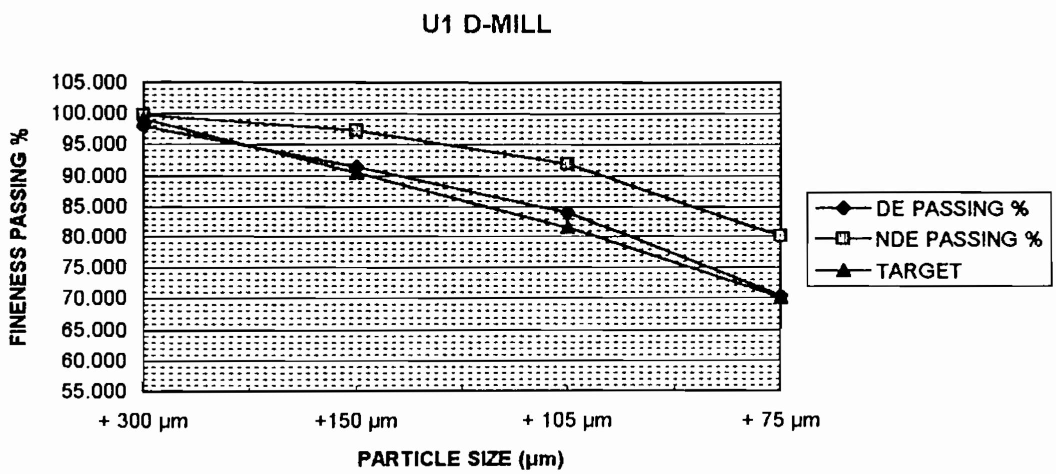
GENERATOR LOAD	**585**	**MW**				
	DE	**NDE**				
PA FLOW	27.980	27.980	**Kg/sec**			
FEEDER SPEED	37.970	38.160	**%**			
CLASSIFIER OUTLET TEMP	77.150	75.420	**°C**			
BYPASS DAMPER POS	20.650	20.430	**%**			
SAMPLE WEIGHT	724.500	607.120	**gr**			
DE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.76	2.85	4	8.61	46.39	62.61
RETAINED %	1.214	4.552	6.389	13.752	74.094	
PASSING %	98.786	94.234	87.845	74.094		
NDE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.06	1	2.34	5.5	50.96	59.86
RETAINED %	0.100	1.671	3.909	9.188	85.132	
PASSING %	99.900	98.229	94.320	85.132		
	+ 300 µm	**+150 µm**	**+ 105 µm**	**+ 75 µm**		
DE PASSING %	98.786	94.234	87.845	74.094		
NDE PASSING %	99.900	98.229	94.320	85.132		
TARGET	99	90.5	81.5	70		



PRE AIRFLOW MILL TEST SHEET

DATE: 20/ 04 /94 **MILL:** 1-D

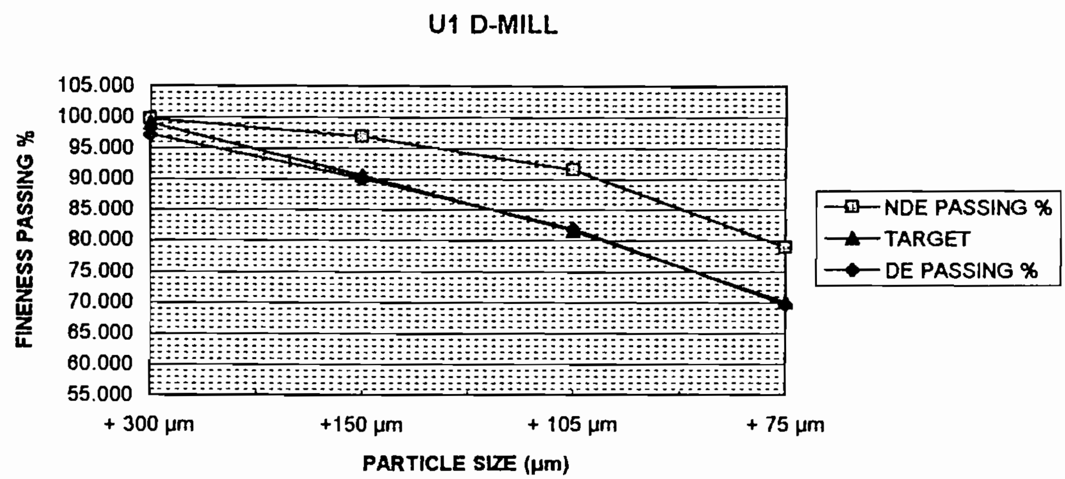
GENERATOR LOAD	**588**	MW				
	DE	**NDE**				
PA FLOW	30.130	30.130	Kg/sec			
FEEDER SPEED	42.760	42.950	%			
CLASSIFIER OUTLET TEMP	74.850	74.390	°C			
BYPASS DAMPER POS	10.000	10.010	%			
SAMPLE WEIGHT	650.000	685.000	gr			
DE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	1.35	4.09	4.81	8.56	44.88	63.69
RETAINED %	2.120	6.422	7.552	13.440	70.466	
PASSING %	97.880	91.459	83.906	70.466		
NDE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.13	1.53	3.05	7.08	46.95	58.74
RETAINED %	0.221	2.605	5.192	12.053	79.928	
PASSING %	99.779	97.174	91.982	79.928		
	+ 300 µm	**+150 µm**	**+ 105 µm**	**+ 75 µm**		
DE PASSING %	97.880	91.459	83.906	70.466		
NDE PASSING %	99.779	97.174	91.982	79.928		
TARGET	99	90.5	81.5	70		



PRE AIRFLOW MILL TEST SHEET

DATE: 20/ 04 /94 **MILL: 1-D**

GENERATOR LOAD	585	MW				
	DE	**NDE**				
PA FLOW	32.400	32.400	Kg/sec			
FEEDER SPEED	45.790	45.990	%			
CLASSIFIER OUTLET TEMP	73.970	73.610	°C			
BYPASS DAMPER POS	0.000	1.562	%			
SAMPLE WEIGHT	797.360	1020.440	gr			
DE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	1.63	4.34	4.89	7.28	41.66	59.80
RETAINED %	2.726	7.258	8.177	12.174	69.666	
PASSING %	97.274	90.017	81.839	69.666		
NDE	**+ 300 µm**	**+150 µm**	**+ 105 µm**	**+ 75 µm**	**- 75 µm**	**SAMPLE**
RETAIN GRAMS	0.17	1.58	2.88	6.94	43.31	54.88
RETAINED %	0.310	2.879	5.248	12.646	78.918	
PASSING %	99.690	96.811	91.563	78.918		
	+ 300 µm	**+150 µm**	**+ 105 µm**	**+ 75 µm**		
DE PASSING %	97.274	90.017	81.839	69.666		
NDE PASSING %	99.690	96.811	91.563	78.918		
TARGET	99	90.5	81.5	70		



SECTION 3:

MAIN AIR FLOW OPTIMISATION TESTS

PF SAMPLING AT ACTUAL TEST PRIMARY AIR FLOWS

D MILL

NON-DRIVE END ONLY

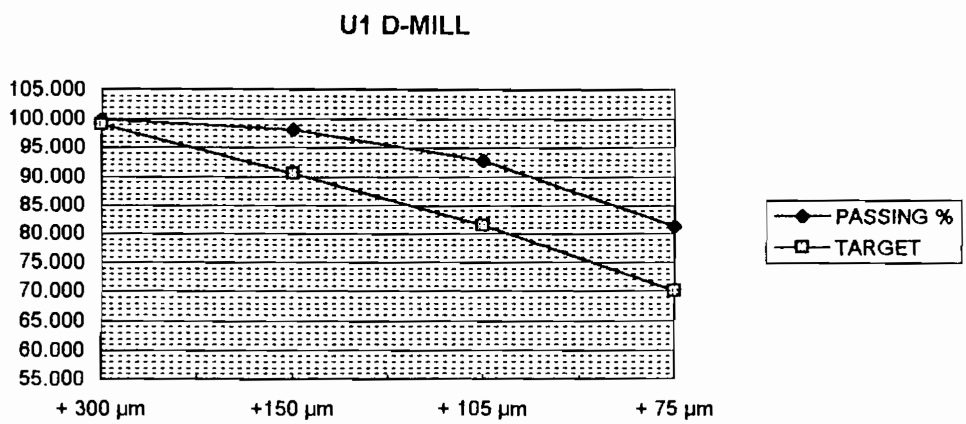
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 : 20.0 : 14h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.12	1.57	5.65	14.75	63.89	78.64
RETAINED %	0.153	1.996	7.185	18.756	81.244	
PASSING %	99.847	98.004	92.815	81.244	18.756	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.847	98.004	92.815	81.244
TARGET	99	90.5	81.5	70



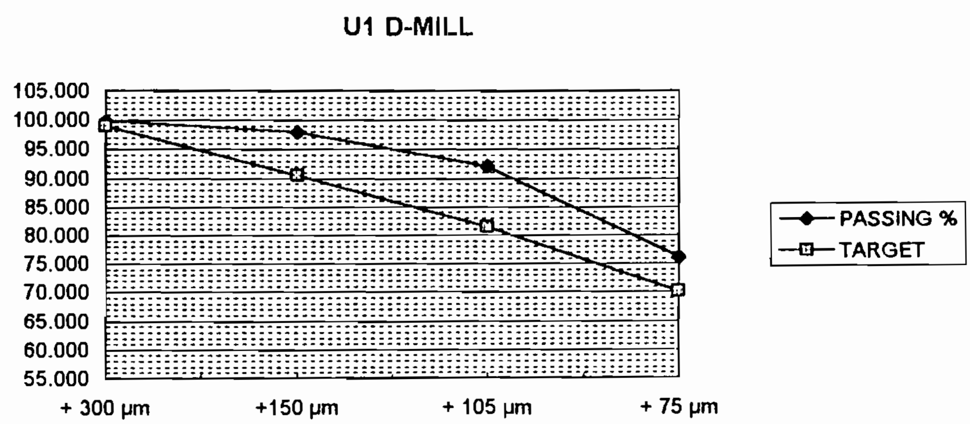
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 :17.5 :15h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.64	6.43	19.24	61.17	80.41
RETAINED %	0.124	2.040	7.997	23.927	76.073	
PASSING %	99.876	97.960	92.003	76.073	23.927	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.876	97.960	92.003	76.073
TARGET	99	90.5	81.5	70



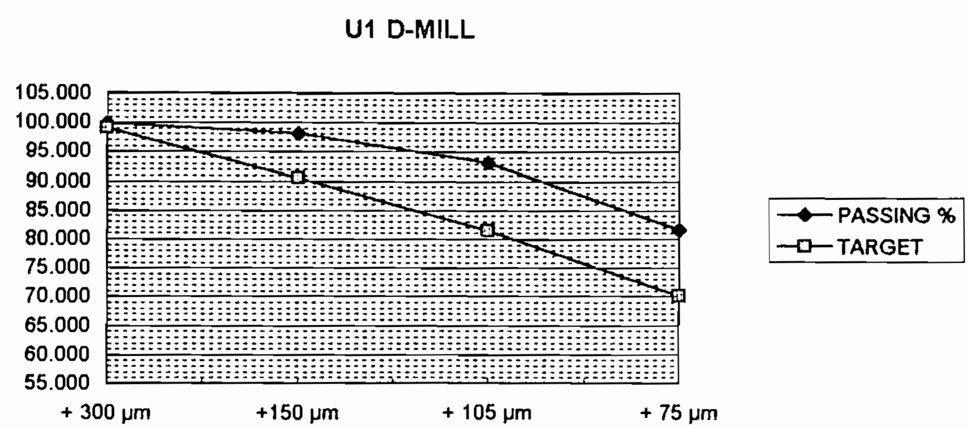
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 : 15 : 16h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.07	1.13	4.01	10.64	47.2	57.84
RETAINED %	0.121	1.954	6.933	18.396	81.604	
PASSING %	99.879	98.046	93.067	81.604	18.396	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.879	98.046	93.067	81.604
TARGET	99	90.5	81.5	70



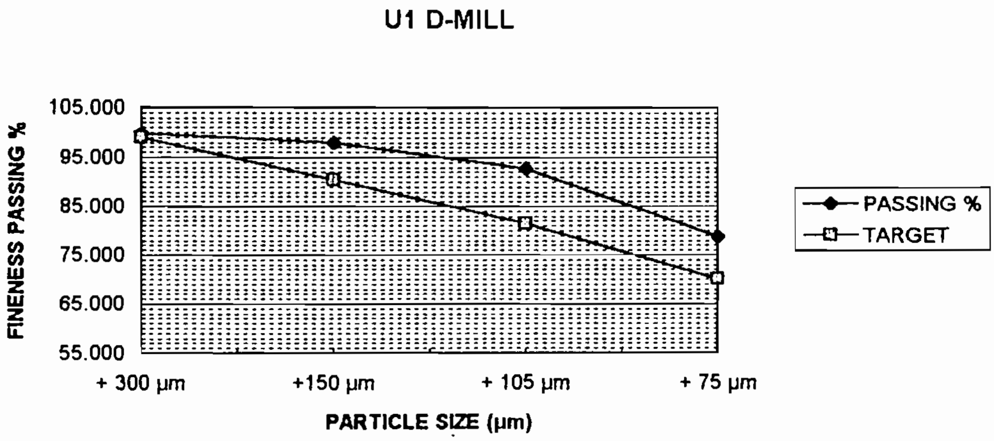
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 :12.5 :17h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.14	1.76	6.18	18.04	67.19	85.23
RETAINED %	0.164	2.065	7.251	21.166	78.834	
PASSING %	99.836	97.935	92.749	78.834	21.166	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.836	97.935	92.749	78.834
TARGET	99	90.5	81.5	70



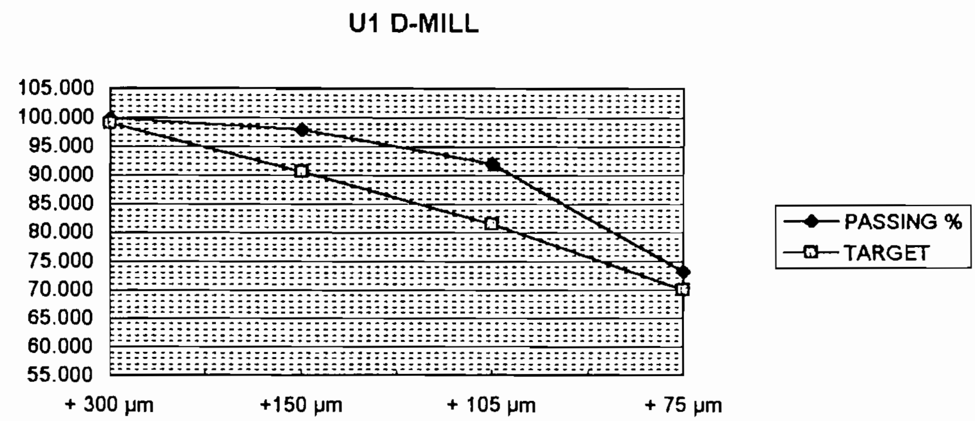
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 :10 :18h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.13	1.76	6.78	22.97	62.83	85.8
RETAINED %	0.152	2.051	7.902	26.772	73.228	
PASSING %	99.848	97.949	92.098	73.228	26.772	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.848	97.949	92.098	73.228
TARGET	99	90.5	81.5	70



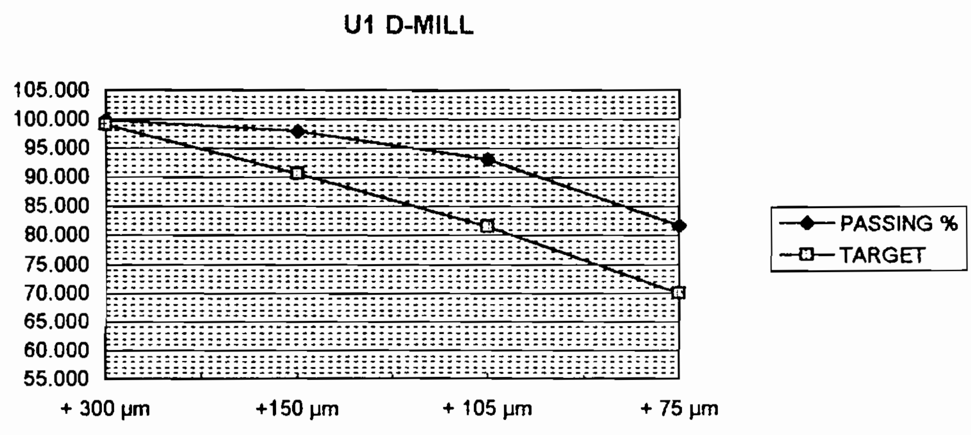
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 630 : 7.5 : 20h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.66	5.51	14.74	65.4	80.14
RETAINED %	0.125	2.071	6.875	18.393	81.607	
PASSING %	99.875	97.929	93.125	81.607	18.393	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.875	97.929	93.125	81.607
TARGET	99	90.5	81.5	70



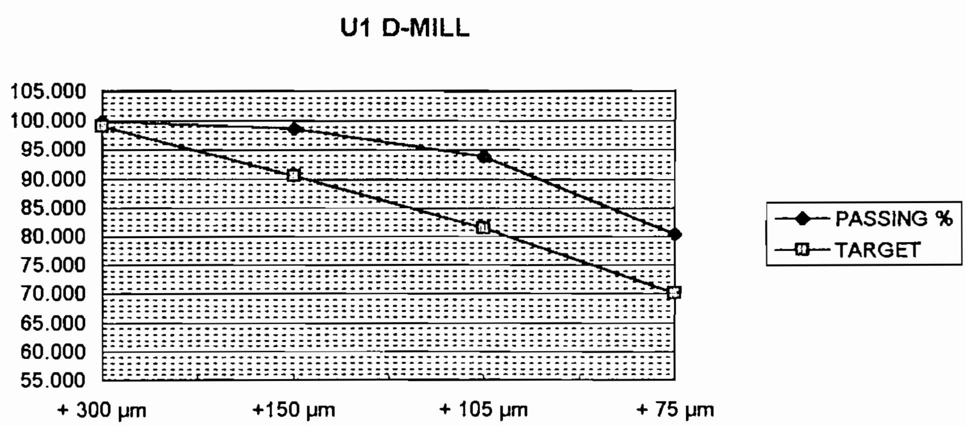
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 550 : 27 : 09h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.87	3.87	12.24	50.34	62.58
RETAINED %	0.064	1.390	6.184	19.559	80.441	
PASSING %	99.936	98.610	93.816	80.441	19.559	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.936	98.610	93.816	80.441
TARGET	99	90.5	81.5	70



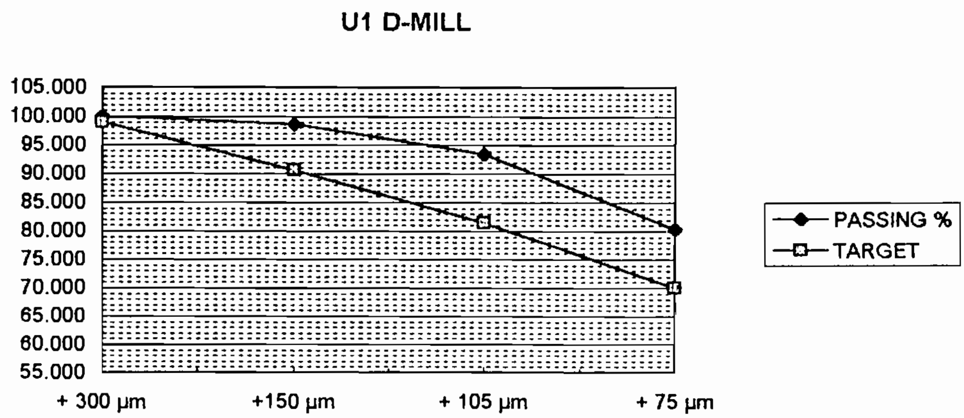
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 550 : 24 : 08h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.81	3.74	11.17	45.77	56.94
RETAINED %	0.053	1.423	6.568	19.617	80.383	
PASSING %	99.947	98.577	93.432	80.383	19.617	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.947	98.577	93.432	80.383
TARGET	99	90.5	81.5	70



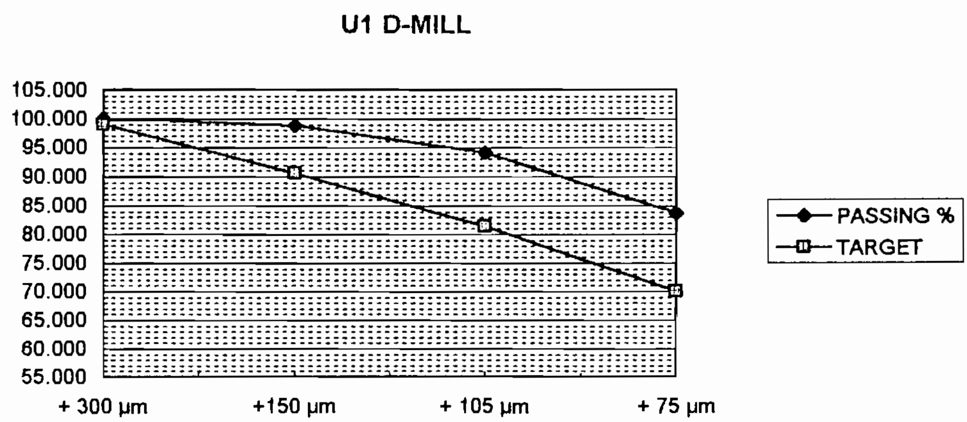
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 550 : 21 : 10h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.69	3.04	8.45	43.67	52.12
RETAINED %	0.058	1.324	5.833	16.213	83.787	
PASSING %	99.942	98.676	94.167	83.787	16.213	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.942	98.676	94.167	83.787
TARGET	99	90.5	81.5	70



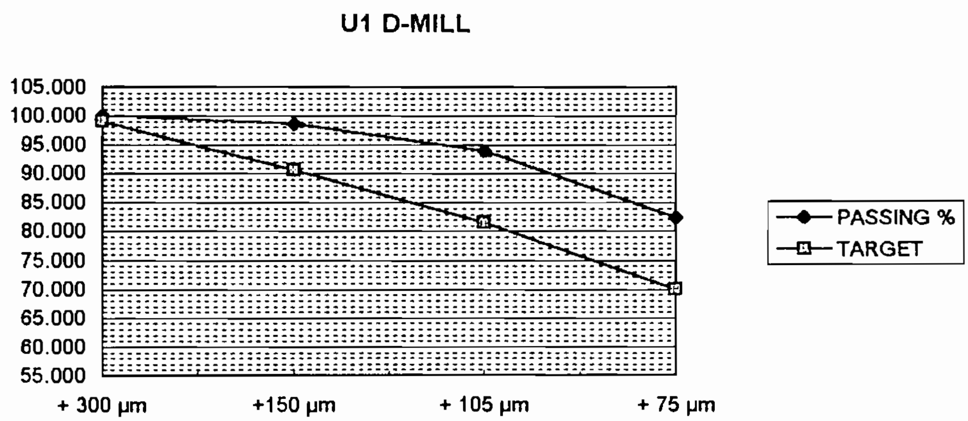
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 550 : 17.5 : 11h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.93	3.91	11.45	53.72	65.17
RETAINED %	0.061	1.427	6.000	17.569	82.431	-
PASSING %	99.939	98.573	94.000	82.431	17.569	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.939	98.573	94.000	82.431
TARGET	99	90.5	81.5	70



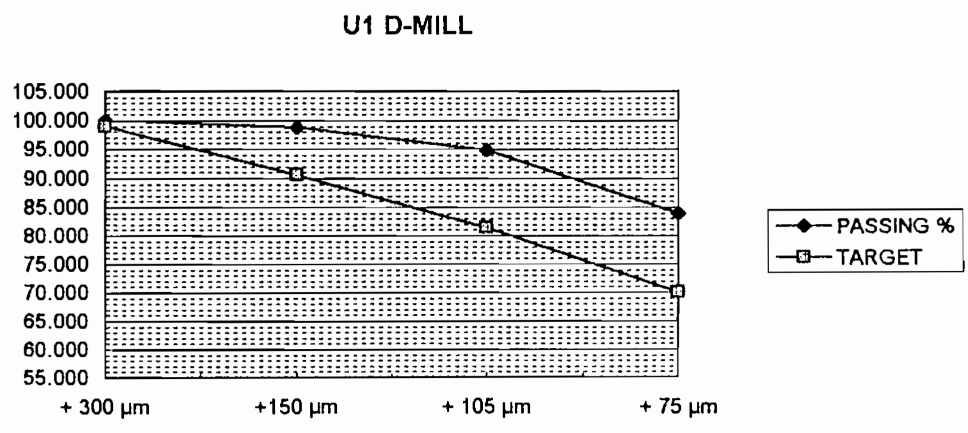
MILL TEST DATA

UNIT : 1 MILL : D TEST No : L 550 : 14 : 12h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.74	3.13	9.6	50.17	59.77
RETAINED %	0.067	1.238	5.237	16.062	83.938	
PASSING %	99.933	98.762	94.763	83.938	16.062	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.933	98.762	94.763	83.938
TARGET	99	90.5	81.5	70



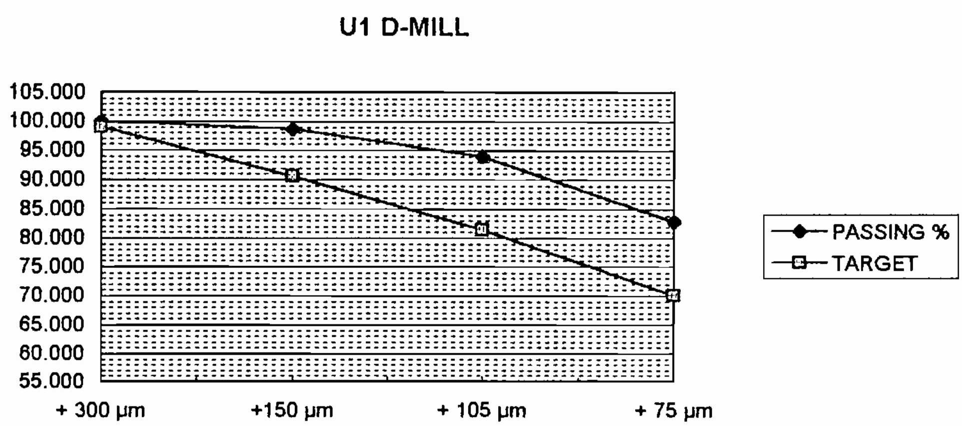
MILL TEST DATA

UNIT : 1 MILL : D TEST No : L 550 : 10 : 13h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	0.91	3.63	10.38	50.22	60.6
RETAINED %	0.083	1.502	5.990	17.129	82.871	
PASSING %	99.917	98.498	94.010	82.871	17.129	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.917	98.498	94.010	82.871
TARGET	99	90.5	81.5	70



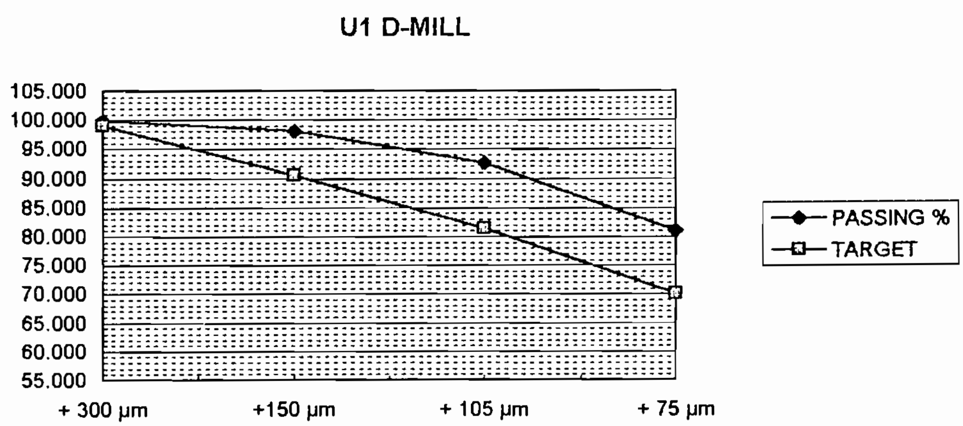
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 29 :11h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	1.07	4.08	10.46	44.62	55.08
RETAINED %	0.054	1.943	7.407	18.991	81.009	
PASSING %	99.946	98.057	92.593	81.009	18.991	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.946	98.057	92.593	81.009
TARGET	99	90.5	81.5	70



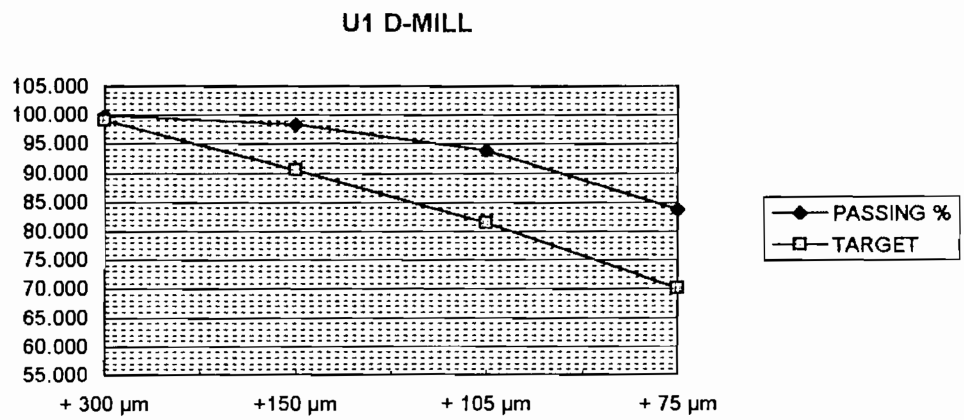
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 26 : 13h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.47	5.27	13.83	71.33	85.16
RETAINED %	0.106	1.726	6.188	16.240	83.760	
PASSING %	99.894	98.274	93.812	83.760	16.240	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.894	98.274	93.812	83.760
TARGET	99	90.5	81.5	70



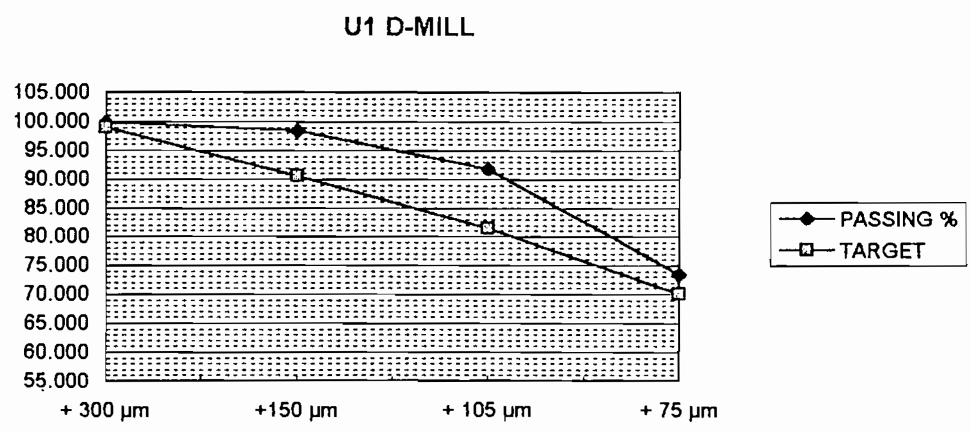
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 23.5 : 14h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.31	6.67	21.63	59.52	81.15
RETAINED %	0.111	1.614	8.219	26.654	73.346	
PASSING %	99.889	98.386	91.781	73.346	26.654	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.889	98.386	91.781	73.346
TARGET	99	90.5	81.5	70



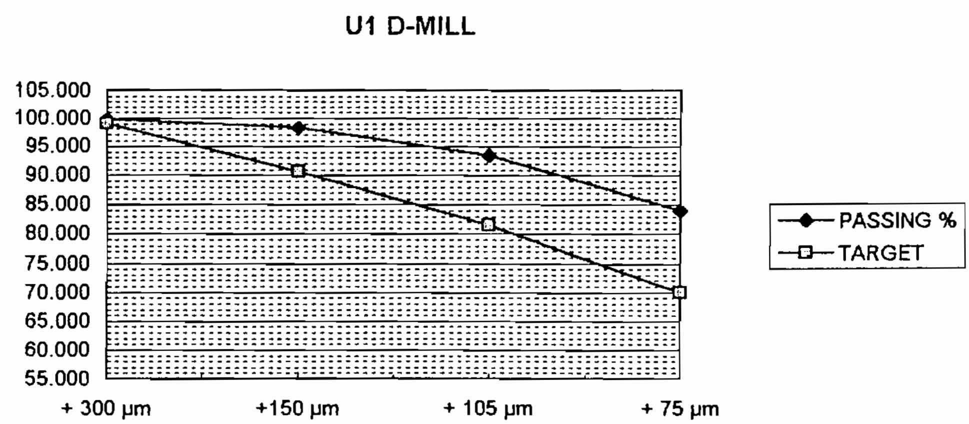
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 20.75 : 15h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.07	1.51	5.62	13.82	72.7	86.52
RETAINED %	0.081	1.745	6.496	15.973	84.027	
PASSING %	99.919	98.255	93.504	84.027	15.973	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.919	98.255	93.504	84.027
TARGET	99	90.5	81.5	70



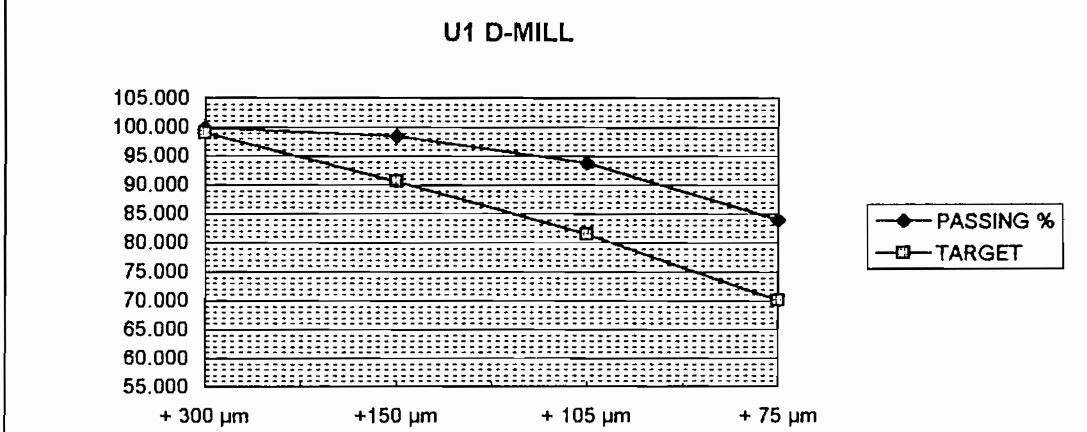
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 18 : 16h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.08	1.22	4.54	11.73	61.41	73.14
RETAINED %	0.109	1.668	6.207	16.038	83.962	
PASSING %	99.891	98.332	93.793	83.962	16.038	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.891	98.332	93.793	83.962
TARGET	99	90.5	81.5	70



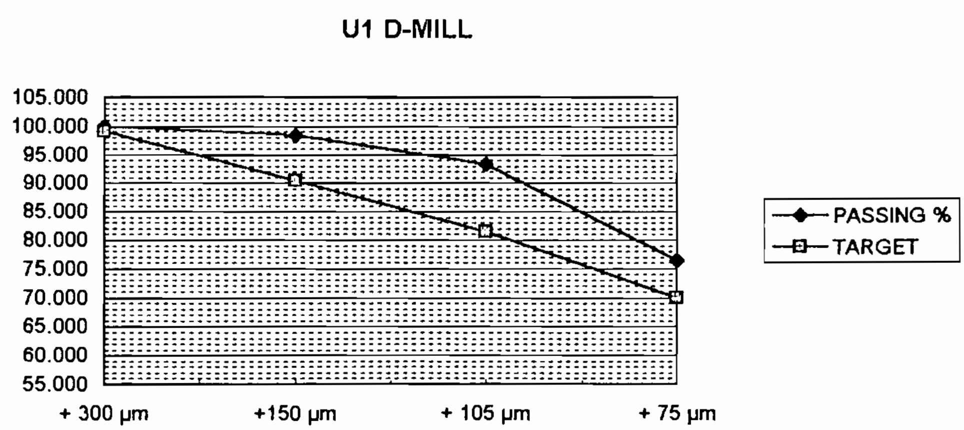
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 500 : 14 : 17h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	1.28	5.25	18.38	59.67	78.05
RETAINED %	0.051	1.640	6.726	23.549	76.451	
PASSING %	99.949	98.360	93.274	76.451	23.549	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.949	98.360	93.274	76.451
TARGET	99	90.5	81.5	70



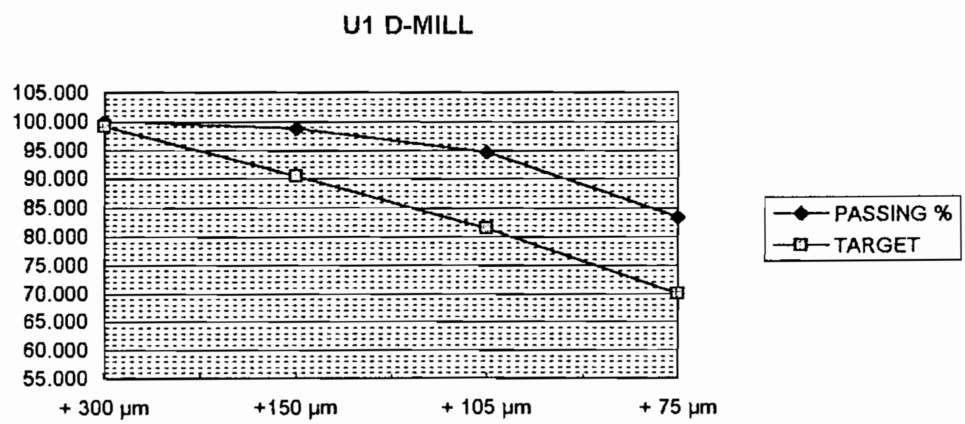
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 450 : 30 : 10h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.86	3.7	11.48	57.38	68.86
RETAINED %	0.044	1.249	5.373	16.672	83.328	
PASSING %	99.956	98.751	94.627	83.328	16.672	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.956	98.751	94.627	83.328
TARGET	99	90.5	81.5	70



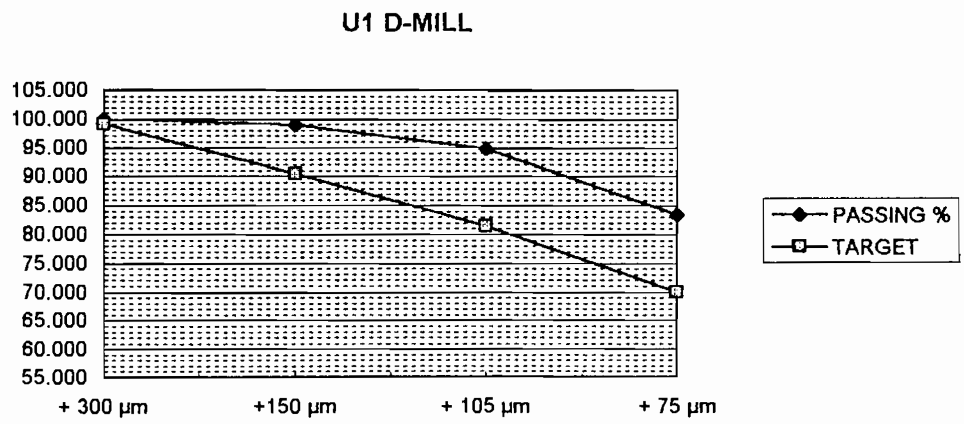
MILL TEST DATA

UNIT : 1   MILL : D   TEST No : L450 : 27 : 11h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.89	3.98	12.72	64.34	77.06
RETAINED %	0.052	1.155	5.165	16.507	83.493	
PASSING %	99.948	98.845	94.835	83.493	16.507	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.948	98.845	94.835	83.493
TARGET	99	90.5	81.5	70



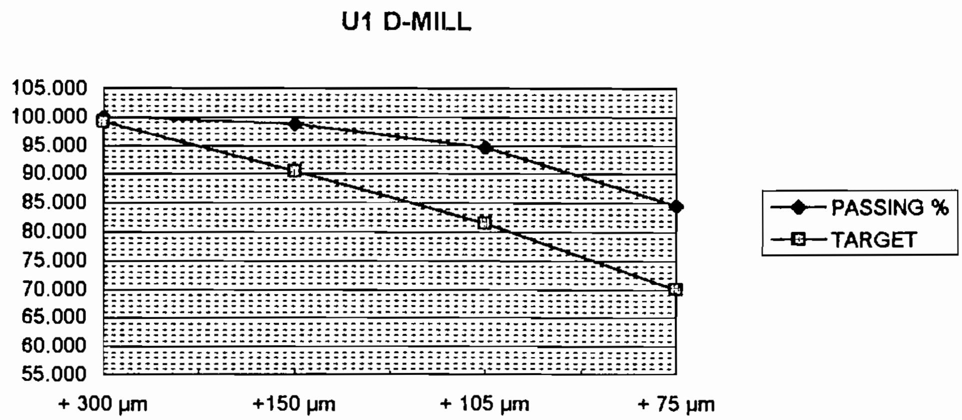
MILL TEST DATA

UNIT : 1 MILL : D TEST No : L 450 : 23 : 13h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	1.08	4.51	13	71.05	84.05
RETAINED %	0.071	1.285	5.366	15.467	84.533	
PASSING %	99.929	98.715	94.634	84.533	15.467	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.929	98.715	94.634	84.533
TARGET	99	90.5	81.5	70



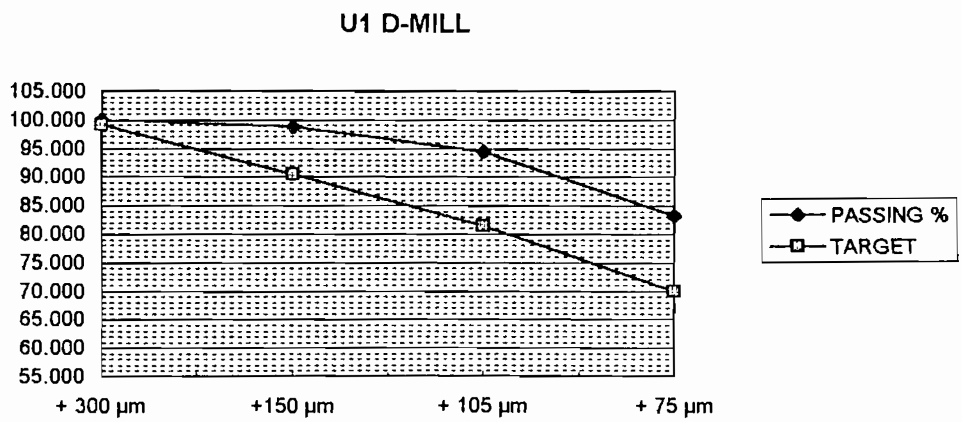
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 450 : 20 : 14h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	1.06	4.54	13.8	68.12	81.92
RETAINED %	0.037	1.294	5.542	16.846	83.154	
PASSING %	99.963	98.706	94.458	83.154	16.846	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.963	98.706	94.458	83.154
TARGET	99	90.5	81.5	70



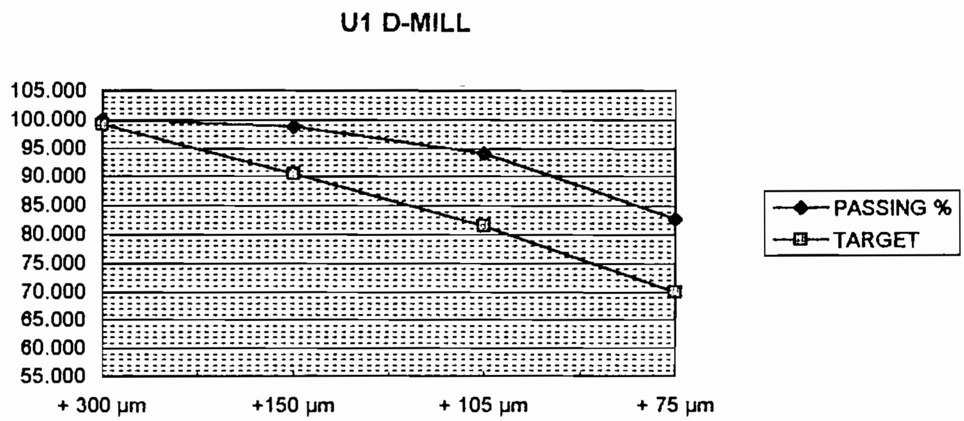
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 450 : 16 : 15h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	1.13	4.98	14.7	69.89	84.59
RETAINED %	0.047	1.336	5.887	17.378	82.622	
PASSING %	99.953	98.664	94.113	82.622	17.378	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.953	98.664	94.113	82.622
TARGET	99	90.5	81.5	70



MILL TEST DATA

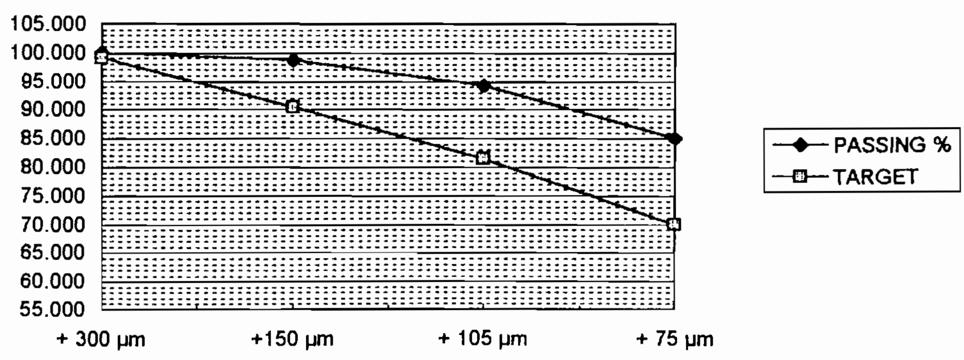
UNIT : 1 | MILL : D | TEST No : L 450 : 12.5 : 16h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	1.07	4.87	12.74	72.41	85.15
RETAINED %	0.047	1.257	5.719	14.962	85.038	
PASSING %	99.953	98.743	94.281	85.038	14.962	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.953	98.743	94.281	85.038
TARGET	99	90.5	81.5	70

U1 D-MILL



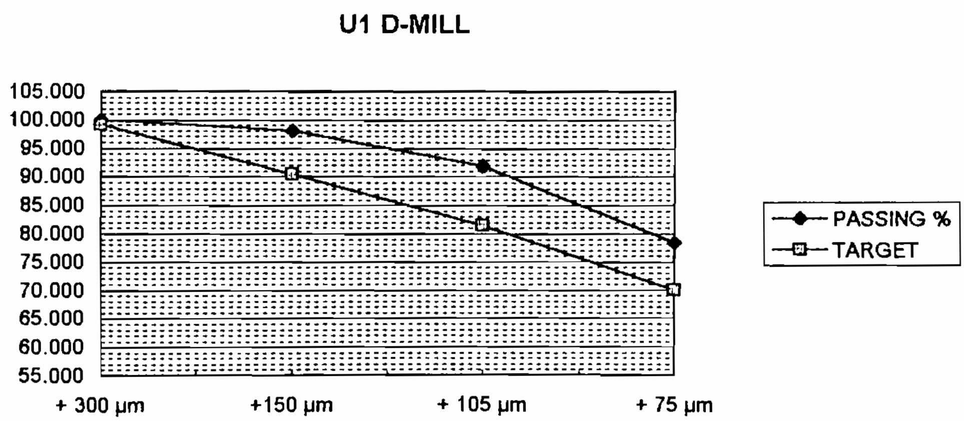
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 400 : 37 : 15h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	1.17	4.58	12.22	44.32	56.54
RETAINED %	0.088	2.069	8.100	21.613	78.387	
PASSING %	99.912	97.931	91.900	78.387	21.613	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.912	97.931	91.900	78.387
TARGET	99	90.5	81.5	70



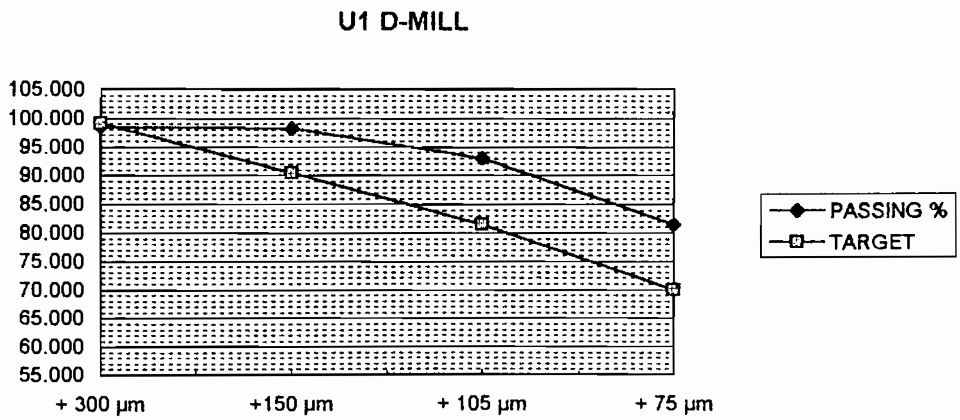
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 400 : 32.5 :16h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.8	1	3.9	10.22	44.95	55.17
RETAINED %	1.450	1.813	7.069	18.525	81.475	
PASSING %	98.550	98.187	92.931	81.475	18.525	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	98.550	98.187	92.931	81.475
TARGET	99	90.5	81.5	70



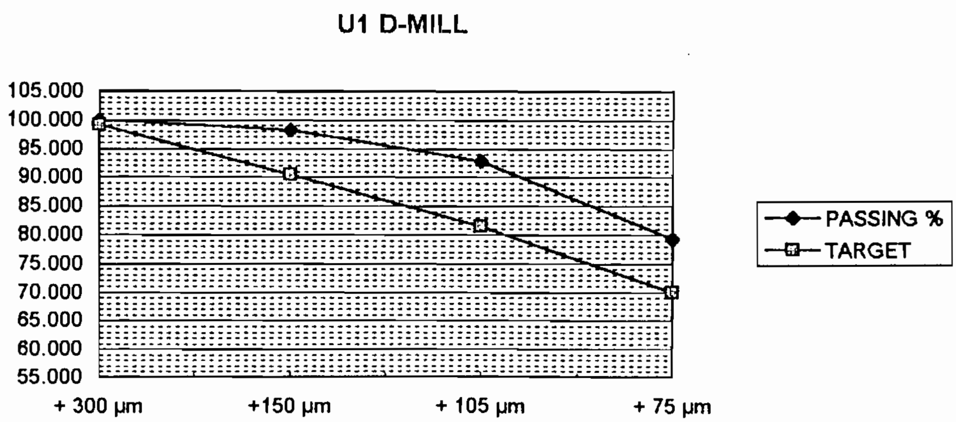
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 400 : 28 : 17h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	0.89	3.61	10.37	39.6	49.97
RETAINED %	0.120	1.781	7.224	20.752	79.248	
PASSING %	99.880	98.219	92.776	79.248	20.752	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.880	98.219	92.776	79.248
TARGET	99	90.5	81.5	70



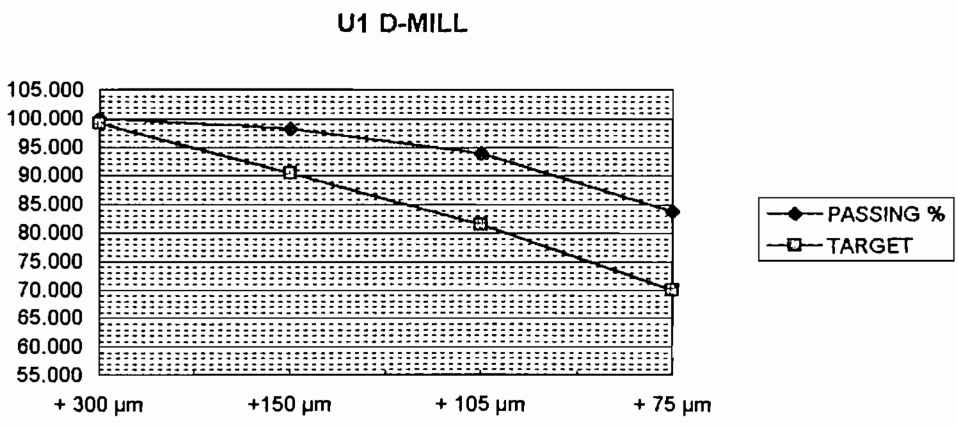
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 400 : 24 : 18h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	0.99	3.3	8.58	44.46	53.04
RETAINED %	0.094	1.867	6.222	16.176	83.824	
PASSING %	99.906	98.133	93.778	83.824	16.176	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.906	98.133	93.778	83.824
TARGET	99	90.5	81.5	70



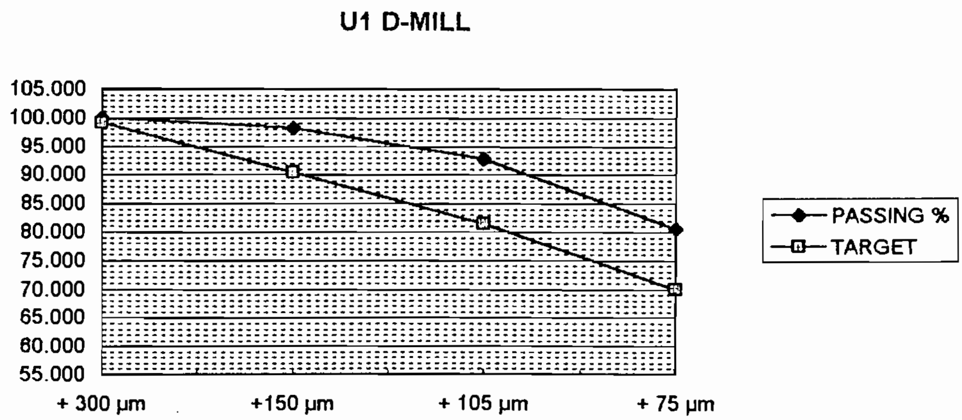
MILL TEST DATA

UNIT : 1 MILL : D TEST No : L400 : 19 :19h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	0.98	3.71	9.9	41.07	50.97
RETAINED %	0.118	1.923	7.279	19.423	80.577	
PASSING %	99.882	98.077	92.721	80.577	19.423	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.882	98.077	92.721	80.577
TARGET	99	90.5	81.5	70



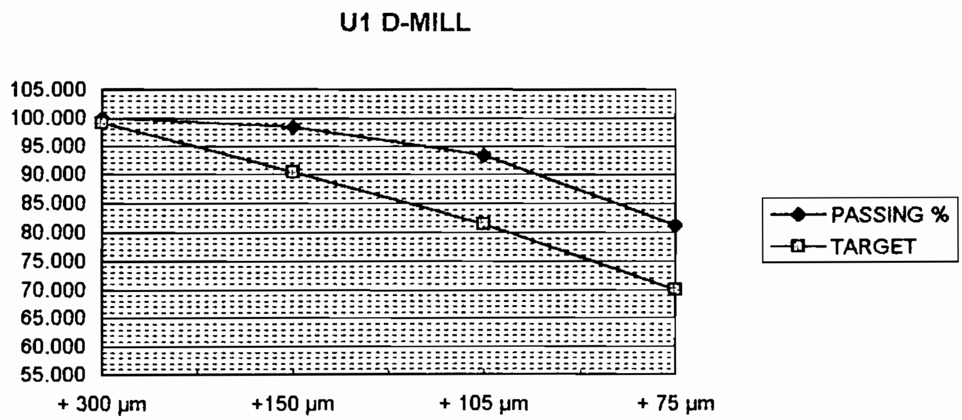
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : L 400 : 15 : 20h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	1.01	3.9	10.9	47.35	58.25
RETAINED %	0.103	1.734	6.695	18.712	81.288	
PASSING %	99.897	98.266	93.305	81.288	18.712	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.897	98.266	93.305	81.288
TARGET	99	90.5	81.5	70



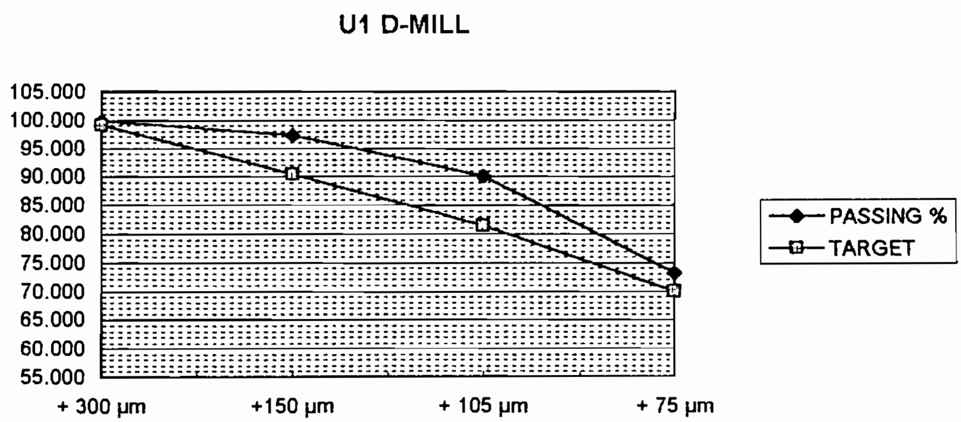
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 630 : 23.5 : 11h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.39	5.2	14.06	38.31	52.37
RETAINED %	0.191	2.654	9.929	26.847	73.153	
PASSING %	99.809	97.346	90.071	73.153	26.847	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.809	97.346	90.071	73.153
TARGET	99	90.5	81.5	70



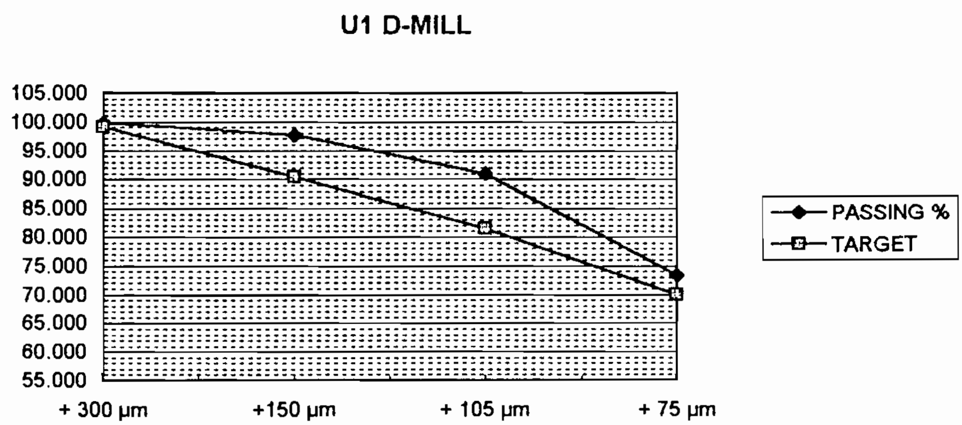
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 630 : 19.5 :12h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.07	1.33	4.84	14.42	39.69	54.11
RETAINED %	0.129	2.458	8.945	26.649	73.351	
PASSING %	99.871	97.542	91.055	73.351	26.649	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.871	97.542	91.055	73.351
TARGET	99	90.5	81.5	70



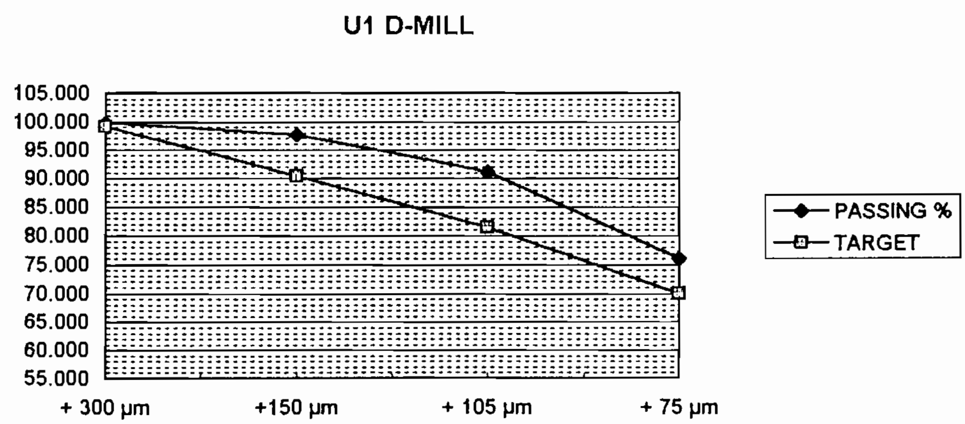
MILL TEST DATA

UNIT : 1 — MILL : D — TEST No : S 630 : 15 : 13h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.51	5.44	14.89	47.07	61.96
RETAINED %	0.161	2.437	8.780	24.032	75.968	
PASSING %	99.839	97.563	91.220	75.968	24.032	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.839	97.563	91.220	75.968
TARGET	99	90.5	81.5	70



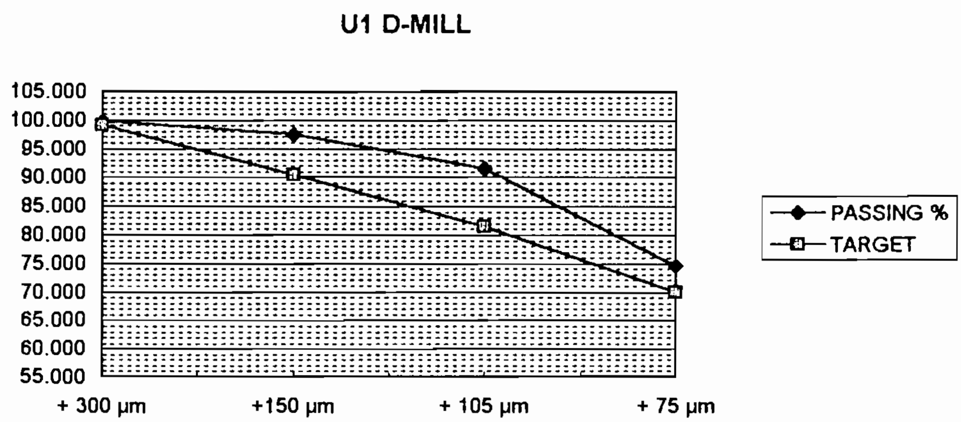
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 630 : 10 : 14h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.12	1.38	4.58	13.68	40.3	53.98
RETAINED %	0.222	2.557	8.485	25.343	74.657	
PASSING %	99.778	97.443	91.515	74.657	25.343	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.778	97.443	91.515	74.657
TARGET	99	90.5	81.5	70



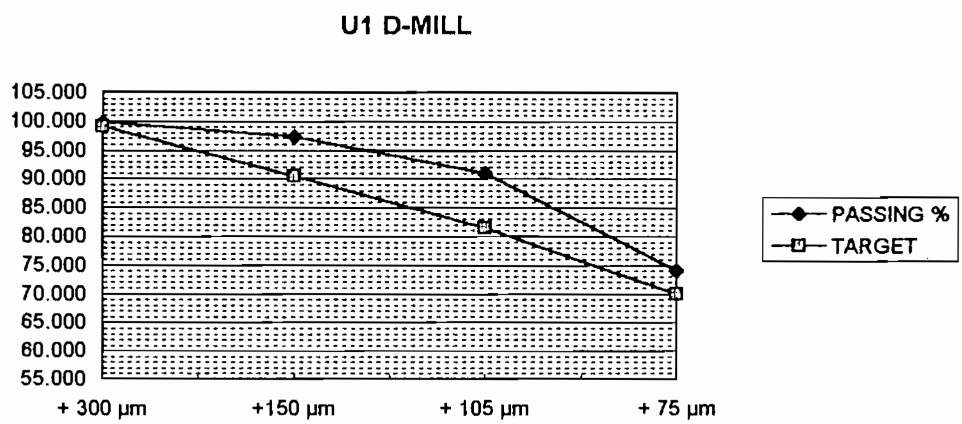
MILL TEST DATA

UNIT : 1   MILL : D   TEST No : S 630 : 8 : 16h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.33	4.53	13.01	37.08	50.09
RETAINED %	0.220	2.655	9.044	25.973	74.027	
PASSING %	99.780	97.345	90.956	74.027	25.973	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.780	97.345	90.956	74.027
TARGET	99	90.5	81.5	70



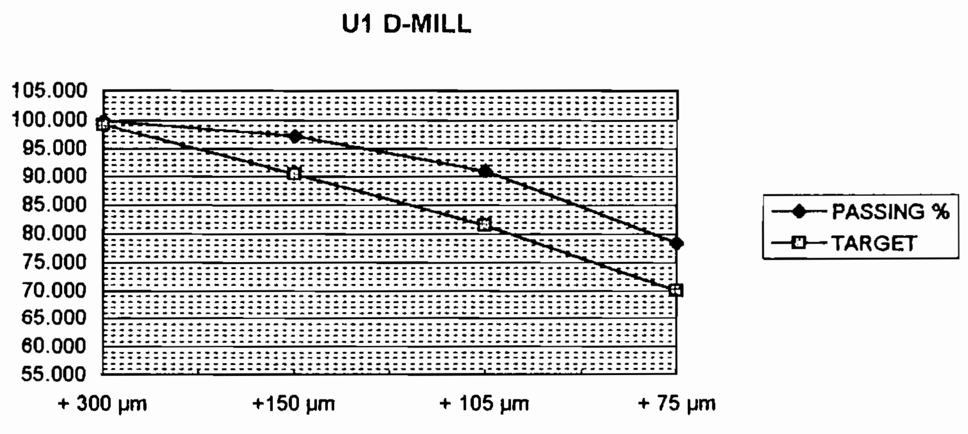
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 630 : 5.5 : 15h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.13	1.47	4.68	11.18	40.68	51.86
RETAINED %	0.251	2.835	9.024	21.558	78.442	
PASSING %	99.749	97.165	90.976	78.442	21.558	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.749	97.165	90.976	78.442
TARGET	99	90.5	81.5	70



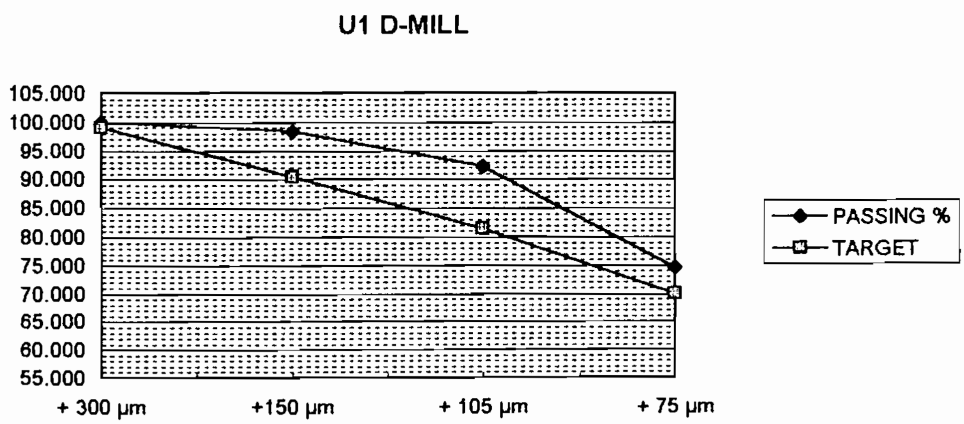
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 550 : 30 : 13h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.82	3.94	12.88	37.68	50.56
RETAINED %	0.059	1.622	7.793	25.475	74.525	
PASSING %	99.941	98.378	92.207	74.525	25.475	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.941	98.378	92.207	74.525
TARGET	99	90.5	81.5	70



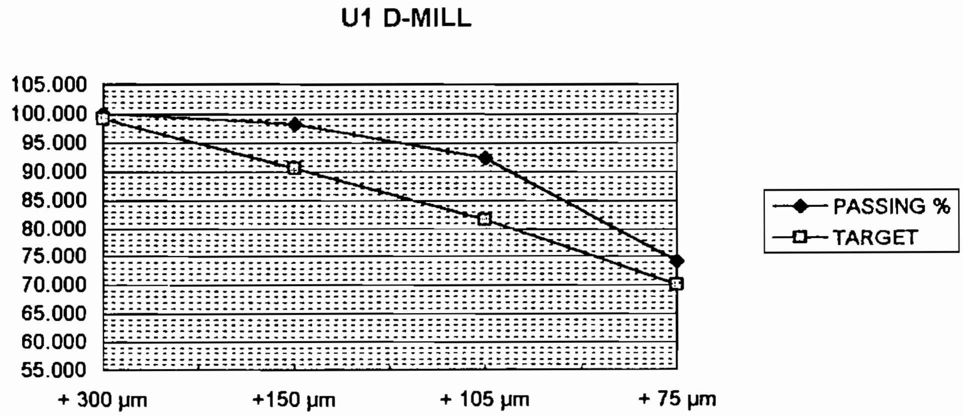
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 550 : 26 : 14h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.95	4.1	13.8	39.69	53.49
RETAINED %	0.056	1.776	7.665	25.799	74.201	
PASSING %	99.944	98.224	92.335	74.201	25.799	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.944	98.224	92.335	74.201
TARGET	99	90.5	81.5	70



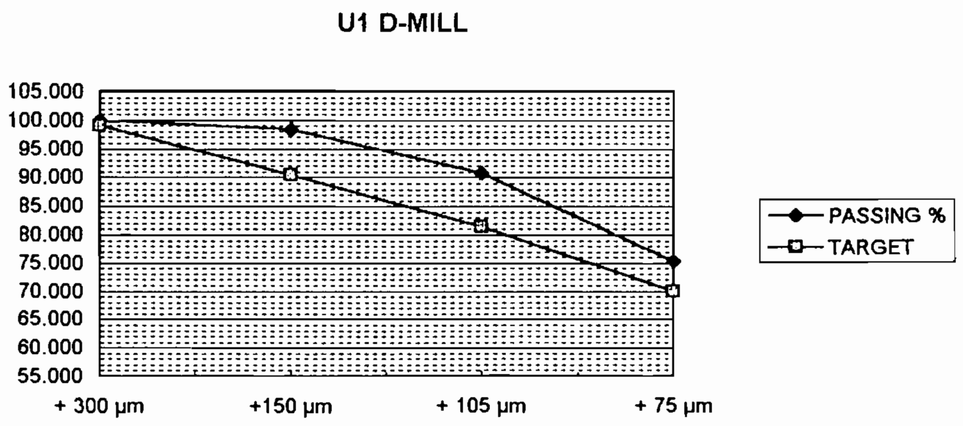
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 550 : 22 : 15h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.88	4.9	13.08	40.02	53.1
RETAINED %	0.075	1.657	9.228	24.633	75.367	
PASSING %	99.925	98.343	90.772	75.367	24.633	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.925	98.343	90.772	75.367
TARGET	99	90.5	81.5	70



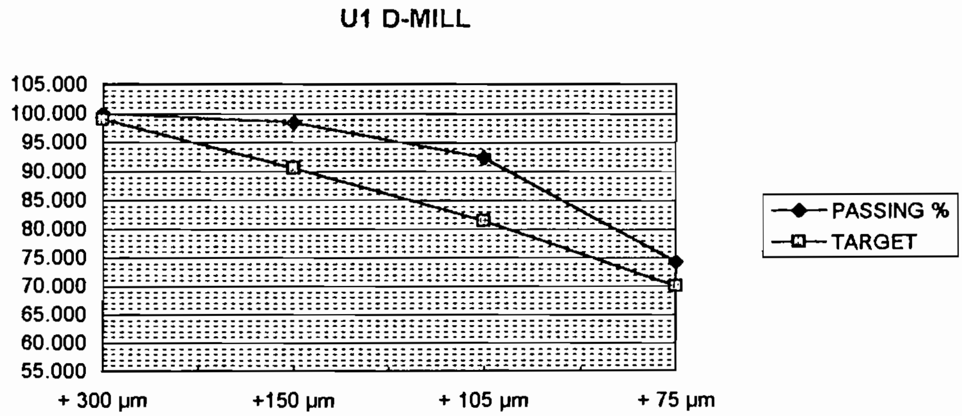
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 550 : 18 : 16h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.81	3.85	12.99	37.39	50.38
RETAINED %	0.060	1.608	7.642	25.784	74.216	
PASSING %	99.940	98.392	92.358	74.216	25.784	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.940	98.392	92.358	74.216
TARGET	99	90.5	81.5	70



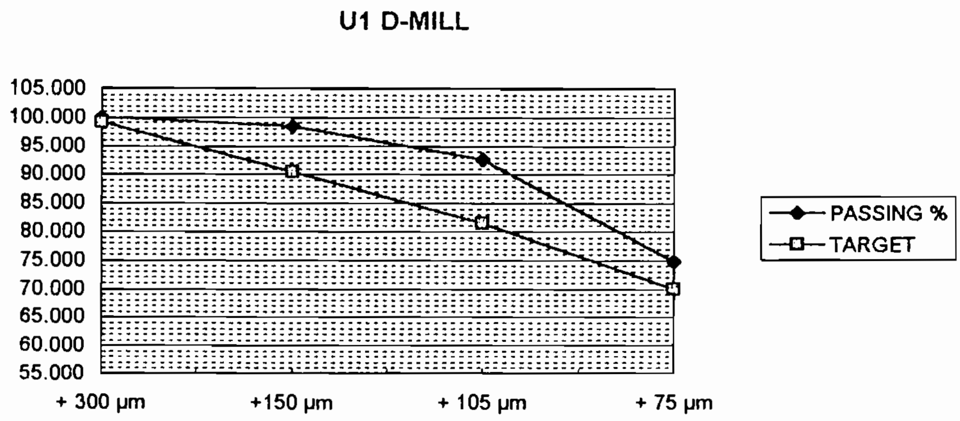
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 550 : 14 : 20h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.79	3.75	12.65	37.52	50.17
RETAINED %	0.060	1.575	7.475	25.214	74.786	
PASSING %	99.940	98.425	92.525	74.786	25.214	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.940	98.425	92.525	74.786
TARGET	99	90.5	81.5	70



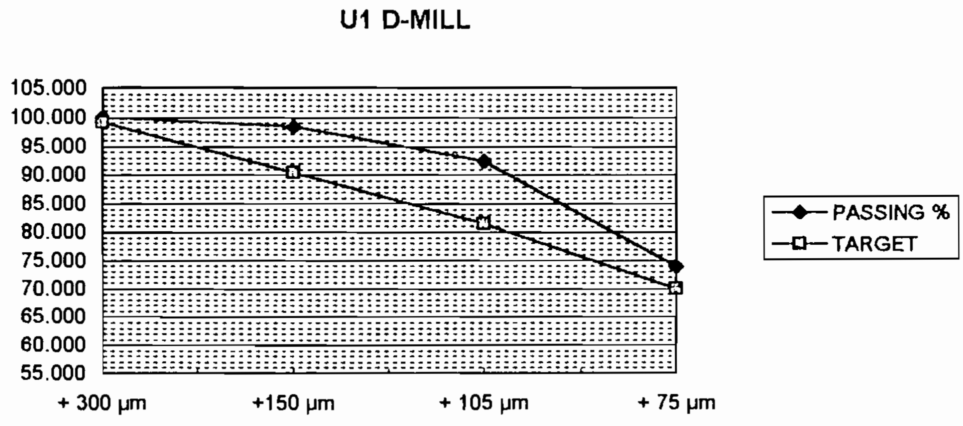
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 550 : 10 : 21h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.85	3.78	13.12	37.12	50.24
RETAINED %	0.060	1.692	7.524	26.115	73.885	
PASSING %	99.940	98.308	92.476	73.885	26.115	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.940	98.308	92.476	73.885
TARGET	99	90.5	81.5	70



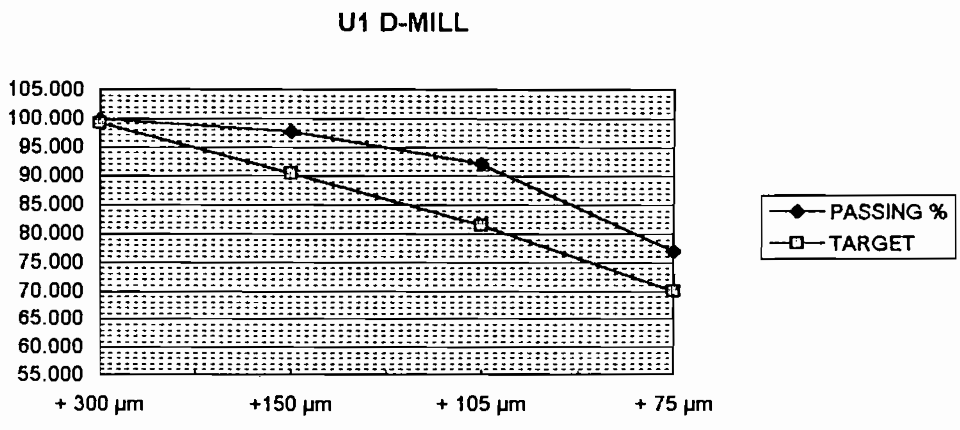
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 500 : 31 :09h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.39	4.54	13.22	43.97	57.19
RETAINED %	0.175	2.430	7.938	23.116	76.884	
PASSING %	99.825	97.570	92.062	76.884	23.116	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.825	97.570	92.062	76.884
TARGET	99	90.5	81.5	70



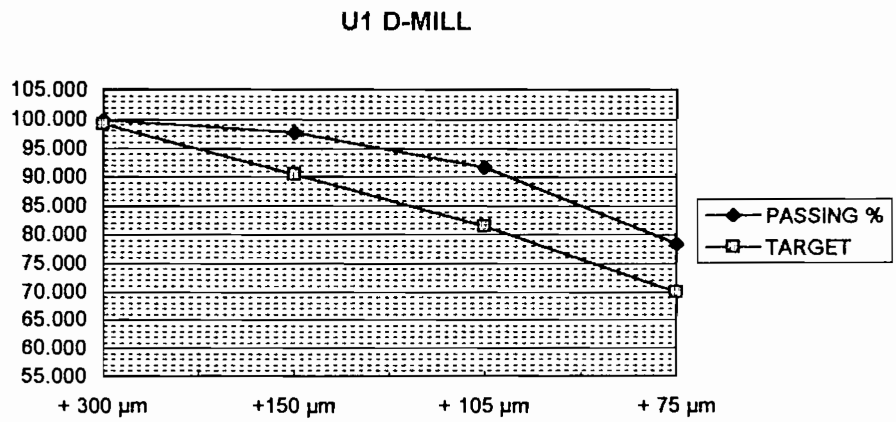
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 500 : 26.5 : 11h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.34	4.63	12.04	43.79	55.83
RETAINED %	0.179	2.400	8.293	21.565	78.435	
PASSING %	99.821	97.600	91.707	78.435	21.565	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.821	97.600	91.707	78.435
TARGET	99	90.5	81.5	70



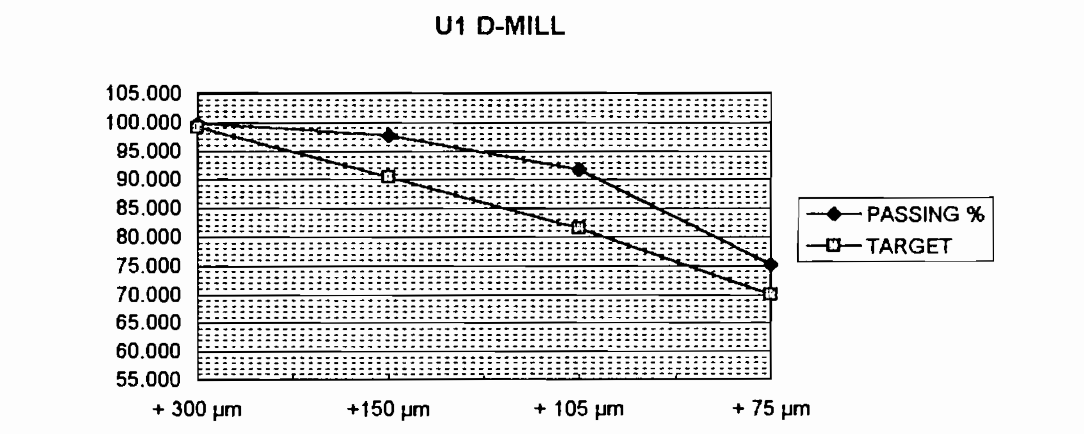
MILL TEST DATA

UNIT : 1 | **MILL : D** | **TEST No : S 500 : 23.5 : 12h00**

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.31	4.42	13.28	40.15	53.43
RETAINED %	0.187	2.452	8.273	24.855	75.145	
PASSING %	99.813	97.548	91.727	75.145	24.855	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.813	97.548	91.727	75.145
TARGET	99	90.5	81.5	70



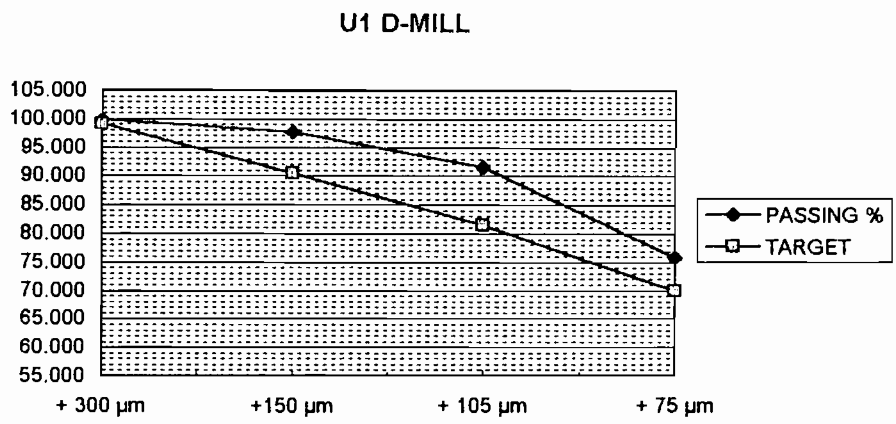
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 500 : 19 : 13h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.29	4.53	12.81	40.14	52.95
RETAINED %	0.189	2.436	8.555	24.193	75.807	
PASSING %	99.811	97.564	91.445	75.807	24.193	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.811	97.564	91.445	75.807
TARGET	99	90.5	81.5	70



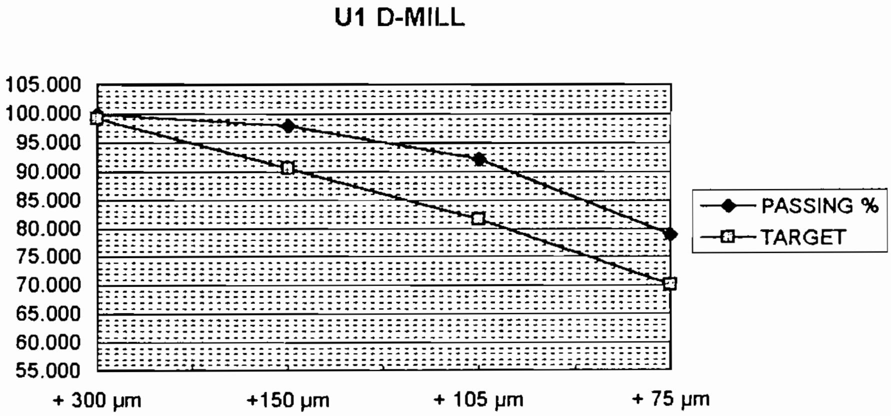
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 500 : 16 :14h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.08	1.13	4.13	11.09	41.37	52.46
RETAINED %	0.152	2.154	7.873	21.140	78.860	
PASSING %	99.848	97.846	92.127	78.860	21.140	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.848	97.846	92.127	78.860
TARGET	99	90.5	81.5	70



MILL TEST DATA

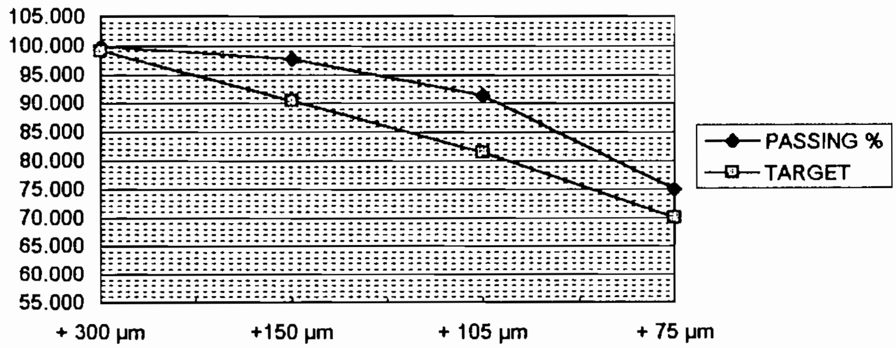
UNIT : 1 | MILL : D | TEST No : S 500 : 11 : 15h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.07	1.26	4.46	12.85	38.42	51.27
RETAINED %	0.137	2.458	8.699	25.063	74.937	
PASSING %	99.863	97.542	91.301	74.937	25.063	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.863	97.542	91.301	74.937
TARGET	99	90.5	81.5	70

U1 D-MILL



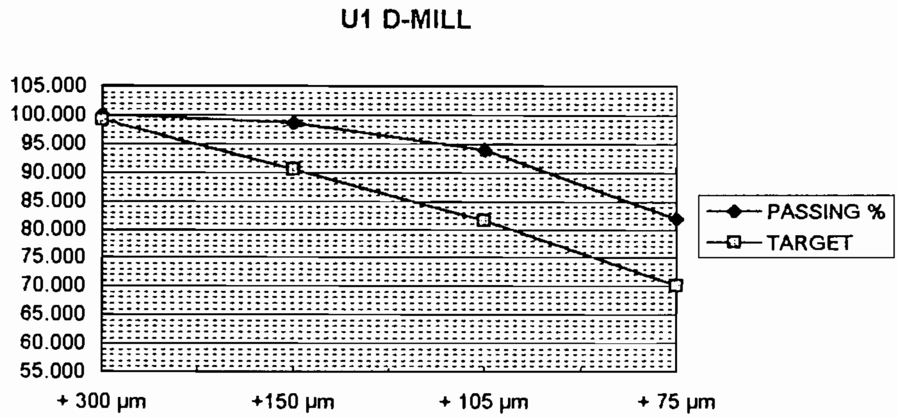
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 450 : 28.5 : 09h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.87	3.61	10.71	48.61	59.32
RETAINED %	0.051	1.467	6.086	18.055	81.945	
PASSING %	99.949	98.533	93.914	81.945	18.055	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.949	98.533	93.914	81.945
TARGET	99	90.5	81.5	70



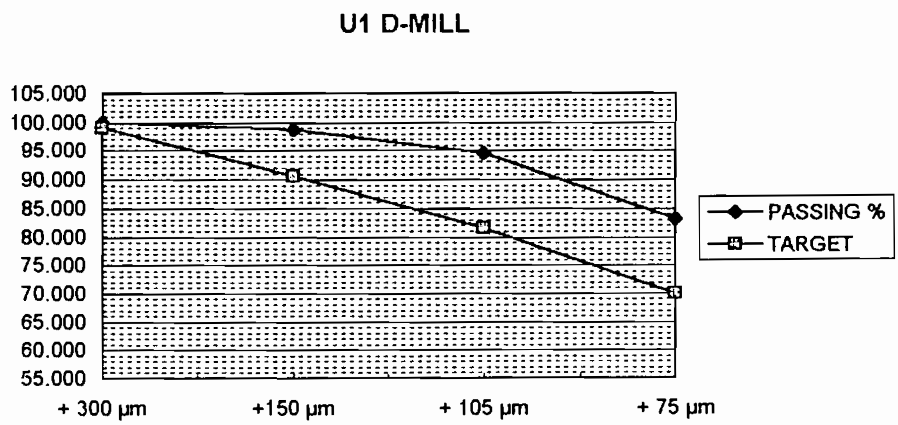
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 450 : 25.5 : 11h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.76	3.12	9.51	47.11	56.62
RETAINED %	0.053	1.342	5.510	16.796	83.204	
PASSING %	99.947	98.658	94.490	83.204	16.796	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.947	98.658	94.490	83.204
TARGET	99	90.5	81.5	70



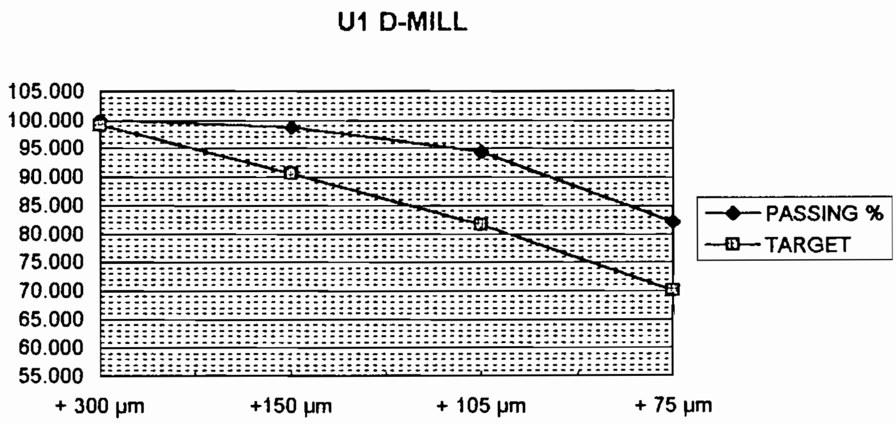
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 450 : 22.5 : 15h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.02	0.73	3.03	9.64	44.33	53.97
RETAINED %	0.037	1.353	5.614	17.862	82.138	
PASSING %	99.963	98.647	94.386	82.138	17.862	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.963	98.647	94.386	82.138
TARGET	99	90.5	81.5	70



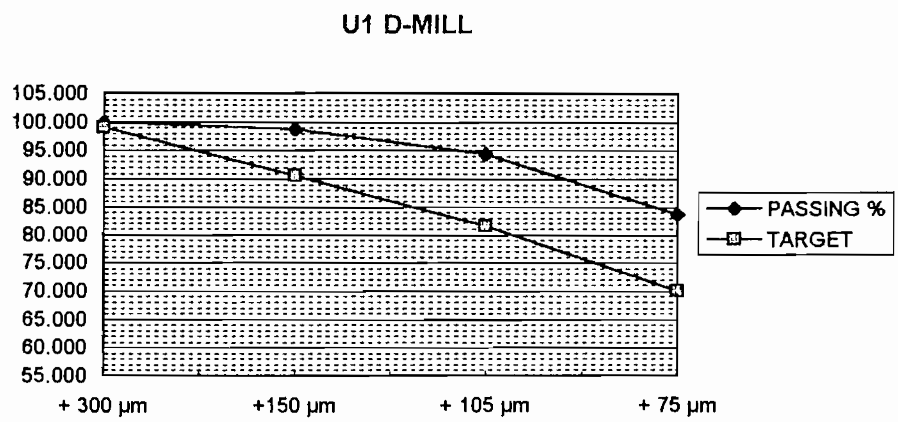
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 450 : 19.5 : 16h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.02	0.71	2.95	8.61	44.3	52.91
RETAINED %	0.038	1.342	5.576	16.273	83.727	
PASSING %	99.962	98.658	94.424	83.727	16.273	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.962	98.658	94.424	83.727
TARGET	99	90.5	81.5	70



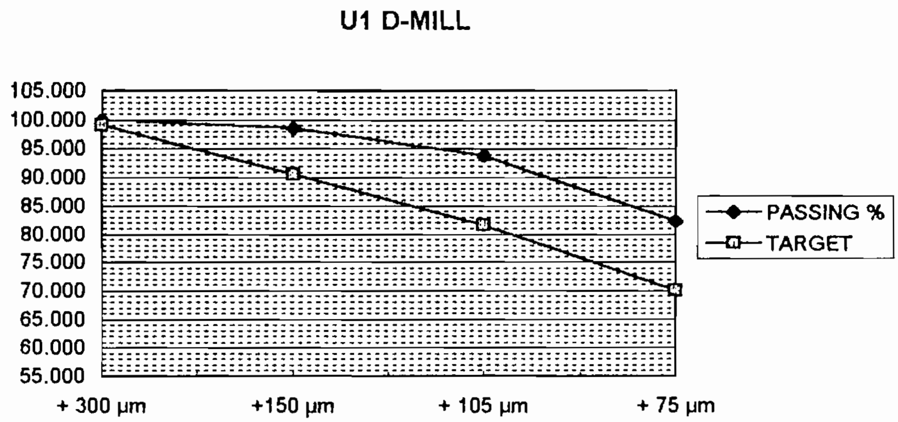
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 450 : 16.5 : 17h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.8	3.47	10.01	46.65	56.66
RETAINED %	0.053	1.412	6.124	17.667	82.333	
PASSING %	99.947	98.588	93.876	82.333	17.667	

GRAPH· DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.947	98.588	93.876	82.333
TARGET	99	90.5	81.5	70



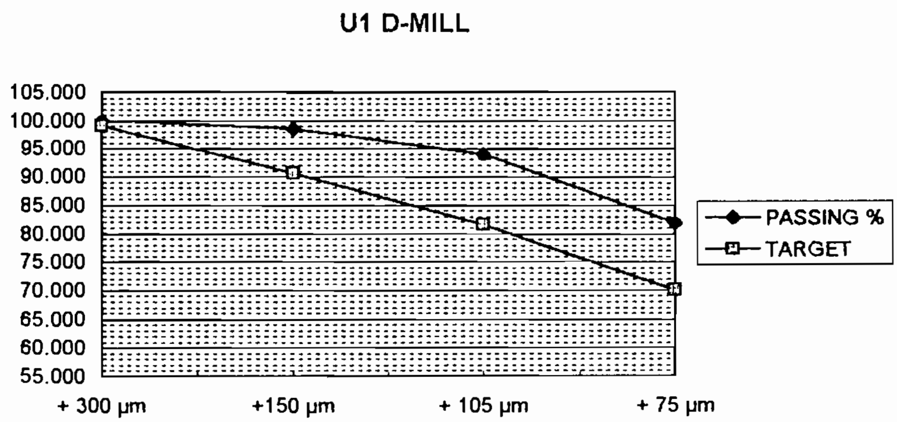
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 450 : 12.5 : 19h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.87	3.61	10.71	48.61	59.32
RETAINED %	0.051	1.467	6.086	18.055	81.945	
PASSING %	99.949	98.533	93.914	81.945	18.055	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.949	98.533	93.914	81.945
TARGET	99	90.5	81.5	70



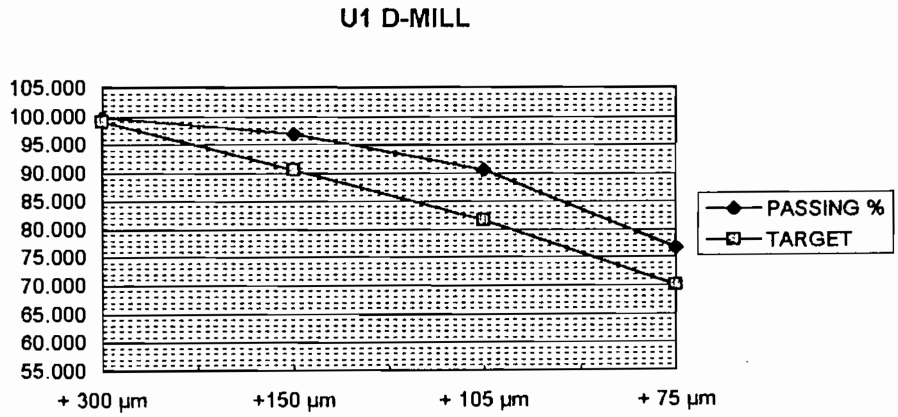
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 400 : 34 : 09h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.62	4.76	11.85	38.8	50.65
RETAINED %	0.217	3.198	9.398	23.396	76.604	
PASSING %	99.783	96.802	90.602	76.604	23.396	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.783	96.802	90.602	76.604
TARGET	99	90.5	81.5	70



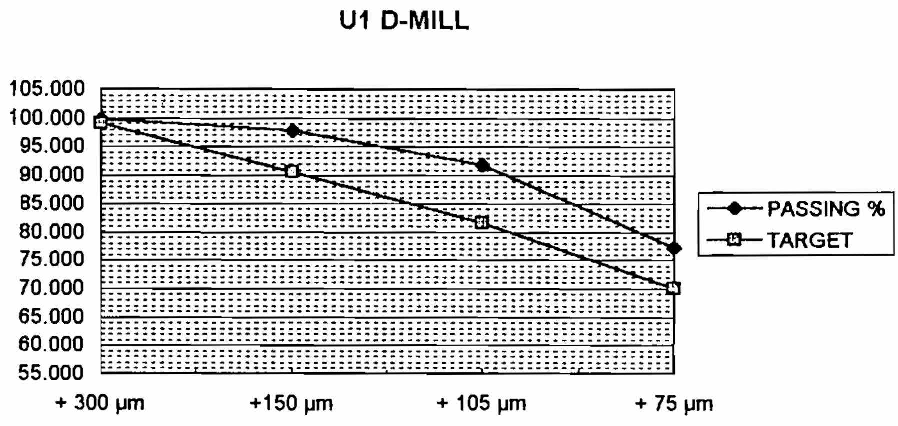
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 400 : 30 : 11h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.11	4.04	11.35	38.53	49.88
RETAINED %	0.200	2.225	8.099	22.755	77.245	
PASSING %	99.800	97.775	91.901	77.245	22.755	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.800	97.775	91.901	77.245
TARGET	99	90.5	81.5	70



MILL TEST DATA

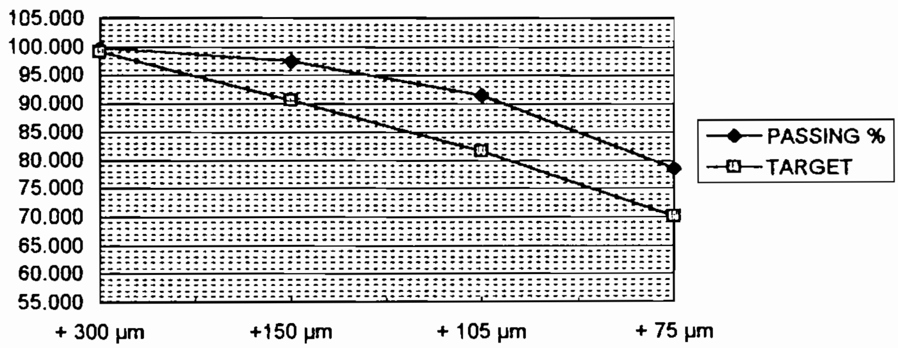
UNIT : 1 MILL : D TEST No : S 400 : 26 : 13h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.12	1.42	4.66	11.84	43.01	54.85
RETAINED %	0.219	2.589	8.496	21.586	78.414	
PASSING %	99.781	97.411	91.504	78.414	21.586	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.781	97.411	91.504	78.414
TARGET	99	90.5	81.5	70

U1 D-MILL



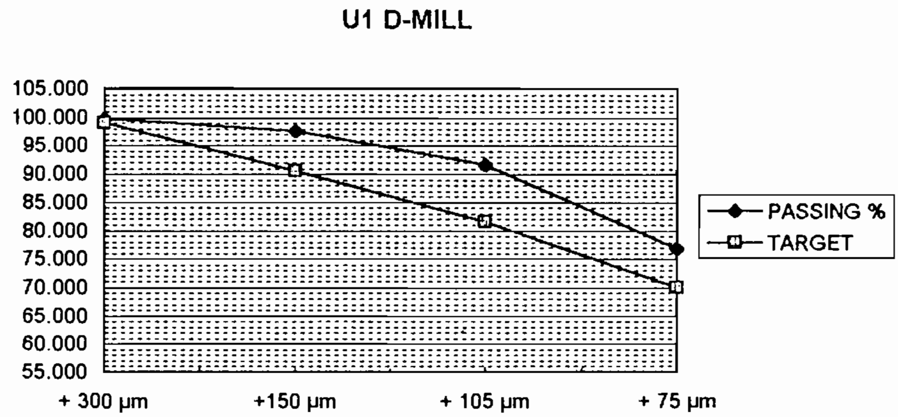
MILL TEST DATA

UNIT : 1 MILL : D TEST No : S 400 : 22 : 14h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.17	4.06	11.41	37.69	49.1
RETAINED %	0.204	2.383	8.269	23.238	76.762	
PASSING %	99.796	97.617	91.731	76.762	23.238	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.796	97.617	91.731	76.762
TARGET	99	90.5	81.5	70



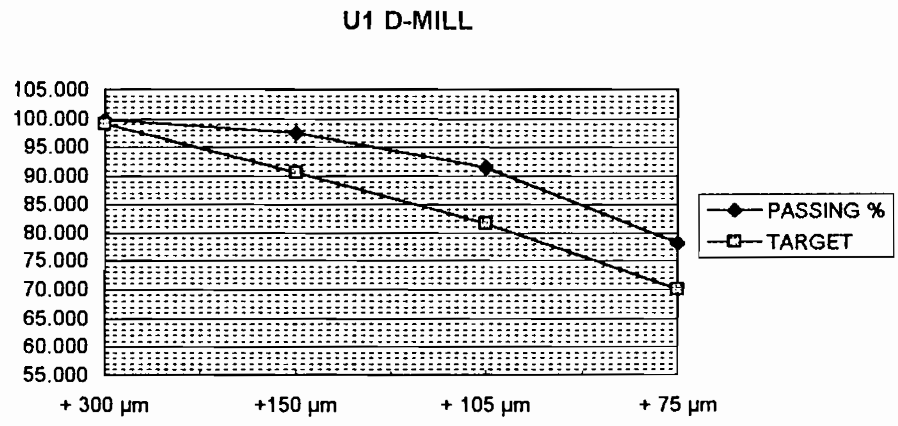
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : S 400 : 18 : 15h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.4	4.67	11.93	42.6	54.53
RETAINED %	0.183	2.567	8.564	21.878	78.122	
PASSING %	99.817	97.433	91.436	78.122	21.878	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.817	97.433	91.436	78.122
TARGET	99	90.5	81.5	70



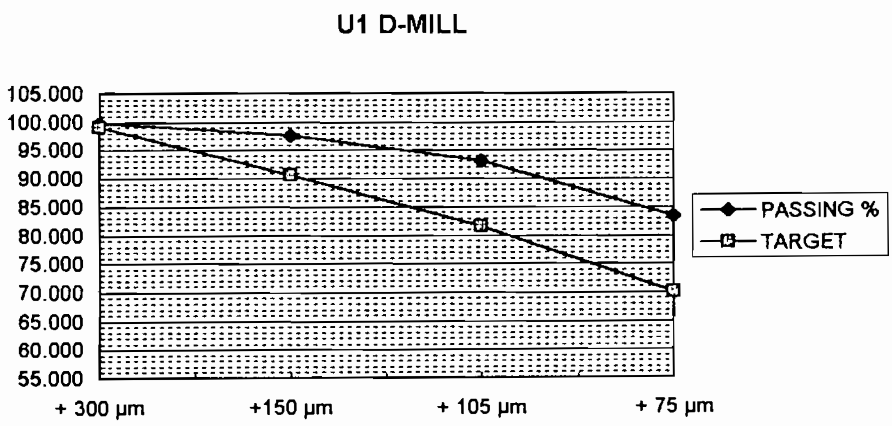
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 21 : 11h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.23	3.43	8.29	41.6	49.89
RETAINED %	0.220	2.465	6.875	16.617	83.383	
PASSING %	99.780	97.535	93.125	83.383	16.617	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.780	97.535	93.125	83.383
TARGET	99	90.5	81.5	70



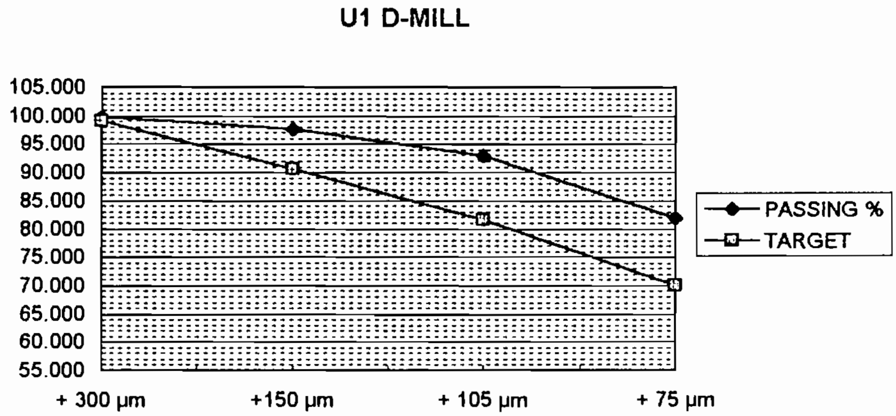
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 18 : 13h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.2	3.6	9.15	41.27	50.42
RETAINED %	0.179	2.380	7.140	18.148	81.852	
PASSING %	99.821	97.620	92.860	81.852	18.148	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.821	97.620	92.860	81.852
TARGET	99	90.5	81.5	70



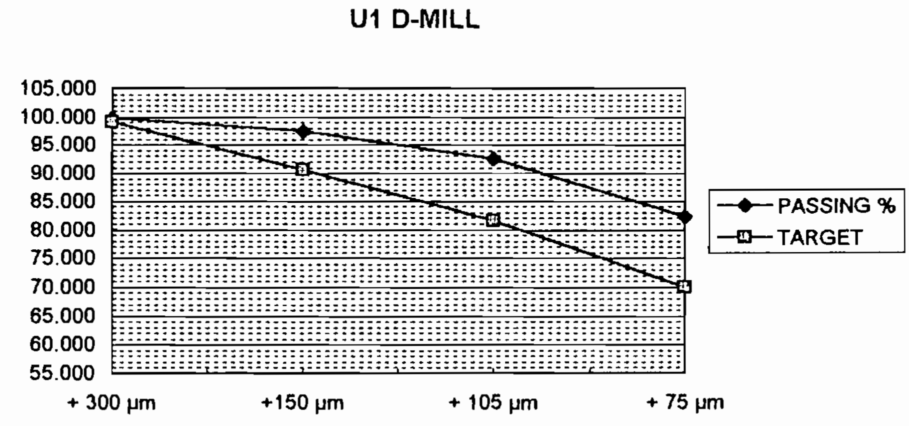
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 15 : 14h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.08	1.28	3.58	8.59	39.81	48.4
RETAINED %	0.165	2.645	7.397	17.748	82.252	
PASSING %	99.835	97.355	92.603	82.252	17.748	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.835	97.355	92.603	82.252
TARGET	99	90.5	81.5	70



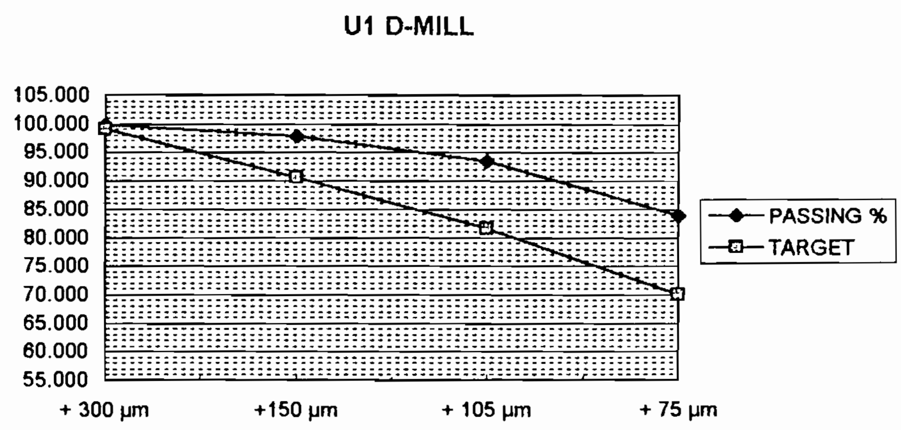
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 11 : 15h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.08	1.05	3.07	7.48	39	46.48
RETAINED %	0.172	2.259	6.605	16.093	83.907	
PASSING %	99.828	97.741	93.395	83.907	16.093	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.828	97.741	93.395	83.907
TARGET	99	90.5	81.5	70



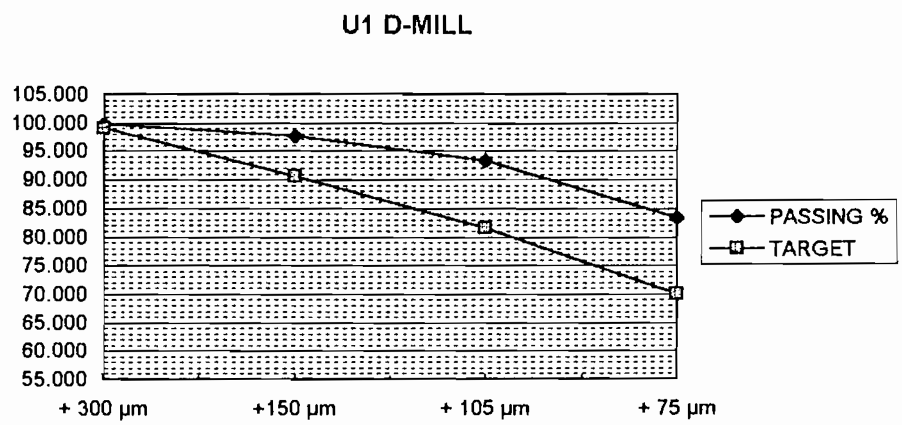
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 8 :16h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.03	2.96	7.38	36.97	44.35
RETAINED %	0.203	2.322	6.674	16.640	83.360	
PASSING %	99.797	97.678	93.326	83.360	16.640	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.797	97.678	93.326	83.360
TARGET	99	90.5	81.5	70



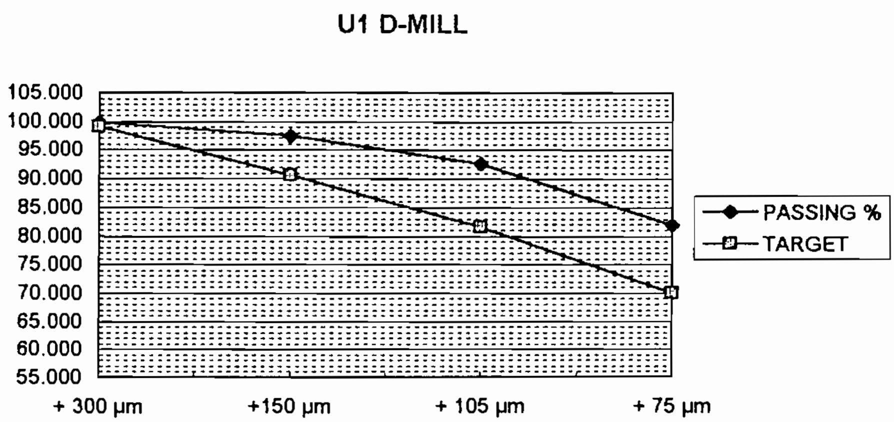
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 630 : 5 :17h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.19	3.37	8.2	37.3	45.5
RETAINED %	0.198	2.615	7.407	18.022	81.978	
PASSING %	99.802	97.385	92.593	81.978	18.022	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.802	97.385	92.593	81.978
TARGET	99	90.5	81.5	70



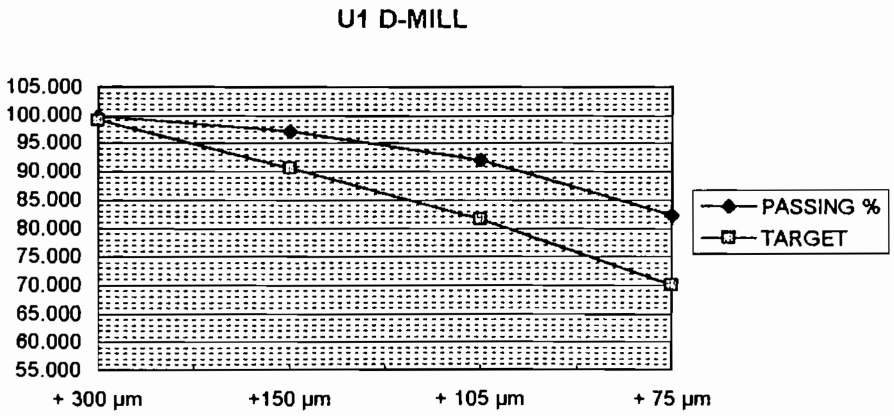
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 550 : 28 : 09h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.11	2.95	6.55	30.38	36.93
RETAINED %	0.244	3.006	7.988	17.736	82.264	
PASSING %	99.756	96.994	92.012	82.264	17.736	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.756	96.994	92.012	82.264
TARGET	99	90.5	81.5	70



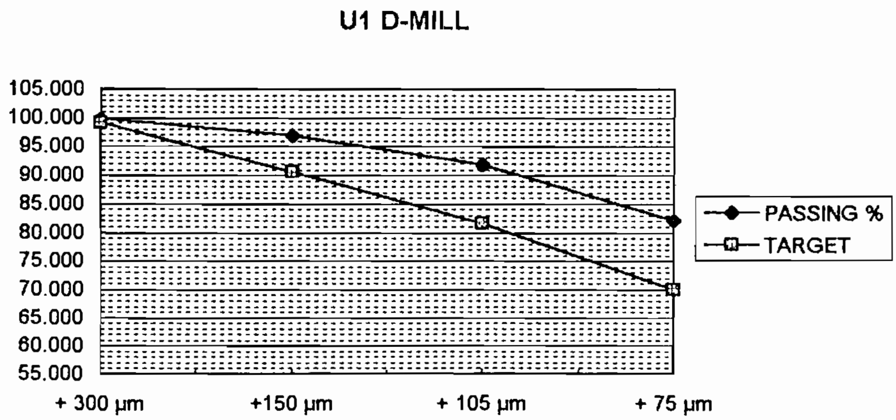
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 550 : 24.5 : 10h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.14	1.48	3.88	8.45	38.93	47.38
RETAINED %	0.295	3.124	8.189	17.835	82.165	
PASSING %	99.705	96.876	91.811	82.165	17.835	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.705	96.876	91.811	82.165
TARGET	99	90.5	81.5	70



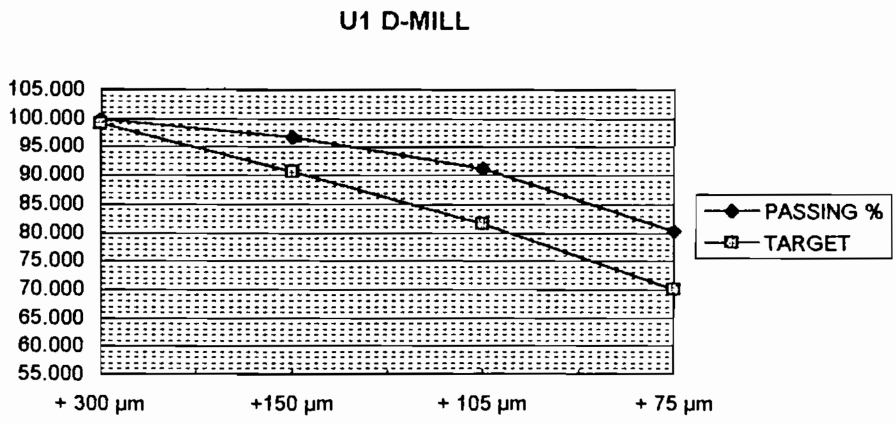
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 550 : 21 : 11h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.32	3.46	7.76	31.44	39.2
RETAINED %	0.281	3.367	8.827	19.796	80.204	
PASSING %	99.719	96.633	91.173	80.204	19.796	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.719	96.633	91.173	80.204
TARGET	99	90.5	81.5	70



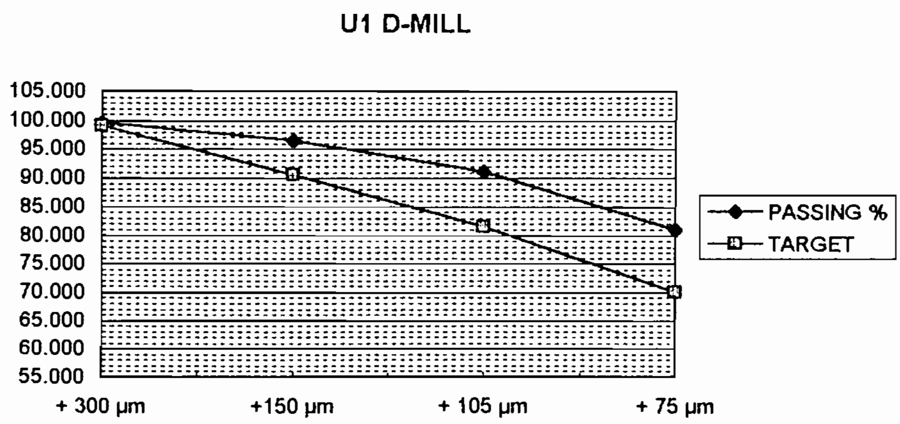
MILL TEST DATA

UNIT : 1   MILL : D   TEST No : H 550 : 17 : 12h15

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.15	1.59	4.08	8.66	36.81	45.47
RETAINED %	0.330	3.497	8.973	19.046	80.954	
PASSING %	99.670	96.503	91.027	80.954	19.046	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.670	96.503	91.027	80.954
TARGET	99	90.5	81.5	70



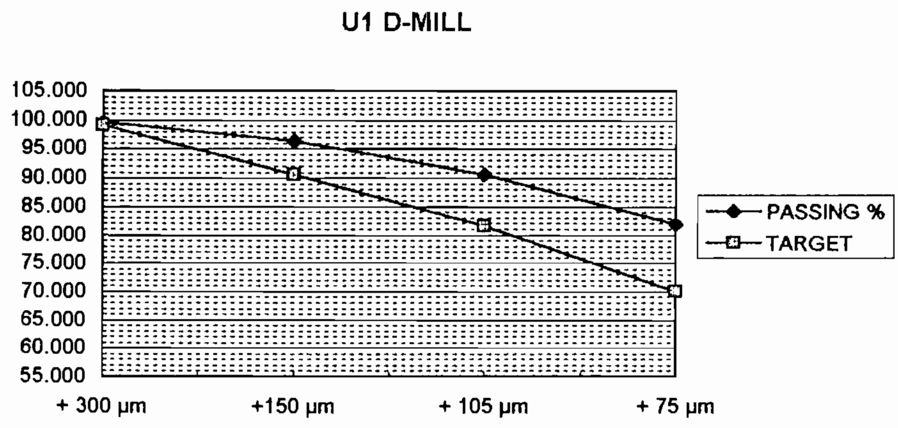
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 550 : 13.5 : 13h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.16	1.72	4.5	8.6	38.76	47.36
RETAINED %	0.338	3.632	9.502	18.159	81.841	
PASSING %	99.662	96.368	90.498	81.841	18.159	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.662	96.368	90.498	81.841
TARGET	99	90.5	81.5	70



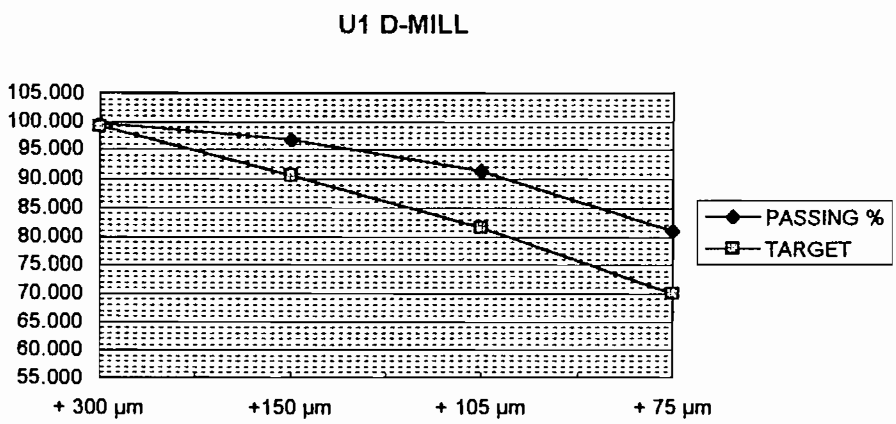
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 550 : 10 : 14h30

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.19	1.56	4.01	8.78	37.57	46.35
RETAINED %	0.410	3.366	8.652	18.943	81.057	
PASSING %	99.590	96.634	91.348	81.057	18.943	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.590	96.634	91.348	81.057
TARGET	99	90.5	81.5	70



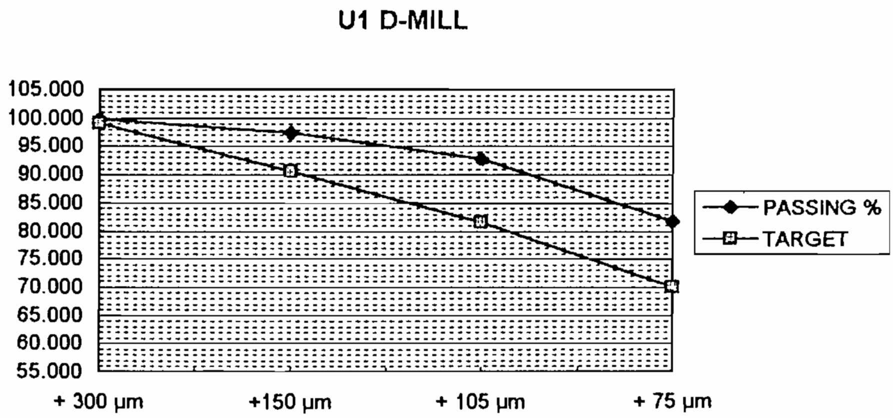
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 500 : 32 : 10h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.26	3.59	9.06	40.62	49.68
RETAINED %	0.201	2.536	7.226	18.237	81.763	
PASSING %	99.799	97.464	92.774	81.763	18.237	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.799	97.464	92.774	81.763
TARGET	99	90.5	81.5	70



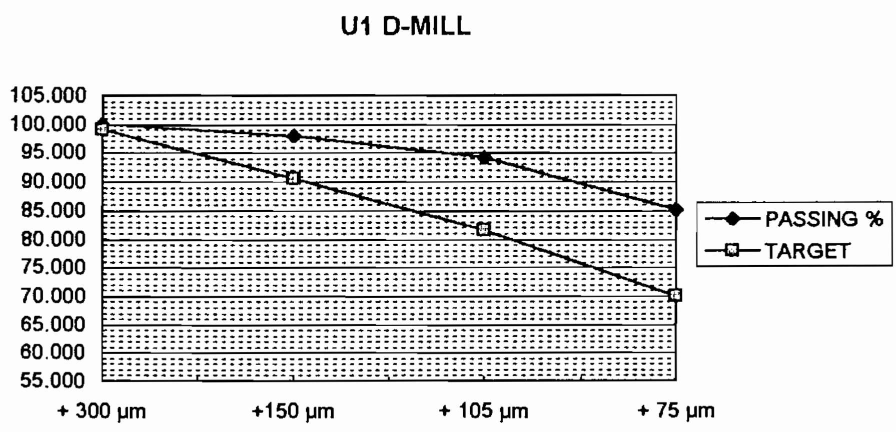
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 500 : 28 : 11h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	0.97	2.79	7.12	40.98	48.1
RETAINED %	0.125	2.017	5.800	14.802	85.198	
PASSING %	99.875	97.983	94.200	85.198	14.802	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.875	97.983	94.200	85.198
TARGET	99	90.5	81.5	70



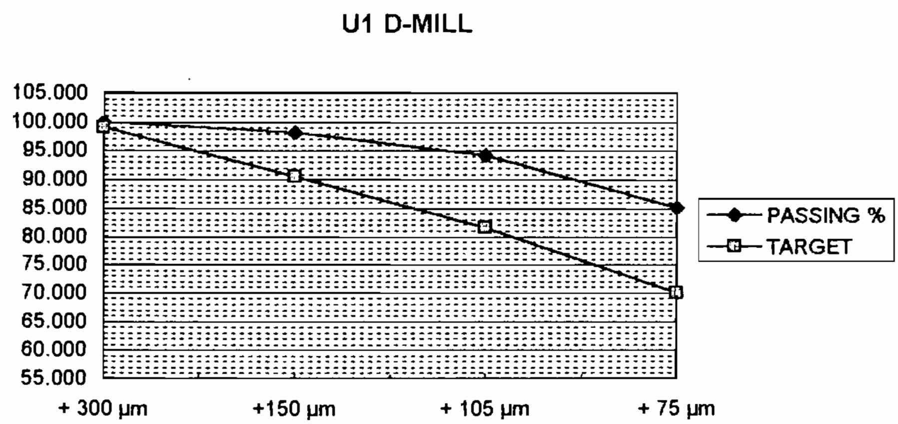
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 500 : 24 : 13h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	0.87	2.68	6.82	39.22	46.04
RETAINED %	0.109	1.890	5.821	14.813	85.187	
PASSING %	99.891	98.110	94.179	85.187	14.813	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.891	98.110	94.179	85.187
TARGET	99	90.5	81.5	70



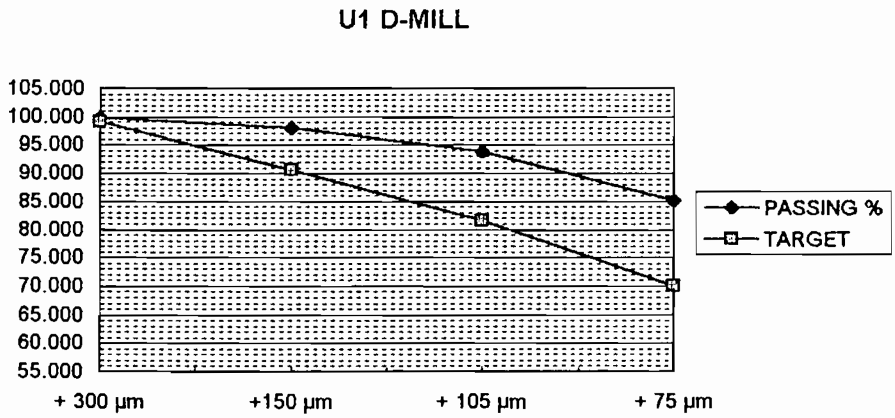
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 500 : 19.5 : 14h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.06	3.26	7.88	45.3	53.18
RETAINED %	0.169	1.993	6.130	14.818	85.182	
PASSING %	99.831	98.007	93.870	85.182	14.818	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.831	98.007	93.870	85.182
TARGET	99	90.5	81.5	70



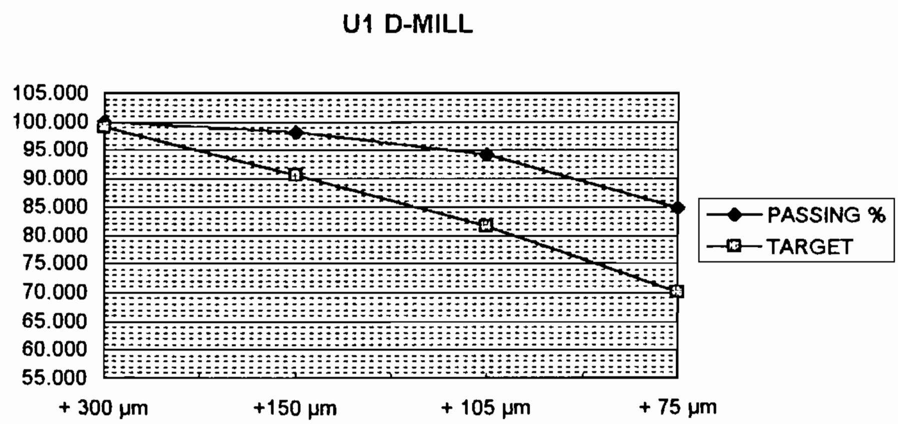
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 500 : 15 : 15h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.81	2.55	6.69	37.02	43.71
RETAINED %	0.092	1.853	5.834	15.305	84.695	
PASSING %	99.908	98.147	94.166	84.695	15.305	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.908	98.147	94.166	84.695
TARGET	99	90.5	81.5	70



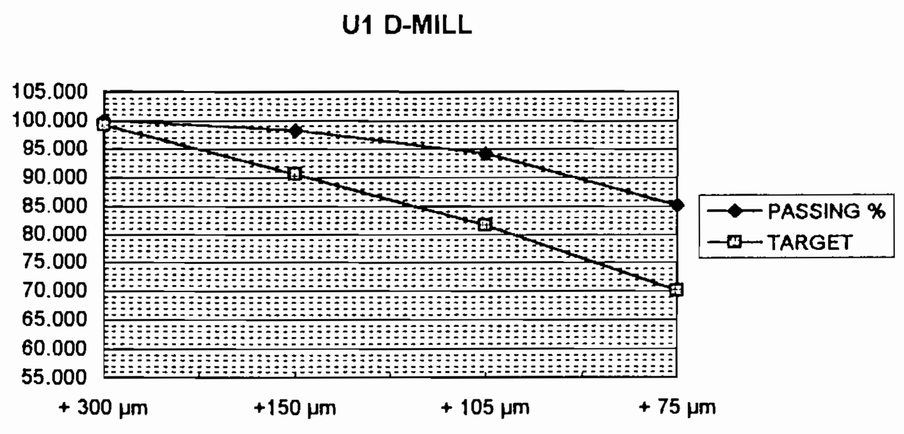
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 500 : 11 : 16h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	0.87	2.8	7.11	40.58	47.69
RETAINED %	0.105	1.824	5.871	14.909	85.091	
PASSING %	99.895	98.176	94.129	85.091	14.909	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.895	98.176	94.129	85.091
TARGET	99	90.5	81.5	70



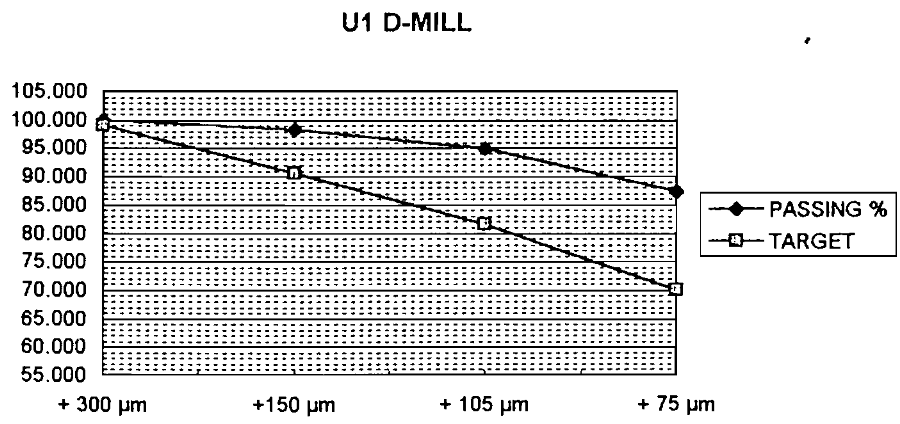
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 450 : 33 : 09h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.03	0.79	2.51	6.19	42.29	48.48
RETAINED %	0.062	1.630	5.177	12.768	87.232	
PASSING %	99.938	98.370	94.823	87.232	12.768	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.938	98.370	94.823	87.232
TARGET	99	90.5	81.5	70



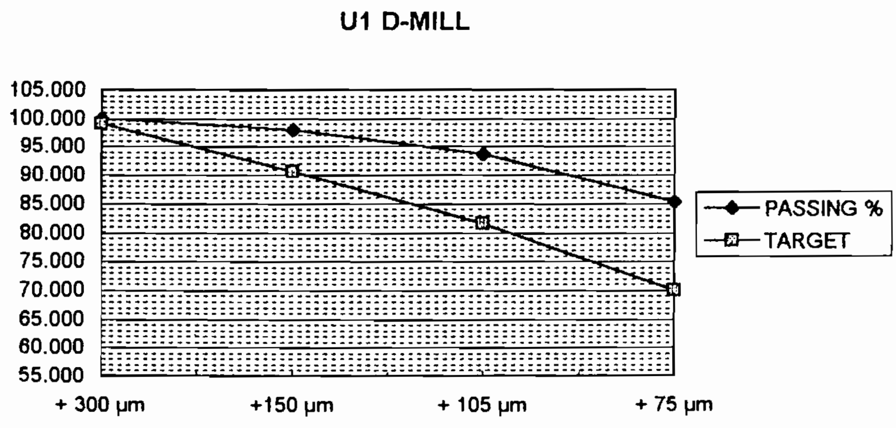
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 450 : 29 : 10h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.06	1.34	4.04	9.25	54.12	63.37
RETAINED %	0.095	2.115	6.375	14.597	85.403	
PASSING %	99.905	97.885	93.625	85.403	14.597	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.905	97.885	93.625	85.403
TARGET	99	90.5	81.5	70



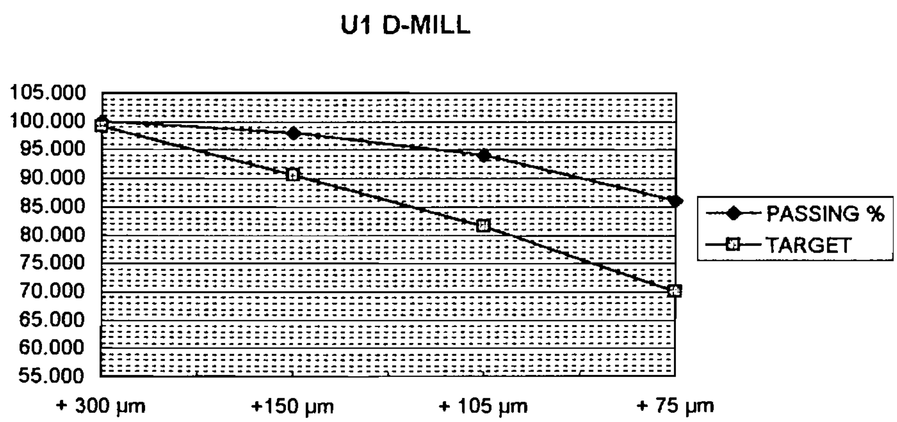
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 450 : 25 : 11h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.05	0.99	2.98	7.02	43.18	50.2
RETAINED %	0.100	1.972	5.936	13.984	86.016	
PASSING %	99.900	98.028	94.064	86.016	13.984	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.900	98.028	94.064	86.016
TARGET	99	90.5	81.5	70



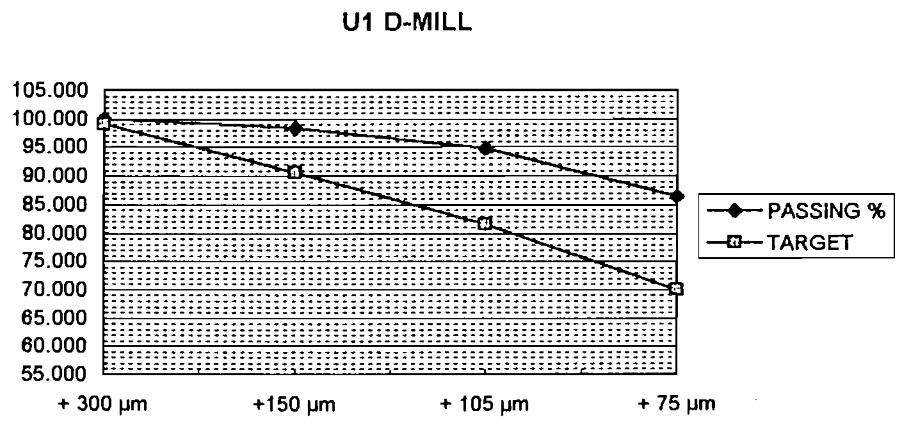
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 450 : 20.5 : 12h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	1	3.01	7.84	49.57	57.41
RETAINED %	0.070	1.742	5.243	13.656	86.344	
PASSING %	99.930	98.258	94.757	86.344	13.656	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.930	98.258	94.757	86.344
TARGET	99	90.5	81.5	70



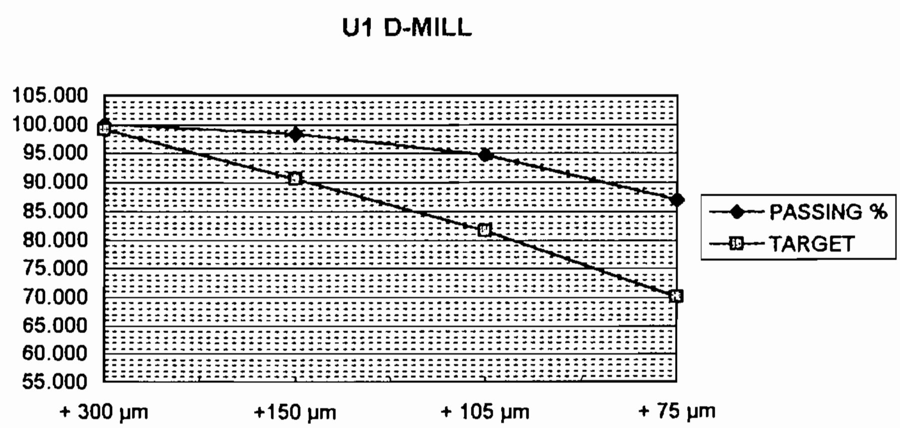
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 450 : 16.5 : 13h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	1.1	3.3	8.16	54.57	62.73
RETAINED %	0.064	1.754	5.261	13.008	86.992	
PASSING %	99.936	98.246	94.739	86.992	13.008	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.936	98.246	94.739	86.992
TARGET	99	90.5	81.5	70



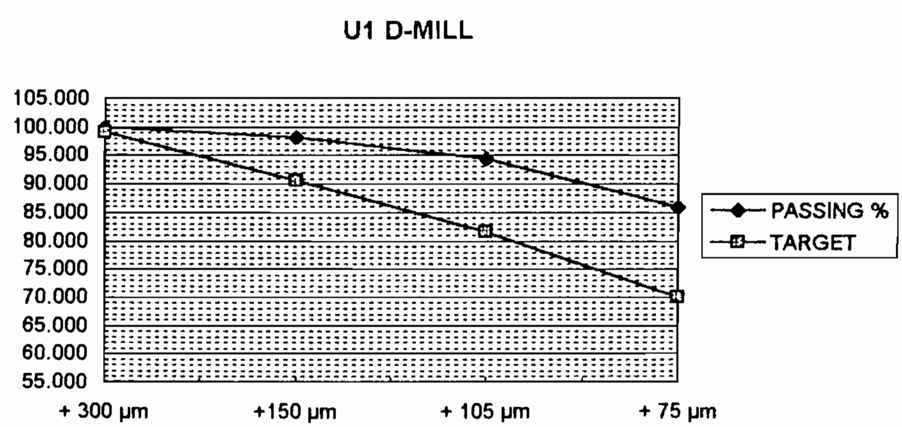
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 450 : 12.5 : 16h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.04	0.94	2.88	7.24	44.01	51.25
RETAINED %	0.078	1.834	5.620	14.127	85.873	
PASSING %	99.922	98.166	94.380	85.873	14.127	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.922	98.166	94.380	85.873
TARGET	99	90.5	81.5	70



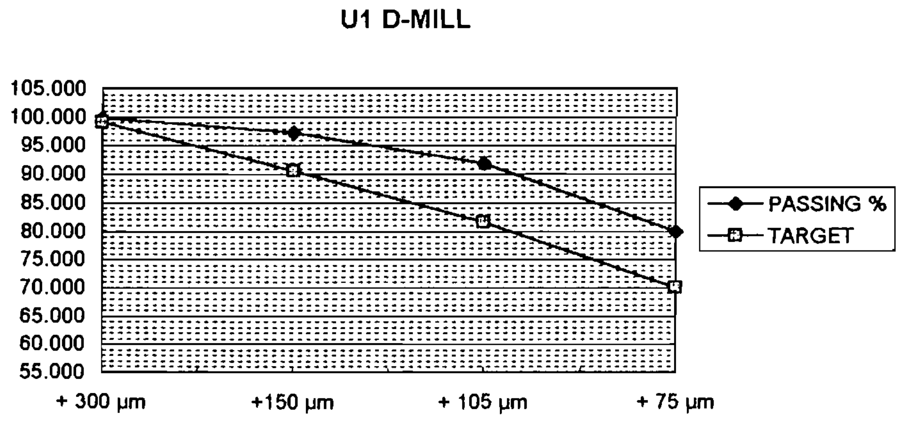
MILL TEST DATA

UNIT : 1 MILL : D TEST No : H 400 : 37 : 00h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.42	4.1	10.11	40.37	50.48
RETAINED %	0.218	2.813	8.122	20.028	79.972	
PASSING %	99.782	97.187	91.878	79.972	20.028	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.782	97.187	91.878	79.972
TARGET	99	90.5	81.5	70



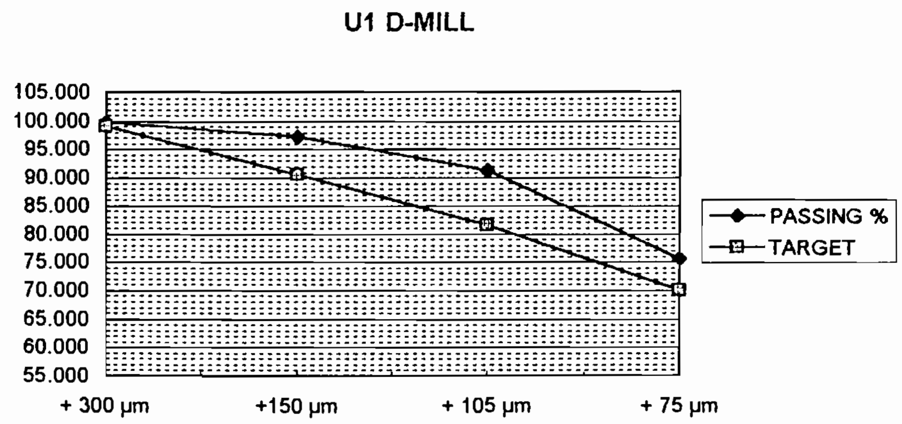
MILL TEST DATA

UNIT : 1 — MILL : D — TEST No : H 400 : 32.5 : 00h55

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.1	1.44	4.42	12.35	38.21	50.56
RETAINED %	0.198	2.848	8.742	24.426	75.574	
PASSING %	99.802	97.152	91.258	75.574	24.426	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.802	97.152	91.258	75.574
TARGET	99	90.5	81.5	70



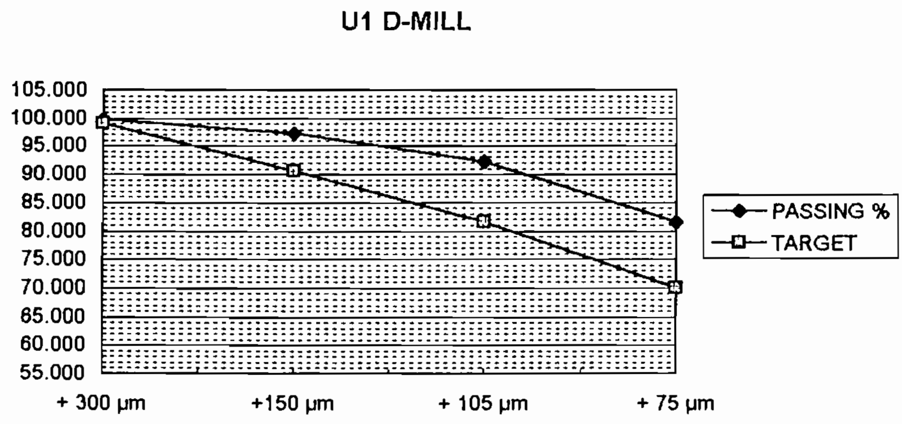
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 400 : 27.5 : 01h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.43	4.1	9.72	43.07	52.79
RETAINED %	0.208	2.709	7.767	18.413	81.587	
PASSING %	99.792	97.291	92.233	81.587	18.413	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.792	97.291	92.233	81.587
TARGET	99	90.5	81.5	70



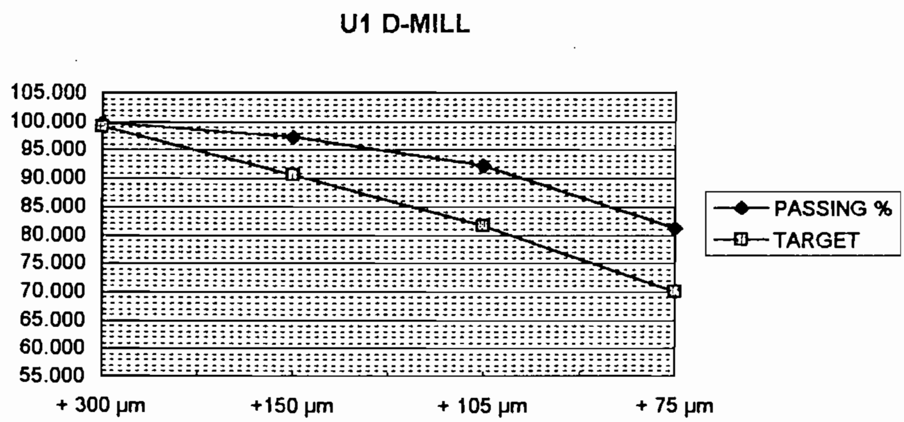
MILL TEST DATA

UNIT : 1 — MILL : D — TEST No : H 400 : 23.5 : 02h35

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.12	1.36	3.79	9.1	39.45	48.55
RETAINED %	0.247	2.801	7.806	18.744	81.256	
PASSING %	99.753	97.199	92.194	81.256	18.744	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.753	97.199	92.194	81.256
TARGET	99	90.5	81.5	70



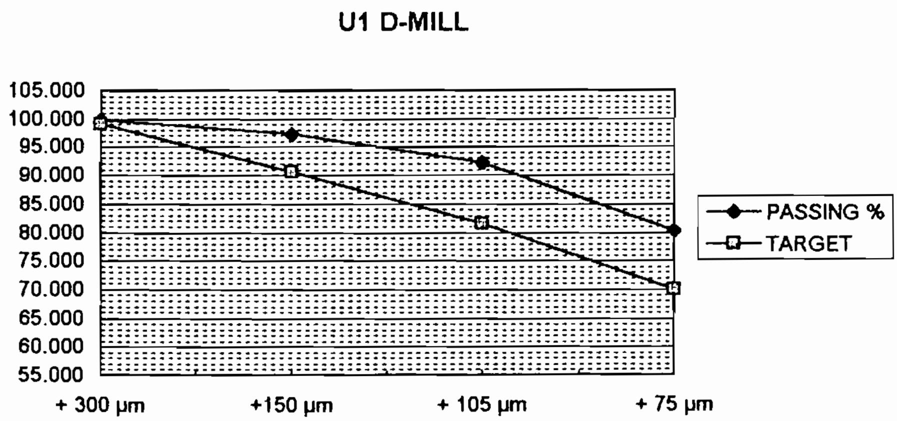
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 400 : 18 : 03h45

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.11	1.34	3.73	9.39	38.11	47.5
RETAINED %	0.232	2.821	7.853	19.768	80.232	
PASSING %	99.768	97.179	92.147	80.232	19.768	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.768	97.179	92.147	80.232
TARGET	99	90.5	81.5	70



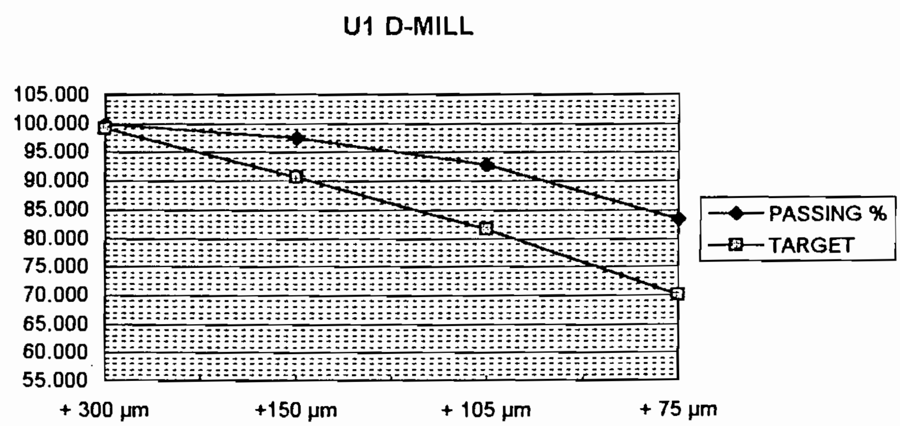
MILL TEST DATA

UNIT : 1 | MILL : D | TEST No : H 400 : 14 : 05h00

NDE	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm	- 75 µm	SAMPLE
RETAINED GRAMS	0.09	1.2	3.35	7.69	38.5	46.19
RETAINED %	0.195	2.598	7.253	16.649	83.351	
PASSING %	99.805	97.402	92.747	83.351	16.649	

GRAPH DATA

	+ 300 µm	+150 µm	+ 105 µm	+ 75 µm
PASSING %	99.805	97.402	92.747	83.351
TARGET	99	90.5	81.5	70



APPENDIX K
REFERENCES AND BIBLIOGRAPHY

APPENDIX K: REFERENCES

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