ICESP X – Australia 2006
Paper 7C1

COST COMPARISONS BETWEEN ELECTROSTATIC PRECIPITATORS AND PULSE JET FABRIC FILTERS AND INHERENT CHALLENGES OF BOTH TECHNOLOGIES AT ESKOM'S 6 X 600 MW UNITS AT DUVHA POWER STATION

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ABSTRACT

3 600 Mw Duvha Power Station situated near Witbank in Mphumalanga Province presents a unique opportunity to make a direct comparison of operating and maintenance costs between electrostatic precipitators (ESP's) and retrofitted pulse jet fabric filters (PJFF's). Units 1 to 3 have the ABB Flakt design PJFF's and Units 4 to 6 have the originally installed Lurgi design ESP's with 5 field 141 $m^2/m^3/s$ specific collecting area (SCA). These ESP's have subsequently been retrofitted with sulphur trioxide flue gas conditioning (SO_3 FGC). This comparison is particularly interesting when viewed in the context of the Legislation which compels either a load reduction or an outage in order to avoid contravening particulate emission Limits and this at a time when there is little reserve margin on the total Eskom System. The trade-off between operational costs and the ability to generate MW's can be complex.

This paper will briefly review some of the early problems experienced with the PJFF's and measures taken to increase bag life, ultimately resulting in a change to a more expensive fabric type. It also reviews some of the day by day operational demands of the ESP's.

1. INTRODUCTION

Construction of Duvha started in 1975. The first 600-MW unit went commercial in 1980, the last in 1984. Units 1, 2 and 3 were initially fitted with AAF ESP's and units 4, 5 and 6 were fitted with the Lurgi type ESP's. AAF ESP's on units 1 to 3 were problematic mainly due to poor collector plate and discharge wire rapper design, which resulted in stack emissions > 800 mg/Sm^3. Feasibility studies were done in 1990 to either upgrade the existing AAF ESP's on units 1, 2 and 3 with the latest design ESP's with flue gas conditioning or to retrofit a pulse jet fabric filter plants (PJFFP) into the existing casing.

During 1992 after intensive PJFFP pilot plant tests it was decided to retrofit PJFFP's into the existing AAF ESP casings. Construction started, and unit 1 was commissioned in August 1993, unit 2 in December 1993 and unit 3 in June 1994. Since the installation of PJFFP's, particulate emissions reduced from > 800mg/Sm^3 to below 30mg/Sm^3.

2. PULSE JET FABRIC FILTER PLANTS ON UNITS 1, 2 AND 3 – BRIEF BACKGROUND

The PJFFP was retrofitted with polyacrylonitrile (PAN) bags and early bag failures occurred after 3000 operating hours. Initial bag tests showed severe chemical degradation and distorted flow distribution which resulted in disintegration of the fiber. The PAN bags were guaranteed to operate 28000 operating hours. Total failure of the plant resulted in total re-bags which had to be done between 12500 and 15000 operating hours. Unit 1 was forced down for 30 days due to a total unexpected failure of the first set of bags which had significant implications in terms of Eskom's generation capacity.

Soon after the first bag failures an intensive research project was started by Eskom's Technology Department which included routine bag testing, trial bag testing and accelerated ageing testing in the laboratory. Computerized flow modeling was used to improve flow distribution at the inlet ducts to improve flow distribution additional guide vanes, splitter plates and egg crates were installed to ensure even flow distribution inside the filter area.

To extend bag life plant process parameters were change such as higher differential set points, lower inlet temp set points and fuel oil 6 that is used during boiler light-ups was changed to waxy Oil 1. Pre-coating with lime instead of ash after a re-bag and lime injection twice a year was done to prevent operation in acid dew point conditions. After implementation of the above PAN bag life improved to 18500 operating hours.

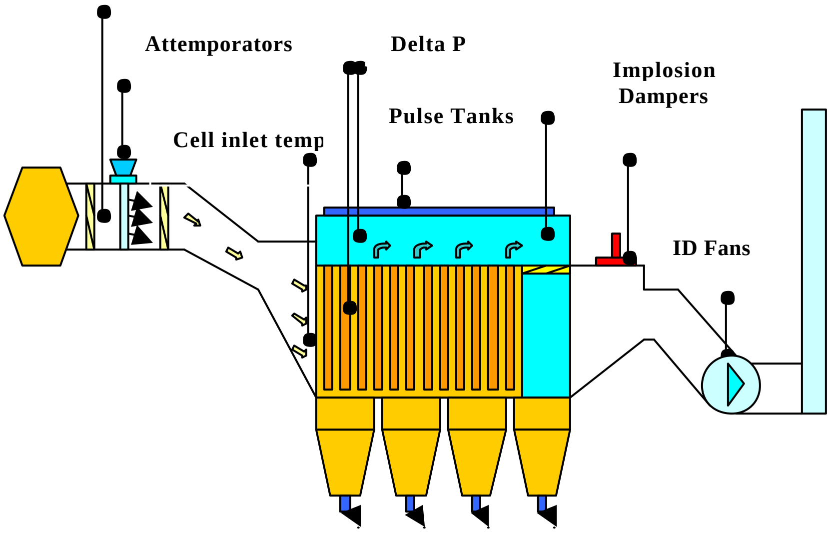
Research done by testing various types of bags both in the Eskom's Technology laboratories as well as physically on the filter resulted in changing from polyacrylonitrile low temperature bags to polyphenylene sulphide polyimide high temperature bags. This resulted in an increased bag life of 32000 operating hours. A business case done before the decision was made showed that the break even point in terms of plant life cycle cost is 25600 operating hours.

3. TECHNICAL SPECIFICATIONS OF THE PJFFP

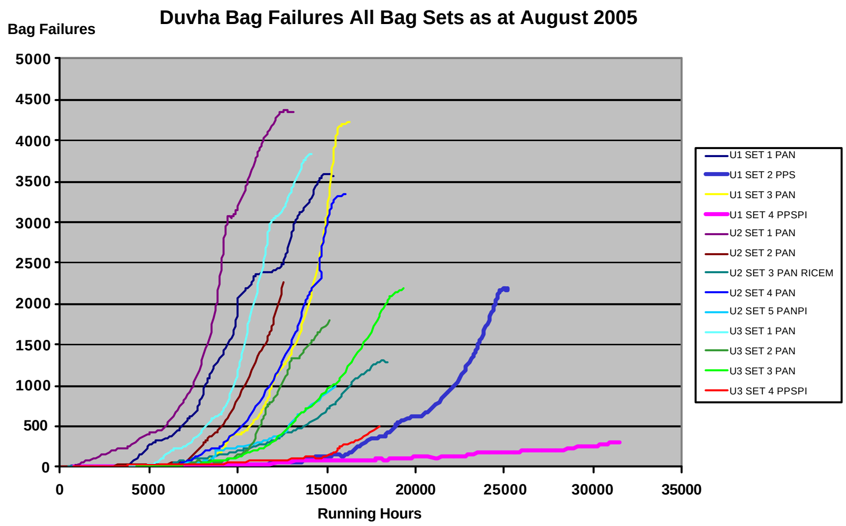
• Number of PPSPI bags per unit	23004
• Bag length	8 meters
• Bag diameter	130 mm
• Total cloth area	75160 m^2
• Filter velocity	0.02 m/sec
• Particulate emission	<50 mg/Sm^3

- Pressure drop 2.3 kPa
- ID fans upgraded 649 m^3/sec/fan
- Total mass of fan = 43 tons driven by a 5,13 MW, 11kV electrical motor.

Layout of PJFFP - Side view

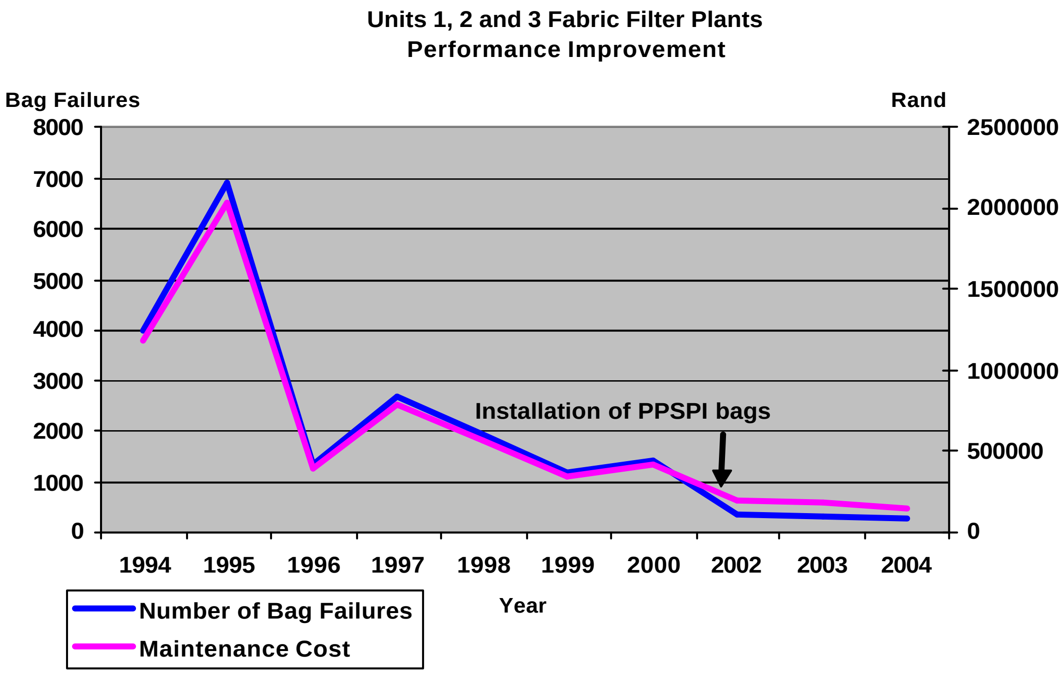


Bag Failure History Chart (Running hours and number of bag failures per set)



The above Chart shows the reduction in bag failures per set as well as the increased operational running hours per set. The first set on unit one shows in total that 4345 bags failed over a period of 13087 operating hours compared to the current set on unit which has run for 31530 operating hours and 308 bag failures. In terms of life cycle of the plant this is a significant operational cost saving.

The Chart below shows the cost saving and reduction of bag failures



4. LURGI ELECTROSTATIC PRECIPITATORS ON UNITS 4, 5 AND 6 SPECIFICATIONS

The ESPs are of the Lurgi design and has two parallel casings equipped with 5 field precipitators with four casings. Ten fields on each of the left- and right hand casings.

• Gas volume flow rate	Between 995 and 1035 m^3/sec
• Gas temperature	Between 110 and 160 °C
• Dust burden at inlet	Between 15,9 and 29,96 g/m^3
• Pressure drop	Between 0,23 and 0,26 kPa
• Specific collecting area	141.6m^2/m^3/sec
• No of fields in series	5
• Plate spacing	300 mm
• Aspect ratio (Length / height)	2
• Gas velocity	1.4 m/s
• Design efficiency	99.60%

5. FLUE GAS CONDITIONING PLANT SPECIFICATIONS ON U4, 5 AND 6

The FGC plant consists off a 150 ton sulfur storage tank complete with two off loading pumps. Aux steam is used to control the temps > 140^{o}C. Two submerged pumps in sulfur supply tank to pump the sulfur to the SO_2 converter controlled by a sulfur flow control valve. A VSD controlled blower is used to control the temperature with ambient air in the air heater to 480^{o}C. Catalytic conversion of SO_2 to SO_3 is taking place in the sulfur burner. The SO_3 is injected via 6 injectors with 4 jets each per duct at the inlet of the ESP. The injection rate, pneumatic controls, sensors, indicating devices, temperatures and alarms are controlled by a PLC.

6. OPERATIONAL COST COMPARISON BETWEEN PJFFP'S AND ESP'S WITH SO_3 FGC

Assumptions and notes PJFFP

- All costs are calculated per unit per annum.
- Life of PPSPI bags are 3.81 years per set (30 000 operating hours).
- Life of PAN Bags initially was 1.59 years per set (12 500 operating hours).
- Load factor 90%.
- Duvha's marginal cost of production is R42/MWh.
- Average power consumption of ID Fans for PPSPI bags is 4.3MW.
- Average power consumption of ID Fans for PAN bags is 4.8MW.
- Average power consumption of ID Fans for ESP's is 3,6MW.

Results PJFFP total operational costs per unit per annum

	PPSPI Bags	**PAN Bags**
Total re-bag cost	R3 158 729	R5 217 211
Total Maintenance cost	R415 454	R1 228 854
Total power consumption cost	R3 019 887	R3 351 015
Total cost	**R6 594 071**	**R9 797 081**

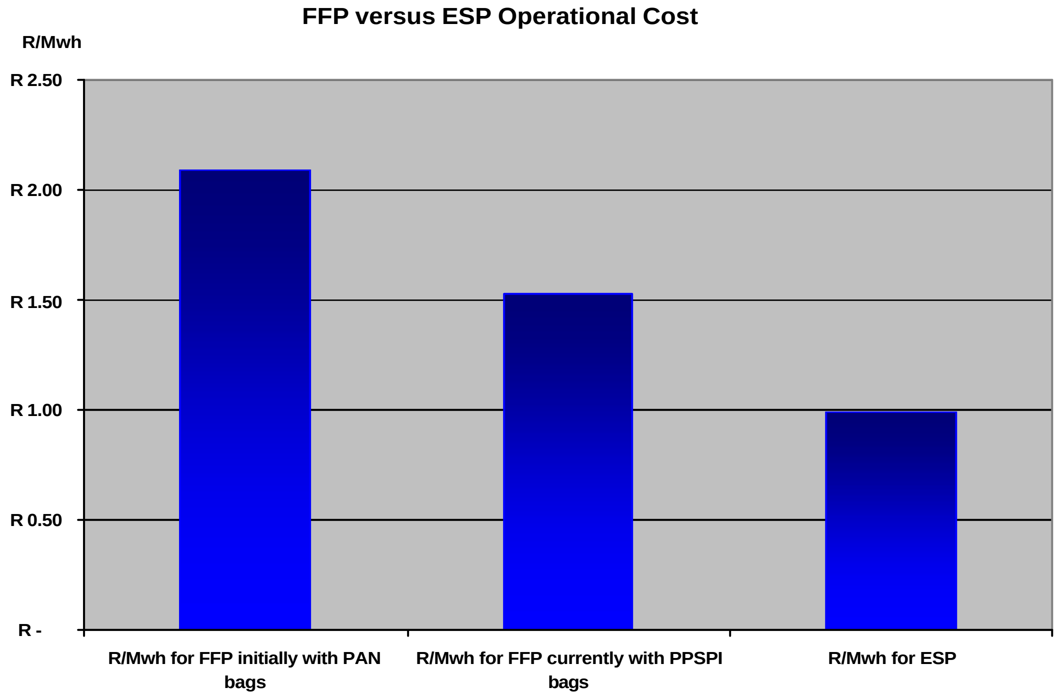
Assumptions and notes ESP's with FGC

- ESP costs were actual costs for three units taken over a 6 year cycle and then calculated per unit per annum.
- Capital cost to upgrade an ESP after 25 years were estimated at R18m per unit.
- ESP maintenance costs includes the SO_3 plant maintenance and sulfur cost.
- Current Rand values were used for actual cost.

Results ESP's with FGC total operational costs per unit per annum

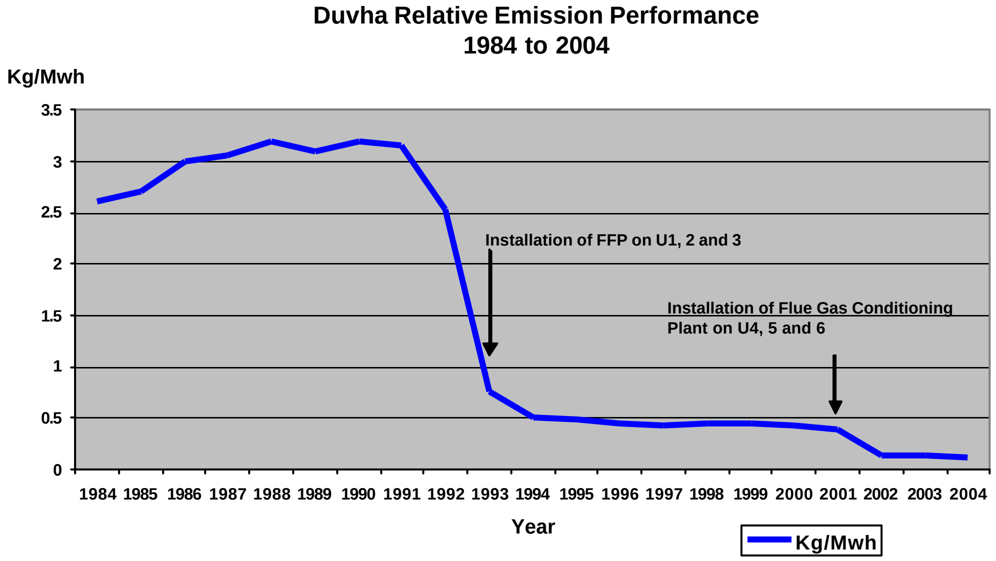
Total outage cost.	R470 000
Total maintenance cost.	R476 200
Capital cost to upgrade ESP's after 25 years.	R720 000
Capital cost of SO_3 Plant.	R268 000
Total power consumption cost.	R2 550 960
Total cost	**R4 485 160**

Results comparing PJFFP's with ESP's with FGC calculated in R/MWH



7. REDUCTION IN PARTICULATE EMISSIONS

The chart below shows the reduction in relative emissions calculated in kg/MWh since 1984 to present. It clearly shows the significant performance improvement since the installation of PJFFP during 1993/94 and FGC during 2005.



8. CONCLUSION

- Bag filter costs reduced from R2.16/MWh to R1.45/MWh since changing from PANPI to PPSPI bags.
- The total bag filter operational costs currently are therefore about R1.45/Mwh.

- The total ESP with SO_3 Plant operational costs = R0.99/Mwh.
- Since the installation of FFP's and SO_3 plants the relative emissions reduced from > 3 Kg/MMh to < 0,12 Kg/MMh.

9. REFERENCES

- KR Parker (1996) Applied Electrostatic Precipitation.

- The McILVAINE Company (1996) – The Fabric Filter Manual.

- ALSTOM Power PESJ084 FGC Operation and Maintenance Manual (1992 – 2000). Eskom Duvha Power Station Contract No 450006159.

10. ACKNOWLEDGEMENT

The author wishes to thank the following for their contributions to this work:

- Eskom, Duvha Power Station Management, for the opportunity of publishing this paper.

- Theo Scholtz for assisting with cost gathering information and calculations.

- James Topkin, Eskom CR&D, for his assistance and specialist knowledge.

- Eskom Generation Technology, especially Rod Hansen, for his assistance and guidance.