REINHOLD ENVIRONMENTAL Ltd.

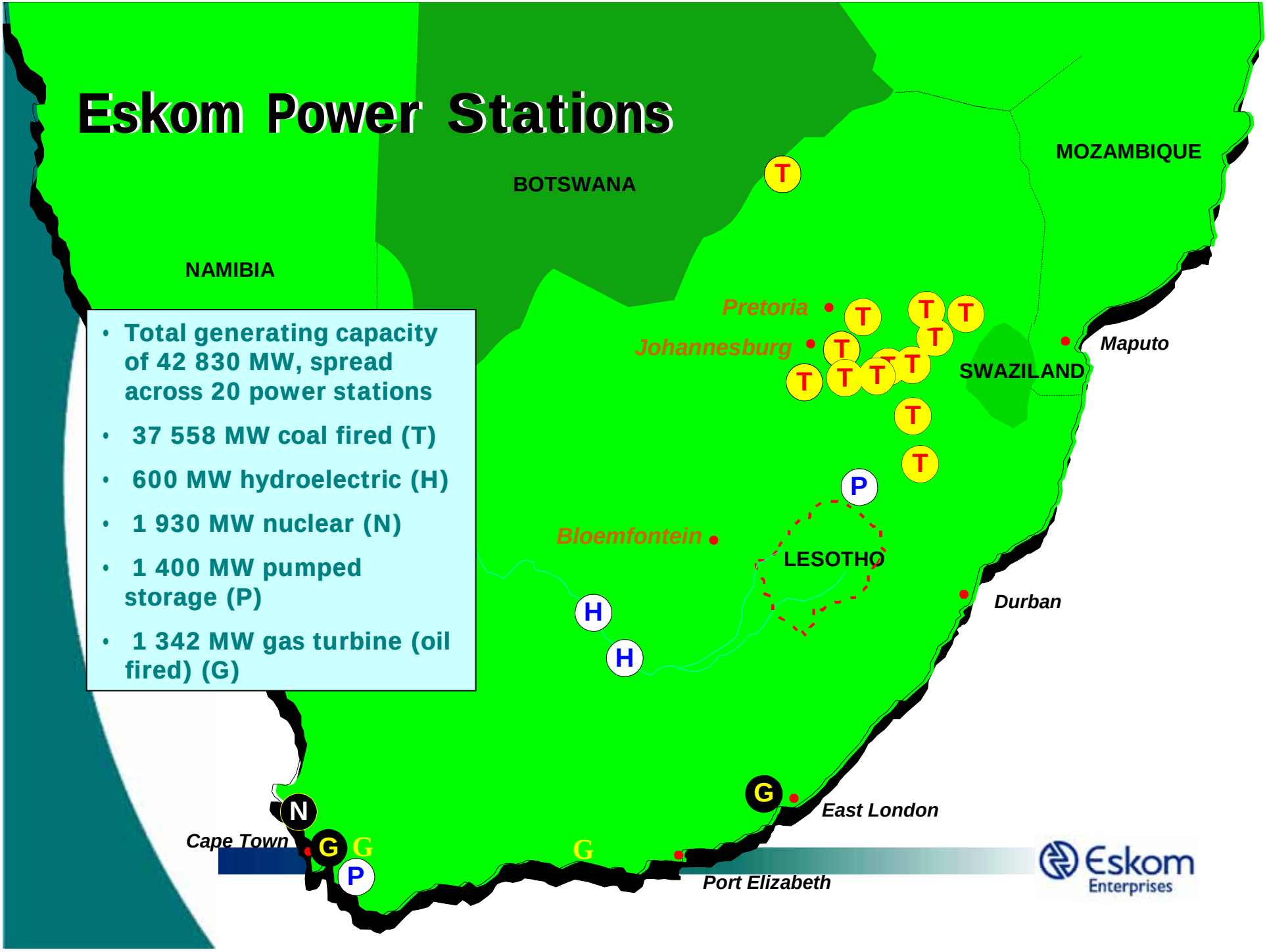
2010 APC Round Table
& Expo Presentation

July 18-20, 2010, in Concord, NC / Hosted by Duke Energy

How condition monitoring can reduce fabric filter operating costs (and some challenges)

Rod Hansen

Eskom Power Stations



- Total generating capacity of 42 830 MW, spread across 20 power stations
- 37 558 MW coal fired (T)
- 600 MW hydroelectric (H)
- 1 930 MW nuclear (N)
- 1 400 MW pumped storage (P)
- 1 342 MW gas turbine (oil fired) (G)

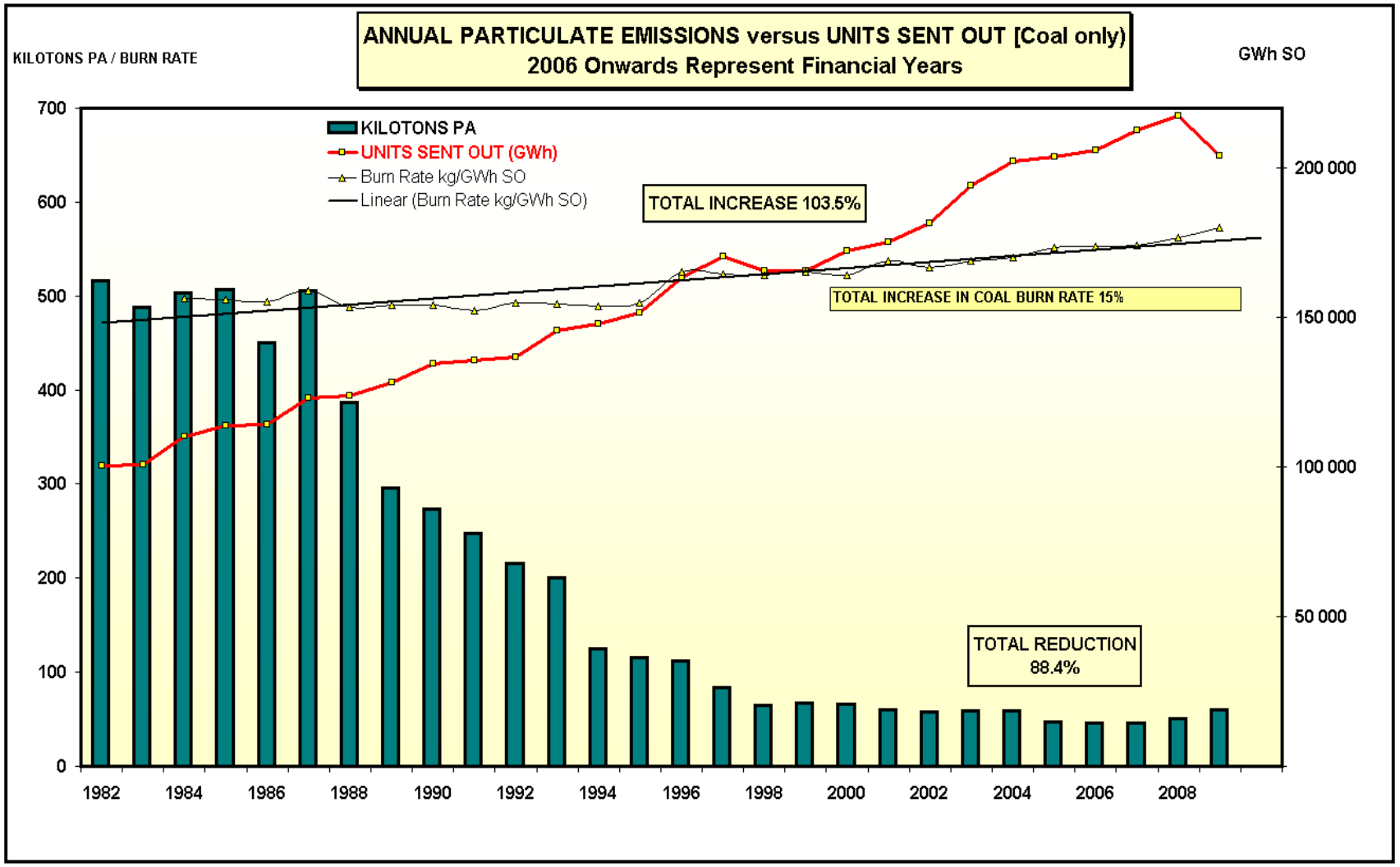
Introduction

Eskom is South Africa's State owned electric utility.
Established in 1923, now one of the world largest coal burning utility (+ 120 Mt annually).
Eskom has a total generating capacity of 42 830 MW with the following energy mix:

- Coal 33 758 MW
- Return to Service (Coal) 3 800 MW
- Hydroelectric 600 MW
- Nuclear 1 930 MW
- Pumped Storage 1 400 MW
- Gas Turbines 1 342 MW

11000 MW in pipeline, first by 2013, fast tracked (coal, pumped storage, gas turbine, wind, solar….)

Particulate Emissions (Historical)

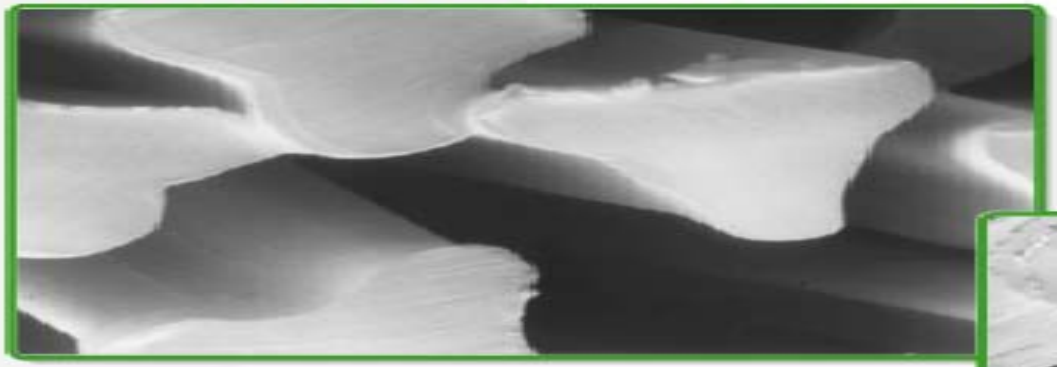


Bag Filters Condition Monitoring

- Routine Fabric Filter Condition Monitoring
- Trial Bags Programme
- The Duvha epic
- Majuba Unit 3 Bags Failure Investigations
- Arnot Unit 5 Fabric Investigation
- Hendrina PPS Fabric Materials Comparison

CROSS-SECTION OF FIBRES

POLYPHENYLENE SULPHIDE



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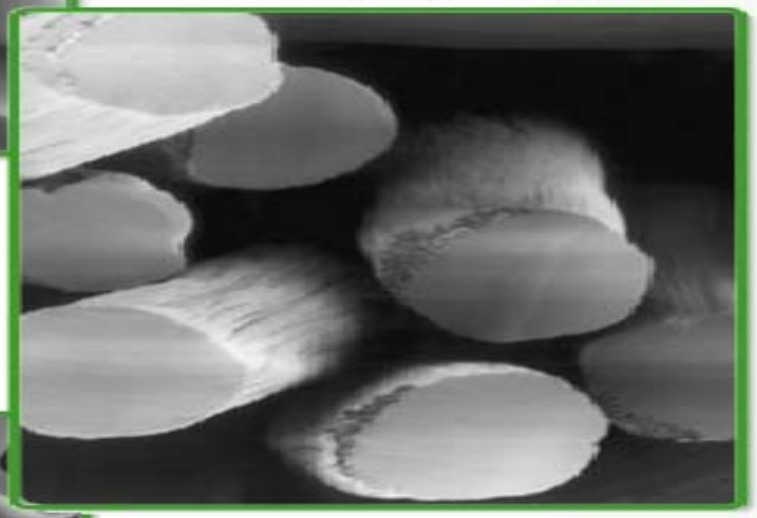

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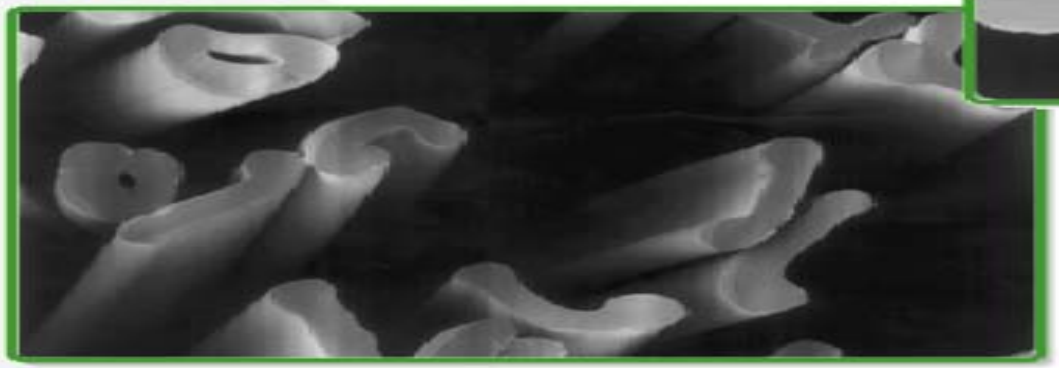

BEIER ALBANY

Fabric Filter Primary Laboratory Testing

- Residual tenacity measurement (*Lloyds* tensile tester)
  - tearing and tensile strength
  - elongation at break
- Air permeability (*Wira* Air Permeator)
- Residual dust mass
- pH (*Crison* pH meter with temperature compensation)
- Mullen's bursting strength
- Scanning Electron Microscopy (SEM)
- Energy Dispersive Spectroscopy (EDS)
  - quantitative and qualitative elemental analysis under SEM

Fabric Filter Specialised Laboratory Testing

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- Photo-acoustic Fourier Transform Infrared Spectroscopy (PAS FTIR)
  - fibre identification
  - degradation kinetics
- Thermo-gravimetric analysis (TGA)
  - loss of mass against temperature
  - sample identification, degradation onset
- Differential scanning calorimetry (DSC)
  - thermal properties of fibres, melting point, cristalinity
- Dynamic Contact Analyser (DCA)
  - surface tension analysis
  - degree of chemical degradation

Recipe?

- Weight
- Needleing
- Filtration batt / membranes?
- Singing
- Calandering
- Heat treatment
- Fibre denier
- Fibre blends – PPS/P84/PTFE
- Scrim
- QA/QC

Eskom's PJFF Plants

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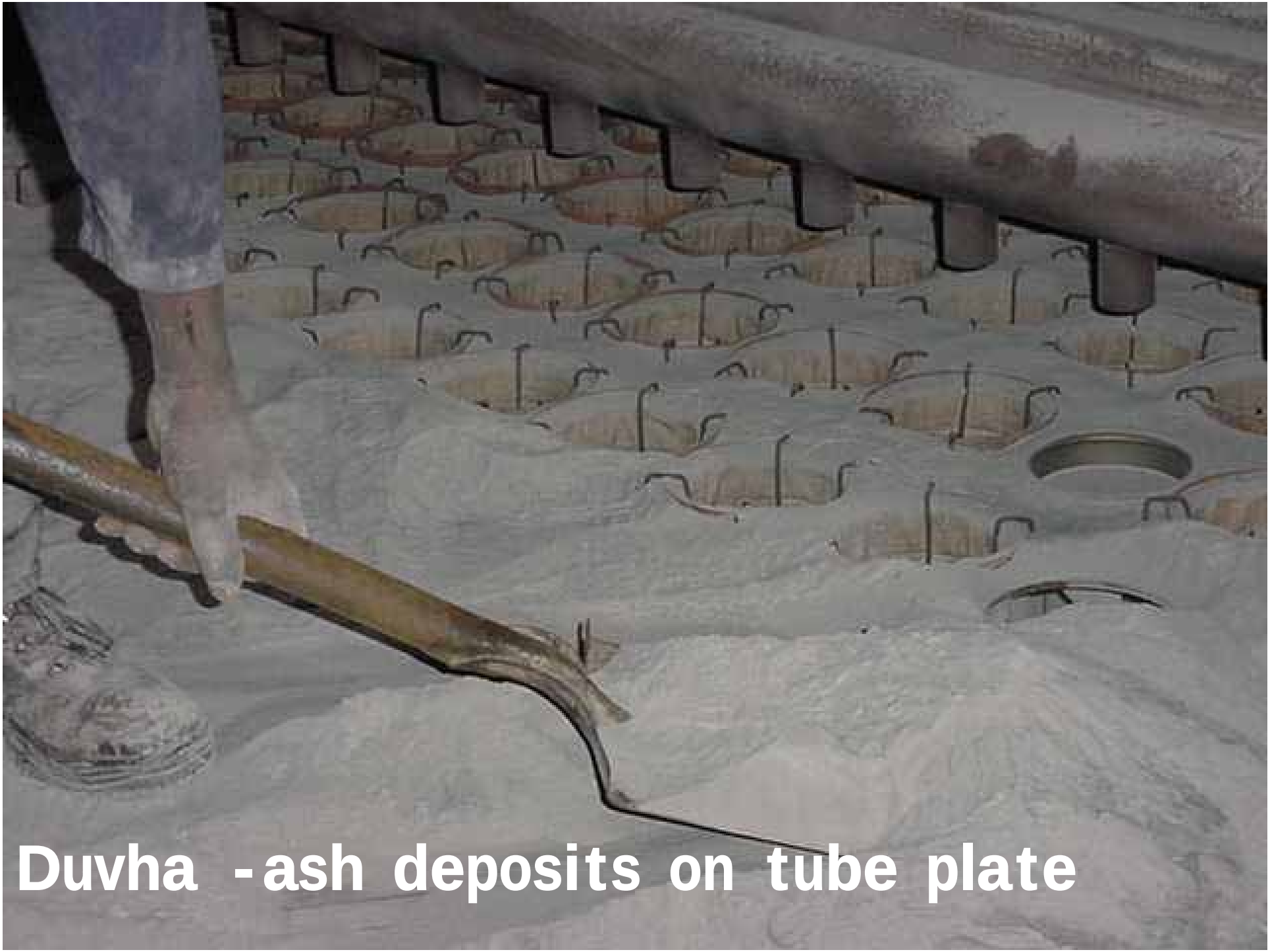
STATION	UNIT	No. OF BAGS/UNIT	BAG LIFE	BAG TYPE
Arnot	1 to 3 4 to 6	13 584 10 934	35 000 32 000	PPS/PTFE/PI PPS/PI
Camden	1 to 4, 7 & 8	9 616	35 000*	PPS/PI
Duvha	1 to 3	26 928	35 000	PPS/PI
Grootvlei	1, 5 & 6	8 832	40 000*	PPS/PI
Hendrina	1, 6 to 10 2 to 5	8 074, 7 984 8 160	36 000 32 000	PPS PAN
Majuba	1 to 3 4 to 6	30 976 32 512	25 000 25 000	PAN/PI PAN/PI

Duvha Power Station

Fabric Filters – Brief Background - cont

- Enhancement Options Investigated During 1990
- Installation of complete new ESP's and a SO_3 plant.
- Upgraded ESP's with the latest technology and a SO_3 plant.
- Pulse Jet Fabric Filters
  - Pre-qualification required the installation of pilot plants.
  - 3 Suppliers installed pilot plants.
  - Pilot plant test results were evaluation during 1992.
  - Project was awarded to and construction started in 1993.
    - ✓ Unit 1 commissioned in July 1993.
    - ✓ Unit 2 commissioned in Dec 1993.
    - ✓ Unit 3 commissioned in June 1994.

Fabric Filters Pilot Plants



Duvha -ash deposits on tube plate

Duvha Performance

- Premature fabric failure
- Acid enrichment of fibres: degradation
- Improved performance; achieved 18500 hrs
  - fuel oil
  - higher DP control set point
  - better operation
- Bag failure pattern
- SO_3 Neutralisation Plant
  - selection of viable systems
  - demonstration plant
  - Converting of the plants to high temperature filtration materials: PPS/PI composite
- Expected bag life after modifications: 28000 hrs

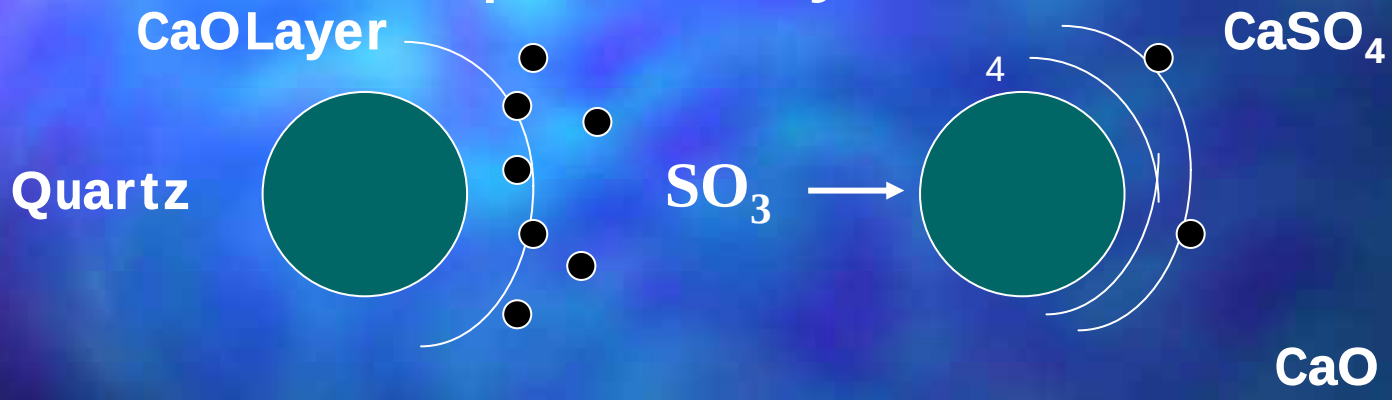
DUVHA
a big challenge !!!

Marrying fabric properties to ash chemistry

- premature failures caused by acid enrichment resulting in acid degradation of fabrics
- Duvha ash chemistry does not neutralise naturally formed SO_3

IDEAL ASH CHARACTERISTICS

- Outer CaO layer
- Inner quartz layer

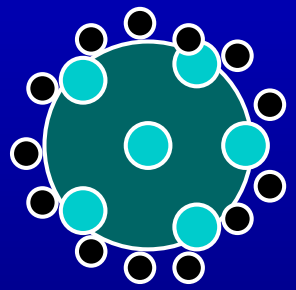


$$CaO + SO_3 = CaSO_4$$

CaO is available to neutralise any acid absorbed onto the ash particles.

DUVHA ASH CHARACTERISTICS

- **CaO forms gelhenhite during combustion**
- Ca is therefore inert and cannot neutralise the acid



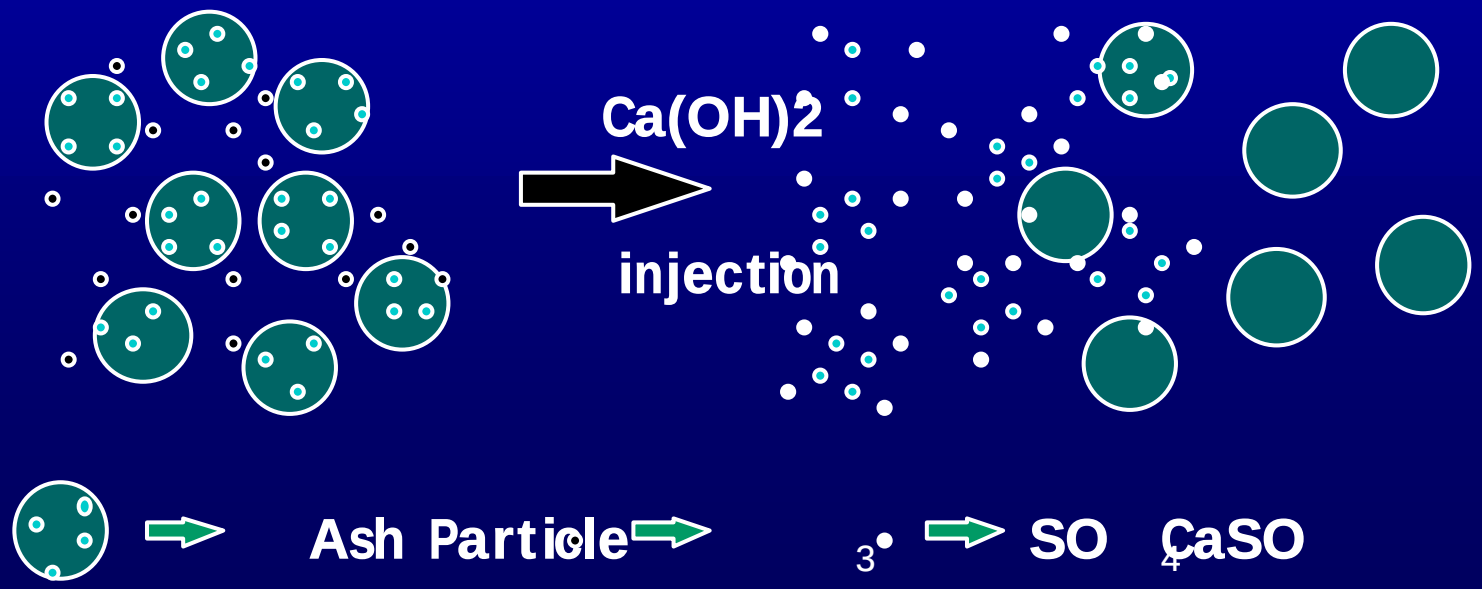
No Neutralisation can occur, hence acid enrichment occurs on the surface of the particles

Gelhenite [$CaAl_2SiO_7$] is formed at 1100 °C + during combustion

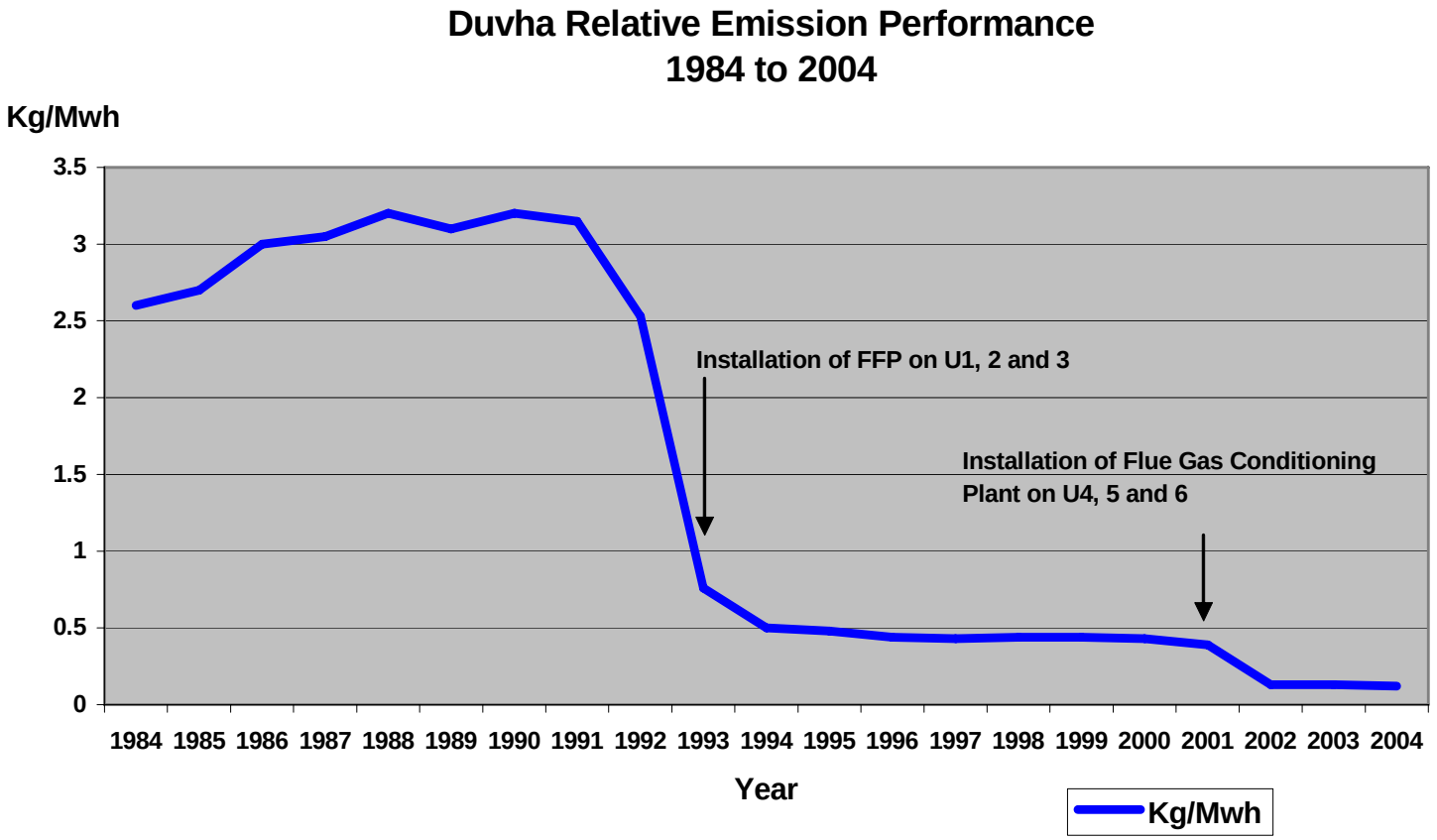
Reaction between Kaolinite Ca(C-H-O) and $CaCO_3$

HOW CAN THE ACID ENRICHMENT BE STOPPED ?

- by neutralising the SO_3 in the flue gas
- pilot plant tests have shown that the injection of hydrated lime ($Ca(OH)_2$) neutralises the SO_3



Results – Reduction in Particulate Emissions



Duvha Conclusion

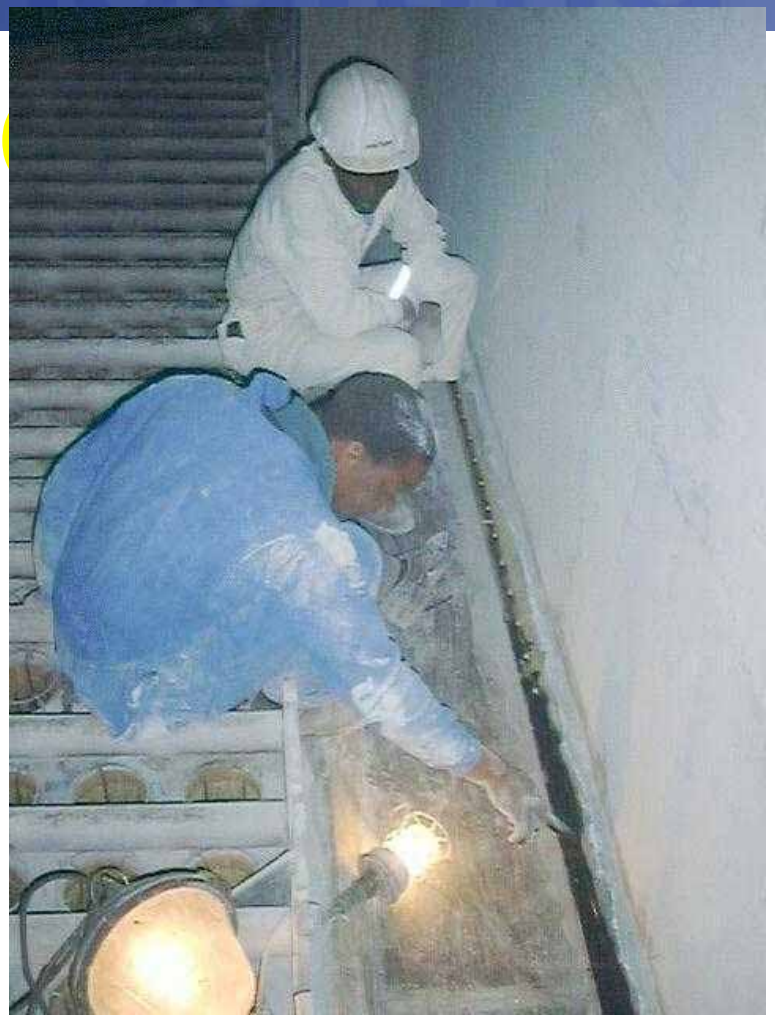
- Bag filter costs reduced from R2.09/Mwh to R1.53/Mwh.
- The total bag filter operational costs = R1.53/Mwh.
- The total ESP and SO_3 Plant operational costs = R0.99/Mwh.

Arnot Power Station

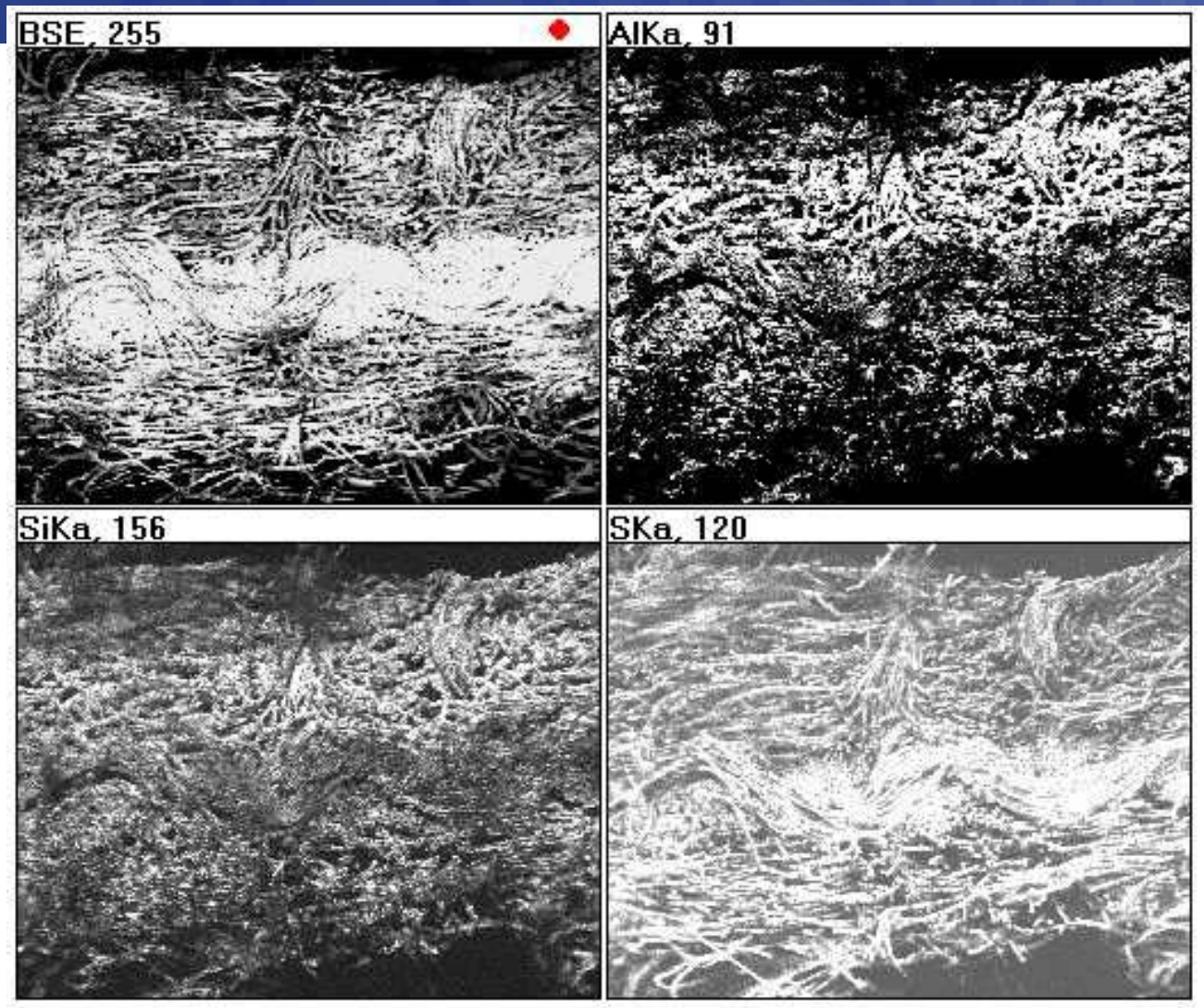
Arnot Performance

- High temperature bags: Procon (PPS)
- Temperature excursion, unit 4 LH
- Control philosophy
- Tube plate sealing leaks: modification for units 1, 2 & 3
- Pulse pipe design modification
- Life prediction: 30 000 – 43 000 hours
- Failure mode: breaking of material / abrasion
- Future plans: improved specification
- Composite material used for the new sets of bags

Tube plate leaks



Arnot U5 PPS/P84 25000hrs



Arnot U5 PPS/P84 25000hrs

Failure Mode and New Specification

- Failure mode identification
  - Localised erosion areas (exception)
  - Fabric damaged due to inadequate length
- Bag house chemistry
  - CaO in dust is reactive
- Future bag characteristics
  - Fine fibre surface area required with the existing pulsing system
  - Fabric residual strength has to be increased
- New specification based on:
  - hybrid scrim: 33% PTFE + 67% PPS
  - hybrid batt: PPS + PPS and P84 mixture on the surface


MAJUBA
- some technical insight -

Majuba Power Station FFP

Majuba Design

- Bag material: PAN and PAN/PI composite
- Fibres: Dralon T, Dolanit & Ricem
- Pulsing system: Low pressure / high volume
- Number of bags: about 31000 - 33000
- Number of cells: 8

Majuba Performance

- Flow distribution
- Tube plate buckling
- Hopper heater elements failure
- Shrinking of bags, lifting of manifolds
  - Dolanit vs Ricem
- Good performance to date
- Two shifting operating mode
- Predicted bag life: 20000 - 22000 hours
- Achieved life: 23000

MAJUBA

U1 - 6

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cause	symtom	cure
Load cycling 2 shifting = excessive dew point exposure	▪ Shortened bag life	▪ Precoating ▪ Thicker dust cake ▪ Keep warm
Flow design, bottom entry, low pressure random pulsing	✔ pulse wave distribution	▪ CFD ▪ Reduce jetting

Majuba Trial Bags Shrinkage Investigation

Shrinkage Measurement on a Trial Bag

Shrinkage Measurement at 6 874 Hours

Longer than normal bags (unit 5)

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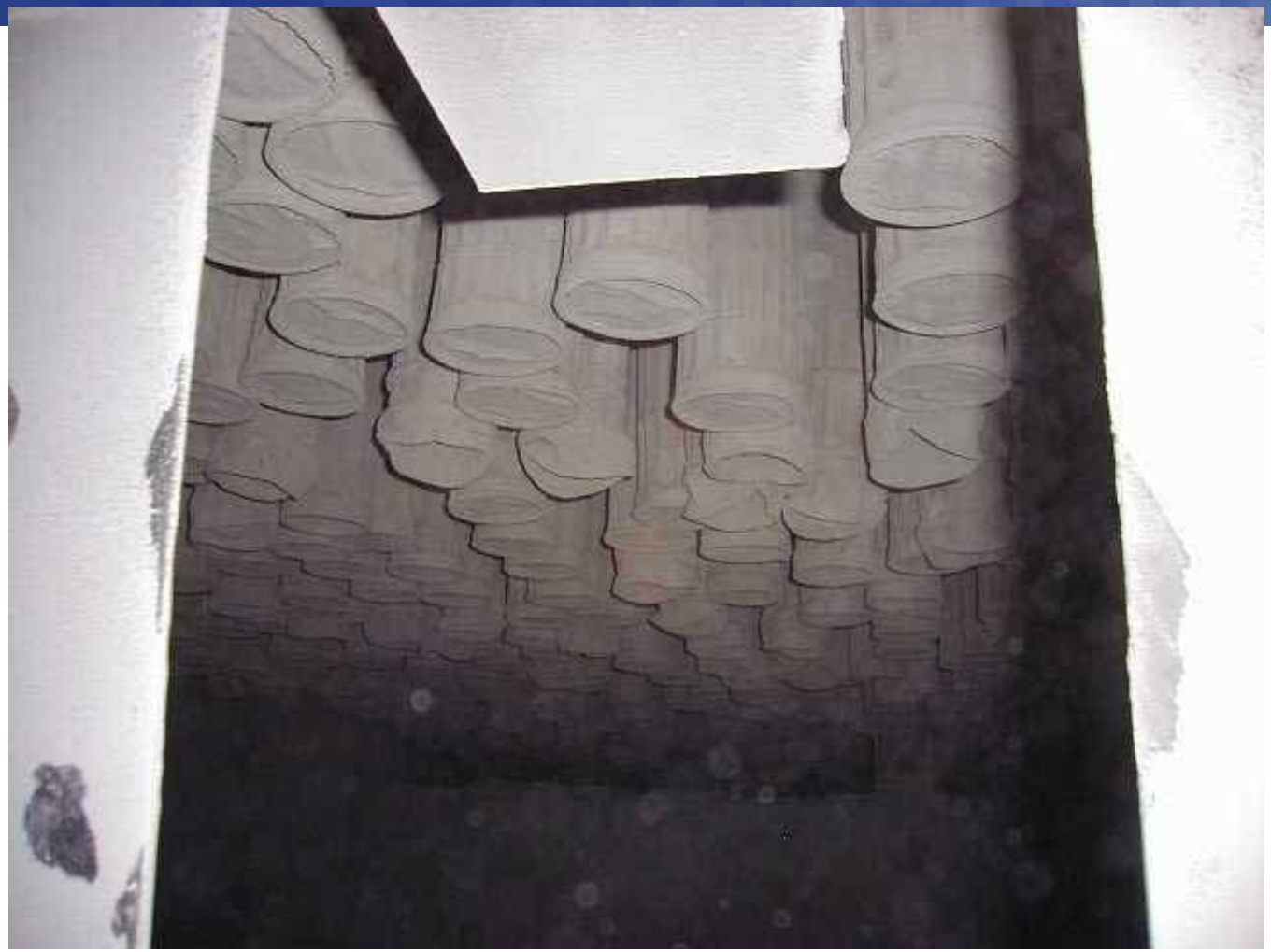

Hendrina Power Station

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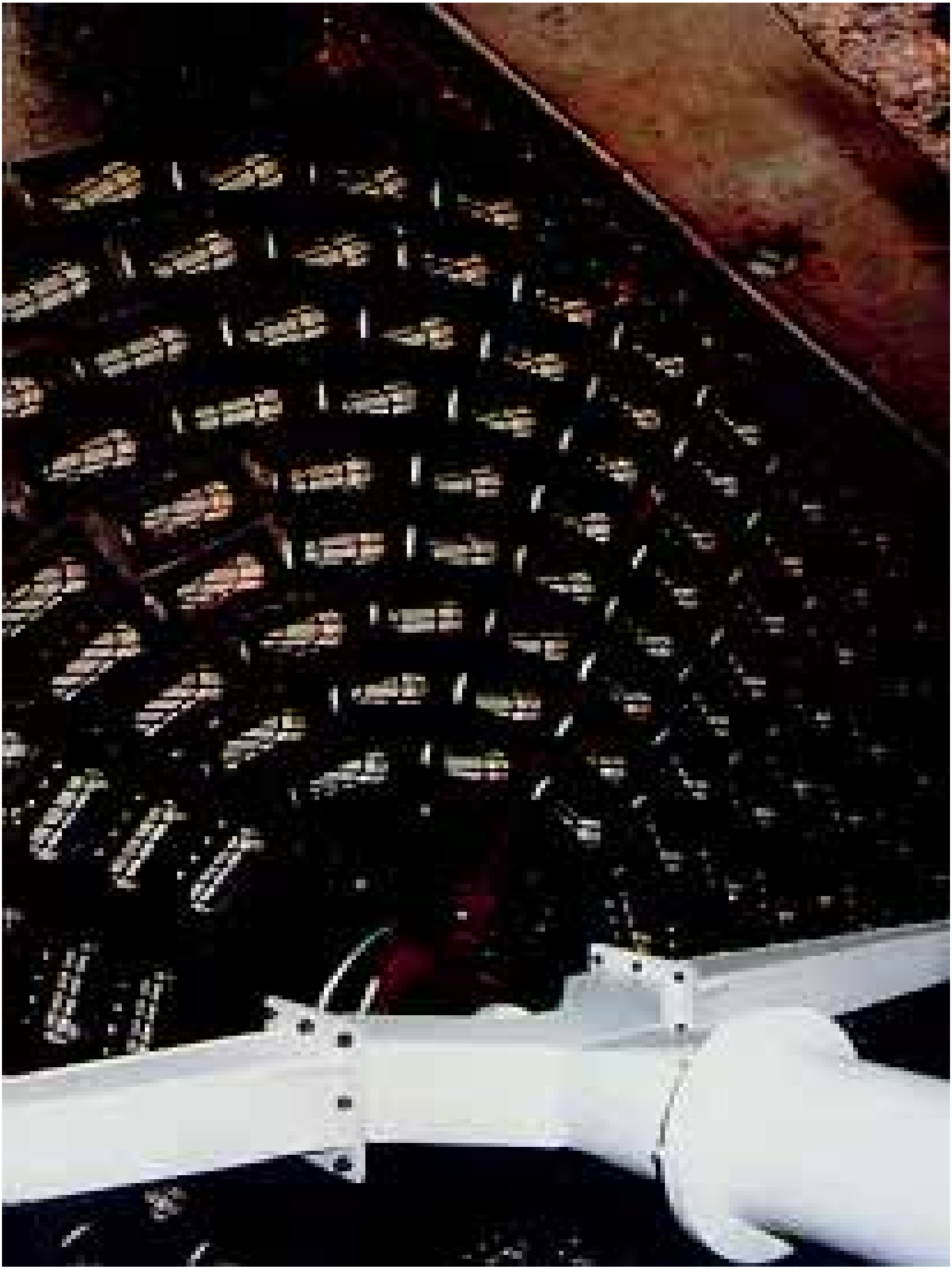
Hendrina Performance

- Fabric shrinkage
- Initial life: 26000 hours
- Present life: 34000 hours (PAN) and 38000 hours (PPS)
- Temperature and chemical degradation
- Revised bag specification
- Good quality checks
- Control philosophy
- In-situ bag filter cleaning



New ESP Conversions to FFP in Eskom

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AND LASTLY

- CAMDEN
  - 8 Boilers retrofitted with FFPs
  - 4 compartments per boiler
  - Bag material: PPS/PI composite and PPS/PI composite with PPS/PTFE Hybrid scrim
- GROOTVLEI
  - 3 Boilers retrofitted with FFPs
  - Bag material: PPS/PI composite with PPS/PTFE Hybrid scrim

THANKS – QUESTIONS?
For Further Info, please contact…

RE Consulting

3850 Bordeaux Drive
Northbrook, IL. 60062

Phone: 847-562-8556
Fax: 847-562-8894
Email: greinhold@reconsulting.info