DESIGN AND OPERATION OF THE ROOIWAL POWER STATION FABRIC FILTER INSTALLATIONS

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SUMMARY:
The paper describes the Rooiwal boiler installations and the tests undertaken in an effort to improve the collection efficiencies of the original precipitators. Finally the decision was taken to install fabric filters (the first such installations on an S.A. power station). The design, commissioning, operation and acceptance tests of the fabric filters are discussed.

1. ROOIWAL POWER STATION : BACKGROUND

The Rooiwal power station is one of the few municipal power stations in South Africa. It belongs to the Pretoria City Council and is situated 35 km North of Pretoria. The station was built in the early 1960's.

1.1 Boiler Plant

The boiler plant technical details can be summarised as follows:

- It consists of 5 pulverised fuel fired YARROW boilers each producing up to 250 tons of superheated steam per hour.
- The steam is fed to 5 steam turbines, each rated at 60 MW (M.C.R.)
- Each boiler is fitted with 4 air swept coal pulverisers with a maximum capacity of 10,45 tons/hour of coal per pulveriser. Usually only 3 pulverisers are in operation with one on standby.
- Boiler off-gas from the furnace is at 1077°C and is passed through a superheater, economiser and air heater after which the gas temperature is down to 141°C.
- There are two induced draught fans per boiler, each handling a maximum of 68,46 m^3/sec at 138°C.
- Off-gas from the 5 boilers are emitted from two stacks at a height of 101 m above ground level.

1.2 Air Pollution Control at Rooiwal

1.2.1 <u>Original equipment</u>

- The station was equipped with 2-field Lodge Cottrell electrostatic precipitators (ESP's).
- Off-gas from each boiler is split into 2 parallel lanes.
- The ESP's serving the No's 3 to 5 boilers were designed with collector plate areas of 8 752 m^2 per boiler and No's 1 and 2 with only 77% of that.
- As was the case with so many installations using the high resistivity ash coals peculiar to especially South Africa and Australia, the ESP's did not perform satisfactorily.
- The No's 3 to 5 ESP's achieve 92% collection efficiency as opposed to the guaranteed levels of 98,75% at ECR. The No's 1 and 2 ESP's only achieved 85% collection efficiency before they were dismantled.
- As a result of the excessive emissions to atmosphere, pressure from the Chief Air Pollution Control Officer mounted.

1.2.2 <u>Testing of enhancement techniques</u>

- Enhancement options which were tested can be divided into 2 categories, viz fly ash conditioning and ESP operational improvements.
- Chemicals which were used in the conditioning tests included SO_3, NH_3, Sodium and T.E.A.
- Operational improvements tested included high voltage pulsing, new power packs with automatic voltage control, changes to the rapping cycle and to the rapping intensity.
- Apart from the T.E.A. tests, some success was achieved with the enhancement techniques.
- In general, the conclusion was reached that such improvements to the No 1 and No 2 boiler ESP's would either be too costly or fall short in required efficiency.
- At this stage enquiries were drawn up to upgrade fly ash collection efficiency at the No 1 boiler.

2. THE BAG FILTRATION OPTION

- Although bag filtration has been used extensively at power stations overseas, no such installation existed in S.A. prior to 1987.

- The Pretoria City Council allowed for the bag filtration option in their enquiry.

2.1 Design Constraints at Rooiwal

Apart from the standard design features incorporated into bag filtration systems, the following design factors were salient at Rooiwal:

- Relatively high gas temperatures (138°C specified).

- Possibility of acid and/or water dewpoint under certain conditions.

- Space limitations. Any equipment offered had to fit into the existing concrete casings housing the ESP's.

- Draught limitations. To avoid the high cost of replacing and operating higher duty fans, the existing induced draught fans were to be incorporated. This allowed a maximum of 2 kPa pressure drop for any new equipment.

- Downtime limitations. As the Council has to purchase any additional electrical requirements from Eskom at prices well above it's own production cost, boiler outages can be expensive and downtime for construction was limited.

2.2 The H.E.S. / Carter Day Design

The successful vendor for boiler No 1 (and subsequently boiler No 2) was Howden Energy Systems using Carter Day technology.

The main differences between Carter Day technology and other reverse pulse baghouses are:

- The Carter Day system uses a low pressure pulse (70-80 kPa). This allows the use of blowers rather than compressors.

- Bags are placed in a circular configuration and are cleaned by a rotating manifold reverse pulse system.

- Bag length is 5,8 m whereas most other systems use up to 3,65 m long bags. This allows much more cloth area to be installed into a given space.

- Bag cages are not circular but are elongated to maximise entry of cleaning air during the rotating pulse.

Salient design features of the Rooiwal baghouses are:

- No of bags / tube plate = 224
- No of tube plates / lane = 6
- No of lanes / boiler = 2
- Total no of bags / boiler = 2688
- Filtration area / bag = 2,26 m^2
- Linear filter velocity (max) = 1,35 m/min
- Tube plate pressure drop (max) = 1,5 kpa
- Filter material used = Ryton
- No of reverse pulse blowers = 3 per boiler
- Blower installed capacity = 22 kW per blower

3. BAGFILTER OPERATIONAL EXPERIENCE

3.1 Commissioning

The cold boilers are started up with oil firing and it is most important to avoid oil depositions directly onto the filter material. The main procedures during commissioning were:

- Start up ID fans.
- Check dP over tube plate.
- Precoat bags with fly-ash until dP has increased by 500 Pa.
- Fire boiler up, using a minimum of oil.
- When fully on pulverised coal, operating at 35 MW, and dP up to about 1,5 kPa, start reverse pulsing.
- Use PLC to control dP to 0,8 kPa (min) and 1,5 kPa (max).

Further boiler outages showed that the plant could be started up on one lane only (using half of the filter capacity) thereby obviating the need to pre-coat both lanes.

3.2 Operational History

The boiler No 1 baghouse was commissioned in August 1987 and operation was highly satisfactory right from the start. This is evidenced by the acceptance test results shown in Table 1 (par 3.4).

This boiler No 2 baghouse was commissioned during May 1988. This baghouse is an exact replica of the No 1 design and is operated under exactly the same conditions, by the same operators from the No 1 and No 2 boiler control room. In spite of this, the No 2 boiler baghouse soon ran into excessive tube plate dP's - going up to 2 kPa during sootblowing at 60 MW.

Bagfilter overpressure conditions have been reported by other power stations (notably Eraring in Australia, Monticello and Brunners Island in the U.S.A.). A great deal of research has been, and is still being done on these.

3.3 Pressure Drop (dP) Troubleshooting

By October 1988 it was clear that the No 2 baghouse was behaving quite differently compared to No 1. The average dP at 48 MW was then 1,2 kPa at No 2 compared to 0,8 kPa at No 1.

During the following 9 months an extensive trouble-shooting campaign was executed. Possible causes investigated were:

* Bag condition
* Fly ash

- concentrations
- particle sizes
- dust cake characteristics

* Boiler operations
  - Excess oxygen
  - Gas flowrates
  - Gas temperatures
  - Combustion efficiency
  - Coal analyses
  - Coal mill parameters

* Pulse cleaning mechanism
  - Condition of blowers, piping, manifolds & valves
  - Pulse air pressure and temperature
  - Pulsing frequency

Initial work on the rotating manifolds and the blowers brought some relief. During the investigations faults in the excess oxygen meters were shown up. Fly-ash dust cake characteristics were shown to be quite different from the No 1 boiler fly-ash and the particles were generally finer, especially in the minus 10 micron range.

After a fair amount of experimenting with the No 2 baghouse parameters, it was concluded that this baghouse required much more pulsing power to obtain similar operating dP's. Rectification measures which were actioned include:

- Off-line pulsing at the No 2 baghouse.
- Interlinking of the No 1 and No 2 bagfilter compressed air manifolds to use excess air from the No 1 blowers at the No 2 baghouse.
- Increasing the size of the blowers at the No 2 baghouse.

Even before increasing the blower sizes, the problem at the No 2 boiler was brought under control to such an extent that the acceptance tests could be done in August 1989.

3.4 Acceptance Tests

The detailed results of the acceptance tests (as compared to the specifications) are given in Table 1. The tests were all done at MCR (60 MW). No 1 boiler was tested on 21 and 22 October 1987 and No 2 boiler on 23 August 1989.

4. CONCLUSIONS

The Howden/Carter Day baghouses have achieved the guaranteed results regarding:

* Emissions
  Howden guaranteed 100 mg/Nm3 and the acceptance tests indicated concentrations of 15 to 48 mg/Nm3.

* Pressure drop (dP)
  The dP was guaranteed at 1,5 kPa between the bagfilter in- and outlet flanges. The test results were 1,34 to 1,45 kPa.

The remaining parameter which is to be met is the bag life guarantee of 15 000 operating hours. Thus far (end May 1990) the No 1 bags have competed 20 363 hours and the No 2 bags have completed 14 684 hours.

The Ryton bags in the No 2 boiler baghouse are still in good condition and should meet the guaranteed bag life. Boiler No 1 bags have already exceeded the guarantee.

Based on it's experience with these baghouses and based on the fact that the control authorities and the public alike have acquired a taste for invisible stack emissions, the Pretoria City Council is now proceeding with the procurement of a baghouse system for the No 3 boiler.

TABLE 1

ACCEPTANCE TEST RESULTS : ROOIWAL NO'S 1 & 2 BAGFILTERS

	Boiler No 2 A Lane/B Lane	Specification Each Lane	Boiler No 1 A Lane/B Lane
Gas Volumes			
- Baghouse Inlet			
Am3/s	81,1 / 63,3	54,59	60,5 / 55,9
Nm3/s	44,1 / 35,5	30,6	33,6 / 30,8
at Temp (^C)	156 / 143	155 (Ave)	148 / 154
at suction (kPa)	1,38 / 1,32	1,07 (Ave)	1,12 / 1,16
- Fan Inlet			
Am3/s	54,52 / 51,64	68,4	56,1 / 54,6
Nm3/s	32,2 / 30,1	38,0	31,9 / 30,6
at Temp (^C)	115 / 121	138	124 / 140
at suction (kPa)	2,5 / 2,7	3,0	2,7 / 2,8
Dust Concentrations			
- Baghouse Inlet			
g/Am3	15,95 / 15,76	-	14,99 / 10,49
g/Nm3	29,4 / 28,1	14-24	25,2 / 19,0
- Fan Inlet			
mg/Am3	28,7 / 25,9	-	8,8 / 13,5
mg/Nm3	44,5 / 48,4	98-168	15,4 / 24,1
Dust Collection Efficiency (%)	99,89 / 99,85	99,3	99,94 / 99,87
Pressure Drop			
Flange to Flange (kPa)	1,45 (Ave)	1,5	1,34 (Ave)
Gas Analyses Inlet			
- O2 (%)	4,4 / 4,7	3,2-4,0	3,6 / 5,5
- CO2 (%)	16,7 / 16,9	-	-
- CO (ppm)	< 50	-	-
- SO2 (g/m3)	1,80 / 1,79	-	-
- H2O (%)	Negl.	-	7,9 / 8,3
Gas Analyses Outlet			
- O2 (%)	4,9 / 4,9	-	4,0 / 5,5
- CO2 (%)	17,3 / 17,6	12,4	-
- CO (ppm)	< 50	-	-
- SO2 (g/m3)	1,12 / 1,25	-	-
- H2O (%)	Negl.	-	6,5/ 6,9
Coal Analyses			
- Moisture (%)	3,32	3,3 (Ave)	-
- Ash (%)	24,56	25,0 (Ave)	-
- CV (MJ/kg)	24,56	25,0 (ave)	-
Dust Analyses			
- C in Ash (%)	7,02	1-10	-
- Mean particle diameter (microns)	12,5 - 14	10-15	-

Notes:

a) Dust collection efficiency is calculated using the mass flow of dust emitted vs the mass flow entering the baghouse.

b) Nm^3/s taken at 0°C and 101,3 kPa.