Effective ventilation of precipitators and substations

by Bev Lawrence and Nick Form, Filtapak

Most plants use electrical equipment with its associated switchgear and control equipment housed in nearby substations. These are often in dusty environments, and have inadequate ventilation systems to prevent dust ingress.

The dust deposits on electrical components result in unreliable operation, and can lead to failure, with the negative impacts of downtime and cost. Effective solutions are readily available.

Background

Many plant processes in South Africa inherently emit large quantities of particulates of various kinds. Without effective capturing of these particulates, our atmospheric environment would be much more dust-polluted than it is. Various techniques are available to plant designers to capture the particulate emissions, including bag-filters and electrostatic precipitators. It is the function of the Department of Health to monitor and police the environment and air quality. This is done through the offices of the Chief Air Pollution Control Officer (Capco), who issues licenses to organisations, setting (usually tough) emission limits, and checking to ensure that the limits are adhered to.

For an organization to be able to meet the limits imposed on it, an air cleaning plant of both high efficiency and reliability is required. An efficiency of more than 99% is typically required, with a reliability to match.

Power station pollution

A modern power station will probably be restricted to an emission limit of 50 mg/m³, which results in the chimney having virtually no visible emission. To achieve this degree of performance with electrostatic precipitators requires that the DC voltage applied between the precipitator electrode wires and collector plates be controlled continuously. The voltage must be elevated to the highest level possible without causing flashover or back corona problems, both of which reduce the collection efficiency. Use will probably also be made of a small quantity of SO₂ gas injection into the emitted gas to further enhance the precipitator performance.

The transformers, rectification and control equipment for this plant is typically housed in a nearby electrical sub-station, the proximity of the electrical equipment to the dust-collection and handling plant creates considerable maintenance problems. The substation cannot be built as totally dust-proof, and the equipment, particularly the power transformers, require considerable cooling. The substation designer thus arranges for the building to be simultaneously ventilated and pressurized by a fan-filter system attached to the plant.

In the case of many plants, the ventilation system installed is not given the design attention required by its vital functions. For without adequate cooling, the finest electrical power and control equipment are just unable to perform. And dust ingress into the substation, either contained in the cooling air or through inadequate pressurization of the building, builds up on the circuits, leading to maloperation and, eventually, failure.

Case study 1

At Eskom's Kendal power station, the largest hard-coal fired plant in the world, the precipitator substations are installed right at the ash handling plant transporting some 10 000 t/day of conditioned (damp) ash to the ash-dumps. The building houses a large quantity of electrical equipment, including two dry-type power transformers and all the associated switchgear and controllers for a very large seven-field precipitator (see Fig. 1). From time to time problems arise where several tons of dry ash dust are deposited next to the sub-stations, resulting in a dust-storm of extremely high concentrations (known at Kendal as a “white-out”).

The six sub-stations were designed each with ventilation systems using centrifugal fans and filters with 1.6 cylindrical paper cartridges. The fans were of a capacity adequate to ventilate the building when the filters were very clean. However the reverse pulse air cleaning system used proved to be extremely unreliable, and within a relatively short period the systems ceased to function effectively, and the buildings became fouled with dust – on the floors, in the switchgear and control equipment cubicles, and on the transformer cooling fins. Equipment reliability suffered, and electrical maintenance staff had to regularly and frequently clean the entire building and all the equipment.

A decision was made to review the design of the ventilation system, and a contract was eventually awarded to completely replace the existing fan-filter units on three of the substations. The systems that were removed would be moved to the other three buildings, giving them two fan-filters each. The new fan-filter units (see Fig. 2) comprised large capacity two-speed fans rated at 6 m³/s against 1.5 kPa at the altitude of 1800 m. This provided sufficient air to adequately cool all the equipment, while maintaining a constant positive pressurisation of 30 Pa throughout the fouling cycle of the filters.

energize - March 2005 - Page 40
The filter stage comprised a mechanical vane-type primary filter with bleed fan which collected and removed 95% of the particulates, expelling them through a side vent on the casing. So effective is this stage that a handful of ash thrown at the inlet vent is immediately seen to be passed out of the side vent (see Fig. 3). The secondary stage comprises a rack of 24 high efficiency, high capacity cartridge filters, which remove virtually all the remaining particles, especially the finer ones. The filtered air is then fed to the building, where the pressurisation ensures no dust ingress occurs.

A weighted louvre damper at the air exit vent is used to ensure a constant internal pressure in the building, regardless of the state of fouling of the filters (see Fig. 4). A highly sensitive and reliable pressure gauge (0 - 100 Pa) is mounted at the door entering the building. The dial is also colour-coded in red and green to allow operating staff to easily ensure that the pressure is adequate, with a notice requesting them to inform maintenance staff if it is not.

The automatic control system for the ventilation unit uses exhaust air temperature and building pressure sensors to monitor the conditions. A low pressure or a high exhaust air temperature condition will switch the fan to high speed, and give an alarm to this effect.

The results of this installation has been that the three buildings thus equipped have been maintained in a spotless condition for several years. And this has resulted in excellent electrical plant reliability with virtually no cleaning required.

On the other three substations, each now being fitted with two of the original ventilation units, a number of modifications were attempted to upgrade the filtering performance (see Fig. 4). After several rounds of unsuccessful efforts, the station management decided to replace them with three new units identical to those on the other three substations.

**Case study 2**

Another plant critical installation at Kendal was the electric feed pump drive equipment room. Each boiler has to have a continuous and reliable supply of return feed water from the steam condensing plant. Kendal was the second Eskom station to use three 50% electrically driven feed pumps, each being driven by a 10 MW synchronous motor fed from a variable speed drive. These 18 drives are housed in 6 equipment rooms 30 X 6 X 6 m (1080 m$^3$), this time on the (relatively) clean side of the station.

Original ventilation equipment included only a large-capacity split-unit air conditioner. As the thyristors in the drives are water-cooled, only nominal heat removal is required to keep the control equipment cool, and the air-conditioner was adequately rated for this. But it failed to keep the building dust-free, and the extremely sensitive control electronics started to cause problems.

A contract was placed with a ventilation equipment supplier for the design, supply and installation of a fan-filter unit to pressurise the building.

The performance of these new units was very poor, and eventually a contract to redesign the ventilation units was awarded. The existing system was then modified to the new design, using similar but simplified design principles to those on the much larger precipitator units (see Fig. 5). This resulted in a high performance ventilation system which is both very operator and maintenance friendly, again providing savings in manpower, with the demanded high reliability from the feed-pump drive system.

Contact Bev Lawrence, Filtapak, Tel (013) 697-4843, bevlawrence@lanitic.net