



## LETHABO POWER STATION - WATER PURIFICATION AND TREATMENT

In using water for steam generation, it is very important that consideration is given to water treatment for the prevention of corrosion of boiler/turbine steam and water tubing, pipes, blades etc as well as scaling and contamination of steam/water.

Lethabo sources its water from the Vaal River and generally, this water is contaminated with organic and inorganic substances, gasses and other impurities. To reduce and eliminate these substances from the raw water, a process of clarification (settling), filtration and demineralisation is used.

Raw water for Lethabo is supplied from the Vaal to two reservoirs with a capacity of 885 000m<sup>3</sup>.

### Clarification

At Lethabo two sets of clarifiers are used. One set is for the clarification of the cooling tower make-up water, mine water and 10% from the hot cooling water returning from the condensers. The second set is primarily used to clarify water, which will be used for potable water and demineralised water production.

The clarifiers are designed to remove all the solid substances (suspended matter) - such as mud, clay and organic matter from the raw water.

The water is fed into the clarifier through a centre pipe in the floor. A chemical, polyelectrolyte is added and mixed into the water. The polyelectrolyte addition acts as a coagulant, resulting in the flocculation of solid substances. The design of the clarifier guides the water flow in an upward direction through the primary section, downward into the secondary section where floc growth continues and eventually into the sedimentation area where the heavy flocculation particles settle down into the bottom of the clarifier basin. This sludge is removed by means of a scraper continually scraping sludge into discharge sumps.

The clear water exits the clarifier at the top through launders with "V" notched metal strips and into a main launder located on the periphery of the clarifier.

### Sand filtration

Clarified water from a holding sump is forced through five horizontal pressurised sand filters.

The bottom of a filter is filled with concrete to form a flat bottom surface area. Nozzles protruding through the concrete are connected to an outlet manifold through which the filtered water leaves the sand filter. On top of the concrete is a layer of gravel (small stones) and this is covered with a layer of sand. The sand does most of the filtration. Water flows from the top through the sand and stones and then out through the outlet manifold.

The water leaves the sandfiltration plant in two streams. One stream goes through a chlorinator to storage tanks and the other to the demineralised plant.

The purpose of chlorine in the potable water is to kill any remaining bacteria thus making the water suitable for human consumption.

When the sand filter unit becomes clogged, the filters are cleaned through backwashing the sand using clean water and compressed air.

### Dissolved Solids

These impurities are dissolved in the water and are therefore not visible. There may be a variety of these impurities in the water, but the ones which cause the most trouble in the boiler, are the compounds of calcium and magnesium such as those listed below:

- Calcium bicarbonate Ca (HCO<sub>3</sub>)<sub>2</sub>
- Magnesium bicarbonate Mg (HCO<sub>3</sub>)<sub>2</sub>
- Calcium sulphate CaSO<sub>4</sub>
- Magnesium sulphate MgSO<sub>4</sub>

These are the compounds which cause 'hardness' of the water and which result in scale deposits in the boiler tubing.

Bicarbonates of calcium and magnesium cause temporary hardness. It is classed as temporary because the bicarbonates can be removed easily from the water by heating it below its boiling point. This causes the bicarbonates to drop out of solution and they deposit as a soft scale. If this heating is carried out before the water enters the boiler, the soft scale will deposit in the feedwater heater. If the bicarbonates are not removed before the water enters the boiler, then they will form a soft scale on the boiler transfer surfaces.

Sulphates of calcium and magnesium cause a permanent hardness, as these compounds cannot be removed by heating the water. They form a hard, dense scale on the boiler heat transfer surfaces.

Deposits of either the soft bicarbonate scale or the hard sulphate scale are undesirable. These deposits will keep the water away from the metal of the boiler tubes (impair heat transfer) and will make these surfaces overheat.

Dissolved solids, being in solution in the water, cannot be removed by filters or settling tanks. Instead, water softeners of various types are used to remove the hardness before the water enters the boiler. Also, chemicals can be added directly to the boiler, which prevents the formation of scale on the surfaces.

If silica (sand) is present in the boiler water, it can be carried over with the steam to the turbine. As the steam flows through the turbine, the pressure drops and the silica forms a deposit on the turbine blades – especially on the large, low-pressure blading of the turbines. This affects the efficiency of the turbine as such deposits cause heat loss and could also result in blade vibrations.

Iron causes scaling of the boiler tubes. This acts as a form of insulation, causing the boiler tubes to overheat. Scaling may also result in the narrowing of the tubes, which would once again restrict the flow of water or steam, thus causing overheating.

The amount of soluble solids present in water may be determined by measuring its conductivity. The greater the amounts of soluble solids present in the water the greater the conductivity of the water will be.

### **Dissolved gases**

Gaseous impurities, which are of concern, are oxygen (O<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>). These are dissolved in the water and they cause corrosion of the boiler metal and piping.

### **Demineralisation (Ion exchange)**

In solution, most of the salts are broken up into positively and negatively charged particles called ions. All the mineral salts must be removed from the water, a process known as demineralisation or de-ionisation is used. A synthetic material called resin, which looks like sand but has a sponge like property and has the ability to exchange these ions, is used in the demineralisation process. The resin is called zeolite.

This process of demineralisation involves using a hydrogen-zeolite cation exchanger to remove the sodium, magnesium and calcium cations and then using an anion exchanger (weak and strong base) to remove the sulphate, chloride and silica anions. In addition, a degasifier, between the cation and anion units, is used to remove any carbon dioxide present. The outflow from the demineralising process is water that is free from all mineral impurities and is equal in quality to distilled water. The water from the anion units flows through the mix-bed (polisher) unit to remove the final traces of cations and anions.

In conclusion, the positive ions are exchanged for hydrogen ions, while the negative ions are exchanged for hydroxide ions. The combination of these two elements, ie hydrogen (H<sub>2</sub>) and hydroxide (OH), produces pure water H<sub>2</sub>O.

When the resin becomes saturated, ie when it has absorbed its maximum capacity of ions, sulphuric acid and caustic soda are used to regenerate the cation and anion resins respectively.

In addition to the treatment of water at the water treatment plant, condensate water from the condensers is allowed to pass through 2 of 3 x 50% polishing units, filled with a combination of cation and anion resins. This is to ensure that the feedwater supply to the boiler is up to chemistry specification prior to admitting water into the boiler.

**Produced by:                    Generation Communication  
    CO 0006 Revision 9 (November 2014)**

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