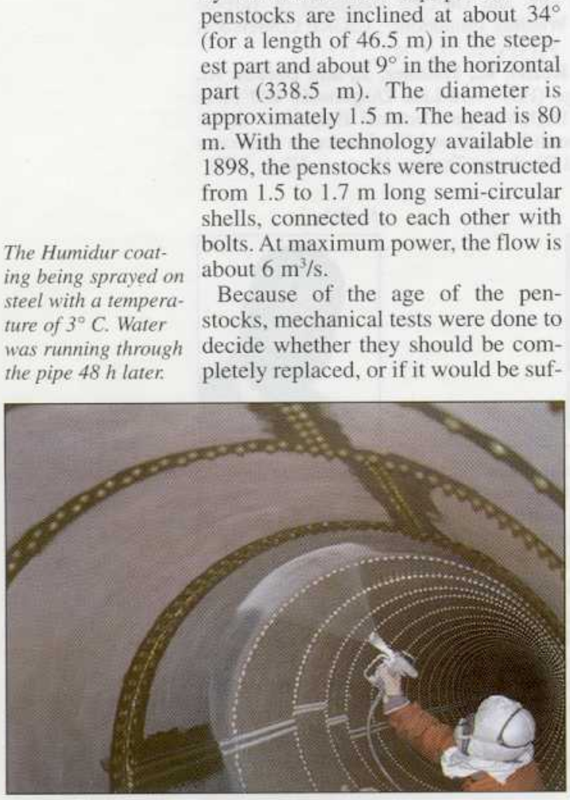
Penstock refurbishment at the Brenner powerplant

A project has recently been carried out at the Brenner powerplant in Austria to renew the internal corrosion protection system on the two penstocks. The new coating offers particularly good resistance to abrasive water, which is a characteristic of the river Obere Sill where the plant is located.

Brenner, which has been in operation since 1898, is one of the oldest hydro plants in Austria. It is one of 43 plants owned and operated by the Tiroler Wasserkraftwerke AG (TIWAG) and also one the smallest, with a capacity of 7.7 MW. It was recently completely automated and is now controlled and monitored from TIWAG's control room 30 km away at Thaur.

The intake structure, desanding system, and rough and fine intake grid collects about 40 tons of material each year from the water of the river Obere Sill. The water level and discharge from the reservoir is regulated by pneumatic pressure sensors/PID control unit. After passing the intake section, water is conveyed through a 420 m-long canal to the automatic inlet gate valves at the two parallel, buried pressure shafts leading to the four horizontal axis Francis turbines. When the machines are not functioning, the water passes through a drainage canal. The pressure shafts are each 412 m long and monitored by ultrasonic flow equipment. The penstocks are inclined at about 34° (for a length of 46.5 m) in the steepest part and about 9° in the horizontal part (338.5 m). The diameter is approximately 1.5 m. The head is 80 m. With the technology available in 1898, the penstocks were constructed from 1.5 to 1.7 m long semi-circular shells, connected to each other with bolts. At maximum power, the flow is about 6 m^3/s.

Because of the age of the penstocks, mechanical tests were done to decide whether they should be completely replaced, or if it would be sufficient to renew the corrosion treatment. Tests revealed that apart from the corrosion damage, the penstocks were in relatively good condition, and therefore it was decided to renew the anti-corrosion protection only.



The Humidur coating being sprayed on steel with a temperature of 3° C. Water was running through the pipe 48 h later.

The previous corrosion protection had been applied 25 years ago. It consisted of the application of two layers of a zinc primer, and a 200 μm topcoat of coal-tar coating. In 1984, as a result of abrasion at the bolts in general and in the bottom half of the pipe specifically, it was decided to apply an extra layer of Inertol 1 coating. Because of the way in which the intake at the plant had been constructed, finer rock sediments in the river Sill (originating from the alpine glaciers) are not able to settle, and contaminate the water entering the intakes of the penstocks.

There are bolts and shell edges in the penstocks which cause local turbulence, and this, in combination with the dispersed sediments, cause very deliterious wear effects on the coating intended for corrosion protection. The coating had to be touched up every winter, but despite this, during the winter inspection in 1995, the top coat could be removed easily with a knife. The zinc primer underneath was completely corroded and had lost its adhesion to the steel.

From the beginning of April through until the end of October, the discharge in the river Obere Sill allows for full capacity flow through both penstocks. During the winter period, however, there is only sufficient water for two machines to run (using one penstock). It was therefore decided to refurbish the corrosion protection system in winter. At the same time generator no. 3 was overhauled. The schedule posed some considerable challenges, since the steel temperatures in winter are at their lowest and it was important not to impose excessive mechanical stresses by heating the air used to control the conditions inside the penstocks. The fact that the steel temperature would be around 2 to 4°C considerably reduced the number of corrosion protection systems which could be used.

Ambient conditions

The flow of air in the penstocks was directed from top to bottom. Because of the limitations posed from the point of view of surface temperature the steel could take, the air blown into the penstock was almost not heated at all, to reduce condensation of humidity forming on the steel surface. Critical moments occurred as a result of some weather conditions; for example, when the so-called Föhn wind occurred, and when the outside air temperature rose sharply to 10 to 15°C. This meant that excessive humidity could enter the pipe, with a considerable risk of condensation (dew point). The normal air temperatures for the time of the year were between 0 and -10°C.

During the entire refurbishment, the most important parameters of the air were automatically logged by computer. Throughout the project, the air temperature was between 5 and 8°C for most of the time, with the steel temperature being between 3 and 7°C and the relative humidity between 15 and 45 per cent.

Surface preparation

The old coating system was removed by blast cleaning with a Korund grit. The surface roughness varied between 30 and 70 μm. The cleaned surface showed some severe corrosion damage, not only because of the high abrasiveness of the water, but also because the previous plant operators had not maintained the corrosion protection and had postponed refurbishment for too long.

Access points to the penstocks were limited. There was one point at the top, a manhole in the middle (where the penstock was only some 30 cm beneath the ground surface) and another possibility through the turbine spiral casing.

Blast cleaning began from the top to the middle manhole for about 120 m, and immediately after blasting 100 m were coated. Next, blast cleaning and coating continued 110 m down from the middle manhole, so some 70 m for blasting and coating remained for the last part.

Coating system

For the new corrosion protection coating system Humidur was chosen, because of its resistance to low temperatures. According to the manufacturer, General Coatings NV of Belgium, it has even been used to protect storage tanks on the island of Spitsbergen, where steel temperatures were as low as -15°C when the steel was coated.

This coating can also be repaired without having to activate or sweep-blast the old coating surface, no matter how old the coating system is. This was especially relevant in the case of Brenner, because of the degree of abrasiveness of the water of the Obere Sill. These characteristics were confirmed by coupon testing and laboratory work carried out in TIWAG's laboratory.

Technical assistance was given by the coating manufacturer. Since Humidur is a solvent-free system, it had to be applied according to strict procedures specified by the manufacturer. In this way it was possible to apply the minimum specified film thicknesses in two or even one single layer on to the steel substrate. For the bolts and the bottom half of the penstocks, a dry film thickness of 1200 µm was specified, whereas for the upper half only a minimum of 600 µm was specified.

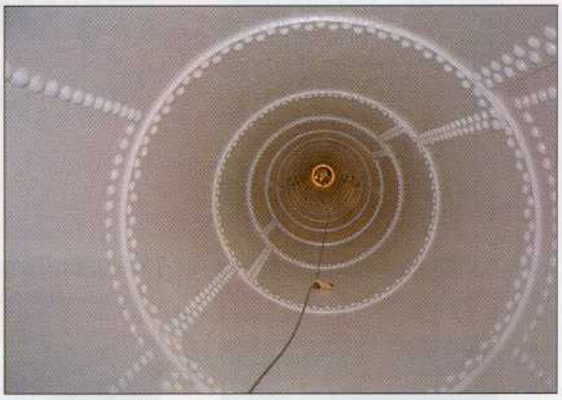
Because of the state of the steel surface, which showed considerable pitting corrosion around the bolts, the bolts and adjacent areas were pretreated by brush in a different colour from that of the layer sprayed subsequently. This made it possible to monitor the degree of abrasiveness and showed whether or not repairs were necessary.

Although the pre-treatment naturally took some time, it made the spray application afterwards much quicker and more efficient (with few overspray losses); one layer of 500 to 600 µm could easily be applied by brush.

The spray application was done using ordinary high pressure airless spraying equipment, a pump connected to high pressure spraying hoses with a length of up to 120 m. The coating material could not be thinned, and therefore the hoses were fitted with heating cables, insulation and thermostats (provided by the coating manufacturer) to maintain the ideal spraying viscosity along the entire 120 m spraying hose. A mean covering rate of about 100 m^2/hour for a 600 µm layer made it possible to cover the 1800 m^2 for each penstock in the shortest possible time.

Every operation was subject to quality control by the corrosion protection team. Not only blast cleaning and spraying operations were controlled, but also the functioning and monitoring of the ambient conditions were checked.

As part of the final acceptance control, around 4000 spot dry film thickness measurements were taken with electromagnetic film thickness measurement apparatus. To check for pores and other surface anomalies, a high voltage direct current meter was used. At the same time as the application, small steel plates were coated, on which destructive tests were subsequently.carried out. For example, a plate was cut in a transverse (vertical) direction, and inspected using microscopic techniques for further investigation into the porosity of the coating material in realistic conditions. Standard tests were also carried out; the adhesion test, for example, showed an adhesion value of more than 140 kg/cm^2. - *Contributed by Ing. E. Rainer, TIWAG, Austria.*



View of the freshly recoated penstock (originally constructed in 1899). An area of 1800 m^2 was coated. (Photos by courtesy of General Coatings BV, Belgium.)

Information:
Mag. Alois Zwanzinger
Corro Tec Korrosionsschutz
Vertriebsges.m.b.H.
Grinzinger Straße 72/E35,
A-1190 Wien
Austria
Tel.: +43/664/103 62 63
Fax: +43/664/77 103 62 63
E-Mail: alois.zwanzinger@aon.at