Renewing anti-corrosion protection at Wehr

The solvent-free two-component epoxy resin system Humidur was recently put to use on a renovation project at the Wehr pumped storage plant in Germany. A Zwanzinger, E. Rainer and T. Huber detail the work involved in renovating the project's anti corrosion protection

SCHLUCHSEEWERK AG operates and maintains five hydro power stations in the Schwarzwald (Black Forest), Germany. One of these projects is the 980MW Wehr pumped storage scheme, which is located in southern Schwarzwald, above the village of Wehr. The project has been in operation since 1976 and features four Francis turbines installed in a hydro cavern.

The project's water supply comes from the Hornberg Basin, on top of Langeck Mountain near Hornberg, part of the town of Herrischried. The water that passes through the turbines is collected in the Wehra basin in the Wehra Valley, near the town of Wehr, below the hydro station.

After more than 30 years of operation, Schluchseewerk decided that the anti-corrosion protection on the inside of the penstocks needed to be renewed.

From the Hornberg basin, an armoured pressure shaft runs in front of the cavern into the upper water distribution pipeline, in which it is divided over the different machine groups. The overall length of the pressure shaft amounts to about 1385m. The inner diameter is 5.53m, reducing to 1.9m in the distribution pipeline. The pipelines of the pressure shaft lie underground and are only accessible from entrances in the upper basin, over the cavern and from the distribution pipeline.

The lower water distribution pipeline can be reached over the cavern – the lower water basin could only be used in a limited way as it remained filled.

Project concept

In 2006, a project group was created consisting of representatives from Schluchseewerk and Tiroler Wasserkraft AG (Tiwag). This group was responsible for the project concept, creation of the tender documents, evaluation of the offers and the decision to award contracts.

The decisive factor in this project was the selection of the coating product to be used. A number of factors had to be considered including: influence on the site installation, climatization, exploration, quality of the blast cleaning, application, controls, schedules, etc. After evaluating several possible solutions, the project group decided that Humidur would be the most appropriate product for this project.

The advantages of this product are essentially its thick layer application, easy repair method, the possibility of applying the product even at low substrate temperatures, experience in comparable projects, and lack of solvents and hazardous substances. Another important aspect was the on-site assistance provided by the coating supplier.

Keeping to schedule

Once the tender for the anti-corrosion work was issued, several international bidders submitted offers, with the contract eventually awarded to German company Arge Bauschutz-Bekor.

The company decided that, in order to meet the strict deadlines set down by the power suppliers, it was necessary to divide and organize the anti-corrosion works into a number of different sections, as shown in Table 1.

Table 1: Schedule of work

Empty the upper basin, pressure shaft and upper water distribution pipeline	2 April 2008 - 10 April 2008
Empty the lower water tunnel and lower water distribution pipeline	14 April 2008 to 18 April 2008
Anti-corrosion works in the pressure shaft	Mid July 2008 to 3 March 2009
Anti-corrosion works in the upper water distribution pipeline	May 2008 to July 2008
Anti-corrosion works in the lower water distribution pipeline	May 2008 to January 2009
Anti-corrosion works on the cylindrical sluice-gate including constructional mechanical repairs	September 2008 to November 2008
Anti-corrosion works Lindau – bypassing	October 2008 to December 2008
Filling the lower water tunnel and distribution pipeline	January 2009
Filling the pressure shaft	17 March 2009 to 26 March 2009
Back into operation	16 March 2009 to 6 April 2009

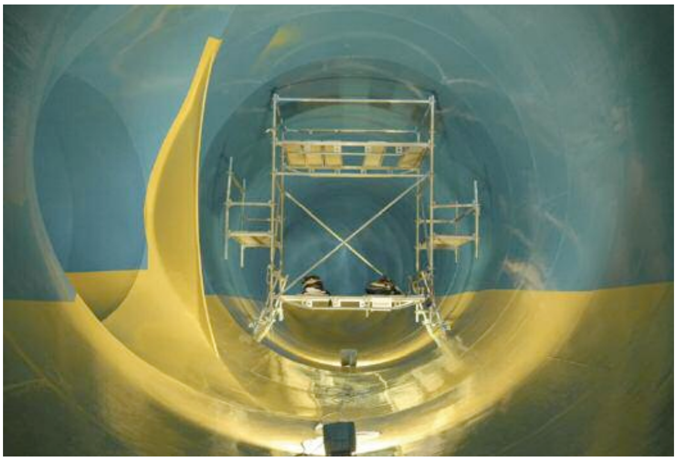
Section by section

After the upper water basin was emptied, phase 1 of the work could begin on the 1385m long, 5.53m diameter penstock shaft, which lies at a gradient of 54%. Once the climatization unit, scaffolding and the movable work station had been installed, work began to remove the old coating and apply the new Humidur coating on the vertical armouring of the intake tower.

In order to meet tight deadlines, phase 2 of the work was carried out parallel to phase 1. This involved renovation works on the interior surface of the upper water distribution pipeline, followed by the renovation works in the pressure shaft.

The third phase of work involved treating the lower water distribution pipeline and the riser shaft for the surge tank, amounting to a total surface area of approximately 9600m^2.

Phase 4 involved treatment of the cylindrical sluice gate in the intake tower. This involved lifting the gate and placing it on a platform to allow access, once the necessary dewatering measures were carried out. An opening of 1.2m x 1.2m was cut into the tower, with



Left, from top to bottom – Application of the first layer of Humidur on the vertical armouring of the intake tower

The finished coating on the lower water pressure pipeline, with the extra layer on the bottom plate and the sickle-shaped part (upper end of the distribution pipeline)

The finished coating of the upper water distribution pipeline with an extra layer on the bottom plate and the sickle-shaped part (most vulnerable parts)

Finished coating on the cylindrical sluice-gate

Application of the second layer of Humidur in the Lindau-bypass

mechanical repairs carried out by the principal engineer, in consultation with the contractor.

The final phase of the work consisted of renewing the interior coating of the Lindau-bypass (about 1500m²).

For the treatment of several smaller parts in the hydro power station, a blasting box (blasting shed) was erected and these works were performed at the same time as the larger parts.

Site requirements

In general, for all the works on the surfaces of Phase 1-5, the equipment had to be asbestos and PAH safe and the works had to be executed in accordance with the prevailing standards. Based on the data provided by the suppliers of the old anti-corrosion product, together with analysis of the newly produced coating material, the hazardous substances in the applied old coating were determined. This is turn led to the development of the anti-corrosion works plan, in accordance with TRGS 519 and 551. As a result of earlier experiences and in consultation with the authorities, it was decided to remove the old coating by means of conventional dry blast cleaning.

Since there was a possibility that percolation water or mountain water could come down from the artificial lake, dewatering had to be installed, in consultation with Schluchseewerk AG.

To make the interior surface of the pressure shaft (Phase 1) accessible for treatment, a movable working platform was necessary. The hoist needed to move such a platform could be attached to securing points already provided for in the upper water basin.

Climatization

Treatment of all the surfaces had to be done in an air-conditioned atmosphere – the surfaces to be treated needed to be permanently dry, even when the weather conditions outside were unfavourable. Moreover, in accordance with the principal engineer's specifications, the surface temperature of the steel armouring in the parts to be treated had to be maintained to at least 5°C above their dew point. The relative humidity of 40% was not to be exceeded until after completion of the first coating layer application.

For technical reasons, it was necessary for the conditioned air to be warmed by means of a heating system equipped with a switchbox and adequate generator sets.

The climatization and ventilation had to be installed in such a way to avoid pulverization. Consequently, it was necessary to clean all the exhaust air through dust filters. In addition, during removal of the old coating layer, asbestos and PAH filter installations also had to be used.

The contractor was responsible for control of the asbestos and PAH content of the exhausted air, and at all times had to prove that the values remained within the legal limits. If the contractor failed to take these measures against pulverization, the works would have been stopped immediately.

Rust removal by blast cleaning

Blast cleaning to remove rust could only start once the air conditioning had been installed and dewatering was functioning. Schluchseewerk prescribed a cleaning up to Sa 3 in accordance with DIN EN ISO 12 944 part 4 and required a purity degree of at least m2/g2 to conform with technical report DIN Nr. 28 (also refer to

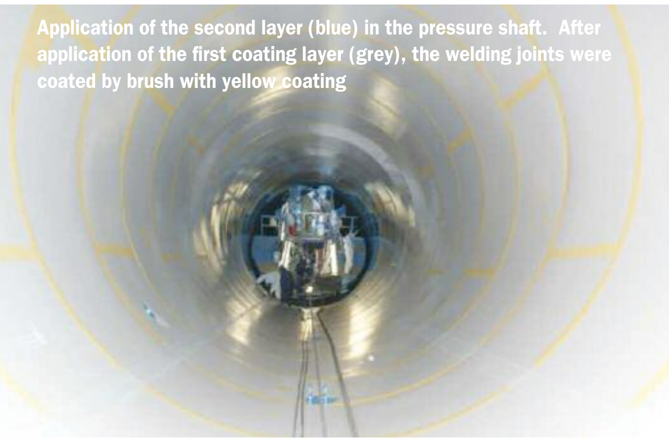
Table 2: Surface area of the works

Work phases	Surface in m²
Phase 1 Pressure shaft	24.000
Phase 2: Upper water distribution pipeline together with the level surface of the pressure shaft	5.400
Phase 3: lower water distribution pipeline with surge tank	9.600
Phase 4: Cylindrical sluice-gate	400
Phase 5: Lindau-bypassing	1.500
Total surface	40.900


Control of the sandblast cleaning in the pressure shaft, final control of the cleaning (adhesive tape test) before release for coating application


The picture shows a part of the climatization installation in the upper basin, for the climatization of the pressure shaft


Part of the housing and the lock system for the black area as well as the measuring equipment to monitor the underpressure


Application of the second layer (blue) in the pressure shaft. After application of the first coating layer (grey), the welding joints were coated by brush with yellow coating

DIN EN ISO 8502, Part 3). In order to assure a maximum adhesion of the coating system on the steel surface, an average roughness degree Rz of at least 60 µm had to be obtained. Only new un-used blast cleaning material could be used during the final blast cleaning phase.

The used blast cleaning material had to be transported, dust free, through an exhaust installation and over a conveyor belt, and deposited in suitable bags in accordance with instructions of the principal engineer and the authorities. The bags then had to be made ready for transport and stored in the dedicated places.

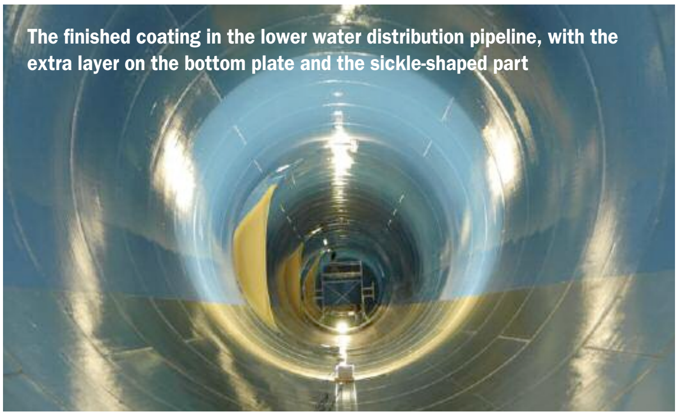
The surface was firstly blast cleaned, against the direction of the air flow, to remove the old coating (black surface). After cleaning and independent measurements by an acknowledged institute, the surface to be treated was released (white surface) and blast cleaned for a second time, with new blast cleaning material, up to a purity degree of Sa3 (Rz > 60 µm) and de-dusted.

The new coating

Following the blast cleaning and sample testing of the welding joints, the surface was ready for the new coating.

In accordance with the specifications of the tender, the solvent-free 2-component epoxy coating Humidur ME was to be applied in two layers (one light grey, the other light blue) with a dry film thickness of at least 600 µm (total dry film thickness of the two layers). In order to ensure a longer lifetime of the anti-corrosion system – taking into account the present erosion in the areas of the bottom plate and the sickle-shaped part – an extra layer of Humidur in sand yellow was applied on the bottom plate and on the sickle-shaped part where erosion was discovered. The total dry film thickness (DFT) in the areas where this extra layer was applied had to be at least 1000 µm. The coating was applied using crosswise airless spraying.

After application of the first layer (directly on the steel – no primer), the coating was tested for open pores by means of a spark test and the coating thickness was measured. Weak spots or open pores were


The finished coating in the lower water distribution pipeline, with the extra layer on the bottom plate and the sickle-shaped part


Inspection of the cleaned steel surface in the lower water distribution pipeline. The amount of dust was tested with adhesive tape, to see whether the purity degree m2/g2 (DIN EN ISO 8502, part 3) has been reached

Ion permeability of Humidur ME

Measuring ion permeability on a coating, according to engineer Peter Heinze, gives an objective opinion about the diffusion tightness of that coating

Why is diffusion tightness such a critical item?
In order to prevent corrosion damage on structural steel, a protective coating can be applied. This coating is expected to maintain a barrier function between steel and water and must be as watertight as possible.

Salts and corrosion residues on the steel surface attract the water, even through a coating. Therefore, the coating applied needs to be diffusion tight. The diffusion process itself can be influenced by different factors, eg. salt residues, dust or dirt on the substrate, solvents in the coating, water quality, etc. In order to determine whether one coating performs better than the other, a specific method of measuring and comparing these coatings is addressed.

Applied measuring methods for diffusion tightness
One accepted method is determining the water vapour transmission rate by the dish method or the cup method (NORM ISO 2528). A small amount of water is kept air-tight in a metal cup, closed by the coating film to be studied. The weight of the total case will be determined at the beginning of the test as well as at the end, while keeping the film thickness in mind, and both results are compared to determine the vapor loss or water loss through the coating film. The cup will suffer different conditions due to changes in temperature and humidity. These results are put in g/m² per day.

Another test for measuring diffusion tightness is the Δ-T Test. This test determines the diffusion rate of water through the coating, based on several parameters eg. the layer thickness of the coating, application of the coating, temperature and quality of the coating. The result of this test is put in days until bubbles appear on the coating surface.

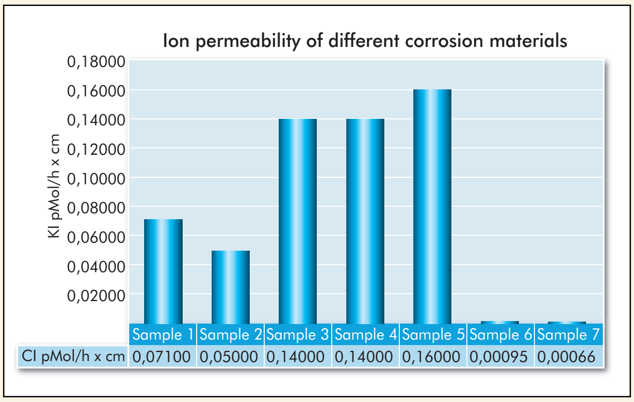
A new measuring method is put into practice…
For the first time during a project in the hydro power sector, quality assurance measures onsite included a new test method for the diffusion tightness. For renovation of the corrosion protection in the Wehr project's pipelines, substrate-free coating films of Humidur ME were produced. In parallel to the application of the Humidur coatings, one-layer and two-layer coating films were applied to a non-adhering foil.

After curing, the films were sent to the laboratory of Mr. DI Heinze (Germany), in order to investigate the ion permeability.

The ion permeability test is a new method to measure quickly, with evidential results, the diffusion tightness and consequently the effectiveness of a coating as a corrosion protection (for further information, see www.ionperm.de). The smaller the ion permeability (IP) and the lower the value of the constant CI, the better the corrosion protective effect of the coating. The constant CI is a reference value that does not depend on the layer thickness.

The diagram below shows the test results of:

- The blue one-layer coating Humidur ME on the pipeline in Wehr.
- The two-layer coating Humidur ME, one blue and one yellow, compared to several conventional coating systems. The one-layer as well as the two-layer Humidur film reveal an essentially lower permeability for ions and therefore a higher diffusion tightness. Consequently, the corrosion protection by Humidur compared to the other coating systems is expected to be considerably better.



Description of the tested coating materials:

- Sample 1 - Epoxy - coaltar combination, solvent free, two layers
- Sample 2 - Epoxy coating material, solvent free, two layers
- Sample 3 - Epoxy - coaltar combination, solvent free, water emulsifying, four layers
- Sample 4 - Epoxy coating material, containing solvent, four layers
- Sample 5 - Epoxy - coaltar combination, low solvent content, four layers
- UWW 1 lb - Humidur ME, one layer
- UWW 2lby - Humidur ME, two layers

These results also confirm the excellent anti-corrosion properties of Humidur. For the Wehr project in particular, the anti-corrosion protection is expected to have a very long life.

Further information about this project and references in the hydro power sector can be found on www.acotec.be or www.corrotec.at.

With consent of engineer Peter Heinze, PH Ionenpermeabilität, Germany and Schluchseewerk AG, owner of the Wehr hydro power station, Germany.

brushed once more and the welding joints were treated with a brush. After quality assurance personnel approved the treated surface, a second layer of Humidur was applied, with the third yellow layer sprayed on the bottom plate and on the sickle-shaped part.

Since no maximum intermediate curing times are needed for this coating, and the fact that the waiting time before the application of the next layer only depends on the mechanical load-bearing capacity (whether the work station can be moved over the coating), a more flexible way of working is possible when compared with traditional coating systems.

The finished average layer thickness amounted to 1200 µm, with 1400 µm applied on the bottom plate and the sickle-shaped part.

Conclusion

To ensure the Wehr hydro plant was only out of service for a short time, the schedule for this project was very tight. The use of the Humidur coating system helped ensure the execution time for this project remained short.

Thanks to the experienced quality assurance team and extensive assistance provided by the coating supplier, the project was completed successfully and to a high quality. New dimensions were reached on this project with regards to the built-in coating quality. IWP&DC

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