# Repair of the anti-corrosion protection of the pressure pipeline at Naturno (Italy) hydropower station

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Summary: The company Azienda Energetica S.p.A. decided to repair the severe corrosion damage to the inside of their pressure pipeline and to the closing devices, after having had them in use for 40 years. The 2000 m long pressure pipe (diameter 2,0 – 1,8 m), with a drop height of 1.135 m, was out of use for three months, from February till mid May 2001, during which period it was treated completely. The old coating, based on coal tar, was removed by sand blasting and the surface was coated in two layers with the solvent free two-component epoxy resin system Humidur®.

## 1. General information about the hydropower station and the pressure pipeline

### 1.1. Power station

The power station in Naturno is the most important and largest installation of Etschwerke AG (Azienda Energetica S.p.A.). It was constructed in the early sixties and came into use in 1963. The hydropower plant is located at the edge of a place called Naturno (in the neighbourhood of Meran) on the river Etsch and was conceived as a peak current power station.

The power station, with an average gross drop height of 1.135 m, is supplied mainly by the reservoir of Vernagt. The reservoir is connected by means of a 15 km long pressure tunnel to the surge chamber built on the mountain Sonnenberg. From the closing devices in the cavern of the surge chamber, a 2000 m long pressure pipeline leads to the power station at the foot of the Sonnenberg.

The power station is equipped with three horizontal doubled Pelton-turbines. Units 1 and 2, (each of them with 60 MW) were installed in 1963. In 1986 a third doubled Pelton-turbine was added, with a capacity of 100 MW. The maximum quantity of water floating through is 18 $m^3$/sec. The yearly energy production of the power station amounts to about 340 GWh.

### 1.2. Pressure pipeline

The whole pressure pipeline is made of steel plate. The first part lies in the tunnel, part of which, up to the sliding gate room, lies in concrete. In this room, two throttle valves are installed, as well as a diversion pipe with a length of about 4 m. The next 100 m of the pipeline lie freely in a horizontal tunnel. Once the pipeline leaves the tunnel, it lies in open air on the mountain slope, down to right in front of the power station, where it goes underground again and, after passing through a short inclined gallery, ends in the distribution pipeline.

Up to the sliding gate room, the diameter amounts to 2400 mm. Further on, it splits up in three parts that have about the same length, but smaller diameters of respectively 2000, 1900 and 1800 mm. The pipelines are supported by a saddle-shaped column, the buckles are anchored in the concrete. The section is divided by 18 buckles into 17 sloping pieces. Under each anchor block, an expansion piece is built in.

The picture on the left shows the pipeline, enveloped in a nearly 5 cm thick insulation, covered on the outside with aluminium foil and canvas. The insulation was applied in the late autumn of 2000, so before the pipe was emptied.

## 2. The concept

### 2.1. Starting point, corrosion damage

Large surfaces of the old coating, on a tar basis, were destructed by rust pustules. These pustules were several cm wide and high. In the bottom area, almost no smooth areas without pitting corrosion or perforations remained to be found.

## 2.2. Planning, coating product, allotment, terms

For the elaboration of the project, to draw up the tender, to evaluate the offers and to choose the company who would execute the works, a project group was assembled in 1999, with representatives of Etschwerke AG and TIWAG.

Of the utmost importance for the project was to decide which coating product would be applied (influence on the installation of the site, acclimatisation, way of entering the pipeline, blasting quality, application, controls, term planning, and so on). Together with TIWAG, several possible alternative solutions, with their advantages and disadvantages, were thoroughly compared. Important aspects for the technical assessment were amongst others the results of the different anti-corrosion systems in reference projects.

In the frame of the assessment of the technical projects, the thick layer product Humidur® with its specific advantages for projects concerning hydro power stations, proved to be the most appropriate system. Moreover, taking into account the period of time during which the works had to be executed, from mid February to mid May, as well as the prevailing exterior circumstances (location of the pipeline, exterior climatic conditions, etc.), calculations showed that under these circumstances and within the terms set forth by Etschwerke, the project was feasible with Humidur® only.

### Coating product

The advantages of this coating product are essentially the easy, thick layer application, the easy method for small repairs (the same product can be applied with a spatula), the possibility to apply the product also at very low surface temperatures (wintertime, high mountains, pipeline in open air, consequently, in spite of the insulation, temperatures below 10° C can be expected, at least temporarily), a lot of references in the field of pipelines, solvent free, high quality, guarantee, and so on.

### Allotment

In the closed invitation for tender, with pre-selection, five international bidders participated. The allotment was granted to the company Ko-Schutz Oberflächentechnik Ges.m.b.H. from Austria (best project, acceptable price, full guarantee for five years, long term experience with Humidur® in hydro power stations, trustworthy and respecting the terms).

### Summary of the terms

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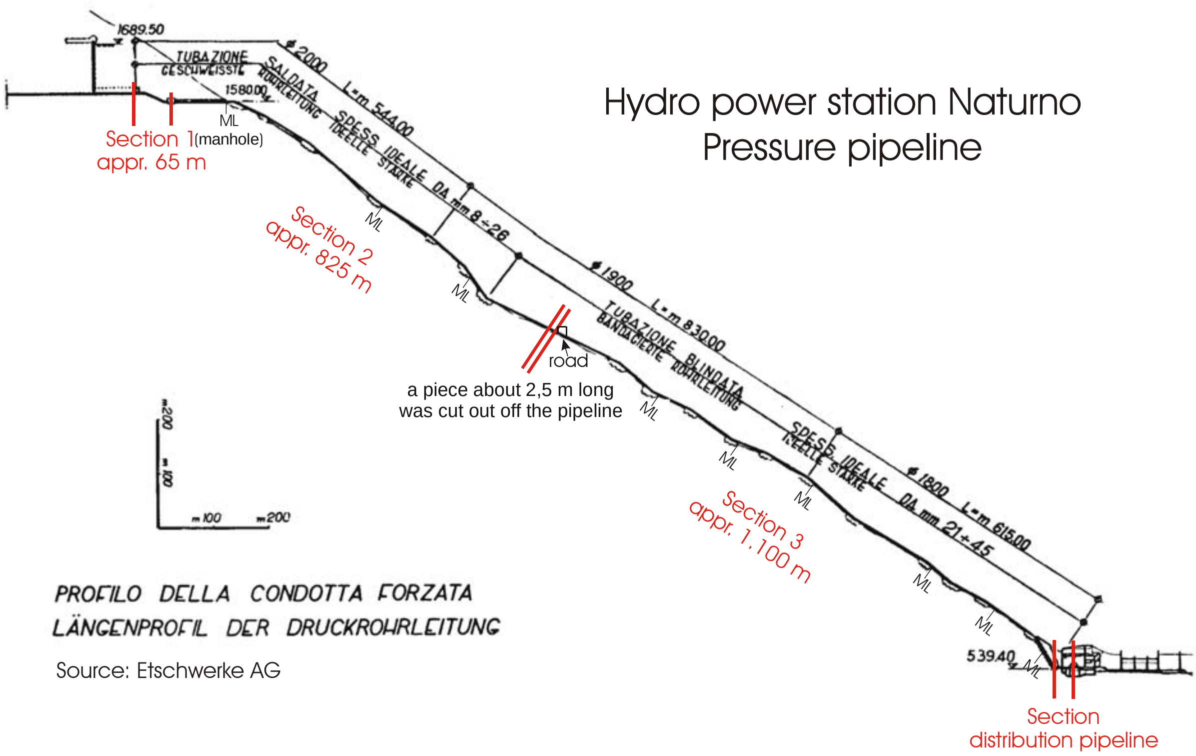
|---|---|
| Insulation works and installation of the site | November 2000 till January 2001 |
| Emptying | 12th of February 2001 |
| Start of the execution | 14th of February 2001 |
| Finishing of the final coating of the last section | 20th of May 2001 |
| Filling of the pressure pipeline | 25th of May 2001 |
| Power station connected to the power supply system | 1st of June 2001 |

## 2.3. Lay-out of the site installation

The following sketch gives a survey of the installation of the site and the actual division of the working sections.

As the pipeline is 2000 m long and had to be completely treated within 90 days, it was divided just above the middle. The only road on the mountain side crosses the pipeline at about 1.100 m, measured from the bottom side. At this spot, a piece about 2,5 m long was cut out off the pipeline, so two completely separate sections, with separate acclimatisation and separate means for entering the pipeline for both halves.




## 2.4. Installation for entering the pipes

The installation for entering the pipes consisted, per section, of a rope winch, the drag cable to which the trolley was connected and cables that were used to attach the material trolley. These cables, with the cable blocks attached to them, also function as a support for the rigging for the drag cable and to avoid that the drag cable would sag or drag too strongly on the surface. The whole of the installation for entering the pipes was of course in theory and later on during its construction tested and inspected by independent experts.

On the **material trolley**, a platform and the sandblasting equipment were installed. The platform was on the one hand used to put the sandblasting material on, temporarily, and on the other hand to collect the sandblasting material that was polluted by the old coating. The sand blasting material, which could be used several times, was separated as thoroughly as possible and shovelled back into the sand blasting unit. The sandblasting was done in sections of about 20 m. The material trolley was attached to the cables and, as it was connected to the working trolley, moved downward to the section that was to be treated.

Due to the different inclinations in the pipeline (about 20° up to almost 60°), the **working trolley** was equipped with two adjustable working platforms. Another important aspect of the working trolley was the two-way communication possibility. A telephone wire was at the same time also used to communicate the control to the security division (for emergency exit, to correct sagging of the cable, …)

### 2.5. Acclimatisation, storage, organisation

At the upper and the lower end as well as in the middle, supply and exhaust air pipes were installed for both sections of the pipe on the slope. Since, as mentioned before, there was only one possibility for access with a motor vehicle over one road, it was necessary to install temporary storage rooms for the sand blasting and coating material. Supply and removal was only possible by helicopter.

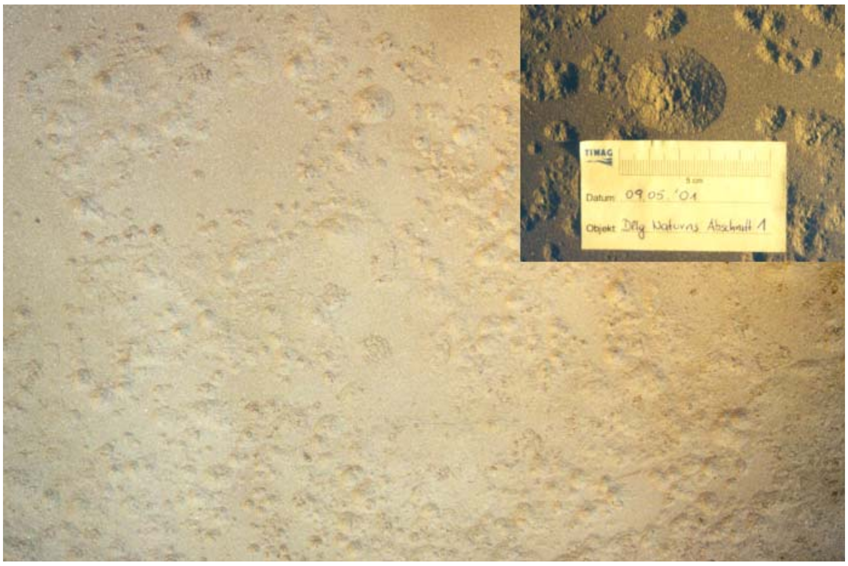
The picture on the left, which was taken after completion of both section 2 and 3, shows the installation of the site at the station in the middle without housing. In the background, you can see the winch chamber. The pulley block is fixed on the lower part of the upper pipe.

After the coating on the slope was finished and the installation for moving through the pipe was disassembled, the piece of the pipe that had been cut out was put back, welded, tested and coated with Humidur®.

It turned out that the **insulation** was not only necessary as a protection against direct sunlight (the slope is located on the south) but also during severe winter time (even on the 20th of April about 50 cm of snow fell) the insulation of the pipeline proved to be necessary. Thanks to the insulation the effect of temperature variations was weakened and the climate (ambient temperature and humidity) could be kept optimal, so that no problems with the dew point turned up. Since, due to reasons of time and efficiency, rather large sections were treated (e.g. 2400 $m^2$ per part of a section), temperatures below the dew point and condensation on the pipeline just before application of the coating, would have been a serious problem.

**3. Removing rust by blast cleaning**

The old coating layer was removed by blast cleaning, first from the top to the bottom. Next, the surface was blast cleaned a second time with new blasting material up to a purity degree of Sa 2 ½ (R,z>40 µm) and de-dusted. This work was done simultaneously in the upper and the lower section (section 2 and 3). After section 2 was completely cleaned and coated, section 1 (surge chamber) was blast cleaned and coated. Finally, the distribution pipeline was treated, since section 3 had to be finished first. For reasons of safety, it was not possible to work in the inclined part (section 3) and the distribution pipeline at the same time.




The picture on the left shows the enormous corrosion damage, visible after removing the rust by blast cleaning.

**4. Structure of the coating application**

After approval of the sand blasting works by the quality assurance personnel of TIWAG and a sample survey test of the welding joints, the partial section concerned was released for coating. In the description of the working method, due to the corrosion damage (especially on the bottom) and to the load that it is expected to be subjected to, it was prescribed that Humidur® would be applied in two layers, of two different colours (the first layer squirrel grey, the second and final layer pure white) with a total dry layer thickness of at least 800 µm on the bottom (circular segment between 4 and 8 o'clock) and at least 600 µm on the remaining part. The application was carried out crosswise, by means of Airless spraying equipment.

After a drying time of 48 hours, it was possible to drive over the first coating layer (applied directly on the steel – no primer) with the trolley, and to check it visually for pores. Open pores, severe pitting corrosion and perforations were repaired with Humidur® P, using a spatula, after which the second and final layer of Humidur® was applied.

Since the coating product does not need any drying between two layers and neither needs a long curing time, compared to conventional coating systems (with primer, several coating layers and long drying times between layers), it makes more efficient working and consequently shorter downtime of the power plant possible.

Thanks to a higher layer thickness for the first layer (about 400 up to 500 µm respectively 700 up to 1000 µm in very severely corroded areas such as the bottom and welding joints) application with a spatula on large surfaces could be avoided. The average layer thickness on the bottom was about 1200 µm and on the rest of the surface about 900 µm.

## 5. Measures taken to assure the quality

In order to finish the project in the shortest possible time, so that the power station would not be out of order for too long, not only the choice of an efficient coating system, but also the accompanying and flexible quality assurance was a decisive factor. TIWAG's experts, charged by Etschwerke, supervised the project from the analysis of the condition of the pipeline onwards, up until the final tests on the new coating, in order to assure an optimal quality.

The quality assurance was, by analogy with the importance of the project, very extensive and consisted, next to a very intensive involvement and coordination of all parties involved, of following the precise technical specifications for the works to be done, establishing the duration and criteria of the guarantee, as well as concrete parameters and tests (see literature: Rainer, Quality Assurance).

## 6. Details for the execution of works in separate sections

### 6.1. Section 2 – partial section flat part

The first partial section in section 2 was a flat part of about 100 m up to the first bend (about 700 m$^2$). The picture shows the application of the first Humidur® layer on the cleaned steel surface.

## 6.2. Section 1 – surge chamber

The surge chamber, which is located on the Sonnenberg, at the end of the pressure tunnel, was completely carved in the rock. The two-room surge chamber consists of a perpendicular rising shaft, a ring-shaped lower room and a rectangular upper room. At the end of the ring-shaped lower room, the reinforced concrete changes to steel armour (the highest spot for the anti-corrosion treatment of the pressure pipeline).

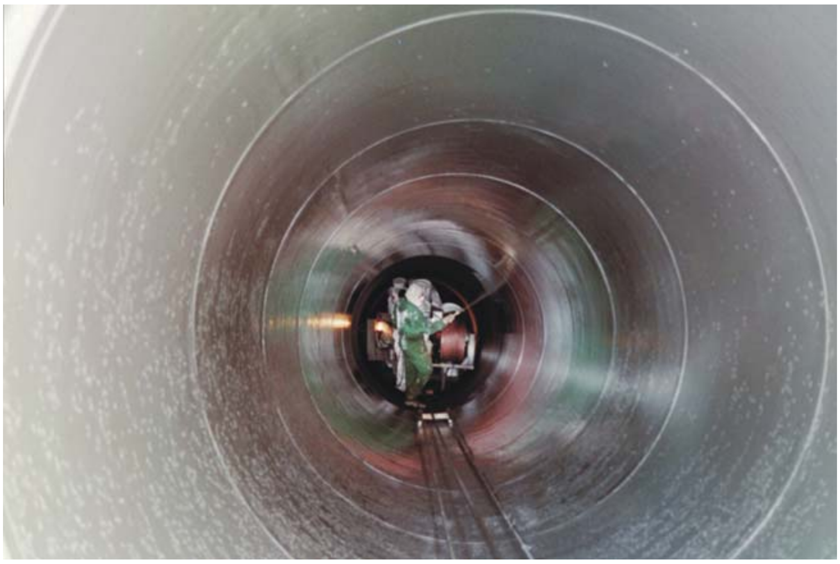
The two butterfly valves that flange the bottom side of the S-shaped armoured supply tunnel, and the diversion pipeline were disassembled. The picture shows the application of the second layer of Humidur® on the S-shaped supply water tunnel. The diameter is 2,4 m, the length up to the sliding room about 65 m. Since the slope was not steep here and not too long, it was not neces sary to use a trolley.

## 6.3. Section 2 and 3 – sloping surface

Section 2 and 3 were divided into several partial sections and each time sandblasted twice. A serious problem was that, on the flat surfaces, the mixture of sand blasting material and old coating did not slide downwards and an extra man was needed for transport of the material. Separating the sand blasting material and the old coating was hard and could only be done with pneumatic means. Collecting and removing the enormous amount of old coating for disposal was hard work for the whole crew.

Just as for the other sections, after the surface had been sandblasted a second time and thoroughly de-dusted, the quality of the sandblasting work was checked by the quality assurance experts of TIWAG. The surface was tested on its purity (Sa 2 ½), roughness (sample survey measurements), on the presence of dust (test with adhesive tape) and on contamination by chlorides and salts. The values found for chlorides and salts were between 20 and 30 mg/m$^2$. Remark: basically, the concentration should be as low as possible, but in any case lower than 40 mg/m$^2$.

In the sloping area too, the perforations and pitting corrosion were deep, especially on the bottom, where the old coating was probably already damaged in an early stage by abrasion.

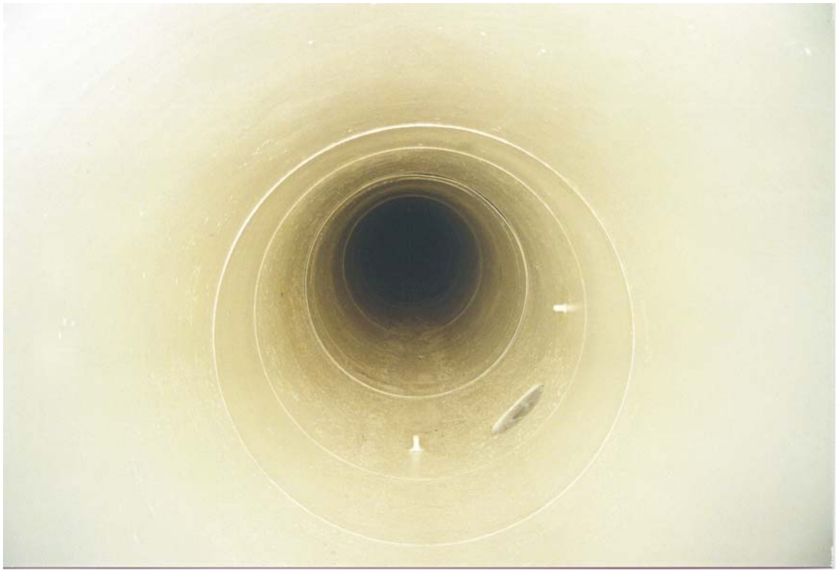


After the sandblasting had been checked, the working trolley was loaded with Humidur® and the first layer of Humidur® was sprayed from the top to the bottom. The Airless spraying equipment was installed on the other end of the trolley, on which the two components of Humidur® were mixed too. Since the ambient temperature temporarily fell below 10° C (especially at night and depending on the temperature outside) only 100 m away from the spot where air was blown in and the Humidur® product cooled down too much, it was necessary to use electrical equipment to heat up the Humidur® product before mixing. Remark: the ideal temperature for the material before mixing is between 20 and 25° C. Additionally, the 10 m long spraying hose too was electrically heated up to about 35° C.

The picture on the left shows the finished first applied layer on the area of a positive bend in the pipeline and the cables and the deflection pulley of the trolley installation. Since the spraying was done from the top to the bottom and the working trolley stood under the newly sprayed surface, the sandblasting works could be continued during curing time. After 48 hours the trolley could drive over the coating and the second layer of Humidur®, this time white-coloured, could be sprayed.

After sufficient curing time, the whole surface was checked for pores with high voltage detectors and the layer thickness was measured. When, during the final checking, pores were found, they were coated with Humidur® (variant for application by brush). Remark: also on the almost cured Humidur® surface, another layer can be applied without blasting or roughening, at any time. This property is an important advantage for applications of more difficult projects. For the treatment of separate sections, it is not necessary to follow a strict time schedule or plan for the different layers (as is the case with traditional products).

Next, the adhesion of the coating was tested by means of the hydraulic adhesion tester P.A.T. (Precision Adhesion Test equipment) and the values were written down in reports. Measured adhesion values of 21 MPa confirm Humidur®'s excellent adhesion.



The picture on the left shows the finished coated pipeline after the trolley installation has been dis-assembled. On the right side there is an inspection manhole, (38 x 28 cm, oval), which was closed during the reparation works, by means of a wooden form.

## 6.4. Section 4 – Distribution pipeline

The distribution pipeline lies in concrete, in a gallery in a rock. From this pipeline, 6 junctions, with a diameter of 700 mm, lead to the separate turbines, over the spherical valves.

The picture on the left shows the distribution pipeline, after the coating was finished, getting more narrow from turbine to turbine. At the end of the distribution pipeline, the exhaust pipes for the acclimatisation were installed.

The distribution pipeline was the last section that was treated and there was not much time left. Immediately after the second layer had been applied, the last spherical valve as well as the diversion pipe were assembled, so that quality controls and improvement works (pores remaining here and there) on the 20th of May 2001 could only be performed at the end of the distribution pipeline, past the further lying exhaust pipes. Therefore, the short final drying was partially done without acclimatisation.

On the 25th of May finally, all inspection manholes were closed, the expansion devices were checked, the pipeline was flushed, the opening at the end of the distribution pipeline was closed and the pipeline was filled, in order to be able to let the machines run a first time, as a test. On the 1st of June 2001, the power station was connected to the net again, as planned.

## 7. Conclusion

Based on an ambitious project for the anti-corrosion treatment of the pressure pipeline, the time needed to execute the works could be restricted to 90 days only. Compared to projects with traditional products and methods, this anti-corrosion system did not only decrease the risk in situations where quality and time are of the utmost importance. Thanks to the essentially short execution time, downtime of the power station and the consequent economical disadvantages due to production loss, could be decreased considerably.

## 8. Literature list

Etschwerke AG: Wasserkraftanlage Naturns, Bozen, Meran *(Hydro power installation Naturno, Bozen, Meran)*

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