BETTER DRINK WATER FOR RO

Source: Hydro-Elektrik GmbH

The town of Jimbolia, with a population of just under 13,000, lies in the western part of Romania, approximately 600 kilometers from the capital of Bucharest, on the border with Serbia. The town's water supply consists of a functioning distribution network into which untreated well water from eight different deep wells was pumped via a temporary storage tank according to need. A water treatment plant built a little over 30 years ago with cascade ventilation was already shut

> "The existing wells are poorly sealed and in need of renovation

down again just a few months after commissioning, as the plant did not operate properly and the building was leaky and completely unusable **(Fig. 1)**.

The deep waters of a geothermal origin typical for the region (water temperature around 20 °C), are reduced, low-oxygen waters with an increased content of primarily ammonia, iron, manganese, in some cases arsenic and increased clouding. The existing wells are poorly sealed and in need of renovation, so that the regular occurrence of coliform germs is more the rule than the exception. In addi-

◀ Figure 1 Existing, dilapidated waterworks

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Turnkey production of a modern waterworks through successful cross-border cooperation.

tion, loading with TOC/DOC and hydrogen sulphide also proved to be unexpectedly high. This had not been indicated by the analysis values used as the basis for the design. The renovation of the wells over the next several years is planned in a further step.

An oxidation stage with ozone for oxidation and disinfection with a subsequent biological filtration stage was defined for the treatment process based on these water parameters. This process had also proven itself in a comparable smaller waterworks in the village of Bobda, which also belongs to the district of Timisoara. Disinfection at the end of the plant is carried out with chlorine – in accordance with the legal requirements in Romania.

Basic data

Based on a moderate increase in population over the next 25 years, the future average daily requirement according to the Romanian dimensioning criteria is Q_d = 2,027 m^3 and the maximum daily requirement is Q_{dmax} = 2,838 m^3. The maximum hourly consumption Q_{hmax} was calculated as approximately 190 m^3/h. For the water storage tank, a minimum volume of 1,014 m^3 (half the daily requirement) was determined. The treatment capacity was defined at approximately 50 l/s based on the maximum daily requirement with 16 hours of operation.

Basic conditions for project development

With deadline specifications for financing, the project had to be completed and the plant had to be in operation by the end of July 2010 at the latest in order

Source: Hydro-Elektrik GmbH

▲ Figure 2 Office complex with attached building for hydrotechnics system

Figure 3 Tank system with water treatment installations

Source: Hydro-Elektrik GmbH

Tab. 1: Composition and strength of important stainless steels

		Typical composite in %						MPa bei 20 °C*	
EN	ASTM	C	N	Cr	Ni	Mo	Sonstige	$R_{P0,2}$	R_m
1.4301	304	0.04	0,04	18.1	8.3	-	-	210	520
1.4541	321	0.04	0.01	17.3	9.1	-	Ti	200	500
1.4404	316L	0.02	0.04	17.2	10.2	2.1	-	220	520
1.4571	316Ti	0.04	0.01	16.8	10.9	2.1	Ti	220	520
1.4162	S32101	0.03	0.22	21.5	1.5	0.3	5 Mn	450	650
1.4462	S32205	0.02	0.17	22.0	5.7	3.1	-	460	640

* Minimum value of EN: MPa – MegaPascal (1 Pa = 1 N/mm²), $R_{P0,2}$ – 0,2 % Dehngrenze, R_m – Zugfestigkeit

Source: Hydro-Elektrik GmbH

to secure the EU grant in the amount of Euro 1,000,000. Due to these specifications, the operator (Aquatim) responsible for the region and the municipality decided in favour of the plans of the Romanian engineering office Aqua Plan West, which designated the building of an industrial building with an office complex for the administration and an attached plant building for the hydrotechnics system **(Fig. 2)**.

The hydrotechnics system was in turn mainly divided into two stainless-steel raw water tanks with a capacity of 100 m³ each, a three-line filter system with a treatment capacity of up to 65 m³/h each and two stainless-steel pure water tanks with a capacity of 570 m³ each. This design made it possible to achieve rapid completion of the construction phase with top quality at comparatively low costs. With conventional concrete tank systems, it would not have been possible to realise this project in this quality, and especially not with such a short building period.

> So-called Duplex-Steels have excellent corrosion resistance

The order in the amount of approximately € 2,100,000 for the turn-key production of the entire plant went to the Romanian company HES from Timisoara together with the company Hydro-Elektrik GmbH in Ravensburg, Germany, as a sub-contractor. Here Hydro-Elektrik GmbH was responsible together with HES for project planning of the plant and for the delivery of all hydraulic and electrical components. The tight time schedule required excellent coordination and scheduling reliability of all partners and parallel production of the technical components at the manufacturing plant in Germany.

The start of planning and construction was in October 2009. Due to the frost to be expected, the concrete floor plate had to be poured and loadable for the installation of the tanks and the building shell had to be built before Christmas of 2009. Despite the at times inclement weather, these goals were achieved. At the same time, the filter tanks and the raw water tanks were produced at the manufacturing plant in Germany. Despite the fact that winter had meanwhile come with snow, the transport and installation of the two raw water tanks and the three filter tanks were transported and installed in the production building on schedule in the week before Christmas of 2009. The conclusion of this work was the preassembly of the supporting floor structure for the pure water tanks. It was therefore still possible to close off and dry the production building inside in time before Christmas. The lean-mixed concrete for the supporting structure of the pure-water tank bases were installed in mid-January. This enabled the pure water tanks with a capacity of 570 m³ and a diameter of 10 meter each to be welded in on site with a special process from the end of February.

Choice of materials

Non-corrosive steels are alloy steels with a chromium content of at least 10 percent. When combined with oxygen, a dense and chemically resistant chromium oxide layer forms on the workpiece surface. This layer just a few atoms thick (referred to as a passive layer) is resistant to many aggressive media and requires no further surface protection for stainless steel. This means that the water is to a certain extent isolated from the alloy elements of the stainless steel by a separating layer.

Mainly austenitic steels are used in the area of the drinking water supply, such as the qualities 304 and 321 respectively the higher alloyed steels 316L and 316Ti. These steels are alloyed with a chrome content of approximately 18 percent **(Tab. 1)**. The higher alloyed steels have an additional content of 2.1 percent molybdenum. The physical properties of these four types of austenitic steel are for the most part identical.

Until a few years ago, so-called Duplex steels were still relatively unknown in water management. These steels have a ferritic and austenitic structure (therefore the name Duplex) and have a considerably higher strength. Due to their much higher chromium content of around 22 percent, these steels also have excellent corrosion resistance, particularly in aqueous solutions. The resistance of Duplex steel S32101 (with an intact passive layer) is higher than that of 321 or approximately as high as that of considerably more expensive 316Ti steel. The high mechanical strength which, however, places especially demanding requirements on processing, but enables a reduction in the material used by up to 25 percent for the dimensioning, is particularly impressive for Duplex steel.

This is the reason why Duplex steel S32101 was selected for the tank systems (raw water storage tank with a diameter of 4.1 m and pure water storage tank with a diameter of 10.0 m). The compact drinking water systems are manufactured completely of high-quality stainless steel 316Ti, as here the highly oxidative level due to ozone had to be taken into account. The connecting pipes are produced of stainless steel 321.

Raw water system

The raw water from the various wells is routed to the new waterworks via a collecting pipe. Following measurement with MID, the water is distributed to the two tanks with an automatic cleaning device and temporarily stored. Shortly after commissioning, heavy deposits already formed on the bottoms of the tanks, which indicate overloaded or bad wells. In addition, outgassing of hydrogen sulphide occurs in the tanks. The tanks also enable additional ventilation for oxygen enrichment and for outgassing of hydrogen sulphide.

Ozone bio-filtration stage

Under the influence of ozone as a strong oxidation agent, the organic carbon compounds with a high molecular weight are split and the concentrations of the compounds with a low molecular weight are increased. This process also increases the levels of assimilable materials (BDOC = Biodegradable Dissolved Organic Carbon) and almost completely destroys the substances providing colouration – provided that there is a sufficient dose of ozone.

In the case of the assimilable fractions, a distinction is again made between slow biodegradable substances (SBDOC)** and rapid biodegradable substances (RBDOC)*** [2].The described conversion of the DOC into assimilable substances also explains why an ozoning stage must always be followed by a biologically optimised reactor or filter. This is normally a filter stage with downstream flow, constructed specifically as a bioreactor and in which the mineralisation or reduction of the amount of nutrients takes place in a completely natural way.

The zone with the highest level of biological activity is in the upper filter bed, because this is where the largest amount of nutrients with rapidly biodegradable substances (RBDOC) is present. End products include water and carbon dioxide.

Ozonation

Generally, both the DOC and the colour must be taken into account when determining the required ozone dose. Depending on the DOC/colour ratio, ozone doses of between 0.8 and 2.5 mg O_3/mg DOC are required. It is obvio-

** SBDOC = Slow Biodegradable Dissolved Organic Carbon
*** RBDOC = Rapid Biodegradable Dissolved Organic Carbon


Source: Hydro-Elektrik GmbH

Figure 4 Pressure booster system for pure water supply

us that at such high doses, excellent and fine-bubbled mixing-in of the ozone followed by blending is extremely important. Venturi/injector combinations have proven especially successful, with which the entire water flow is treated with a highly-concentrated ozone/air mixture. The reaction with slow-reacting water constituents takes place in the downstream reaction tank. The substances providing colouration have already mostly been destroyed with ozone shortly after the initial reaction. Iron, manganese and arsenic are oxidised, as is any hydrogen sulphide still present. The disinfection, in which viruses, parasites and germs alike are reliably killed due to the high concentration time (CT) values, occurs parallel to the oxidation. Due to the long period spent in the reaction tanks and the high ozone doses, a generously dimensioned ozone biofiltration system – despite its high ozone consumption – is also always a reliable barrier in accordance with the multi-barrier principle. The target ozone contents at the end of the reaction line should therefore not be less than 0.2 and 0.3 mg O3/l. The ozone generators installed in this system supply up to 3 x 150 g ozone per hour, which is equivalent to a maximum ozone dose of 2.3 g/m³.

Oxygen production

Technically produced oxygen is used for ozone production. So-called PSA systems are suitable for decentralised oxygen production. These increase the oxygen content up to a purity value of up to 95 percent by filtering out nitrogen. PSA stands for Pressure Swing Adsorption. In the first step, the air must be compressed, dried and filtered. Standardised compressor units with a compressed-air cooler are generally used for this purpose. The compressed air pressed to 7.5 bars in this way is fine-filtered and fed to the oxygen generators. The oxygen generators consist of two tanks filled with so-called molecular sieves. When pressurised, these molecular sieves absorb atmospheric nitrogen. This results in an increase in the oxygen concentration outside the sieve. During the first pressure relief, oxygen escapes which is specifically routed into the oxygen tank. With a complete drop in pressure, the oxygen also escapes from the molecular sieve again. It is routed directly to the outside air.

Filter design

The filter in the ozone biofiltration system must fulfil several tasks. Besides breaking down residual ozone in water – a prerequisite for biological activity – and holding back turbidities, particles and viruses, the filter must also be a good bio-reactor. In principle, biological colonisation occurs on almost all filter materials. However, it must be noted that filter systems used in water treatment must also cover downtimes.

Materials based on active porous carbons or filter carbons are far superior here to other porous materials (e.g. pumice or broken bloating clay). In the first few weeks, absorptive acting carbon takes on a very heavy load of organic materials, and therefore also probably represents a source of nutrition for the micro-organisms during filtration downtimes. The colonisation of a filter with activated carbon also occurs more quickly than is the case with other materials. The water temperature has only a slight influence on the bioactivity and breakdown rates with respect to the DOC, which can be up to 30 percent.

Biologically active filters should only be flushed with water. Depending on the filter design, backwash-water quantities to be used vary between 35 and 45 m/h. The amount of backwash-water need is around 5 to 6 m^3 per m^2 of filter area. Air flushing must be checked in individual cases. After flushing the filter, the first filtrate (approximate quantity of a filter volume) must be carried off. The filter run times must be adapted to the respective raw water conditions. Less than 1.5 percent of the treated water quantity must be used for the filter flushing. Ozone biofiltration systems can be operated round the clock without any problem. It is preferable to use chlorine or ozone for the final disinfection.

Pure water supply

Pure water is pumped by means of a fully automated pressure booster system with four pumps. The system supplies up to 240 m^3/h at constant pressure and approximately 30 m WS.

Summary

A cross-border-cooperation requires particular care when managing the project. A certain incalculable residual risk must always be taken into account. Residual risks are in particular the type of financing and the reliability and the informative value of water analyses.

References:

[1] NTNU – Norwegian University of Science and Technology, Trondheim, Prof. Dr. Hallvard Ødegaard.

[2] „Testing Ozonation-Biofiltration Plant" SINTEF in Trondheim/Norway; Results of a research assignment of Hydro-Elektrik GmbH, 1999-2001.

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ABSTRACT

Die Stadt Jimbolia (dt. Hatzfeld) liegt im westlichen Teil Rumäniens. Die Wasserversorgung der Stadt besteht aus einem funktionierenden Verteilungsnetz, in das unaufbereitetes Brunnenwasser aus acht verschiedenen Tiefbrunnen eingespeist wurde. Bei den für die Region typischen Tiefenwässern handelt es sich um reduzierte, sauerstoffarme Wässer mit erhöhten Gehalten an Ammonium, Eisen, Mangan, TOC, Schwefelwasserstoff sowie erhöhter Trübung und bakterieller Belastung. Für den Aufbereitungsprozess wurde auf Grund dieser Wasserparameter eine Oxidationsstufe mit Ozon zur Oxidation und Desinfektion mit nachfolgender biologischer Filtrationsstufe festgelegt. Die betriebsabschließende Desinfektion erfolgt mit Chlor. Die Wassertechnik besteht aus zwei Rohwasserbehältern (je 200 m^3) aus Edelstahl, einer dreistraßigen Filteranlage mit je bis zu 65 m^3/h Aufbereitungsleistung, zwei Reinwasserbehältern aus Edelstahl mit je 570 m^3 Inhalt sowie einer Druckerhöhungsanlage. Durch diese Konstruktion konnte eine zügige Bauabwicklung mit höchster Qualität bei vergleichsweise günstigen Kosten erreicht werden. Planungs- und Baubeginn war im Oktober 2009, Inbetriebnahme der Anlage im Juni 2010.