# Innovative Drinking Water Softening forms the Basis for a Joint European Project

*As part of the cross-border EU-subsidised project "Safeguarding the water supply in the German-Luxembourg border area", the three neighbouring water supply associations along the River Mosel (SIDERE (Luxembourg), Verbandsgemeindewerke Konz (VGW Konz, Germany) and water supply Saar-Obermosel (WSO, Germany)) have agreed a joint action plan in order to guarantee the supply of water in the future. To this end, the hydraulic capacity of the existing central drinking water treatment plant Wasserliesch (VGW Konz) had to be extended, and the approximately 30 year-old plant had to be fully renovated to reflect the current state of the art.*

## The starting situation

Luxemburg's *drinking water association SIDERE* (Syndicat Intercommunal pour la Distribution d`Eau potable dans la Région de l`Est), which was founded in 1994, today supplies an area that covers a total of 11 communities with a daily water consumption of up to 11,000 m$^3$. The continuous increase in water consumption coupled with more dry spells has highlighted the worrying shortage of water in this area. Although far-reaching infrastructure measures such as the expansion of central water reservoirs have prevented the threat of supply shortfalls, they have not solved the basic water shortage problem.

VGW Konz with the branches water supply and waste water disposal were founded as part of the administrative reform in 1976. According to the new municipal regulations, the tasks of water supply and waste water disposal were transferred from the individual communities to the newly founded municipalities. The VGW Konz works supply the town Konz and its numerous surrounding districts and outlying communities having a total of approximately 32,000 inhabitants and an annual water turnover in excess of 1.4 million m$^3$.

The former water works Trier-Saarburg has been closed in 2009 and the existing plants were transferred to the newly founded *Water Supply Saar-Obermosel (WSO)*, which supplies the communities in the regions Konz and Saarburg with drinking water.

## The subsidised program INTERREG

The European Union uses European regional development funds to subsidise cross-border cooperation between neighbouring areas in order to create a common living, natural and economic area and to strengthen the border regions on a long-term basis. The supported project "Safeguarding the water supply of the population on both sides of the Mosel in the German-Luxembourg border area" (www.interreg-4agr.eu) offers an approach for safeguarding the water supply through cross-border cooperation.

With collaborating and creating collective structures (networking the two supply systems) an improvement of both the quality standards and the efficiency of the water supply are expected.

The central agreed target of supplying water to Luxembourg has made the following subsidised net investments necessary.

On the German side (VG Konz):

- The construction of 6 new wells in water works Wasserliesch
- Conversion/renovation of the drinking water softening plant in the water works Wasserliesch
- Renewal of the machinery in the pumping station Oberbillig

On the Luxembourg side (SIDERE):

- Construction of an underwater pipeline through the Mosel
- approx. 1,000 m water pipeline construction
- Construction of a transfer shaft.

The budgeted total investments of € 2,812,800 are being subsidised by the EU with approx. € 843,840 as part of the INTERREG IV A Greater Region 2007–2013 program.

## Water treatment with RDC softening in water works Wasserliesch

The raw water from several deep wells in the Allbach Valley has been collected in the high-level tank of Wasserliesch since 1977. It was already possible in 1984 to commence treatment involving softening with the RDC process (**r**apid **dec**arbonisation) followed by multi-layer filtration.

Softening in VGW Konz was necessary in order to halve the groundwater's high 28 °dH hardness. A further reduction of the water hardness to values below 15 °dH was and remains unachievable with rapid decarbonisation due to the high magnesium content in the raw water.

The softening system principally consisted of a 10 m high reactor for decarbonisation with lime milk and quartz sand dosing. The raw water was fed into the closed RDC softening process from the various deep wells as an initial treatment step. At the same time, a quantity-proportional amount of lime milk was added, with quartz sand being added discontinuously as a contact grain. The lime pellets growing in the fluidised bed were removed from the process discontinuously. The softened water (total hardness approx. 15–16 °dH) was forwarded out of the reactor into the central high-level tank, running off freely via a closed single-layer filter system in order to eliminate turbidities.

The main steps of the entire treatment process ran automatically. After almost 30 years of plant operation, the softening process control, the hydraulic adaptation to the fluctuating water demand, the lime milk treatment and addition, the contact grain infeed and the pellet extraction had to be renewed and harmonised to each other with a central, modern process controller.

## Renovation and optimisation

The renovation work started in 2011 on the central water softening system in the water works Wasserliesch (**fig. 1**). The aim was to soften and treat approx. 1 million m³/a water from the existing and new deep wells in the future. The basic idea behind the modernisation work on the existing plant was to continuously use the main existing installations and to optimally adapt them to the increased demand for water in the future from both a technical and operational point of view. In addition to the hydraulic extension of the entire plant, the aim was also to further reduce the total hardness of the water with high magnesium content. Besides renovating the RDC reactor and modernising the process sequence, all peripheral systems associated with the softening process were restructured from the ground up.

By integrating a nanofiltration system (NF) into the bypass of the RDC softening, it was possible to increase both the softening performance and the hydraulic throughput of the plant. A newly constructed process control system (PCS) with modern control and regulation technology guarantees an operating sequence that is as autarkic and as economically optimised as possible.

The capacity of the existing storage silo for holding the hydrated lime was increased to approx. 65 m³. Two lime milk batching and dosing tanks are loaded alternately via two volumetric dry material dosing units.

A completely newly constructed lime milk dosing/ring pipe system provides the hardness-controlled and pH value-controlled lime milk dosing in the RDC softening process. The lime milk dosing is guaranteed by two redundant centrifugal pressure pumps that maintain the supply system pressure in the ring pipe system.

The seed grain loading with quartz sand into the RDC reactor was also a completely new set-up and was made fully automated. During operation, quartz sand is added to the softening process from time to time, depending on the size of the fluidised pellet bed in the reactor. Automatic addition is performed by a process unit consisting of a quartz sand reservoir, a rotary feeder and an elevator feeder station carrying process water.

The surplus pellet mass is removed from the RDC reactor discontinuously and with process control during ongoing reactor operation. The pellets are transported by a simple centrifugal pump through an opening in the nozzle plate below the conical reactor area into the external sieving container, from which the pellets can be taken to be reused in agriculture.

The lower part of the existing RDC reactor (raw water infeed and fluidised bed) was completely renewed (**fig. 2**). This involved separating off the complete lower raw water section so that a new type of nozzle plate could be installed. The installation of an intermediate base in the RDC softening system has already proved to be extremely successful in the process known as the "Rastatt Process" using lime milk. The installation of the bell nozzle plate as an intermediate base in the existing RDC reactor has decisive advantages for the process sequence, for maintenance of the reactor system and therefore in terms of economy. As a result, with the newly developed system nozzles and by adding lime milk suspensions it is possible to reliably guarantee a clear separation between the pellet fluidised bed and the raw water chamber. Normally, it is not necessary to optimise the flow in the infeed section of the reactor. No sand or pellet displacements occur towards the raw water intake. All valves, units and pipelines on the raw water side are thereby protected.

Starting up of the reactor and the generation of a uniform piston flow is guaranteed at all times by the nozzle plate and the process control. Optimised and variable lime milk dosing via dosing lances above the nozzle plate guarantees optimum reaction kinetics and the associated optimum utilisation of the lime milk activity. The pellets are also removed via an opening in the nozzle plate, supported by fittings that direct the flow.

*Fig. 1. Panorama of the water works.* © VGW Konz

*Fig. 2. New intake, RDC reactor.* © Hydro-Elektrik GmbH

**Table 1.** Process parameters of the treatment plant in the water works Wasserliesch before and after the plant optimisation. © IB Eppler

| **Parameter** | | **Raw water** | **after treatment with old RDC system** | **RDC and NF system (reactor discharge)** | | **RDC and NF system (supply network)** |
|---|---|---|---|---|---|---|
| | | Wells 3 and 5 | Situation before 2012 | without $CO_2$ dosing | with $CO_2$ dosing (80 mg/L) | with $CO_2$ dosing (80 mg/L) |
| pH value | | 7.35 | 7.91 | 8.13 | 7.6 | 7.94 |
| Temperature | [°C] | 11.5 | 11.5 | 11.8 | 12.5 | 13.3 |
| el. conductivity (25 °C) | [µS/cm] | – | approx. 500 | 512 | 431 | 495 |
| Ca | [mg/L] | 101.7 | 32.6 | 33.8 | 37.9 | 41.4 |
| Mg | [mg/L] | 50.1 | 49.3 | 38.8 | 34.5 | 37 |
| Total hardness | [°dH] | 25.7 | 15.9 | 13.6 | 13.2 | 14.3 |
| Turbidity | [FNU] | – | 0.11 | 14.6 | 15.74 | 0.22 |
| Calcite solubility | [mg/L] | – | –2.63 | –3.7 | 2.83 | –5.8 |
| Saturation index | | 0.16 | 0.31 | 0.18 | –0.02 | 0.47 |
| $K_{s\,4.3}$ | [mol/m³] | 7.03 | 3.15 | 2.93 | 3.32 | 3.27 |
| $K_{B\,8.2}$ | [mol/m³] | 1.04 | 0.03 | 0 | 0.15 | 0.03 |
| $NO_3^-$ | [mg/L] | 1.8 | 3.3 | 2.1 | 5.7 | 1.6 |
| $Cl^-$ | [mg/L] | 33.9 | 37.7 | 34.4 | 8.9 | 30.4 |
| $SO_4^{2-}$ | [mg/L] | 105.4 | 91.2 | 80.8 | 63.4 | 83.2 |

Water circulation was subsequently integrated into the RDC softening process.

Slight turbulences in the pellet fluidised bed are designed via gentle circulation when there are longer production downtimes to avoid possible agglutinations. The circulation pumps guarantee internal water circulation with a minimum rate of ascent in the reactor.

Discharge out of the pressure-closed reactor takes place via an "overflow bell" in the reactor head. The bypass water softened via the NF membrane system (and which therefore contains carbon dioxide) is fed into the reactor head in order to further reduce the hardness and to prevent renewed calcification in the pipeline system as far as the filters.

*Fig. 3. RDC reactor (left) with filter system (centre).*


The feed water volume of the membrane system is approx. 35 m³/h, the permeate volume is 28 m³/h and the accumulation of concentrate is 7 m³/h. Pressure booster pumps upstream of the system generate the required pressure level (approx. 7.5 bar). A prefilter unit protects the membranes against contamination by particles from the wells.

A dose of low-phosphate anti-scalant is added in order to prevent inorganic deposits from forming on the membranes. $CO_2$ is also added from a storage tank in order to further reduce the dosage of anti-scalant and to adjust the $CO_2$ content in the bypass water flow. A further addition of $CO_2$ to adjust the pH value (close to the balance pH value) in the reactor discharge was also realised.

## Process parameters

The **table** shows as an example the treatment capacity of the entire plant at the water works Wasserliesch before and after the plant optimisation. In each case it is necessary to take into account the different raw water compositions when evaluating and comparing the data. The most important characteristics are:

- The total hardness can be reduced from approx. 16 °dH to approx. 14 °dH
- The addition of acidic permeate (if necessary enriched with $CO_2$) in the reactor head minimises the lime precipitation in the reactor discharge and improves the discharge turbidity with a comparable raw water matrix (**table 1**).

## Technical data of the complete plant (fig. 3)

- Drinking water production: approx. 1,400,000 m³/a
- Softening capacity: from 28 °dH to approx. 13–14 °dH by adding $Ca(OH)_2$ and NF permeate admixture
- RDC reactor:
  - Average daily delivery rate: $Q_m$ = 2,700 m³/d

- Maximum delivery rate: $Q_{max}$ = approx. 3,000 $m^3$/d ($130\ m^3/h$)
- Diameter/surface area: 1.40 m/1.54 $m^2$
- Height: approx. 10 m total
- Rate of ascent: 55–85 m/h

- NF membrane system:
  - Average daily delivery rate: $Q_m = 550\ m^3/d$
  - Maximum delivery rate: $Q_{max}$ = approx. 670 $m^3$/d ($28\ m^3/h$)
  - Modular rack system with 8" wound modules
  - CIP station, double cartridge filter
  - Anti-scalant dosing,
  - $CO_2$ dosing with mass control proportional to the quantity
  - Flux: 23.8 $L/m^2 \cdot h$

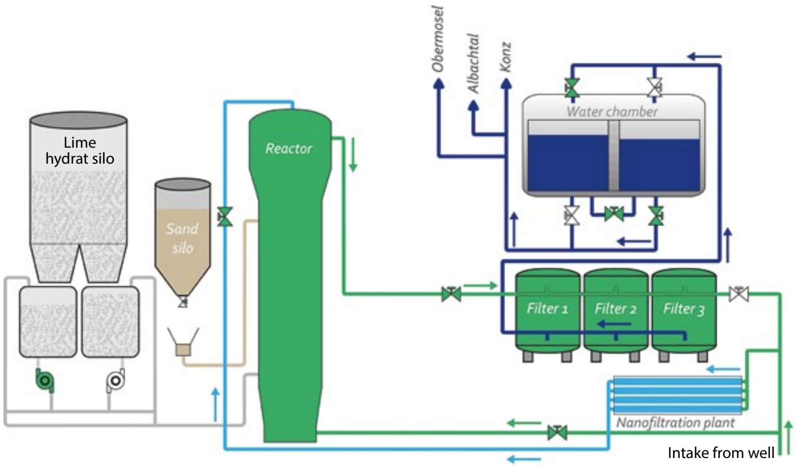


*Fig. 4. Simplified process schematic.*


## Summary

The renovation and optimisation measures illustrated for the existing drinking water softening plant VGW Konz represents the key to exemplary cross-border cooperation between Luxembourg and German water suppliers. Arising from a European joint project aimed at safeguarding the population's water supply on both sides of the Mosel, it was necessary to completely overhaul and rebuild the measurement, regulation and control systems of the existing water treatment and softening plant at the water works Wasserliesch. The task was to largely utilise the existing installations, while optimally adapting the process and hydraulic technology of the existing treatment systems to meet a demand for water that will be around 20% greater in the future. Following the measures to adapt the existing filter stages to the increased hydraulic throughput, modern measurement, regulation and control technology for the treatment and softening process was integrated into the switchgear. The main requirements for the planner were to increase the water production of the entire treatment process and to permanently reduce the target hardness via complete modernisation of the existing RDC softening system. Both aims were achieved through a combination of the existing RDC technology and modern membrane softening technology in conjunction with measurement, regulation and control technology tailored to both the process sequence and the operating sequence.

## Drinking water softening – Explanation of the schematic (fig. 4)

The raw water is carried upwards in the reactor by the "fluidised bed method". Lime milk is added and the raw water flows from below through the reactor and through a special nozzle plate, so that the sand bed can expand to form a fluidised bed. As a result of the increase in the pH value, lime accumulates on the sand grains and pellets (lime pearls) are formed that are gradually and automatically removed from the process.

The water hardness can be further reduced by integrating a nanofiltration system into the bypass of a RDC softening system. For the first time, with this system optimisation a treatment process has been selected that combines two technically different softening processes in one central system. The main advantage here was the maintenance of the specified RDC reactor technology and the associated operating sequence. A modern programmable logic controller (PLC) provides an automated operating sequence and guarantees a high degree of system technology availability.

## Authors

**Ralf Zorn**
Wassermeister |
Verbandsgemeindewerke Konz (VGW Konz) |
An der Granahöhe |
D-54332 Wasserliesch |
Phone +49 6501 9472-990 |
Fax +49 6501 83-107 |
E-Mail: zorn.fb5@konz.de |
www.konz.de

**Ulrich Kornhaas**
Geschäftsführer |
Ingenieurbüro
ALWIN EPPLER GmbH & Co. KG |
Gartenstrasse 9 |
D-72280 Dornstetten |
Phone +49 7443 944-65 |
Fax +49 7443 944-50 |
E-Mail: ulrich.kornhaas@eppler.de,
www.eppler.de

**Thomas Gessler**
HydroGroup/Hydro-Elektrik GmbH |
Angelestrasse 48/50 |
D-88214 Ravensburg |
Phone +49 751 6009-46 |
Fax +49 751 6009-33 |
E-Mail: thomas.gessler@hydrogroup.de,
www.hydrogroup.de