Water Treatment System Replacement in Perspective of Long Term Krško NPP Operation

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ABSTRACT

Quality of a demineralized water for power plant needs deteriorated over time and some components were loosing up their performance. Adding additional mixed bed and replacement of selected components like reverse osmosis membranes and electrodeionisation units were an option, however in perspective of possible operation even beyond 60 years of the power plant contributed to a decision to replace practically the whole system.

The system replacement took a longer period of time and therefore a temporary mobile water treatment plant was used to supply demineralised water to the plant during the demolition, installation and testing period.

Project finally resulted in a stable high quality demineralised water in automatic operating mode without constant presence of the system operators. All relevant chemistry parameters of demineralized water are kept extremely low and in accordance with the best industry standards and praxis. Chemistry parameters create chemistry performance indicators which is further input to calculate plant performance indicators as defined by WANO (World Association of Nuclear Operators).

The system is controlled via an upgraded man machine interface from a local operating console with connection to a main plant control room. Compatibility with other plant system overview and control is assured.

Stable high water quality has a potential to significantly contribute to control of corrosion processes of vital plant components like steam generators and other power plant systems, both on primary as well as on secondary site in general. This is of a great importance in perspective of long term NPP operation, especially beyond 60 years plant operating lifetime.

Keywords: *demineralised water, long term operation, corrosion, chemistry parameters, performance indicator*

1 INTRODUCTION

Demineralised water production is one of a crucial entry processes to assure day-to-day plant operation inside chemistry specifications as well as long term corrosion control of plant system's construction materials. Chemistry specifications include control parameters with clearly defined action levels that will consequentially require even a plant shutdown if the parameters are not restored inside defined time limits. Plant technical specifications also contain limitations of chemistry parameters for certain plant operating modes.

From long term perspective, chemistry contaminants are of great importance in a corrosion processes control. Corrosion cannot be stopped by the definition, however control of chemistry parameters can significantly slowdown the corrosion rate. Therefore, there is a significant corelation between corrosion control and lifetime of a power plant components. Among big components, steam generators are due to thermohydraulic operating conditions susceptible to corrosion processes

as stress corrosion cracking and phenomena related to hard sludge deposits. Overall low Sodium and silica concentrations are of a great importance to suppress those phenomena.

EPRI guidelines and WANO recommendations serve as an industry references. Comparing to original Westinghouse specifications, provided at the time of the power plant construction, today's chemistry reference values are much more stringent than the original ones. Water treatment technology as well as analytical methods of impurity measurements allow production and monitoring of higher quality demineralized water, and this is an ongoing process. Especially availability of in-line instruments for monitoring of extremely low values of impurities in combination with automatic stop of the process contribute significantly to suppression of integral exposure of plant system components to detrimental effects.

Selection of state-of-the-art technological solutions in water treatment and selection of high-quality equipment assure a robust and very pure demineralised water production. The system is operated via Scada, which include system start and system stop in relation to needs of makeup of plant demineralised water storage tanks. Therefore, system automation allows only intermittent presence of the system operating personnel.

2 DESCRIPTION OF THE PROJECT

Conceptual design as well as project specification were developed as an inhouse products with a support of feasibility study to screen the market for best available technology for our current and future needs. The dynamics of plant makeup water needs is rather specific. During steady state power plant operation, two parallel lines with a capacity of two m^3/h each is sufficient. However, during power plant maintenance and refueling outage and during startup operations, water consumption is in another range of magnitude. For this reason, beside small capacity lines there are three parallel lines with a capacity of 20 m^3/h each.

Public procurement process was deployed based on the very detailed project specification and feasibility study to assure delivered products are of a high quality and meet expectations of the investor. Project implementation was run as a turnkey project, but with a strong oversight of the all phases from the inhouse team. The system started production of the demineralised water in second half of the year 2025.

3 DESCRIPTION OF THE SYSTEM

3.1 Raw Water Filtration

Well water is used as a main water source. Sand filters with anthracite are the only part of the system that remained from the old system. It is followed by microfiltration. Mechanical particles are therefore removed from the raw water not only to assure particles free demineralized water at the end of the process but also to prevent damage on reverse osmosis membranes.

Figure 1: Sand Filters

Figure 2: Microfiltration Skid

3.2 UV Disinfection

UV lamps are deployed for disinfection to prevent microbiological growth on inside surfaces of the system components. Especially sensitive are reverse osmosis membranes. Nuclear industry in general does not require antiseptic environment like some other industries. Control of

microbiological growth across plant systems is assured based on a case-by-case approach, adopted to specific system conditions.

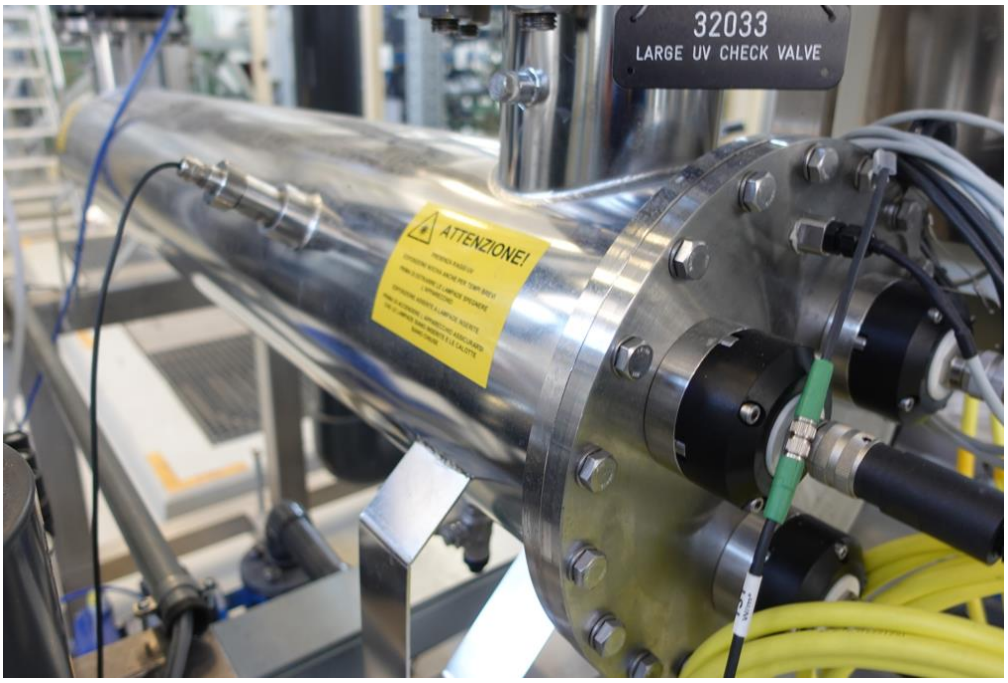

Figure 3: UV Disinfection

3.3 Reverse Osmosis (RO)

Three large and two small RO lines assure sufficient capacity and expected flexibility in demineralised water production in all modes of the power plant operations. Membrane technology is widely recognised as an effective and sustainable method in water softening, driven by electric power without use of chemicals during operation.

Figure 4: Large RO

3.4 Softeners

Next step in water demineralization is softening to further reduce concentration of ionic impurities. Parallel or consecutive lineup is enabled to increase the efficiency.

Figure 5: Softeners

3.5 Degasification

Gas transfer membranes are deployed to remove gases, mainly oxygen and carbon dioxide. With the use of nitrogen, achieved oxygen levels are even lower.

Figure 6: Gas Transfer Membranes

3.6 Electrodeionisation

Electrodeionisation (EDI) is a next step in polishing to further remove ionic impurities at already very low entry concentrations. Driving force of removal is strong electrical field to attract ions from water between electrically charged plates.

Figure 7: EDI module

3.7 Final Polishing

Final polishing mixed bed ion exchange resin removes traces of remaining ionic impurities, especially sodium to assure quality of demineralised water is as specified and even better.

Figure 8: Polishing Mixed Beds

3.8 Monitoring and Control

Inline monitors provide instant information of parameters values and trigger alarm and auto stop action in case of parameter's drift. Scada serves as a human machine interface. Instant values as well as history data is available. There is also connection to plant information system.

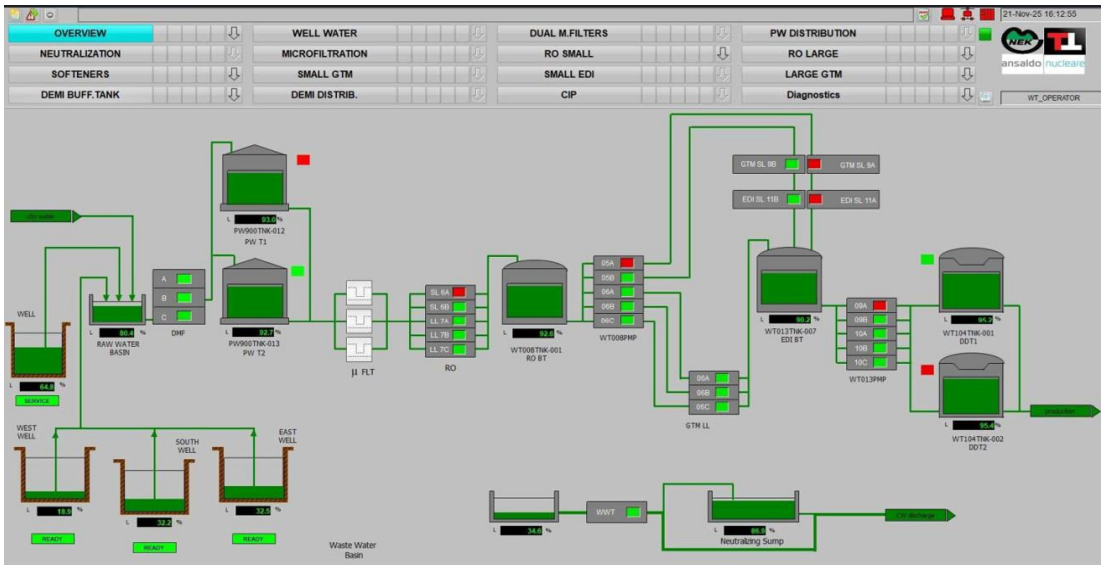

Figure 9: System Monitoring and Control

4 CONCLUSION

Extensive project was launched to upgrade the demineralised water production system. Best available and sustainable technology is used to fulfil present and future requirements as per industrial guidelines recommendation. System is in operation less than one year and it is to early to evaluate and quantify effects on plant systems, however higher quality of demineralised water is already undisputable.

Long term, high quality demineralised water has a significant impact on reducing corrosion processes in power plant systems. Nuclear industry is facing with the tendency of significant prolongation of plant lifetime from initial 40 to 60, 80 years or even beyond. Low integral long term exposure of power plant system components to impurities has a positive effect on suppression of corrosion processes and consequentially on health of vital components.

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