BIOLOGICAL TREATMENT AND ULTRAFILTRATION OF LAUNDRY EFFLUENT WASTE CAN REDUCE WASTE VOLUMES AND EFFLUENT ACTIVITY

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ABSTRACT

Nuclear Power Stations (NPS) and other nuclear facilities can generate large quantities of liquid waste in their nuclear laundry and their showers in the controlled area. An innovative-patented treatment process (BIBRA) was developed in Germany. This new process has significantly reduced the TOC content in the effluent, the resulting waste volumes and increased the decontamination factor. The process has been advanced in replacing the centrifuge with crossflow filtration as separation process.

INTRODUCTION

Nuclear Power Stations (NPS) generate annually several hundred, sometimes several thousand cubic meters liquid waste in their nuclear laundry and their showers in the controlled area. These effluents are radioactively contaminated and must be cleaned before release into the environment.

Main ingredient of this liquid waste stream are the constituents of the cleaning detergents as wells as small quantities of other organic materials such as fibers, oils, grease, and other hydrocarbon based compounds.

Standard cleaning methods such as filtration using precoat filters, evaporation, or centrifuges generate large quantities of residual waste while having moderate decontamination factors. An annual waste volume of for example 6600 m^3 can result in two and more tons of radioactive waste for final disposal.

In Germany all radioactive wastes must be stored in interim storage until a final repositiory will be available. Therefore volume minimization as a cost saving measure is one of the key elements in German NPS waste treatment.

For this reason pre-coat filtration that is generating relatively high volumes of waste has been abandoned in Germany almost 20 years ago. Evaporation and drying is still used especially since relatively high decontamination factors can be achieved. However the most significant disadvantage of evaporation is the high content of inactive salts and other non radioactive compounds that will remain in the final waste.

Decanter/- separator centrifuge combinations could reduce the waste volumes since they allow dissolved inactive salts to pass through the system. Unfortunately variations in the feed composition that result in higher concentrations of dissolved radionuclides and/or colloidal particles require for acceptable removal the introduction of flocculants or powdered resins. While this process is less complex as evaporation it produces similar waste volumes but with lower decontamination factors.

To eliminate the unnecessary secondary waste generating overdosage of flocculants or powdered resins these liquid wastes are typically collected for several days, measured and treated as appropriate. During

this time biological processes will initiate hydrogensulfite generation and more importantly suspended radioactivity will get dissolved. The longer these waters are retained, the less efficient the decanter-/ separator centrifuge.

THE BIBRA PROCESS IN COMPARISON TO OTHER TREATMENT METHODS

An innovative patented treatment process (BIBRA) combining biological treatment and a separator centrifuge was developed in the Gundremmingen NPS starting in 1996 to solve these problems /1/. To date this process has been successfully implemented in the German NPS of Gundremmingen, Kahl, Brunsbüttel, Stade, Isar 1 and Neckarwestheim. These represent almost 30% of the German NPS.

This new process has not only significantly reduced the TOC content in the effluent and waste volumes (6600 m^3 result in only 160 kg final waste) of BWR and PWR but at the same time has increased the decontamination factor to 20 and more. The cost savings experienced within the plant are more than €125,000/a. These savings do not account the additional substantial savings on handling, disposal containers, transportation, interim storage and final disposal.

Figure 1 shows the waste generation and decontamination factors for different processes cleaning this liquid in a BWR in comparison to the patented biological treatment process.

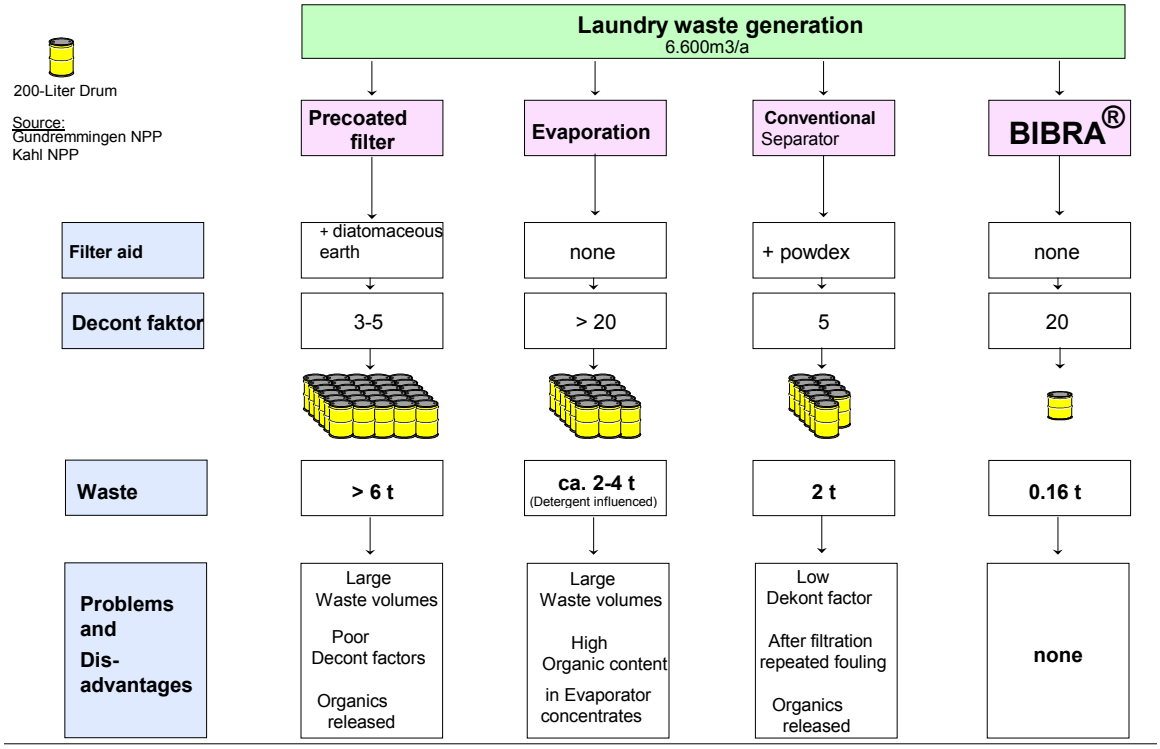

Fig. 1 Laundry waste generation based on different treatment methods

While this process has demonstrated significant volume reductions and cost savings for both BWR and PWR, it is mainly limited by the separation efficiency of the separator. Eder et.al. report in /2/ for PWR an average radioactivity reduction from 2,5 E6 Bq/m^3 to 6,0 E4 Bq/m^3 or an average decontamination factor of about 40. The chemical oxygen demand which is in this case reduced from 100-150 mg O_2/kg in the separator influent to 62-95 mg O_2/kg in the separator effluent shows a reduction factor of less than 2.

Hence more than 50% of the organic content, and other inorganic compounds that can be oxidized (e.g. iodide, nitrite, sulfurcompounds) pass the separator. A laboratory test to filter this separator effluent using a 0,1 □m filter further reduced the chemical oxygen demand to 24-53 mg O_2/kg or approximately another 50%. The only explanation for this is that at least 25% of the remaining solids are still suspended and pass the separator as colloides. These passing colloids carry probably another significant portion of the suspended activity.

SELECTING AN IMPROVEMENT OPTION FOR THE BIBRA PROCESS

In order to advance the biological treatment of radioactive wastes it is therefore required to find an alternative separation mechanism without loosing the advantages of discharging the inactive salts. An engineering review of possible separation processes that could help to remove these residual activity was conducted. It determined that crossflow filtration and in particular microfiltration or ultrafiltration were the most promising technologies to further improve the separation efficiency. Ultrafiltration is able to remove bacteria, proteins and similiar while allowing dissolved materials such ad salts to pass (Fig. 2).

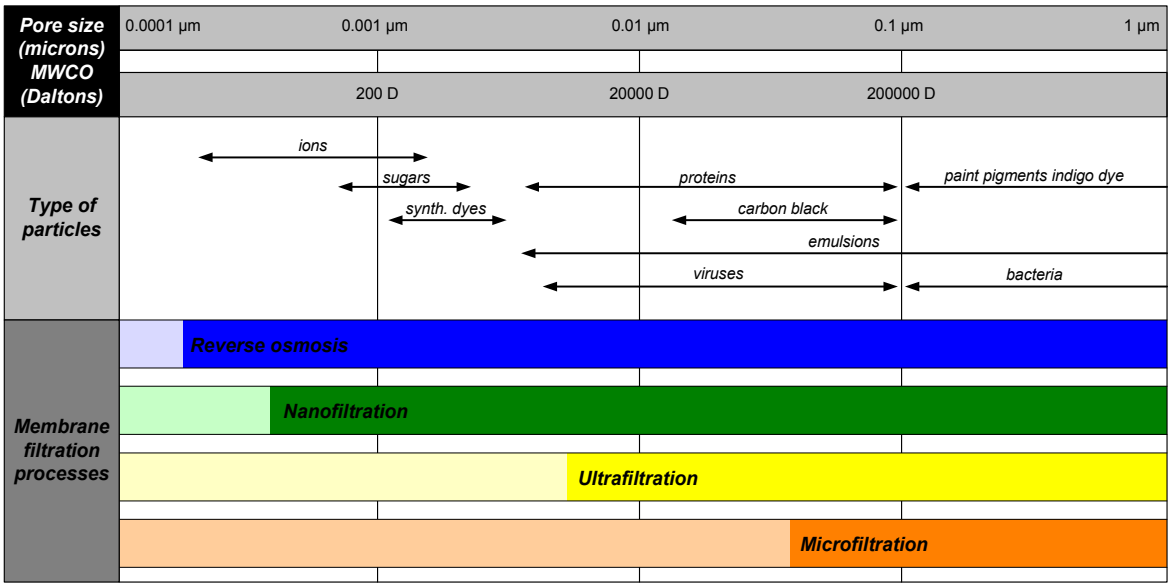

Fig. 2 Characterization of crossflow membranes based on pore size

Drawback for crossflow filtration systems is that they can experience significant problems with fouling (blocking) of the membranes from suspended solids (TSS) which typically requires the introduction of aggressive chemicals and that all these systems generate an effluent concentrate of typically 2% to 10 % of their throughput. In case of e.g. 6600 m^3/a waste generation a volume between 120 and 600 m^3/ a concentrate would require additional treatment and conditioning.

Almost at the same time as the biological treatment process was developed in Germany, RWE NUKEM matured crossflow filtration for nuclear applications in the U.S.A. and developed the answer to virtually eliminate the generation and treatment of large concentrate volumes coming from Ultrafiltration or Microfiltration systems /3/. This extensive, nuclear specific knowledgebase made it a natural development to test this patent pending process as an alternative and potential replacement for a separator.

In 2001 RWE NUKEM took over the responsibility from RWE Power and E-ON to economically decommission the Versuchsatomkraftwerk Kahl (Experimental Reactor Kahl) VAK to green field. This NPS was commissioned in 1960 to establish nuclear power in Germany, test equipment and train operators for the later build German power generating NPS. VAK was also the second German NPS that had successfully installed a fully functional biological treatment including separator. Since this NPS is currently under decommissioning it was the perfect location to test both technologies for benchmarking and direct comparison with real wastes without colliding with operational needs of large power reactors.

CONCLUSION

After commissioning of a pilot ultrafiltration system that uses the US know how and patent pending technology, the new separation technology was successfully tested and benchmarked at VAK from October 2002 to April 2003.

The testing has demonstrated that:

- The patent pending ultrafiltration system can efficiently replace the centrifuge
- The for nuclear applications engineered system has robust operational characteristics
- The throughput of the pilot system is approximately 200 l/h
- The ultrafiltration system showed equal or better decontamination factors than the centrifuge
- The permeate activity was constantly at or below the detection limit (< 2,4 Bq/m^3 for Co60)
- The concentrates can be conditioned to meet German disposal regulations

REFERENCES

1 "BIBRA – Biologische Behandlung von radioaktivem Abwasser" – Krumpholz et.al. - ATW 1999, 44 - Page 145-176

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3 "U.S. Nuclear Power Stations reduce liquid waste processing costs and clean liquid waste to the detection limits""- Rosenberger - ATW 2002, Page 681-686