Decontamination and Recycling of Radioactive Material from Retired Components

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ABSTRACT

This paper describes the development of the EPRI DFDX (Decontamination For Decommissioning, electrochemical ion eXchange) process for the chemical decontamination of reactor coolant systems and components. A US patent has been awarded and a plant, conforming to exacting nuclear industry standards, has been constructed to demonstrate the process at a number of sites. The plant has completed successful demonstration tests at Studsvik in Sweden and Dounreay in Scotland. The R&D phase for this technology is now complete, and the plant is now in commercial operation in the United Kingdom.

INTRODUCTION

There are significant potential benefits, both economic and environmental, in recycling materials from retired nuclear facilities for new controlled uses within the nuclear industry. The EPRI DFDX Process is an efficient and economic decontamination method for preparing materials for recycle. This technology includes processing of the radioactive solution using electrochemical ion exchange. Recent results from field-tests in Sweden and UK will be presented, and the use of this process for recycling activities will be described.

DESCRIPTION

The "EPRI DFD" (Decontamination for Decommissioning) Process achieves efficient removal of radioactivity with minimum waste from retired nuclear components and plant systems. The process uses dilute fluoroboric acid with controlled oxidation potential. By removing all the outer scale and a thin layer of base metal from the surfaces, contamination can in many cases be reduced below the levels required to allow clearance (free-release) or recycle. This process has been applied successfully by EPRI licensees to many different components, in addition to the primary coolant systems of the Big Rock Point BWR and the Maine Yankee PWR in the United States and Zorita in Spain, including pumps and heat exchangers, and material from DOE facilities. A key aspect of the existing technology that required further development for new applications of the DFD process is the management of secondary waste. Essentially, the disposal of the resulting radioactive ion exchange resin is unpopular and expensive, and is therefore the main constraint limiting further applications (Ref 1).

The EPRI DFDX process was developed to overcome this disadvantage. This patented process is the adaptation of the technology of electrochemical ion exchange, in which conventional cation exchange resin is used to take the metallic and radioactive ions out of the decontamination solution. However, instead of the resin being in a self-standing column, it is contained between the cathode and anode compartments of an electrochemical cell. The radioactive metal ions are deposited on the cathode as metal. The overall process enables the collection of radioactive contamination from a thin layer of the surface of components and systems and its conversion into metal powder for disposal, driven by electrical energy. The metal powder, consisting primarily of iron, nickel and cobalt (including Co-58 and Co-60 radioisotopes) is easily collected. No other wastes are generated, and thus the new development represents almost theoretical efficiency of decontamination.

RESULTS

A plant has been constructed, to exacting standards necessary for work on nuclear fuel reprocessing plant sites. The central feature of this plant is the electrochemical cell, which removes dissolved radionuclides from solution and deposits them as metal particles in a porous carbon felt within the cell (Figure 1). The cell can also be used with the conventional EPRI DFD Process to treat solution from regeneration of the ion exchange resin. The plant has its own standard transport container for transfer between nuclear sites. The plant is sufficient in size to complete certain commercial scale decontamination tasks, such as cleaning fuel reprocessing plant components, and can also be used to apply the conventional EPRI DFD Process (Figure 2). The plant has been successfully operated at Studsvik in Sweden, where it has been used to clean a variety of nuclear plant artifacts, and at Dounreay in Scotland, where it has been used to decontaminate a wide range of artifacts arising on that site. A wide range of contaminated artifacts, including some with alpha contamination, were successfully decontaminated to background levels.

Embedded pipelines frequently present a decommissioning challenge in the nuclear industry. A UK nuclear customer has a buried pipeline which has been used to carry effluent solutions from the site to a disposal point some considerable distance from the on-site effluent discharge point. For decommissioning this line, decontamination could potentially be achieved by recirculation of a water-based decontamination solution through the line. The solution would dissolve radioactivity, and this would be accompanied by collection of dissolved radioactivity by passing the recirculating solution though ion exchange resin beds or by using the "EPRI DFDX Process" as described here. In order to demonstrate the feasibility of a possible decontamination operation an artifact test was performed. For this test, a short section from the actual pipeline was removed and then exposed to the EPRI DFDX Process, with successful removal of contamination.

While initial cell design had its origins in non-nuclear applications, work has now been completed to adapt the electrochemical cell design to make it suitable for use in high radiation environments. The major change required is the ease of access and the removal of the metal loaded carbon electrodes when full or at the end of processing. Other changes include the optimization of the cell compartments to reduce the electrical resistance and to efficiently utilize the electric current when working at low acid concentrations. Additionally there are design changes to avoid current leakage through the electrolytes and through tracking to earth via the cell supports, feed pipes or auxiliary equipment. The new cell design will be described.

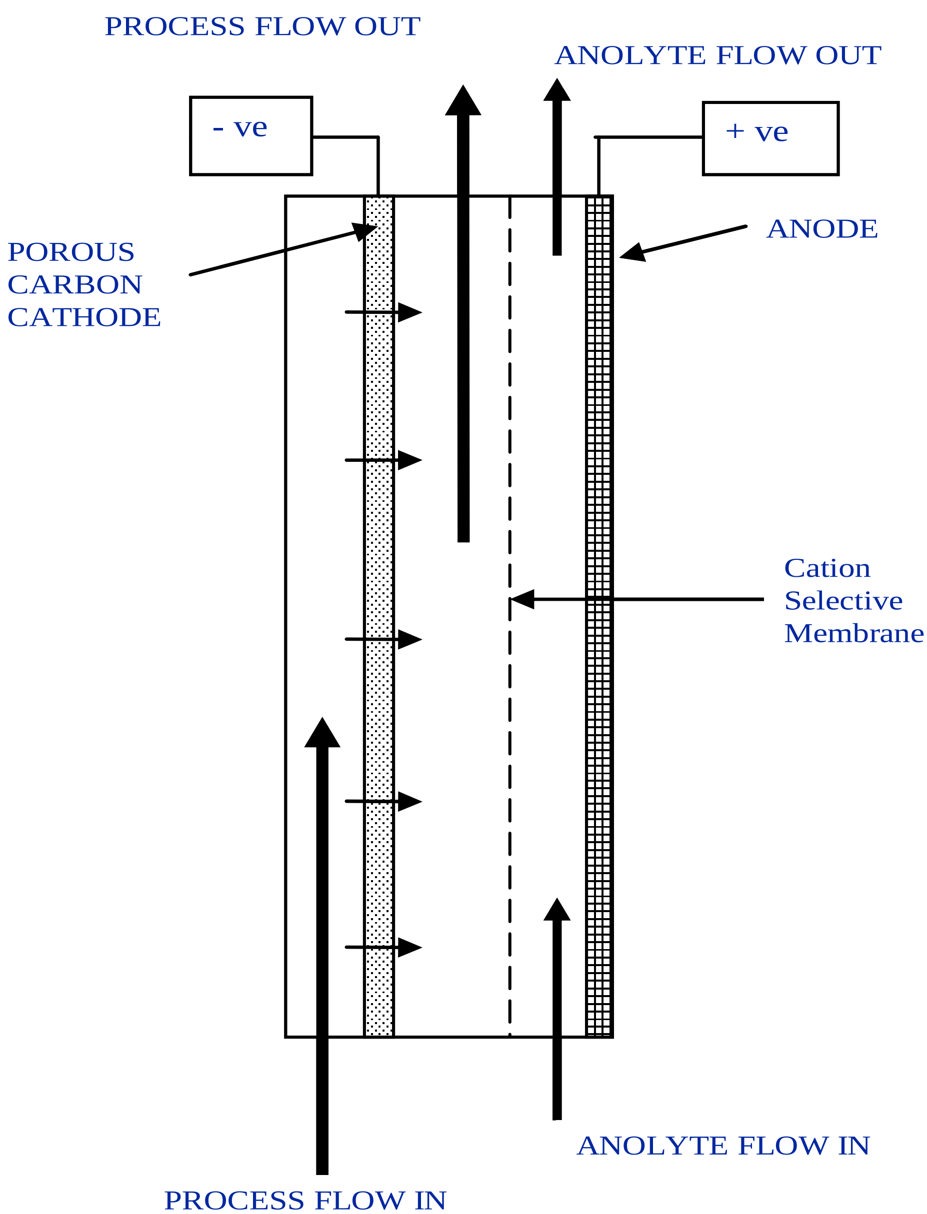

Fig. 1. Diagram of a porous carbon EPRI DFDX electrochemical cell

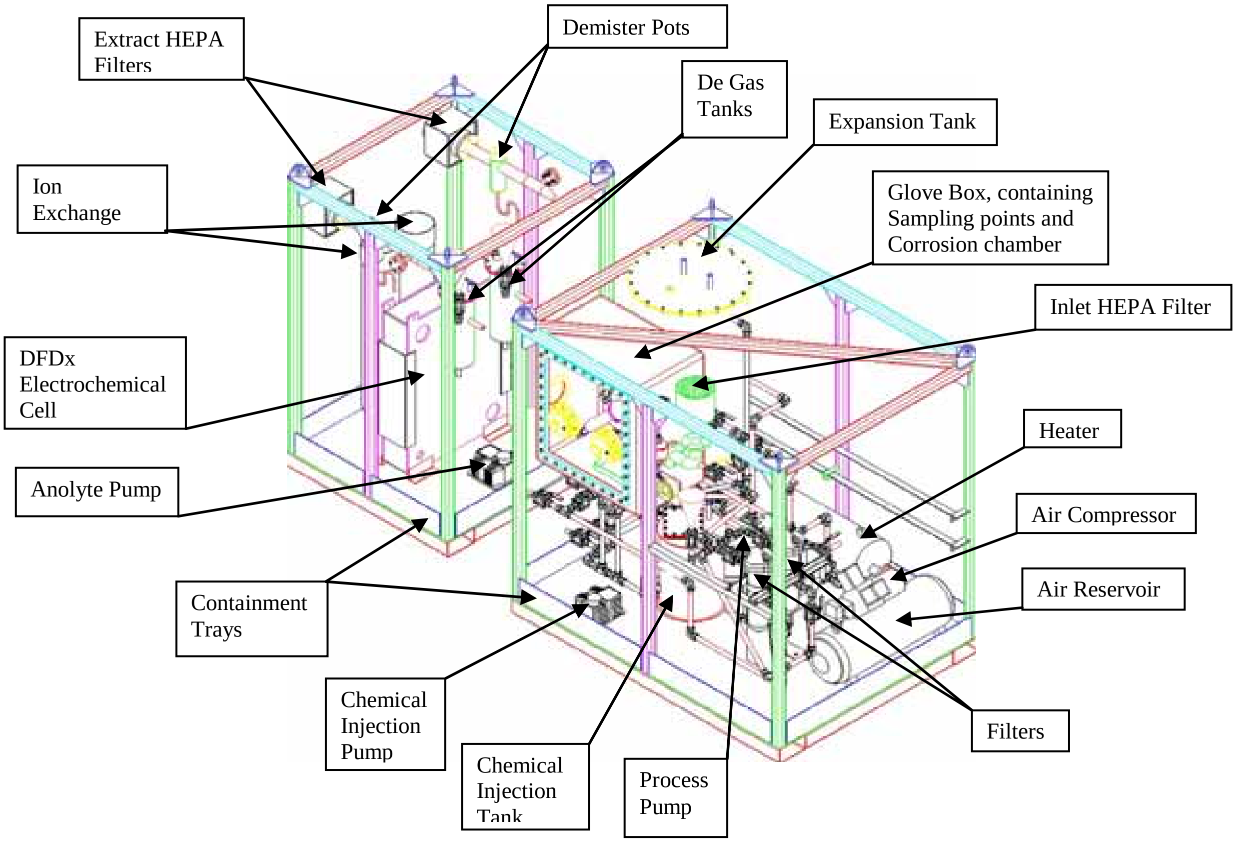

Fig. 2. Diagram of the Process and Treatment Skids

This process reduces the volume of waste arising from the DFD Process by a factor of 10. Waste volume reduction achieved by electrochemical ion exchange permits collection of the radioactive residue as metal particles, which can conveniently be fluidized into a small container for storage or disposal as radioactive waste. Alternatively, the radioactive residue can be collected on a carbon fiber mat which performs as the cathode, for disposal. The volume of the metallic waste is sufficiently small that storage, for example, in a nuclear facility’s fuel pool, to take advantage of radioactive decay, is technically feasible.

There are a number of other advantages of the process. Because the final waste form does not include organic components, it avoids hazards due to decomposition and gas generation due to radiolysis of the final waste form. The waste can also readily be processed into a suitable form (eg shielded drums) for long term on-site storage.

CONCLUSION

There are significant potential benefits, both economic and environmental, in recycling materials from retired nuclear facilities for new uses rather than disposing of them as radioactive waste. Although it is technically possible to decontaminate many retired nuclear components to reduce contamination levels to below those appropriate for free release into the public domain, there is public unease at the prospect of formerly contaminated materials passing into unrestricted public use. Greater support for recycle can be achieved by converting decontaminated materials into products for new controlled uses, particularly within the nuclear industry. This work shows that good economics can be achieved by decontaminating the materials and then using existing non-radioactive facilities to fabricate new components for reuse in the nuclear industry.

REFERENCES

1. Bradbury, D., Bushart, S.P., Elder, G and Wood, C. J. “Decontamination and Recycling of Radioactive Material from Retired Components,” ANS Conference on Decommissioning, Decontamination & Reutilization, Denver August 7–11, 2005.