Radio Active Waste Plants – Back to the Future - 8324

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Abstract

This paper outlines the potential to provide smaller, potentially modular radwaste plants, suitable for new reactor proposals, within increasingly strict environmental control regimes, and with reduced discharge authorisations. Aker Kvaerner have been involved in the design, build and commissioning of radwaste plants over many years and provided the plant for Sizewell B, one of the last major PWR's to be built anywhere in the world. Unit operations and design characteristics of radioactive waste processing plant are discussed. It is concluded that these have changed little in the past 30 years. The traditional build characteristics and metrics of large radioactive waste processing facilities are described in both the reprocessing and the power generation industries. New reactor and fuel characteristics are described and used to highlight areas of potential design improvement, reducing the size, complexity, construction programme and cost of future power reactor radwaste facilities.

1. Introduction

The historical process design of large waste facilities has changed little in the past 30 years, the principal unit operations are given in Table 1:

SOLID	LIQUID	GAS
Incinerate	Ion Exchange	Filtration
Compact	Precipitation / Filtration	Adsorption
Encapsulate	Evaporation	

Table 1. Unit Operations

Some Examples of these processes are given below:

2. Conventional Design Practice

At Sellafield, the Site Ion Exchange Effluent Plant (SIXEP) is an early generation of Radwaste plant for the treatment of site magnox sourced liquid effluents, designed in the late 1970's, and based on the use of filtration and ion exchange. The plant is monolithic, some 100m x 50m x 30m and the processing capacity some 4000m3/day. 70,000 te of concrete were used in construction.

Figure 1 shows a view of a Universal Vessel designed by Aker Kvaerner for the SIXEP facility at Sellafield. This common vessel was designed for operation with both media filtration and ion exchange.

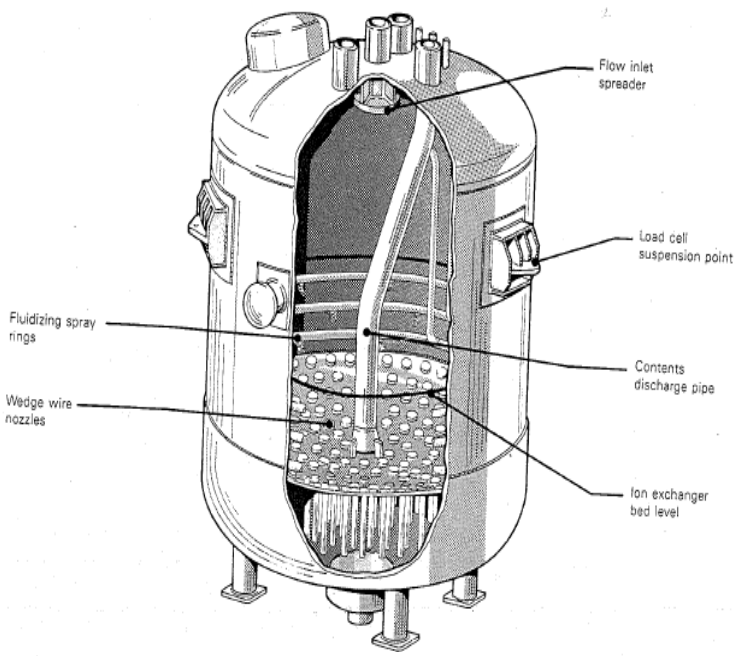

Figure 1. SIXEP Universal Vessel

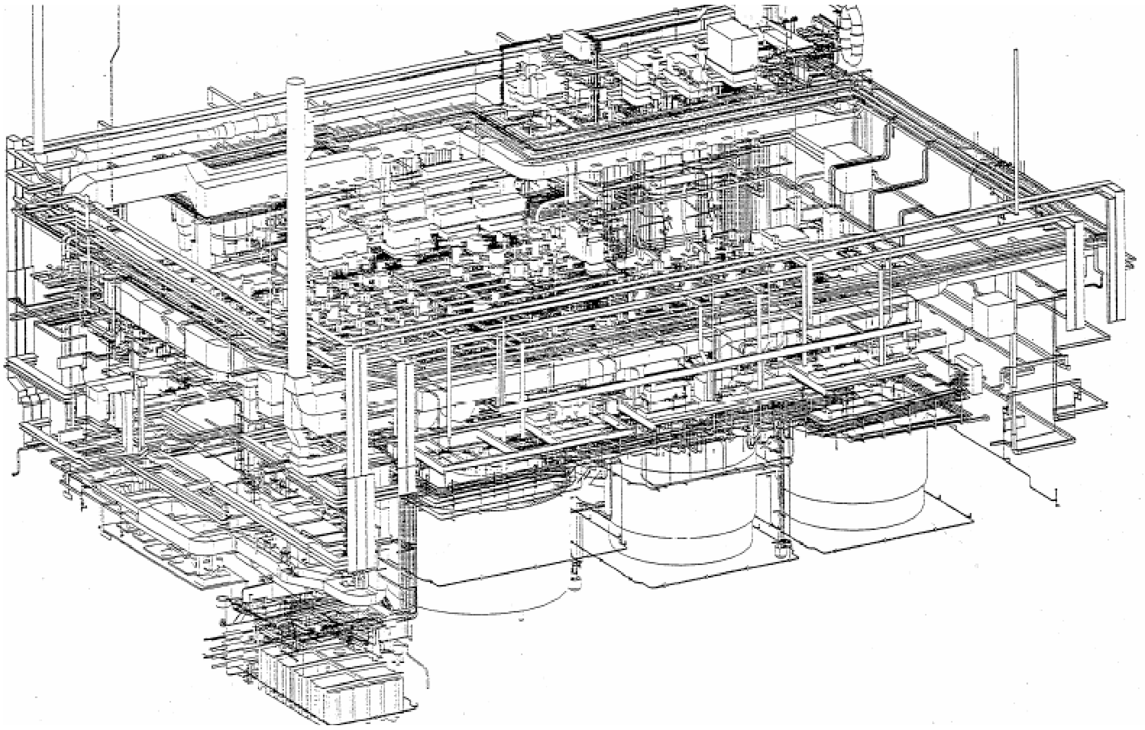

Figure 2. Cutaway of EARP.

Figure 2 shows a view of the Enhanced Actinide Removal Plant (EARP) processing plant, designed and constructed by Aker Kvaerner. This large (65m x 45m x 35m) effluent treatment facility at Sellafield is still in service, and was constructed to meet waste requirements for medium and low active waste streams. The process basis for this facility was advanced chemical adsorption, and ultrafiltration, engineered to meet exacting operational and performance standards. High DF's were achieved for Actinides, Cs, Sr and Co. This plant is also monolithic, and used some 60,000 te of concrete, with over 30 km of pipework and 50 km of cabling.

Sizewell B Radwaste Plant is a fully integrated facility, designed and constructed in the late 1980's by Aker Kvaerner, and of similar size to the previous examples. In contrast, this plant uses the whole range of available process technologies for the treatment of gaseous, liquid and solid wastes arising from the operation of the Sizewell B PWR. This facility has nearly 400 cells, and processes almost all the active wastes on the site.

3. Process Performance

These plants have had a significant effect on operational performance. Figure 3 shows the reduction in historical Discharges from Sellafield in relation to SIXEP and EARP.

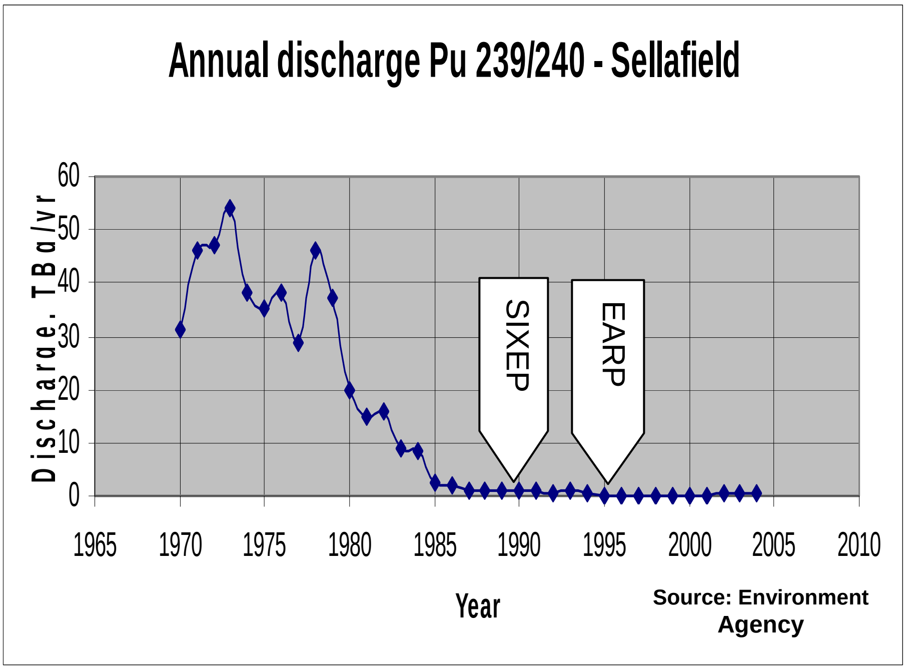

Figure 3. Historical Discharges at Sellafield

4. Commonalities

These examples serve to illustrate the similarities:

- All use the basic unit operations to provide very effective operation
- All these facilities required large buildings of bulk poured concrete, with Monolithic construction
- All contained many interacting and inter-related systems, requiring a long and complex design and build.

5. Impact of New Technologies

We now have new or intensified technologies in a number of areas such as ion exchange and filtration. These have allowed performance improvements on a scale we could not conceive just a few years ago.

6. UK Energy Supply Issues

In the face of global energy demand, global warming and security of supply economics, the development of safe, economic advanced reactor designs is now of great importance.
In the historical context above, conventional radwaste plant may not at first sight meet improved safety, cost and construction objectives.
Accordingly, this paper describes how improved safety, cost and performance objectives can be achieved in radwaste processing for advanced reactors.

7. Advanced Reactor Design

For illustration, the Westinghouse AP1000 design basis has been used to assess the design of a future radwaste facility:
Figure 4 shows the design metrics for the AP1000 compared with previous generation PWR technology: These achievements will deliver improvements in safety, operability, shortened construction programme and reduced cost.

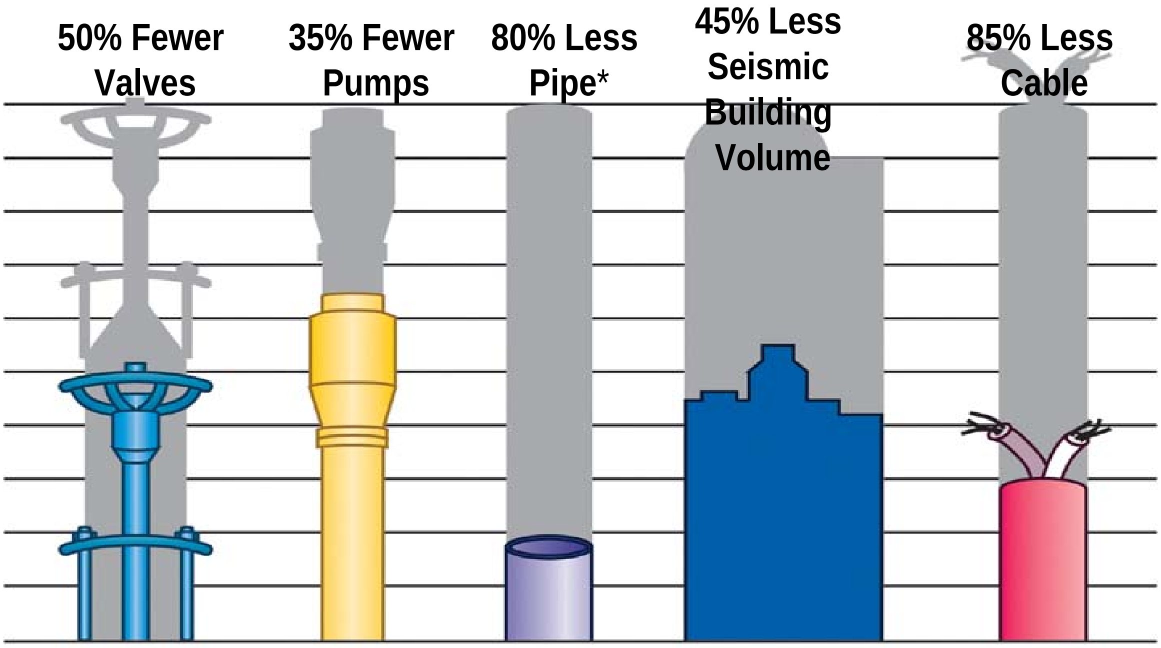

Figure 4. AP1000 Metrics. Source: Westinghouse

In applying these metrics to a future radwaste plant design, we also note the following:

a) Fabricated PWR Fuel Quality is now higher than ever; the operational design basis for Sizewell expressed as %Failed Fuel can now be exceeded by up to x100. This produces corresponding reductions in leakage of fission product activity.
b) Materials development and improved water chemistry have lead to much reduced corrosion product formation.
c) These in turn lead to much reduced primary and secondary coolant activities, giving:
    - Reduced shielding requirement in normal operation.
    - Reduced environmental impact, lower activity discharge.
d) The use of conventional effluent treatment processes as described earlier is now significantly enhanced by the availability of new materials in Ion Exchange and membrane technology.

8.0 Summary: Implications for Design

Taking these factors into account, we can now expect that compared to Sizewell B radwaste plant, it is possible to match the AP1000 metrics given in Figure 4 above.

In principle, this could deliver a building and plant volume of the order of one third to one half of that for Sizewell. It may be possible to make larger reductions in building volume although this is primarily due to the removal of evaporation and relocation of gaseous waste processing.

Figure 5 shows a view of one process area of a simplified future radwaste plant, designed with these principles:

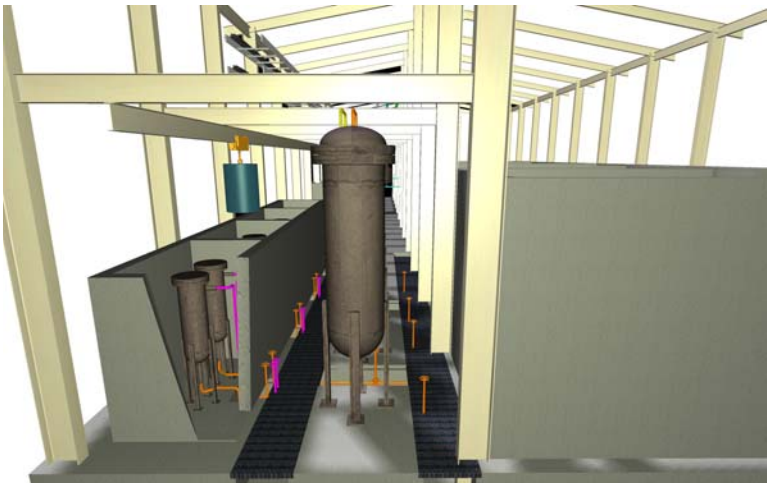

Figure 5. Cutaway view of New Radwaste Facility

The expected improvements are:

- Reduced complexity and interactions significantly improve operational safety
- Process intensification and close alignment of processes against reactor waste streams deliver reduced plant size.
- Accelerated construction; this becomes possible because of reduced building size, and improved, fit-for-purpose building design.
- Programme: The use of skid mounted package plant, modular ‘pack’ systems for filters and ion exchangers, can shorten construction time.
- Allowance for sub contractor support service, by provision of Docking Bays and subcontractor Laydown areas, allows the future use of specialist waste services.
- Environmental; Reduced operational source terms gives potential for significantly reduced liquid and gaseous effluent levels.
- Solid Waste; improved ion exchange processes deliver equivalent performance with reduced waste volumes.
- Increased use of modular design and skid mounted systems.
- As a whole, these allow optimal design for the whole life cycle.

- Although more intensive, the processes have still not changed from those of the past. Hence, ***Back to the Future.***

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References:

1. M. Howden , Progress in the reduction of radioactive discharges from Sellafield, BNFL