Evolution of Clearance Standards and Implications for Radwaste Management of Fusion Power Plants

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The issue of radioactive waste management presents a top challenge for the nuclear industry. As an alternative to recycling or disposal in repositories, many countries are proceeding successfully with the process of developing clearance guidelines that allow solids containing traces of radioactive materials to be cleared from regulatory control and unconditionally released to the commercial market after a 100 year storage period. While the external components surrounding the nuclear island could meet the clearance requirements, researchers have constantly applied the clearance criteria to the in-vessel components as well in an attempt to further minimize the volume of waste assigned for geological burial in repositories.

The clearance limits developed by the International Atomic Energy Agency (IAEA) over the past decade have been used worldwide for diverse range of fusion concepts from MFE tokamaks and stellarators to IFE laser, heavy ion, and Z-pinch applications. With the emergence of the new 1996 European Union (EU) clearance standards by EURATOM and the more recent US guidelines for solid materials by the Nuclear Regulatory Commission (NRC), we took the initiative to compare the IAEA, EU, and US-NRC clearance limits in order to identify the implications on the ARIES fusion waste management approaches and highlight the areas of discrepancy and agreement for the isotopes of interest to fusion applications. For this purpose, we employed a simplified model in which SiC-based and FS-based systems undertook the appropriate arrangement of the in-vessel and ex-vessel components using the physical and operating parameters of the ARIES-CS compact stellarator power plant.

We observed a notable difference between the clearance limits for the 1650, 300, and 67 radionuclides developed by the IAEA, EU, and US-NRC, respectively. At first glance, we noticed that the US-NRC standards are the most conservative, followed by the IAEA's, then the EU's. However, applying the limits to the ARIES-CS design, the trend was reversed with the EU clearance index being the highest for all components at 100 y after shutdown. According to the three standards, none of the power core components (blanket, shield, vacuum vessel, and magnet) can be cleared after the 100 y storage period as their clearance indexes exceed unity by a wide margin. The building that surrounds the power core is subject to a less severe radiation environment and thus contains residual radioactivity. The building represents no risk to the public health and safety and it appears feasible to release its constituents (concrete and reinforcing mild-steel) to the commercial market or nuclear industry after a relatively short storage period of 25 y or less, depending on the limit. Of interest is that the building dominates the low-level waste stream and its release saves a substantial disposal cost for such a large quantity, freeing ample space in the repositories for higher level wastes.

This exercise is proving valuable in understanding the differences between the various clearance standards. While US clearance standards now exist for a limited number of radionuclides that are important to the fission industry, no such standards are in place for radionuclides of interest to fusion facilities. Before fusion penetrates the energy market, the US-NRC should develop fusion-specific standards that address the safe release of fusion solids with trace levels of radioactive materials.