

D-³He Fueled Fusion Devices as a Step Towards Total Fusion Safety

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Nuclear fusion is seen as a “clean” source of energy. However, the attractive safety and environmental potential of fusion can only be fully realized by reducing the impact of materials activation and tritium inventory. The stress on fusion safety has stimulated worldwide research for fuel cycles other than D-T. With advanced cycles, such as D-³He, it is not necessary to breed and fuel large amounts of tritium. The D-³He fuel cycle in particular is not completely aneutronic due to the side reactions. Neutron wall loadings, however, can be kept low (by orders of magnitude) compared to D-T fueled plants with the same output power, eliminating the need for replacing the first wall and shielding components during the entire plant lifetime. Other attractive safety characteristics include low activity and decay heat levels, low-level waste, and low releasable radioactive inventory from credible accidents.

There is a growing international effort to alleviate the environmental impact of fusion and to support the most recent trend in radwaste management that suggests replacing the geological disposal option with more environmentally attractive scenarios, such as recycling and clearance [1,2,3]. We took the initiative to apply these approaches to existing D-³He designs: the ARIES-III power plant [4] and the Candor experiment [5]. Furthermore, a comparison between the radiological aspect of the D-³He and D-T fuel cycles was assessed and showed notable differences [6].

For the ARIES-III power plant, we estimated the highest possible activity to evaluate the disposal, recycling, and clearance options for managing the radwaste after decommissioning [6]. We compared the results to a D-T system to highlight the differences and the environmental impact. The results show that all ARIES-III in-vessel components qualify as Class A waste, the least hazardous type based on the U.S. guidelines. Potentially, all components can be recycled using conventional and advanced

remote handling equipment. The bioshield contains traces of radioactivity and can be cleared from regulatory control after a relatively short period of time (~10 y).

Results obtained for the Candor experiment indicate that no environmental problems arise from such a device, from the radiological point of view, even with the presence of D-T plasma triggering. Candor does reach the zero-waste option as all wastes can be cleared within 100 y [6].

The D-³He cycle offers safety advantages and could be the ultimate response to the environmental requirements for future nuclear power plants. Furthermore, the low neutron production helps overcome some of the engineering and material hurdles to fusion development. Studies for the development of advanced fuel cycles should be carried out in parallel with the current mainstream fusion pathway that primarily focuses on D-T tokamaks, such as ITER, test facilities, DEMO, and power plants.

References

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