WHAT IS CLAIMED IS:

1. A nuclear reactor comprising:

a fuel-salt mixture comprising:

a molten salt; and

a fissionable material dissolved in the molten salt, and

a core vessel having a first end and a second end, the core vessel containing a moderator structure with a moderator material comprising a zirconium hydride (ZrHx) in which x is between 1 and 4;

wherein the core vessel and the moderator structure define a pathway containing the fuel-salt mixture, the pathway extending from the first end of the core vessel to the second end of the vessel,

wherein a first portion of the pathway extends between the moderator structure and an interior wall of the core vessel such that, during operation, the fuel-salt flowing through the pathway surrounds the moderator structure, and

wherein a second portion of the pathway is disposed within the moderator structure.

2. The nuclear reactor of claim 1 in which the moderator material comprises $ZrH_{1.6}$, particularly wherein the zirconium hydride is in a crystalline form.

3. The nuclear reactor of claim 1 in which the moderator material comprises a form of lithium hydride.

4. The nuclear reactor of claim 1 in which the moderator material comprises a form of yttrium hydride, particularly wherein the form of yttrium hydride comprises yttrium(II) hydride (YH_2), yttrium(III) hydride (YH_3), or a combination thereof.

5. The nuclear reactor of claim 1 in which the moderator material comprises a form of zirconium deuteride.

6. The nuclear reactor of claim 1 in which the fissionable material comprises plutonium or uranium from spent nuclear fuel; particularly in which the fissionable material comprises a fissile-to-fertile ratio in the range of 0.01-0.25.

7. The nuclear reactor of claim 1 in which the molten salt comprises lithium fluoride, particularly in which the lithium fluoride is enriched in its concentration of

Li-7.

8. The nuclear reactor of claim 1 in which solubility of actinides in the molten salt is sufficient to permit the fissionable material to become critical, particularly in which the solubility of actinides in the molten salt is at least 0.3%.

9. The nuclear reactor of claim 8 in which the solubility of actinides in the molten salt is at least 12%.

10. The nuclear reactor of claim 8 in which the solubility of actinides in the molten salt is at least 20%.

11. The nuclear reactor of claim 1 comprising a secondary loop and a heat exchanger to exchange heat between the primary loop and the secondary loop.

12. The nuclear reactor of claim 1 comprising an intermediate loop, a secondary loop, a heat exchanger to exchange heat between the primary loop and the intermediate loop, and an additional heat exchanger to exchange heat between the intermediate loop and the secondary loop.

13. The nuclear reactor of claim 1 also comprising a freeze valve actively and continuously cooled, the freeze valve being configured to enable flow between the primary loop and an auxiliary containment subsystem_when the freeze valve is no longer actively cooled, more particularly being configured to enable flow between the primary loop and a passively cooled storage tank of the auxiliary containment subsystem when the freeze valve is no longer actively cooled.

14. A method comprising:

in the nuclear reactor of claim 1, flowing fissionable material and a molten salt past a moderator material that comprises a zirconium hydride (ZrHx) in which x is between 1 and 4.

15. The method of claim14 in which flowing the fissionable material and the molten salt past the moderator material comprises flowing a fuel-salt mixture through the core vessel.

16. The method of claim 14 in which the fissionable material comprises an entire spent nuclear fuel actinide vector.

17. The method of claim 14 in which the fissionable material comprises portions but not all of the actinides of spent nuclear fuel.

18. The method of claim 14 in which the fissionable material comprises unprocessed spent nuclear fuel.