SAND2022-13227C

Proliferation Resistance and Physical Protection of the Six GIF Generation IV Nuclear Energy Systems and Crosscutting Topics: 2021-2022 Update

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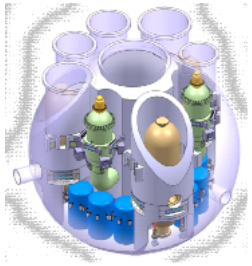
ABSTRACT

- A key goal of the Generation IV International Forum is to promote advanced reactor designs that are the least desirable route for diversion or theft of weapons-usable materials and provide increased physical protection against acts of terrorism.
- Proliferation Resistance & Physical Protection (PR&PP) white papers have been updated for the six Generation IV reactor systems.
- A companion crosscut report has also been completed.

BACKGROUND / INTRODUCTION

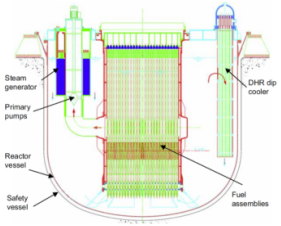
- The past decade has seen a resurgence of interest in advanced reactor deployment driven by both national research programs and private and venture capital investment.
- The PR&PP white papers and crosscut document are meant to support the nuclear industry, policy makers, and researchers with recommendations to enhance proliferation resistance and provide more robust protections for advanced nuclear energy systems.
- The PR&PP Evaluation Methodology is a fundamental underpinning of this work.
- Each white paper summarizes the technology, overview of the fuel cycle, PR&PP system elements and potential adversary targets, PR features, and PP features.

Gas Fast Reactor



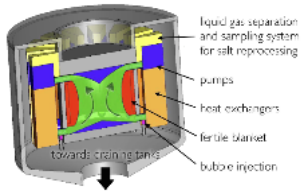
Intrinsic PR arises since there is no separation of actinides. PP is robust given the containment building and refractory fuel.

Lead Fast Reactor



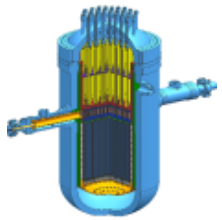
PR arises from the elimination of enrichment in the fuel cycle and highly automated operation with difficult-to-access cores. The inert lead coolant and low pressure provides a PP advantage.

Molten Salt Reactor



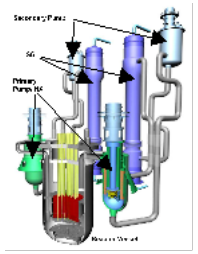
The large amount of salt needed for a significant quantity and difficult-to-access material provide technical difficulties in obtaining material, but accountancy challenges will be similar to bulk handling facilities.

Super Critical Water Reactor



PR&PP risks are similar to existing large light water reactors (LWRs), and the nuclear community has a great deal of experience safeguarding and protecting LWRs.

Sodium Fast Reactor



Operations under sodium, requiring specialized equipment and handling, may provide a PR advantage. Sabotage scenarios should consider sodium, but sodium loops are protected in all reference designs

Very High Temperature Reactor

The high dilution factor of TRISO fuels is a PR advantage. PP should adequately protect spent fuel.

CROSSCUTTING TOPICS

Fuel Type Physical Form, Chemical Form, Isotopic Composition

Coolant/ Moderator Material Opacity, Physical State, Inertness

Refueling Modes Batch, Continuous

Small Modular & Micro Options Sealed Core, Transportable

Fuel Cycle Architecture Open, Closed, Co-location

Life Cycle Design, Operation, Decommissioning

Flexibility Load Following, Non-electric Applications

Safeguards Topics Safeguards by Design, Inspections

Cyber Threat Secure Architecture, Supply Chain

Operational Transparency Data Sharing, Authentication

Safety Interface Integration of 3S

Economics Avoid Costly Retrofits

CONCLUSION

- A key goal of the Generation IV PR&PP working group is to promote the incorporation of PR&PP by design early in the design process.
- These concepts help promote robust, secure, and economically competitive nuclear energy systems.
- The lessons learned and recommendations are for advanced reactor designers and policy makers in understanding PR&PP topics.

REFERENCES & ACKNOWLEDGEMENTS

- The PR&PP white papers and crosscut document may be found at https://www.gen-4.org/gif/jcms/c_9365/pr-pp.
- The authors would like to acknowledge the support of the full Generation IV International Forum PR&PP working group, both current and past members and System Steering Committees for their collaboration on this work..

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