Fast Test Reactor Working Group

Prepared by the Members of the Fast Reactor Working Group

December 24, 2016

Dr. Michael Corradini
Dr. Alfred Sattelberger
DOE Nuclear Energy Advisory Committee

Subject: Fast Test Reactor Requirements Summary

Dear Dr. Corradini and Dr. Sattelberger:

To support recent discussion and activities related to the development and deployment of a fast test reactor in the US, the industry Fast Reactor Working Group (FRWG) has prepared this requirements summary to provide certain scoping guidance on what test reactor capabilities would be useful for commercial reactor technology developers.

The FRWG strongly supports the deployment of a domestic fast test reactor that is operational by December 31, 2026. A fast test reactor will serve as critical infrastructure to support next generation reactor technology and US nuclear technology competitiveness. The FRWG is also uniquely aware of the challenges of using international fast neutron irradiation capabilities. In general, international pathways are not a viable option for US companies to use, despite their existence. Considering the scientific and technological benefits of having a fast test reactor, such an asset is crucial for maintaining and enhancing US leadership in nuclear technology and for efficiently and effectively developing and deploying commercial advanced reactors in the United States to meet energy needs well into the future.

The FRWG consists of the following developers and industry leaders:

- Oklo
- GE Hitachi Nuclear Energy
- TerraPower
- Advanced Reactor Concepts
- Westinghouse
- General Atomics
- Southern Company
- Duke Energy
- Exelon

This document provides high-level information, and is expected to evolve to include more detail as efforts progress. This summary is not intended to replace or override the needs and requirements presented by individual companies.

Purpose

A fast test reactor should be designed to be a versatile and capable machine that can support the research, development, and deployment of next generation nuclear fuels and materials for several decades. The reactor should be part of a user facility that can accommodate a variety of activities spanning fundamental scientific research to new fuel and performance capability commercialization.

The potential use cases of a fast test reactor are broad, and could include the following:

- Accelerated characterization of the radiation resistance of new materials and alloys in a nuclear reactor environment for both fission and fusion reactors.
- Fuel and material qualification for use in both the operating fleet and next generation reactors.
- Testing and demonstration of new sensors and detectors for use in nuclear reactor environments.
- Rapid material compatibility surveys to determine what materials are compatible in a reactor environment that might warrant future study.
- Develop new insights and understanding of how materials behave at the microstructure level and at the atomistic scale.
- Qualify iterative fuel designs to support uprates and improvements in next generation reactors.
- Verification and validation of modeling and simulation tools and methodologies.

Timeline

The FRWG believes the deployment of a fast test reactor should be a national priority, and should be implemented on an aggressive deployment schedule. The fast test reactor should be operational by December 31, 2026, at the latest. It is an asset that should be part of the US nuclear infrastructure and critical to the development, licensing, and deployment of advanced reactors in the US, and therefore should be deployed within a ten year timeframe, or less, to best support US nuclear technologies. The FRWG membership would already be widely employing the capabilities of a fast test reactor if it currently existed.

It is also worth noting that some developers are pursuing deployment schedules that would occur before a fast test reactor would be operational. However, these designers agree that a fast test reactor would enable performance improvements for those technologies. There is clear consensus for the need for a fast test reactor within ten years regardless of each developer's timeline.

Spectrum

The reactor should operate on a fast spectrum. Where possible, thermal flux traps may also be beneficial.

Irradiation Footprints

Areal size: A variety of in-core and ex-core irradiation positions that could accommodate small irradiation volumes (single pin), rabbit systems, and full width commercial (flat-to-flat or equivalent) dimension fuel assemblies. This dimension varies, but generally does not exceed 18 cm.

Length size: Irradiation length scales of 1-2 m are sufficient; however, some above-core space should be provided to support the testing of certain above core fuel designs, such as venting.

In general, a fast test reactor should be able to accommodate a variety of simultaneous irradiation campaigns ranging from test assembly irradiation to rapid turnaround sample irradiations. It is difficult to predict quantities, but the members of the FRWG are inclined to pursue a design philosophy that creates enough irradiation space so that there is always some vacancy in a fast test reactor. This will help cultivate a culture of moving quickly and dynamically through research, development, and deployment.

In-Core Loops

An in-core loop to support different coolants and fuels is necessary to achieve enduring versatility. Furthermore, support structures that enable smaller scale in-core loops in the form of integrated assembly packages that can be assembled ex-core, and suspended from above the core, and then removed entirely from the reactor should be considered as a complementary capability to larger in-core loops.

Temperatures

- Primary coolant temperatures 400-600ºC.
- Loop coolant temperatures up to 1000ºC.
- Peak irradiation temperature capabilities up to 2600ºC.

Neutron Flux Characteristics

- At least $5x10^{15}$ n/cm^{2}-s.
- Should achieve more than 30 dpa/yr.

Ex-Core Component Testing

The reactor should accommodate enough internals volume to support testing various prototypic systems, structures, and components that developers might consider incorporating into their design. This might include certain pumps or control mechanisms. These will generally be less than full scale.

Additionally, the reactor should support the testing of in-pool, opaque fluid viewing and handling technologies. This is particularly important for liquid metal cooled reactor developers, but there is also interest from the salt-cooled developers.

A fast test reactor also provides a testing and demonstration platform for advanced sensors, and instrumentation and control systems. This is another key technology research, development, and deployment area that is crucial for commercializing advanced reactors.

Fuel Handling

An expanded fuel fabrication facility should be coupled with the deployment of a fast test reactor to support prototypic fuel fabrication as part of fuel qualification efforts. Additionally, a post irradiation examination (PIE) facility should be coupled with the fast test reactor to accelerate PIE of irradiated fuels and materials. The FRWG recommends the driver fuel of the fast test reactor should also be used to expand the fuel performance database of that fuel type as much as possible.

Finally, the transportation and sharing infrastructure should be expanded between existing assets and future assets, such as the fast test reactor and associated facilities, to maximize utilization and support research, development, and deployment of new technologies. This will help avoid access bottlenecks and expedite technology development.

Conclusions

While the specific needs of each member developer in the FRWG varies, the membership believes that a fast test reactor should incorporate the capabilities and features outlined in this document. The FRWG strongly supports deploying a fast test reactor that is operational within ten years, and considers it vital to new U.S. advanced reactor technology development and competitiveness.

Sincerely,

Jacob DeWitte, Ph.D.
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Chair, Fast Reactor Working Group

cc: Dr. Joy Rempe