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FY2021 September Monthly Status Report for the Versatile Test Reactor

October 2021

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Changing the World's Energy Future

Idaho National Laboratory

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FY 2021 September Status

SOLVING ENERGY CHALLENGES THROUGH SCIENCE

Versatile Test Reactor

Tom O'Connor, Federal Project Director

Greetings All. September marked the end of Fiscal Year (FY) 2021. In my opinion, and echoed by my management, VTR cranked out several successes despite the many obstacles thrown in our path. We received Secretarial approval to use a uranium plutonium zirconium metal alloy driver fuel, issued the first-ever Environmental Impact Statement (EIS) for a Department of Energy (DOE) nuclear reactor and completed all milestones, all while working remotely. We further fleshed out our plutonium supply options, received Headquarters' approval to sign the Blanket Master Contract (BMC), signed a Memorandum of Understanding (MOU) to facilitate collaboration between VTR and TerraPower's Natrium demonstration project, and amped up our outreach efforts. The only blemish on our record comes from a lack of FY 2022 appropriations despite receiving Congressional authorization via the Energy Act of 2020. Now we are in a "hurry up and wait" phase with FY 2022 activities funded under a continuing resolution (CR). I believe our communication efforts, through seminars with the Atlantic Council, congressional outreach and a National Security Council briefing will result in funding VTR in a manner that allows us to focus on higher risk items and sustain overall progress. We've demonstrated that we can deliver, and I look forward to an even greater level of success in FY 2022. Stay well.

Project Highlights

Thomas Fanning, Program Overview

Planning for potential expenditure of CR funds in addition to carryover funds has been initiated and several possible activities have been identified. Priority will be given to tasks that can be completed in a short time frame (approximately three months) to advance the design or reduce risk of VTR systems and components and that could potentially support other sodium fast reactor (SFR) designs if project funding is not restored. Risks of spending CR funds were identified, and efforts are under way to manage those risks. Five PICS:NE work packages for FY 2022 have been established and approved for Plant Design; Core, Fuel, and Safety; Experiment Development; Shared Services; and Capital Project. The work packages define scope only for October 2021 through January 2022, consistent with available carryover funding. Additional scope that could be performed with CR funds has also been identified, with execution of that scope potentially limited by resource availability.

In place of the Quarterly Integration meeting, a management review meeting was held on September 15. The morning session focused on project financial status and the progress made toward wrapping up fuel fabrication, fuel design, core design, safety analysis, and safety basis activities. The afternoon session started with remarks from Dr. Katy Huff, Acting Assistant Secretary of Nuclear Energy. Additionally, General Electric-Hitachi LLC (GEH) and Bechtel National Incorporated (BNI) participated to summarize hold and restart activities for the plant design. The Technical Advisory Committee provided initial feedback on the meeting and will follow-up with written comments.

As Tom O'Connor mentioned, the BMC between Battelle Energy Alliance (BEA) and BNI for engineering, procurement, and construction (EPC) has been approved by the DOE Business Clearance Center. Future engineering design work will be dependent on three factors: first, BEA and BNI signing the BMC; second, BNI

establishing subcontracts with their partners, GEH and TerraPower; and third, FY 2022 funding appropriations or other measures adequate to support a work order (Release) under the BMC to resume the design process.

A coordination meeting on the VTR non-proliferation assessment took place between the U.S. Department of Energy, Office of Nuclear Energy (DOE-NE) and the National Nuclear Security Administration (NNSA) Office of Defense Nuclear Nonproliferation (DNN) on September 20. VTR staff provided an overview of the VTR plant design, core design, fuel fabrication, and spent fuel disposal plans to DOE-NE, DNN, and the national laboratory Nonproliferation Assessment (NPA) team. Initial questions on anticipated waste streams and the potential role of international collaborators in the design or use of the VTR facility were addressed. A follow-up meeting will be scheduled in October. The NPA is expected to be completed in November.

VTR Executive Director Kemal Pasamehmetoglu met with DOE program managers and Congressional staff to clarify adjustments made to the VTR funding profile to better align it with the Advanced Reactor Demonstration Projects (ARDP) schedule. Kemal also presented "Versatile Test Reactor for Clean Energy Options" to the Osher Lifelong Learning Institute at Boise State University. The lecture addressed how the VTR fits within the U.S. vision for the 21st century's energy infrastructure to support carbon-free electricity generation and the decarbonization of other energy-intensive sectors. The lecture also highlighted VTR aspects that allow accelerated experiments on long-term performance of fuels, materials, instruments, and sensors in a reactor environment.

Finally, VTR said goodbye to two staff members: Acting Project Manager Jordi Roglans-Ribas and Plant Engineering Director George Malone. We wish Jordi and George well in their new endeavors and extend thanks for a job well done. You will both be missed.

Nuclear Design

Completed high-level milestones on electromagnetic (EM) pump model development and on decomposing system and component safety functions. Completed internal milestones in the fuel manufacturing area. Continued preparing Hold and Restart forms and identified and prioritized activities for continuation into early FY 2022.

VTR Plant Engineering

Produced a Roadmap to Restart Strategy document defining the needs and steps required to successfully restart the VTR project. Issued the Design Authority Hold and Restart form that summarized project status, technical needs, gaps, open items, and concerns and is intended to provide technical direction upon restart.

The Dounreay In-Vessel Transfer Machine (IVTM) information exchange effort is proceeding with the user agreement currently being reviewed by United Kingdom (UK) export control. Plans for the information exchange will follow the agreement.

VTR Experiments

Hold and Restart (H&R) reports have been collected and will be submitted to Confluence along with the appropriate forms. These reports identify needed and planned restart activities for each of the experiment vehicles (EV) and support areas. Additionally, 27 graduate students that will be graduating within the next academic year (2021-2022) were identified and these students will be partially funded to complete their degrees.

Upcoming Events:

American Nuclear Society Winter Meeting, November 30 – December 3, 2021, Washington DC.

NURETH-19, 19th International Meeting on Nuclear Reactor Thermal Hydraulics, March 2022, Brussels, Belgium.

IAEA International Conference on Fast Reactors and Related Fuel Cycles (FR22), April 2022, China

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Technical Highlights

Steve Unikewicz, Reactor Technical Integration

Fast Flux Test Facility (FFTF) Documentation and Data Recovery

A Design Information Request (DIR) requesting design documents and drawings on the Control Rod Drive Mechanisms (CRDMs) used in the Fast Flux Test Facility (FFTF) is nearing completion. All documents have been found that can be found. All 14 H-4-drawings have been found and converted into electronic format and all 243 Royal Industries' drawings have likewise been retrieved and converted into electronic format. This information package of documents/drawings is proceeding through Export Control and Information Release. It is anticipated to clear early in FY 2022. Once cleared, the entire document/drawing information package will be placed on the VTR Confluence Site.

A second DIR has been received requesting design documents and drawings on the Dump Heat Exchangers (DHXs) is nearing completion. This DIR requests drawings, OMMs, design specifications, and design and test reports. All documents that can be found have been located and converted into electronic format. To facilitate the search process for the drawings, a hierarchical top-down search process was developed starting with top-level drawings and proceeding toward lower-tier drawings. A total of 44 top-level drawings have been found and converted into electronic format. The entire document/drawing information is proceeding through Export Control and Information Release. It is anticipated to clear early in FY 2022. Once cleared, the entire document/drawing information package will be placed on the VTR Confluence Site. There are a total of more than 2,500 drawings associated with the DHXs.

VTR Control Rod Mechanical Design Analysis

Completed an analytical benchmark for use by Argonne National Laboratory (ANL) and Pacific Northwest National Laboratory (PNNL) in resolving any uncertainties in the design of an absorber bundle for a control rod. This document has been sent to ANL for review and use in benchmarking the control rod design analysis for the VTR.

Thomas Fanning, Nuclear Technical Integration

Fuel Design and Analysis

Focused work on closing and documenting tasks selected for priority. Completed the Fuel Design and Analysis Project Hold and Restart form with input from Idaho National Laboratory (INL), Oak Ridge National Laboratory (ORNL), and ANL. Identified and prioritized activities for continuation into early FY 2022.

Prepared the second of two U-Pu-Zr-Ga/HT9 diffusion couples for scanning electron microscope (SEM) characterization of microchemistry. Lamellae of apparent Zr-Ga intermetallic precipitates were removed from the second of two samples from an Experimental Breeder Reactor (EBR-II) X521 U-Pu-Zr-Ga fuel rod. When completed, the characterization should indicate the composition and specific intermetallic Zr-Ga compound that

formed during irradiation. Completed and distributed the Integral Fast Reactor (IFR)-1 sensitivity and uncertainty quantification report draft for review, and transmitted comments from reviewers.

Completed the remaining assembly conceptual design work that could be accomplished prior to project closure and prepared an updated list of conceptual design drawings for fuel assemblies and in-core components.

Fuel Manufacturing

Continued project Hold and Restart planning and documentation, and remaining details of FY 2022 scope are being finalized. Finalized over a dozen internally-tracked deliverables to close out FY 2021. TerraPower (TP) finalized the HT-9 welding report and published four new specifications related to HT-9 feedstock and components. Released a study on storage constraints and options for nuclear materials in consideration of the need to store over one core of fuel prior to initial fuel loading and startup. The full set of drawings for all planned prototype equipment designed at INL was completed on time, including the slug sizing and characterization system, mold removal device, and a machine to remove “nail head” ends of cast slugs. Published a report summarizing these designs and describing the prototype testing plan. The team previously obtained fabrication quotes for some of these prototypes and have developed bills of materials for the others; manufacturing can start upon availability of funding. Published a conceptual design report for the rod loading and final welding system and glovebox.

Completed a comprehensive model update and completed a review draft of a report describing the system model functionality and the basis for the initial set of assumptions. This model is the result of several months of collaborative work and is expected to provide critical support to planned evaluations to compare manufacturing sites and how the manufacturing work may be divided between them.

Published a scoping study that examines options for fresh fuel scrap processing and disposition, including a pre-conceptual design, and identifies next steps in the design process. This report leverages Surplus Plutonium Disposition (SPD) development and represents the most detailed evaluation to date of the requirements and design of such a system. This system is important as it may have substantial footprint requirements that could potentially impact site suitability.

Continued work on the casting system prototype design, and the team completed the 60% design review and site visit with the furnace subcontractor. Natrium personnel joined the design review based on initial evaluations that indicated that this prototype system may be applicable for Natrium fuel manufacturing process development with few, if any, modifications. This work represents an early collaboration opportunity that could save Natrium months of development and design time.

Core Design

VTR Shielding Analysis

The shielding analysis objective is to evaluate the sufficiency of the VTR radiation shields to protect people and equipment from radiation damage. GEH reviewed the first-round shielding analyses and provided feedback and comments. Collaborated closely with GEH to resolve the comments, including resolving the differences found between the VTR design and the shielding model, updating the shielding model based on the most recent design information, and performing additional analyses to address questions raised (e.g., the impact of Upper Internal

Structure). The secondary sodium activity, one of the important parameters having a strong impact on the in-vessel shielding arrangement, was calculated with the updated model. The results showed non-negligible difference from the previous result. Further analyses may be needed once the dose rate limit around the secondary loop is decided. Based on the most recent design information, additional analyses are needed including the evaluation of the dose rate above the Head Access Area, the assessment of radiation damage on the in-vessel equipment, and the air dust activation analysis in the Reactor Vessel Auxiliary Cooling System (RVACS).

Transient Safety Analysis

Safety Analysis

Completed a September milestone to document the status of the EM pump modeling capability in SAS. The milestone includes a summary of the theory behind the equivalent circuit EM pump model, the required SAS4A/SASSYS-1 input for the detailed and simple EM pump modeling options, as well as a demonstration of the simple EM pump model using a prototypic SFR. To support software quality assurance (SQA), the software requirement specification and the software design description documents are being finalized for the new EM pump model.

Completed drafts of Hold and Restart forms identifying VTR safety analysis tasks that will be completed during the planned carryover period and what tasks should be prioritized if the project restarts later.

GEH delivered a response to a design information request on the B24 secondary system geometry. The dimensions collected were obtained from a review of the Navisworks model for the VTR plant design. Some minor differences were noted, but dimensions related to the modification to use a single pump per secondary loop are not available. Updates will be implemented in the SAS model and their impact on the transient simulations assessed.

SAS-Dakota simulations were performed to assess the sensitivity of the SAS predictions of the response to the Protected Station Blackout transient to variations in core heat transfer coefficients and primary pump performance characteristics. The results are being documented as an ANL VTR technical memo to preserve the effort for future work.

SAS Verification and Validation (V&V)

Continued archiving and documenting V&V analyses for project hold, including the verification of core radial expansion model and the SAS-computational fluid dynamics (CFD) coupling verification testing.

Prepared for review a list of modeling assumptions and inputs for the Mixing Components Test Facility (MCTF) validation case. A draft version of the gap analysis report, which summarizes progress completed to date and initial results, has been completed on the V&V effort for SAS.

Safety Basis

Completed the ex-vessel dose consequence Engineering Calculation and Analysis Report (ECAR) revision that incorporates the VTR waste streams. Completed the VTR ex-vessel hazard evaluation Technical Evaluation (TEV) revision for the VTR facility and completed the safety basis milestone by issuing the TEV for the Safety

SSC classification list integrated with Doors. Continued natural phenomena hazard (NPH) design categorization and prepared a draft to support design efforts.

Probabilistic Risk Assessment (PRA)

Continued archiving and documenting PRA analyses for project hold, including the mechanistic analysis of RVACS reliability, which has been under development utilizing SAS4A/SASSYS-1. Completed a draft version of the report on the validation of the Simplified Radionuclide Transport (SRT) source term analysis code aerosol models, which summarizes progress completed to date and initial results. Generally, the "Henry model" in SRT for aerosol deposition is in good agreement with experimental results concerning sodium aerosols behavior.

Sodium Fire Hazard Analysis and Software V&V

Documented the status of the SPCA-ANL sodium fire analysis code in a report currently under final review. Sodium fire analysis and software V&V efforts are being archived and documented for project hold. Continued efforts to complete a draft the M43 sodium fire analysis Hold and Restart form.

Modified the SPCA-ANL code to enable simulation of the AB5 and AB6 tests which included oxygen and nitrogen injection during the tests. Comparing results to results from other sodium fire software tools. Sample spray and pool fire scenarios are also being simulated for comparison. Continued code modernization. Began efforts to convert the previous SPCA II user's manual to a working document which will be updated as the new code's user manual in FY 2022.

Kevan Weaver, Experiments Technical Integration

All university partners have documented current work status through Hold and Restart (H&R) reports and forms which identify needed and planned restart activities for the four experiment vehicle types and support areas. Completed H&R reports and forms will be submitted to the Confluence site. Identified 27 students to provide partial funding to complete their graduate degree.