INL/MIS-20-57198-Revision-0

NS&T Highlights November/December 2019

Joel Newman Hiller

February 2020

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

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Nuclear Science & Technology

November/December 2019 Highlights

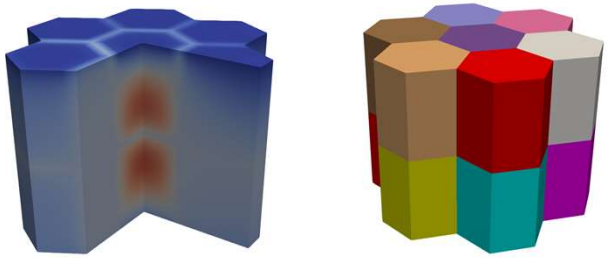
www.inl.gov

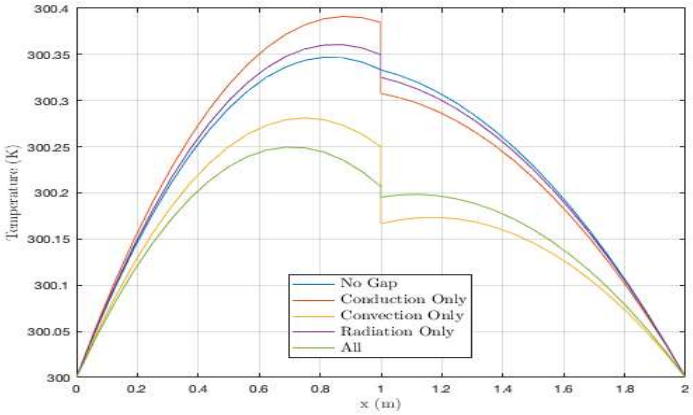
Idaho National Laboratory

Idaho National Laboratory

New MAMMOTH Methodology Improves Understanding of Reactor Thermal Effects

- Modeling heat transfer mechanisms within coolant channels is vital for understanding the thermal profile and heat flux in nuclear reactors.
- Coolant gaps can be very small in advanced reactor designs (microreactors and VHTRs), and resolving them in a finite element mesh creates myriad solver issues.
- Effects of conduction, convection and radiation are all considered, and the model can be directly coupled to any MOOSE app.





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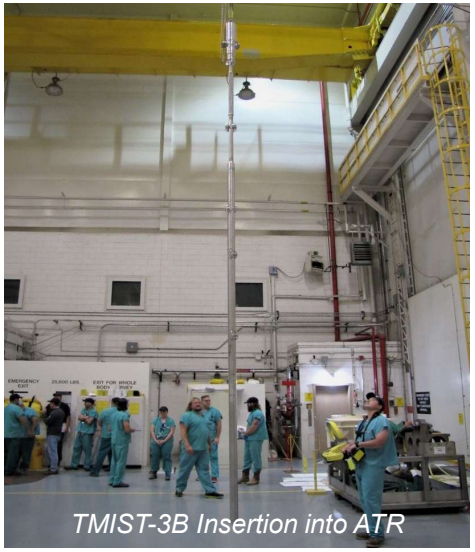
MOOSE

UNITED STATES NUCLEAR REGULATORY COMMISSION

Idaho National Laboratory

New Tritium Sustainment Experiment at ATR Supports National Defense Goals

- The TMIST-3B test train began its first irradiation cycle at ATR on Nov. 11, 2019. The experiment will accumulate over 500 effective full power days (EFPDs) of irradiation by July 2023.
- The test train will provide real-time tritium release data from six flow-through capsules containing lithium aluminate and cermet pellets having a variety of microstructural features and burnup rates.
- The 13 closed capsules will provide insight into the mechanisms controlling the release of tritium from TPBAR (tritium-producing burnable absorber rod) pellets, enabling better predictive models and options for increasing TPBAR production and/or decreasing TPBAR permeation.



TMIST-3B Insertion into ATR

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Pacific Northwest NATIONAL LABORATORY

National Nuclear Security Administration

ATR IRRADIATION TESTING FACILITY OF CHOICE

Idaho National Laboratory

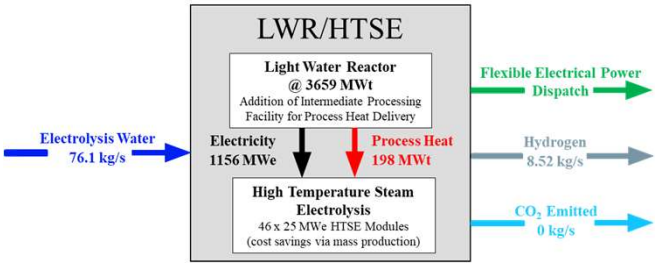
Process and Economic Models Completed for Modular Electrolysis Plant

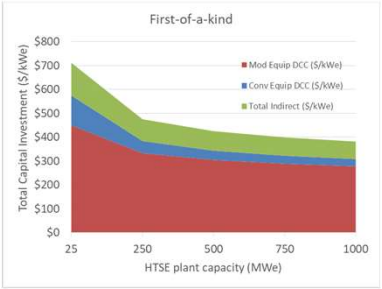
New process model for modular, light water reactor-integrated, high temperature steam electrolysis (HTSE) plant:

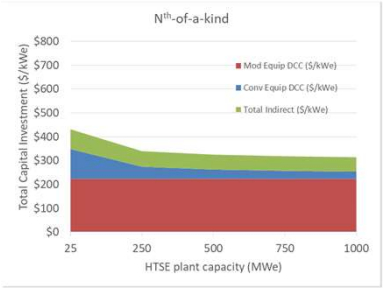
- Addresses deployment challenges of the previous stick-built, large-vessel design.
- Compatible with phased demonstration/deployment activities.
- Incorporates operating conditions and performance data from FuelCell Energy and Exelon.

New economic model evaluates HTSE capital expenditures as a function of plant scale:

- Cost correlations incorporated into RAVEN to support current Exelon and Xcel CRADA analyses.
- Model accounts for conventional and modular components.
- Model supports first-of-a-kind, Nth-of-a-kind plant scenarios.







Preliminary RAVEN hydrogen/power dispatch optimization analyses indicate that achieving capital cost targets is a key step in achieving price parity with steam methane reforming.

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LWRS LIGHT WATER REACTOR SUSTAINABILITY

Idaho National Laboratory

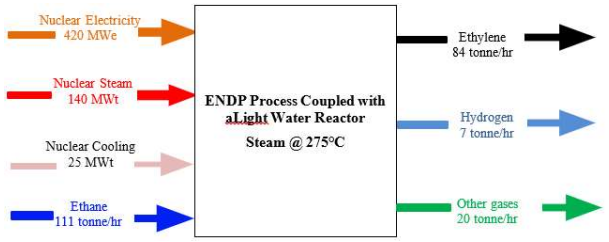
LWRS Program Models New Process for Reducing Cost of Polymer Production

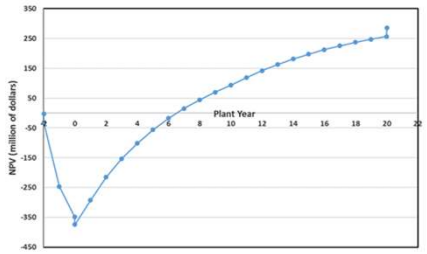
The newly modeled process converts natural gas condensate (ethane and propane) into monomers (ethylene and propylene), using electricity and thermal energy from LWR plants.

The economic model included market trend projections for polymers and plastics, and a comparison with conventional steam cracking of ethane.

Game-changing outcomes:

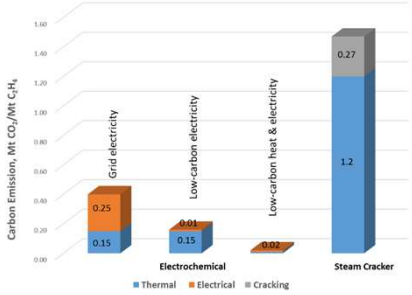
- Reduced cost of polymers production
- Dramatic reduction in air emissions; especially CO_2
- A net positive 12% internal rate of return
- Utilizes abundant domestic supply of natural gas condensates





Plastics & Resins

Ethylene Glycol



CO_2 Emissions Reduction

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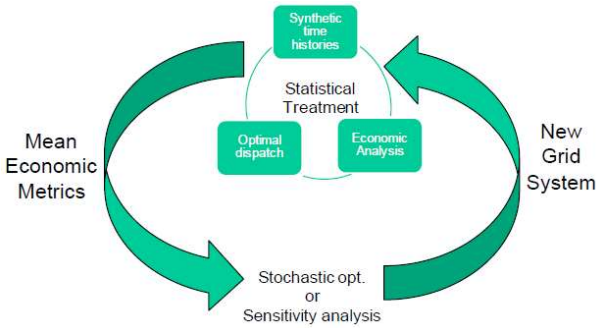
LWRS LIGHT WATER REACTOR SUSTAINABILITY

Idaho National Laboratory

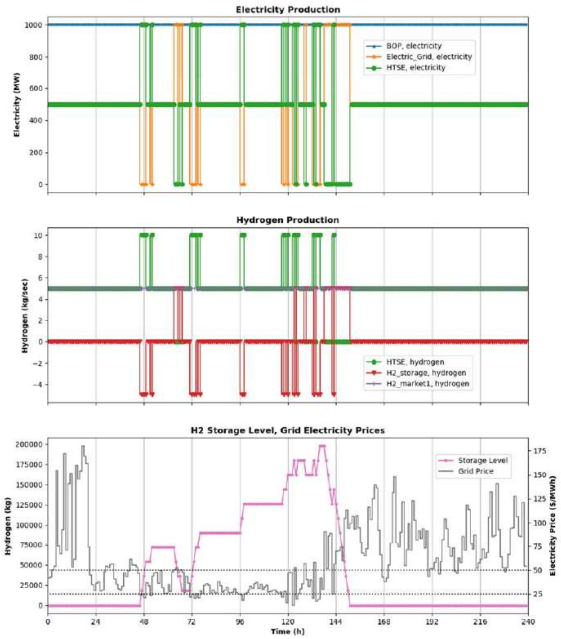
New Tool Optimizes Use of LWR for Electricity and Hydrogen Production in Deregulated Markets

- HERON (Holistic Energy Resource Optimization Network) plugin for RAVEN analyzes plant operations to aid in electricity market assessments, optimizing electricity grid and capacity.
- HERON use for deregulated markets was demonstrated, showing optimization of steam dispatch of electricity to grid and hydrogen production.
- 20-year grid pricing synthetic history training developed for wide variety of timeframes.

HERON extends the use of RAVEN to energy systems optimization analysis in support of technical and economic assessments by INL



HERON's RAVEN-running-RAVEN Workflow



Demonstration for dispatch of electricity to grid and hydrogen production

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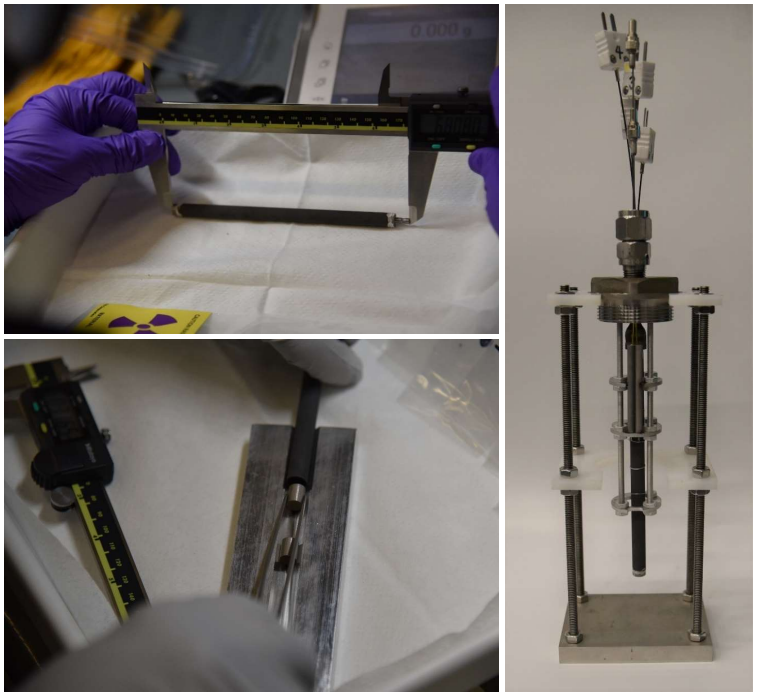
LWRS LIGHT WATER REACTOR SUSTAINABILITY

Idaho National Laboratory

TREAT Completes Separate Effects Tests for ATF Concept Uranium Silicide Fuel

- The team conducted tests on uranium silicide (U_3Si_2) rodlets with silicon carbide cladding, which is one accident-tolerant fuel concept.
- Tests were completed in a separate effects test holder (SETH) capsule.

Completed Level 2 milestone: "Perform transients on ATF concepts in SETH capsule (~3 transients)" ahead of schedule.



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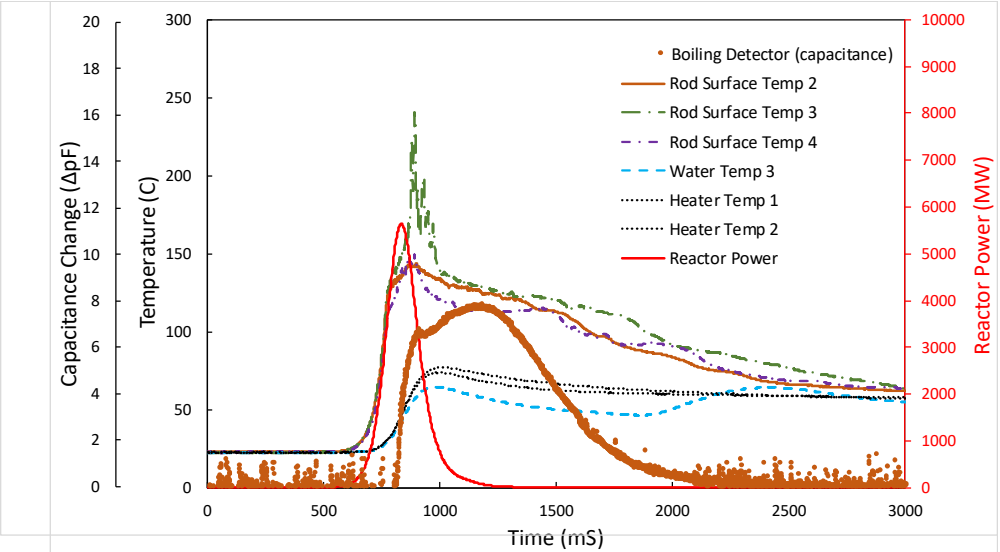
Transient Test Program
Enabling World Class Nuclear Energy R&D

Idaho National Laboratory

TREAT Completes Test of New Instrumentation Package

- The experiment included the first application of a non-fueled, nuclear heated rod to measure in-pile transient critical heat flux.
- Novel instrumentation package performed exceptionally well, demonstrating first in-pile performance of a capacitive-based boiling detector.
- Successful performance of the entire experimental system is crucial for supporting INL-led efforts to answer high impact transient critical heat flux questions related to nuclear fuel performance.



Preliminary data from transient #1 (CHF-A1) – the INL-developed boiling detector demonstrated superb performance in measuring water voiding events

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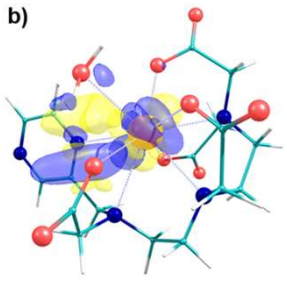
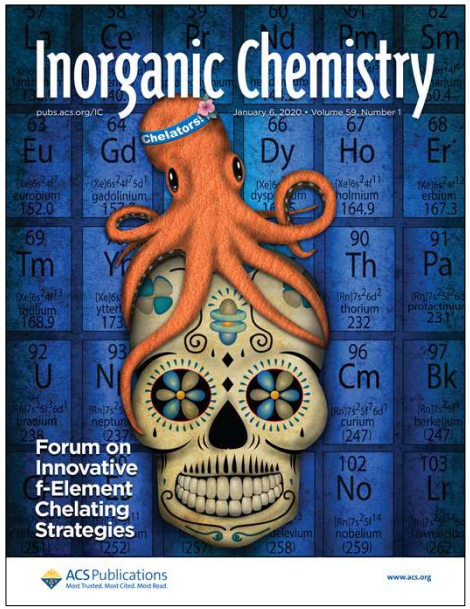
Transient Test Program
Enabling World Class Nuclear Energy R&D

Idaho National Laboratory

INL Researchers Invited to Contribute to Special Issue of Inorganic Chemistry

- INL researchers (Grimes, Heathman and Zalupski) study novel metal chelators to improve methods of differentiating trivalent actinides from trivalent lanthanides. The research efforts are supported by synthetic and computational efforts from ORNL.
- Their recent study of the electronic influence of *N*-2-pyrazinylmethyl structural group in the coordination of trivalent *f*-elements was published in a special forum issue of *Journal of Inorganic Chemistry.*
- This publication marks the seventh novel chelator the authors have reported on, assembling a vast thermodynamic knowledge of structure-function relationships for radiometal chelation applications.





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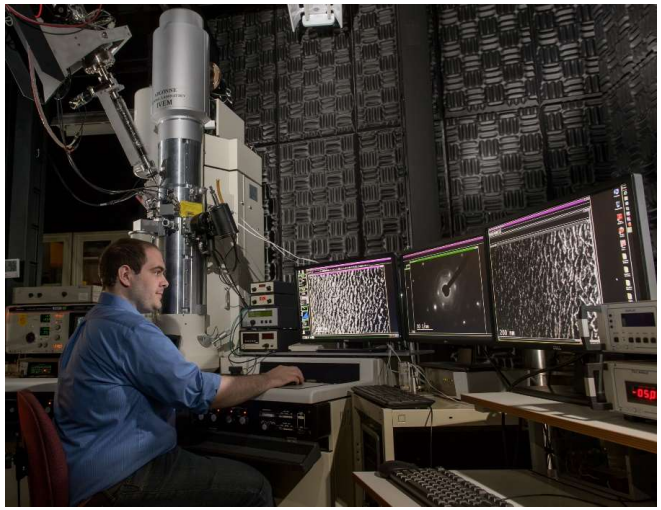
Grimes, T.S.; Heathman, C.R.; Jansone-Popova, S.; Ivanov, A.S.; Bryantsev, V.S.; Zalupski, P.R. "**Exploring Soft Donor Character of the N-2-Pyrazinylmethyl Group by Coordinating Trivalent Actinides and Lanthanides Using Aminopolycarboxylates**," *Inorg. Chem.*, 2020, 59(1), 138-150.

U.S. DEPARTMENT OF ENERGY

Idaho National Laboratory

NSUF Project Finds High Radiation Tolerance in Gd_2O_3 and Lu_2O_3 Fuels

- A Nuclear Science User Facilities (NSUF) team irradiated fuels at a high level to determine the degradation at the fuel pellet rim.
- No observable structural change was observed in either fuel during the test.
- **Team**: Rodney Ewing (PI) and Chien-Hung Chen at Stanford University
- **NSUF Facility**: Intermediate Voltage Electron Microscopy (IVEM) Tandem Facility at Argonne National Laboratory
- Published in *Applied Physics Letters* in January 2018 as part of a project completed in November 2019.



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NSUF Nuclear Science User Facilities

Idaho National Laboratory

Secretary of Energy Honor Awards Recognizes the NICE Future Initiative Team

- The U.S. Nuclear Innovation: Clean Energy (NICE) Future Initiative Team received the Secretary of Energy's Achievement Award for showing that nuclear energy can be integrated with other clean energy technologies to create a thriving, emissions-free economy.
- INL's participation includes Dr. Shannon Bragg-Sitton, who serves as the NICE Future Initiative technical lead. INL communications staff Kortny Rolston-Duce and Joe Campbell provided significant support.
- More information on the initiative is available at https://nice-future.org.

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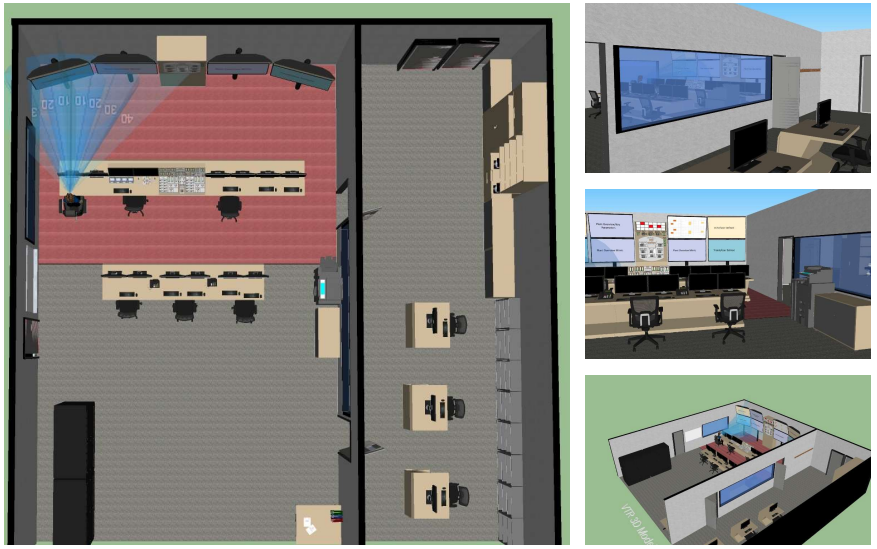
Idaho National Laboratory

New 3D Model of VTR Main Control Room Supports Conceptual Design and Evaluation Activities

- The model offers a dimensionally correct representation of the Versatile Test Reactor main control room, designated workstation and operating equipment such as the Group View Display System.
- Loading the model in VR enables immersive walkthroughs for effective communication of important design considerations.
- Anthropometrically correct operator mannequins provide a platform to address human factors in engineering, supporting legibility requirements and workplace design.



3D Model of the VTR Main Control Room

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HITACHI

Idaho National Laboratory

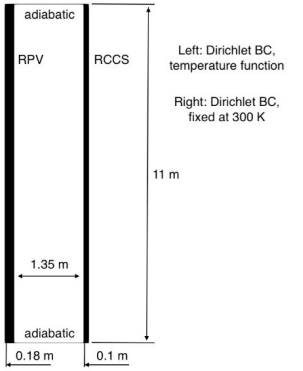
VTR VERSATILE TEST REACTOR

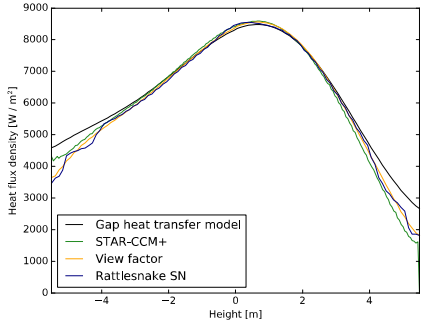
MAMMOTH Team Delivers Multiphysics Capabilities to NRC

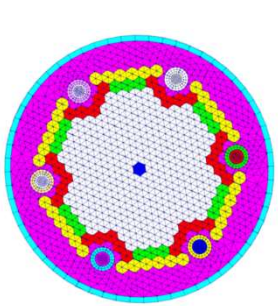
MAMMOTH team is developing NRC's advanced reactor, multiphysics capabilities.

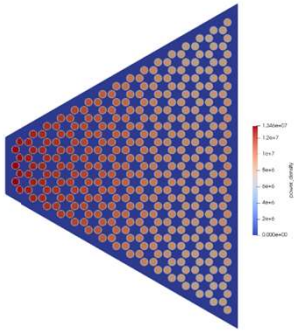
The first set of deliverables was submitted to NRC on Dec. 6:

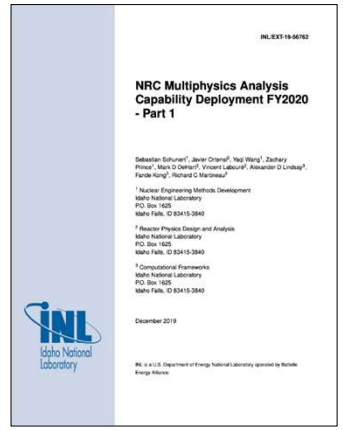
- Reactor Cavity Cooling System (RCCS) Model
- Thermal gap models for HTGRs & micro-reactors
- Micro-reactor meshing capabilities
- Micro-reactor heat pipe overcooling transient with thermal expansion feedback

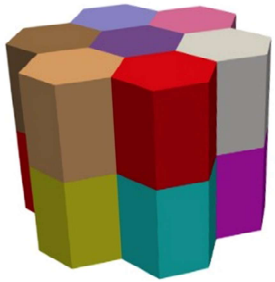




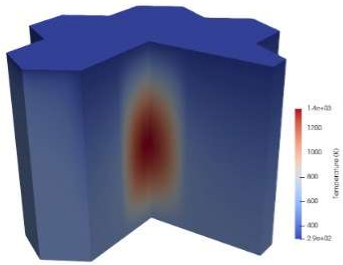




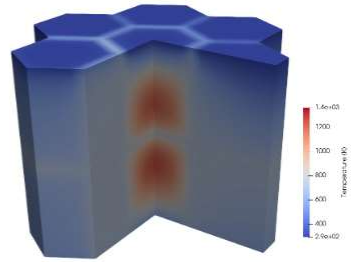




14 block test problem



Perfect thermal contact



Gap heat transfer model

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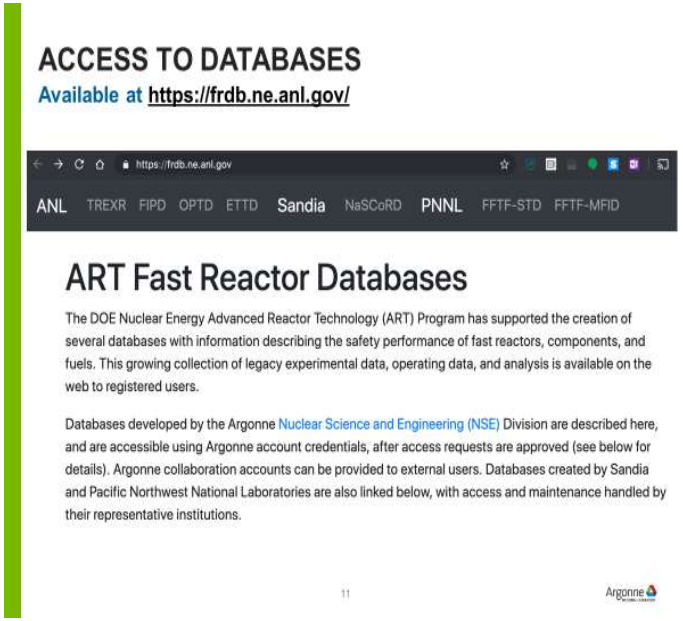
Idaho National Laboratory

GAIN Hosts Fuel Irradiation Workshop at INL

- The Gateway for Accelerated Innovation in Nuclear (GAIN) Initiative hosted the Legacy Fuel Irradiation and Testing Database Workshop at INL.
- Metallic fuel researchers from INL Argonne, Los Alamos and Pacific Northwest national laboratories discussed how to share the data available in their databases with appropriate DOE national laboratories.
- The workshop emphasized collaboration between the four labs to complete the Metallic Fuel and Testing Databases and provide early access to the data by DOE programs.



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Idaho National Laboratory

GAIN Announces NE Voucher Recipients

- On December 19, 2019, GAIN announced the NE Voucher Recipients for Round 1 FY2020:

GAIN NE Voucher Recipient	Proposal	Partner Facility
Hydromine, Inc.	On-Line Lead/Water Heat Exchanger Sensor/System Feasibility	Pacific Northwest National Laboratory
Lightbridge Corporation	Advanced Test Reactor Experiment Design for Measurement of Lightbridge Fuel™ Thermophysical Properties	Idaho National Laboratory

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Idaho National Laboratory

INL Provides Control Room Modernization Training to Nuclear Group from Mexico

- The Human Factors and Reliability Department hosted delegation from Laguna Verde Nuclear Generating Station and National Institute for Nuclear Research. This marked the first human factors training offered at INL through a new agreement with the International Atomic Energy Agency.
- Week-long control room modernization training used examples from U.S. commercial fleet and DOE reactors, covering human factors first principles such as signal detection and monitoring, and applied topics such as digital prototyping and regulatory framework for upgrades.
- Training also made use of interactive demonstrations in the Human Systems Simulation Laboratory.

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IAEA

CFE Comisión Federal de Electricidad

instituto nacional de investigaciones nucleares

Idaho National Laboratory

New Sawtooth Supercomputer Arrives

- Sawtooth ranks 37th on the 2019 Top 500 fastest supercomputers in the world, the highest ranking reached by an INL supercomputer.
- Currently being installed in the new Collaborative Computing Center (C3), the computer contains approximately 100,000 compute cores with a performance of approximately 6 petaflops. It will also include GPU capabilities.
- Sawtooth is currently being installed and is expected to be operational in March.

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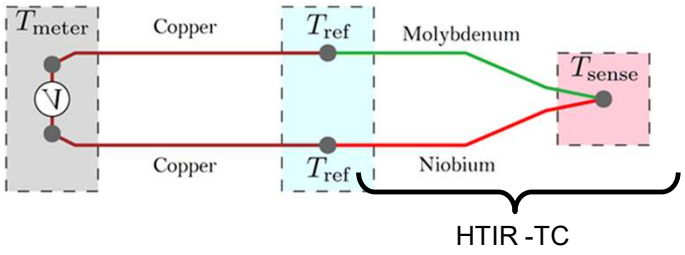
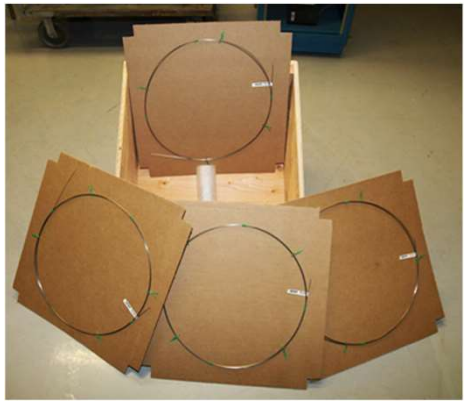
Idaho National Laboratory

High Temperature Irradiation Resistant Thermocouple Wins R&D 100 Award

- The High Temperature Irradiation Resistant thermocouple (HTIR-TC) was developed for use in material testing reactors under very high temperatures and radiation with minimal drift – filling a critical need in irradiation testing.
- The HTIR-TC has been successfully licensed by a commercial partner, Idaho Laboratories Corporation.
- For over 70 full-power-days at ATR the HTIR-TC recorded max temperatures of 1510°C.





The winning research team of Kurt Davis, Dr. Joshua Daw, and Dr. Richard Skifton.
Not pictured: Dr. Pattrick Calderoni.

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Idaho National Laboratory | Nuclear Science & Technology

November/December New Hires

Corey McDaniel

Nuclear Science and Technology
C000

Bradley Williams

Nuclear Science and Technology
C000

Taylor Hill

NS&T Operations
C001

John Shaver

NS&T Operations
C001

Idaho National Laboratory

Nuclear Science & Technology

November/December New Hires

Anna Podgorney

Innovative Nuclear Research Integration
C070

Lori Suitter

Reactor Systems Design and Analysis
C100

Yasir Arafat

Nuclear Engineering Methods Development
C120

Andrew Bascom

Experiment Analysis
C130

Idaho National Laboratory

Nuclear Science & Technology

November/December New Hires/Transfers

Jason Christensen

Regulatory Support
C210

Michael Norato

Fuel Cycle Science and Technology
C400

Sherry Gallup

Advanced Scientific Computing
C500

Jacques LaBranche

High Performance Computing & Data Analytics
C520

Idaho National Laboratory

Nuclear Science & Technology

November/December New Hires/Transfers

Allen Roach

Nuclear Materials C610

Antonio Martin Recuero

Computational Mechanics and Materials C650

Dewen Yushu

Computational Mechanics & Materials C650

Publications

- 1. J. Jiang and C. Wang, “Review-Electrolytic Metal Atoms Enabled Manufacturing of Nanostructured Sensor Electrodes,” Journal of The Electrochemical Society, 2020, 167, 037521.
- Grimes, T.S.; Heathman, C.R.; Jansone-Popova, S.; Ivanov, A.S.; Bryantsev, V.S.; Zalupski, P.R. “Exploring Soft Donor Character of the N-2-Pyrazinylmethyl Group by Coordinating Trivalent Actinides and Lanthanides Using Aminopolycarboxylates,” *Inorg. Chem.*, 2020, 59(1), 138-150.

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