# POLICY ISSUE
# (Information)

December 12, 2014 SECY-14-0142

FOR: The Commissioners

FROM: Brian W. Sheron, Director
Office of Nuclear Regulatory Research

SUBJECT: NRC PARTICIPATION IN THE HALDEN REACTOR PROJECT DURING 2015-2017

PURPOSE:

The purpose of this memorandum is to inform the Commission of the results of the U.S. Nuclear Regulatory Commission's (NRC's) past participation in the Halden Reactor Project (HRP) and the staff's plans to continue participating in the project during 2015–2017.

SUMMARY:

The HRP is a cooperatively funded international research and development project that operates under the auspices of the Organisation for Economic Co-operation and Development's Nuclear Energy Agency (OECD/NEA). The HRP is located in Halden, Norway, and managed by the Norwegian Institute for Energy Technology (Institutt for Energiteknikk). The international organizations actively participating in the HRP represent a cross section of the nuclear community: licensing and regulatory authorities, national research organizations, reactor and fuel vendors, and utilities. The U.S. HRP membership is divided between the signatory member, the NRC, and associated parties General Electric/Global Nuclear Fuel, Westinghouse Electric Company, Electric Power Research Institute, and the U.S. Department of Energy. Both signatory members and associated parties provide funding to the HRP and receive all research results and data, but only signatory members hold voting rights on the Halden Board of Management for their country. Associated parties may be observers to the Halden Board, and are encouraged to provide technical input into the proposed program of research at Halden.

CONTACT: Matthew Hiser, RES/DE
(301) 251-7601

The HRP research programs address four primary areas: (1) nuclear fuels, (2) irradiation-assisted degradation of nuclear reactor materials, (3) digital systems, and (4) human factors. Results and information from HRP research directly support program office user need requests and Commission-directed activities. Participation has also maximized use of NRC research funds by leveraging the resources of other HRP participants. In addition, participation in the HRP facilitates cooperation and technical information exchange with the participating countries. The staff plans to continue to participate in the project for the 2015–2017 agreement period because of the highly leveraged research benefits in key technical areas, as well as the excellent opportunity for international cooperation and information exchange.

BACKGROUND:

The NRC and its predecessor, the U.S. Atomic Energy Commission, have participated in the HRP since its inception in 1958. The HRP membership has expanded over the years and currently includes 31 organizations from 20 countries (Enclosure 1). The HRP plans its program in 3-year agreement periods. The current agreement expires at the end of the calendar year 2014, and the upcoming cycle covers the period from 2015–2017. In advance of each 3-year program, Halden prepares a research proposal detailing the planned areas for the upcoming 3-year period. The research proposal is provided to HRP member organizations for review. HRP also visits each member organization to formally present the proposal and to discuss how the proposal could be improved for each member's needs. HRP members provide feedback by ranking each proposed project to communicate their preferences for the direction and approach of the specific proposed projects. HRP reconciles this feedback and uses it to prioritize its activities.

The HRP is organized into two parallel research programs: the fuels and materials (F&M) program and the Man-Technology-Organization (MTO) program. The F&M program focuses on nuclear fuels and nuclear reactor materials performance through tests conducted in the Halden Boiling Water Reactor (HBWR). The HBWR supports instrumented in-reactor testing of fuel and reactor materials using numerous experimental loops that run through the reactor core. Since its initial startup, the reactor facility has been progressively updated and currently contains multiple loops to simulate both boiling-water reactor (BWR) and pressurized-water reactor (PWR) environments. Fuels research includes loss-of-coolant accident (LOCA) testing, fission gas release studies, and fuel and cladding creep experiments. Materials research projects focus on irradiation-assisted stress corrosion cracking tests, stress relaxation, and creep experiments for reactor internals materials.

The MTO program focuses on digital instrumentation and control (I&C) systems, human factors, and human performance. The HRP uses nuclear power plant (NPP) simulators, a virtual environment, and an integrated operations laboratory to support this research. For instance, the Halden Man-Machine Laboratory (HAMMLAB) includes a reconfigurable simulator control room with hardware and software to simulate PWR and BWR plants in France and Sweden. HAMMLAB recently added new simulators to simulate U.S. Westinghouse PWR designs. The HAMMLAB conducts human performance research generally using operators from Sweden. In recent years, the laboratory also has started to use operators from U.S. plants and recently included staff from the NRC's Technical Training Center. The broad insights derived from the Halden simulator experiments have general applicability to U.S. research for the purposes of better understanding and improving human performance.

The HRP has been endeavoring to coordinate their research programs and the needs of member organizations through frequent interactions. The Halden Board of Management (HBM)

meets semiannually to provide project oversight and review and to decide whether to approve or disapprove the HRP's plans. HBM consists of representatives from signatory members (no more than one per country). Mr. Richard Correia, Director of RES's Division of Risk Analysis, is currently the NRC's voting representative on the HBM. The Halden Program Group (HPG) also meets semiannually and provides a technical advisory forum for member organizations to give technical recommendations to the HRP. The NRC technical staff members serve as representatives on the HPG and interact with HRP to ensure the agency's research needs are represented in HRP projects. They also collaborate with representatives from other member organizations to provide input regarding the scope and focus of research to HRP.

DISCUSSION:

The NRC has benefited from participation in the HRP because the research results have supported regulatory products, leveraged limited nuclear safety resources, supported knowledge transfer to the NRC staff, and supported the NRC's international communication, coordination, and collaboration efforts. By taking part in this multinational research agreement, the NRC leverages its resources to collect a large amount of valuable data. Involvement in the HRP also supports knowledge transfer to the NRC staff through visits to the HRP facilities and rotational opportunities. The HRP is well equipped to support such rotations through its secondee program that allows guest researchers from all of the member countries to partake in short-term assignments at the HRP. NRC has previously sent junior staff on rotation to Halden in the areas of fuels and human factors to gain a deeper understanding of the research performed at Halden. Finally, participation in the HRP provides an ideal venue for cooperation and information exchange with international counterparts.

During the current 2012-2014 program period, the NRC has received the benefit of many research products from HRP. Enclosure 2 provides a listing of HRP reports for the 2012-2014 time period (those reported up to October 2014 are included in this listing). The following subsections briefly describe the benefits derived by the NRC from past and continued participation in the HRP for each area of work. Enclosure 3 provides a more detailed discussion of these areas along with examples of regulatory products.

Nuclear Fuels

Fuel damage criteria and computer codes that describe fuel rod behavior are used in reactor safety analyses. These criteria and codes are used to ensure fuel integrity during normal operation (including anticipated transients) and to ensure that fuel subjected to postulated accidents does not exceed established safety limits. These criteria and computer codes were originally developed from a database largely related to low-burnup fuel with Zircaloy cladding. The HRP fuel program is enhancing this database by addressing the effects of longer fuel burnup times, new fuel and cladding materials that are being used to achieve high burnups, and mixed-oxide (MOX) fuel that will be used for plutonium disposition in the United States.

Data from the HRP fuel program have been employed directly in recent staff reviews of industry fuel behavior codes. These data, which take several years to gather, are also essential for updating the NRC's fuel codes and materials properties library to support audits of industry safety analyses. The fuel properties and codes also are used to assess spent fuel storage and transportation. Of particular interest to the NRC is the HRP's extensive LOCA test series that enhanced NRC's fuel code calculations and directly informed the proposed rulemaking for Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors". During the next 3 years, the

HRP will continue research of high interest to the NRC in the area of fuel testing and performance.

Nuclear Reactor Materials

The HRP has provided fundamental technical information, which supplements the results generated under NRC research programs to better understand the performance of irradiated reactor internals materials. The HRP has been an essential partner in evaluating the irradiation-assisted stress-corrosion cracking (IASCC) of light-water reactor (LWR) materials. The staff used HRP facilities to irradiate materials that were later tested under the NRC's research program at Argonne National Laboratory to measure crack initiation, fracture toughness, and crack growth rate under representative LWR conditions. The NRC staff uses such data to inform its license renewal reviews of licensee aging management programs for reactor pressure vessel internals, which includes technical input for the guidance in the Generic Aging Lessons Learned report. The NRC also has used the information from the HRP materials testing program to provide part of the technical basis for the review of industry's plans to inspect PWR reactor vessel internals. Over the next 3-year period, the HRP plans to continue irradiated material testing, which will augment the technical basis for assessing the structural integrity of reactor vessel internals during potential subsequent license renewal periods.

Human Factors

The HRP's human factors research program has six sections: human reliability, human and organizational factors, human-system-interfaces (HSI), control-room design and evaluation, outage and field work, and future operational concepts. Overall, the research examines aspects of human performance and human factors considerations in new and existing nuclear plants, and the usage of new and existing technologies. The results of HRP research have served as a part of the technical basis for NRC regulatory guidance for reviewing changes to control rooms for operating reactors, new reactor applications, license amendment requests, and plant inspections. Key guidance documents whose development and updating have been supported by HRP research include NUREG-0700 "Human-System Interface Review Guidelines" and NUREG-0711 "Human Factors Engineering Program Review Model." For instance, the MTO program has been closely working with the NRC and other international organizations on collecting human reliability data, which provided benchmarking for the NRC's development of improved human reliability methods. In addition, the HRP's integrated systems validation project has provided useful information for the NRC's effort to update human factors review guidance in this area. During the next 3 years, the HRP will continue research of high interest to the NRC, particularly in the area of human reliability analysis.

Digital Instrumentation and Controls

HRP's digital systems research has two broad categories—software systems dependability and operation and maintenance support. NRC's primary interest in this area is the development of a safety demonstration framework that is being addressed by the HRP through its research area of software systems dependability. In the current program period, the HRP has coordinated international expert elicitations and a workshop hosted at the NRC in March 2014 on the topic of developing a safety demonstration framework for digital I&C systems. These activities lay the groundwork for further HRP development to address the challenges and to identify best practices for safety demonstration. Safety demonstration methodologies directly support NRC's Digital I&C Research Plan and are of high value for developing regulatory guidance.

Halden Agreement

The Halden Agreement is an OECD/NEA agreement that describes the terms and conditions of participation in the Halden Reactor Project. NRC staff has engaged with the HRP on various areas of potential improvement to the Halden Agreement. These areas include clarification of the rights and responsibilities of signatory members and associated parties, procedures for recruitment of new members and distribution of Halden research results, and transparency in the proposal ranking process and the financial contributions of associated parties. NRC staff has been pleased with the level of engagement from the HRP on a number of these issues and continues to work with the HRP and other HRP members to continue to make progress in these areas. In addition, NEA has encouraged Halden to update the Halden agreement to be more consistent with other NEA agreements. Therefore, as recommended by the HBM, the HRP has made significant updates to the Halden Agreement for the upcoming 2015-2017 period to address some of the areas for improvement described above.

Halden Reactor License Renewal

The Norwegian nuclear regulatory authority has recommended approval of a renewed license for the HBWR to continue operating from 2015 through 2024. Final approval of the renewed license is expected by the King of Norway before the end of 2014. In the unlikely scenario that the operating license for the HBWR is not renewed, the NRC staff will take appropriate action regarding NRC's participation in HRP during 2015-2017. The status of the HBWR's license renewal will be known prior to NRC providing any funding for the 2015 – 2017 period.

RESOURCES:

The cost of the NRC's participation in the HRP during the 2012–2014 agreement period was 33 million Norwegian kroner (NOK). HRP's initial request to HRP members was for a 10-percent increase in contributions for the 2015-2017 period. According to the HRP, a roughly 10-percent increase every 3 years is needed to maintain the same level of effort to cover higher costs due to inflation and cost-of-living increases in salaries and benefits. At the June 2014 HBM meeting, HRP presented a 2015-2017 program plan with no increase in fees. Under this plan, lower priority projects in all areas would be suspended.

The Halden Board of Management came to a unanimous decision of no increase in fees due to economic conditions among HRP members. Therefore, the cost of the NRC's participation in the HRP during the 2015–2017 agreement period is 33 million Norwegian kroner (NOK). This amounts to a total obligation of about $1.72 million per year given an exchange rate of 6.41 NOK to the dollar[1].

$2.0 million has been budgeted each year in the FY 2015 and FY 2016 budget requests. Funding for FY 2017 will be addressed through the agency's Planning, Budgeting, and Performance Management (PBPM) process. The FY 2015 and FY 2016 funds are located in the Research Product Line of the Operating Reactors Business Line.:

[1] The exchange rate of 6.41 NOK to the dollar was calculated on September 17, 2014. Within the last year, the exchange rate has ranged from 5.75 to 6.42 NOK to the dollar, which corresponds to an annual NRC contribution range of $1.71M to $1.91M.

COORDINATION:

The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections. The Office of the General Counsel has no legal objection to this paper. The Office of International Programs has no objections to this paper.

**/RA/**

Brian W. Sheron, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Members of the Halden Reactor Project
2. Listing of Halden Reports for 2012-2014
3. Extended Summary of NRC Involvement in the Halden Reactor Project

COORDINATION:

The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections. The Office of the General Counsel has no legal objection to this paper. The Office of International Programs has no objections to this paper.

**/RA/**

Brian W. Sheron, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Members of the Halden Reactor Project
2. Listing of Halden Reports for 2012-2014
3. Extended Summary of NRC Involvement in the Halden Reactor Project

**ADAMS Accession No.: ML14294A004**

| OFFICE | RES/DE/CMB | QTE | RES/DE/CMB | D: RES/DE | D:RES/DSA | D:RES/DRA |
|---|---|---|---|---|---|---|
| NAME | M. Hiser | J. Zabel | M. Srinivasan | B. Thomas | M. Case | R. Correia |
| DATE | 10/20/14 | 10/20/14 | 10/27/14 | 11/13/14 | 11/14/14 | 11/17/14 |
| OFFICE | OCFO | OGC (N. Crimm for) | OIP (E. Stahl for) | NRR (J. Uhle for) | RES Mail Room | RES |
| NAME | T. Grancorvitz | M. Doane | N. Mamish | W. Dean | K. Johnson | B. Sheron |
| DATE | 11/25/14 | 11/24/14 | 11/19/14 | 11/26/14 | 12/02/14 | 12/12/14 |

**OFFICIAL RECORD COPY**