**From:** Mike Billone <billone@anl.gov> RES
**To:** 'Ralph Meyer' <ROM@nrc.gov>
**Date:** 1/27/06 12:31PM
**Subject:** RE: AGHCF and IML

Dear Ralph,

1. We moved the out-of-cell LOCA apparatus out of AGHCF on Jan. 13th to a non-controlled lab area (G117) to conduct oxidation/quench testing on as-fabricated and prehydrided cladding as quickly as possible. This also allows us to do the ring-compression tests in a non-controlled lab in the table top Instron, which we purchased sometime in early 2004.

2. We plan to move it to the IML Cell by the end of April 2006 to conduct the oxidation/quench tests with defueled high-burnup cladding. Of course, testing of nonirradiated cladding can continue in the IML cell, but the time per test will increase. For irradiated and contaminated materials, the ring-compression tests are done in Rob's glove-boxed Instron.

Please look at my Executive Summary (first 2 pages of enclosure) sent to everyone up to the level of Finck. You may want to read the last paragraph in particular. I do not know if Finck has distributed to Joyce and Rosner.

Also, enclosed in the same document are the details from which the executive summary was written. The pictures may be useful in refreshing your memory.

Mike

P.s. I have left in the stuff about the EPRI-Framatome and DOE-RW projects, because they are related to the NRC LOCA and SNF work.

-----Original Message-----
From: Ralph Meyer [mailto:ROM@nrc.gov]
Sent: Friday, January 27, 2006 10:58 AM
To: billone@anl.gov
Subject: AGHCF and IML

Mike,

Please let me know if there are any inaccurate statements in the following.

Ralph

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Don,

Mike is doing something right now that eliminates about 80% of our activities in the AGHCF, and I am not sure this is fully understood. I didn't understand it until very recently.

We have a LOCA testing apparatus (furnace and related components) inside the appha-gamma hot cell and another identical apparatus just outside the window. They share a common instrument console. These two pieces of apparatus are used for all our high-temperature LOCA testing, whether the cladding has fuel in it or not. The vast majority of the tests are done with de-fueled cladding and unirradiated cladding. But all of this is

A-17

within the bounds of the AGHCF.

The identical out-of-cell apparatus has just been moved to the Irradiated Materials Laboratory (IML), which is a non-nuclear facility. In the future, all of the testing of de-fueled cladding and unirradiated cladding will be done in the IML. This move alone will reduce our activities in the AGHCF by about 80%.

The remaining activities that require the alpha-gamma hot cells are defueling of cladding specimens and testing of a small number of specimens with fuel inside. These are important activities, which we would like to continue through 2008, but they are just a small fraction of what we have been doing in the AGHCF.

I hope you will take this substantial reduction into account in our future discussions.

Ralph

**Plan to Continue Programmatic Work outside of the AGHCF**
M.C. Billone
January 20, 2006

## Executive Summary

The AGHCF has been used for sample preparation and testing to generate data essential to the NRC, DOE, EPRI and the nuclear industry to ensure the safe operation of nuclear reactors and the safe transport of spent nuclear fuel. By order of the ANL Lab Director, this work was suspended temporarily on July 26, 2005 to allow full focus on corrective actions resulting from the DOE-OA audit. On January 16, 2006, the Director announced in the Argonne News that the AGHCF would no longer be used to conduct programmatic work. Because of the importance of the ANL work to nuclear-reactor and spent-fuel-transport safety, a plan has been developed to perform the required testing in onsite facilities outside the AGHCF, as well as offsite facilities. The plan addresses the data needs of the major sponsors (NRC, EPRI, Framatome, and DOE-RW) related to high-burnup cladding performance during in-reactor loss-of-coolant accidents, during normal performance, and during spent-fuel-cask transport accidents and sabotage.

Most of data needed to resolve nuclear safety and fuel transport issues can be performed in non-controlled areas and in the Irradiated Materials Laboratory (IML), which is a radiological facility. The dominant effects of high-burnup operation on cladding embrittlement are increased hydrogen pickup and irradiation hardening. Baseline data using nonirradiated-prehydrided cladding alloys can be generated in non-controlled areas. These areas have been secured and movement of non-contaminated equipment from the AGHCF to these areas is in progress. Upon completion of the nonirradiated cladding work (≈April 2006), the oxidation/quench apparatus will be moved into an IML cell to enable continued testing of defueled, high-burnup cladding alloys for nuclear-safety data generation. A limited supply of defueled, high-burnup Zry-4, M5 and ZIRLO cladding is available to initiate this work, and an additional shipment (Studsvik to ANL) of high-burnup ZIRLO cladding has been arranged by NRC for the fuel-transport work. The samples will be unloaded in an IML cell. Previously, defueled and fueled high-burnup cladding alloys were oxidized-and-quenched in the AGHCF in-cell apparatus, which because of heavy contamination will remain in-cell. Mechanical properties tests for generating in-reactor-accident and fuel-transport data will continue to be performed in the IML.

Cladding mechanical properties testing for EPRI-Framatome (June-December 2006) can also be conducted in the IML. However, ANL can no longer accept into the AGHCF the M5 fuel rod segments for this work. The laboratory (e.g., Studsvik, ORNL) that accepts the four high-burnup M5 rods will also perform the mechanical properties testing. ANL has offered to serve as a consultant to this program to help ensure its success.

For defueled cladding, test sample preparation is required. This work has been performed in glove boxes in the Electron Beam Laboratory (EBL), which is an extension of the AGHC area. The preparation work, along with SEM imaging, can continue in this area if the EBL, which has no fuel, is sealed off from the AGHCF and reclassified as a radiological facility. An alternative plan is to perform the sample preparation in other non-nuclear facility areas within ET, but this approach would cause schedule delays and increased costs. These areas have been identified.

In order to complete the test matrices for high-burnup Zry-4, ANL would need to outsource to an offsite nuclear facility the sectioning-and-defueling of high-burnup fuel-rod segments (≤0.9 m long) currently in the AGHCF. BWXT, ORNL, INL and VNC have hot cells with this capability. Defueled samples (80-mm long) could be shipped back to ANL by air transport. The cost of outsourcing this work would be offset by not having to pay AGHCF management and maintenance charges (30% of research budget). As hot-cell facilities would not accept the liability of increased fuel inventory without the financial benefit of the R&D program, ANL would need a partner lab (e.g., BWXT) to do this work, and ANL may have to accept receipt of the removed fuel, as well as the defueled cladding. In order to complete the test matrices for high-burnup ZIRLO and M5 cladding, ANL would request that EPRI or NRC arrange for shipments of defueled cladding segments to ANL.

NRC and DOE-RW data needs requiring tests with fueled cladding cannot be performed at ANL outside the AGHCF. This work includes loss-of-coolant-accident integral tests, spent-nuclear-fuel bending and impact tests, and fabrication-shipment of fueled rodlets to SNL for the cask-sabotage program. If NRC and DOE-RW do want this work to continue at another nuclear facility, ANL should assist in this transition by allowing shipments of fueled cladding segments from the AGHCF to the other nuclear facility, as well as by sharing experience, expertise, equipment drawings, operation manuals and test plans. The ANL data generated for these programs are already available through publications and informal letter reports, most of which are readily available from the NRC ADAMS. For the SNL rodlet project, BWXT is developing in-cell capabilities to do the final pressurization and laser-welding. However, ANL would have to weld the end-fixtures in the AGHCF before shipping the fueled samples (eight samples, each with 55-mm of fuel) to BWXT.

The sponsors of the ANL programs, particularly the NRC, have a heavy financial investment in the work previously performed in the AGHCF and an urgent need for more high-burnup cladding data. The Chairman of the NRC has recently approved a three-year extension of the ANL program under the assumption that the AGHCF would be available. The sponsors are well aware that the high-burnup cladding, the test facilities and the expertise they need currently reside at ANL. They will protest to the highest level of DOE the recent ANL directive regarding the AGHCF status. The proposed path forward will not be sufficient to satisfy NRC, EPRI and the nuclear industry. EPRI, who paid for the shipments of fuel to the AGHCF, has a significant financial investment in the ANL program, as well as the same data needs as NRC. Within the decision to discontinue programmatic work in the AGHCF, ANL may want to consider a less rigid position, which would allow the shipment of fuel-rod segments from the AGHCF to offsite facilities and possibly the receipt of fuel-rod segments and/or removed-fuel from those facilities. Activities that lead to a reduction in AGHCF fuel inventory can be viewed in terms of packaging and shipping, rather than programmatic, especially as the preparation of fuel segments for shipment does not involve experimental work and is very low risk. A higher level of compromise would be to allow sectioning and defueling to continue in the AGHCF for a transition period (<6 months) with all programmatic testing performed outside the AGHCF. This option is much lower risk to ANL and AGHCF than the risks associated with transporting fuel and receiving removed fuel (swarf). Full compromise would be to allow the NRC work to continue in the AGHCF for up to 3 years.

## 1. Background

The major programs within the ET Irradiation Performance Section (IPS), which were planning to make use of the AGHCF, are: NRC loss-of-coolant accident (LOCA) program, NRC spent nuclear fuel (SNF) program, Framatome-EPRI project for mechanical properties testing of high-burnup M5 cladding, test-rodlet fabrication for DOE-RW-sponsored SNF sabotage program at SNL, and DOE-RW-sponsored work on integrity of SNF high-burnup cladding during cask transport accidents. Smaller programs (<$100K each) include work for Global Nuclear Fuel (nonirradiated), for the consortium of Gamma Engineering, Westinghouse, NovaTech (nonirradiated), for Exelon (nonirradiated) and for the RERTR program (irradiated fuel plates). Table 1 summarizes the budgets, status and facility needs for the programs requiring tests with fueled and defueled high-burnup material. Table 2 summarizes non-nuclear-facility areas within ET in which programmatic work can continue, as well as work which needs to be outsourced or transferred to an offsite nuclear facility.

The AGHCF was closed temporarily to programmatic work by order of the ANL Director on July 26, 2005. On January 13, 2006, the on-line version of the Argonne News communicated the Director's decision to permanently discontinue programmatic work in the AGHCF. A plan has been formulated to continue the generation of most of the test data needed by the sponsors in non-nuclear ANL facilities and to outsource or facilitate transition to an offsite nuclear facility all testing and characterization requiring fueled samples.

## 2. NRC-sponsored Research

### 2.1 LOCA-relevant Research

The data to be generated in the ANL LOCA program are critical to the revision of the licensing criteria (10 CFR 50.46) for light-water reactors. The recent letter from NRC licensing (Office of Nuclear Reactor Regulation – NRR) to EPRI and the nuclear vendors (see Appendix A) emphasizes the importance of this work and what materials are needed from the nuclear industry to complete this work. As the letter was sent prior to the recent decision on the AGHCF status, ANL is listed both as the lab doing this work and the lab that will receive the additional fuel-rod segments to complete this work. The statement of work (SOW) for the ANL FY06-08 LOCA and SNF programs is very specific with regard to what tests need to be conducted to resolve licensing issues for both LOCA and SNF cask-transport. The samples used to conduct these tests include as-fabricated cladding (nonirradiated), prehydrided cladding (nonirradiated), defueled high-burnup cladding (≈1 R/h/25-mm), and fuel-rod segments.

ET/IPS has conducted tests with as-fabricated and prehydrided cladding samples in F113 just outside AGHC WS#6 and tests with fueled and defueled high-burnup cladding inside AGHC WS#6, with both sets of test equipment sharing the same out-of-cell instrumentation and control (I&C) system (see Fig. 1). While this arrangement is scientifically sound, it is no longer possible to perform these tests at these locations. However, the data for nonirradiated cladding can be generated in a non-controlled lab space. The out-of-cell apparatus and I&C system are being moved to such an area to allow resumption of testing with nonirradiated materials.

Table 1 Summary of Current and Proposed ET/IPS Programs and Facilities that Involve the Use of High-burnup Fuel and Cladding

| Sponsor | Program | Previous Years (funding) | FY06-08 funding | Facilities & Labs* Used/Planned | Activities |
|---|---|---|---|---|---|
| NRC-RES | LOCA & SNF | 9 y ($21M) | $7.5M | AGHC<br>EBL<br>IML<br>DL-114 | Cut, defuel, sample prep, metallography, testing<br>Cleaning, fine cutting, SEM (no fuel)<br>EDM machining, testing (no fuel)<br>Hydrogen and oxygen measurements (no fuel) |
| EPRI-FANP | M5 Mechanical Properties | 0 y ($0) | $1M (proposed) | AGHC<br>EBL<br>IML | Cut, defuel, sample prep, store for NRC work<br>SEM fractography<br>EDM machining, testing (no fuel) |
| DOE-RW | SNF | 2 y ($1M) | $1.3M (proposed) | AGHC<br>IML<br>DL-114 | Cut, defuel, sample prep, metallography<br>Testing<br>Hydrogen analysis |

*AGHC (in AGHCF) is a Category 2 Hazard Nuclear Facility; EBL (in AGHCF) can be sealed off from the hot-cell area to make it a radiological facility; IML and DL-114 are radiological facilities outside of the AGHCF.

Table 2 Plan for Continuation of Work with Defueled Cladding at ANL and Transition of Fuels Work to Offsite Facilities*

| Sponsor | Program | FY06-08 funding | Facilities & Labs Used/Planned | Activities |
|---|---|---|---|---|
| NRC-RES | LOCA & SNF | TBD <$7.5M | Non-ANL**<br>ANL-EBL<br>ANL-IML<br>ANL Glove Boxes<br>ANL-DL-114 | Fueled LOCA integral tests, fueled bend & impact tests<br>Sample preparation, SEM, metallography<br>EDM machining, mechanical properties testing<br>Welding, radial hydride treatment<br>Hydrogen and oxygen measurements |
| EPRI-FANP | M5 | >$1M | Non-ANL** | Receive, section, defuel, perform mechanical properties tests |
| DOE-RW | SNF | $650K<br>$650K<br>(proposed) | Non-ANL**<br>ANL-EBL<br>ANL Glove Boxes<br>ANL-IML<br>DL-114 | Fueled bending tests<br>Sample preparation, metallography<br>Welding, radial hydride treatment<br>Testing<br>Hydrogen analysis |

*It is assumed that ANL will be allowed to load casks from the AGHCF-CTA with fuel rod and plate segments for shipment to offsite nuclear facilities; ANL may have to accept back into the AGHCF the swarf from cutting and defueling for fuel originating in the AGHCF.

**Costs and schedule are highly uncertain; "Non-ANL" facility to be determined by sponsor with ANL's guidance; other than the AGHCF, no other hot-cells are conducting tests with fuel-rod segments. For the SNF Rodlet project, BWXT is developing the capability (in-cell laser welding) to complete the fabrication.

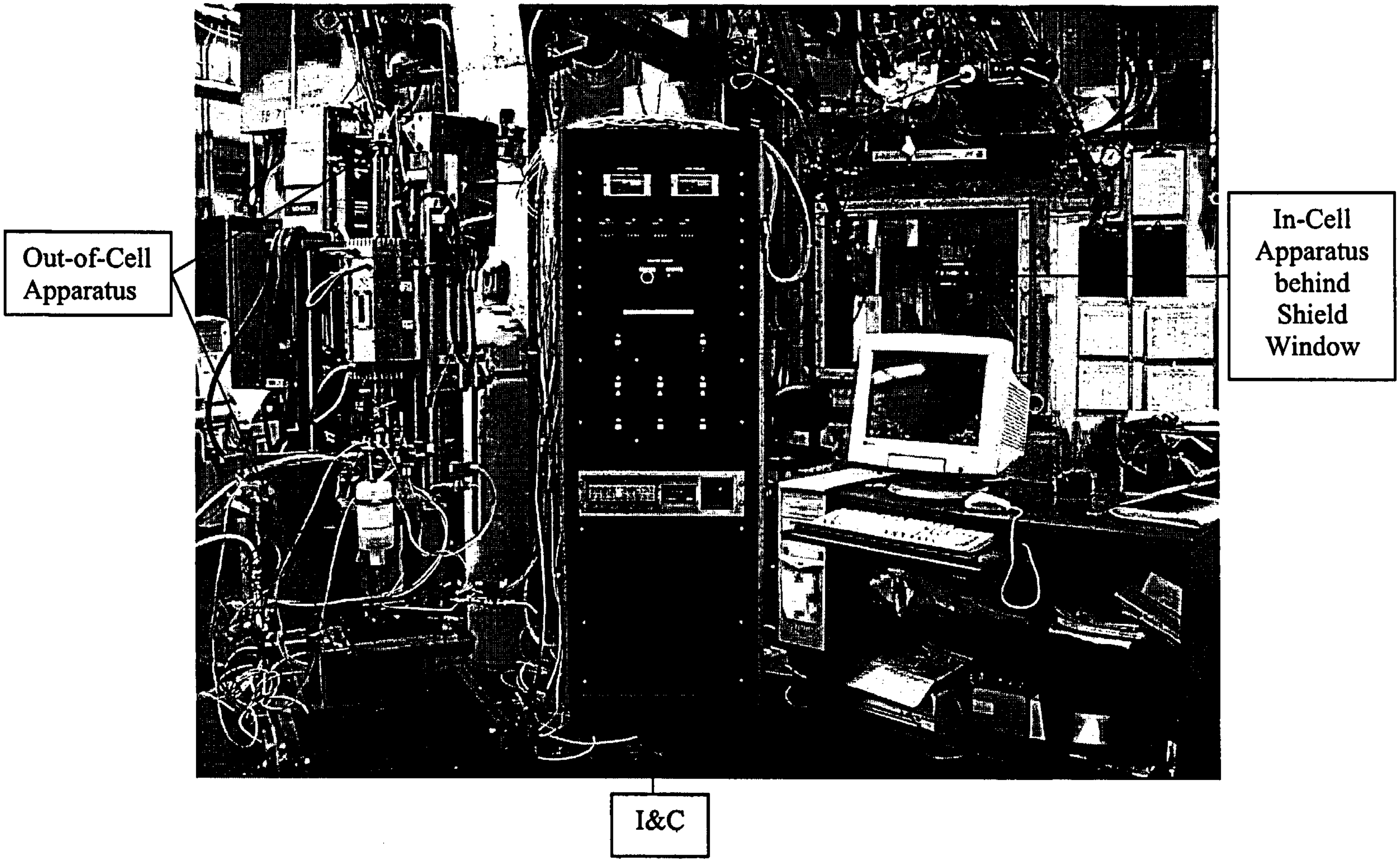


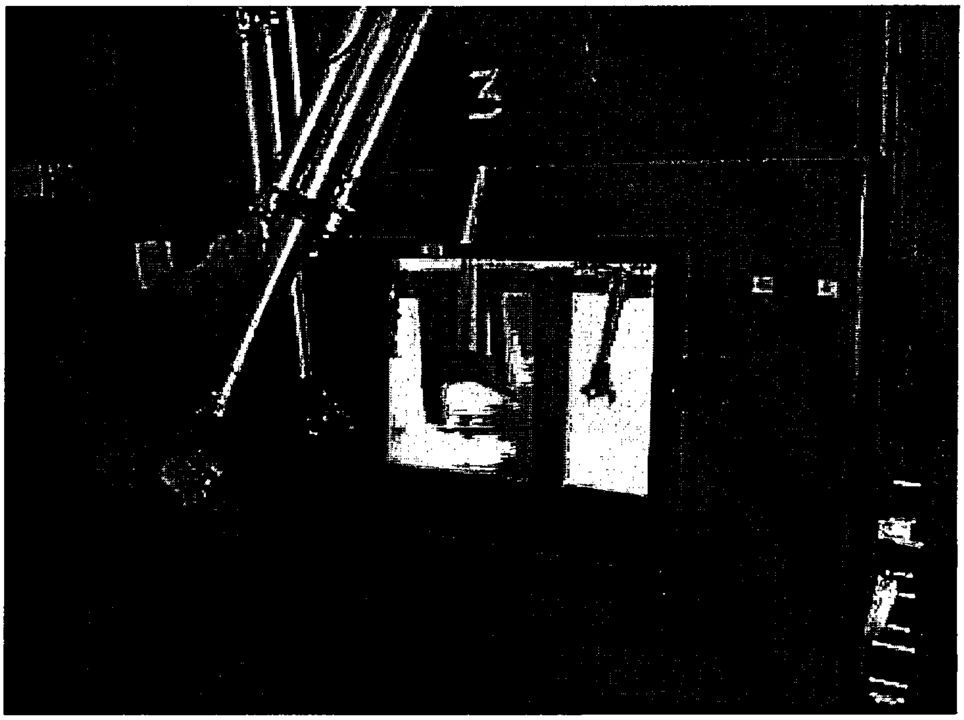

Fig. 1. Former location of the out-of-cell LOCA oxidation/integral test apparatus in AGHCF just outside WS #6; similar apparatus is located inside of WS#6 (behind the shield window shown in the figure) for testing defueled and fueled high-burnup cladding.

The test data needed for defueled, high-burnup cladding can be generated in the ET Irradiated Materials Laboratory (IML), which contains four beta-gamma air cells and manipulators for remote handling (see Fig. 2). The IML is a radiological (non-nuclear) facility, does not require a DSA, and does not require the USQ procedure. Legacy material (e.g., irradiated stainless steel, vanadium alloys, etc.) is currently being transferred from the IML to the AGHC to assure that the IML remains well below the limit for a non-nuclear facility even with additions of high-burnup cladding test samples. Following completion of the work with prehydrided materials (≈April 2006), the out-of-cell LOCA apparatus will be moved to an IML Cell for testing defueled high-burnup cladding samples. A limited supply of defueled, high-burnup Zry-4, ZIRLO and M5 cladding is available at ANL to initiate the testing.

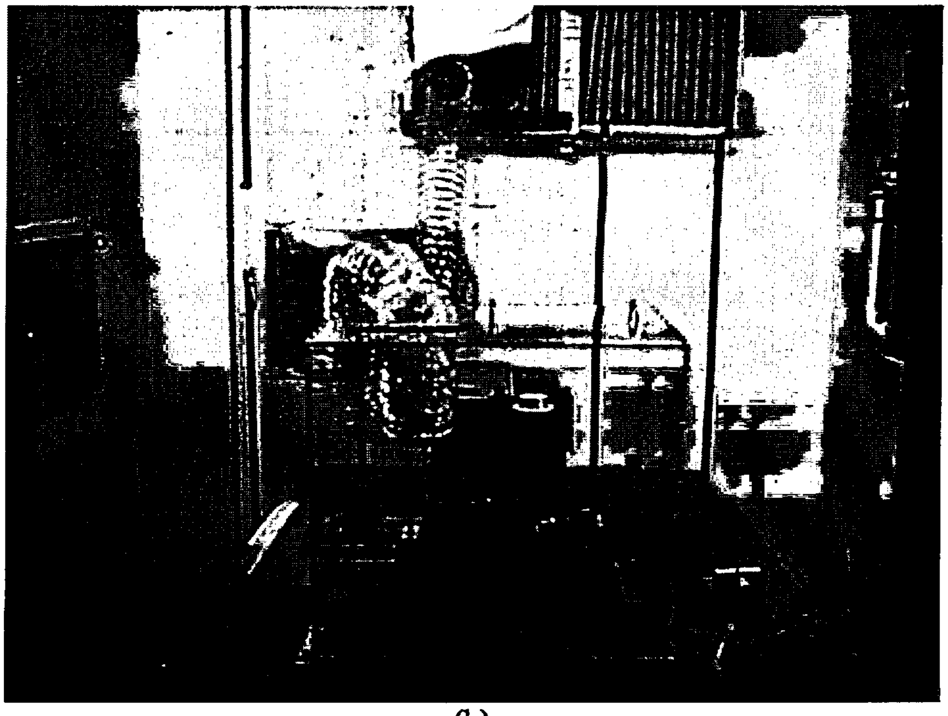
Sample cutting and cleaning has been done in a glove box in the Electron Beam Laboratory (EBL), which is currently part of the AGHCF. This area contains no fuel, can be separated from the AGHCF by sealing off one entrance and can be re-classified as a non-nuclear area to allow continued use of the glove box, as well as the SEM imaging system, for irradiated materials. A shielded optical microscope (metallograph) can be added to this area or to the IML to match the capabilities currently available in the AGHCF (see Fig. 3). Efforts are in progress to locate a used or surplus metallograph (< 10-years-old) that has capabilities for remote sample location in a shielded area. A microhardness tester is already available in the IML Instron glove box (see Fig. 4). An alternative approach would be to use glove boxes in other non-nuclear ET areas for cutting, cleaning, and metallography. These glove boxes have been identified and secured for this work in case they are needed. Of course, there would be schedule delays and cost increases if this approach were to be adopted.

In order to complete the NRC LOCA test matrix, it would be necessary to outsource the sectioning of Zry-4 fuel-rod segments (<0.9-m long) into shorter lengths (≈80 mm), defueling these samples in nitric acid, and shipping them back to ANL by ordinary freight in Type A shipping packages. The additional cost of shipping and defueling would be offset by not having to pay 30% of the IPS research budget for AGHCF management and maintenance costs. BWXT, ORNL, INL and VNC have this capability. VNC is a private GNF hot cell. Framatome and Westinghouse most likely would not agree to send their fuel segments to a competitor. INL has severe restrictions from the State of Idaho with regard to receiving and storing nuclear fuel and is not a viable option at this time. ORNL is eager to do the work. They are also eager to "grab" all the NRC LOCA and SNF research. As such, they are, and have been, competitors to ANL. BWXT appears to be willing to do the defueling if ANL accepts the removed fuel, as well as the defueled cladding. If the size of the fuel-rod segments in the AGHC becomes a practical issue with regard to shipping cask compatibility, some fuel-rod sectioning may be required in the AGHCF.

Based on the NRC-NRR letter to EPRI (see Appendix A), industry must either supply ANL with high-burnup M5 and ZIRLO rod-segments to complete the LOCA testing or industry must do the testing themselves. Under the current directive issued by the Lab Director, ANL would not be able to receive these rod segments in the AGHCF, section them and defuel them. There are several possibilities that would enable ANL to acquire the defueled cladding segments it needs to conduct the testing outside the AGHCF. For the four high-burnup M5 rods to be shipped from INL to another hot-cell facility, EPRI or NRC could arrange for the sectioning and



(a)



(b)

Fig. 2. External (a) and internal (b) views of IML Cell#3. The old Electro-Discharge Machine (EDM) shown in (b) has been removed and will be replaced with a new one currently out-of-cell. The air-cell inner dimensions are 6-ft wide by 5-ft deep by 9-ft 8-in. high.

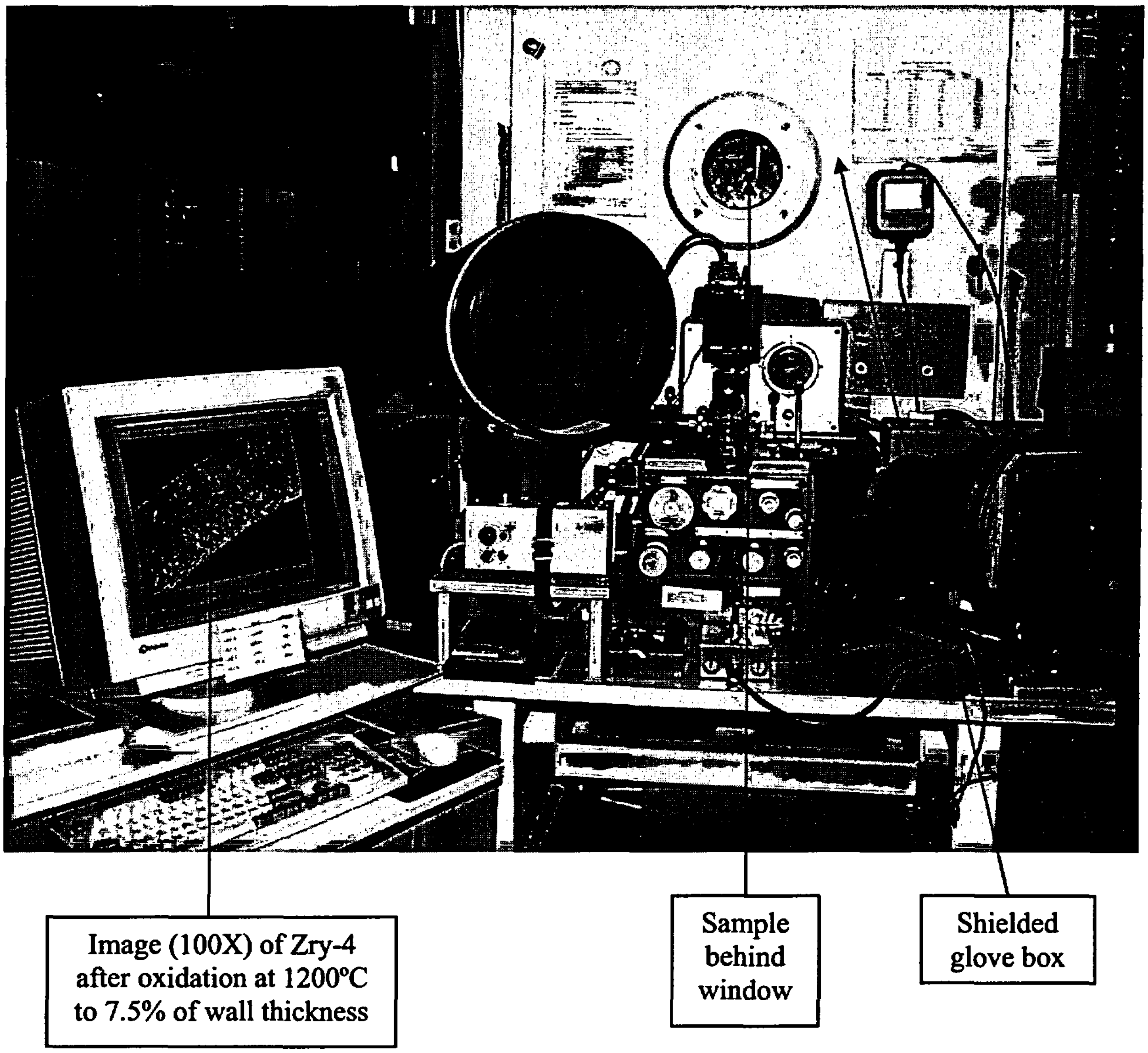



Fig. 3. Optical microscope (Leitz Metallograph) with magnification capability up to 500X, remote specimen location in shielded glove box, and microhardness tester. It is currently located at the end of AGHCF WS#4 to allow direct transport of mounted sample from in-cell to shielded glove box for imaging.

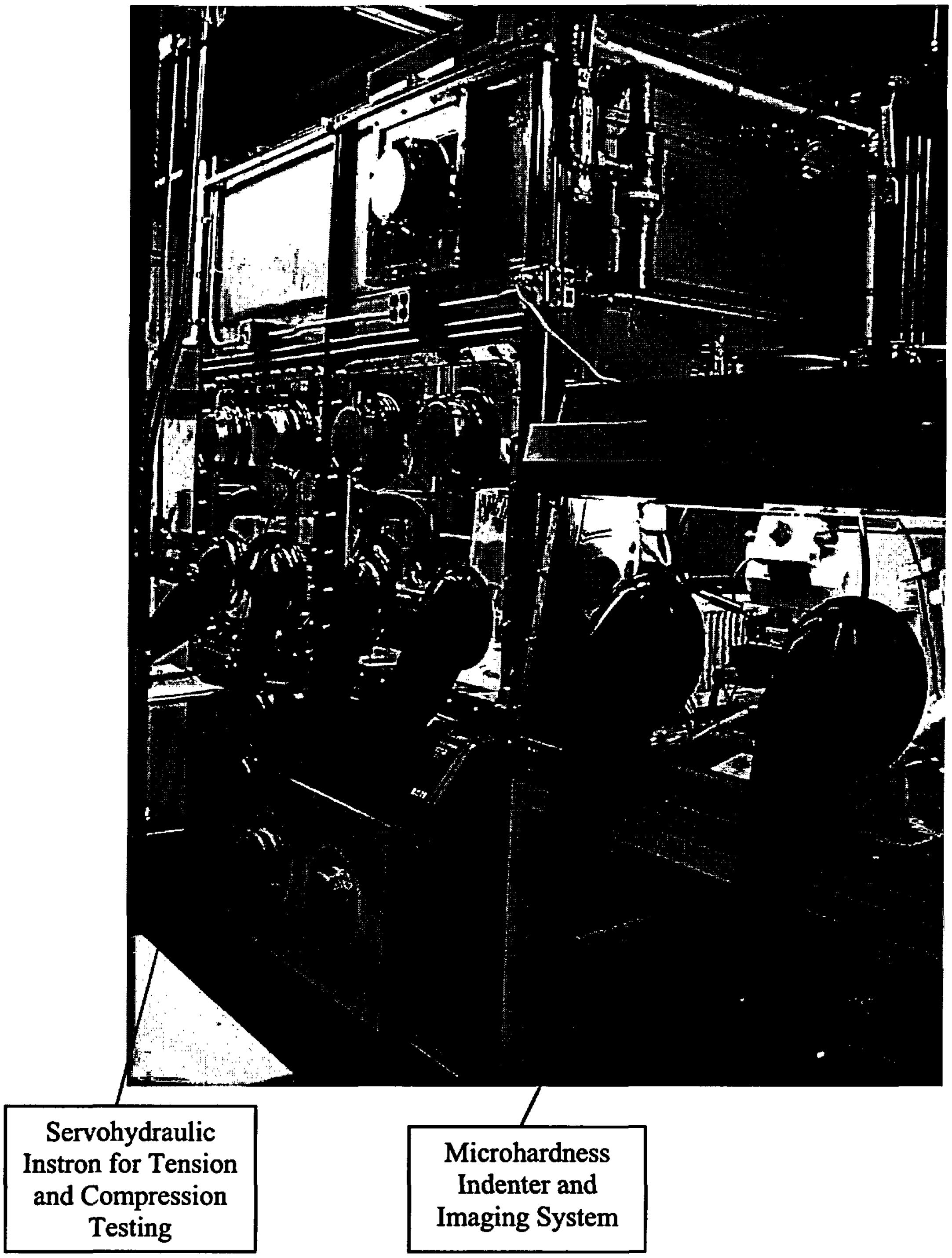



Fig. 4. Radiological-control glove boxes in IML for microhardness indenting and testing, for sample imaging, for sample preparation and for mechanical properties testing.

defueling of 80-mm-long segments, as well as the shipment of these defueled cladding segments to ANL. If there is enough high-burnup ZIRLO remaining at Studsvik, EPRI or NRC could arrange for sectioning-and-defueling and shipment of 80-mm-long defueled cladding segments to ANL.

This plan would allow generation of about 80% of the LOCA data requested by NRC. However, without additional defueled cladding samples, this would be reduced significantly. The confirmatory LOCA integral tests with fueled, high-burnup samples could not be performed at ANL without the use of the AGHC. The tests generate extremely interesting first-of-a-kind data, but these data may not be essential for revision of the LOCA licensing criteria. If NRC decided to pursue such testing at another national lab, the main role for ANL would be to transfer fueled cladding segments and to provide technical expertise, equipment design and test plans.

## 2.2 SNF-relevant Research

The NRC SOW (Appendix B) for FY06-08 includes mechanical properties testing of prehydrided cladding and defueled, high-burnup cladding, with only about 10% of the testing to be performed with fueled cladding samples. Mechanical properties tests using prehydrided and high-burnup cladding samples are currently performed in the IML (see Fig. 4). The AGHCF is used for sectioning, defueling, and other sample-preparation activities (e.g, oxide removal). Oxide removal can be done in one of the EBL glove boxes. Glove boxes in non-nuclear radiological-control areas have also been secured for sample preparation as an alternative approach to using the EBL glove boxes. A shipment (Studsvik to ANL) of defueled, high-burnup ZIRLO cladding (eight 80-mm-long samples) is expected within a few months to initiate this testing. Similar to the needs of the LOCA research program, sectioned-and-defueled high-burnup Zry-4 and M5 cladding samples would be needed to complete the test matrix, as well as additional ZIRLO samples. Thus, the SNF and LOCA have the same needs to outsource the sectioning and defueling and the same issues with regard to the removed fuel.

About 10% of the testing (bending and impact test) is to be performed with fueled cladding. NRC has the option of pursuing such testing at another nuclear facility. However, other than ANL, no other hot-cell is currently conducting mechanical tests with fueled cladding.

## 7. Summary

### 7.1 NRC-sponsored LOCA Program

The out-of-cell LOCA oxidation/integral apparatus has been moved to a non-controlled area to allow data to continue to be generated for as-fabricated and prehydrided cladding. A hot-cell in a non-nuclear facility – Irradiated Materials Laboratory (IML) – has been identified for LOCA-apparatus installation to allow testing of defueled cladding, of which we have a limited supply. BWXT has the sectioning-defueling capabilities, but it will only do so if we are allowed to ship the fuel-rod segments to them and accept both the defueled cladding and the removed fuel (swarf). The transport back and forth creates much higher risk to ANL than the sectioning-defueling in the AGHCF. ANL should weigh these risks. Without the AGHCF, we will not be able to conduct the tests with fueled cladding. It is unlikely that another lab can generate such data before it is needed by NRC licensing. Also, start-up costs would be very high.

### 7.2 NRC-sponsored SNF Program

The issues are the same. The work with defueled cladding is already being conducted in the IML, but we will soon run out of defueled cladding. Also, we had planned to use IML Cell #4, which is the same cell we would have to use for the LOCA work, to precondition the SNF cladding. We cannot do both LOCA testing and SNF preconditioning in the same cell. Bend and impact tests with fuel-rod segments cannot be done at ANL outside the AGHCF.

### 7.3 EPRI-Framatome Project

If ANL cannot use the AGHCF to accept the fuel for this program, it will also not get the program. ANL is the first choice for this program. Studsvik and ORNL are also being considered by the sponsors as backups. By not getting the program, we would not be receiving directly the M5 cladding we need to complete the LOCA and SNF test matrices.

### 7.4 DOE-RW SNF Program

Program goals and issues are the same as for the NRC SNF program. However, the proposal to continue this work into FY06 and beyond has not yet been funded by DOE-RW. Without the AGHCF, the probability of getting DOE-RW funding is essentially zero. Without the funding, we do not need a path forward for this program.

January 6, 2006

Mr. J. J. Sheppard
Chairman, EPRI Fuel Reliability Program
President & Chief Executive Officer
South Texas Project Electric Generating Station
P. O. Box 289
Wadsworth, TX 77483

Mr. David J. Modeen
Vice President, Nuclear Power and Chief Nuclear Officer
Electric Power Research Institute
1300 West W. T. Harris Boulevard
Charlotte, NC 28262

Dear Mr. Sheppard and Mr. Modeen:

Since 1998, Electric Power Research Institute (EPRI) has been working cooperatively with the Nuclear Regulatory Commission (NRC) on a fuel-related research program at Argonne National Laboratory (ANL). During that time, EPRI provided shipping, cutting, and precharacterization of 17 Zircaloy-clad high-burnup fuel rods for testing. This work is providing the technical basis for a revision to regulatory criteria for loss-of-coolant accidents, as well as providing information that is needed for the licensing of spent fuel casks.

Although much of this work has now been completed, and numerous data reports have been provided to EPRI, additional testing is needed in FY 2007 and 2008 on high-burnup fuel rods with the more advanced ZIRLO™ and M5™ cladding alloys. The NRC has initiated a three-year extension to the Argonne program that includes this testing, but to complete the work the NRC again needs EPRI's help with the supply of high-burnup fuel rods. The planned research should be familiar to the staff who have been involved at EPRI, Westinghouse, and Framatome ANP. Responsibilities of each party would be the same as before, and formal extensions of agreements are under discussion. Specifically, the NRC is requesting that EPRI provide shipping, cutting, and precharacterization of high burnup ZIRLO™ and M5™-clad fuel rods.

Given our current understanding of cladding performance following LOCAs based on testing done to date, in the absence of a comprehensive data base of irradiated cladding material performance, the staff may find it necessary to require that each fuel vendor conduct a LOCA test program (similar to the next phase at ANL) on irradiated fuel cladding to establish acceptance criteria for their current cladding alloys as well as future alloys.

The NRC's Office of Nuclear Reactor Regulation is now on a course to initiate rulemaking that would eliminate restrictions to specific zirconium cladding alloys in 10 CFR 50.46. Testing of ZIRLO™ and M5™-clad fuel rods is essential to complete this process and to provide the qualification of a hydrogen-charging procedure that could avoid extensive testing of irradiated fuel rods in the future. We would appreciate your commitment to help us complete this work by providing an adequate supply of ZIRLO™ and M5™ -clad fuel rods with high burnup for testing during the FY 2007-2008 time period.

Sincerely,

/RA/

Thomas O. Martin, Director
Division of Systems Safety
Office of Nuclear Reactor Regulation

cc: Rosa L. Yang, EPRI
David J. Colburn, Westinghouse
Roger S. Reynolds, Framatome ANP
Gerald A. Potts, Global Nuclear Fuel

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Sincerely,

/RA/

Thomas O. Martin, Director
Division of Systems Safety
Office of Nuclear Reactor Regulation

cc: Rosa L. Yang, EPRI
David J. Colburn, Westinghouse
Roger S. Reynolds, Framatome ANP
Gerald A. Potts, Global Nuclear Fuel

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OFFICE OF NUCLEAR REGULATORY RESEARCH
DIVISION OF SYSTEMS ANALYSIS & REGULATORY EFFECTIVENESS
STATEMENT OF WORK

PROJECT TITLE: ADVANCED FUEL CLADDING RESPONSE TO LIMITING CONDITIONS

JOB CODE: multi
CONTRACTOR: ANL
SITE: Argonne
STATE: Illinois

NRC PROJECT MANAGER: Harold Scott
301-415-6771

PRINCIPAL INVESTIGATOR: Mike Billone
630-252-7146

B&R NUMBER: 66015111205

PERIOD OF PERFORMANCE: December 2005 through November 2008

LEVEL OF EFFORT: 16 staff years.

1. BACKGROUND

Testing is being performed on high-burnup fuel rods with ZIRLO™, M5™, and Zircaloy cladding, along with archival tubing for those rods, to characterize their behavior under conditions of interest. The fuel rod specimens must be remotely handled and tested in hot cells, so procedures are tedious and costs are high.

Two sets of conditions are of interest in relation to licensing criteria that need updating and evaluation models that need assessing. One corresponds to loss-of-coolant accidents (LOCAs) in operating reactors, and the other corresponds to dry cask conditions for transportation and storage.

On August 21, 2003, the staff informed the Commissioners of an Updated Program Plan for High-Burnup LWR Fuel that addressed these two areas of interest. Because it was clear that high-burnup fuel rods with ZIRLO™ and M5™ cladding would not be available for testing for several years, the plan adopted a reasonable assumption that the burnup effects on LOCA behavior would be similar in all the zirconium alloys and that alloy effects would show up in tests with unirradiated material. Therefore, the test plan called initially for samples of high-burnup fuel rods with Zircaloy cladding along with samples of unirradiated Zircaloy, ZIRLO™, and M5™ cladding. Confirmatory tests with samples of high-burnup fuel rods with ZIRLO™ and M5™ cladding were to follow when that material was provided by the industry, which is cooperating in this research.

Under LOCA conditions, burnup-related effects can alter (a) cladding embrittlement, (b) oxidation kinetics, (c) ballooning and related flow blockage, and (d) axial fuel relocation into ballooned regions. A limit on cladding oxidation to prevent embrittlement is given in 10 CFR

50.46(b)(2), and this limit needs to be revised to account for burnup effects and differences in cladding alloys. A performance-based revision is planned to accommodate newer cladding alloys such as Framatome's M5™ alloy and Westinghouse's Optimized ZIRLO™ cladding, which are not covered by the present rule. The revision of 10 CFR 50.46(b)(2) only involves cladding embrittlement, although all of the above-mentioned phenomena are being investigated in this program. Therefore, only the embrittlement results are needed to initiate rulemaking, and investigation of the others can be completed after rulemaking starts.

LOCA testing in the first half of FY 2006 will provide the rest of the data needed to initiate rulemaking on 10 CFR 50.46(b)(2), and a discussion of the technical basis for this rulemaking was provided in a memorandum to the Commissioners on September 29, 2005. Integral tests, including a determination of ballooning size, axial fuel relocation, and fracture behavior, on high-burnup fuel rods with Zircaloy cladding will be completed in the second half of FY 2006. Except for results from a small number of de-fueled irradiated ZIRLO™ and M5™ cladding specimens, the data obtained in FY 2006 will be predominantly on Zircaloy-clad fuel rods. High-burnup fuel rods with ZIRLO™ and M5™ cladding are not yet available.

Preparations are underway at EPRI and Framatome ANP to provide high-burnup fuel rods with M5™ cladding for testing at ANL. These fuel rods are expected to arrive at the laboratory in June 2006 and be ready for testing in FY 2007. Industry plans for providing ZIRLO™-clad fuel rods for testing in FY 2008 have not been completed, but those rods have been requested. The LOCA testing of high-burnup fuel rods with M5™ and ZIRLO™ cladding in FY 2007 and FY 2008, respectively, is needed to confirm the assumption that burnup effects on LOCA behavior are similar in all alloys and to qualify pre-hydrided material as a substitute for irradiated material for the purpose of testing future cladding alloys at a much lower cost. Because we already know that one high-burnup effect (viz. hydrogen absorption) differs from alloy to alloy, it is important to see if the overall variations of LOCA behavior are within the bounds produced by our assumption.

10 CFR 71.55, 71.71, and 72.122 contain requirements for fuel rods in dry casks during transportation and storage. The phenomena that affect these requirements include hydride reorientation, crush resistance, and bending stiffness. Testing of these phenomena under dry cask conditions is also needed on high-burnup fuel with Zircaloy, ZIRLO™ and M5™ cladding. This testing uses the same hot cells, equipment, techniques, and source of test specimens as the LOCA-related testing. Consequently, these tests are proceeding in the same program as the LOCA-related tests and are included in this funding request. As with the LOCA-related tests, most of the testing on Zircaloy-clad fuel will be completed in FY 2006, M5™-clad fuel in FY 2007, and ZIRLO™-clad fuel in FY 2008, although small pieces of de-fueled irradiated ZIRLO™ will be tested earlier.

A final element of this program will provide mechanical properties for Zircaloy, ZIRLO™ and M5™ cladding that apply to LOCAs, dry casks, and other situations. Burnup affects these properties primarily as the result of hydrogen pickup from the normal corrosion process and radiation damage. Alloy and fabrication effects may also be significant. These properties are needed for almost all analyses that are made with computer codes used by applicants in preparing submittals and by the staff in reviewing submittals and making independent calculations related to fuel behavior. These properties will be measured during FY 2006-2008 as high-burnup fuel rods become available.

## 2. OBJECTIVE

This program will provide the technical basis for (a) revising cladding limits in 10 CFR 50.46(b) for loss-of-coolant-accident (LOCA) analysis, (b) upgrading Interim Staff Guidance No. 11 for reviewing transportation and storage of spent fuel casks, and (c) evaluating the adequacy of related evaluation models.

## 3. PREVIOUS WORK PERFORMED

### LOCA-related Tests with Zircaloy Cladding

In previous years, the only high-burnup fuel rods available for testing had the older Zircaloy cladding alloy. These rods were first used to develop appropriate testing techniques and basic oxidation data. In FY 2005, work focused on generating the data base that would be needed for rulemaking on 10 CFR 50.46(b), working on the assumption that burnup effects will be similar in all zirconium-based cladding alloys and that alloy effects will show up in tests with unirradiated material.

Oxidation kinetics data have been generated for as-fabricated, prehydrided and high-burnup Zircaloy cladding. Results to date confirm the best-estimate model (Cathcart-Pawel) recommended in Regulatory Guide 1.157 (1989) for calculating the metal-water reaction rate. The hydrogen content in high-burnup cladding has no effect on the oxidation kinetics, weight gain and oxidation level. For low predicted oxidation values (3-10%), the oxidation rate of high-burnup Zircaloy-4 is slightly slower than for as-fabricated cladding due to the presence of the corrosion layer formed during reactor operation. Thus, use of the Cathcart-Pawel model tends to give a slight over-prediction of transient oxidation for high-burnup cladding.

Following high-temperature steam oxidation and quench, unirradiated Zircaloy-4 cladding has been subjected to post-quench-ductility tests to determine ductility as a function of oxidation temperature, hydrogen content, and extent of oxidation. These tests were unique in that data were generated for samples with 200-800 ppm hydrogen at fixed oxidation values. The results are significant because high-burnup Zircaloy-4 with about 100 microns of corrosion layer has approximately 600-800 ppm hydrogen. The embrittlement oxidation levels are well below the 17% specified in 10 CFR 50.46(b), especially if the best-estimate model is used to calculate oxidation. The results for prehydrided cladding served as a baseline for planning and interpreting in-cell tests using high-burnup Zircaloy-4.

Samples from the high-burnup Zircaloy-clad fuel rods had corrosion layers of 50-100 microns and hydrogen contents of 400-800 ppm. Twelve ductility tests were completed: six with double-sided oxidation and six with single-sided oxidation. The results to date suggest the following: (a) the oxygen in both the corrosion layer and the fuel-cladding bond layer diffuses into the metal and contributes to cladding embrittlement, (b) corroded cladding embrittles at about the same rate as bare prehydrided cladding, even though transient weight gain and oxidation increase is slower, (c) prehydrided cladding may be a reasonable surrogate for high-burnup cladding, (d) slow-cooling enhances ductility compared to quenched cladding, and (e) the inclusion of the corrosion layer in the calculation of total oxidation, as recommended in NRC Information Notice 98-29, appears to account for the embrittling effects of hydrogen.

Four LOCA integral tests have been completed with fueled high-burnup BWR segments.

These tests showed essentially no difference between as-fabricated and high-burnup ballooning-burst temperature and pressure, balloon size and axial extent of ballooning. The results also show excellent gas communication through the high-burnup fuel to the balloon region. However, high-burnup test segments showed much higher hydrogen pickup – as much as 3000 ppm of secondary hydrogen – in the balloon due steam oxidation inside the segments. These results indicate that the balloon region will embrittle at much less than 17% oxidation due to the high hydrogen pickup. This effect is not accounted for by the addition of the corrosion layer – only 10 microns – in the total oxidation.

LOCA-relevant tests with ZIRLO and M5 Cladding

The emphasis of this work has been on oxidation kinetics and post-quench ductility of unirradiated ZIRLO and M5, as compared to Zircaloy-4. For ZIRLO, very little work has been reported in the open literature. The limited testing done by Westinghouse in their comparison of ZIRLO to Zircaloy-4 is company-proprietary. Framatome, in cooperation with EdF and CEA, has sponsored an extensive comparison of M5 and Zircaloy-4 oxidation rate and post-quench ductility. Although some of this work is being published in the open literature, much of it remains company-proprietary. The ANL program is unique in that all three alloys are tested in the same apparatus for the same time-temperature oxidation and in the same ring-compression machine with data interpreted by a common methodology.

Oxidation kinetics tests for as-fabricated samples have demonstrated that all three alloys (Zircaloy-4, ZIRLO and M5) oxidize at the same rate at 1100°C and 1200°C, while at 1000°C ZIRLO oxidizes slower than Zircaloy-4 and M5 oxidizes slower than both Zircaloy-4 and ZIRLO. Following the oxidation-quench preparation of these samples, metallography, hydrogen analysis, and microhardness characterization have been performed. In parallel, ring-compression tests have been conducted. The results at 1000°C are particularly interesting: the alloys all embrittle after the same exposure time, independent of the measured weight gain and oxidation. Therefore, the ductility decrease and the embrittlement correlate much better with the oxidation calculated with the Cathcart-Pawel model, even though it is not a best-estimate for these advanced alloys. The results following 1200°C oxidation and quench are also important. When tested at room temperature, all three alloys embrittle at about 8-10% oxidation. However, retesting at 135°C – the core temperature following quench – enhances ductility such that the embrittlement oxidation is 18-20% when calculated with the Cathcart-Pawel model.

Cask-related Tests with Zircaloy Cladding

Characterization, creep and mechanical properties of low-burnup (36 GWd/t) PWR fuel following 15-years of dry-cask storage has been completed and documented in NUREG/CR-6831. Additional work for cladding creep, mechanical properties and axial diffusion of hydrogen has been documented in conference and open literature papers. The results were used in formulating NMSS ISG-11, Revisions 2 and 3. Creep tests have also been completed on high-burnup PWR Zircaloy-4 cladding. Both the low- and high-burnup creep results support the ISG position that creep during storage is not an issue for the temperature limit of 400°C specified in ISG-11 for normal drying, transfer, and storage operations.

Following the completion of the thermal-creep work and consistent with NMSS user needs, this effort was redirected towards generating data for the assessment of high-burnup cladding integrity during post-storage fuel retrieval and transport. Drying of high-burnup fuel produces high stress conditions, and high stress conditions can lead to unfavorable precipitation of hydrogen during transfer and storage and low failure resistance. Both prehydrided and high-burnup cladding have been exposed to cooling from 400°C at hoop stresses in the range of 0-150 MPa. The unfavorable precipitation of hydrogen appears to occur at drying stress > 90 MPa. However, more data are needed in this area to correlate decrease of failure energy with drying stress. In order to complete the test matrix in this area, crush impact tests, in addition to the high-strain-rate ring-compression tests are needed. Equipment has been constructed and tested out-of-cell to simulate the decrease of gas pressure and hoop stress during the slow cooling following the drying operation. That equipment will be available in-cell for testing high-burnup cladding samples by the end of CY2005.

Mechanical Property Tests

Hoop tensile properties have been determined for as-fabricated Zircaloy-2 and Zircaloy-4 and for intermediate-burnup (50 GWd/MTU) PWR cladding. Measurement of hoop tensile properties, which was halted by NRC in FY2005 to expedite the LOCA work, will be re-initiated in FY2006 with cladding samples from high-burnup PWR rods.

Axial tensile properties have been measured at room temperature and 400°C for as-fabricated Zircaloy-2 and Zircaloy-4, for low-burnup PWR Zircaloy-4 (36 GWd/MTU) and for high-burnup PWR Zircaloy-4. Work is in progress to complete the test matrix by determining the properties for high-burnup PWR cladding at intermediate temperatures, at two different hydrogen levels, and at low- and high-strain rates. The test results give stress-strain properties needed for fuel-rod code analyses, as well as the failure limits needed for assessment of extent of cladding failure during in-reactor and cask-transport accidents.

4. WORK TO BE PERFORMED

Task 1: LOCA-related Tests

Complete testing of irradiated Zircaloy fuel rod and cladding specimens to support rulemaking. This testing should include the small number of specimens of irradiated ZIRLO and M5 cladding received from Studsvik. Perform confirmatory testing over a sufficient range of parameters of irradiated ZIRLO and M5 fuel rod and cladding specimens to determine any significant differences in LOCA behavior compared with irradiated Zircaloy. Perform validation testing of irradiated ZIRLO, M5, and Zircaloy cladding specimens in comparison with pre-hydrided specimens of matching unirradiated specimens to qualify a pre-hydrided surrogate for future testing of burnup effects.

Subtask A: Ductility Tests

Perform approximately 60 ring-compression tests, with microscopy, microhardness, and hydrogen measurements as necessary, to determine the effects of oxidation temperature, corrosion thickness, cooling rate, and alloy composition. Include tests with pre-hydrided unirradiated specimens for comparison.

Subtask B: Oxidation Tests

Perform approximately 40 tests to determine the time at which breakaway oxidation occurs as a function of oxidation temperature, corrosion, and alloy composition. Include hydrogen measurements as a means of pinpointing the breakaway process.

Subtask C: Integral Tests

Perform approximately 12 simulated LOCA tests on long specimens of high-burnup fuel rods, and perform a like number of simulated LOCA tests on unirradiated archive tubing. Determine balloon dimensions, fuel relocation if any, and hydrogen and oxygen concentrations throughout the ballooned region. Perform 4-point bend tests on surviving specimens. Perform approximately 24 ring-compression tests on selected ring specimens, which are cut from undeformed regions of the integral test specimen.

Estimated Completion Date: September 30, 2008
Estimated Level of Effort: 37 staff-months (FY06)
40 staff-months (FY07)
29 staff-months (FY08)

Task 2: Cask-related Tests

Complete testing of irradiated Zircaloy, ZIRLO, and M5 fuel rod and cladding specimens for hydride reorientation relative to drying and dry storage. Perform appropriate impact (i.e., high strain rate) tests on irradiated Zircaloy, ZIRLO, and M5 fuel rods relative to cask drop for transportation conditions. Complete rod stiffness and bending failure measurements on irradiated Zircaloy, ZIRLO, and M5 fuel rods relative to critical configurations for transportation conditions.

Subtask A: Hydride Reorientation

Perform approximately 80 ring-compression tests on irradiated Zircaloy, ZIRLO, and M5 cladding to determine the effects of peak drying temperature, stress from unbalanced pressures, hydrogen content from corrosion, and alloy composition on hydride reorientation.

Subtask B: Impact Tests

Perform approximately 27 ring-compression-type crush-impact tests, as needed, on irradiated Zircaloy, ZIRLO, and M5 cladding with a special tup to determine the effects of temperature, hydrogen content, and alloy composition on cladding failure.

Subtask C: Rod Stiffness and Failure Bending Moment

Make approximately 6 measurements at two relevant temperatures of bending stiffness and failure moment on long specimens of irradiated Zircaloy, ZIRLO, and M5 specimens with fuel inside.

Estimated Completion Date: June 30, 2008
Estimated Level of Effort: 20 staff-months (FY06)
20 staff-months (FY07)

14 staff-months (FY08)

Task 3: Mechanical Property Measurements for LOCA, Cask, and Other Applications

Measure deflection as a function of load, including standard properties (yield stress, ultimate tensile stress, uniform elongation, total elongation, etc.), as functions of temperature, hydrogen content, strain rate, and irradiation. The temperature range of interest is from room temperature to 800°C. Provide a test matrix in the Form 189. Complete the measurements that are underway on Zircaloy, and make similar measurements on ZIRLO and M5 cladding.

Subtask A: Uniaxial Axial Tensile Tests (approximately 60 measurements)

Subtask B: Uniaxial Ring Tensile Tests (approximately 100 measurements)

Subtask C: Plane Strain Tensile Tests (approximately 45 measurements)

Estimated Completion Date: September 30, 2008
Estimated Level of Effort: 6 staff-months (FY06)
9 staff-months (FY07)
11staff-months (FY08)

Task 4: NRC Technical Support

NRC technical support may be requested by the NRC Project Manager during the rulemaking hearing on 10 CFR 50.46(b), for ACRS meetings, for holding meetings with cooperating research partners (EPRI, Framatome, Westinghouse, etc.), and other unanticipated activities.

Estimated Completion Date: September 30, 2008
Estimated Level of Effort: 1 staff-month (FY06)
1 staff-month (FY07)
1 staff-month (FY08)

Task 5: Program Management

Update the program Test Plan to reflect emerging results, prepare monthly letter status reports, interface with NRC and other sponsors, conduct annual review meetings, and perform necessary administrative functions related to hot cell operation.

Estimated Completion Date: September 30, 2008
Estimated Level of Effort: 1 staff-month (FY06)
1 staff-month (FY07)
1 staff-month (FY08)

5. MEETINGS AND TRAVEL

Travel for this program generally consists of domestic and foreign information exchange meetings, presentations at program review meetings, formal paper presentations at technical society and NRC-sponsored meetings, and special training courses. Travel by Argonne staff to such meetings will be pre-approved by the NRC with formality appropriate for the meeting. For foreign travel, this includes submittal of NRC Forms 445, "Request for Approval of Official Foreign Travel." The FY2006 and 2007 budgets allow for 6 domestic trips and 2 foreign trips per year.

6. NRC-FURNISHED MATERIALS

Seven high-burnup BWR Zircaloy-2 and ten high-burnup PWR Zircaloy-4 fuel rods have been provided to ANL to conduct LOCA-relevant research as well as general mechanical properties tests. Three additional medium-burnup PWR Zircaloy-4 rods have also been provided, with an additional two such rods supplied for possible future programs. Three low-burnup Surry PWR rods were supplied for cask-related research. The DOE will retain ownership of the fuel from these rod segments and will be responsible for removal of the fuel from ANL to a repository at a later date.

Small pieces of de-fueled M5 and ZIRLO cladding have been provided to ANL from the Studsvik laboratory in Sweden. Additional similar shipments will be provided as needed.

In addition to the irradiated materials already received, additional shipments, as needed to do NRC-funded research, will be made in the future. NRC is working with EPRI to supply ANL with segments from a high-burnup M5 rods and with high-burnup ZIRLO rods. Schedules for LOCA integral testing of these high-burnup rods are dependent upon receipt of these rods.

7. RELATIONSHIP TO OTHER PROJECTS

Cognizance of other research sponsored by the NRC (domestic and foreign), Department of Energy, reactor vendors, electrical utilities and other organizations will be maintained, and available results will be evaluated for use in this project. ANL results will also be made available to NRC partners. Particular attention will be given to NRC projects at PNNL, Halden, Studsvik, and IRSN (France). Collaboration will be maintained with other NRC partners (e.g., JAERI) who are doing LOCA-relevant research.

8. REPORTING REQUIREMENTS AND SCHEDULE

Monthly Letter Status Report: Monthly letter status reports (MLSRs) will be submitted to the NRC Project Manager (H. H. Scott) by the end of the month following the reporting period and will cover technical progress, financial status, meetings and travel, publications and presentations, and any problems encountered. Copies will be provided to the Division Director, ATTN: Management Analyst; and the Division of Contracts and Property Management (DCPM), Office of Administration. Copies without the budget and cost pages will also be provided to EPRI, EPRI consultants, DOE, and other NRC offices. The reports will identify the title of the project, JOB CODE, Principal Investigator, period of performance, and reporting period and will contain information requested by NRC.

Other Technical Reports: ANL will prepare letter reports, more formal reports (e.g., NUREG/CR), and outside publications at the completion of specific milestones. ANL will follow provisions of Management Directive 3.9 with regard to all publications.

NRC has developed an electronic document management system, Agency wide Documents Access and Management System (ADAMS). All documents mailed from ANL to NRC (e.g., letters, technical reports, NRC Form 189s, MLSRs, and other mail) should have "Addressee Only" on the envelope to keep it from being entered into ADAMS.

9A. PUBLICATIONS

The Office of Nuclear Regulatory Research (RES) encourages the publication of the scientific results from RES-sponsored programs in refereed scientific and engineering journals as appropriate. If the laboratory proposes to publish in the open literature or present the information at meetings in addition to submitting the required technical reports, approval of the proposed article or presentation should be obtained from the NRC Project Manager. The RES Project Manager shall either approve the material as submitted, approve it subject to NRC suggested revisions, or disapprove it. In any event, the RES Project Manager may disapprove or delay the presentation or publication of papers on information that is subject to Commission approval that has not been ruled upon or which has been disapproved.

Additional information regarding the publication of NRC-sponsored research is contained in NRC Management Directives 3.8, "Unclassified Contractor and Grantee Publications in the NUREG Series," and 3.9, "NRC Staff and Contractor Speeches, Papers, and Journal Articles on Regulatory and Technical Subjects." If the presentation or paper is in addition to the required technical reports and the RES Project Manager determines that it will benefit the RES project, the Project Manager may authorize payment of travel and publishing costs, if any, from the project funds. If the Project Manager determines that the article or presentation would not benefit the RES project, the costs associated with the preparation, presentation, or publication will be borne by the contractor. For any publication or presentations falling into this category, the NRC reserves the right to require that such presentation or publication will not identify the NRC's sponsorship of the work.

9B. STANDARDS FOR NUREG-SERIES MANUSCRIPTS

The NRC will capture each final NUREG-series publication in its native application. Therefore, ANL will submit the final manuscript that has been approved by the NRC PM in both electronic and camera-ready copy.

All format guidance, as specified in NUREG-0650, Revision 2, remains unchanged with one exception. ANL is no longer required to include the NUREG-series designator on the bottom of each page of the manuscript. The NRC will assign this designator when the camera-ready copy is sent to the printer and will place the designator on the cover, title page, and spine. The designator for each report will no longer be assigned when the decision to prepare a publication is made. The NRC's Publishing Services Branch will inform the NRC PM of the assigned designator when the final manuscript is sent to the printer.

10. PROPOSED PERSONNEL

Information regarding the qualifications of the ANL Principal Investigator and other staff should be provided separately from the Form 189.

11. SUBCONTRACTOR AND CONSULTANT INFORMATION

None planned

12. SPECIAL FACILITIES, IF REQUIRED

Research in this project will be conducted in ANL's Alpha-Gamma Hot Cell Facility and related laboratory facilities.

13. CONFLICT-OF-INTEREST INFORMATION

ANL should describe in general terms any work being performed in the Energy Technology Division on behalf of an entity that is regulated by the NRC and demonstrate that such work does not constitute a conflict of interest. Such demonstration is not needed for the present program, which is being conducted in cooperation with regulated entities, because NRC has established memoranda of understanding with EPRI, DOE-NE, and Framatome ANP, and has exchanged informal letters with Westinghouse for conduct of this research; these exchanges have addressed this matter. The NRC Form 189 should by reviewed by Argonne's Corporate Scope Coordinator and a declaration made, if appropriate, that work proposed does not duplicate work being performed for others including other organizational components of the NRC. Further, the work will be conducted so as to avoid any bias in the performance of work and to avoid any unfair competitive advantage as a result thereof.

14. CLASSIFICATION OR SENSITIVITY, IF APPLICABLE

Not applicable.

15. FEDERAL INFORMATION PROCESSING (FIP) RESOURCES

All Federal Information Processing resources used in this project are obtained through Argonne National Laboratory or the U.S. Department of Energy. No NRC-furnished information technology (IT) equipment, IT services or IT access is anticipated.

16. APPROPRIATE USE OF GOVERNMENT FURNISHED INFORMATION TECHNOLOGY (IT) EQUIPMENT AND/OR IT SERVICES/ACCESS

Use of Laboratory or Government-furnished information technology equipment, services and access is governed under the provisions of an existing DOE order.

17. TECHNICAL DIRECTION

Technical direction will be provided by the Project Manager, Harold Scott, who can be contacted at:

Harold Scott, Mail Stop T-10K8
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Telephone: 301-415-6771
Fax: 301-415-5160
E-mail: HHS@NRC.GOV

Magnetic media, fragile or time-sensitive material should be sent via commercial carrier to:

Harold Scott, Mail Stop T-10K8
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, Maryland 20852-2738

## 18. SCHEDULE REQUIREMENTS

| | |
|---|---|
| Task 1: LOCA-related Tests | |
| NUREG/CR with all data necessary to support rulemaking | 03/06 |
| NUREG/CR with confirmatory data for M5 cladding | 09/07 |
| NUREG/CR with confirmatory data for ZIRLO cladding | 09/08 |
| Task 2: Cask-related Tests | |
| NUREG/CR on hydride reorientation in Zircaloy and ZIRLO cladding | 06/06 |
| NUREG/CR on crush tests for Zircaloy and M5 cladding | 06/07 |
| NUREG/CR on bending tests for Zircaloy, ZIRLO, and M5 cladding | 06/08 |
| Task 3: Mechanical Property Measurements for LOCA, Cask, and Other Applications | |
| NUREG/CR on mechanical properties of Zircaloy cladding | 09/06 |
| NUREG/CR on mechanical properties of M5 cladding | 09/07 |
| NUREG/CR on mechanical properties of ZIRLO cladding | 09/08 |
| Task 4: NRC Technical Support | N/A |
| Task 5: Program Management | N/A |

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