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IGORR6

Workshop on R&D Needs and Results

Chaired by

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(By D. L. Selby)

1. Introduction

The IGORR R&D workshop has become an important part of every IGORR meeting, providing an open forum to 1) report on R&D work in progress that is not appropriate for a full paper, 2) identify an issue or problem for open debate and discussion, and 3) request specific technical data or information. The write-up of the R&D workshop is divided into two sections: Old R&D topics from IGORR meetings 1 - 5 and New R&D topics. Although time did not permit a discussion of the outstanding old R&D topics during the meeting, a discussion of these items is provided below.

2. Old R&D Topics (From IGORR meetings 2 - 5)

Over the first five IGORR meetings a number of items have been presented under the R&D workshop forum and almost forty requests for data have been made. The following table provides a list of those R&D topics that are not considered closed. Note that the Item Number@ column in the table provides a number representing the IGORR meeting when the topic was raised and a letter that provides an designation of the particular topic at the meeting presented. As a result of presentations made at the IGORR-6 meeting, several of these topics can now be removed from this list. It is important that time be made available at the next IGORR meeting to determine the status of the various open items.

Item Number	Contact Person	Issue	Comment/Status
2B	Klaus Böning (TUM)	Burnable poison irradiation	Unknown
3F	Doug Selby (ORNL)	Test of cryogenic circulators for single-phase forced-convection cold sources	Although ORNL has performed some tests of their own, there is still a desire to obtain information on circulator lifetime and failure modes.
4C	Klaus Böning (TUM)	Thermal-hydraulic data (flow instability) on the heat transfer in fuel elements (up to 500 W/cm ²) for high cooling water velocities	Unknown

4D	Charlie McKibben (MURR)	Method to calculate the decay time required after full power operation before the core is safe in air	It is not clear that the need for this information still exists.
5A	Klaus Böning (TUM)	Irradiation tests of highly enriched silicide fuel up to high fission densities in the silicide particles	Information on this subject was presented in the R&D open forum. It is believed that this can now be removed from the list.
5B	H. J. Didier (Siemens)	Afterheat removal from highly loaded fuel elements cooled by natural convection, including flow reversal	See paper of J. Adamek at this IGORR meeting. It is believed that this can now be removed from the list.
5C	Albert Lee (AECL)	Probabilistic safety analysis work to support major research reactor refurbishments	Unknown, however, it should be noted that a detailed probabilistic safety analysis of the HFIR has been performed.
5D	Kir Konoplev (PNPI)	Cold neutron source benchmark experiment on an existing critical facility	An ISTC proposal has been submitted that if funded should have some initial results to report at the next IGORR meeting.
5E	Edgar Koonen (SCK-CEN)	Embrittlement, fracture toughness and fatigue crack growth on irradiated series 5000 and 6000 aluminum alloys	Unknown, however, it should be noted that fatigue curves have been included in the ASME code case (N-519) for Al-6061 developed under the ANS project.
5F	Guy Gistau (Air Liquide)	Survey of operating cold neutron sources and their comparison based on identical evaluation criteria.	Survey was performed and reported on during the IGORR-6 meeting. This item will now be removed from the list.
5G	Jean-Luc Minguet (Technicatome)	Comparison of regulations for research reactors in various participating countries	The progress of this work was reported on during the R&D open forum discussion.

3. New R&D Topics (From IGORR-6)

During the first two days of the meeting, five people signed up to present material during the R&D open forum session on seven different subjects. The material presented and the discussion that ensued are summarized below under the R&D topics 6A through 6G.

R&D Topic 6A - Colin West presented material on beam tube design optimization. This summarized work performed at ORNL as part of the HFIR upgrade program. Discussion focused on the calculated factor of two enhancement of the neutron current in the guide that could result from the new proposed beryllium wings inside the beam tube and the additional factor of two that could be obtained by flaring the beam tubes. The question was raised concerning why the beryllium wings needed to be inside of the beam tube. The answer given was that with the wings outside the beam tube the beam tube would be elliptical rather than circular. This would require unacceptably thick beam tubes because the reflector water outside the beam tube is pressurized in the HFIR system. It was pointed out that the beam tubes are not pressure boundaries in many reactors and thus a focusing geometry outside of the beam tube could potentially be implemented. This would also simplify cooling of the beryllium if cooling is required. Lee Robertson at ORNL (e-mail: robertsonjl@ornl.gov) was given as the contact for the beryllium wing work and Herb Mook also at ORNL (e-mail: mookhjr@ornl.gov) was indicated as the contact for the beam tube flare work.

R&D Topic 6B - Klaus Böning (TUM) reported on an irradiation test of the FRM-II fuel. This irradiation test was performed in the French reactor SILOM. Although the FRM-II core uses two separate fuel enrichment regions (1.5 g/cm^3 and 3.0 g/cm^3), only the lower density fuel was tested because the fission density (1.2×10^{22} fissions/cm³ of U_3Si_2) and uranium burnup (55% of $\text{U}235$ consumed) at the end of the 52 day fuel cycle are much higher in the lower density fuel. The 1.5 g/cm^3 fuel plate was irradiated for 10 SILOM cycles. The preliminary results indicate that the plate swelling is approximately 10% of the plate fuel meat thickness as expected.

R&D Topic 6C - Hans-Joachim Roegler (Siemens) brought up the subject of neutron converters for discussion in the open forum. He noted that three people Edgar Koonen (SCK-CEN, Belgium, BR2 reactor), Lin Wen Hu (MIT reactor, USA), and Klaus Gobrecht (FRM-II reactor, Germany) presented material on neutron converters, but that there did not appear to be a standard approach to a neutron converter. It was noted in discussion that converters can range from depleted fuel elements to a single fuel plate; converters can be located close to the core or outside of the core region; and the converter beam can be shutdown by absorber between converter and core or by withdrawal of the converter. Safety issues such as activity outside of the core region, the need for active cooling of the converter, decay heat removal, reactivity feedback to the reactor core, and instrumentation and control all depend on these design choices. It was

Roegler's opinion that a survey of converter designs and documentation of why certain design choices were made would be very useful to future neutron convertor designers. When asked if he would be willing to coordinate the collection of such information, he indicated that he would be willing to do so; but that it would require cooperation from those organizations that have been involved in the design of converters.

R&D Topic 6D - Jean-Luc Minguet (Technicatome, France) brought up the subject of the comparison that he had agreed to perform concerning regulations for research reactors in participating countries. He indicated that at present he had only received responses to the questionnaire he prepared from a couple of organizations. Several groups indicated that they had just recently received the questionnaire and thus had not had time to complete it. Dan Litai (IAEA, Austria) commented that this would be very useful information and that his office frequently received requests from countries wanting to know regulatory practices in other countries. All groups were encouraged to complete the questionnaire and return it as soon as possible. It was hoped that a report on this survey could be presented at the next IGORR meeting.

R&D Topic 6E - Doug Selby (ORNL, USA) presented information on three cold source related R&D topics. He reported on a parametric study of the impact of the ortho/para-hydrogen ratio for different hydrogen cold source geometries (work performed by Jim Bucholz, ORNL). The conclusion of the study was that variances in the ortho/para ratio could have a significant or no impact on the cold neutron beam depending on the source geometry. Doug also presented data on the comparison of supercritical and liquid hydrogen cold source physics performance. A concern had been raised that although the hydrogen density might be the same for the two hydrogen states, there was a potential for differences in the neutron physics associated with the different hydrogen states. Discussions were held with Tim Broom (ISIS facility, United Kingdom) and he agreed to make a cold neutron beam spectrum measurement with the ISIS cold source running in the normal liquid state and with the cold source in the supercritical state. Over the measured spectrum range ($< 1 \text{ \AA}$ to 7 \AA), no difference in the cold neutron spectrum was observed for the two hydrogen states. A similar comparison for neutron wavelengths greater than 7 \AA may be performed in the future. Finally, research work on a solid methane pellet moderator concept was reported on. It was indicated that methane pellets had been produced and additional funding was being sought to complete the concept development of such a moderator. Colin West (ORNL, USA) indicated that if a solid pellet moderator could be developed there could be a desire to try and lower

the moderator temperature down to as low as 4 K in order to perform certain physics tests.

R&D Topic 6F - Doug Selby (ORNL, USA) made a request for certain cold source related data. He asked if any organization had data that could be used to benchmark the nuclear heat load calculations performed by MCNP. He also asked if anyone had data concerning the diffusion of hydrogen through aluminum at room temperature conditions.

R&D Topic 6G - As a follow-up to discussions under R&D topic 6E concerning solid pellet moderators, Colin West made a request for neutron scattering cross section data for very cold (~10 K or less) solid moderator materials, such as methane.