From: Frankl, Istvan
Sent: Fri, 24 Feb 2017 19:15:25 +0000
To: Hiser, Matthew
Subject: RE: Harvesting Announcement Email

Thanks, Matt.

Please let me know if you need assistance with assuring NRR participation.

Steve

From: Hiser, Matthew
Sent: Friday, February 24, 2017 1:22 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting Announcement Email

Hi Steve,

I don't have final names for DE (Poehler or Cheruvenki) or DLR (Yoo or Hiser) or concrete (Mita's lead). I have talked to the DE and DLR staff and they know they need their management to support their time. I don't know when DE and DLR will decide who their confirmed attendees will be, but I think this email should go out regardless to make the broader staff aware in general.

I'll contact Donna-Marie to see what interaction there should be with OIP.

Thanks!
Matt

From: Frankl, Istvan
Sent: Friday, February 24, 2017 1:10 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Harvesting Announcement Email
Importance: High

Matt,

Obviously, NRR staff will need OK from their BCs. Please reach out to the tentative attendees from NRR and confirm their participation and then update the list with the confirmed NRR attendees.

Since regulator(s) from other countries will participate, we may need to notify OIP. Please reach out to Donna-Marie for clarification and assistance.

Thanks,

Steve

From: Hiser, Matthew
Sent: Friday, February 24, 2017 12:53 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting Announcement Email

Hi Steve,

We have talked to Mark Yoo and Allen Hiser in DLR for that slot (one of them) and I spoke with Jeff Poehler about he or Ganesh for the NRR/DE spot (I followed this up with an email with Dave Rudland on cc).

Mita was going to reach out to her counterparts in NRR for the NRR concrete person. I think it would be Angela Buford from DLR most likely…

Thanks!
Matt

From: Frankl, Istvan
Sent: Friday, February 24, 2017 12:48 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Harvesting Announcement Email
Importance: High

Thanks, Matt.

Who are the attendees from NRR? Do I need recommendations from my counterparts?

Steve

From: Hiser, Matthew
Sent: Friday, February 24, 2017 12:43 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting Announcement Email

Hi Steve,

No, I haven't received any more presentation titles since the agenda I sent yesterday, so that is the latest.

I have attached a list of attendees, both external and NRC.

Thanks!
Matt

From: Frankl, Istvan
Sent: Friday, February 24, 2017 12:30 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>

Subject: RE: Harvesting Announcement Email
Importance: High

Matt,

I expect questions from my NRR counterparts, so please send me the preliminary list of attendees and their affiliation. If from NRC, please identify the office/division/branch.

I am ready to send the announcement, so if you have more up-to-date draft agenda, please attach it to your response.

Thanks,

Steve

From: Frankl, Istvan
Sent: Friday, February 24, 2017 9:31 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Harvesting Announcement Email

Thanks, Matt.

I will .

Steve

From: Hiser, Matthew
Sent: Friday, February 24, 2017 9:27 AM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting Announcement Email

Hi Steve,

Feel free to go ahead and send the email if you like Rob's edits. They're fine with me…

Thanks!
Matt

From: Tregoning, Robert
Sent: Thursday, February 23, 2017 3:45 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Announcement Email

Matt:

See my suggested edits and comments;

Dear RES and NRR BCs:

RES is hosting a workshop on ex-plant materials harvesting at NRC headquarters on March 7-8, 2017. The scope includes ~~any~~ metallic, electrical, and concrete materials or components that could benefit from harvesting~~, including metallic, electrical, and concrete components~~. I have attached the agenda and workshop introduction slides that cover meeting logistics, motivation, approach, expected outcome, and session expectations.

This workshop includes about two dozen external participants, including representatives from DOE and EPRI as well as international research organizations ~~in~~ from Japan, Europe, and Canada. ~~Unfortunately, these is limited space available for NRC staff in the room. We have reached out to selected staff in RES and NRR to participate in the room to ensure we can fully support the workshop topics.~~ {I would delete this; why do we need to raise this and provide a negative impression}. A webinar will be available to allow ~~additional~~ NRC staff to observe and participate in the workshop: https://attendee.gotowebinar.com/register/6076202901971284226 .

If you have any questions or need additional information about the workshop, please contact myself or Matt Hiser on my staff.

Sincerely,
Steve Frankl

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Thursday, February 23, 2017 2:23 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Announcement Email

Updated attachments with slight tweaks per our discussion Steve (added “draft” label to agenda given missing presentation titles, added summary report bullet to expected outcome slide).

Rob and Pat, feel free to wordsmith email below before Steve sends it out tomorrow.

Thanks!
Matt

Matthew Hiser

Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

From: Hiser, Matthew
Sent: Thursday, February 23, 2017 9:27 AM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: Harvesting Announcement Email

Email to send to following RES and NRR BCs regarding workshop. Please take a look and provide any comments or feedback today if possible, so Steve can send email.

Send to:

RES/DE/CIB – Raj Iyengar
RES/DE/ICEEB – Ian Jung
RES/DE/SGSEB – Dogan Seber
NRR/DLR/RARB – Dennis Morey
NRR/DLR/RASB – Brian Wittick
NRR/DLR/RSRG – Steve Bloom
NRR/DE/EPNB – Dave Alley
NRR/DE/EVIB – Dave Rudland
NRR/DE/EEEB – Jake Zimmerman

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If you have any questions or need additional information about the workshop, please contact myself or Matt Hiser on my staff.

Sincerely,
Steve Frankl

Matthew Hiser
Materials Engineer

US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

Note to requester: The box with the X inside it is the Word attachment, which is immediately following.

From: Hiser, Matthew
Sent: Wed, 18 Oct 2017 20:43:51 +0000
To: Tregoning, Robert;Hull, Amy;Purtscher, Patrick;Ramuhalli, Pradeep
Cc: Frankl, Istvan;Audrain, Margaret;Moyer, Carol
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants
Attachments: IAEA PLiM Hiser 10-18-2017.docx

Hi Rob, Amy, Pat, Pradeep,

I have adapted our previous poster / presentation into a paper (attached) on very short notice. The deadline for PLiM papers is technically today, but given the extremely late notice, hopefully they can live with receiving it early next week following staff and management review here.

If you can possibly take a look at this by tomorrow (Thursday) or Friday and provide any feedback, that would be great.

I still need to clean up the references section, so don't mind the very casual state of it now. I'll clean that up tomorrow hopefully…

Thanks!
Matt

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

From: Hiser, Matthew
Sent: Tuesday, October 10, 2017 4:41 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

<< File: NRC PLiM slides on Harvesting.pptx >>

Hi Rob, Amy, Pat,

Here's is my adaptation of the poster info (along with some additional insights from the workshop) into slides for PLiM.

Please feel free to comment and edit freely. Ideally, we'd like to have these mostly agreed on at a technical level by COB tomorrow (Wednesday) to be able to discuss with NRR on Thursday and enter into management review and concurrence.

Thanks!
Matt

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

From: Tregoning, Robert
Sent: Tuesday, October 10, 2017 8:32 AM
To: Hiser, Allen <Allen.Hiser@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>
Cc: Thomas, Brian <Brian.Thomas@nrc.gov>; Wilson, George <George.Wilson@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Allen:

Thanks for the head's up and for offering to make a presentation on this for RES. We're targeting to put together a 20 minute presentation on harvesting that we can discuss with you on Thursday morning. We'll also cover your points 2 and 3 at that time.

Cheers,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission

Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Allen
Sent: Tuesday, October 10, 2017 7:27 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>
Cc: Thomas, Brian <Brian.Thomas@nrc.gov>; Wilson, George <George.Wilson@nrc.gov>
Subject: FW: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants
Importance: High

Another twist to the harvesting paper/presentation/poster for the PLiM conference.

I am willing to make a presentation at this "side event" if RES will put together slides - I would shoot for 20 minutes.

A couple of questions on this topic:

1. Can RES pull together a presentation in the next day or two, that we can discuss Thursday AM?

2. Has a paper been prepared (it appears from below that this is possible for inclusion in the conference proceedings)? If so, can I get a copy of it, or other background information.

3. When will the poster be available to be mailed to Lyon? (Can I get a copy of what it will look like?)

I am sure that other questions will arise.

Allen

-----Original Message-----
From: KANG, Ki-Sig [mailto:K.S.Kang@iaea.org]
Sent: Tuesday, October 10, 2017 7:17 AM
To: Hiser, Allen <Allen.Hiser@nrc.gov>
Cc: KHAELSS, Martina <M.Khaelss@iaea.org>; KRIVANEK, Robert

<R.Krivanek@iaea.org>; 4th PLiM Conference - Contact Point <4th-PLiM-Conference.Contact-Point@iaea.org>
Subject: [External_Sender] Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Dear Allen,

Regarding " Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants", now this paper will be presented on poster session in programme.

I think all of participants will be very interesting to this topic. But we have no time slot to present in oral session. Thus I recommend to arrange a side event to introduce this topic from 13:20 -14:00 on 24, Oct (Tuesday) if you want.
We can arrange the meeting room for presentation and discussion. Please think about and let me know.

Ki- Sig KANG

Technical Head (PLiM/LTO)
Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency
Tel: +43 1 2600 22796
Fax: +43 1 2600 29598
E-mail: Ki-Sig.KANG@iaea.org

Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

M. Hiser[a], P. Purtscher[a], P. Ramuhalli[b], A. B. Hull[a], R. Tregoning[a]

[a]U. S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Division of Engineering
Washington, DC

[b]Pacific Northwest National Laboratory
Richland, WA, USA

Abstract. Recent developments, including strong interest in extended plant operation and plans to shut down a number of nuclear power plants (NPPs), provide opportunities for harvesting components that were aged in representative light water reactor (LWR) environments. Technical issues associated with extended plant operation, such as reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation of reactor internals and primary components, concrete structures and containment degradation, and electrical cable aging, may be used to focus harvesting efforts on high-priority issues. Harvesting can provide highly representative aged materials for research and may be the only practical source of representative aged materials in some cases. Harvesting is expensive and time-consuming, which makes it essential to focus on technical needs of high importance and seek leveraging and cooperation among multiple organizations whenever possible. NRC is interested in engaging with other organizations to prioritize data needs for harvesting, identify areas of common interest, and develop a database for sources of materials for harvesting.

1. Background

Recent developments in the nuclear industry include stronger interest in extended plant operation and plans to shut down a number of nuclear power plants (NPPs). In the U.S., there is strong interest in extending NPP lifespans through subsequent license renewal (SLR) from 60 to 80 years [1]. Extended plant operation and SLR raise a number of technical issues that may require further research to understand aging mechanisms. U.S. utilities and the U.S. Nuclear Regulatory Commission (NRC) have focused on the aging of systems, structures, and components and in particular four key SLR issues: reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation of reactor internals and primary components, concrete structures and containment degradation, and electrical cable aging [2]. Meanwhile, in recent years, a number of NPPs, both in the U.S. and internationally, have shut down or announced plans to shut down for various reasons, including economic, political, and technical challenges. Unlike in the past when there were very few plants shutting down, these new developments provide opportunities for harvesting components that were aged in representative light water reactor (LWR) environments. In a third related development, economic challenges and limited budgets have restricted the resources available to support new research, including harvesting programs. Given this constrained budget environment, aligning interests and leveraging with other organizations is important to allow maximum benefit and value for future research programs.

2. NRC Experience with Harvesting

NRC has significant experience with harvesting plant components and performing research on harvested materials to address technical issues. This experience includes a range of components from plants in various stages of operation both in the U.S. and internationally. Some of the harvesting projects that the NRC has participated in include:

- RPV materials from the decommissioned Gundremmingen plant in Germany to study fluence rate effects on RPV embrittlement [3],
- Cast austenitic stainless steel (CASS) materials from the decommissioned Shippingport reactor in the U.S. to study CASS thermal embrittlement [4],
- RPV materials from the unfinished or never-operated Shoreham and Midland plants to improve understanding of flaw distributions for RPV embrittlement concerns [5-6],
- RPV head control rod drive mechanism penetrations from the operating North Anna and Davis-Besse plants in the U.S. to study primary water stress corrosion cracking (PWSCC) of nickel alloys and the effectiveness of non-destructive evaluation (NDE) methods [8-12],
- Reactor coolant system (RCS) piping nozzle weld materials from the operating V.C. Summer plant in the U.S. to study PWSCC of nickel alloys [11-12],
- Reactor internals materials from the decommissioned Jose Cabrera (known as Zorita) plant in Spain to study high-fluence irradiation effects on stainless steel alloys [13],
- Aluminum-based neutron-absorbing materials from the decommissioned Zion plant in the U.S. to study degradation in the spent fuel pool environment [14],
- Electrical cables from the decommissioned Zion and Crystal River plants in the U.S. to investigate cable degradation [15],
- Electrical bus ducts from the decommissioned Zion plant in the U.S. to study high-energy arc faults in electrical enclosures [16].

NRC is also aware of other harvesting efforts without NRC participation led by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE) and other research organizations.

As described above, NRC's experience is that harvesting has contributed significantly to improved understanding of important technical issues for nuclear safety. For RPV materials, harvesting has increased knowledge of embrittlement mechanisms and the underlying flaw distributions in the RPV to allow reduction in unnecessary conservatism as appropriate. For nickel alloys, harvesting has improved understanding of the PWSCC mechanism, while also increasing confidence in the ability of NDE methods to detect and characterize flaws. Finally, recent work on electrical enclosures has helped to identify a potential new safety issue associated with high-energy arc faults in electrical components containing aluminum [17].

3. NRC Perspective and Lessons Learned from Harvesting Experience

From NRC's perspective and experience, the primary role of harvesting is to provide confirmation of other research results from simulated aging conditions. In many situations, accelerated aging through higher flux test reactor irradiations or elevated temperatures can be used to generate significant data to understand aging effects in a more cost-effective manner. Limited harvesting efforts of materials from highly representative service environments can help provide data to confirm and increase confidence in the broader database from accelerated aging studies.

NRC's experience with harvesting has provided a number of technical and logistical lessons learned. Harvesting can provide highly representative aged materials for research and may be the only practical source of representative aged materials in some cases. For example, achieving high fluence levels with representative irradiation conditions through other means can be very challenging. It is also essential to gain as much information as possible regarding the materials and environment (temperature, fluence, irradiation conditions, chemistry, humidity, etc.) in advance before committing to a specific harvesting project.

In terms of logistics lessons learned, harvesting is expensive and time-consuming; therefore, focusing on technical needs of high importance is key to ensure good value. Likewise, leveraging and cooperation among multiple organizations helps to mitigate cost challenges. A final logistical lesson has been that it is quite challenging to transport irradiated materials, particularly internationally, so minimizing or avoid such transportation in harvesting programs is highly recommended.

4. NRC Activities on Harvesting

The primary focus of NRC's harvesting interests are on the four key issues identified for SLR: reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation of reactor internals and primary components, concrete structures and containment degradation, and electrical cable aging [2]. As described in Section 2 above, NRC has previously pursued harvesting for similar materials to address these technical issues. However, increasing operating time with extended plant operation leads to new technical gaps in understanding of material behavior at higher fluences and longer exposures to aging conditions.

NRC has recently undertaken an effort, with the assistance of Pacific Northwest National Laboratory (PNNL), to develop a strategic approach for harvesting aged materials from NPPs. Due to limited opportunities, past harvesting efforts have been reactive to individual plants shutting down and beginning decommissioning. Given the expected availability of materials from numerous plants and anticipated research needs to better understand aging out to 80 years of operation, the NRC is pursuing a more proactive approach to prioritize the data needs best addressed by harvesting and identify the best sources of materials to address high-priority data needs for regulatory research.

5. Prioritization of Data Needs Best Addressed by Harvesting

The first step in this strategic approach is to prioritize data needs for harvesting. A data need describes a particular degradation scenario (combination of material and environment) and should be defined with as much detail as appropriate in terms of the material (alloy, composition, etc.) and environment (temperature, fluence, chemistry, etc.).

A number of criteria may be considered when prioritizing the data needs for harvesting, including:

- Applicability of harvested material for addressing critical gaps
    - Harvesting for critical gaps should be prioritized over less essential technical gaps
- Ease of laboratory replication of the degradation scenario
    - For example, simultaneous thermal and irradiation conditions are difficult to replicate or accelerated aging may not be feasible for a mechanism sensitive to dose rate. Other degradation scenarios may be more easily replicated in simulated aging conditions and of lower priority for harvesting.
- Unique field aspects of degradation
    - For example, legacy materials (fabrication methods, composition, etc.) that are no longer available, but may play an important role in a potential degradation scenario, could increase the priority of harvesting.

- Fleet-wide vs. plant-specific applicability of data
    - There is greater value in addressing an issue applicable to a larger number of plants compared to one that only supports a small number of plants.
- Harvesting cost and complexity
    - For example, harvesting unirradiated concrete or electrical cables is less expensive and less complex than harvesting from the reactor internals or RPV. This cost and complexity consideration may increase the priority of lower cost needs and decrease the priority of higher cost needs, such as highly irradiated materials.
- Availability of reliable inspection methods for the degradation scenario
    - If mature inspection methods exist and are easy to apply to monitor degradation, harvesting may be less valuable. If inspection methods do not exist, harvesting may be essential to ensure confidence that the aging will not challenge a safety function for the component.
- Timeliness of the expected research results relative to the objective
    - The ability of a potential harvesting program to provide results in time to meet the objective of the work is important. Having high confidence that results will be timely to address the need increases the priority.
- Availability of materials for harvesting

The above potential criteria provide a systematic approach to prioritize data needs for harvesting. Different organizations may weigh and consider each of these criteria differently based on their interests and perspectives, but each criteria is likely relevant to some degree for any organization. NRC is interested in engaging with other organizations to prioritize data needs for harvesting and identify areas of common interest.

6. Database of Sources of Materials for Harvesting

Another activity NRC is pursuing is the potential development of a database for sources of materials for harvesting, which could include both previously harvested materials and those available for future harvesting. This database would allow for aligning of high-priority data needs to the available sources of materials. As with the data needs effort, the level of detail for the sources of materials database should be appropriate for the factors influencing decision-making. NRC is interested in engaging with other organizations to develop a database for sources of materials for harvesting.

7. Conclusions

NRC's experience is that harvesting can yield highly representative and valuable data on materials aging, but these efforts may be expensive and challenging. Having a clearly defined objective and early engagement with other stakeholders, including the NPP from which harvesting will take place, are key to success. As specific harvesting opportunities are identified through this strategic approach, the NRC welcomes opportunities for cooperation and leveraging resources with other interested research organizations.

References

1. https://www.nrc.gov/reading-rm/doc-collections/commission/slides/2017/20170426/remer-20170426.pdf
2. https://www.nrc.gov/docs/ML1405/ML14050A306.pdf

3. J.R. Hawthorne and A.L. Hiser, Experimental Assessments of Gundremmingen RPV Archive Material for Fluence Rate Effects Studies, NUREG/CR-5201 (MEA-2286), U.S. Nuclear Regulatory Commission, October 1988.
4. O.K. Chopra, and W.J. Shack, Mechanical Properties of Thermally Aged Cast Stainless Steels from Shippingport Reactor Components, NUREG/CR-6275 (ANL-94/37), U.S. Nuclear Regulatory Commission, April 1995.
5. G. J. Schuster, S. R. Doctor, S.L. Crawford, and A. F. Pardini, Characterization of Flaws in U.S. Reactor Pressure Vessels: Density and Distribution of Flaw Indications in the Shoreham Vessel, NUREG/CR-6471 Volume 3, U.S. Nuclear Regulatory Commission, November 1999.
6. G. J. Schuster, S. R. Doctor, A.F. Pardini, and S.L. Crawford, Characterization of Flaws in U.S. Reactor Pressure Vessels: Validation of Flaw Density and Distribution in the Weld Metal of the PVRUF Vessel, NUREG/CR-6471 Volume 2, U.S. Nuclear Regulatory Commission, August 2000.
7. D.E. McCabe, et al. Evaluation of WF-70 Weld Metal From the Midland Unit 1 Reactor Vessel, NUREG/CR-5736 (ORNL/TM-13748), U.S. Nuclear Regulatory Commission, November 2000.
8. S.E. Cumblidge, et al. Nondestructive and Destructive Examination Studies on Removed-from-Service Control Rod Drive Mechanism Penetrations, NUREG/CR-6996, U.S. Nuclear Regulatory Commission, July 2009.
9. S.E. Cumblidge, et al. Evaluation of Ultrasonic Time-of-Flight Diffraction Data for Selected Control Rod Drive Nozzles from Davis Besse Nuclear Power Plant, PNNL-19362, Pacific Northwest National Laboratory, April 2011.
10. S.L. Crawford, et al. Ultrasonic Phased Array Assessment of the Interference Fit and Leak Path of the North Anna Unit 2 Control Rod Drive Mechanism Nozzle 63 with Destructive Validation, NUREG/CR-7142 (PNNL-21547), U.S. Nuclear Regulatory Commission, August 2012.
11. B. Alexandreanu, O.K. Chopra, and W.J. Shack, Crack Growth Rates in a PWR Environment of Nickel Alloys from the Davis-Besse and V.C. Summer Power Plants, NUREG/CR-6921 (ANL-05/55), U.S. Nuclear Regulatory Commission, November 2006.
12. https://www.nrc.gov/docs/ML0816/ML081690334.pdf NUREG/CR-6964
13. https://www.nrc.gov/docs/ML1415/ML14153A403.pdf
14. https://www.nrc.gov/docs/ML1501/ML15015A021.pdf
15. https://lwrs.inl.gov/Materials%20Aging%20and%20Degradation/Status_Report_and_Research_Plan_for_Cables_Harvested_from_Crystal_River_Unit_3_Nuclear_Generating_Plant.pdf
16. https://www.nrc.gov/docs/ML1606/ML16064A250.pdf

From: Hiser, Matthew
Sent: Tue, 10 Oct 2017 20:40:39 +0000
To: Tregoning, Robert;Hull, Amy;Moyer, Carol;Purtscher, Patrick
Cc: Frankl, Istvan
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants
Attachments: NRC PLiM slides on Harvesting.pptx

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Thanks!
Matt

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

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Cc: Thomas, Brian <Brian.Thomas@nrc.gov>; Wilson, George <George.Wilson@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Allen:

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Cheers,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
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Sent: Tuesday, October 10, 2017 7:27 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>
Cc: Thomas, Brian <Brian.Thomas@nrc.gov>; Wilson, George <George.Wilson@nrc.gov>
Subject: FW: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants
Importance: High

Another twist to the harvesting paper/presentation/poster for the PLiM conference.

I am willing to make a presentation at this "side event" if RES will put together slides - I would shoot for 20 minutes.

A couple of questions on this topic:

1. Can RES pull together a presentation in the next day or two, that we can discuss Thursday AM?

2. Has a paper been prepared (it appears from below that this is possible for inclusion in the conference proceedings)? If so, can I get a copy of it, or other background information.

3. When will the poster be available to be mailed to Lyon? (Can I get a copy of what it will look like?)

I am sure that other questions will arise.

Allen

-----Original Message-----
From: KANG, Ki-Sig [mailto:K.S.Kang@iaea.org]
Sent: Tuesday, October 10, 2017 7:17 AM
To: Hiser, Allen <Allen.Hiser@nrc.gov>
Cc: KHAELSS, Martina <M.Khaelss@iaea.org>; KRIVANEK, Robert <R.Krivanek@iaea.org>; 4th PLiM Conference - Contact Point <4th-PLiM-Conference.Contact-Point@iaea.org>
Subject: [External_Sender] Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Dear Allen,

Regarding " Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants", now this paper will be presented on poster session in programme.

I think all of participants will be very interesting to this topic. But we have no time slot to present in oral session. Thus I recommend to arrange a side event to introduce this topic from 13:20 -14:00 on 24, Oct (Tuesday) if you want.
We can arrange the meeting room for presentation and discussion. Please think about and let me know.

Ki- Sig KANG

Technical Head (PLiM/LTO)
Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency
Tel: +43 1 2600 22796
Fax: +43 1 2600 29598
E-mail: Ki-Sig.KANG@iaea.org

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

M. Hiser[a], P. Purtscher[a], P. Ramuhalli[b], A. B. Hull[a], R. Tregoning[a]
[a]U.S. Nuclear Regulatory Commission (NRC), Washington, D.C., USA
[b]Pacific Northwest National Laboratory (PNNL), Richland, WA, USA

Outline

- Background and Motivation
- NRC Harvesting Experience
- Recent NRC Activities
  - Criteria for Prioritizing Data Needs
  - Database for Sources of Materials
- Path Forward

Background and Motivation

- Recent trends in global nuclear industry:
  - Interest in extending nuclear power plant (NPP) lifespans
    - Technical basis for managing aging of systems, structures, and components for longer time
  - Numerous NPPs, both in U.S. and internationally, have announced plans to or already have shut down
    - New opportunities for harvesting components that were aged in representative light water reactor (LWR) environments
- Limited budgets have restricted the resources available to support new research, including harvesting programs
  - Aligning interests and leveraging with other organizations is important to maximize value

NRC Harvesting Experience

- NRC has participated in numerous harvesting programs over the years:
  - RPV, CRDM penetrations, RCS piping, RPV internals, neutron absorbers, and cables
  - From operating and decommissioning plants in U.S. and internationally
- Significant value in using harvested components to confirm data from other research programs
  - Harvesting materials from highly representative long-term aging environments increases confidence in safety margins

Technical Lessons Learned

- Harvesting can provide highly representative aged materials for research
  - May be only practical source of representative aged materials, particularly if irradiation and temperature are important factors
    - Achieving high fluence levels with representative irradiation conditions through other means is very challenging
  - May be able to use limited harvested materials to validate larger accelerated aging data set
- Important to gain as much information as possible in advance before committing to specific harvesting project
  - Ideally a bounding, yet realistic, material/environment
  - Understand material information (CMTRs if available) and plant operating conditions

Logistical Lessons Learned

- Harvesting is an expensive, time-consuming effort
  - Must balance cost with potential benefits carefully
  - High technical relevance of materials is needed to ensure value
- Leveraging resources with other research organizations helps mitigate cost challenges
  - Can introduce challenges for testing when aligning research priorities and interests of multiple organizations
  - May be needed, particularly for expensive testing of irradiated materials
- Transporting irradiated materials, particularly internationally, is cumbersome and time-consuming
  - Avoiding extra transport, especially between countries, is highly recommended

Recent NRC Activities

- Strategic approach to materials harvesting
  - Due to limited opportunities, past harvesting efforts have generally been reactive to individual plants shutting down
- Prioritize the data needs best addressed by harvesting
  - Criteria for harvesting prioritization developed by PNNL
- Workshop held in March 2017 at NRC HQ to discuss all aspects of harvesting with other interested stakeholders
  - Good discussion of experience, including challenges and pitfalls, from those with firsthand knowledge

Potential Criteria for Harvesting Prioritization

- Applicability of harvested material for addressing critical gaps
  - Harvesting for critical gaps prioritized over less essential technical gaps
- Ease of laboratory replication of the degradation scenario
  - For example, simultaneous thermal and irradiation conditions are difficult to replicate
- Unique field aspects of degradation
  - For example, unusual operating experience or legacy materials (fabrication methods, etc.) no longer available
- Fleet-wide vs. plant-specific applicability of data

Potential Criteria for Harvesting Prioritization

- Harvesting cost and complexity
  - For example, harvesting unirradiated concrete or electrical cables less expensive and less complex than harvesting from the reactor internals
- Availability of reliable in-service inspection (ISI) techniques for the material / component
  - If mature inspection methods exist and are easy to apply, harvesting may be less valuable
- Availability of materials for harvesting
- Timeliness of the expected research results relative to the objective

Database for Sources of Materials

- NRC is pursuing the development of a database for sources of materials for harvesting
  - Includes both previously harvested materials and those available for future harvesting
- Allow for aligning of high-priority data needs to the available sources of materials
  - The level of detail should be appropriate for the factors influencing decision-making
- NRC is interested in engaging with other organizations in developing the database

Conclusion and Path Forward

- Harvesting can yield highly representative and valuable data on materials aging
  - Having a clearly defined objective and early engagement with other stakeholders are keys to success
- Data Needs Prioritization and Sources of Materials Database
  - NRC is interested in working with other organizations to identify high-priority data needs of common interest
- As specific harvesting opportunities are identified, NRC welcomes opportunities for cooperation and leveraging with other interested research organizations

From: Frankl, Istvan
Sent: Fri, 29 Jan 2016 11:00:21 -0600
To: Hiser, Matthew
Cc: Hull, Amy
Subject: RE: Harvesting One Pager
Attachments: Harvesting One Pager (IF).docx

Note to requester: Attachment is immediately following.

Thanks, Matt.

Nice one-pager.

I have a few comments and revisions. Please see the attachment for details.

Thanks,

Steve

From: Hiser, Matthew
Sent: Friday, January 29, 2016 10:05 AM
To: Frankl, Istvan; Hull, Amy
Subject: Harvesting One Pager

Hi Steve and Amy,

Please find attached the one-pager on the harvesting project to help facilitate transition with Aloysius.

Thanks!
Matt

Strategic Approach to Ex-Plant Harvesting (1/29/2016)

Background

- Understanding the causes and control of degradation mechanisms forms the basis for developing aging management programs (AMPs) to ensure the functionality and safety margins of NPP systems, structures, and components (SSC). The resolution to these issues should provide reasonable assurance of safe operation of the components in the scope of license renewal during the subsequent period of extended operation.
- In many cases, the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in NPPs is incomplete. A strategic approach to the harvesting, examination and testing of materials and components from decommissioned reactors can dramatically increase our knowledge-acquisition rate in this very important area.
- This project is to develop a strategic approach to ex-plant harvesting and was originally conceived and initiated through the NRC's Long-Term Research Program (LTRP).

Facts

- A new task order ~~(NRC-HQ-25-14-D-0001 Task Order Number~~ (NRC-HQ-60-15-T-0023) was placed with the Pacific Northwest National Lab (PNNL) Enterprise Wide Agreement (NRC-HQ-25-14-D-0001) in September 2015 to support NRC in developing a strategic approach to ex-plant harvesting. Task 1 focuses on a scoping study to pull in information from other sources (EMDA, GALL, ASME code, etc.) to populate an information tool that will allow the prioritization of harvesting opportunities.
- An internal NRC working group consisting of staff from RES and NRR was formed to advise the strategic harvesting effort.
- NRR/DLR staff and management have expressed strong support and interest in this project and intend to develop a user need request (UNR) to support this effort in the context of Subsequent License Renewal (SLR).

Commented [IF1]: What is the status of this?

Status

- Under Task 1 of the task order, PNNL is currently working on developing examples for dissimilar metal welds and cables of what type of information will be captured and how it will be presented.
- The working group has met once in December and has another meeting scheduled for February to review some information put together by PNNL.

Next Steps

- By mid-February, PNNL should provide examples for dissimilar metal welds and cables in the information tool. This will allow NRC (likely through the working group) to review what type of information will be captured and how it will be presented.
- NRC staff should work with PNNL to organize a public workshop to discuss the topic of ~~,~~ ex-plant harvesting and engage relevant stakeholders, particularly EPRI, industry, and DOE that can help provide information and cooperation in these efforts.
- RES staff should work with NRR staff to develop an updated UNR incorporating this strategic harvesting effort.

Commented [IF2]: Is this a different UNR, or the new one?

Note to requester: Attachment is immediately following.

From: Frankl, Istvan
Sent: Fri, 29 Jan 2016 17:53:14 +0000
To: Hiser, Matthew
Cc: Hull, Amy
Subject: RE: Harvesting One Pager
Attachments: Harvesting One Pager (IF).docx

Thanks, Matt.

I implemented your clarifications in the attachment.

I will schedule meeting with Aloysius and you for early next week to discuss this assignment. I am also thinking about reassigning the GSI-191 effort to him. Any thoughts on this?

Steve

From: Hiser, Matthew
Sent: Friday, January 29, 2016 12:16 PM
To: Frankl, Istvan
Cc: Hull, Amy
Subject: RE: Harvesting One Pager

Hi Steve,

OK, I accepted your revisions (attached). To answer your questions:

1. What is the status of UNR?
    a. As far as I know, Amy has had some limited discussion with DLR staff and management and they support this effort and would like to put in UNR. I don't think there has been much more progress made on that front, which is something that Aloysius could hopefully lead.
2. Is this a different UNR, or the new one?
    a. I was referring to the same one as above. There are already UNRs for RES support for SLR, so whether it is "updating" those old ones or creating a "new" UNR from scratch is not much different in my mind.

Thanks!
Matt

From: Frankl, Istvan
Sent: Friday, January 29, 2016 12:00 PM
To: Hiser, Matthew
Cc: Hull, Amy
Subject: RE: Harvesting One Pager

Thanks, Matt.

Nice one-pager.

I have a few comments and revisions. Please see the attachment for details.

Thanks,

Steve

From: Hiser, Matthew
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Thanks!
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- RES staff should work with NRR staff to develop a new UNR or update the existing UNR for SLR to ~~an updated UNR~~ incorporat~~e~~ing this strategic harvesting effort.

Note to requester: The attachments are both immediately following.

From: Hiser, Matthew
Sent: Mon, 23 Oct 2017 12:45:05 +0000
To: Tregoning, Robert;Hiser, Allen
Subject: RE: Harvesting Poster
Attachments: IAEA PLiM Hiser 10-23-2017.docx, NRC PLiM slides on Harvesting final.pptx

Here's the latest version of the paper (at division level management for approval).

I also attached the slides, which I had sent a couple weeks back.

Did the poster make it to the hotel?

Thanks for presenting and good luck!

Matt

From: Tregoning, Robert
Sent: Monday, October 23, 2017 8:41 AM
To: Hiser, Allen <Allen.Hiser@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Harvesting Poster

Allen:

Do you have the final presentation and latest version of the paper? I'll ask Matt to send you the latest version just in case. Then you can peruse the paper for some additional information. Thanks again for covering……

RT

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Allen
Sent: Monday, October 23, 2017 8:38 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: Harvesting Poster
Importance: High

FYI - The poster presentation has gone from lunchtime to in-session in 1.5 hours due to a cancellation.

Any last minute thoughts to convey?

HARVESTING OF AGED MATERIALS FROM OPERATING AND DECOMMISSIONING NUCLEAR POWER PLANTS

M. Hiser, P. Purtscher, A. B. Hull, R. Tregoning
U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research
Washington, DC
Email: matthew.hiser@nrc.gov

P. Ramuhalli
Pacific Northwest National Laboratory
Richland, WA, USA

Abstract

Recent plans to shut down a number of nuclear power plants (NPPs) provide opportunities for harvesting components that were exposed to actual light water reactor (LWR) environments. Technical issues associated with extended plant operation, such as reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation of reactor internals and primary components, concrete structures and containment degradation, and electrical cable aging, may be used to focus harvesting efforts on high-priority issues. Harvesting can provide highly representative aged materials for research and, in some cases, may be the only practical source of representative aged materials to address high-priority issues. Harvesting can be expensive and time-consuming, which makes it essential to focus on those technical needs with the highest importance and cooperate with multiple organizations whenever possible to optimally leverage resources. NRC is interested in engaging with other organizations to prioritize data needs for harvesting, identify areas of common interest, and develop a database for sources of materials for harvesting.

1. BACKGROUND

Recent developments in the nuclear industry include stronger interest in extended plant operation and plans to shut down a number of nuclear power plants (NPPs). In the U.S., there is strong interest in extending NPP lifespans through subsequent license renewal (SLR) from 60 to 80 years [1]. Further research may be required to understand age-related degradation throughout the SLR period to help ensure that aging management programs are adequate. U.S. utilities and the U.S. Nuclear Regulatory Commission (NRC) are focused on the aging of systems, structures, and components in four key technical areas: reactor pressure vessel (RPV) embrittlement, irradiation-assisted degradation (IAD) of RPV internals and primary components, concrete structures and containment degradation, and electrical cable aging [2]. In recent years, a number of NPPs, both in the U.S. and internationally, have shut down or announced plans to shut down. Unlike in the past when there were very few decommissioning plants, these plant shutdowns provide opportunities for harvesting components that were exposed to actual light water reactor (LWR) environments. Additionally, harvesting programs can be costly and complex. Given these constraints, aligning interests and leveraging with other organizations is important to allow maximum benefit and value for future research programs.

2. NRC EXPERIENCE WITH HARVESTING

NRC has significant experience with harvesting plant components and performing research on harvested materials to address technical issues. This experience includes a range of components from plants in various stages of operation both in the U.S. and internationally. Some of the harvesting projects that the NRC has participated in have studied the following materials or components:

- RPV materials from the decommissioned Gundremmingen plant to study fluence rate effects on RPV embrittlement [3],
- Cast austenitic stainless steel (CASS) materials from the decommissioned Shippingport reactor. to study CASS thermal embrittlement [4],
- RPV materials from the unfinished or never-operated Shoreham and Midland plants to improve understanding of flaw distributions for RPV embrittlement concerns [5-6],
- RPV head control rod drive mechanism penetrations from the operating North Anna and Davis-Besse plants to study primary water stress corrosion cracking (PWSCC) of nickel alloys and the effectiveness of non-destructive evaluation (NDE) methods [8-12],
- Reactor coolant system (RCS) piping nozzle weld materials from the operating V.C. Summer plant to study PWSCC of nickel alloys [11-12],

- Reactor internals materials from the decommissioned Jose Cabrera (known as Zorita) plant to study high-fluence irradiation effects on stainless steel reactor internals materials [13],
- Aluminum-based neutron-absorbing materials from the decommissioned Zion plant to study degradation in the spent fuel pool environment [14],
- Electrical cables from the decommissioned Zion and Crystal River plants to investigate cable degradation [15],
- Electrical bus ducts from the decommissioned Zion plant to study high-energy arc faults in electrical enclosures [16].

As illustrated by these programs, NRC's experience is that harvesting has contributed significantly to improved understanding of important technical issues for nuclear safety. For RPV materials, harvesting has increased knowledge of embrittlement mechanisms and the underlying flaw distributions in the RPV to allow reduction in unnecessary conservatism. For nickel alloys, harvesting has improved understanding of PWSCC and the development of acceptable inspection intervals, while also increasing confidence in the ability of NDE methods to detect and characterize flaws. Finally, recent work on electrical enclosures has helped to identify a potential new safety issue associated with high-energy arc faults in electrical components containing aluminum [16].

3. NRC PERSPECTIVE AND LESSONS LEARNED FROM HARVESTING ACTIVITIES

From NRC's perspective, a principal role of harvesting is to confirm other research results from simulated aging conditions. In many situations, accelerated aging through higher flux test reactor irradiations or elevated temperatures can be used to generate significant data to understand aging effects in a more cost-effective manner. Limited harvesting efforts of materials from actual service environments can help confirm the adequacy of the knowledge gained from accelerated aging studies, and thus increase the confidence in the broader knowledge base.

However, in certain situations, harvesting may be the only practical source of representative aged materials. For example, achieving high fluence levels with representative irradiation conditions through accelerated aging can be very challenging. Additionally, it is essential to gain as much information as possible regarding the materials and environment (temperature, fluence, irradiation conditions, chemistry, humidity, etc.) in advance before committing to a specific harvesting project so that the implications of the results from evaluating the materials can be properly understood.

Pragmatically, harvesting can be expensive, complex, and time-consuming; therefore, focusing on technical needs of high importance will help ensure good value. Likewise, leveraging and cooperation among multiple organizations helps to mitigate cost challenges. It is also quite challenging to transport irradiated materials, particularly internationally, so minimizing or avoiding transportation of irradiated materials is highly recommended.

4. NRC ACTIVITIES ON HARVESTING

NRC is potentially interested in harvesting materials to assess age-related degradation in the four technical areas identified previously: RPV embrittlement, IAD of RPV internals and primary components, concrete structures and containment degradation, and electrical cable aging [2]. The focus is to understand the impact of extended plant operation on material behavior, including the effects of higher fluences and longer exposures to aging conditions.

NRC has recently undertaken an effort, with the assistance of Pacific Northwest National Laboratory (PNNL), to develop a strategic approach for harvesting aged materials from NPPs. Past harvesting activities have been narrowly focused on the relatively few opportunities to get materials from decommissioning plants. Given the expected availability of materials from numerous plants and identified research needs to better understand aging out to 80 years of operation, the NRC is developing a more proactive approach to prioritize the data needs best addressed by harvesting and identify the best sources of materials to address high-priority data needs for regulatory research.

5. PRIORITIZATION OF DATA NEEDS BEST ADDRESSED BY HARVESTING

The first step in this strategic approach is to prioritize data needs for harvesting. A data need describes a particular degradation scenario (i.e., combination of material and environment) and should be defined with as much detail as appropriate in terms of the material (e.g., alloy, composition) and environment (e.g., temperature, fluence, chemistry).

A number of criteria are being considered for prioritizing the harvesting data needs, including:

— Applicability of harvested material for addressing critical gaps
  - Harvesting to address critical gaps should be prioritized over less essential technical gaps
— Ease of laboratory replication of the degradation scenario
  - Degradation mechanisms that are harder to replicate with simulated aging conditions would be of higher priority for harvesting. For example, simultaneous thermal and irradiation conditions are difficult to replicate outside of the plant environment. Alternatively, accelerated aging may not be feasible for a mechanism sensitive to dose rate. These two degradation mechanisms may be best evaluated using harvested materials.
— Unique field aspects of degradation
  - For example, legacy materials (e.g., fabrication methods, composition) that are no longer available, but may play an important role in a potential degradation mechanism, would have a higher priority than harvesting materials that can be obtained from other sources.
— Fleet-wide vs. plant-specific applicability of data
  - There is greater value in developing knowledge to address an issue that may be applicable to a larger number of plants compared to one that may only affect a relatively small number of plants.
— Harvesting cost and complexity
  - Activities with higher costs and complexity are less attractive than similar activities with lower costs and that are simpler to execute.. For example, harvesting unirradiated concrete or electrical cables is less expensive and less complex than harvesting from the RPV internals or the RPV.
— Availability of reliable inspection methods for the degradation scenario
  - If mature inspection methods exist and are easy to apply to monitor degradation, harvesting may be less valuable. If inspection methods do not exist, harvesting may be essential to ensure confidence in the assessment of age-related degradation in that particular component.
— Timeliness of the expected research results
  - The ability of a potential harvesting program to provide timely results to support either a technical or regulatory need is important. Having high confidence that results will be timely increases the priority.
— Availability of materials for harvesting
  - The availability of materials to harvest for a particular data need is clearly essential and increases the priority.

The above potential criteria provide a systematic approach for prioritizing harvesting data needs. Different organizations may weigh these criteria differently, but the criteria are intended to be comprehensive. NRC is interested in engaging with other organizations to further refine these criteria, use them to prioritize data needs for harvesting, and ultimately identify areas of common interest that may provide optimal harvesting opportunities.

6. DATABASE OF SOURCES OF MATERIALS FOR HARVESTING

The NRC is also developing a database that identifies sources of materials for harvesting. This database will include both previously harvested materials and those which may be available for future harvesting. This database will be used to align the high-priority harvesting needs to the available materials. As with the harvesting prioritization effort, the level of detail for the sources of materials database should be appropriate for the factors influencing decision-making. NRC is interested in engaging with other organizations to develop a database that identifies sources of materials for harvesting.

7. CONCLUSIONS

NRC's experience is that harvesting can yield highly representative and valuable knowledge about materials aging. However, these efforts may be expensive and challenging. Having a clearly defined objective and early engagement with other stakeholders, including the decommissioning plant where harvesting will take place, are necessary to ensure project success. As specific harvesting opportunities are identified through this strategic approach, the NRC will develop strategies for pursuing these opportunities. The NRC also welcomes collaboration from other interested research organizations both in developing the proactive harvesting strategy and in pursuing harvesting opportunities of mutual interest.

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[2] U.S. NUCLEAR REGULATORY COMMISSION, "Ongoing Staff Activities to Assess Regulatory Considerations for Power Reactor Subsequent License Renewal," SECY-14-0016, 2014, https://www.nrc.gov/docs/ML1405/ML14050A306.pdf.

[3] HAWTHORNE, J.R., HISER, A.L., "Experimental Assessments of Gundremmingen RPV Archive Material for Fluence Rate Effects Studies," NUREG/CR-5201 (MEA-2286), U.S. Nuclear Regulatory Commission, October 1988.

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[5] SCHUSTER, G. J., DOCTOR, S. R., CRAWFORD, S.L., PARDINI, A. F., "Characterization of Flaws in U.S. Reactor Pressure Vessels: Density and Distribution of Flaw Indications in the Shoreham Vessel," NUREG/CR-6471 Volume 3, U.S. Nuclear Regulatory Commission, November 1999.

[6] SCHUSTER, G. J., DOCTOR, S. R., PARDINI, A.F., CRAWFORD, S.L., "Characterization of Flaws in U.S. Reactor Pressure Vessels: Validation of Flaw Density and Distribution in the Weld Metal of the PVRUF Vessel," NUREG/CR-6471 Volume 2, U.S. Nuclear Regulatory Commission, August 2000.

[7] MCCABE, D.E., ET AL., "Evaluation of WF-70 Weld Metal From the Midland Unit 1 Reactor Vessel," NUREG/CR-5736 (ORNL/TM-13748), U.S. Nuclear Regulatory Commission, November 2000.

[8] CUMBLIDGE, S.E., ET AL., "Nondestructive and Destructive Examination Studies on Removed-from-Service Control Rod Drive Mechanism Penetrations," NUREG/CR-6996, U.S. Nuclear Regulatory Commission, July 2009.

[9] CUMBLIDGE, S.E., ET AL., "Evaluation of Ultrasonic Time-of-Flight Diffraction Data for Selected Control Rod Drive Nozzles from Davis Besse Nuclear Power Plant," PNNL-19362, Pacific Northwest National Laboratory, April 2011.

[10] CRAWFORD, S.L., ET AL., "Ultrasonic Phased Array Assessment of the Interference Fit and Leak Path of the North Anna Unit 2 Control Rod Drive Mechanism Nozzle 63 with Destructive Validation," NUREG/CR-7142 (PNNL-21547), U.S. Nuclear Regulatory Commission, August 2012.

[11] ALEXANDREANU, B., CHOPRA, O.K., SHACK, W.J., "Crack Growth Rates in a PWR Environment of Nickel Alloys from the Davis-Besse and V.C. Summer Power Plants," NUREG/CR-6921 (ANL-05/55), U.S. Nuclear Regulatory Commission, November 2006.

[12] ALEXANDREANU, B., CHOPRA, O.K., SHACK, W.J., "Crack Growth Rates and Metallographic Examinations of Alloy 600 and Alloy 82/182 from Field Components and Laboratory Materials Tested in PWR Environments," NUREG/CR-6964 (ANL-07/12), U.S. Nuclear Regulatory Commission, May 2008.

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[14] U.S. NUCLEAR REGULATORY COMMISSION, "Acquisition and Testing of Zion Spent Fuel Pool Neutron Absorber Materials," Addendum to Memorandum of Understanding between NRC and EPRI, 2014, https://www.nrc.gov/docs/ML1501/ML15015A021.pdf.

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United States Nuclear Regulatory Commission
Protecting People and the Environment

Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

M. Hiser[a], P. Purtscher[a], P. Ramuhalli[b], A. B. Hull[a], R. Tregoning[a]
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Outline

- Background and Motivation
- NRC Harvesting Experience
- Recent NRC Activities
  - Criteria for Prioritizing Data Needs
  - Database for Sources of Materials
- Path Forward

Background and Motivation

- Recent trends in global nuclear industry:
  - Interest in extending nuclear power plant (NPP) lifespans
  - Numerous NPPs, both in U.S. and internationally, have announced plans to or already have shut down
- Limited budgets have restricted the resources available to support new research, including harvesting programs
  - Aligning interests and leveraging with other organizations is important to maximize value

NRC Harvesting Experience

- NRC has participated in numerous harvesting programs over the years:
  - RPV, CRDM penetrations, RCS piping, RPV internals, neutron absorbers, and cables
  - From unfinished, operating ,and decommissioning plants in U.S. and internationally
- Significant value in using harvested components to confirm data from other research programs

Technical Lessons Learned

- Harvesting can provide highly representative aged materials for research
  - May be only practical source of representative aged materials
  - May be able to use limited harvested materials to validate larger accelerated aging data set
- Important to gain as much information as possible in advance before committing to specific harvesting project

Logistical Lessons Learned

- Harvesting is an expensive, time-consuming effort
- Leveraging resources with other research organizations helps mitigate cost challenges
- Transporting irradiated materials, particularly internationally, is cumbersome and time-consuming

Lifting operation for irradiated materials transport cask

Recent NRC Activities

- Strategic approach to materials harvesting
  - Due to limited opportunities, past harvesting efforts have generally been reactive to individual plants shutting down
- Prioritize the data needs best addressed by harvesting
- Workshop held in March 2017 at NRC HQ to discuss all aspects of harvesting with other interested stakeholders

Potential Criteria for Harvesting Prioritization

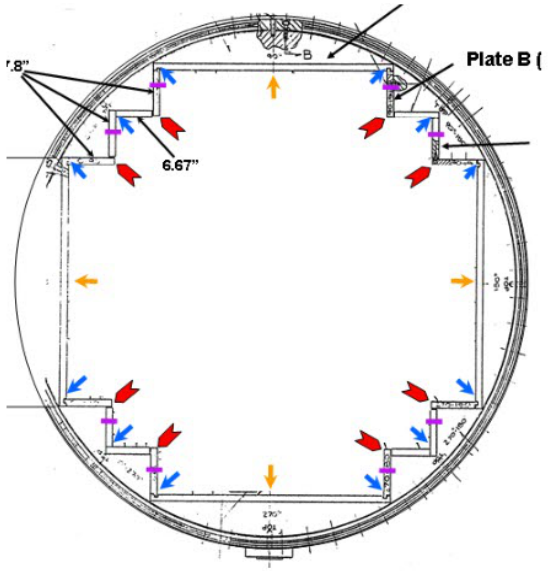
- Applicability of harvested material for addressing critical gaps
- Ease of laboratory replication of the degradation scenario
- Unique field aspects of degradation
- Fleet-wide vs. plant-specific applicability of data

Potential Criteria for Harvesting Prioritization

- Harvesting cost and complexity
- Availability of reliable in-service inspection (ISI) techniques for the material / component
- Availability of materials for harvesting
- Timeliness of the expected research results relative to the objective

Database for Sources of Materials

- NRC is pursuing the development of a database for sources of materials for harvesting
- Allow for aligning of high-priority data needs to the available sources of materials
- NRC is interested in engaging with other organizations in developing the database



Example of reactor internals harvesting plan

Conclusion and Path Forward

- Harvesting can yield highly representative and valuable data on materials aging
- Data Needs Prioritization and Sources of Materials Database
- As specific harvesting opportunities are identified, NRC welcomes opportunities for cooperation and leveraging with other interested research organizations

Note to requester: The boxes with the X inside them are the two Word attachments, and the one Power Point attachment, which are immediately following.

From: Hiser, Matthew
Sent: Mon, 30 Jan 2017 14:39:47 +0000
To: Purtscher, Patrick
Subject: RE: Harvesting Workshop
Attachments: Workshop Planning 1-30-17.docx, GoToMeeting.docx, Harvesting Workshop intro slides 1-23-17.pptx

Will do Pat – here are the documents we'll be speaking to.

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

From: Purtscher, Patrick
Sent: Monday, January 30, 2017 8:57 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Harvesting Workshop

(b)(6)

You can call me at [redacted], 10 AM.

-----Original Appointment-----
From: Hiser, Matthew
Sent: Wednesday, January 25, 2017 9:12 AM
To: Hiser, Matthew; Tregoning, Robert; Purtscher, Patrick
Subject: Harvesting Workshop
When: Monday, January 30, 2017 10:00 AM-11:00 AM (UTC-05:00) Eastern Time (US & Canada).
Where: HQ-TWFN-10A73-8p

Discuss latest status of workshop planning.

Workshop Contacts

Name	Organization	Email	Contact Through
Taku Arai	CRIEPI	arait@criepi.denken.or.jp	Rob
Sadao Higuchi	CRIEPI	higuchi@criepi.denken.or.jp	
Rachid Chaouadi	SCK-CEN	rachid.chaouadi@sckcen.be	Rob
Kazunobu Sakamoto	JNRA	kazunobu_sakamoto@nsr.go.jp	Rob
	JAEA		
Gerry van Noordennen	Energy Solutions	gpvannoordennen@energysolutions.com	Matt
Bill Zipp	Dominion	william.f.zipp@dom.com	Matt
Sherry Bernhoft	EPRI	sbernhoft@epri.com	
Robin Dyle	EPRI	rdyle@epri.com	
Jean Smith	EPRI	jmsmith@epri.com	
Al Ahluwalia	EPRI	kahluwal@epri.com	
Tom Rosseel	DOE	rosseeltm@ornl.gov	
Rich Reister	DOE	Richard.Reister@nuclear.energy.gov	
Keith Leonard	DOE	leonardk@ornl.gov	
Mikhail A. Sokolov	DOE	sokolovm@ornl.gov	
Leo Fyfeld	DOE/PNNL		
Pat Purtscher	NRC	Patrick.Purtscher@nrc.gov	
Rob Tregoning	NRC	Robert.Tregoning@nrc.gov	
Matt Hiser	NRC	Matthew.Hiser@nrc.gov	
Anders Jenssen	Studsvik	anders.jenssen@studsvik.se	Matt/Jean
Daniel Tello	CNSC	daniel.tello@canada.ca	Matt
	CNL		
	AECL		
Heather Malikowski	PWROG	Heather.Malikowski@exeloncorp.com	Matt
Jim Molkenthin	PWROG	molkenjp@westinghouse.com	Matt
Regis Nhili	MAI	regis.nhili@edf.fr	Rob
Uwe Jendrich	GRS	Uwe.Jendrich@grs.de	Rob
Pradeep Ramuhalli	PNNL	Pradeep.Ramuhalli@pnnl.gov	

Session	NRC Lead	DOE Lead	EPRI Lead
1	Rob Tregoning	Rich Reister	Sherry Bernhoft/Robin Dyle
2	Pat Purtscher	Keith Leonard	Sherry Bernhoft/Robin Dyle
3	Matt Hiser	Tom Rosseel	Sherry Bernhoft/Robin Dyle
4	Matt Hiser	Tom Rosseel	Sherry Bernhoft/Robin Dyle
5	Rob Tregoning	Rich Reister	Sherry Bernhoft/Robin Dyle

NRC Presentations

Session	Topic	Speaker
1	Why our organization is interested in harvesting	Tregoning
2	Overview of data needs best addressed by harvesting	Pradeep / PNNL
3	Available materials from decommissioning plants and past harvesting programs	Hiser
4	Perspective on Harvesting Lessons Learned / Prior Experience	TBD
5	Technical information needed for informed harvesting decisions	Pradeep / PNNL
5	Perspective on future harvesting planning	Tregoning

Session	Topic	Organization	Speaker	Status
1	Why our organization is interested in harvesting	EPRI		
		DOE	Rich Reister	
		NRC	Robert Tregoning	
		MAI		Emails exchanged
		JNRA/CRIEPI/JAEA		Emails exchanged
	PANEL DISCUSSION			
2	Overview of data needs best addressed by harvesting	PNNL (for NRC)	Pradeep Ramuhalli	
	Perspective on detailed data needs from harvesting	EPRI		
		DOE	Keith Leonard	
		SCK-CEN		Emails exchanged
		JNRA/CRIEPI/JAEA		Emails exchanged
3	Available materials from decommissioning plants and past harvesting programs	NRC	Matt Hiser	
	Available materials from operating reactors and past harvesting programs	EPRI		
		PWROG		Emails exchanged
	Available materials at DOE labs from past harvesting programs	DOE	Tom Rosseel	
	Upcoming decommissioning sites	Energy Solutions	Gerry van Noordennen	Confirmed
	International sources of materials	MAI		Emails exchanged
		JNRA/CRIEPI/JAEA		Emails exchanged
		CNSC		Confirmed – speaker TBD
		Korea		EPRI/ Ahluwalia
4	Perspective on Harvesting Lessons Learned / Prior Experience	EPRI		
		DOE	Tom Rosseel	
		NRC		
	Decommissioning process and harvesting: schedule, site-specific, timing for different components	Energy Solutions	Gerry van Noordennen	Confirmed
	Utility-Owner perspective on harvesting and decommissioning	Dominion	Bill Zipp	Confirmed
	International decommissioning and harvesting experience	Germany?		Emails exchanged
5	Technical information needed for informed harvesting decisions	PNNL (for NRC)	Pradeep Ramuhalli	
	Perspective on future harvesting planning	EPRI		
		DOE	Rich Reister	
		NRC	Robert Tregoning	
		MAI		Emails exchanged
		JNRA/CRIEPI/JAEA		Emails exchanged
	PANEL DISCUSSION			
	Discussion of Next Steps / Actions			

GoToMeeting: http://drupal.nrc.gov/sites/default/files/GTM-Scheduling-Inst.pdf
http://fusion.nrc.gov/ois/team/CSD/CSB/GoToMeeting/Lists/Using%20GoToMeeting%20At%20NRC/Print%20view.aspx?View=%7B988A7CE0-DE09-4629-98E4-F3BB501687E4%7D&ShowInGrid=HTML
http://fusion.nrc.gov/ois/team/CSD/CSB/GoToMeeting/Lists/Links/AllItems.aspx

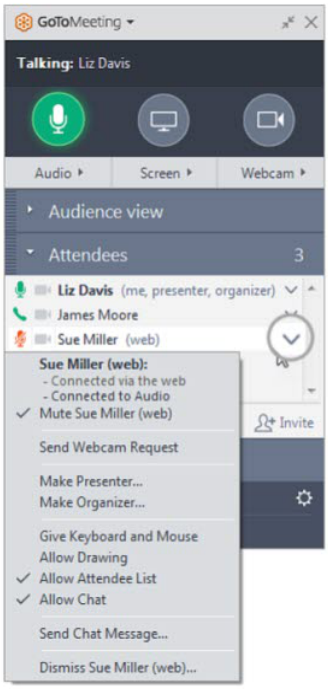
4 Manage attendees

The Attendees pane lets you see all the participants in your meeting and gives you access to GoToMeeting controls. Click the Arrow icon next to any participant's name to see all options, including the following:

- Mute their audio
- Promote them to co-organizer
- Allow them to use drawing tools or keyboard/mouse control (learn more)

Hide Attendee or Chat panes from others

Dismiss attendees



7 Share your screen

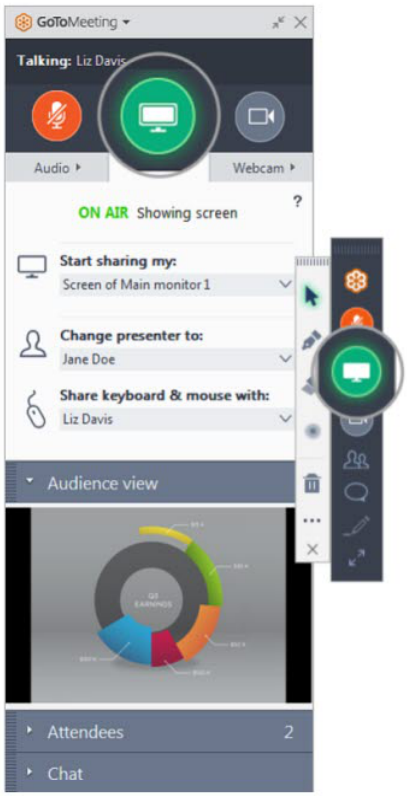
You can share your screen or even a specific application with the other attendees in the meeting. Use the **Screen button** in your Control Panel or Grab Tab to quickly start and stop sharing the screen of your main monitor.

» Open the **Screen tab** to see additional options:

- Use the **Start sharing my** drop-down menu to share a different monitor or even a specific application (such as Powerpoint).
- Use the **Change Presenter to** menu to transfer the presenter controls to another person.
- Use the **Share keyboard & mouse with** menu to allow other attendees to control the mouse and keyboard on the screen you are sharing.

Allow others to draw on the screen

Pause screen sharing



8 Chat with others

The Control Panel includes a Chat pane where you can exchange messages with other attendees. You'll see message notifications appear if your Control Panel is minimized to the Grab Tab.

» Use the **To** drop-down menu to select your recipients:

- Select **Everyone** to send a public message to all participants.
- Select **Organizer(s) only** to send a message only to organizers and co-organizers.
- Select a specific individual to send a private message to just that person.

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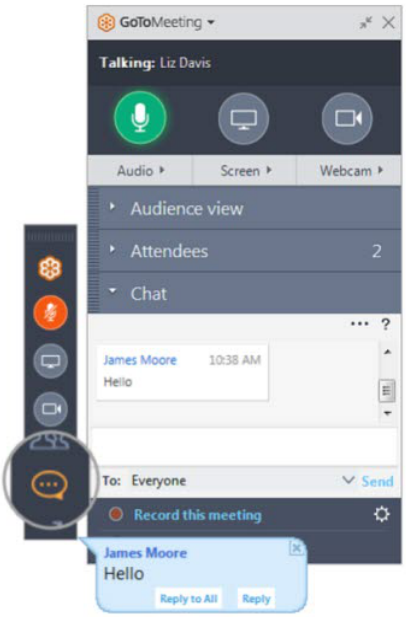
You can save a .RTF file of the transcript by clicking **GoToMeeting** in the top menu, then selecting **Save Chat Log**. When prompted, select a place on your computer to save the file and click **Save**.



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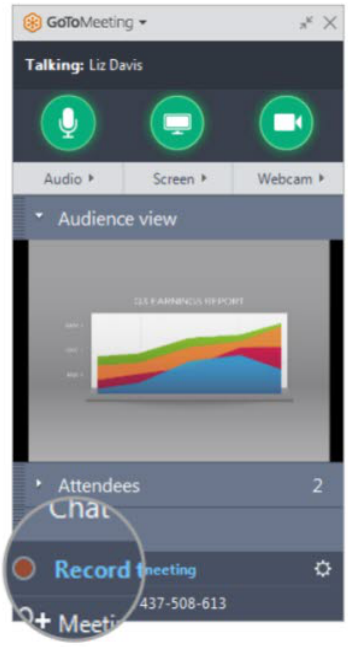
- Click **Record this meeting** at the bottom of the Control Panel to get started.
- Once your meeting is over, the Recording Manager will automatically prompt you to convert the recording.

v Stop recording

^ Find my recordings

Your raw recording files are saved to the computer, where they are stored and ready to be converted to a shareable format. You can see where your recordings are stored by going to **GoToMeeting Preferences** > **Recording**. Learn more.



Ex-Plant Materials Harvesting Workshop

March 7-8, 2017

USNRC HQ

Rockville, MD, USA

Motivation

- With plants shutting down both in the U.S. and internationally, there are increasing opportunities to harvest components from decommissioning plants
  - Past harvesting efforts generally more reactive and ad hoc as opportunities arose, rather than proactively planned
- Ex-plant materials are valuable because they have been exposed to actual in-service plant operating conditions
  - Reduces the uncertainty associated with the applicability of the aging conditions
- Insights from research on harvested materials can address technical data needs identified for extended plant operation
- Lessons learned from past harvesting programs can help improve future harvesting efforts
  - Challenges encountered in previous programs can be shared and mitigated or avoided in future programs

Approach

- Domestic and international researchers, industry, regulators, and decommissioning companies' discuss benefits and challenges with ex-plant harvesting
  - Encourage sharing of lessons learned as well as areas of common interest for potential new research programs
- Workshop consists of topical sessions with short presentations and significant time for open discussion
  - Goal is to maximize engagement among all meeting participants, rather than presenter/audience mentality
- Scope includes any materials aging issue that could benefit from harvesting: metals, cables, and concrete

Expected Outcome

- Participants are better informed and aware of the benefits and challenges associated with ex-plant harvesting
- Discussions help identify areas of common interest for harvesting to address technical data needs
- Presentations and discussions provide the starting point for a “database” of harvested materials and future harvesting opportunities
- Contacts are made among research organizations to allow for further discussion of specific harvesting projects

Session Expectations

- Session 1 Motivation for Harvesting
  - Perspective from panel participants on their organizations' interest in and motivation for harvesting
  - Brief (5-10 minute) presentation from each panel member followed by open and panel discussion
- Session 2 Technical Data Needs for Harvesting
  - Presenters share high-priority data needs that are best addressed by harvesting from their organization's perspective
    - Where does harvesting hold particular value compared to other sources of technical data
  - 15-20 minute presentations followed by open discussion of technical data needs for harvesting

Session Expectations

- Session 3 Sources of Materials
  - Information on previously harvested materials and future harvesting opportunities
    - Materials in “boneyards” at research and vendor facilities
    - Decommissioning plants that may allow for future harvesting
  - Short 5-10 minute presentations followed by open discussion
  - Starting point for potential database of previously harvested materials and future harvesting opportunities
- Session 4 Harvesting Experience: Lessons Learned and Practical Aspects
  - Forward-looking lessons learned from past harvesting programs
    - Pitfalls to avoid and strategies to improve likelihood of success
  - Practical perspective from non-researchers on how harvesting interfaces with the decommissioning process
  - International decommissioning and harvesting experience
  - 20-30 minute presentations followed by open discussion

Session Expectations

- Session 5 Future Harvesting Program Planning
  - Technical and logistical information needed when planning a specific harvesting program
  - Perspective from panel participants on their organizations' future harvesting planning
  - Next steps and actions from workshop
  - Potential areas of common interest for future harvesting programs
  - Brief (5-10 minute) presentation from each panel member followed by open and panel discussion

Note to requester: Attachments are immediately following.

From: Hiser, Matthew
Sent: Mon, 21 Nov 2016 13:56:33 +0000
To: Tregoning, Robert
Cc: Purtscher, Patrick
Subject: RE: harvesting workshop
Attachments: NRC Harvesting Workshop Announcement.docx, Workshop Agenda 11-4-16.docx

Hi Rob,

I have attached the latest version of the announcement and agenda. I think the announcement is good and ready for distribution.

For the agenda, the latest status is I sent it to you, Pat, Jeff, and Allen for comment / feedback. Once we are relatively happy internally, it can go to EPRI/DOE for feedback / a meeting to discuss.

The other big things we need to do is determine whether this meeting should be open or closed and contact speakers.

Side note: Greg said transcription services were "free" to him when he did the concrete workshop a couple years ago (covered under some other contract I presume). Of course, that could have changed so I need to contact the right people for more info.

Thanks!
Matt

From: Tregoning, Robert
Sent: Monday, November 21, 2016 8:19 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: FW: harvesting workshop

Matt:

Is announcement finished at this point so I can start sending it out? We need to finalize our strawman agenda so it can be sent to both EPRI and DOE. We also need to arrange a meeting to flush this agenda out in December. We should have the agenda finalized before the holidays and speakers contacted if possible. Do you agree?

(b)(6) [redacted] Pat and I will have to drive this ground in your absence.

Cheers,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Sokolov, Mikhail A. [mailto:sokolovm@ornl.gov]
Sent: Monday, November 21, 2016 8:03 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: [External_Sender] harvesting workshop

Hi Rob,
It was nice to see you last week in Orlando.
I forgot to ask you. You are organizing the "harvesting" workshop in March. Since I am involved in Ginna baffle bolts and Zion RPV project, I would be interested in participating to hear the NRC take on this subject. However, there was some moves in dates for it. Have you settled with dates? I have some other commitments in March and trying to manage my trips.
Thanks,
Mikhail

Dr. Mikhail A. Sokolov
Oak Ridge National Laboratory
P.O. Box 2008, M.S. 6151 (*for delivery use* 1 Bethel Valley Road)
Oak Ridge, TN 37831
865-574-4842 (ph.)
865-241-1026 (fax)
sokolovm@ornl.gov

Ex-Plant Materials Harvesting Workshop

Location: NRC HQ in Rockville, MD

Dates: March 7-8, 2017

Motivation:

- There are increasing opportunities to harvest the safety-critical components from decommissioning plants, both domestic and international.
- The harvested materials are valuable because they have been exposed to actual in-service plant operating conditions (temperature, irradiation, coolant, etc.), unlike virgin materials tested under simulated conditions in the lab.
- Data from ex-plant materials should help address technical gaps identified for extended operation of nuclear power plants due to highly relevant aging conditions.

Purpose and Objective:

- For NRC staff and interested stakeholders to have greater awareness and knowledge of the benefits and challenges associated with ex-plant harvesting.
- Facilitate contacts and communication to enable specific cooperative ex-plant harvesting programs to be initiated.

Workshop Topics:

- Harvesting decision-making and prioritization
    - Technical data needs best addressed by harvesting
    - Technical information needed in advance of harvesting
- Sources of materials:
    - Decommissioning reactors
    - Operating reactors – replaced components
    - Previous harvesting programs – “boneyards”
    - Tracking available materials
- Harvesting process
    - Lessons learned from harvesting experience
    - Perspective of utility-owner and decommissioning contractor on harvesting
    - Communication and coordination between decommissioning and researchers
- International collaborative programs on specific components at specific plants

Draft Agenda – March 7-8, 2017 Harvesting Workshop

Tuesday, March 7, 2017
Introduction

- NRC overview of workshop purpose and objectives 8:00 – 8:10

Session 1: Lessons learned from harvesting experience

- EPRI Perspective on Harvesting Lessons Learned 8:10 – 8:45
  - Zorita, Baffle Bolts, Barsebeck, etc.
- DOE Perspective on Harvesting Lessons Learned 8:45 – 9:20
  - Zion, etc.
- NRC Perspective on Harvesting Lessons Learned 9:20 – 9:50
  - Shoreham, St. Lucie, Zorita, Zion, etc.

BREAK 9:50 – 10:05

- Japan – JNES / JNRA 10:05 – 10:40
  - International Perspective on Harvesting Lessons Learned

DISCUSSION 10:40 – 11:30
LUNCH 11:30 – 12:30

Session 2: Technical data needs best addressed by harvesting

- PNNL/NRC 12:30 – 12:55
  - Overview of data needs best addressed by harvesting
- Belgium - Tractebel 12:55 – 1:20
  - Perspective on harvesting data needs, particularly RPV
- Korea – KAERI? 1:20 – 1:45
  - Perspective on harvesting data needs, Kori plant
- Switzerland – ENSI or PSI? 1:45 – 2:10
  - Perspective on harvesting data needs, Muhleberg

DISCUSSION 2:10 – 2:45
BREAK 2:45 – 3:00

Session 3: Sources of Materials

- NRC 3:00 – 3:15
  - Available materials from decommissioning plants and past harvesting programs
- EPRI / NEI 3:15 – 3:45
  - Available materials from operating reactors and past harvesting programs
- DOE (ORNL?) 3:45 – 4:15
  - Available materials at DOE labs from past harvesting programs
- IAEA ? 4:15 – 4:45
    - International harvesting opportunities

DISCUSSION 4:45 – 5:30

Wednesday, March 8, 2017
Session 4: Practical aspects of Harvesting

- US decommissioning company 8:00 – 8:40
    - Decommissioning process vs. harvesting: schedule, site-specific, timing for different components
- International decommissioning company – Germany? 8:40 – 9:20
    - Decommissioning and harvesting plans and experience
- US utility 9:20 – 10:00
    - Decommissioning process and plans
    - Owner perspective on harvesting and decommissioning

BREAK 10:00 – 10:15

- Researcher perspective – EPRI or DOE or international 10:15 – 10:45
    - Practical challenges to plan for and carry out harvesting

DISCUSSION 10:45 – 11:45
LUNCH 11:45 – 12:45

Session 5: Harvesting Decision-making

- PNNL / NRC 12:45 – 1:15
    - Technical information needed for informed harvesting decisions
- EPRI/NEI 1:15 – 1:45
    - Balancing costs and benefits to ensure value from harvesting
- DOE 1:45 – 2:15
    - Applying past experience to future harvesting decisions
- International - ? 2:15 – 2:45
    - Harvesting decision-making
- DISCUSSION 2:45 – 4:00
    - Potential harvesting partnerships
        - RPV, internals, piping, concrete, cables
        - US, international opportunities

Discussion Topics

- Harvesting decision-making and prioritization
    - Technical data needs best addressed by harvesting
    - Technical information needed in advance of harvesting
- Sources of materials:
    - Decommissioning reactors
    - Operating reactors – replaced components
    - Previous harvesting programs – “boneyards”
    - Tracking available materials
- Harvesting process
    - Lessons learned from harvesting experience
    - Perspective of utility-owner and decommissioning contractor on harvesting
    - Communication and coordination between decommissioning and researchers
- International collaborative programs on specific components at specific plants

Note to requester: Attachments are immediately following.

From: Hiser, Matthew
Sent: Fri, 3 Mar 2017 12:48:56 +0000
To: Kirk, Mark
Cc: Tregoning, Robert
Subject: RE: Input on Harvesting Slides
Attachments: Harvesting Workshop Final Agenda.docx, Final Harvesting Workshop Attendees.docx

Hi Mark,

Thank you for your input on the slides. We had a final meeting yesterday afternoon to go over the attendee list and agenda (both attached for your awareness). We are really tight on space for the workshop as we've had several late external requests to participate and wanted to include at least a couple spots for NRR staff. Plus this workshop covers electrical and concrete topics as well, so that makes the limited space more challenging.

We'd like to see if you could participate in the workshop via the webinar (https://attendee.gotowebinar.com/register/6076202901971284226). Obviously, this is not the most ideal situation, but we really appreciate your understanding and engagement in the workshop. Rob will plan to cover the RPV discussion for NRC in the room.

We are planning a dinner with workshop attendees on Tuesday night starting around 6:00. I would like to invite you to join the dinner. Please let me know by Monday if possible so I can finalize the headcount.

Thanks!
Matt

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

From: Kirk, Mark
Sent: Wednesday, March 01, 2017 12:45 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Input on Harvesting Slides

You bet.

Looking forward to your meeting

mark

From: Hiser, Matthew
Sent: Wednesday, March 01, 2017 12:42 PM

To: Kirk, Mark <Mark.Kirk@nrc.gov>
Subject: RE: Input on Harvesting Slides

Hi Mark,

Thank you for taking a look at the slides and providing input. I reworded the statement for your first comment (now "Ideally a bounding, yet realistic, material/environment"). The idea of that bullet is that we choose to harvest from a plant with more severe conditions (be they material composition or environment or both depending on the mechanism) than most (ie, bounding (or nearly so), yet realistic). This may be in contrast to accelerated aging tests where we may take certain parameters to very unrealistic, but conservative, values to understand a mechanism.

For your second comment, I replaced the language on RPV data needs with your suggestion. The original language came from what I gathered through separate discussions with you and Rob and my limited understanding of RPV materials. Thank you for clarifying and correcting the language.

Thanks!
Matt

From: Kirk, Mark
Sent: Wednesday, March 01, 2017 9:57 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Kirk, Mark <Mark.Kirk@nrc.gov>
Subject: RE: Input on Harvesting Slides

Hi Matt –

Thanks for providing me the opportunity to comment (sorry it has taken me so long to get to this).

I have one editorial and one technical comment, as detailed below. I'm around today, Friday, & Monday if you want to discuss. On Thursday I'll be working remote – you can call me on (b)(6) (b)(6)

Best

Mark

Slide 4, NRC perspective slides**, editorial / logical comment**

- You say *"Ideally a bounding, yet broadly representative, material/environment".* This is a contradictory statement; if something is bounding it is, by definition, NOT representative. Representative would be something closer to average conditions.

Slide 3, NRC Technical Data Needs, **technical comment**

- You say we want a "High fluence vessel with relatively high levels of minor alloying elements (Mn, P, etc.)
  - I agree with the "high fluence" part … but we should explain why we want this.
  - I don't understand / don't agree with the alloying elements part for several reasons:

        - In RPV steels phosphorus is not an alloying element, it is a tramp
        - If the reason for looking for "moderately" high Mn is to search for the ever illusive late blooming phase, then we would need to say that we need a high combination of Mn & Ni … and not moderately high, but REALLY high. What we would need is, in fact, so high that I can tell you it does not exist in the USA fleet. We should not bother to look – it's not there.
- Given all of this I suggest a re-wording of your bullets under RPV, as follows:

- **High fluence & high shift vessel with well-established unirradiated properties (or a means to estimate them)**
    - Through thickness section to validate fluence & attenuation models
    - Measure fluence, toughness, & chemistry as a function of through-thickness position
- **Samples from virtually any vessel**
    - Of sufficient size to enable measurement of both the Charpy transition curve and master curve transition temperature T_0
    - This testing
        - Enables demonstration of the conservatism of regulatory approaches for transition temperature prediction
        - Provides data supporting evolution from the use of correlative (Charpy-based) to direct measurement (fracture toughness-based) approaches

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From: Hiser, Matthew
Sent: Wednesday, February 22, 2017 10:08 AM
To: Nove, Carol <Carol.Nove@nrc.gov>; Kirk, Mark <Mark.Kirk@nrc.gov>; Oberson, Greg <Greg.Oberson@nrc.gov>; Focht, Eric <Eric.Focht@nrc.gov>
Subject: Input on Harvesting Slides

Hi Carol, Mark, Greg, and Eric,

We are hosting a workshop with a number of external participants in two weeks to discuss ex-plant materials harvesting. I know I've discussed this with at least a couple of you. I have attached the workshop introduction slides that cover meeting logistics, motivation, approach, expected outcome, and session expectations for your awareness.

I have also attached PP slides for NRC presentations in sessions 2, 3, and 4. These slides have been developed primarily with input from myself, Rob Tregoning and Pat Purtscher. The intent of these slides is to be a discussion starter and provide NRC's perspective on the session topics related to harvesting.

Some of the topics covered in these slides include RPV, NDE, PWSCC, and NAM, so I'd like to share them with each of you for a quick review. Please let me know if you have any questions and provide any comments or feedback at your earliest convenience.

Thanks!
Matt

Matthew Hiser
Materials Engineer

US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62
Matthew.Hiser@nrc.gov

Ex-Plant Materials Harvesting Workshop Agenda

Tuesday, March 7

Session	Time	Organization	Speaker	Presentation Title
Intro	8:00	NRC	Robert Tregoning	Welcome and Introduction to Workshop
1	8:15 – 8:45	DOE	Rich Reister	DOE Perspectives on Material Harvesting
		EPRI	Sherry Bernhoft	EPRI Perspective on Harvesting Projects
		NRC	Robert Tregoning	NRC Perspective on Motivation for Harvesting
		GRS	Uwe Jendrich	Role of GRS in Decommissioning and LTO
		CRIEPI	Taku Arai	CRIEPI Motivations for Harvested Material
	8:45 – 9:45	DISCUSSION		
9:45-10:00		**BREAK**		
2	10:00 – 10:20	PNNL (for NRC)	Pradeep Ramuhalli	Data Needs Best Addressed By Harvesting
	10:20 – 10:30	NRC	Matthew Hiser	High-Priority Data Needs for Harvesting
	10:30 – 10:55	DOE	Keith Leonard	LWRS Program Perspective on the Technical Needs for Harvesting
	10:55 – 11:20	SCK-CEN	Rachid Chaouadi	Review of past RPV sampling test programs and perspective for long term operation
	11:20 – 11:45	Westinghouse	Arzu Alpan	Importance of Harvesting to Evaluate Radiation Effects on Concrete Properties
	11:45 – 12:30	DISCUSSION		
12:30 – 2:00		**LUNCH**		
3	2:00 – 2:10	NRC	Matthew Hiser	Sources of Materials: Past NRC Harvesting and U.S. Decommissioning Plants
	2:10 – 2:35	EPRI	Al Ahluwalia	Harvesting Plans for Materials Aging Degradation Research in Korea and Sweden
	2:35 – 2:50	DOE/ORNL	Tom Rosseel	Materials Harvested by the LWRS Program
	2:50 – 3:00	DOE/INL	John Jackson	NSUF Material Sample Library
	3:00 – 3:15	Energy Solutions	Gerry van Noordennen	Zion Material Harvesting Program
	3:15 – 3:30	Westinghouse	Arzu Alpan	Potential Harvesting of Concrete from Mihama Unit 1
	3:30 – 3:45	**BREAK**		
	3:45 – 4:00	GRS	Uwe Jendrich	Plants in Decommissioning in Germany
	4:00 – 4:15	CNSC	Daniel Tello	Evaluating Structures, Systems & Components from Decommissioned/Decommissioning Nuclear Facilities in Canada
	4:15 – 5:00	DISCUSSION		

Wednesday, March 8

Session	Time	Organization	Speaker	Presentation Title
4	8:00 – 8:30	EPRI	Jean Smith	Lessons Learned: Harvesting and Shipping of Zorita Materials
	8:30 – 9:00	DOE	Tom Rosseel	LWRS Program: Harvesting Lessons Learned
	9:00 – 9:30	NRC	Matthew Hiser	NRC Perspective on Harvesting Experience and Lessons Learned
	9:30 – 10:00	CRIEPI	Taku Arai	CRIEPI Research Activities with Harvested Materials
	10:00 – 10:15	**BREAK**		
	10:15 - 10:45	Energy Solutions	Gerry van Noordennen	Zion Harvesting Experience and Lessons Learned
	10:45 - 11:15	Dominion	Bill Zipp	Kewaunee Insights on Material Harvesting
	11:15 – 12:00	DISCUSSION		
12:00 – 1:30		**LUNCH**		
5	1:30 – 1:45	PNNL (for NRC)	Pradeep Ramuhalli	Technical Information Needed for Informed Harvesting Decisions
	1:45 – 2:30	DISCUSSION		
	2:30 – 3:00	Action Items and Next Steps		
	3:00 – 4:00	EPRI	Sherry Bernhoft	Closing Thoughts
		DOE	Rich Reister	
		NRC	Robert Tregoning	
		ALL		

Workshop Attendees

	Name	Organization
Japan	Taku Arai	CRIEPI
	Sadao Higuchi	CRIEPI
	Kazunobu Sakamoto	JNRA
	Yasuhiro Chimi	JAEA
Europe	Uwe Jendrich	GRS
	Rachid Chaouadi	SCK-CEN
	Guy Roussel	Bel V
Canada	Daniel Tello	CNSC
	Désiré Ndomba	CNSC
	Karen Huynh	AECL
US industry	Gerry van Noordennen	Energy Solutions
	Bill Zipp	Dominion
	Mark Richter	NEI
	Arzu Alpan	Westinghouse
EPRI	Sherry Bernhoft	EPRI
	Robin Dyle	EPRI
	Jean Smith	EPRI
	Al Ahluwalia	EPRI
DOE	Tom Rosseel	ORNL
	Rich Reister	DOE
	Keith Leonard	ORNL
	Mikhail A. Sokolov	ORNL
	John Wagner	INL
	John Jackson	INL
	Pradeep Ramuhalli	PNNL
NRC	Pat Purtscher	NRC/RES
	Rob Tregoning	NRC/RES
	Matt Hiser	NRC/RES
	Mita Sircar	NRC/RES
	Tom Koshy	NRC/RES
	Jeff Poehler	NRC/NRR
	Allen Hiser	NRC/NRR
	Angela Buford	NRC/NRR
	Pete Ricardella	NRC/ACRS

Note to requester: The attachments are immediately following.

From: Hiser, Matthew
Sent: Fri, 3 Feb 2017 18:31:35 +0000
To: Purtscher, Patrick
Subject: RE: RE: Draft slides
Attachments: Ex-Plant Materials Harvesting Workshop.pptx, NRC Technical Data Needs for Harvesting.pptx

Pat: here's my draft email to Pradeep. If you get the chance to review his slides today and largely agree, please send with me on cc. I might try to give him a call just to make sure my feedback is clear. Thanks!

Hi Pradeep,

Thank you for sharing these slides. I've attached a PP that we are distributing to speakers and attendees describing the workshop overall as well as expectations for each session. We just developed this in the past few days, and are starting to distribute now. Please take a look for your awareness.

I think these slides are a good starting point, but are a little too broad for the sessions we're envisioning.

For the first presentation in session 2, I would focus on capturing Section 3.3 from the draft report you sent a couple days ago. So focus on the criteria for prioritizing harvesting data needs and the examples that PNNL analyzed in the report: CASS, cables, DMWs, internals. We are planning a very short NRC slot in session 2 to cover more comprehensively NRC's data needs for harvesting; we want you to cover the criteria and 4 examples and we'll lay out the whole range of high-priority data needs for metals, cables, and concrete. I've attached the current draft of our slides for you awareness…

From the slides you have now for session 2, here's my suggestions:

- I would delete slide 2 because it is high-level and more captured in Session 1.
- Keep slide 3 to capture briefly Ch. 2 ideas: why do harvesting , which leads to prioritization criteria
- Add a slide to capture Section 3.1/3.2 on lit review / basis for information
- Add slide or two on criteria: why these criteria, how are they applied/used
- Add several slides going through examples (maybe 1 slide/example) and how criteria led to an outcome
    - In other words, explain why we're interested in harvesting cables, CASS, and internals, but not DM welds so much
- That's it!

For session 5 slides, I'd like to focus on Section 4.2 from your report with references to 4.1 (harvesting experience) as needed to explain why we'd like various pieces of information for harvesting planning. Suggestions on specific slides:

- Delete slides 11/12 – don't need to cover info tool in this presentation
- Maybe 1 or 2 background slides referring to harvesting experience (Ch. 4.1) in general

- Focus several slides on Section 4.2 going in-depth on what information is needed for harvesting planning
    - This presentation sets the stage in Session 5 for a discussion of harvesting plans from the various participants, so we want to thoroughly systematically lay out what information we think is helpful for informed decision-making

Thanks!
Matt

From: Ramuhalli, Pradeep [mailto:Pradeep.Ramuhalli@pnnl.gov]
Sent: Friday, February 03, 2017 10:37 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: [External_Sender] RE: Draft slides

Shoot! Will resend in a bit.

With best regards,
Pradeep

Pradeep Ramuhalli, PhD.
Senior Research Scientist
Pacific Northwest National Laboratory
pradeep.ramuhalli@pnnl.gov
509-375-2763

Sent from my Android phone using Symantec TouchDown (www.symantec.com)

-----Original Message-----
From: Hiser, Matthew [Matthew.Hiser@nrc.gov]
Received: Friday, 03 Feb 2017, 4:46AM
To: Ramuhalli, Pradeep [Pradeep.Ramuhalli@pnnl.gov]; Purtscher, Patrick [Patrick.Purtscher@nrc.gov]
Subject: RE: Draft slides

FYI – slides didn't make it through…

From: Ramuhalli, Pradeep [mailto:Pradeep.Ramuhalli@pnnl.gov]
Sent: Friday, February 03, 2017 1:36 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Cc: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: [External_Sender] Draft slides

Symantec Mail Security replaced Harvesting workshop slides draft.pptx with this text message. The original file was a malformed file, therefore it cannot be scanned and was quarantined.

ID:HQPWMSMRS04::SYQ3370fc312
The email message was also quarantined.

Ex-Plant Materials Harvesting Workshop

March 7-8, 2017

USNRC HQ

Rockville, MD, USA

Meeting Logistics

- Workshop will be held at NRC's Three White Flint North building
  - Directly adjacent to the White Flint Metro station
  - Nearest hotel within walking distance: Bethesda North Marriott Hotel & Conference Center
- Workshop is a non-public meeting to encourage open discussion
  - Presentations and meeting summary will be distributed among meeting participants only
- GoToMeeting webinar will be available to support additional attendees
  - Webinar attendees will be primarily observers
    - Limited opportunities for webinar attendee participation in discussion if time allows
  - Discussion will be recorded through GoToMeeting software to aid capturing discussion in meeting summary

Motivation

- With plants shutting down both in the U.S. and internationally, there are increasing opportunities to harvest components from decommissioning plants
  - Past harvesting efforts generally more reactive as opportunities arose, rather than proactively planned
- Ex-plant materials may be valuable because they have been exposed to actual in-service plant operating conditions
  - Can reduce the uncertainty associated with the applicability of the aging conditions
- Insights from research on harvested materials can address technical data needs identified for extended plant operation
- Lessons learned from past harvesting programs can help improve future harvesting efforts
  - Challenges encountered in previous programs can be shared and mitigated or avoided in future programs

Approach

- Domestic and international researchers, industry, regulators, and decommissioning companies' discuss benefits and challenges with ex-plant harvesting
  - Encourage sharing of lessons learned as well as areas of common interest
- Workshop consists of topical sessions with short presentations and significant time for open discussion
  - Goal is to maximize engagement among meeting participants
- Scope includes any materials aging issue that could benefit from harvesting, including metals, cables, and concrete

Expected Outcome

- Participants become better informed and aware of the benefits and challenges associated with ex-plant harvesting
- Discussions help identify areas of common interest for harvesting to address technical data needs
- Presentations and discussions provide the starting point for a “database” of harvested materials and future harvesting opportunities
- Contacts are made among research organizations to allow for further discussion of specific harvesting projects
- Workshop summary documenting discussion will be distributed among participants

Session Expectations

- Session 1 Motivation for Harvesting
  - Perspective from panel participants on their organizations' interest in and motivation for harvesting
  - Brief (5-10 minute) presentation from each panel member followed by general discussion
- Session 2 Technical Data Needs for Harvesting
  - Presenters share high-priority data needs that may be best addressed by harvesting
    - Where does harvesting hold particular value compared to other sources of technical data
  - 15-20 minute presentations followed by open discussion of technical data needs for harvesting

Session Expectations

- Session 3 Sources of Materials
  - Information on previously harvested materials and future harvesting opportunities
    - Materials located at research and vendor facilities
    - Decommissioning plants that may allow for future harvesting
  - Short 5-10 minute presentations followed by open discussion
  - Starting point for potential database of previously harvested materials and future harvesting opportunities
- Session 4 Harvesting Experience: Lessons Learned and Practical Aspects
  - Improving future efforts with lessons learned from past programs
    - Pitfalls to avoid and strategies to improve likelihood of success
  - Practical perspective from non-researchers on how harvesting interfaces with the decommissioning process
  - International decommissioning and harvesting experience
  - 20-30 minute presentations followed by open discussion

Session Expectations

- Session 5 Future Harvesting Program Planning
  - Technical and logistical information needed when planning a specific harvesting program
  - Perspective from panel participants on the workshop
  - Next steps and actions from workshop
  - Potential areas of common interest for future harvesting programs
  - Brief (5-10 minute) presentation from each panel member followed by general discussion

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC High-Priority Data Needs for Harvesting

NRC Staff

March 7, 2017

Metals

- RPV
  - High fluence & high shift vessel with well-established unirradiated properties (or a means to estimate them)
    - Through thickness section to validate fluence & attenuation models
    - Measure fluence, toughness, & chemistry as a function of through-thickness position
  - Samples from virtually any vessel
    - Of sufficient size to enable measurement of both the Charpy transition curve and master curve transition temperature T_0
    - This testing
      - Enables demonstration of the conservatism of regulatory approaches for transition temperature prediction
      - Provides data supporting evolution from the use of correlative (Charpy-based) to direct measurement (fracture toughness-based) approaches

Metals

- CASS and Internals
  - High fluence reactor internals
    - >50 dpa 304 SS from high core outlet temp plant
    - Bounding temperature and high fluence for void swelling
  - Thermally aged unirradiated CASS
    - >30 years at ~320°C; Validate accelerated aging data
  - Moderate fluence (1-2 dpa) CASS
    - Bolster technical basis for embrittlement in this fluence range
- Components with known flaws
  - Example: weld overlays over known flaws
    - NDE evaluations or to assess effectiveness of mitigation techniques
- Components with limiting fatigue life
  - Confirm fatigue calculations are accurate by inspecting for flaws

Electrical

- Cables
  - Low and medium voltage cables
  - Cables protected with fire retardant coating
- Electrical components
  - 1E MOVs from harsh and mild environments
  - 1E Air operated valves; 4160 1E breakers
  - 1E Molded case breakers 480V, 250V DC, 125 VDC,
  - 1E Relays from mild environment GE – HFA, Agastat timing relays, any from Westinghouse, Potter Brumfield, Stuthers Dunn etc.,
  - Electrical penetrations; Batteries
- Fire research interest
  - Electrical enclosures
    - Distribution : switchgear, MCCs, LCs | Control : Horseshoe, SSCP, ASP, etc.

Concrete

- Structures exposed to high radiation
- Post-tensioned structures
- Corrosion of reinforcing steel, tendon, liner, embedment
- Spent fuel pool and transfer canal-boric acid attack on concrete in PWRs
- Alkali Aggregate Reaction
- Large structural sections for testing

From: Hiser, Matthew
Sent: Tue, 31 Jan 2017 14:39:52 +0000
To: Tregoning, Robert
Subject: RE: RE: Participation in Harvesting workshop from JAEA

Thanks Rob! Glad things have fallen in place quickly this week...

-----Original Message-----
From: Tregoning, Robert
Sent: Tuesday, January 31, 2017 9:05 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: RE: Participation in Harvesting workshop from JAEA

Okay, I'm caught up with my emails except for SCK-CEN which we should send by the end of the week (by Thursday). We still need to hear back from GRC. I'll call or email if I haven't gotten a response by tomorrow. Hopefully, the Japanese and MAI will also be finalized this week.

Thanks for your help,

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

-----Original Message-----
From: Hiser, Matthew
Sent: Tuesday, January 31, 2017 8:39 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: RE: RE: Participation in Harvesting workshop from JAEA

Rob:

Dr. Chimi:

Thank you for your interest in the workshop. I have attached the workshop announcement and condensed agenda along with a few slides describing the motivation for the workshop and the expectations for each session. The workshop is divided into 5 sessions, each with a combination of presentations and discussion:

1. Session 1 will consist of short presentations and a panel discussion on the motivation for harvesting.
2. Session 2 will discuss data needs best met through harvesting.
3. Session 3 will discuss sources of materials for harvesting programs 4. Session 4 will discuss lessons-learned from past harvesting programs and practical aspects associated with harvesting.
5. Session 5 will attempt to summarize the workshop and planning a harvesting program, as well as discuss actions and next steps

We would like to invite you to present in any of these sessions. For sessions 1, 3, and 5, we are looking for brief 5-

10 minute presentations, so just a few slides at most on motivation for harvesting, sources of materials, and any future harvesting plans. For sessions 2 and 4, the presentations are anticipated to be longer, perhaps 20-30 minutes, covering data needs best addressed through harvesting (session 2) and lessons learned from previous harvesting experience (session 4).

For logistics, the workshop will be held at NRC's headquarters, which is at the White Flint Metro station:

Three White Flint North
11601 Landsdown Street
North Bethesda, MD 20852

The nearest hotel is across the street: http://www.marriott.com/hotels/travel/wasbn-bethesda-north-marriott-hotel-and-conference-center/ . Please let me know if you need any other information regarding location or accommodations.

Please let me know if you would be able to participate and which sessions you would be willing to support. We will look forward to your participation and contribution to the workshop!

Rob

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research Division of Engineering | Corrosion and Metallurgy Branch
Phone: 301-415-2454 | Office: TWFN 10D62 Matthew.Hiser@nrc.gov

-----Original Message-----
From: Tregoning, Robert
Sent: Tuesday, January 31, 2017 6:45 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: FW: RE: Participation in Harvesting workshop from JAEA

Matt:

Here's JAEA. Can you also put together an email for them as well? Let's ask them in this email if they are willing to participate in any of the sessions.

Thanks for your help,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

-----Original Message-----
From: Yasuhiro Chimi [mailto:chimi.yasuhiro@jaea.go.jp]
Sent: Tuesday, January 31, 2017 2:05 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>

Subject: [External_Sender] RE: Participation in Harvesting workshop from JAEA

Dear Mr. Robert Tregoning,

My name is Yasuhiro Chimi. I'm a member of Nuclear Safety Research Center, Japan Atomic Energy Agency (JAEA), and in charge of IASCC study of stainless steels.

As Mr. Kazunobu Sakamoto told you, I would like to attend the harvesting workshop. Could you give me some more information on the workshop, such as registration, venue, accommodation, how to get there, etc.?

I'm looking forward to hearing from you.

Sincerely yours,

Yasuhiro Chimi

Yasuhiro Chimi, Ph.D.

Materials and Water Chemistry Research Group Materials and Structural Integrity Research Division Nuclear Safety Research Center Sector of Nuclear Safety Research and Emergency Preparedness Japan Atomic Energy Agency (JAEA)

Phone: +81-29-282-6473 , Fax: +81-29-282-5406
E-mail: chimi.yasuhiro@jaea.go.jp

-----Original Message-----
From: Tregoning, Robert [mailto:Robert.Tregoning@nrc.gov]
Sent: Monday, January 23, 2017 11:01 PM
To: 坂本 一信 <kazunobu_sakamoto@nsr.go.jp>
Cc: chimi.yasuhiro@jaea.go.jp; Yutaka Nishiyama (nishiyama.yutaka93@jaea.go.jp) <nishiyama.yutaka93@jaea.go.jp>; 髙倉 賢一 <kenichi_takakura01@nsr.go.jp>; 田口 清貴 <kiyotaka_taguchi@nsr.go.jp>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: RE: Participation in Harvesting workshop from JAEA

Kazu:

It’s always so good to hear from you. I look forward to hearing from your colleague at JAEA about participation in the harvesting workshop. I also will be in touch with you shortly to coordinate and finalize the contributions from Japan so that we can finalize the agenda.

Warm regards,

Rob

Robert Tregoning

Technical Advisor for Materials

US Nuclear Regulatory Commission

Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738

ph: 301-415-2324

fax: 301-415-6671

From: 坂本 一信 [mailto:kazunobu_sakamoto@nsr.go.jp]
Sent: Thursday, January 19, 2017 9:19 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: chimi.yasuhiro@jaea.go.jp; Yutaka Nishiyama (nishiyama.yutaka93@jaea.go.jp) <nishiyama.yutaka93@jaea.go.jp>; 髙倉 賢一 <kenichi_takakura01@nsr.go.jp>; 田口 清貴 <kiyotaka_taguchi@nsr.go.jp>
Subject: [External_Sender] Participation in Harvesting workshop from JAEA

Hi Rob,

A staff of our technical support organization JAEA wants to participate in the workshop and will contact you soon.

So I would appreciate if you could accept his participation.

Thanks for your cooperation in advance.

Best regards,

Kazu

Note to requester: Attachments are immediately following.

From: Tregoning, Robert
Sent: Wed, 23 Nov 2016 07:26:04 -0600
To: Brock, Kathryn;Hiser, Matthew
Cc: Frankl, Istvan
Subject: RE: RIC sessions
Attachments: #20 RES Technical Issues - Advanced Non-Light Water Reactors.pdf, #25 RES - Leveraging International Research and Facility to Inform Regulator Decision-Making.docx, #4 NRO - Advanced Non-Light Water Reactors - International Coordination and Collaboration.docx, NRC Harvesting Workshop Announcement.docx, Workshop Agenda 11-4-16.docx

Kathryn:

Attached are the following:

1. Write-ups for the related sessions on ANLWR and Leveraging International Research (ignore the numbers on the files). Also, please note that these write-ups are sparse; there's not much information on them.
2. Harvesting workshop announcement
3. Draft harvesting workshop agenda (this is very draft. We haven't reached internal consensus yet or shared with EPRI/DOE). I would share with him the topics we are planning but not the details of the agenda.

I'll let Matt provide the bullets. There are several other RIC sessions with an international flavor. I can provide you with any of those write-ups as you like.

Let me know if you have any questions about any of these attachments or need additional information.

Cheers,

Rob

Robert Tregoning
Technical Advisor for Materials
US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Brock, Kathryn
Sent: Wednesday, November 23, 2016 7:31 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RIC sessions

Hey Rob and Matt,

I'm wondering if you can help me with something. While I'm in Vienna next week I'm meeting with Ed Bradley, who is part of Nuclear Energy at IAEA and is working to develop cooperative research programs. So I have two requests..can you please provide a bit of info:

- Matt…bullets on our effort to do materials harvesting as well as an agenda for the meeting after the RIC, or perhaps info on who will be participating.
- Rob…summaries of the RIC sessions T1, "Advanced non LWR international coordination and collaboration" and TH29, "Leveraging Internationals Research and Facility to Inform Regulatory Decisionmaking".

I figure I can tell him about the RIC and the harvesting meeting and perhaps he can decide if he thinks it would be worthwhile to support.

Thanks!!!

RIC 2017

PROPOSED TECHNICAL "SESSION" SUBMISSION FORM

Part 1: Session Title and Description

- Session Description: The topic should be relevant, topical, new or emerging, and of interest to the audience. The title should be relatively short, creative, and appealing. The description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages. ***Note: Descriptions (.doc or .docx) are limited to 950 characters including spaces and punctuation.***

Submitting Office(s): *Enter office acronym (if a joint session, enter lead office followed by supporting office)*	RES
Session Title: *Title should be relatively short, creative, and appealing*	Advanced Non-Light Water Reactors - International and Domestic Experience in Addressing the Technical Issues and Challenges
Session Description: *Description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages*	As part of the near-term implementation of NRC's vision and strategy for improving the agency's readiness to regulate advanced non-light water reactor (ANLWR) technologies, this session will provide a forum for presenting and discussing the technical challenges and opportunities in modeling and testing of reactor designs, high temperature applications of materials, and advanced fuels for ANLWRs, including high-temperature gas reactors, liquid-metal fast reactors, and molten salt reactors. Topics will include international experience in gas-cooled reactors, pebble-bed moderated reactors and sodium-cooled fast reactors, DOE research activities, and NRC plans and activities in this area.
Session Chair: *Enter first and last name, position title, division name and office. Example: John Doe, Deputy Director, Division of Engineering, NRR/NRC*	Kathy Brock, Deputy Director, Division of Engineering, RES/DE
Potential Speakers/Panelists: *Enter name, position title, and organization for each speaker or panelist (list in order they will be presenting, if known)*	1) Hans Gougar, INL; 2) Dominic Hittner, AREVA; 3) Sodium Reactor Center, IGARC, India; 4) Mike Davies, AMEC, UK; 5) Tai Asayama, JAEA, Japan; 6) Celine Cabet, CEA, France; 7) Gyeong-Hoi Koo, KAERI, Korea; 8) NRC; 9) DOE; 10) Elysium, NY (Molten Salt Reactor developer)
Session Coordinator: *Enter first and last name, position title, division name, office, telephone number, and email address. Example: John Doe, Branch Chief, Division of Engineering, NRR/NRC, 301-415-0000, John.Doe@nrc.gov*	Raj Iyengar, RES/DE Steve Bajorek/Nate Hudson, RES/DSA Steve Downey, NRO
Topic Submitted By: *If the name(s) of the Session Chair and/or Coordinator are not known, enter a point of contact name for the topic submission*	Raj Iyengar, RES/DE

ENCLOSURE 1

RIC 2017

Part 2: Session Format

Session Format Options: *(based on technical sessions being 90 minutes in length)*

- **Presentation Format:** Generally this format consists of one Session Chair and up to four speakers. The Session Chair provides a brief introduction and each speaker has approximately 15 minutes to give his or her presentation as it relates to the main session topic. ***Note: If the Session Chair is also a panel member, then presentation time is reduced for each speaker accordingly.***

- **Discussion Format:** Generally this format consists of one Session Chair and up to four speakers. The Session Chair takes approximately 10 minutes to provide introductory remarks and presents an overview of the main topic to be discussed. The panel discussion of the topic runs for approximately 50 minutes, followed by a question and answer period for approximately 30 minutes. ***Note: Typically the panelists do not have prepared presentation slides for the discussion portion.*** The Session Chair uses the last 5 minutes to wrap-up the session.

- **Workshop Format:** Generally this format consists of one Session Chair and up to four speakers. This forum provides an interactive learning environment. The room set is in small break-out groups. The Session Chair and speakers present different aspects of the main session topic, and encourage participants to breakout into small groups for discussion or case study analysis. To aid in the discussion, the Session Chair and/or speakers may provide workbooks or session materials to session participants.

Session Format: *Enter "Presentation," "Discussion," or "Workshop"*	

Send completed submission form to RICMST.Resource@nrc.gov by **September 29, 2016**

RIC 2017

PROPOSED TECHNICAL "SESSION" SUBMISSION FORM

Part 1: Session Title and Description

- Session Description: The topic should be relevant, topical, new or emerging, and of interest to the audience. The title should be relatively short, creative, and appealing. The description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages. ***Note: Descriptions (.doc or .docx) are limited to 950 characters including spaces and punctuation.***

Submitting Office(s): *Enter office acronym (if a joint session, enter lead office followed by supporting office)*	RES
Session Title: *Title should be relatively short, creative, and appealing*	Leveraging International Research and Facility to Inform Regulator Decision-Making
Session Description: *Description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages*	How NRC and Industry leverages the international research and facilities to helps identify and resolve safety issues, make regulatory decisions, develop guidance and promulgate regulations for nuclear facilities and nuclear material users who are regulated by the agency.
Session Chair: *Enter first and last name, position title, division name and office. Example: John Doe, Deputy Director, Division of Engineering, NRR/NRC*	Edwin Hackett
Potential Speakers/Panelists: *Enter name, position title, and organization for each speaker or panelist (list in order they will be presenting, if known)*	Margaret McGrath, Halden Labs Maria Krosnic, NEI, CNO or alternate Aladar Csontos, EPRI Veronique Rouyer, Chadarache Nuclear center
Session Coordinator: *Enter first and last name, position title, division name, office, telephone number, and email address. Example: John Doe, Branch Chief, Division of Engineering, NRR/NRC, 301-415-0000, John.Doe@nrc.gov*	Donna-Marie Sangimino SR. International Relations Officer International Program Team/PMDA Office of Regulatory Research
Topic Submitted By: *If the name(s) of the Session Chair and/or Coordinator are not known, enter a point of contact name for the topic submission*	Rebecca Tadesse

ENCLOSURE 1

RIC 2017

Part 2: Session Format

Session Format Options: *(based on technical sessions being 90 minutes in length)*

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Session Format: *Enter "Presentation," "Discussion," or "Workshop"*	Presentations

Send completed submission form to RICMST.Resource@nrc.gov by **September 29, 2016**

RIC 2017

PROPOSED TECHNICAL "SESSION" SUBMISSION FORM

Part 1: Session Title and Description

- Session Description: The topic should be relevant, topical, new or emerging, and of interest to the audience. The title should be relatively short, creative, and appealing. The description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages. ***Note: Descriptions (.doc or .docx) are limited to 950 characters including spaces and punctuation.***

Submitting Office(s): *Enter office acronym (if a joint session, enter lead office followed by supporting office)*	NRO
Session Title: *Title should be relatively short, creative, and appealing*	Advanced Non-Light Water Reactors - International Coordination and Collaboration
Session Description: *Description should include details that gives the audience a better understanding of the focus of the session, its purpose, goals, learning objectives, and any takeaway messages*	This session will explore the international coordination and collaboration activities associated with advanced non-light water reactors (LWRs). It will include presentations regarding the Group on the Safety of Advanced Reactors (GSAR), the Generation IV International Forum (GIF), and DOE international non-LWR research collaboration. Coordinating with RES to see if they can add a topic to this session.
Session Chair: *Enter first and last name, position title, division name and office. Example: John Doe, Deputy Director, Division of Engineering, NRR/NRC*	D. Jackson, Division of Engineering Infrastructure and Advanced Reactors, NRO/NRC Backup: Amy Cubbage, Division of Engineering Infrastructure and Advanced Reactors, NRO/NRC
Potential Speakers/Panelists: *Enter name, position title, and organization for each speaker or panelist (list in order they will be presenting, if known)*	GSAR - Amy Cubbage or Anna Bradford, GIF - John Kelly or Francois Gauché (the new Chair), DOE - Shane Johnson or John Kelly
Session Coordinator: *Enter first and last name, position title, division name, office, telephone number, and email address. Example: John Doe, Branch Chief, Division of Engineering, NRR/NRC, 301-415-0000, John.Doe@nrc.gov*	Nishka Devaser, Project Manager, Division of Engineering Infrastructure and Advanced Reactors, NRO, 301-415-5196, Nishka.Devaser@nrc.gov Backup: Andrew Yeshnik, Acting Technical Assistant, Division of Engineering Infrastructure and Advanced Reactors,301-415-5777, Andrew.Yeshnik@nrc.gov
Topic Submitted By: *If the name(s) of the Session Chair and/or Coordinator are not known, enter a point of contact name for the topic submission*	

RIC 2017

Part 2: Session Format

Session Format Options: *(based on technical sessions being 90 minutes in length)*

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Session Format: *Enter "Presentation," "Discussion," or "Workshop"*	Presentation

Send completed submission form to RICMST.Resource@nrc.gov by **September 29, 2016**

Ex-Plant Materials Harvesting Workshop

Location: NRC HQ in Rockville, MD

Dates: March 7-8, 2017

Motivation:

- There are increasing opportunities to harvest the safety-critical components from decommissioning plants, both domestic and international.
- The harvested materials are valuable because they have been exposed to actual in-service plant operating conditions (temperature, irradiation, coolant, etc.), unlike virgin materials tested under simulated conditions in the lab.
- Data from ex-plant materials should help address technical gaps identified for extended operation of nuclear power plants due to highly relevant aging conditions.

Purpose and Objective:

- For NRC staff and interested stakeholders to have greater awareness and knowledge of the benefits and challenges associated with ex-plant harvesting.
- Facilitate contacts and communication to enable specific cooperative ex-plant harvesting programs to be initiated.

Workshop Topics:

- Harvesting decision-making and prioritization
    - Technical data needs best addressed by harvesting
    - Technical information needed in advance of harvesting
- Sources of materials:
    - Decommissioning reactors
    - Operating reactors – replaced components
    - Previous harvesting programs – “boneyards”
    - Tracking available materials
- Harvesting process
    - Lessons learned from harvesting experience
    - Perspective of utility-owner and decommissioning contractor on harvesting
    - Communication and coordination between decommissioning and researchers
- International collaborative programs on specific components at specific plants

Draft Agenda – March 7-8, 2017 Harvesting Workshop

Tuesday, March 7, 2017
Introduction

- NRC overview of workshop purpose and objectives 8:00 – 8:10

Session 1: Lessons learned from harvesting experience

- EPRI Perspective on Harvesting Lessons Learned 8:10 – 8:45
  - Zorita, Baffle Bolts, Barsebeck, etc.
- DOE Perspective on Harvesting Lessons Learned 8:45 – 9:20
  - Zion, etc.
- NRC Perspective on Harvesting Lessons Learned 9:20 – 9:50
  - Shoreham, St. Lucie, Zorita, Zion, etc.

BREAK 9:50 – 10:05

- Japan – JNES / JNRA 10:05 – 10:40
  - International Perspective on Harvesting Lessons Learned

DISCUSSION 10:40 – 11:30
LUNCH 11:30 – 12:30

Session 2: Technical data needs best addressed by harvesting

- PNNL/NRC 12:30 – 12:55
  - Overview of data needs best addressed by harvesting
- Belgium - Tractebel 12:55 – 1:20
  - Perspective on harvesting data needs, particularly RPV
- Korea – KAERI? 1:20 – 1:45
  - Perspective on harvesting data needs, Kori plant
- Switzerland – ENSI or PSI? 1:45 – 2:10
  - Perspective on harvesting data needs, Muhleberg

DISCUSSION 2:10 – 2:45
BREAK 2:45 – 3:00

Session 3: Sources of Materials

- NRC 3:00 – 3:15
  - Available materials from decommissioning plants and past harvesting programs
- EPRI / NEI 3:15 – 3:45
  - Available materials from operating reactors and past harvesting programs
- DOE (ORNL?) 3:45 – 4:15
  - Available materials at DOE labs from past harvesting programs
- IAEA ? 4:15 – 4:45
    - International harvesting opportunities

DISCUSSION 4:45 – 5:30

Wednesday, March 8, 2017
Session 4: Practical aspects of Harvesting

- US decommissioning company 8:00 – 8:40
    - Decommissioning process vs. harvesting: schedule, site-specific, timing for different components
- International decommissioning company – Germany? 8:40 – 9:20
    - Decommissioning and harvesting plans and experience
- US utility 9:20 – 10:00
    - Decommissioning process and plans
    - Owner perspective on harvesting and decommissioning

BREAK 10:00 – 10:15

- Researcher perspective – EPRI or DOE or international 10:15 – 10:45
    - Practical challenges to plan for and carry out harvesting

DISCUSSION 10:45 – 11:45
LUNCH 11:45 – 12:45

Session 5: Harvesting Decision-making

- PNNL / NRC 12:45 – 1:15
    - Technical information needed for informed harvesting decisions
- EPRI/NEI 1:15 – 1:45
    - Balancing costs and benefits to ensure value from harvesting
- DOE 1:45 – 2:15
    - Applying past experience to future harvesting decisions
- International - ? 2:15 – 2:45
    - Harvesting decision-making
- DISCUSSION 2:45 – 4:00
    - Potential harvesting partnerships
        - RPV, internals, piping, concrete, cables
        - US, international opportunities

Discussion Topics

- Harvesting decision-making and prioritization
    - Technical data needs best addressed by harvesting
    - Technical information needed in advance of harvesting
- Sources of materials:
    - Decommissioning reactors
    - Operating reactors – replaced components
    - Previous harvesting programs – “boneyards”
    - Tracking available materials
- Harvesting process
    - Lessons learned from harvesting experience
    - Perspective of utility-owner and decommissioning contractor on harvesting
    - Communication and coordination between decommissioning and researchers
- International collaborative programs on specific components at specific plants

Note to requester: Attachment is immediately following.

From: Hiser, Matthew
Sent: Mon, 14 May 2018 19:47:29 +0000
To: Frankl, Istvan
Subject: Re: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Attachments: NRC-industry materials meeting - IAD&Harvesting draft slides 5-14-18.pptx

Hi Steve,
Here's my revision to address your edits. For the one edits I didn't have any changes for: it is MRP-227, Rev. 1 that is under review with Rob and Pat's involvement (the first one was Rev. 0). I also updated the speaker notes as requested.
Thanks!
Matt

From: Frankl, Istvan
Sent: Monday, May 14, 2018 2:45 PM
To: Hiser, Matthew
Subject: RE: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26

Thanks, Matt.

I left the slides with my markups on your chair.

I will need your revision by COB today if possible.

Steve

From: Hiser, Matthew
Sent: Friday, May 11, 2018 12:53 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Rao, Appajosula <Appajosula.Rao@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26

Hi guys,

I have drafted a few slides for the IAD and harvesting topics for the NRC-industry meeting the week after next. Please take a look and provide any edits or comments.

Thanks!
Matt

From: Frankl, Istvan
Sent: Monday, May 07, 2018 5:11 PM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Focht, Eric <Eric.Focht@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Rao, Appajosula <Appajosula.Rao@nrc.gov>
Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
Subject: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

I had discussion with Rob this morning on the slides for the 30 minute CMB summary. His recommendation was that CMB and CIB use the format of the ACRS briefing slides on DE research (attached), The basic format for the ACRS slides called for 2 pages for each program area (max 3 pages if needed) covering basically four topics for each program: Overview, Ongoing Activities, Accomplishments and Path forward.

Our slides for the Materials Exchange meeting will also need to implement the guidance provided by NRR below.

Thanks,

Steve

From: Frankl, Istvan
Sent: Friday, May 04, 2018 10:13 PM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Focht, Eric <Eric.Focht@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Rao, Appajosula <Appajosula.Rao@nrc.gov>
Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
Subject: REMINDER ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

All,

This is a friendly reminder for the program leads to send me about 3 slides for their specific topic below ASAP but no later than COB Tuesday.

The attached draft agenda is still evolving but based on the latest alignment meeting with DMLR yesterday, there is no major change in the CMB specific sessions. Here are some guidance and takeaways provided by NRR:

- The focus of the presentations should be on the impact of the results to plant operation and licensing, and not an emphasis on "here is what we are doing." Make sure the intended messages are clear in each area.

- The question to keep in mind for all of the NRC presentations is: why should the industry care about the information the NRC is presenting? If we cannot identify a current or short-term aspect that the industry should care about, then we should hold the topic to a possible presentation at a future meeting.

Please let me know if you need further guidance or clarifications on the above.

Thanks,

Steve

From: Frankl, Istvan
Sent: Wednesday, April 25, 2018 11:28 AM
To: RES_DE_CMB <RESDECMB@nrc.gov>
Subject: ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

All,

The attachment is the latest NRR draft agenda. We will need to provide input for AM methods and have responsibility for the 30 minute time slot on 5/23 for "Status of Related Research" in CMB. If you have comments on the draft agenda, please send them to me by COB Friday.

For AM I want to make sure that we are aligned with our counterparts in NRR/NRO on the proposed presentation(s) and presenter(s). (Amy, please get back to me on this.)

For our 30 minute time slot we can cover summaries of some or all topics proposed earlier. Here is the list:

1. Harvesting – Current plans and activities
2. IAD – confirmatory testing plans
3. PWSCC Crack Growth – Current research plans and results
4. Status Update on the PWSCC Initiation Program
5. Status of Confirmatory Research for SLR/LTO

At this stage, I will ask the respective leads to draft about 3 summary slides for each of the above topics.

.
Thanks,

Steve

From: Rudland, David
Sent: Wednesday, April 25, 2018 6:22 AM
To: Alley, David <David.Alley@nrc.gov>; Ruffin, Steve <Steve.Ruffin@nrc.gov>; Collins, Jay <Jay.Collins@nrc.gov>; Cumblidge, Stephen <Stephen.Cumblidge@nrc.gov>; Davis, Robert <Robert.Davis@nrc.gov>; Tsao, John <John.Tsao@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Fairbanks, Carolyn <Carolyn.Fairbanks@nrc.gov>; Hovanec, Christopher <Christopher.Hovanec@nrc.gov>; Yee, On <On.Yee@nrc.gov>; Cheruvenki, Ganesh <Ganesh.Cheruvenki@nrc.gov>; Hoffman, Keith <Keith.Hoffman@nrc.gov>; Medoff, James <James.Medoff@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>; Mitchell, Matthew <Matthew.Mitchell@nrc.gov>; Rezai, Ali <Ali.Rezai@nrc.gov>
Subject: FW: 2018-05-22 agenda draft

Everyone

Please take a look at the draft agenda for the materials meeting and let me know if you have any comments. We are still determining who will be making what presentation. Can I please get your comments by April 30?

Ali, did Allen talk with you about getting the meeting set up?

Thanks
Dave

David L. Rudland, Ph.D.
Senior Technical Advisor for Nuclear Power Plant Materials
Division of Materials and License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Stop: OWFN-11F01
11555 Rockville Pike
Rockville, MD 20852-2738
Office: (301) 415-1896
(b)(6) Cell: [redacted]
Email: david.rudland@nrc.gov

From: Dyle, Robin [mailto:rdyle@epri.com]
Sent: Tuesday, April 24, 2018 9:00 PM

To: Hiser, Allen <Allen.Hiser@nrc.gov>; Rudland, David <David.Rudland@nrc.gov>
Subject: [External_Sender] 2018-05-22 agenda draft

Gents – here is a first cut at the agenda. I'll let the 2 of you coordinate with your peers. I sent a copy to the industry leads for their review and comment. We can adjust as needed.

I'm not sure this bunch will interested in the advanced non-LWRs. If we need more time for other items we could reduce the time for that topic. Also we are very light on Thursday morning so we can stretch out some items or finish Wednesday afternoon.

Thoughts?

Robin Dyle
Office: 205-426-5371
(b)(6) Cell: [redacted]

Irradiation-Assisted Degradation

- Overview
  - Objective: Evaluate the effects of irradiation and LWR environment on the performance of reactor pressure vessel (RPV) internals
  - Applications:
    - Regulatory guidance and reviews for the aging management of RPV internals
  - Collaboration: EPRI, Halden, International Regulators
- Ongoing activities for Irradiation Assisted Degradation (IAD)
  - CGR and fracture toughness testing of irradiated ex-plant plate and weld materials
  - Evaluation of industry-developed CGR reference curves for irradiation-assisted stress corrosion cracking (IASCC) of stainless steels
- Accomplishments
  - Effectively leveraged partnerships with EPRI and international researchers to conduct high-priority irradiated materials testing on high fluence stainless steel materials harvested from Zorita

Summary of Comments on PowerPoint Presentation

Page: 1

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 10:48:54 AM

Irradiation Assisted Degradation (EAD)
Overview
Objective: Evaluate the effects of irradiation and LWR environment on the performance of reactor pressure vessel (RPV) internals
Applications:
Regulatory guidance for the aging management of RPV internals and reviews
Collaboration: EPRI, Halden, International Regulators
Ongoing activities for Irradiation Assisted Degradation (IAD)
CGR and fracture toughness testing of irradiated ex-plant plate and weld materials
Evaluation of industry-developed CGR reference curves for irradiation-assisted stress corrosion cracking (IASCC) of stainless steels
Accomplishments
Effectively leveraged partnerships with EPRI and international researchers to conduct high-priority irradiated materials testing on high fluence stainless steel materials harvested from Zorita

IAD activities are focused on mechanical testing and microstructural characterization of ex-plant baffle plate and weld materials, including those acquired in cooperation with EPRI from the Zorita reactor in Spain as well as potential research on baffle bolts removed from service during recent inspections.
IAD activities also include completing fracture toughness testing on irradiated and thermally aged cast stainless steel (CASS) materials and providing technical support for the review of industry-developed CGR reference curves for IASCC of stainless steels.

Note to requester: The Summary pages contain the comments included in the powerpoint presentation file. Please note the date/time stamp on the summary pages reflect only when these additional pages were created, not the creation date/time of the presentation file itself.

IAD Path Forward

- Final results on cooperative Zorita baffle plate and weld materials testing expected in 2018 and 2019
- Confirmatory testing of Zorita baffle plate and weld materials at ANL underway
- Further irradiation of Zorita welds to higher fluence at Halden expected to provide additional data through 2023
  - Recent news of Halden shutdown will delay these plans
- Continue technical support on IASCC CGR reference curves , the review of MRP-227, Rev.1, etc.

Page: 2

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 10:48:54 AM

IAD Path Forward

Path Forward

Cooperative testing with EPRI (and others) of the Zorita baffle plate and weld materials are expected to be completed in 2018 and 2019, respectively. The scope of this work includes tensile properties, transmission electron microscope (TEM) to assess void swelling and testing for crack initiation, CGR and fracture toughness.

Independent confirmatory testing on Zorita baffle plate and weld materials currently underway at ANL. This will provide further insights and clarity on the results from the cooperative testing.

Welds from Zorita at an initial dose of 2 dpa will be further irradiated at Halden to a final dose of 5 and 8 dpa. The 5 dpa specimens are expected to complete irradiation by 2020 and the 8 dpa specimens by 2023. The recent news of Halden's decision to shutdown will delay these plans. NRC is developing backup plans and will pursue cooperative efforts with other organizations such as EPRI as appropriate.

RES/DE continues to provide technical support for regulatory activities related to IAD and, in particular, the review of MRP-227, Rev. 1 and an ASME Code Case on IASCC CGR reference curves.

Ex-Plant Materials Harvesting

- Overview
  - Objective: Prioritize technical needs best addressed by harvesting and identify best value harvesting opportunities
  - Driver: Support technical bases to make regulatory decisions for materials degradation during long-term operation
- Ongoing activities
  - Report from PNNL identifies potential criteria for prioritizing harvesting needs and provides some history and lessons learned from past harvesting efforts
    - Focused on main issues for materials degradation during long-term operation: RPV, internals, concrete, electrical
  - NRC staff performing internal prioritization of issues best addressed by harvesting
  - NRC staff compiling information on available materials:
    - Previously harvested from prior programs
    - From decommissioning plants

Page: 3

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 10:48:54 AM

Harvesting
Overview
Objective: Prioritize technical needs best addressed by harvesting and identify best value harvesting opportunities
Driver: Support technical bases to make regulatory decisions on applications for SLR
Collaboration: DOE, EPRI
Ongoing activities
Report from PNNL identifies potential criteria for prioritizing harvesting needs and provides some history and lessons learned from past harvesting efforts
Focused on main issues for materials degradation during long-term operations: RPV, internals, concrete, electrical
NRC staff performing internal prioritization of issues best addressed by harvesting to focus efforts and activities
NRC staff compiling information on available materials:
Previously harvested from prior programs
From decommissioning plants

Harvesting Accomplishments and Path Forward

- Accomplishments
  - Workshop held in March 2017 with DOE, EPRI, industry and international stakeholders
  - PNNL report near completion
- Path Forward
  - Use criteria to identify NRC priorities for harvesting
  - Review available materials from all sources and compare to identified priorities
  - Seek cooperation and leveraging from other interested organizations to implement best value opportunities for harvesting
  - Continually reassess priorities and available materials based on latest information

Page: 4

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 10:48:54 AM

SLR Accomplishments and Path Forward

Accomplishments

Workshop held in March 2017 with DOE, EPRI, industry and international stakeholders

- Valuable insights from harvesting experience that can be applied to maximize value of future harvesting efforts

PNNL report near completion

Path Forward

Use criteria to identify NRC priorities for harvesting

Review available materials from all sources and compare to identified priorities

Seek cooperation and leveraging from other interested organizations to implement best value opportunities for harvesting

Continually reassess priorities and available materials based on latest information

Note to requester:
Attachment is
immediately following.

From: Hiser, Matthew
Sent: Fri, 11 May 2018 16:53:06 +0000
To: Tregoning, Robert;Audrain, Margaret;Hull, Amy;Purtscher, Patrick;Rao, Appajosula
Cc: Frankl, Istvan
Subject: RE: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Attachments: NRC-industry materials meeting - IAD&Harvesting draft slides 5-11-18.pptx

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Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
Subject: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

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Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
Subject: REMINDER ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

All,

This is a friendly reminder for the program leads to send me about 3 slides for their specific topic below ASAP but no later than COB Tuesday.

The attached draft agenda is still evolving but based on the latest alignment meeting with DMLR yesterday, there is no major change in the CMB specific sessions. Here are some guidance and takeaways provided by NRR:

- The focus of the presentations should be on the impact of the results to plant operation and licensing, and not an emphasis on "here is what we are doing." Make sure the intended messages are clear in each area.

- The question to keep in mind for all of the NRC presentations is: why should the industry care about the information the NRC is presenting? If we cannot identify a current or short-term aspect that the industry should care about, then we should hold the topic to a possible presentation at a future meeting.

Please let me know if you need further guidance or clarifications on the above.

Thanks,

Steve

From: Frankl, Istvan
Sent: Wednesday, April 25, 2018 11:28 AM
To: RES_DE_CMB <RESDECMB@nrc.gov>
Subject: ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

All,

The attachment is the latest NRR draft agenda. We will need to provide input for AM methods and have responsibility for the 30 minute time slot on 5/23 for "Status of Related Research" in CMB. If you have comments on the draft agenda, please send them to me by COB Friday.

For AM I want to make sure that we are aligned with our counterparts in NRR/NRO on the proposed presentation(s) and presenter(s). (Amy, please get back to me on this.)

For our 30 minute time slot we can cover summaries of some or all topics proposed earlier. Here is the list:

1. Harvesting – Current plans and activities
2. IAD – confirmatory testing plans
3. PWSCC Crack Growth – Current research plans and results
4. Status Update on the PWSCC Initiation Program
5. Status of Confirmatory Research for SLR/LTO

At this stage, I will ask the respective leads to draft about 3 summary slides for each of the above topics.

.

Thanks,

Steve

From: Rudland, David
Sent: Wednesday, April 25, 2018 6:22 AM
To: Alley, David <David.Alley@nrc.gov>; Ruffin, Steve <Steve.Ruffin@nrc.gov>; Collins, Jay <Jay.Collins@nrc.gov>; Cumblidge, Stephen <Stephen.Cumblidge@nrc.gov>; Davis, Robert <Robert.Davis@nrc.gov>; Tsao, John <John.Tsao@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Fairbanks, Carolyn <Carolyn.Fairbanks@nrc.gov>; Hovanec, Christopher <Christopher.Hovanec@nrc.gov>; Yee, On <On.Yee@nrc.gov>; Cheruvenki, Ganesh <Ganesh.Cheruvenki@nrc.gov>; Hoffman, Keith <Keith.Hoffman@nrc.gov>; Medoff, James <James.Medoff@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>; Mitchell, Matthew <Matthew.Mitchell@nrc.gov>; Rezai, Ali <Ali.Rezai@nrc.gov>
Subject: FW: 2018-05-22 agenda draft

Everyone

Please take a look at the draft agenda for the materials meeting and let me know if you have any comments. We are still determining who will be making what presentation. Can I please get your comments by April 30?

Ali, did Allen talk with you about getting the meeting set up?

Thanks
Dave

David L. Rudland, Ph.D.
Senior Technical Advisor for Nuclear Power Plant Materials
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Rockville, MD 20852-2738
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(b)(6) Cell: [redacted]
Email: david.rudland@nrc.gov

From: Dyle, Robin [mailto:rdyle@epri.com]
Sent: Tuesday, April 24, 2018 9:00 PM

To: Hiser, Allen <Allen.Hiser@nrc.gov>; Rudland, David <David.Rudland@nrc.gov>
Subject: [External_Sender] 2018-05-22 agenda draft

Gents – here is a first cut at the agenda. I'll let the 2 of you coordinate with your peers. I sent a copy to the industry leads for their review and comment. We can adjust as needed.

I'm not sure this bunch will interested in the advanced non-LWRs. If we need more time for other items we could reduce the time for that topic. Also we are very light on Thursday morning so we can stretch out some items or finish Wednesday afternoon.

Thoughts?

Robin Dyle
Office: 205-426-5371
(b)(6) Cell: [redacted]

Irradiation-Assisted Degradation

- **Overview**
  - Objective: Evaluate the effects of irradiation and LWR environment on the performance of reactor pressure vessel (RPV) internals
  - Applications:
    - Regulatory guidance for the aging management of RPV internals and reviews
  - Collaboration: EPRI, Halden, International Regulators
- **Ongoing activities for Irradiation Assisted Degradation (IAD)**
  - CGR and fracture toughness testing of irradiated ex-plant plate and weld materials
  - Evaluation of industry-developed CGR reference curves for irradiation-assisted stress corrosion cracking (IASCC) of stainless steels
- Accomplishments
  - Effectively leveraged partnerships with EPRI and international researchers to conduct high-priority irradiated materials testing on high fluence stainless steel materials harvested from Zorita

Summary of Comments on PowerPoint Presentation

Page: 1

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:10:24 AM

My name is Steve Frankl. I am the Branch Chief of the Corrosion and Metallurgy Branch (CMB) in RES/DE. The focus of regulatory research in my branch is material performance and degradation in the operating environment of Nuclear Power Plants (NPPs).

Environmentally Assisted Degradation (EAD)
Overview
EAD evaluates the effects of corrosion, aging and irradiation on the performance of primary system piping, reactor pressure vessel (RPV) internals and RPV head penetrations
Driver: Reactor coolant pressure boundary leakage and component integrity
Applications/ use:
PWSCC crack growth rate (CGR) disposition curves and xLPR Code results to inform regulatory decisions on inspection requirements
Regulatory guidance for the aging management of RPV internals and regulatory reviews
Cooperate with EPRI, Halden and International Regulators

Ongoing Activities

EAD research in CMB covers PWSCC and IAD.

PWSCC initiation and CGR testing
RES/DE has recently started cooperative effort with EPRI for PWSCC initiation testing on Alloy 600/82/182 and Alloy 690/52/152 to support the xLPR project and to conduct confirmatory research. NRR will use the data to support its review of the xLPR code.

PWSCC CGR testing is being conducted to obtain data for Alloy 690/52/152 to inform inspections requirements for upper heads, piping welds, overlays, inlays and onlays. RES/DE also participates through our contractors in the development of PWSCC CGR reference curves.

IAD
IAD activities are focused on mechanical testing and microstructural characterization of ex-plant baffle plate and weld materials, including those acquired in cooperation with EPRI from the Zorita reactor in Spain as well as potential research on baffle bolts removed from service during recent inspections.
IAD activities also include completing fracture toughness testing on irradiated and thermally aged cast stainless steel (CASS) materials and providing technical support for the review of industry-developed CGR reference curves for IASCC of stainless steels.

Next slide please.

Note to requester: The Summary pages contain the comments included in the powerpoint presentation file. Please note the date/time stamp on the summary pages reflect only when these additional pages were created, not the creation date/time of the presentation file itself.

IAD Path Forward

- Final results on cooperative Zorita baffle plate and weld materials testing expected in 2018 and 2019
- Confirmatory testing of Zorita baffle plate and weld materials at ANL underway
- Further irradiation of Zorita welds to higher fluence at Halden expected to provide additional data through 2023
  - Recent news of Halden shutdown will delay these plans
- Continue technical support on IASCC CGR reference curves , the review of MRP-227, Rev.1, etc.

Page: 2

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:10:24 AM

IAD Accomplishments and Path Forward

Accomplishments

We published several NUREG/CRs on thermal and irradiation embrittlement of CASS (NUREG/CR-7184, NUREG/CR-7185 and NUREG/CR-4513 Rev. 2) and on fracture toughness of thermally aged and irradiated stainless steels (NUREG/CR-6960, -7184, -7185).

Effective leveraging with EPRI and other research organizations has enabled significant research on high fluence stainless steel materials harvested from Zorita which provides highly representative data on baffle plate and weld materials to higher fluence levels.

Path Forward

Cooperative testing with EPRI (and others) of the Zorita baffle plate and weld materials are expected to be completed in 2018 and 2019, respectively. The scope of this work includes tensile properties, transmission electron microscope (TEM) to assess void swelling and testing for crack initiation, CGR and fracture toughness.

Independent confirmatory testing on Zorita baffle plate and weld materials will be performed at ANL beginning in 2018. This will provide further insights and clarity on the results from the cooperative testing.

Welds from Zorita at an initial dose of 2 dpa will be further irradiated at Halden to a final dose of 5 and 8 dpa. The 5 dpa specimens are expected to complete irradiation by 2020 and the 8 dpa specimens by 2023.

RES/DE continues to provide technical support for regulatory activities related to IAD and, in particular, the review of MRP-227, Rev. 1 and an ASME Code Case on IASCC CGR reference curves.

Next slide please.

Ex-Plant Materials Harvesting

- Overview
  - Objective: Prioritize technical needs best addressed by harvesting and identify best value harvesting opportunities
  - Driver: Support technical bases to make regulatory decisions on applications for SLR
  - Collaboration: DOE, EPRI
- Ongoing activities
  - Report from PNNL identifies potential criteria for prioritizing harvesting needs and provides some history and lessons learned from past harvesting efforts
    - Focused on 4 main SLR issues: RPV, internals, concrete, electrical
  - NRC staff performing internal prioritization of issues best addressed by harvesting
  - NRC staff compiling information on available materials:
    - Previously harvested from prior programs
    - From decommissioning plants

Page: 3

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:10:25 AM

SLR
Overview:
The subsequent license renewal (SLR) program coordinates research across the Division to address technical issues and knowledge gaps for extended reactor operation to 80 years and is aimed at ensuring that we have the necessary technical bases to make regulatory decisions on applications for SLR.
Driver: Support technical bases to make regulatory decisions on applications for SLR
Applications/ use:
SLR guidance documents (GALL-SLR, SRP-SLR)
Confirmatory review of SLR applications
SLR research is coordinated through domestic and international research for Long Term Operation (LTO) through MOUs/ IAs with:
DOE's Light Water Reactor Sustainability (LWRS) program
EPRI's LTO program, and
International collaboration on SLR-related research topics.
[SKIP] [IFRAM – International Framework on Reactor Aging Management – Network of researchers concerned with materials degradation. As we re-establish this group, we hope to facilitate information exchange and cooperative research with counterpart organizations (although none is specifically planned under IFRAM).]

Ongoing activities:
The 4 key technical issues for SLR were documented in the SRM to SECY-14-0016:
Reactor pressure vessel (RPV) neutron embrittlement at high fluence
IAD / IASCC of RPV internals and primary system components
Concrete and containment degradation - due to alkali silica reaction (ASR) and irradiation damage
Electrical cable qualification and condition assessment – with focus on degradation of electrical and control cables

Cooperative research (with data sharing and independent assessment) is ongoing with DOE and EPRI.
We have biweekly coordination calls
Monthly subject matter expert discussions on concrete and cables research programs, and
EPRI/ NRC/ DOE joint roadmap meetings 2-3 times per year to update the tracking of research tasks.

Coordination with international counterparts is ongoing through multilateral working groups on technical topics including the 4 key technical issues.
[SKIP sub-bullets below]
The IFRAM network was recently re-launched by RES/DE. The current IFRAM Chairman is in Korea.
Participants include China (Chinese Academy of Science), Japan (Tohoku Univ.), Korea (KINS, Seoul Nat'l Univ.), and USA research organizations, including DOE and EPRI
There was a side-meeting at the IAEA Plant Life Management (PLiM) Conference, 10/26/2017, to invite additional participants.
IFRAM is independent from, but complementary to, other international organizations, such as IAEA SALTO, CODAP, CADAK, OECD-CSNI, ICG-EAC, Halden Reactor Project (HRP), etc.

In order to improve our understanding of in-service degradation of materials, RES/DE is developing a proactive strategy to evaluate material harvesting opportunities to support materials aging research and to help coordinate efforts to harvest components from reactors entering decommissioning.
A harvesting workshop in spring 2017 addressed factors to consider, prioritization, and lessons learned
A poster and presentation were completed for the recent PLiM conference
Ongoing work is directed toward developing a database to help prioritize harvesting, so that we can be ready for harvesting opportunities in the future.
Next slide please.

Harvesting Accomplishments and Path Forward

- Accomplishments
  - Workshop held in March 2017 with DOE, EPRI, industry and international stakeholders
  - PNNL report near completion
- Path Forward
  - Use criteria to identify NRC priorities for harvesting
  - Review available materials from all sources and compare to identified priorities
  - Seek cooperation and leveraging from other interested organizations to implement best value opportunities for harvesting
  - Continually reassess priorities and available materials based on latest information

Page: 4

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:10:25 AM

SLR Accomplishments and Path Forward
Accomplishments:
In 2016, NRC, DOE and EPRI held "deep dive" meetings to share information on materials degradation issues (and sub-issues) identified in the Expanded Materials Degradation Analysis (EMDA). Independent and collaborative research is ongoing to close out most technical sub-issues.

[SKIP] [A few sub-issues were later deemed to be of lower significance and they are not being pursued at this time (e.g., very high dose effects, such as void swelling, in stainless steels) – this is not closed out – IF].

The NRC aging management guidance documents for SLR (GALL-SLR and SRP-SLR) were published in July, 2017 with extensive input from RES/ DE staff.

[SKIP sub-bullets below]
Generic Aging Lessons Learned (GALL) report was updated for SLR (published as NUREG-2191) GALL-SLR contains generic aging effects to be managed and guidance to applicants on developing robust aging management programs (AMPs)
Standard Review Plan was updated for SLR (published as NUREG-2192). SRP-SLR provides guidance to the staff on reviewing SLR applications, including AMPs for operation to 80 years.

The staff and industry briefed the Commission on the status of preparations for SLR reviews on April 26, 2017.

One of the SLR-related sub-issues is quantifying the fatigue life of metals in LWR environments. Fatigue is called out over 100 times in the GALL-SLR and SRP-SLR. The revised guidance documents on fatigue (NUREG/CR-6909, Rev. 1 and Regulatory Guide 1.207) are now in publication:

[SKIP sub-bullets below]
NUREG/CR-6909, Rev. 1, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials"
Regulatory Guide 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors" (DG-1309)

Path Forward
Ongoing research is focused on the four key technical issues and, in particular, on the open sub-issues.

In the near-term:
RES/DE will support NRR with confirmatory reviews of plant specific gap analyses of the treatment of RPV internals for the first SLR applications.
Continue collection of RPV embrittlement data from industry-led surveillance program to confirm predictive methods.
[SKIP] (Eventually (~2019), there may be a need to revise RG 1.99 to reflect longer-term data trends. (CIB))
Test CGR of concrete susceptible to ASR (Jose), and
Begin accelerated aging under both gamma radiation and elevated temperature of representative cable samples. Tom Koshy will cover this topic later.

[SKIP sub-bullets below]
Samples will be aged in controlled environments, at Sandia Lab.
Testing of mechanical, chemical, and electrical properties will be done at NIST.
At the same time, industry condition monitoring techniques are being assessed.

In the long-term:
RES/DE will continue research on IAD of RPV internals at medium and high fluence levels,
Evaluating impacts of IASCC, loss of fracture toughness and void swelling
IAD research requires leveraging and long lead-times through ~2023 and beyond
Collect RPV embrittlement data through the LR and SLR periods to confirm data trends (CIB), and
Continue confirmatory research on concrete degradation including effects of ASR and irradiation on the structural performance of concrete with collaborative research agreements. This topic will be covered by Dr. Jose Pires later.

[SKIP sub-bullets below]
ASR tests at NIST, complemented by DOE-funded work at Univ. of Tennessee
ASR-susceptible concrete blocks are exposed to elevated temperature & humidity.
ASR testing: non-destructive examinations (NDE), mechanical tests of cracked concrete
Irradiation effects assessments are based on reviews of industry reports and information from academic and regulatory counterparts.
A decision will be made by staff sometime in 2018 whether to pursue additional NRC-led testing of irradiated concrete.
Opportunities to harvest irradiated concrete from decommissioned plants will be sought.
If necessary, additional specimens may be exposed to controlled irradiation (e.g., in Halden or ATR), then tested.

Next slide please.

From: Moyer, Carol
Sent: Mon, 14 May 2018 18:44:13 +0000
To: Frankl, Istvan
Subject: RE: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Attachments: Long term materials degradation slides_CEM_rev2.pptx

Note to requester: Attachment is immediately following.

Revised again, as directed.

From: Moyer, Carol
Sent: Monday, May 14, 2018 12:36 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: Re: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26

Steve,

Revised slides and notes are in the attached file, addressing your comments.

Carol

From: Moyer, Carol
Sent: Tuesday, May 08, 2018 6:23 PM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Cc: Hull, Amy <Amy.Hull@nrc.gov>
Subject: RE: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26

Steve,

Draft slides for Long-Term Materials Degradation (nee SLR Research) are attached. I kept most of the Notes text that had been in the ACRS slides, as it is still applicable.

Carol

From: Frankl, Istvan
Sent: Monday, May 07, 2018 5:11 PM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Focht, Eric <Eric.Focht@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Rao, Appajosula <Appajosula.Rao@nrc.gov>
Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
Subject: UPDATE ACTION: Topics for Materials Exchange Meeting May 22-26
Importance: High

I had discussion with Rob this morning on the slides for the 30 minute CMB summary. His recommendation was that CMB and CIB use the format of the ACRS briefing slides on DE research (attached), The basic format for the ACRS slides called for 2 pages for each program area (max 3 pages if needed) covering basically four topics for each program: Overview, Ongoing Activities, Accomplishments and Path forward.

Our slides for the Materials Exchange meeting will also need to implement the guidance provided by NRR below.

Thanks,

Steve

From: Frankl, Istvan
Sent: Friday, May 04, 2018 10:13 PM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Focht, Eric <Eric.Focht@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Rao, Appajosula <Appajosula.Rao@nrc.gov>
Cc: Christensen, Jason <Jason.Christensen@nrc.gov>; Harris, Brian <Brian.Harris2@nrc.gov>
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At this stage, I will ask the respective leads to draft about 3 summary slides for each of the above topics.

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Subject: FW: 2018-05-22 agenda draft

Everyone

Please take a look at the draft agenda for the materials meeting and let me know if you have any comments. We are still determining who will be making what presentation. Can I please get your comments by April 30?

Ali, did Allen talk with you about getting the meeting set up?

Thanks
Dave

David L. Rudland, Ph.D.
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(b)(6) Cell: [redacted]
Email: david.rudland@nrc.gov

From: Dyle, Robin [mailto:rdyle@epri.com]
Sent: Tuesday, April 24, 2018 9:00 PM
To: Hiser, Allen <Allen.Hiser@nrc.gov>; Rudland, David <David.Rudland@nrc.gov>
Subject: [External_Sender] 2018-05-22 agenda draft

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Thoughts?

Robin Dyle
Office: 205-426-5371
(b)(6) Cell: [redacted]

Long-Term Materials Degradation

- Overview
  - Objective: Coordinate confirmatory research programs to address technical issues and knowledge gaps for extended reactor operation to 80 years
  - Driver: Support technical bases to make regulatory decisions on applications for subsequent license renewal (SLR)
  - Applications:
    - SLR guidance documents (GALL-SLR, SRP-SLR)
    - Confirmatory review of SLR applications
  - Collaboration: DOE, EPRI, international counterparts
- Ongoing activities
  - **4 key technical issues:** 1) RPV embrittlement at high fluence; 2) IAD of RPV internals; 2) concrete and containment degradation, and 4) electrical cable qualification and condition assessment
  - Coordination with DOE and industry counterparts
  - Coordination with international counterparts through multilateral working groups
  - Developing a proactive strategy to evaluate material harvesting opportunities to support materials aging research




Summary of Comments on PowerPoint Presentation

Page: 1

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:32:45 AM

SLR
Overview:
The long-term materials degradation (LTMD) program coordinates research across the Division to address technical issues and knowledge gaps related to extended reactor operation to 80 years and is aimed at ensuring that we have the necessary technical bases to make regulatory decisions on applications for subsequent license renewal (SLR).
Driver: Support technical bases to make regulatory decisions on applications for SLR
Applications/ use:
SLR guidance documents (GALL-SLR, SRP-SLR)
Confirmatory review of SLR applications
Confirmatory research for Long Term Operation (LTO) is coordinated with domestic and international counterparts through MOUs/ IAs with:
DOE's Light Water Reactor Sustainability (LWRS) program
EPRI's LTO program, and
International collaboration on SLR-related research topics.
For example, IFRAM – International Framework on Reactor Aging Management – is a network of researchers concerned with materials degradation.

Ongoing activities:
The 4 key technical issues for SLR were documented in the SRM to SECY-14-0016:
Reactor pressure vessel (RPV) neutron embrittlement at high fluence
IAD / IASCC of RPV internals and primary system components
Concrete and containment degradation - due to alkali silica reaction (ASR) and irradiation damage
Electrical cable qualification and condition assessment – with focus on degradation of electrical and control cables

The 4 key technical issues are all materials-related, hence the new terminology, "Long-Term Materials Degradation."
More information related to the metals-focused topics was presented under EAD: PWSCC and IAD (previous slides).

Cooperative research (with data sharing and independent assessment) is ongoing with DOE and EPRI.
We have biweekly coordination calls
Monthly subject matter expert discussions on concrete and cables research programs, and
EPRI/ NRC/ DOE joint roadmap meetings 2-3 times per year to update the tracking of research tasks.

Coordination with international counterparts is ongoing through multilateral working groups on technical topics including the 4 key technical issues.

In order to improve our understanding of in-service degradation of materials, RES/DE is developing a proactive strategy to evaluate material harvesting opportunities to support materials aging research and to help coordinate efforts to harvest components from reactors entering decommissioning.
A harvesting workshop in spring 2017 addressed factors to consider, prioritization, and lessons learned.
A poster on harvesting was presented at the 2018 NRC RIC.
Ongoing work is directed toward developing a database to help prioritize harvesting, so that we can be ready for harvesting opportunities in the future.

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LTMD Accomplishments and Path Forward

- Accomplishments
  - NRC published aging management guidance documents with significant RES contributions: NUREG-2191 (GALL-SLR), NUREG-2192 (SRP-SLR)
  - Revised guidance on fatigue life in LWRs: NUREG/CR-6909, RG 1.207
- Path Forward
  - Near Term:
    - Evaluate need to revise Regulatory Guide 1.99 on RPV embrittlement
    - Support NRR with confirmatory reviews of plant-specific analyses of RPV internals and possible concrete degradation for the first SLR applications
    - Test CGR of concrete susceptible to alkali-silica reaction (ASR)
    - Begin radiation and thermal aging of representative electrical cables
  - Long Term:
    - Continue to trend RPV properties through period of extended operation
    - Continue to assess properties of RPV internals materials at medium and high fluence through further irradiation of ex-plant materials
    - Determine need for long-term irradiation of concrete specimens
    - Assess cable condition monitoring techniques

Number: 1 Author: Presenter Subject: Presentation Notes Date: 2/26/2021 11:32:45 AM

SLR Accomplishments and Path Forward
Accomplishments:
In 2016, NRC, DOE and EPRI held "deep dive" meetings to share information on materials degradation issues (and sub-issues) identified in the Expanded Materials Degradation Analysis (EMDA). Independent and collaborative research is ongoing to close out most technical sub-issues.

The NRC aging management guidance documents for SLR (GALL-SLR and SRP-SLR) were published in July, 2017, with extensive input from RES/DE staff.
Generic Aging Lessons Learned (GALL) report was updated for SLR (published as NUREG-2191). GALL-SLR contains generic aging effects to be managed and guidance to applicants on developing robust aging management programs (AMPs).
Standard Review Plan was updated for SLR (published as NUREG-2192). SRP-SLR provides guidance to the staff on reviewing SLR applications, including AMPs, for operation to 80 years.

One of the identified SLR-related sub-issues is quantifying the fatigue life of metals in LWR environments. Fatigue is called out over 100 times in the GALL-SLR and SRP-SLR. The revised guidance documents on fatigue (NUREG/CR-6909, Rev. 1 and Regulatory Guide 1.207) are now in publication.
NUREG/CR-6909, Rev. 1, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials"
Regulatory Guide 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors" (DG-1309)

Path Forward
Ongoing research is focused on the four key technical issues and, in particular, on the open sub-issues.

In the near-term:
Continue collection of RPV embrittlement data from industry-led surveillance program to confirm predictive methods.
RES/DE will support NRR with confirmatory reviews of plant-specific analyses for RPV internals and for possible concrete degradation for the first SLR applications.
Test the crack growth rate (CGR) in a controlled environment of concrete susceptible to ASR
Begin accelerated aging of representative cable samples under both gamma radiation and elevated temperature.

In the long-term:
Collect RPV embrittlement data through the LR and SLR periods to confirm data trends (CIB)
RES/DE will continue research on IAD of RPV internals at medium and high fluence levels through further irradiation of ex-plant materials.
Evaluating impacts of IASCC, loss of fracture toughness, and void swelling
IAD research requires leveraging and long lead-times through ~2023 and beyond
Continue confirmatory research on concrete degradation including effects of ASR and irradiation on the structural performance of concrete.
ASR testing: non-destructive examinations (NDE), mechanical tests of cracked concrete
Irradiation effects assessments are based on reviews of industry reports and information from academic and regulatory counterparts.
A decision will be made by staff sometime in 2018 whether to pursue additional NRC-led testing of irradiated concrete.
Opportunities to harvest irradiated concrete from decommissioned plants will be sought.
Evaluate industry (EPRI) guidance on cable condition monitoring, and benchmark the CM guidance against operating experience.

Note to requester:
Attachment is
immediately following.

From: Audrain, Margaret
Sent: Thu, 14 Dec 2017 14:33:05 +0000
To: Hiser, Matthew
Subject: FW: Re: upcoming visit
Attachments: UIC talk on ASR_ANL.pdf

From: Sasan Bakhtiari [mailto:bakhtiari@anl.gov]
Sent: Wednesday, December 13, 2017 1:09 PM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>
Cc: Natesan, Krishnamurti <natesan@anl.gov>; Heifetz, Alexander <aheifetz@anl.gov>
Subject: [External_Sender] Re: upcoming visit

Pat,

As followup to our conversation this morning, attached is Alex's recent presentation on concrete ASR. He is the PI of that work and is Cc'd on this email. Please feel free to contact Alex directly for any questions you might have about this subject. Thanks,

Sasan

--
Sasan Bakhtiari
Nuclear Engineering Division
Argonne National Laboratory
Off: 630.252.8982
(b)(6) Cell: [redacted]
Fax: 630.972.4511
bakhtiari@anl.gov
--

On 12/11/2017 1:05 PM, Purtscher, Patrick wrote:

> Good afternoon,
>
> One quick question, what room and bldg. will we be meeting at on Wednesday?
>
> (b)(6) My cell phone no. is [redacted] if there are any last minute changes.
>
> Thanks,
>
> Pat

From: Purtscher, Patrick
Sent: Tuesday, December 05, 2017 11:17 AM
To: 'Natesan, Krishnamurti' <natesan@anl.gov>
Cc: Sasan (bakhtiari@anl.gov) <bakhtiari@anl.gov>; 'Majumdar, Saurin' <majumdar@anl.gov>
Subject: upcoming visit

Good morning,

I wanted to confirm with you my plans for the upcoming visit to ANL. Tuesday afternoon, I would like to address the majority of the SGT issues. There would be some time on Wednesday morning before 10 AM to finish up any SGT issues not completed on Tuesday. Then on Wednesday when Meg Audrain gets there from NRC headquarters, we will meet about harvesting needs to address materials aging degradation for extended plant operation. This will include all materials, I am most aware of the metals issues, but this is more generic. Questions regarding electrical cables and concrete have been specifically noted as important.

Pat

From: Purtscher, Patrick
Sent: Thursday, November 30, 2017 2:45 PM
To: Majumdar, Saurin <majumdar@anl.gov>
Cc: Sasan (bakhtiari@anl.gov) <bakhtiari@anl.gov>; Natesan, Krishnamurti <natesan@anl.gov>
Subject: RE: Re: file transfer

I plan to be there by noon on Tuesday the 12th. I need to talk to you and Sasan about the status of reports on U-bend cracking and ODSCC of straight tubes. I also need to talk to Ken Natesan and Sasan about the close out of tasks for the term of the current TIP-5 program, the future for TIP-6, and the status of the laboratory test equipment. On Wednesday the 13th, I have a separate meeting with any interested ANL staff where I and another NRC RES employee will be discussing the new effort the NRC is taking to compile a list of all ex-plant materials available for possible future research into aging effects, this includes metals and non-metallic materials like concrete and cables. I think this meeting will be no earlier than 10 AM on the 13th. I also have a phone call set up that I have to call in for from noon to 1 PM central time. I need to leave for the airport by 3:30 PM I think to catch a [redacted] flight home.

(b)(6)

Pat

From: Majumdar, Saurin [mailto:majumdar@anl.gov]
Sent: Thursday, November 30, 2017 10:57 AM

To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: [External_Sender] Re: file transfer

Can you send me the agenda?

From: Patrick Purtscher <Patrick.Purtscher@nrc.gov>
Date: Wednesday, November 29, 2017 at 11:30 AM
To: Saurin Majumdar <majumdar@anl.gov>
Subject: file transfer

I got the file, thanks.

I plan to be at ANL on Dec. 12 and 13. Will you be available to talk about the report?

Pat

ANALYSIS OF ALKALI-SILICA REACTION IN CONCRETE WITH MICROWAVE BACKSCATTERING AND IMPEDANCE SPECTROSCOPY

ALEXANDER HEIFETZ (NE/ANL)
SASAN BAKHTIARI (NE/ANL)
PETER ZAPOL (MSD/ANL)
ANTHONY BENTIVEGNA (CTLGROUP)

Argonne National Laboratory

Civil and Materials Engineering, UIC

8 December 2017

OUTLINE

- Introduction to alkali-silica reaction (ASR) in concrete
- ASR accelerated tests
- Analysis of ASR with
  - Microwave backscattering
  - Impedance spectroscopy
- Brief review of delayed ettringite formation (DEF)
- 3-D printing of concrete
- Summary

ALKALI-SILICA REACTION (ASR) IN CONCRETE

ASR OVERVIEW

- ASR is common form of damage in aging concrete
  - Concrete mixes containing alkaline Portland cement and silica-rich aggregates are chemically unstable
  - Reaction leads to ASR gel and microcracks formation, and concrete expansion
  - Large visible cracks may take decades to develop

Example of ASR damage in concrete (FHWA, 2012)

- Examples of problems caused by ASR
  - Concrete cracking weakens structure resilience to extreme events (e.g. earthquake)
  - Concrete expansion causes tensioning of other structural elements (e.g. bridge steel cables)
  - Concrete platform expansion causes misalignment of bi-static radar station

Distribution of some of the reported ASR cases in the USA since 1940. Each star represents a reported case of ASR. (FHWA, 2003)

- No remedy for ASR exists
  - Mitigation may consist of confinement

RECENT INTEREST IN ASR

- Concrete degradation is a challenge to nuclear energy sustainability
- Nuclear energy brief facts
  - Fleet of about 100 commercial light water reactors (LWR) in US
  - Provide about 20% of energy in US
  - LWR average age is close to 40 years
  - Expected to last additional 20-40 years
- Nuclear industry is highly regulated
  - Nuclear Regulator Commission (NRC) issues 40-year licenses for reactor operation
- NRC confirmed ASR in Seabrook NPP in 2011
  - Mitigation plan for ASR damage is required for relicensing

Seabrook Station NPP, Seabrook, NH (NRC Digital Archives)

INDUSTRY APPROACH TO ASR DAMAGE ASSESSMENT

No reliable non-destructive tests exist

Undesirable for high-value structures

Core Extrusions
Multiple cores from different sites
Multiple cores from same site for each destructive test

↓

Destructive Laboratory Test
Petrography/DRI Assessment
Chemical analysis of pore solution (ICP/MS)
Destructive fracture mechanics tests

↓

Structural Stability Calculations
Modeling of stresses in the entire structure
Prediction of mechanical fracture and resilience

Example:
Concrete cores from 60 year old bridge

8ft depth

52ft depth

CONVENTIONAL APPROACH TO ASR ASSESSMENT

- Microscopy of polished thin sections
  - Optical
  - Scanning electron (SEM) with elemental analysis
- Pore solution elemental analysis
  - Solution extracted with pore press
  - Elemental analysis with ICP/MS
- Length expansion is the only reliable NDE indicator
  - Not quantitative
- No reliable quantitative NDE signatures have been found
  - Recent R&D focused on linear and non-linear UT

Length expansion measurement at CTLGroup

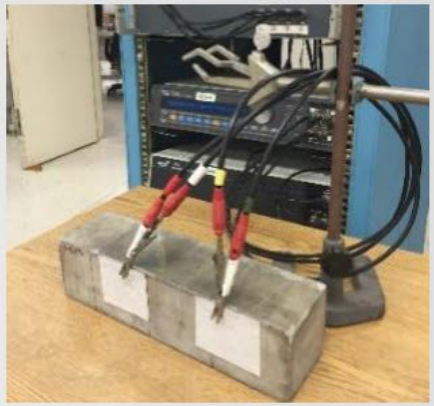
PROJECT GOALS

- Discover new ASR signatures
  - Analyze data obtained from macroscopic nondestructive measurements
  - New signatures correlate with standard length expansion ASR indicator

- Expected outcome
  - Obtain quantitative information about ASR from nondestructive measurements
  - May lead to development of new in-situ QNDE methods

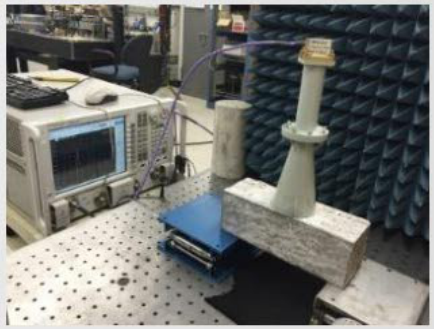
APPROACH

- Study properties of ASR-affected concrete specimens using
  - Microwave Backscattering
  - Impedance Spectroscopy
  - Thermal tomography



Impedance spectroscopy at ANL

- Validate with a set of accelerated ASR specimens
  - Year-long study of ASTM C1293 small concrete prisms
  - Year-long size scaling study with large reinforced concrete blocks made with ASTM C1293 concrete mixes



Microwave backscatter at ANL

BRIEF COMPARISON TO PRIOR WORK

Microwaves

- Prior studies of ASR in small mortar samples placed inside microwave waveguide (Missouri S&T, Georgia Tech)

Impedance Spectroscopy

- Prior studies of concrete material properties characterization, but not ASR (Northwestern & NIST)

MATERIAL PREPARATION

ASR IN CONCRETE PRISMS

- CTLGroup developed concrete prism specimens according to ASTM 1293 standard
- Two types of mixes
  - Reactive (**RA**)
  - Non-reactive (**NR**)
- Properties
  - Concrete prisms 3"x3"x11.25“
  - Both RA and NR contain small reactive aggregates and large non-reactive aggregates
  - ASR mitigated in NR by partially substituting fly ash for Portland cement

Concrete Component or Property	Material or Property	Sieve (in)	RA (% vol)	NR (% vol)
Portland Cement	pH = 13.1		13.5	9.4
Fly Ash	(Class F)		-	4.8
Coarse Aggregates	Crushed limestone	¾ - ½	14	14
		½ -3/8	14	14
		3/8 – ¼	14	14
Fine Reactive Aggergates	Quartz, feldspar, chert, glassy volcanic particles	< 3/8	25.2	24.2
Water			17.7	17.7
Air Voids			1.5	2
Compressive strength (psi @28 days)			7200	6300

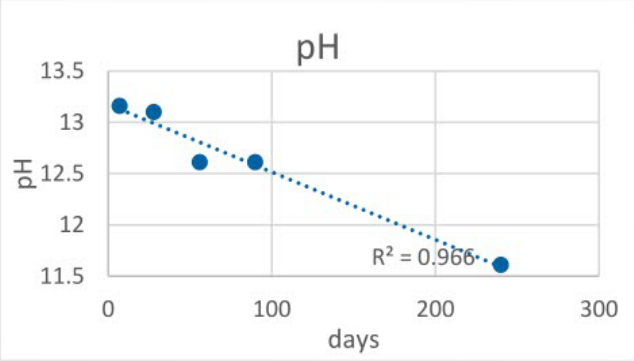
ASR DEVELOPMENT AND MONITORING

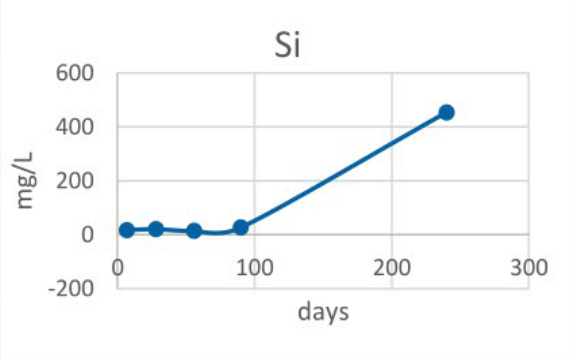
- Specimens were kept at CTL in environmental humidity chamber
  - 38C and 95% RH
- Specimens were taken out of chamber at specified intervals and transferred to ANL
  - 28, 56,120, 183 and 365 days
  - Removal from chamber arrests ASR progression
- Monitoring at CTL
  - Length expansion and mass change measurements
  - Petrography of select specimens
  - Pore solution extraction

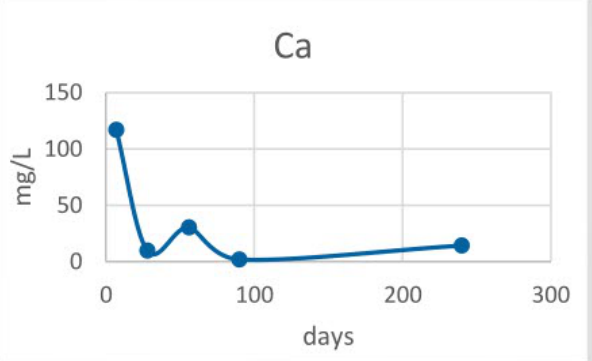
ASR specimens stored over water in CTL

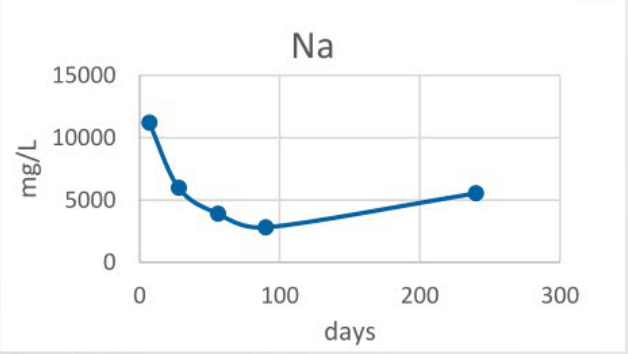
PORE SOLUTION ANALYSIS

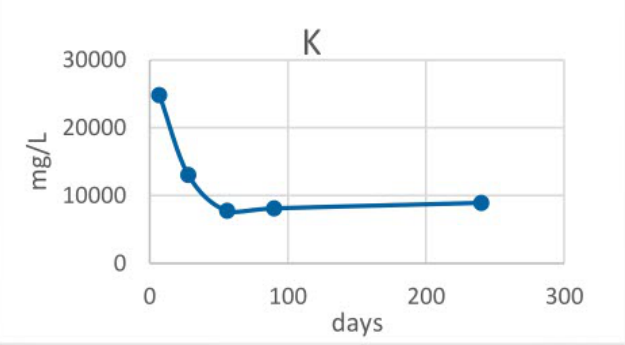
- Specimens are crushed
- Pore solution extracted in high pressure device (up to 200,000 psi) and analyzed using ICP/MS

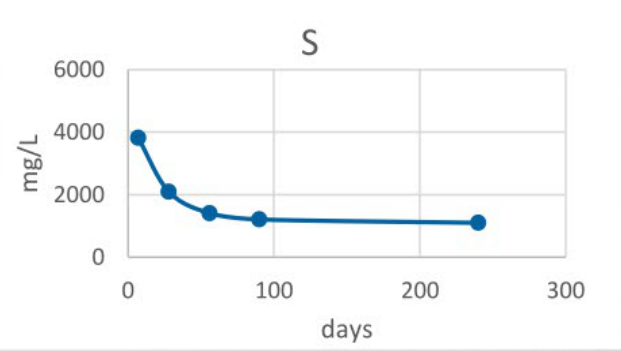








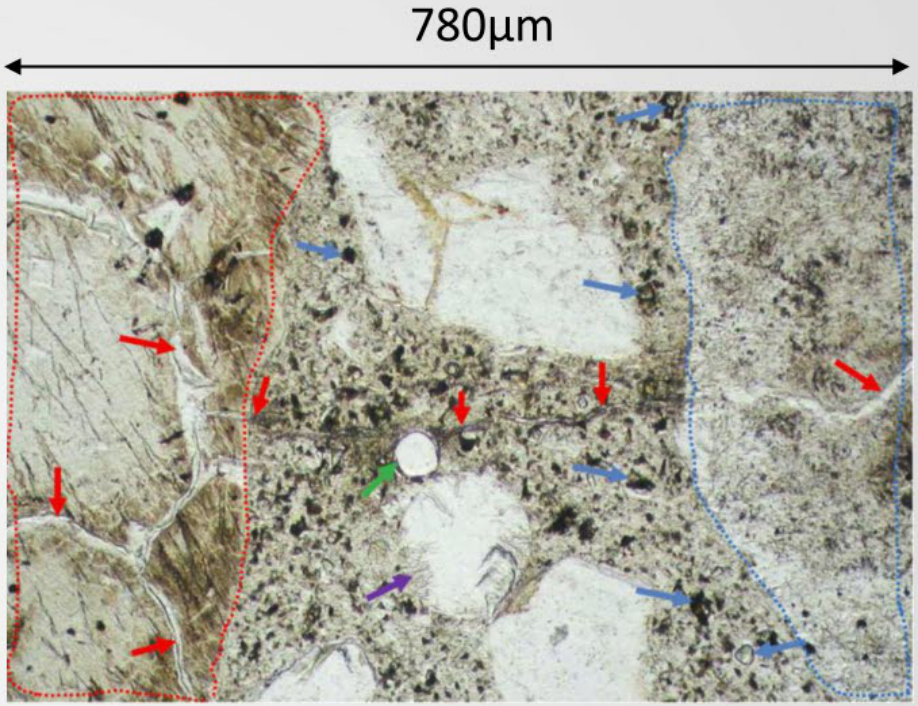




PETROGRAPHY ANALYSIS

- High resolution optical microscopy of grinded 20µm thick concrete sections
- Analyzed 1st and 12th month specimens

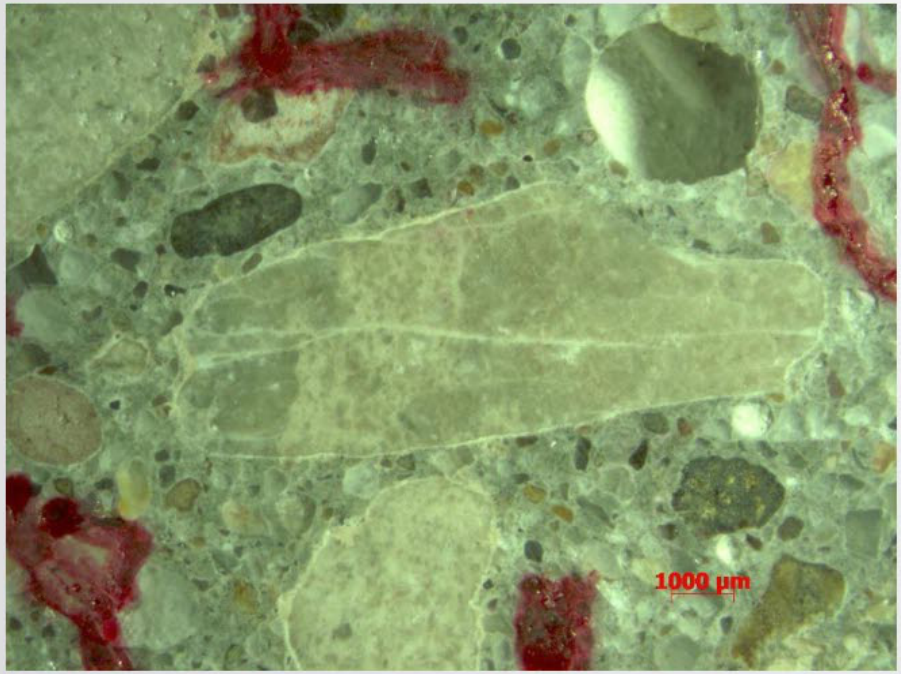
Damage Type	RA		NR	
	1st Month	12th Month	1sr Month	12th Month
ASR gel partially to completely filing air voids	Many	Many	Several	Several
ASR gel partially to completely filing microcracks	Several	Several	None	Few
Microcracks extending from within RFA and around CA	Some	Many	None	Very few
DRI	323	662	15	39

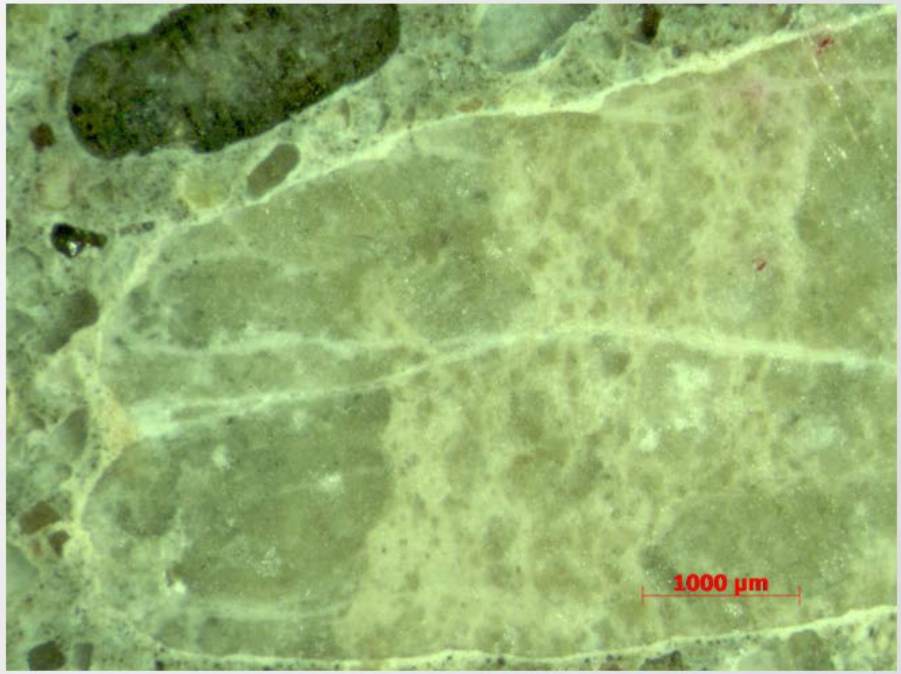


Example of 12th month specimen imaged with plane polarized light. Blue arrows designate residual Portland cement grains. Microcracks (red arrows) extend from a reacted volcanic glass fine aggregate particle (red encirclement) into the paste and nto another reacted volcanic glass particle (blue encirclement). ASR gel lines an air void. Ettringite is observed lining another air void (purple arrow).

ACOUSTIC MICROSCOPY

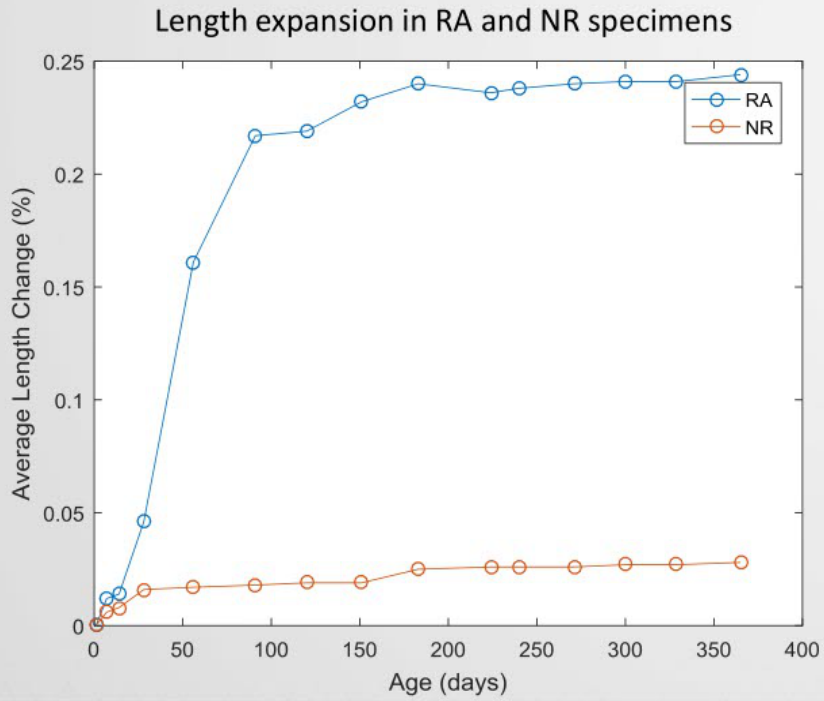
- Examples of Sonoscan acoustic microscopy at UIC (A. Chudovsky's group)

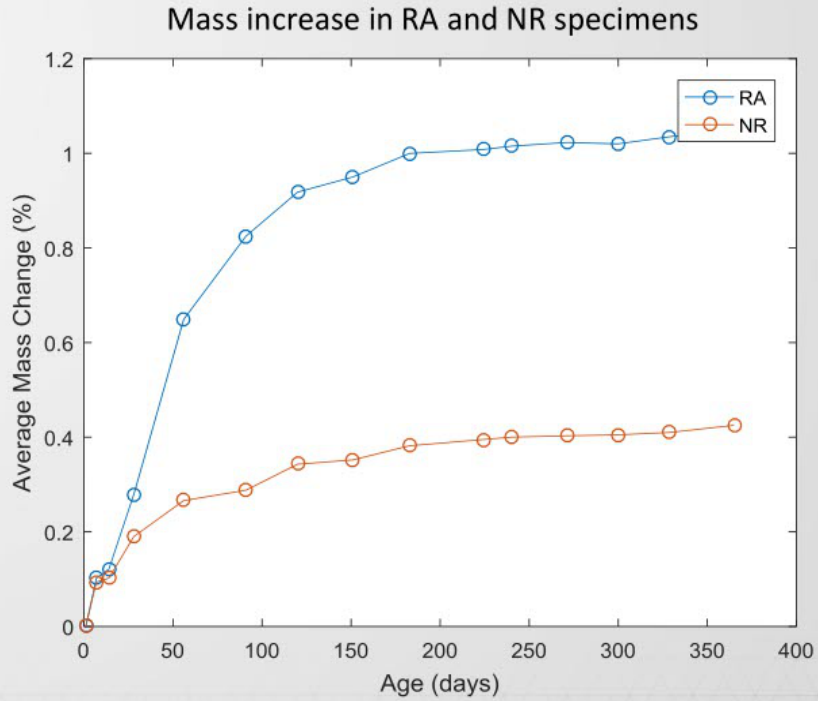




CONCRETE PRISM CONDITION MONITORING

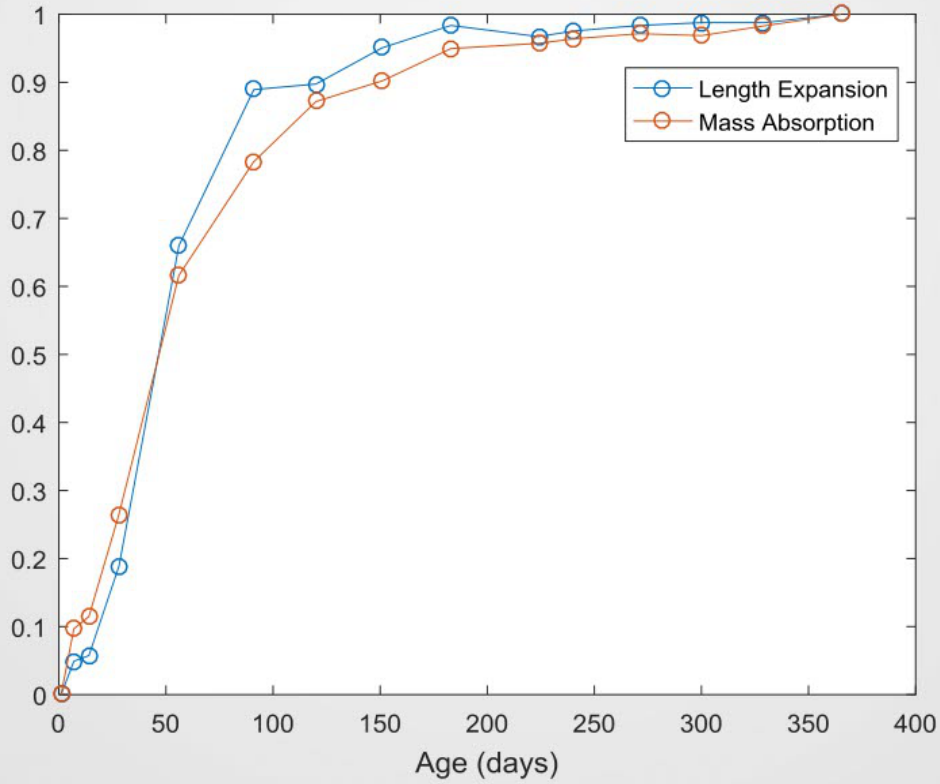
- Length expansion and mass increase measurements
- ASTM threshold for ASR confirmation is 0.04% length expansion





NORMALIZED AND OVERLAID LENGTH AND MASS EXPANSIONS

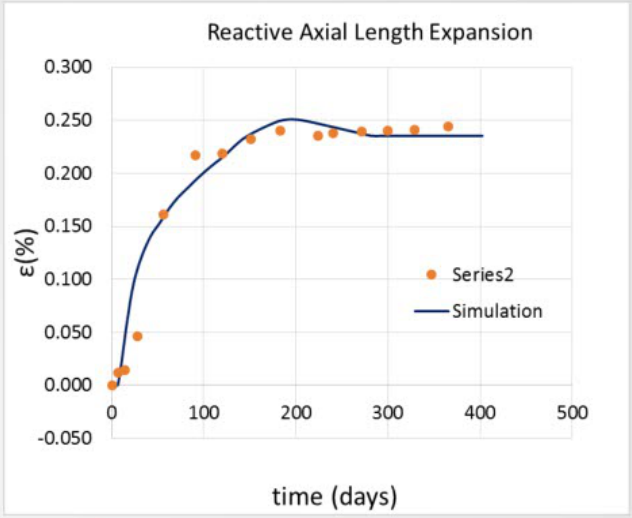
- Reactive specimens
- Reaction stops after 180 days



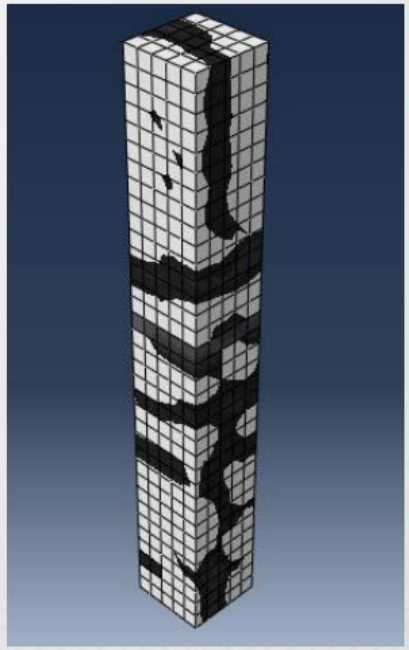
COMPUTER SIMULATIONS OF ASR DAMAGE

- Calculated ASR damage in concrete using Microplane model (Caner-Bažant 2013)

- Predict most cracks to develop with normal orientation to the largest dimension of the sample.



Modeling ASR strain



Predicted cracking pattern visualized with Abaqus

ASR ANALYSIS

- Focus on ASR at material surface
- Surface consists of a layer of cement paste and sand
  - No coarse aggregates
- ASR gel appears on the surface because of either
  - Gel migration
  - ASR in the surface layer

MICROWAVE BACKSCATTERING (MBS)

RATIONALE FOR MBS

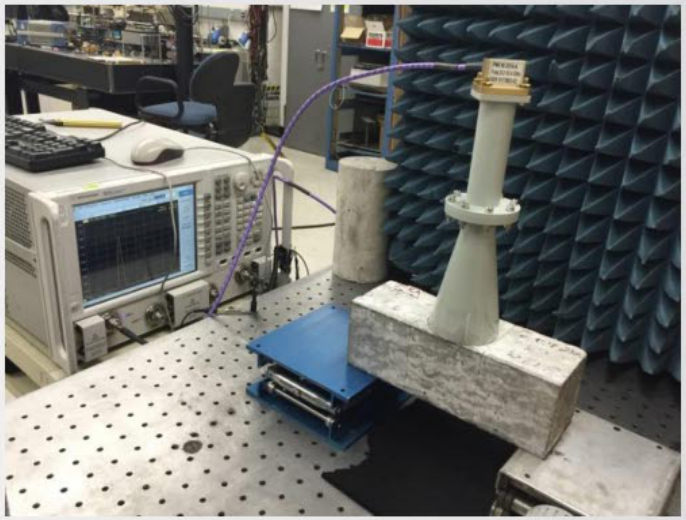
- Microwaves are very sensitive to water
- Higher ASR gel content can lead to more water absorption

Substance	$\varepsilon/\varepsilon_0$
Water	55
Alkalai-silica glass 6.4% Na_2O, 6.4% K_2O, 87.2% SiO_2	5.50
Coarse Aggregate	6
Cement (Portland)	4
Sand (fine aggregate)	2.3

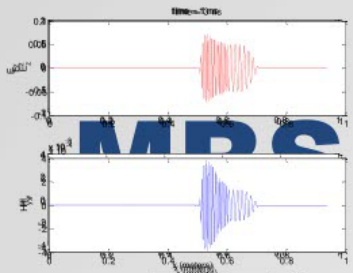
Values taken from Von Hippel's reference

MBS IN TIME DOMAIN

- Measured microwave backscattering as S_{11} network parameter using Keysight PNA
- Convert frequency-swept PNA signal into time-domain pulse with on-board FFT
  - X-band antenna (8.2GHz to 12.4GHz) slides along concrete prism
  - Measured S_{11} values averaged over spatial positions
- Calculate ε (real part) from front surface reflection ($r=S_{11}$)

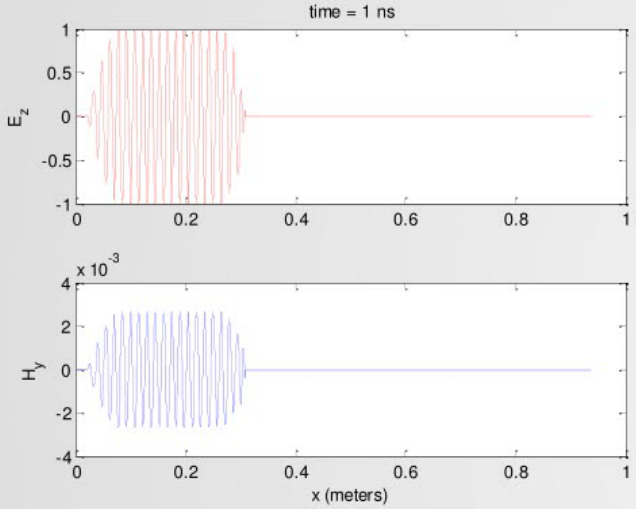


MBS measurement setup at ANL

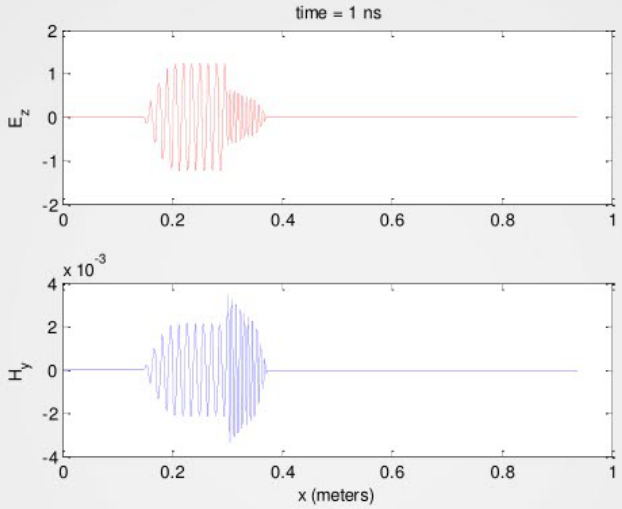


MRS VISUALIZATION

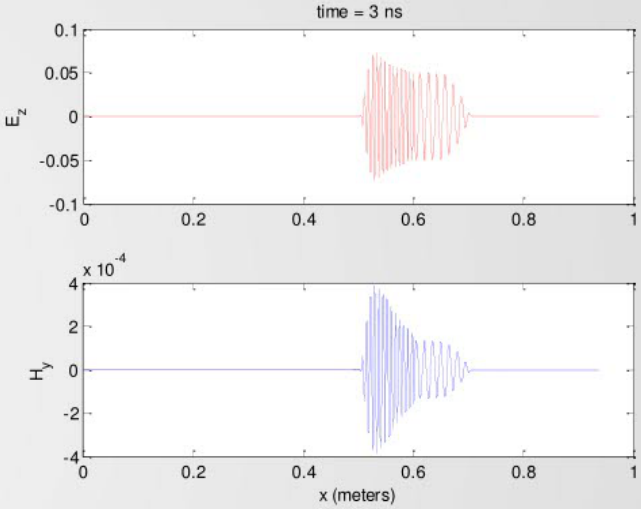
- FDTD visualization of microwave pulse propagation and reflection from concrete slab



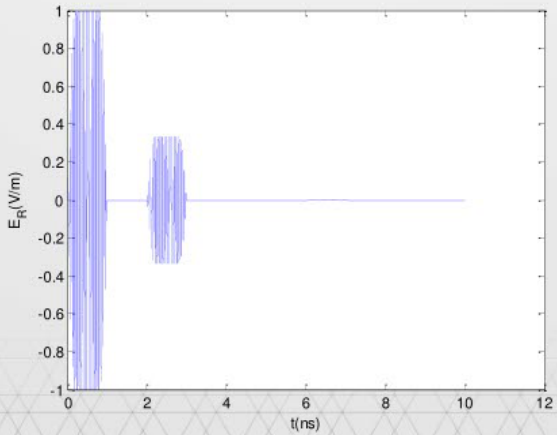
Incident pulse in air



Reflection from front edge



Reflection from back edge



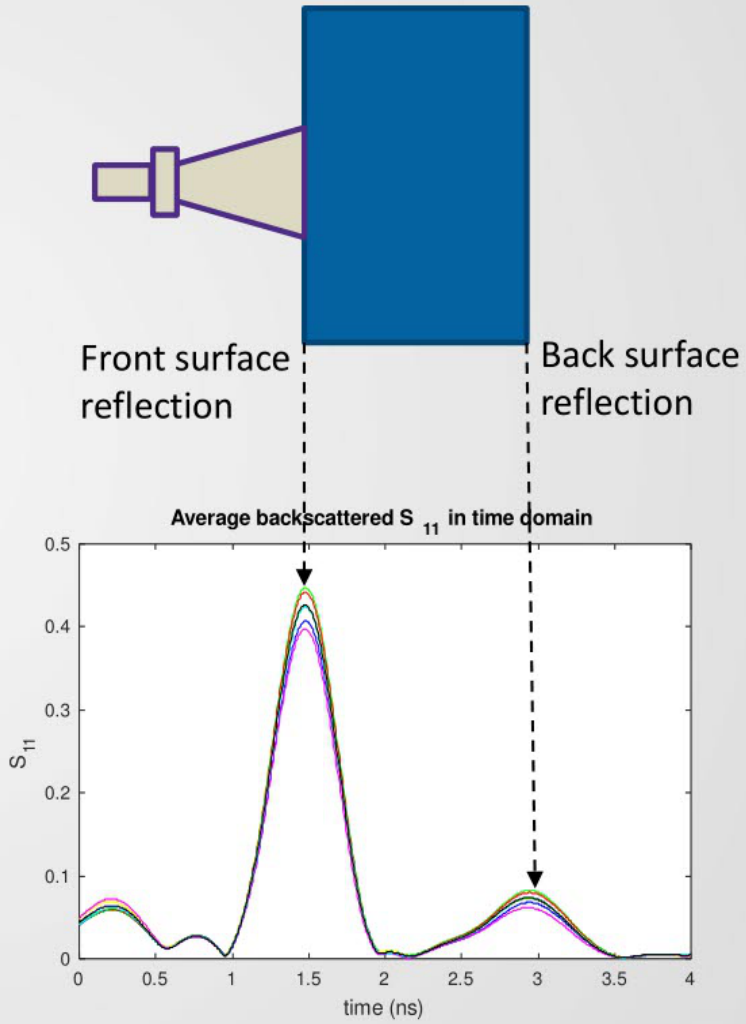
Reflected E-field

MBS IN TIME DOMAIN

- Backscattered signal has two peaks corresponding to front and back surface reflections

- Calculate ε (real part) from front surface reflection r

$$r = \frac{\sqrt{\varepsilon} - 1}{\sqrt{\varepsilon} + 1} \quad \Rightarrow \quad \varepsilon = \left(\frac{1 + r}{1 - r} \right)^2$$



VALIDATION WITH STANDARD MATERIALS

- Calculated epsilon from microwave surface backscattering compared to values in Von Hippel's reference

Material	Measured/ Calculated	Tabulated	Error (%)
Plexiglass	2.63	2.59	1.5
Silicone Rubber	2.86	3	4.6
Alumina-Silicate Ceramic	5.32	4.95	7.4

MAXWELL GARNETT (MG) MODEL FOR DATA INVERSION

- Effective medium dielectric constant for cement with water

$$\varepsilon_{eff} = \varepsilon_c + 3\varepsilon_c \frac{f_w \dfrac{\varepsilon_w - \varepsilon_c}{\varepsilon_w + 2\varepsilon_c}}{1 - f_w \dfrac{\varepsilon_w - \varepsilon_c}{\varepsilon_w + 2\varepsilon_c}}$$

known

ε_w = dielectric permittivity of water

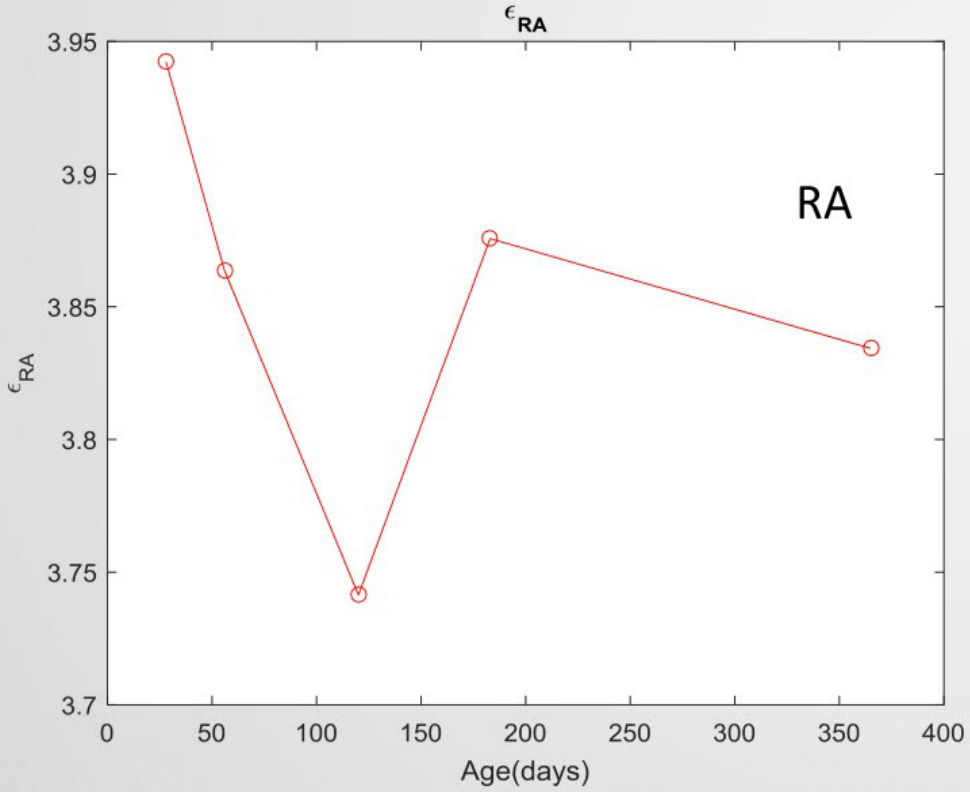
ε_c = dielectric permittivity of cement

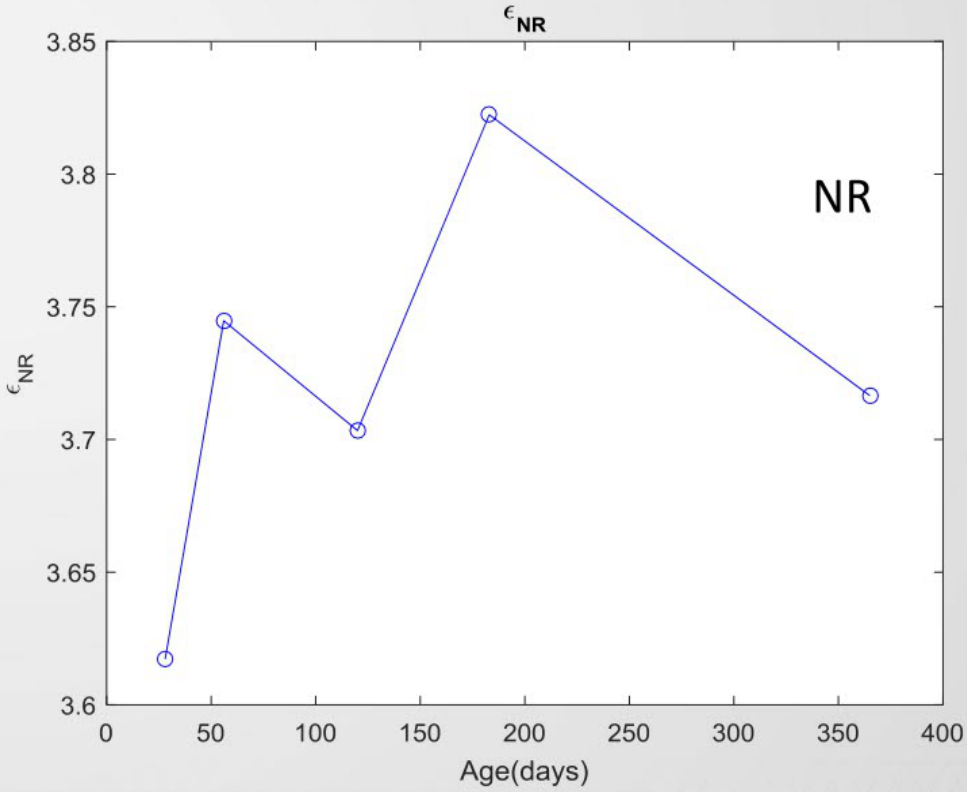
- Water volume fraction can be calculated as

$$f_w = \frac{\varepsilon_w + 2\varepsilon_c}{\varepsilon_w - \varepsilon_c} \frac{\varepsilon_{eff} - \varepsilon_c}{\varepsilon_{eff} + 2\varepsilon_c}$$

DEHYDRATED SPECIMENS

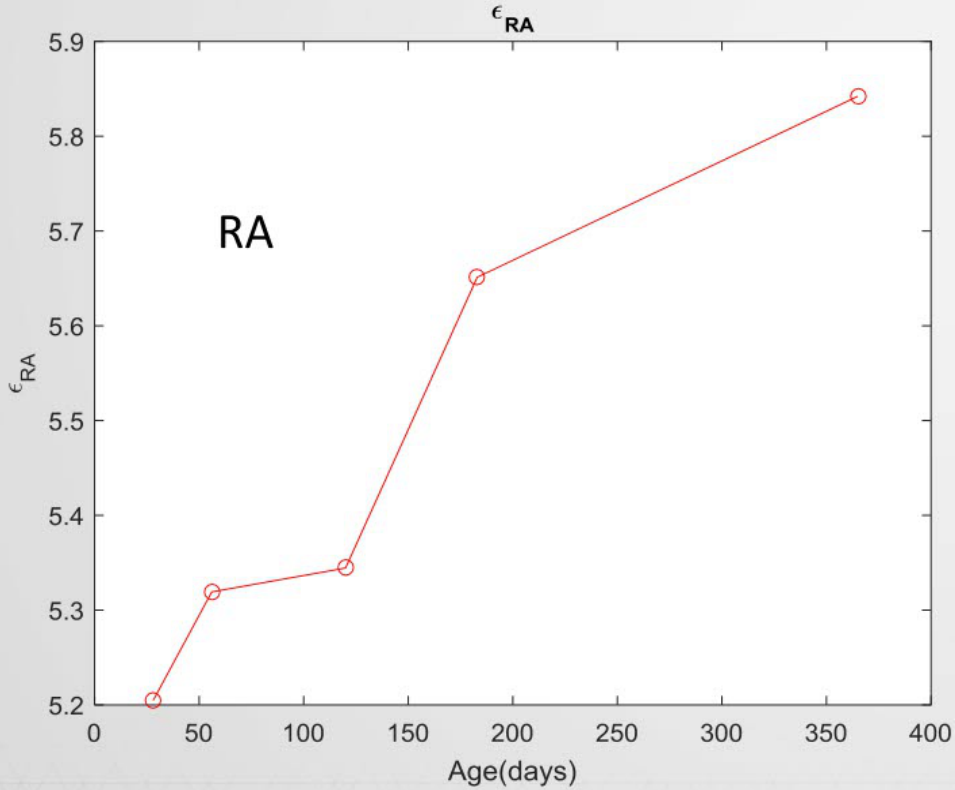
- Dehydrate all specimens via oven drying until steady-state mass is reached
- Measure microwave backscattering and calculate epsilon
- Assume this to be ε_c

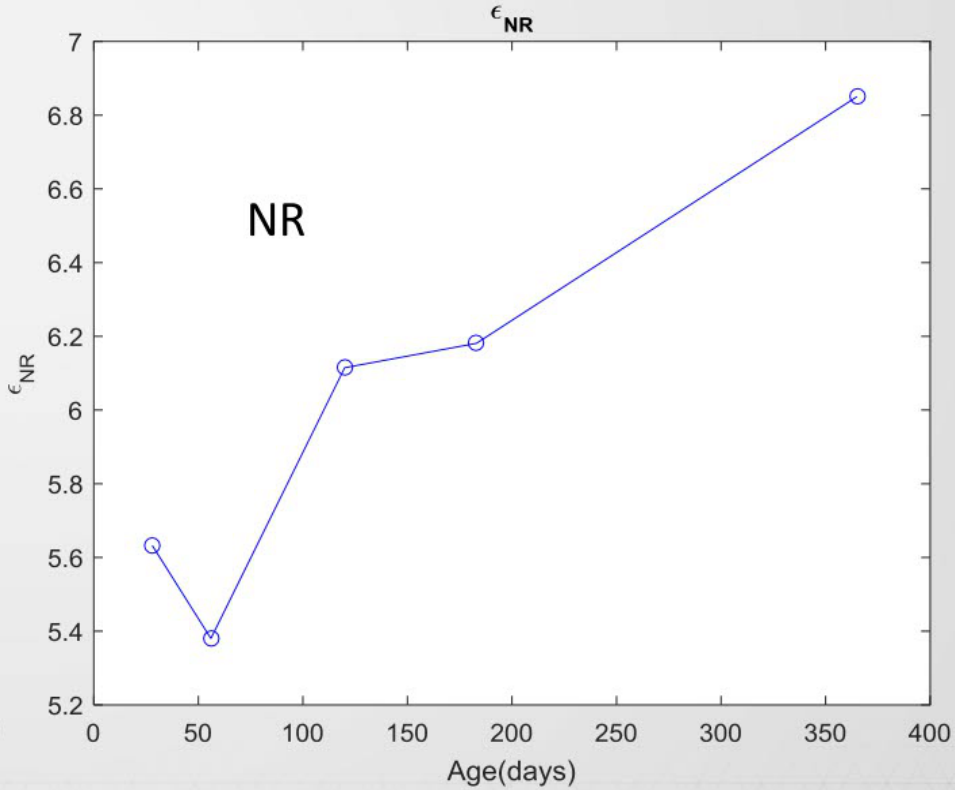




HYDRATED SPECIMENS

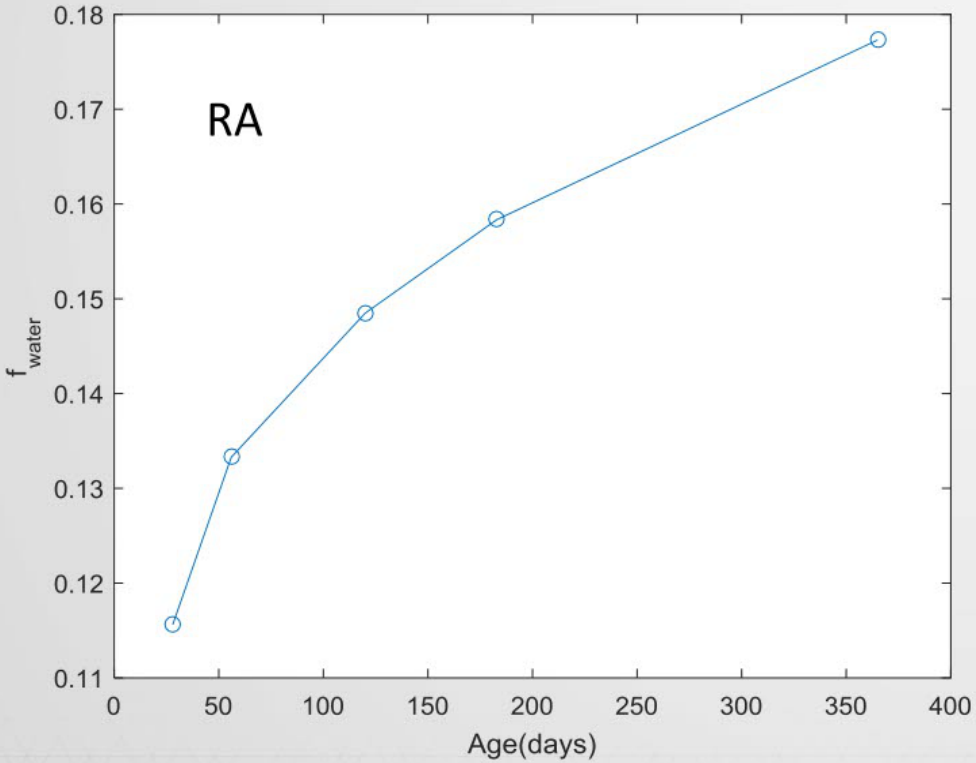
- Hydrate all specimens in water bucket until steady-state mass is reached
- Measure microwave backscattering and calculate epsilon
- Assume this to be ε_{eff}

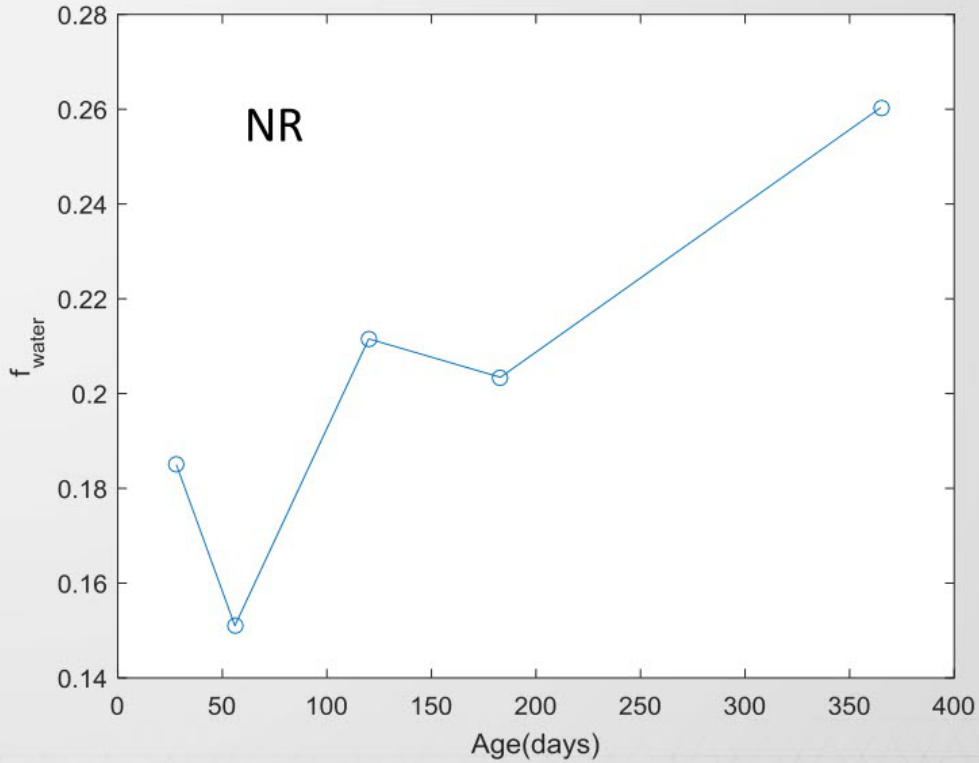




ESTIMATED WATER VOLUME FRACTION FROM MG

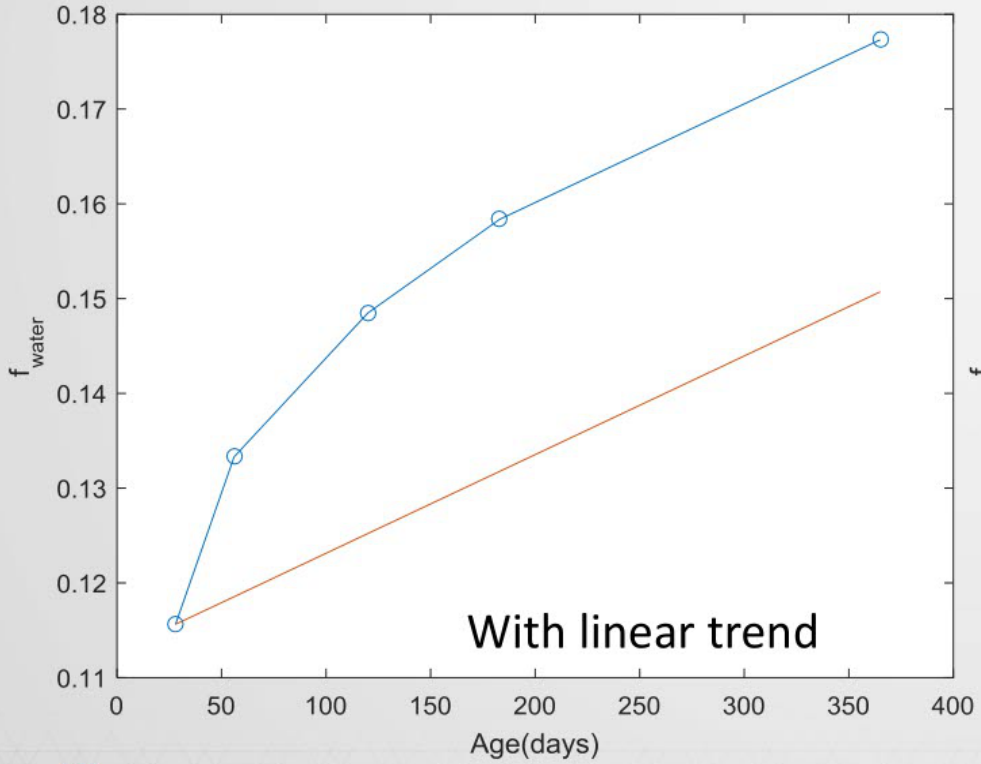
- Water volume fraction for both reactive and non-reactive specimens have linear increase trends
  - Could be due to a combination of processes unrelated to ASR

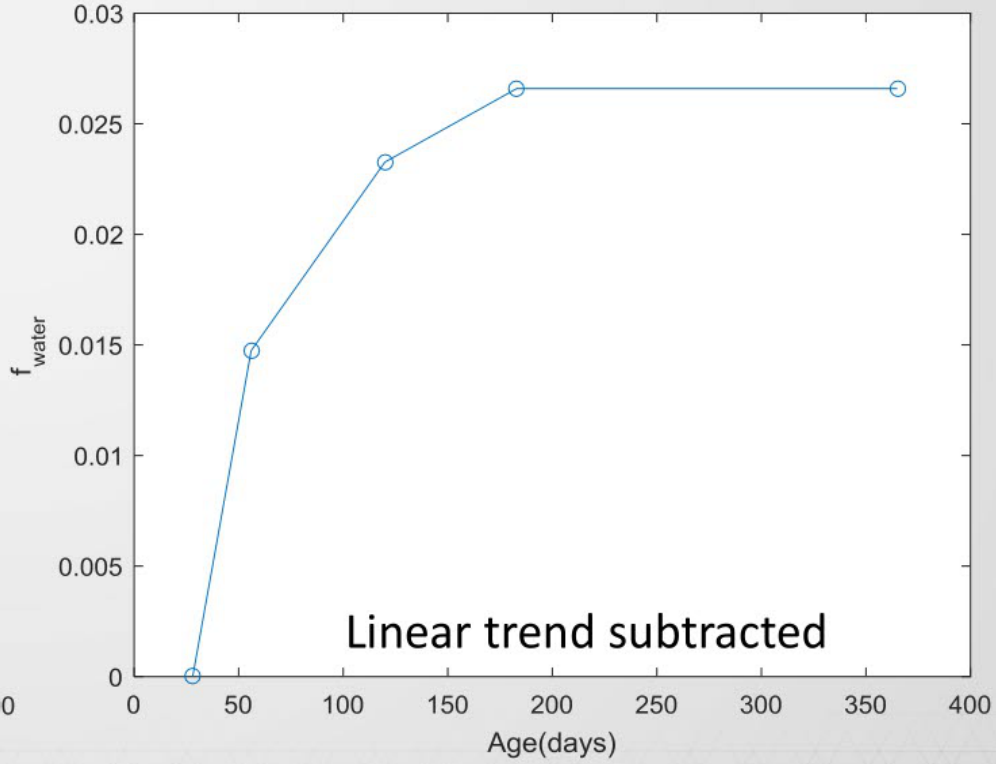




ANALYSIS OF REACTIVE SPECIMEN DATA

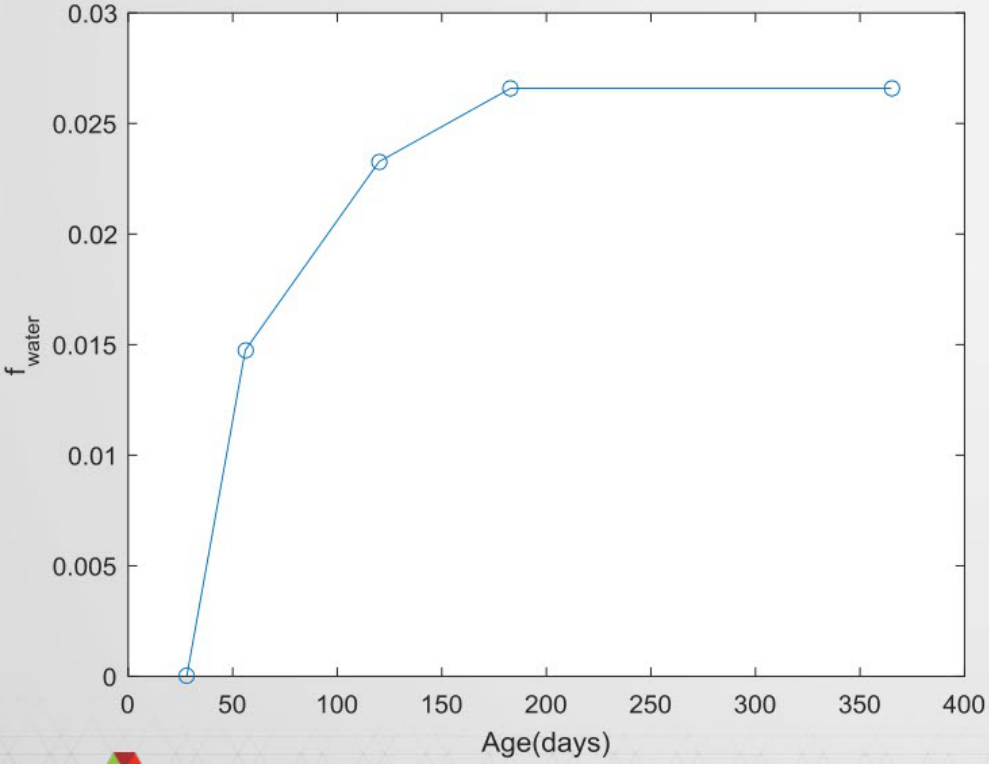
- ASR stops after 180 days
- Assume linear increase between 180 and 365 days is unrelated to ASR
- Find a linear fit to this segment and subtract linear fit from the curve

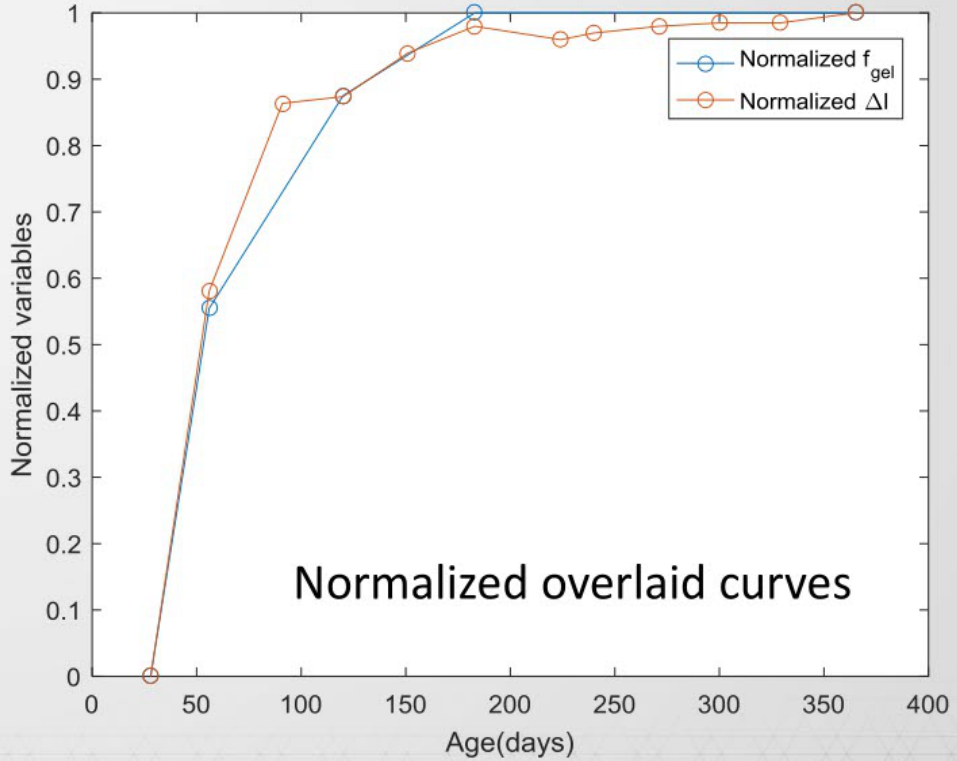




NONLINEAR RESIDUAL

- Assume residual is related to ASR gel volume fraction
  - Numbers agree with the estimates from petrography
- Validate with length expansion data





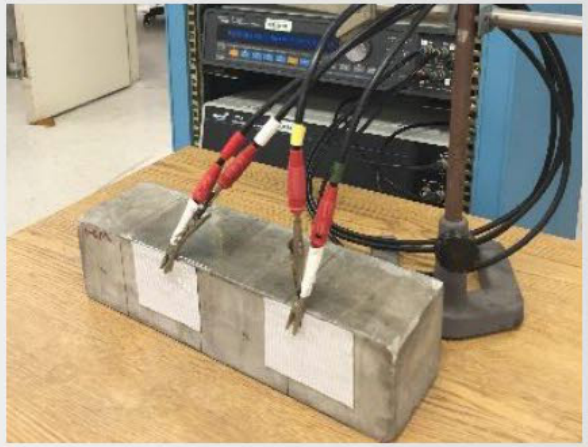
ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY (EIS)

RATIONALE FOR EIS

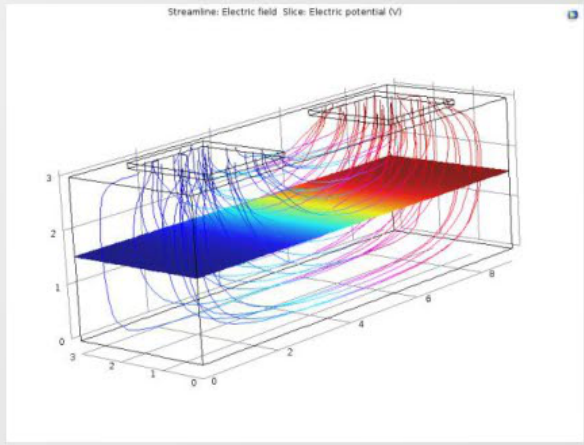
- Electrical conduction occurs through connected network of pore solution
- Gel diffusion into pores and microcracks could disrupt network connectivity

EIS OF CONCRETE

- One-sided electrical property measurement of concrete with Solartron
  - 2-point probe geometry using flexible carbon black electrodes
  - Uniform electrical coupling to rough concrete surface
  - Increase repeatability of measurements by averaging over 2”x2” electrode area
- Penetration depth
  - Electrodes placed at 5” distance center-to-center
  - Computer simulations of uniform dielectric indicate 3” penetration depth



EIS measurement setup at ANL

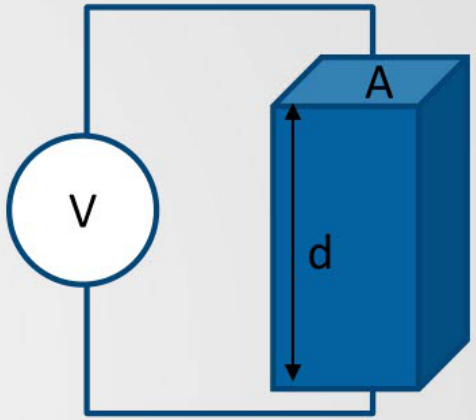


Preliminary COMSOL simulation of IS

BRIEF REVIEW OF EIS

- Measurement of complex valued impedance

$$Z(\omega) = R(\omega) - j/\omega C(\omega)$$

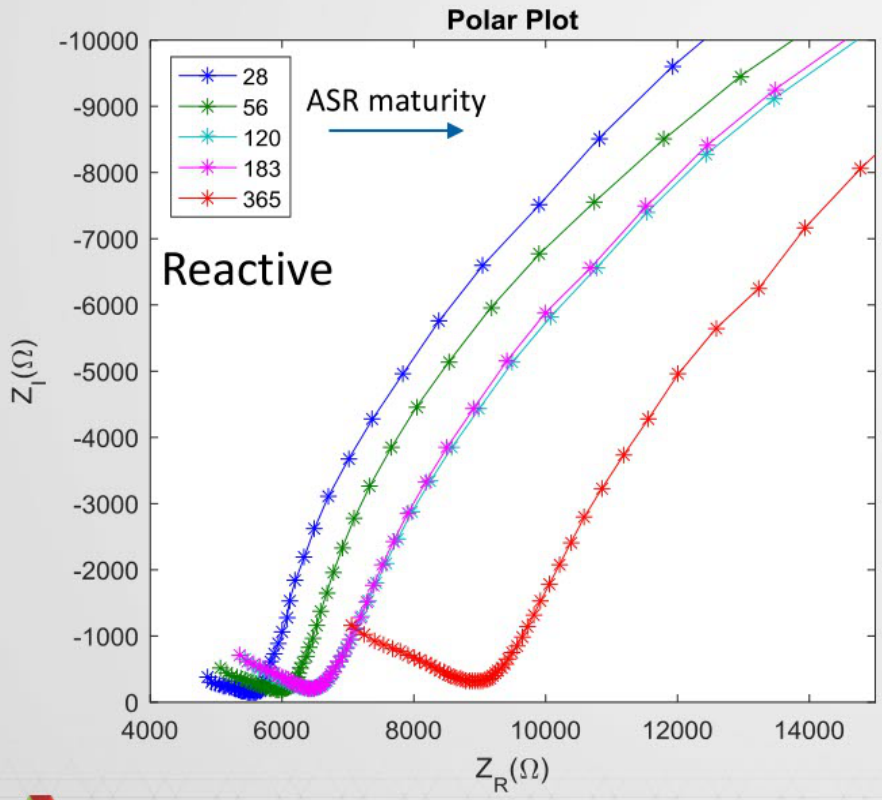


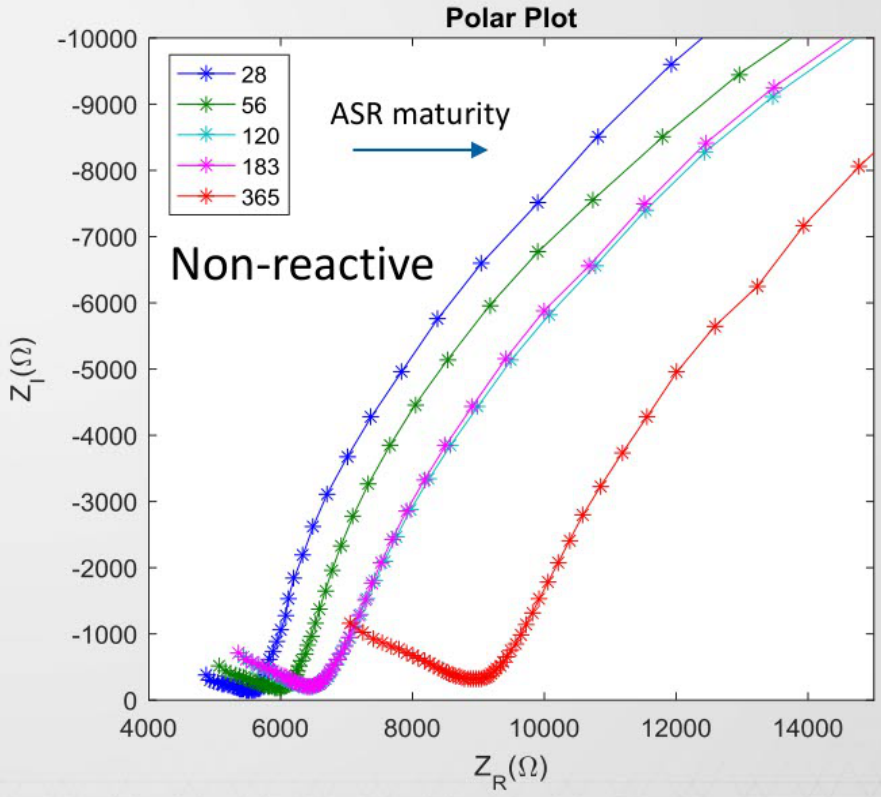
- In this study
  - 1V AC potential difference
  - Frequency sweep from 10mHz to 150KHz

- Different ways to present the data
  - |Z| and phase(Z) a functions of ω
  - Z_R and Z_I as functions of ω
  - Z_I vs. Z_R (polar or Nyquist plot)

EIS OF HYDRATED CONCRETE PRISMS

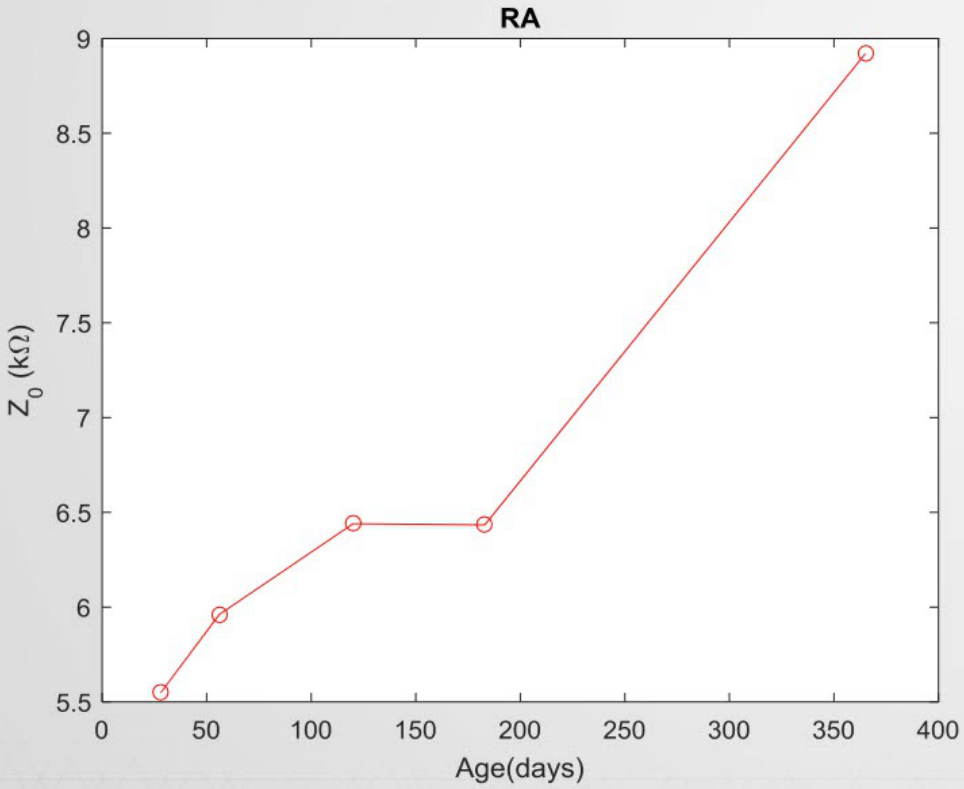
- All RA and NR prism specimens were hydrated to equalize initial imbibed water levels
- Bulk resistance (inflection point, where $Z_0 = Z_R$ and $Z_I = 0$) as invariant in measurements
  - Independent of electrode type (compared carbon black and copper foil)
  - Independent of translation of electrodes along prism when relative distance is fixed

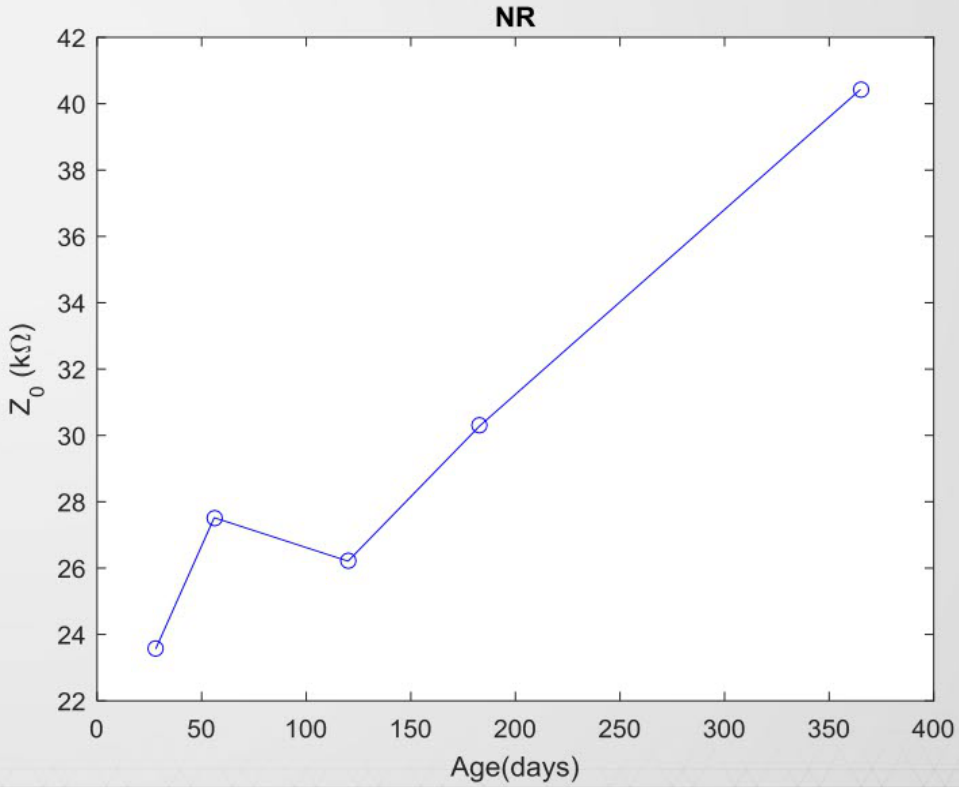




EIS DATA ANALYSIS

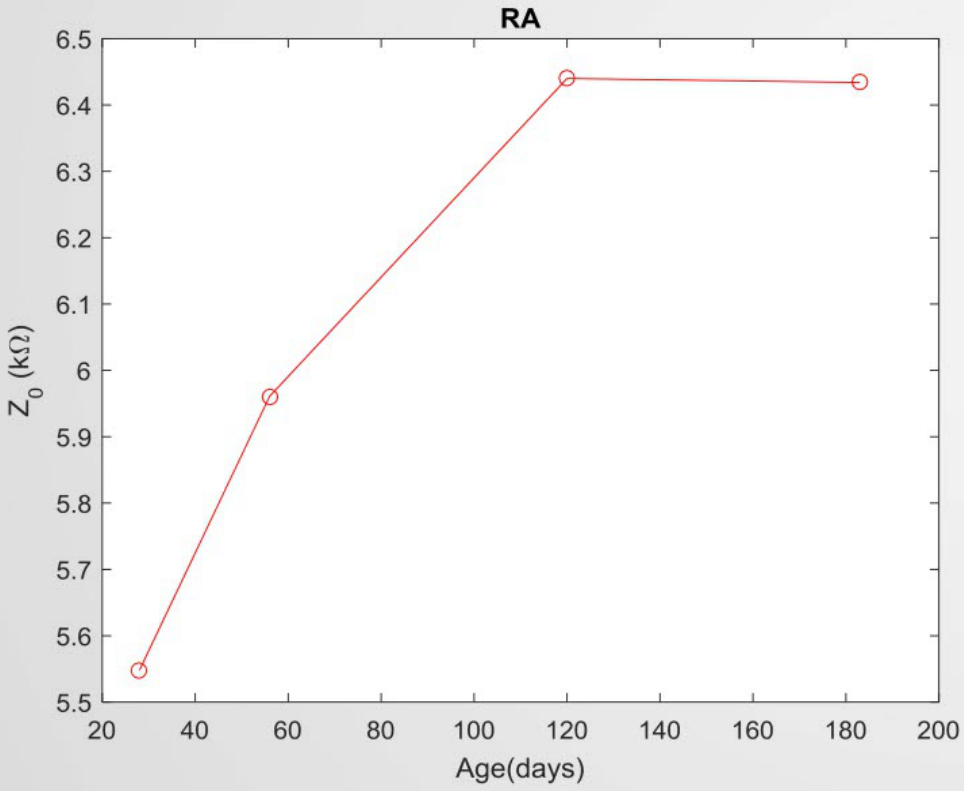
- Z_0 increases for both reactive and non-reactive specimens with ASR maturity
- Ignore the data point at 365 days

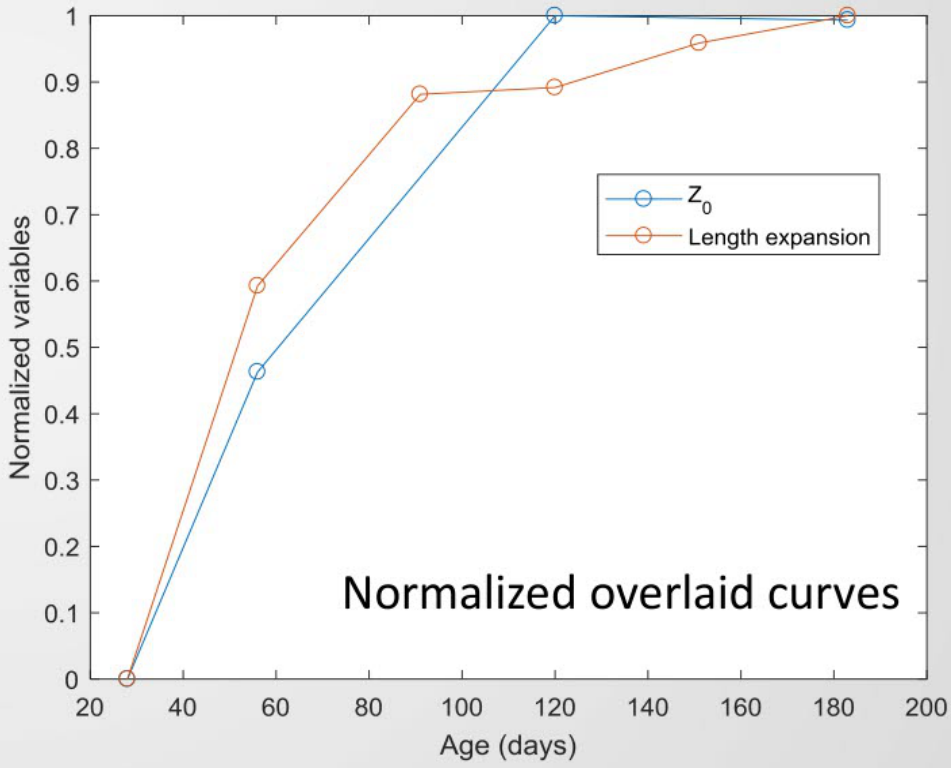




EIS DATA ANALYSIS

- Correlation with length expansion



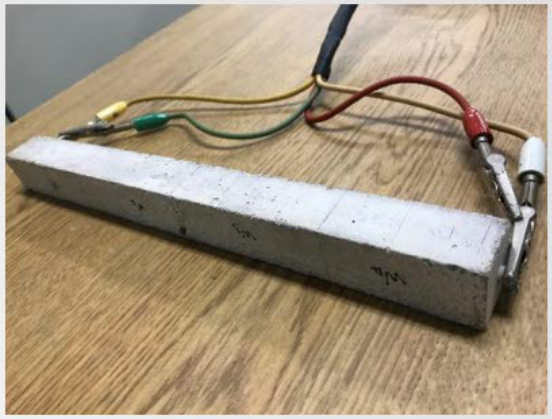


CONSIDER DIFFERENT REACTION

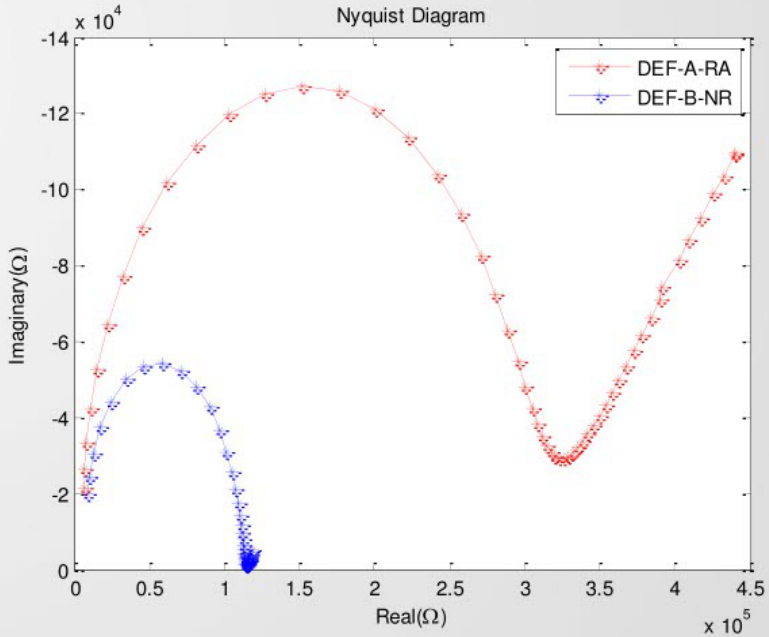
DEF SPECIMENS

- Delayed ettringite formation (DEF) reaction
  - Occurs because of improper curing of cement at high temperature and late formation of ettringite microscopic crystals
  - Causes long term expansion cracking of concrete

- Preliminary analysis of DEF and age-matched control mortar bar specimens (1"x1"x12")



DEF mortar bar specimen at ANL



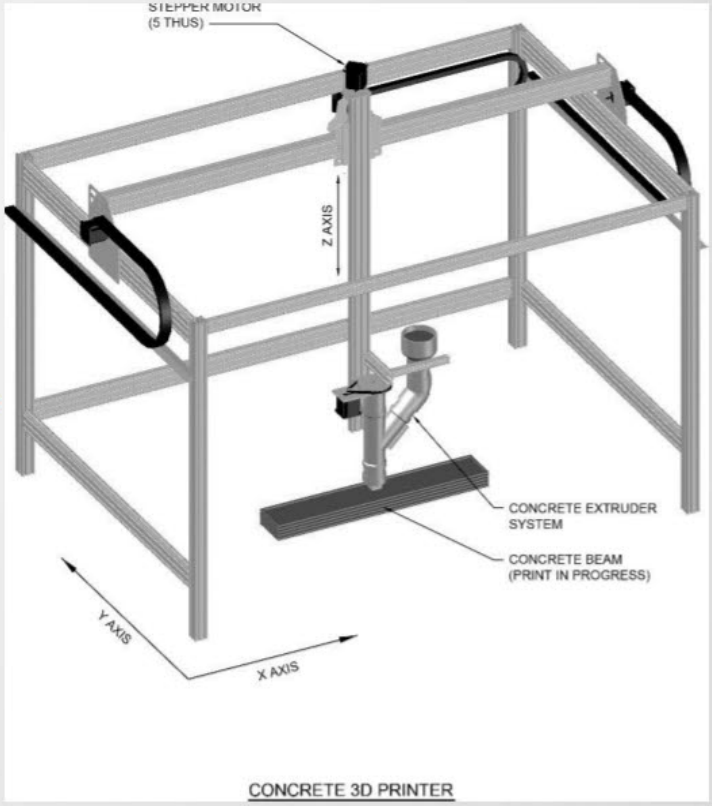
IS response of DEF (red) and control (blue) mortar bar specimens

3-D PRINTING OF CONCRETE

3-D PRINTED CONCRETE STRUCTURES

- Emerging approach to build concrete structures without molding formwork

3-D concrete printer at CTL



ADVANTAGES AND LIMITATIONS

- Advantages
  - In-situ on-demand construction
  - Construction in hazardous environment
    - High nuclear radiation zone
    - Under water

- Current technology limitations
  - Requires manual feed of concrete mix
  - Feedline clogging limits aggregate size
    - Mortar is produced instead of high strength concrete
  - No established NDE methods or quality control

EXAMPLES OF PRINTED STRUCTURES

- Dome

Tower

Bricks

- Specimens brought to Argonne

OBJECTIVE

- Develop capability to estimate curing progress and compressive strength in-situ using EIS
- Flexible electrodes confirm to rough surface of 3-D printed structure
- EIS provides information on free water content

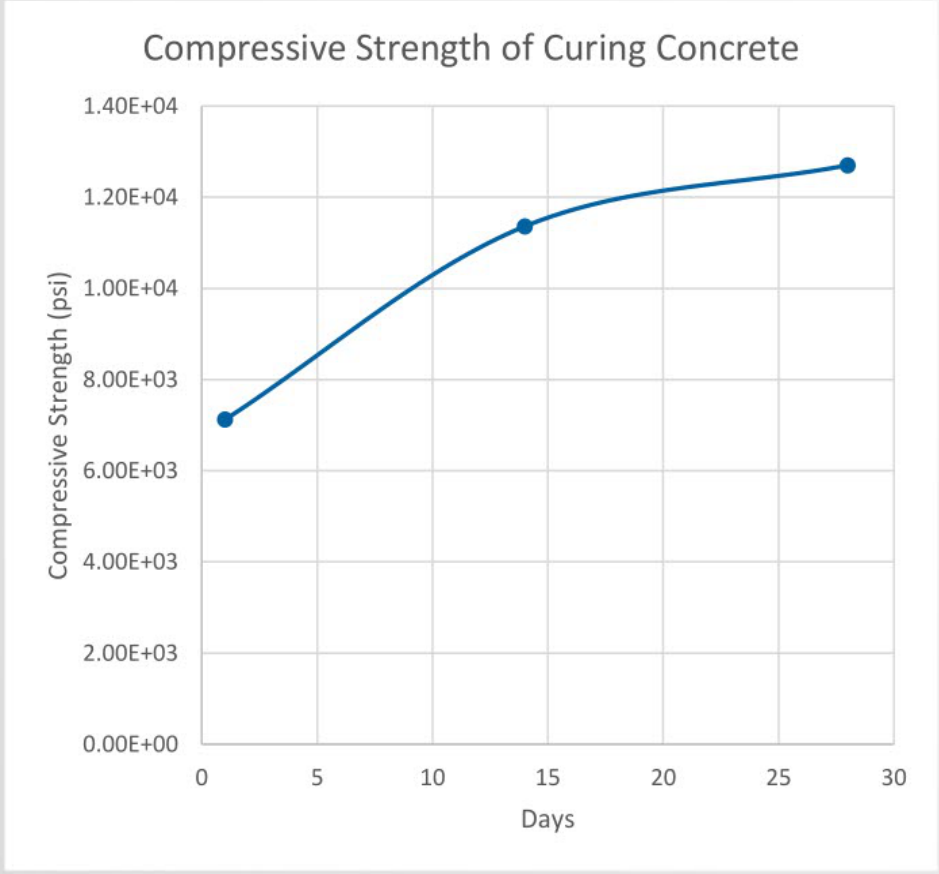
MONITORING OF 3-D PRINTED CONCRETE CURING

- A set of 3-D printed cylinders is divided into two batches
- Curing of 3-D printed concrete cylinders concurrently monitored
  - Destructively (mechanical strength test) at CTLGroup
  - Nondestructively (impedance spectroscopy) at Argonne
    - Flexible electrodes couple to rough surfaces

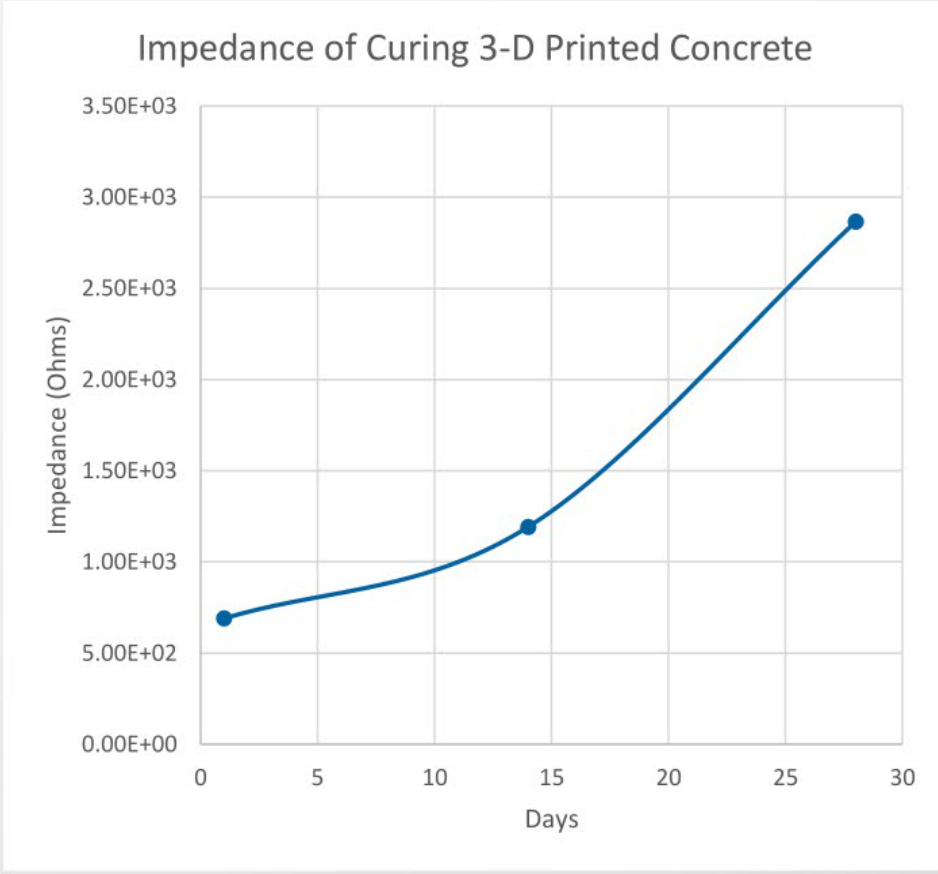
3-D printed cylinders at CTLGroup

MONITORING OF 3-D PRINTED CONCRETE CURING

Destructive Test

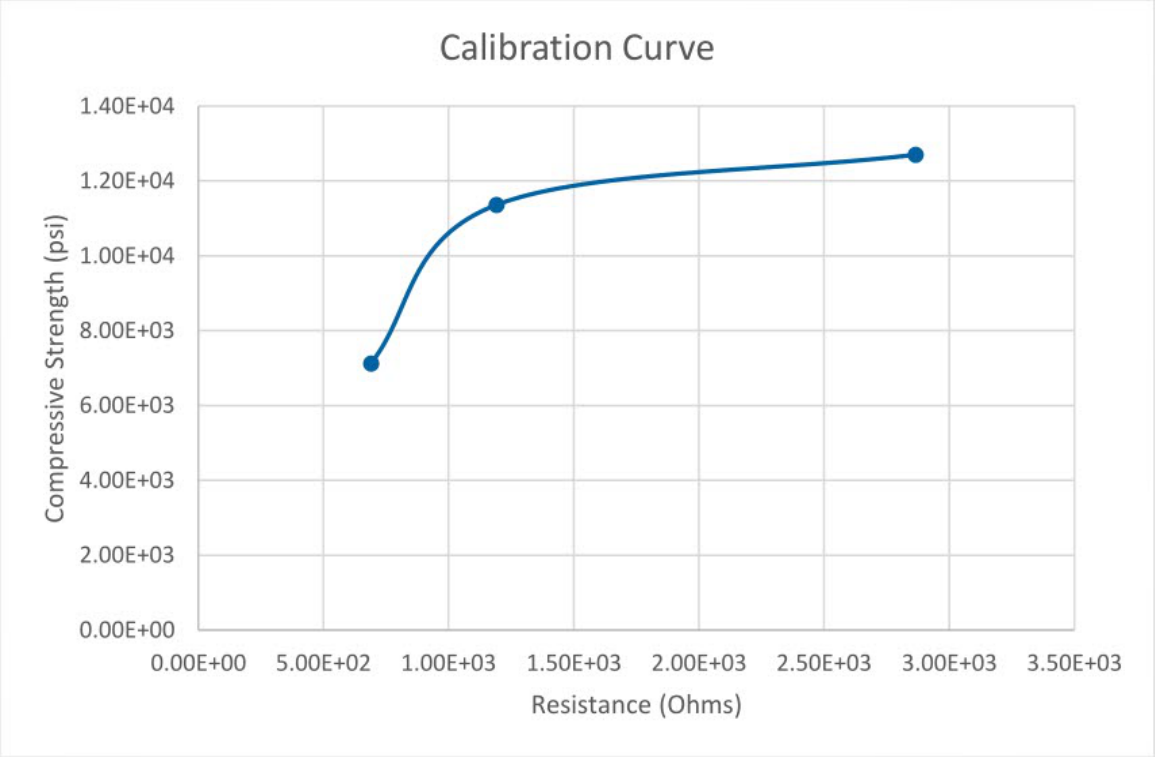


Nondestructive Test



MONITORING OF 3-D PRINTED CONCRETE CURING

- Developed calibration curve



PUBLICATIONS AND PRESENTATIONS

- A. Heifetz, S. Bakhtiari, J. Lu, I. Aronson, V. Vinokour, and A.F Bentivegna, "Development of non-destructive methods for detection of alkali-silica reaction in concrete structures," presented at the 43rd Annual Review of Progress in Quantitative Nondestructive Evaluation, Georgia Tech, Atlanta, GA, July 2016.
- A. Heifetz, S. Bakhtiari, J. Lu, I.S. Aranson, V.M. Vinokur, A.F. Bentivegna, "Development of microwave and impedance spectroscopy methods for in-situ nondestructive evaluation of alkali-silica reaction in concrete," AIP Conference Proceedings 1806(1), 12003 (2017).
- A. Heifetz, S. Bakhtiari, J. Lu, A. Bentivegna, "Nondestructive evaluation of alkali-silica reaction in high-strength concrete for aging structure sustainability," Transactions of American Nuclear Society 116, 453-456 (2017).
- A. Heifetz, S. Bakhtiari, J. Lu, and A. Bentivegna, "Nondestructive evaluation of alkali silica reaction in high-strength concrete for aging structures sustainability," presented at the American Nuclear Society Annual Meeting (ANS 2017), San Francisco, CA, June 2017.
- A. Heifetz, S. Bakhtiari, J. Lu, E.R. Koehl, A.F. Bentivegna, C. Arboleda, "Development of electrochemical and electrophysical methods for nondestructive evaluation of chemo-mechanical damage in concrete," presented at the 44th Annual Review of Progress in Quantitative Nondestructive Evaluation, Utah State University, Provo, UT, July 2017.
- S. Bakhtiari, H.T. Chien, A. Heifetz, T.W. Elmer, "Nondestructive testing research and development efforts at Argonne National Laboratory – An overview," submitted to Materials Evaluation (2017).
- A. Heifetz, P. Zapol, S. Bakhtiari "Application of microwave backscattering and impedance spectroscopy to nondestructive evaluation of alkali-silica reaction in concrete," manuscript in preparation for Journal of Applied Physics (2017).

SUMMARY

- Presented recent results of ASR analysis at Argonne
  - Analysis based on accelerated ASTM 1293 small prisms
  - Signatures found in microwave backscattering and impedance spectroscopy correlate with length expansion
- Next steps
  - Analyze data from cores taken from large blocks
  - Develop quantitative models of observations

ACKNOWLEDGEMENT

- Special thanks to all contributors
- Argonne
  - Sasan Bakhtiari, Peter Zapol, Igor Aronson, Dick Koehl, Mitch Farmer
- CTLGroup
  - Anthony Bentivegna, Catalina Arboleda, Greg Naweem
- Other collaborators
  - Sasha Chudnovsky (UIC), Zdenek Bazant (Northwestern)
- Interns and summer students
  - Yangquing Liu (UIC), Peter Bevington (UChicago), Juan Lu (IIT)

- Project sponsored by Argonne Nuclear Science and Technology LDRD

Note to requester:
Attachment is
immediately following.

From: Hiser, Matthew
Sent: Mon, 9 Jul 2018 15:33:29 +0000
To: Koshy, Thomas;Murdock, Darrell;Sircar, Madhumita;Pires, Jose
Cc: Purtscher, Patrick;Audrain, Margaret;Tregoning, Robert
Subject: FW: Irradiated materials from NRU reactor
Attachments: Reactor Artefacts Project (ReAP) February 8, 2018.pdf

Dear Mita and Tom,

I wanted to share some information I received regarding irradiated materials / harvesting from the NRU reactor in Canada. The slides on concrete and electrical components are #30-39. Please let me know if there's anything of interest to your areas in what they show on those slides.

Thanks!
Matt

Reactor Artefacts Project (ReAP)

February 8, 2018

Introduction

- National Research Universal (NRU) went critical in 1957.
- The original vessel was replaced in 1974.
- NRU missions:
  - Supply industrial and medical radioisotopes
  - Enable fuel and materials R&D for power reactor development
  - Sophisticated material characterization through the neutron beam line.
- In 2018 March, NRU will be shutdown and there is a desire to exploit this asset through artefact harvesting.

Introduction

- The NRU Harvest Project was developed as part of the Federal Nuclear Science & Technology (FNST) program managed by AECL.
- An inventory of materials with operating conditions has been prepared.
- These artefacts, which would otherwise become waste, present a research opportunity to be used to solve industry issues.

Purpose of the Meeting

- Awareness of project and framework.
- Presentation of the CNL inventory of artefacts.
- Obtain input from industry.
- Discussion of sample projects.

Framework for the Project (draft)

- Collaborative research project.
- Participation in three ways:
  - Participants contribute financially
  - In-kind contribution
  - Combination of financial and in-kind contributions
- Contributors/collaborators can participate in various aspects of the research project.

Framework for the Project (draft)

- Collaboration with industry will help to grow the project.
- Scope will be developed with input from participants.
- CNL will perform research, co-ordinate collaborative efforts, manage administrative details and organize a joint steering committee to oversee the project.
- Results will be shared with project participants and with the Canadian Federal Family.

Areas of Interest

Aging and material degradation issues in the following areas will be assessed:

- Effects of irradiation damage on reactor internals
- Concrete Aging and Degradation
  - ASR
  - Structural assessment of irradiated concrete
- Cable Aging and Degradation
  - Cable vulnerability studies based on temperature and irradiation
- Fuel Assessment (not discussed at this time)

Artefacts Inventory

Overview

- Artefacts Inventory (in- and out-of-core)
- Opportunities for Research using Artefacts to Resolve Issues in Nuclear Industry
- Timelines for Extraction of Artefacts

Artefacts for Research & Investigation

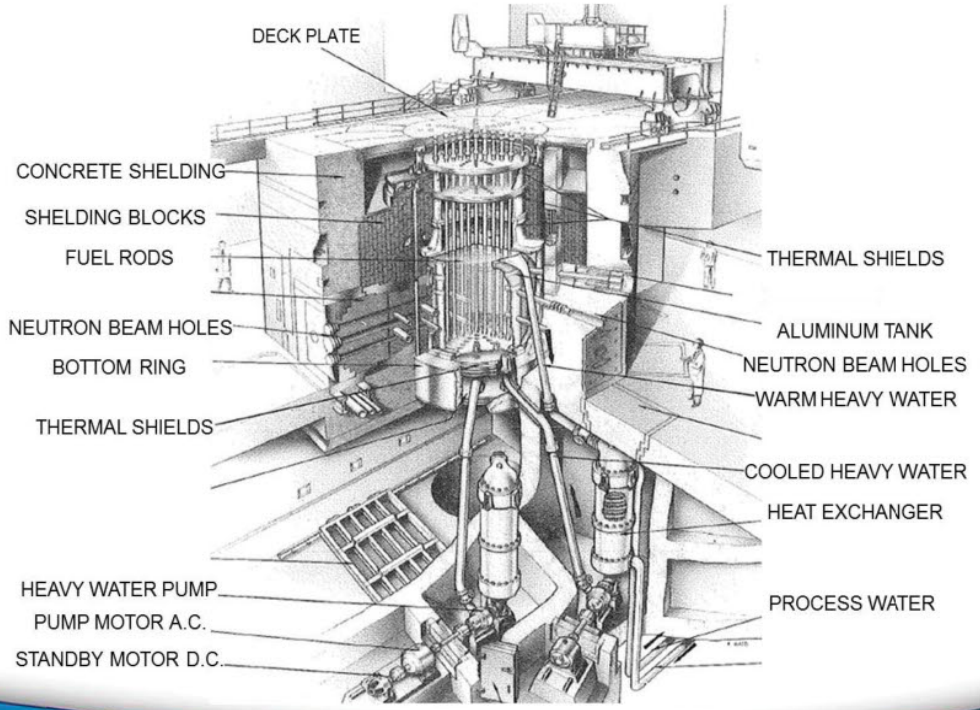
Materials and components have been irradiated in NRU since 1957 (365k hrs), some were irradiated since 1974 vessel replacement (270k hrs) over a wide range of temperature (35 °C to 310 °C), flux and neutron spectrum. NRU is heavy water moderated.

The NRU inventory includes:

- Structural materials

steels, Inconels, zirconium, aluminum, concrete;

- a thermal graphite column;
- flux detectors;
- equipment (including pumps);
- elastomers/seals;
- electrical cables.



NRU Structural Materials and Conditions

Assembly	Alloy	Irradiation conditions
Loop pressure tubes	Zr-2.5Nb Pressure Tubes – various manufacturing routes	Up to 8 yrs irradiation, 250-300°C Up to $6x10^{25}$ n/m^2 (E>1MeV)
Loop liner tubes – high strength secondary containment	Zr-2.5Nb (3 available)	Up to 9.5 yrs irradiation, 50 °C Up to $7.3x10^{25}$ n/m^2 (E>1MeV)
Control rod shroud tube	Zr-2 annealed tube: 4-11/16" OD x 0.046" wall X-750 spring: nominally 3-7/16" ID and 3/16" wire ASTM B637 N07750 Type 1, 2 or 3 304 SS rings riveted at either end of the assembly	Up to 44 yrs, 35 °C. Zr-2: up to 2.9 $x10^{27}$ n/m^2 (E<0.625 eV) X-750: ~$4x10^{26}$ n/m^2 (E<0.625 eV), 10 dpa, 5000 appm He 304: $2x10^{26}$ n/m^2 (E<0.625 eV), 2 dpa, 900 appm He
Blowdown Test Facility pressure tube	347 stainless tube 4.25" OD x 0.313" wall thickness	8 yrs irradiation, temp not constant, varied from 40 to 300°C, 10.5 MPa $6.6x10^{26}$ n/m^2 (E<0.625 eV) , $2x10^{24}$ n/m^2 (E>1 MeV) 4 dpa damage, 1600 appm Helium
Lower header cups	304 stainless steel (43 available) top tapered part scales to ~7/16" or 11 mm thick x ~1.6" or 40 mm long	Up to 44 yrs irradiation, 35 °C $4.1x10^{26}$ n/m^2 (E<0.625 eV) 2 dpa, 800 appm He
Vessel baffle plate	304 or 347 stainless steel plate 1" x 3.75" x 2 ft long	44 yrs irradiation, 35°C 0.4 dpa, 135 appm He
Vessel bolts	Inconel X-750	44 yrs irradiation, 35°C Less than 0.4 dpa and 135 appm He
Loop fuel carriage tie rod	Inconel X-750, AMS-5667 ½" bar (10 available)	life limit is 1000 days 250 to 300 °C
Iodine rods, Vessel, Re-entrant can	Aluminum Alloys Al -5052 Alcan 57S	44 yrs, 35 to 55 °C Up to 2.3 $x10^{27}$ n/m^2 (E<0.625 eV) 0.25 dpa, 4.5 Si atom %
Thermal column	Graphite	44 yrs, 15 to 230 °C Up to $7.1x10^{26}$ n/m^2 (E<0.625 eV)
Biological Shield/Interspace concrete	Heavy concrete	60 yrs, 27 to 49 °C Up to $2.5x10^{21}$ n/m^2 (E<0.625 eV) $3.6x10^{19}$ n/m^2 (E> 1MeV)

Research Opportunities using Artefacts:
Long-term Operation of CANDU Calandria Vessels

ISSUE: The CANDU calandria vessel and its components are not replaced during refurbishment, remain fit-for-service for periods up to 100 EFPY – identified in Roadmap for the Long-Term Operation of CANDU Reactor Components (ref. OP-17-7006).

Currently part of FNST Project.

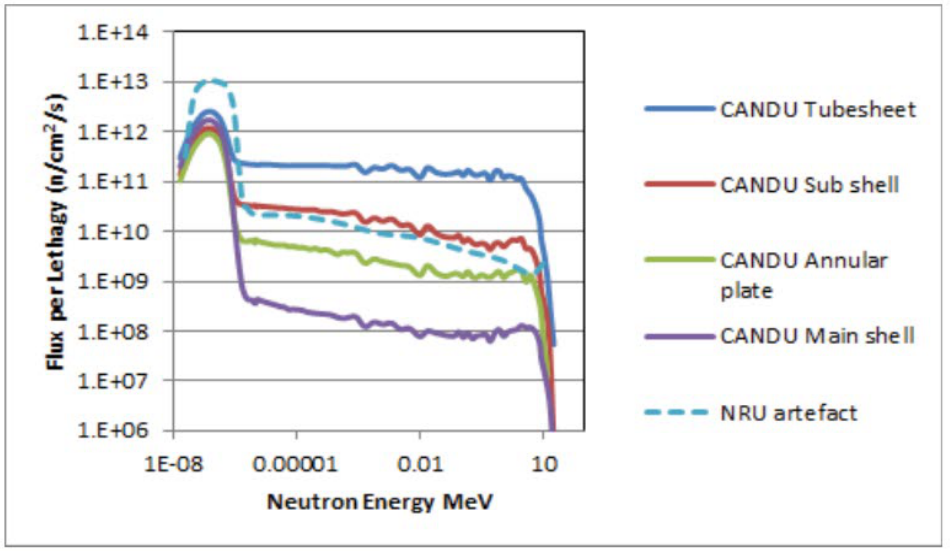
Research Opportunities using Artefacts:
Long-term Operation of CANDU Calandria Vessels

Industry Issue	Artefact Material	Work Scope Proposed
Supporting operation of CANDU calandria vessels to 100 year life	Materials of interest are 304L and 308L weld metal Available from NRU is 304 irradiated at the appropriate (low) temperature, to an almost bounding DPA and excess He	Radiation damage characterization Mechanical property tests Stress corrosion cracking tests Investigating repair technology

Research Opportunities using Artefacts:
Long-term Operation of CANDU Calandria Vessels

304 SS materials irradiated in NRU up to 2 dpa, 820-870 appm helium

100 year Calandria vessel
C6 tubesheet mid-lattice:
3 dpa, 330 appm He
(60 yr: 1.7 dpa, 145 appm He)
C6 tubesheet at CT: 3.7 dpa, 45 appm He
(60 yr: 2.2 dpa, 18 appm He)



NRU Artefact

Research Opportunities using Artefacts:
Development of Dosimetry Methodology

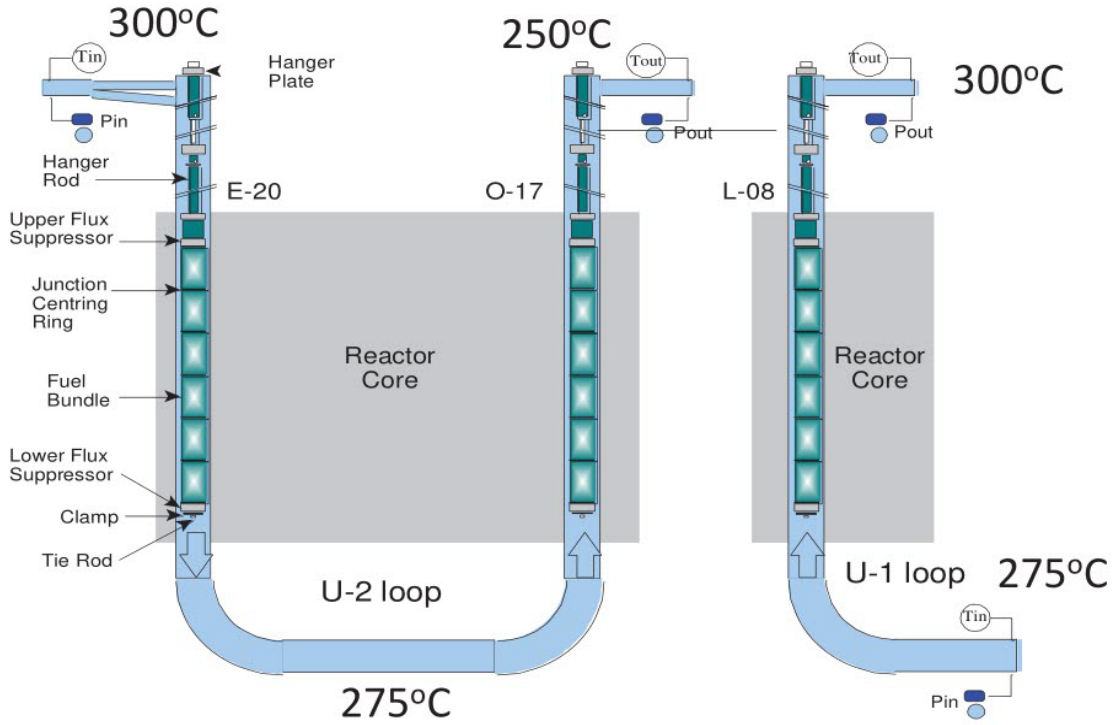
OPPORTUNITY: Develop dosimetry methods to determine the neutron dose on ex-service materials. Currently part of FNST project.

Industry Issue	Artefact Material	Work Scope Proposed
Develop dosimetry methods to determine the neutron dose on ex-service materials	Various components from NRU to cover a wide range of fluences	Establish procedures for sub-sampling harvested material and measurement of the required isotopic ratios

Research Opportunities using Artefacts:
Development of Dosimetry Methodology

- Isotopic ratio measurements of activation products are known to be an accurate approach to determining the dose and are used in international safeguards programs to establish reactor operating history.

NRU Loop Pressure Tubes



Light water cooled.

NRU Zr Alloy Loop Pressure Tubes

Pressure Tube Identification Number	Material	Date of Installation	Temp °C	Press (MPa)	Peak flux $x10^{17}$ $n/m^2/s$ E> 1MeV	Time in NRU loops EFPH
50206	27% cold drawn Zr-2.5Nb Pickering A tube	1975 to 1984 1984 to 1988	275-300 250-275	9-10 10-11	2.6	53,400 15,400
50207	24% pilger Zr-2.5Nb	1976-1984	275-300	9-10	~2.5	22,000
50209	As extruded 2.8% CW Excel	1982 to 1985 1985 to 1991	250-275 275-300	10-11 9-10	~2.5	13,034 12,060
50210	Annealed Excel	1984 to 1991	275-300	9-10	~2.5	29,426
50213	25% pilger Zr-2.5Nb	1988 to 1991 1994 to 1996	250-275 275-300	10-11 9-10	~2.5	14,232 15,000
50215	35-45% CW Zr-2.5Nb (TG3R1)	1994 to 1998	250-275	10-11	~2.5	22,000
50216	20-30% CW Zr-2.5Nb Quadmelt, beta quench at log stage.	1994 to present	275-300	9-10	~2.5	59,600
50217	35-45% CW Zr-2.5Nb (TG3R1)	1997 to 2000	275-300	9-10	~2.5	15,000
50218	20-30% CW Zr-2.5Nb Quadmelt, beta quench at log stage	1998 to present	250-275	10-11	~2.5	38,200
50219	20-30% CW Zr-2.5Nb Qinshan tube, quenched hollow billets	2000 to present (loop shutdown in 2009)	275-300	9-10	~2.5	25,400

Research Opportunities using Artefacts:
Effect of Manufacture Route on PT Mechanical Properties

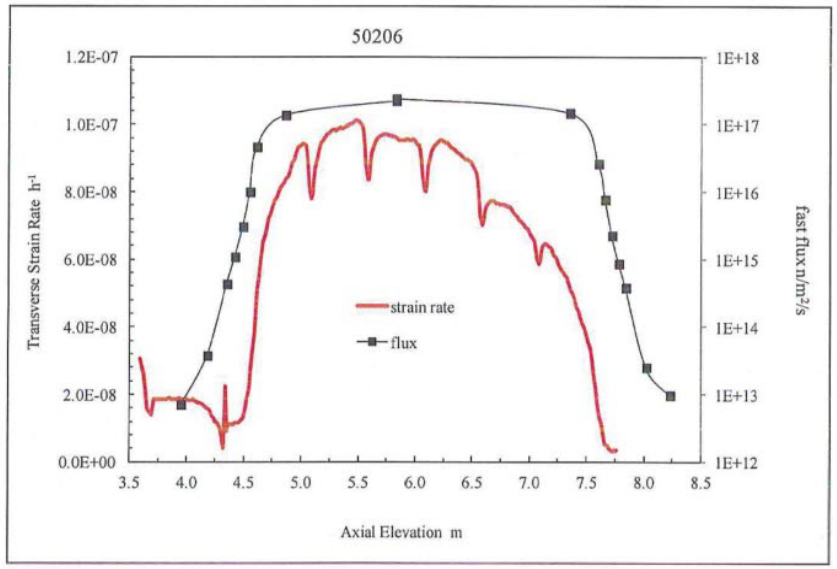
OPPORTUNITY: Obtain the irradiated properties from pressure tubes with various manufacture routes.

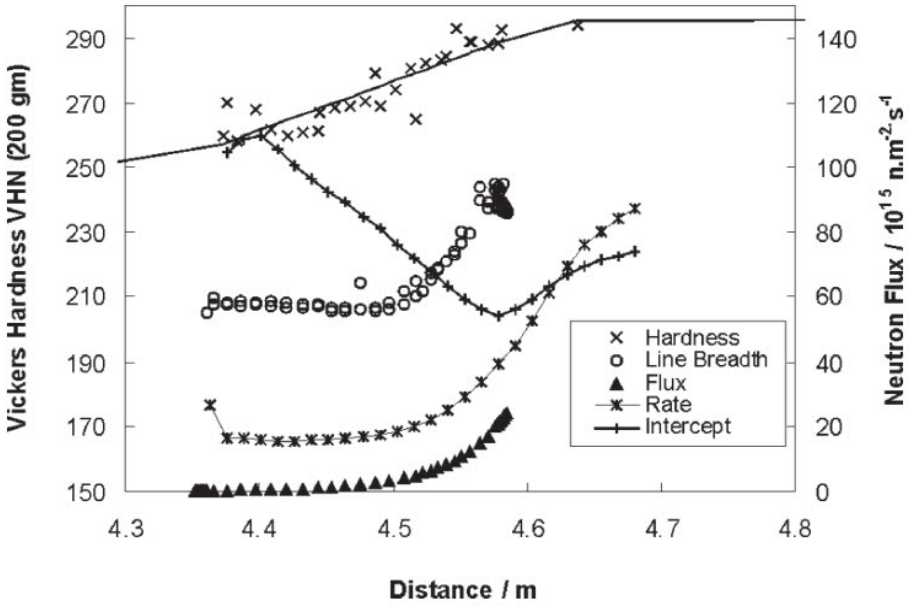
Industry Issue	Artefact Material	Work Scope Proposed
Effect of manufacture route on pressure tube properties	NRU loop pressure tubes – wide range of fluence	Microstructure characterization Creep, fracture toughness, hydrogen ingress, corrosion

Research Opportunities using Artefacts:
Effect of Manufacture Route on PT Mechanical Properties

- Range of manufacture routes: regular CANDU PTs (double and quad melt), Qinshan tubes (electrolytic powder), TG3R1 (fabrication tailored for low elongation) and pilgered tubes.
- Transition from high to low to no flux.
- Irradiation “top-up” in a fast flux reactor to get higher fluence properties.

Effect of Irradiation Damage on Pressure Tubes: Assessment of Assembly 50206





Ref: Griffiths et al, J. of ASTM (2007)

Hardening is observed at very low doses, below the level at which dislocation loops form.

Research Opportunities using Artefacts:
Effect of Microstructure Evolution

ISSUE: In the body of a CANDU pressure tube the flux effect on DHC is well characterized. At the ends of the pressure tubes the low flux effects are more difficult to predict.

Industry Issue	Artefact Material	Work Scope Proposed
Develop understanding of the effect of microstructure evolution on DHC – low flux effects	NRU loop pressure tubes – wide range of flux and fluences	Microstructure characterization DHC tests

- The NRU pressure tubes provide material over a wide range of flux and fluence to determine the effect of microstructure evolution on DHC.

Research Opportunities using Artefacts:
Improved PT/CT Gap Measurements

ISSUE: The PT/CT gap measurements towards the outlet end of the tube are known to be biased and recently attributed to variability in resistivity.

Industry Issue	Artefact Material	Work Scope Proposed
Improved PT/CT gap measurements – critical for leak before break	NRU loop pressure tubes –wide range of fluence	NDE tests to examine PT resistivity over the full length of the fuel channel

Research Opportunities using Artefacts:
Improved PT/CT Gap Measurements

- In absence of a technique to actually measure resistivity in-situ and perform the compensation, a better normalization scheme could be derived from a better understanding of the resistivity changes along the entire PT.
- Benefit PT/CT gap measurements including CIGAR/ANDE/BRIMS and AFCIS.
- Resistivity measurements can also be used to understand PT microstructure non-destructively.

Irradiation Effects on 347 Stainless Steel

OPPORTUNITY: component with low dpa, high helium.

Loop tube: 4 dpa damage, 1600 appm Helium, operating temperature not constant ranged from 40 to 300°C, 10.5MPa, 6.6×10^{26} n/m^2 (E<0.625 eV), 2×10^{24} n/m^2 (E>1 MeV)

Type 347 stainless steel is used for baffle bolts in PWR – exposed to primary water, high temperatures and irradiation. Issues include IASCC and fatigue.

Research Opportunities using Artefacts:
Effect of temperature and dose rate on helium bubble evolution in Inconel X-750

OPPORTUNITY: Effects of specimen size, temperature and dose rate to support models on irradiation effects on Inconel X-750

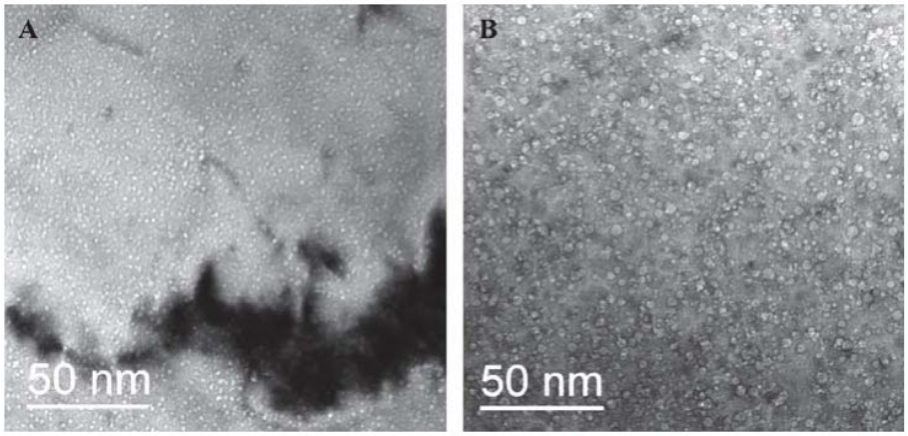
Industry Issue	Artefact Material	Work Scope Proposed
Support for the end of life irradiation studies on Inconel X-750	X-750 hanger bars Control rod shroud tube spring Vessel bolt	Microstructure characterization Tensile testing, hardness testing.

Research Opportunities using Artefacts:

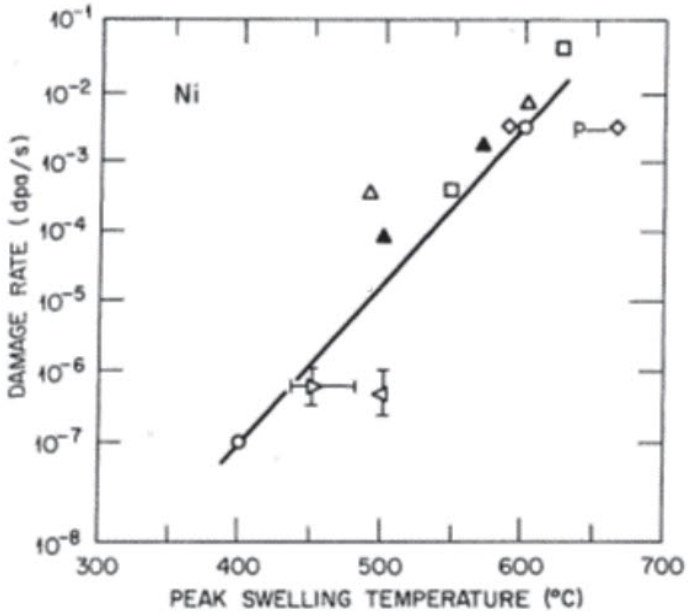
Effect of temperature and dose rate on helium bubble evolution in Inconel X-750

- NRU material has sufficient volume to make full-size specimens to determining how specimen size effects irradiated mechanical properties.
- X-750 irradiated in different positions in NRU may provide mechanical property data irradiated at various temperatures and dose rates.
- Data can be used to validate models outside of temperature and dose range.

Temperature and Dose Rate Effects in Inconel X-750



Ref: Judge et al JNM 457 (2015)



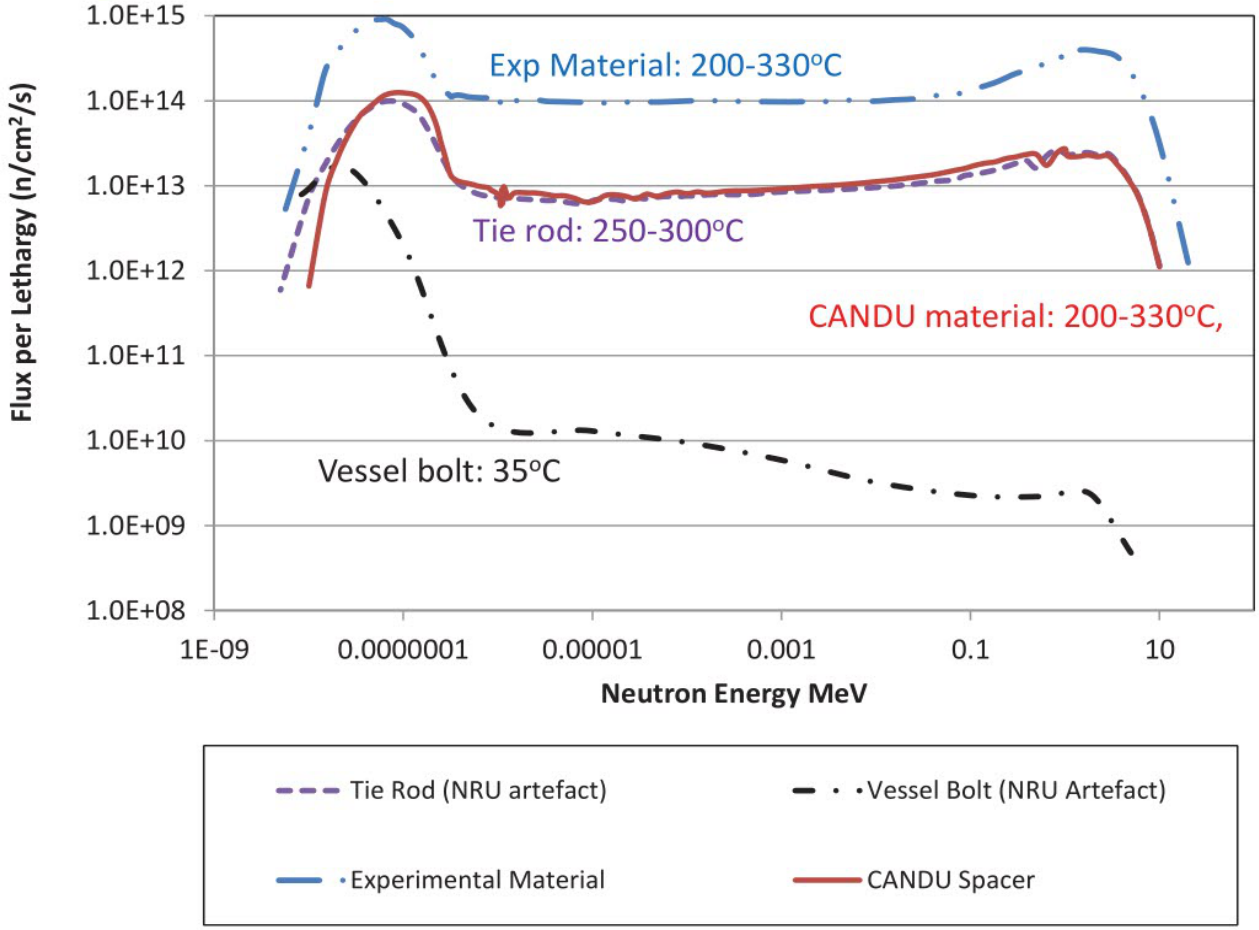
Ref: Packan et al JNM 78 (1978)

Larger bubbles and lower density (330°C),

Smaller bubbles and higher density (200°C)

High damage rates alter the temperature dependence of the development of microstructural defects.

Comparison of Artefact X-750 Materials against Industry Materials

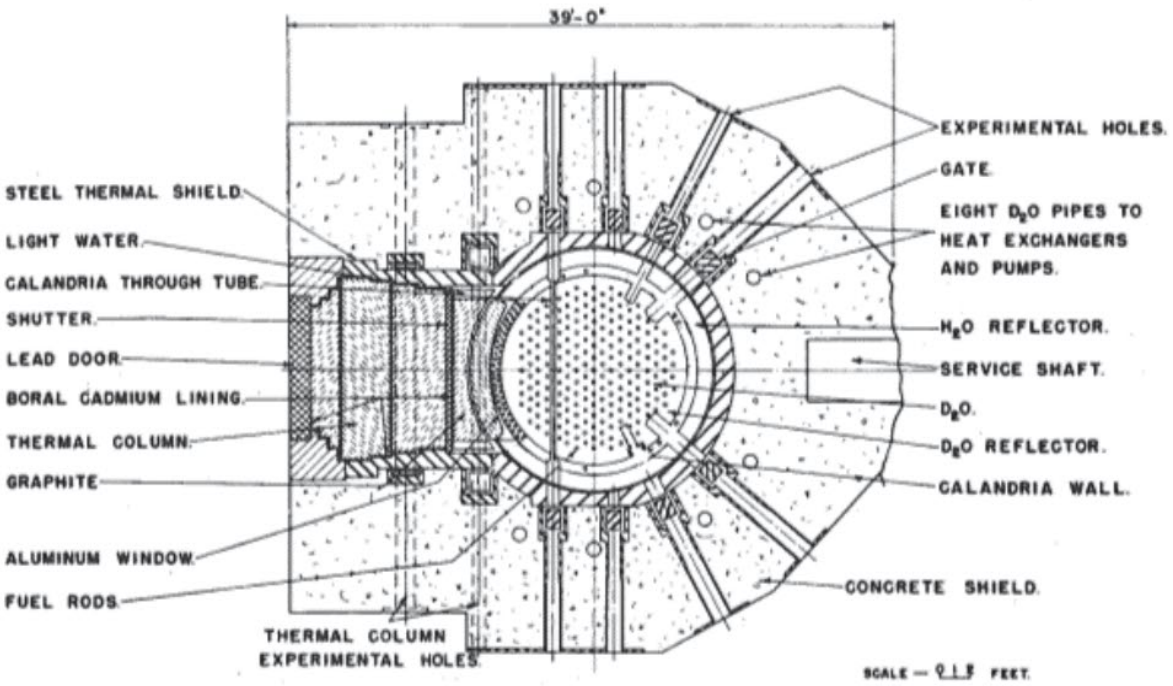


Irradiation Effects on Concrete

ISSUE: Concrete structures and components perform important safety functions (e.g., containment & shielding) - chronic, low dose neutron exposure on the integrity of the biological shield concrete will affect mechanical properties.

Irradiation Effects on Concrete

Concrete in NRU



- Concrete cores from NPD.
- Opportunity to get concrete cores from G2, Douglas Pt, WR1 and from waste canisters at WL.

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Irradiation Effects on Concrete and NRU Artefacts

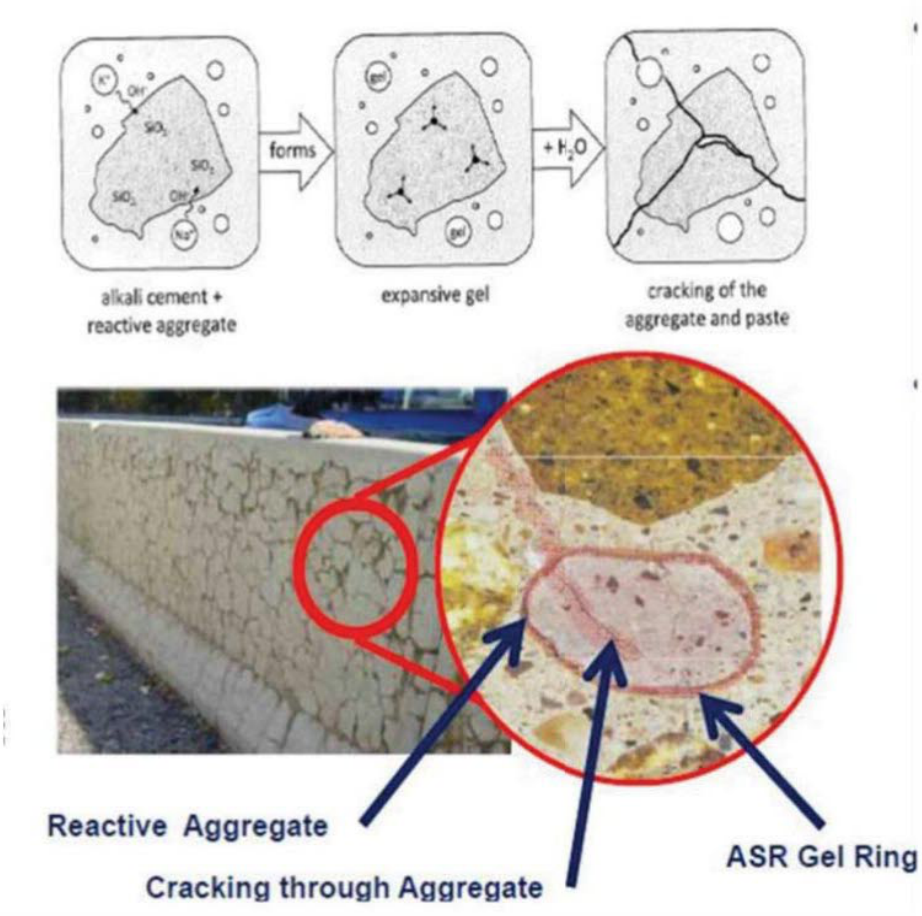
- Critical levels indicated at $1x10^{19}$ to $1x10^{20}$ n/cm^2 E<0.1 MeV [Hilsdorf curve]
- Potential for irradiation to affect microstructure of concrete (e.g, aggregate expansion, shrinkage of cement paste, cracking)
- Heavy concrete from NRU in service for 60 years at 27 to 49°C up to $2.5x10^{17}$n/cm^2 (E<0.1 MeV)

Irradiation Effects on Concrete and NRU Artefacts

- NRU Shield plugs reside in unused experimental hole ports which penetrate the Biological Shield to enable experimental neutron beam research equipment
- Relatively straightforward for removal.
- Some shield plugs are original, ports were not accessed during the lifetime of the reactor.

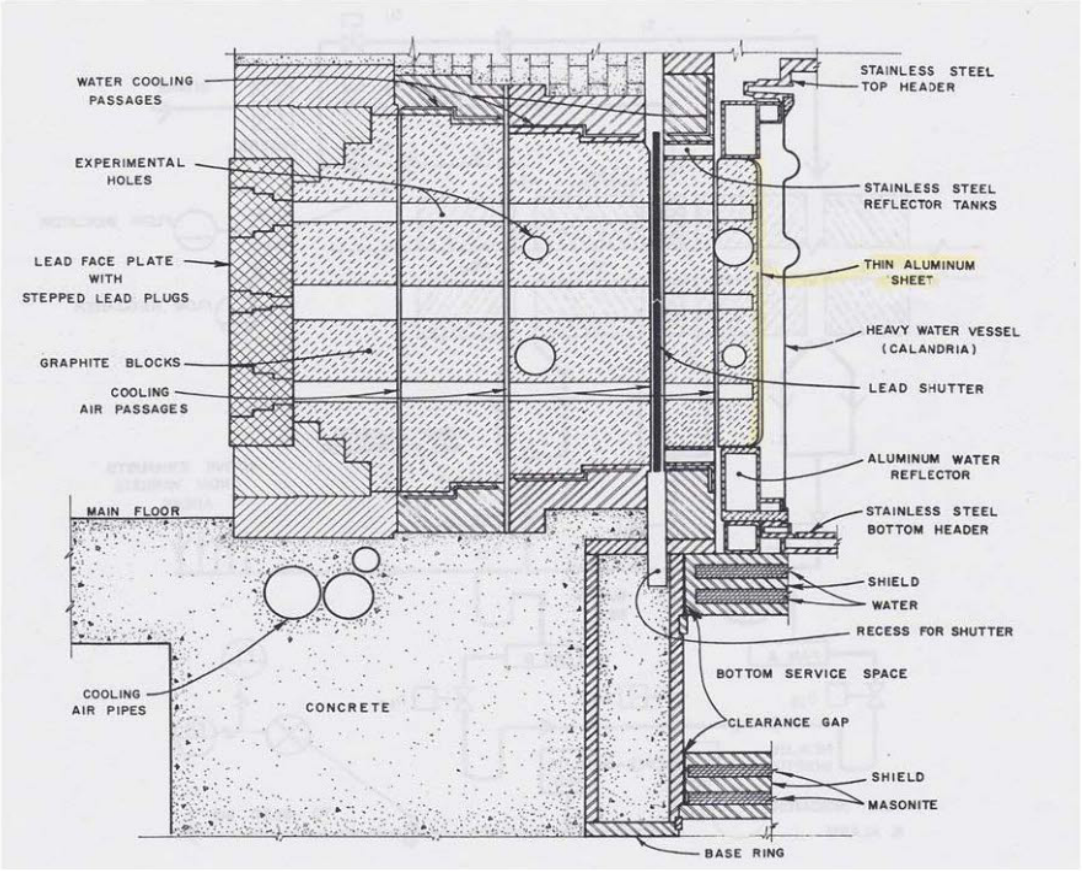
Concrete Aging and Degradation

- Evaluating effects of Alkali Silica Reaction (ASR) on structural performance of concrete under design basis static and dynamic loads
- Causes expansion, cracking, loss of mechanical properties.
- ASR is a concern for susceptible aggregates.
- Question surrounding likelihood of occurrence.



Graphite Artefact from NRU

- Five graphite sections about 2.4 m x 2.4 m at the inner end to 3.2m x 3.2m at the outside end, total length of 3.7 m.
- In service for 44 yrs, 15 to 230 °C, up to 7.1×10^{22} n/cm^2 (E<0.625 eV)



Flux Detectors in NRU

Flux Detector	Service	Operation
P18 beside U-2 loop position O17	replaced in 1996/1997	Helium atmosphere maintained
E22 beside U-2 loop position E20	flux detector wires were replaced 1998/1999, the rod was not replaced, dates back to the 1974	Helium atmosphere maintained
L06 beside U-1 loop position L08	replaced in 1996/1997	Helium atmosphere maintained
M23 beside loop position L-24	M-23 has not been replaced, dates back to 1974	Not in operation since 1991

Each insert contains twelve self-powered flux detectors six of which have platinum-clad Inconel emitters and six with vanadium emitters.

Instrument Control Cables from NRU

Cable Jacket Material	Type	Voltage	Installation Date	Temperature	Radiation Field
PEEK (tan)	18 gauge, 26 conductor	600V rating, up to 120 VAC	mid 90s or after 2004-2008	20 to 300°C, A-41002-SP-5	Max 10 R/hr
XLPO (black)	18 gauge, 24 conductor	Up to 130 VDC, Up to 120 VAC	later 2012 until 2016	20-65°C, 90°C MAX, forced area cooling, NRU-150901-SP-001, humidity 10-100%	Max 10 R/hr
Polyimide	2 conductor, twisted pair				Physics Core calculations required.
PTFE Dielectric, FEP Jacket	RG393 Coax	Up to 600 VDC (1500V rating)	W51 in RM315 - 3 sets of cables installed in mid to late 90s	65°C MAX at Faces, Room Temperature 30°C Max for other cables.	Physics Core calculations required.
LDPE Dielectric, PVC Jacket	RG11 Coax	Up to 600 VDC	W51 in RM315 - 3 sets of cables installed in mid to late 90s	65°C MAX at Faces, Room Temperature 30°C Max for other cables.	Physics Core calculations required.
PE Dielectric, PVC Jacket	RG108 Twinax	Up to 600 VDC	W51 in RM315 - 3 sets of cables installed in mid to late 90s	65°C MAX at Faces, Room Temperature 30°C Max for other cables.	Physics Core calculations required.
HABIA HFI 140 - rated for 10^6 Gy	20 gauge	600V	Max once a year swap, 5 year replacement	wire (-50°C/+120°C)	Max 10 R/hr
HABIA HFI 140 - rated for 10^6 Gy	22 gauge	600V	Max once a year swap, 5 year replacement	wire (-50°C/+120°C)	Max 10 R/hr

Cable Aging and Degradation

ISSUE: aging of elastomers results from oxidation leading to degradation of their mechanical properties, induces a loss of dielectric strength and increased leakage current.

- Identify compound material formulation using NIT or FTIR
- variety of cable testing techniques to assess the condition of retrieved cables that were naturally aged in the reactor.

Cable Aging and Degradation

- compare results using of reference destructive techniques (tensile testing for example) and non-destructive or semi-destructive techniques (such as cable indentation, measurement of electrical dissipation factors, or differential scanning calorimetry)
- Compare expected damage versus observed damage based on residency time
- Assess the validity of accelerated aging performed in the laboratory to simulate natural aging at much lower temperatures and much lower dose rates.

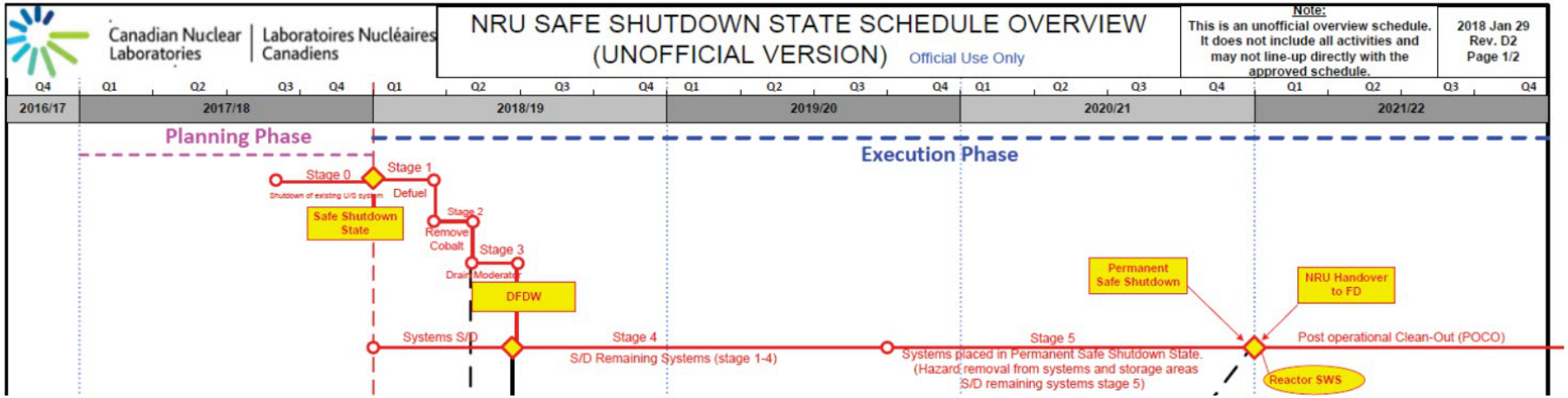
NRU Out-of-core Assemblies

Assembly	Material	Temp °C	Estimated Accumulated Dose (kRad)	Operating Duration In Years
U2 loop - Auxiliary Heliflow Cooler	Inconel and 347 stainless steel	300	265	N/A
MHWP Shafts	316 stainless steel	40	185	various (MHWP#1, 5 and 6: more than 15 years)
Polymers for Fluid Sealing	Various polymers (PEEK/PTFE/EPDM/Viton/ Nitrile – Buna N)	Various 20 to 300	various	various
Lower Service Space Piping	Stainless steel (304/316)	40 typical	7173	Up to 60
Electrical/ Instrumentation Cabling	Various	40 typical	Upper service space: 759 Heat Exchanger Rooms: 846	Up to 60
Helium Freezer Driers - Finned Tubes	304 stainless steel	-79 to 74	803	Up to 60
Copper in High Dose Rate Locations	Copper	-79 to 74	803	Up to 60
Tubes in Main Heat Exchangers	304 stainless steel	50	846	Up to 60
Gibbsite Assessment	Gibbsite	Up to 121	NA	Up to 60
Adjuster Rod Cabling	Electrical wiring	40	274	53
Loop Flux Detector Cabling	Electrical wiring	N/A	759	44
Resistance Temperature Detector Wiring in Heat Exchanger Rooms	Electrical wiring	40	846	Up to 60
Thermocouples in Biological Shield	Instrument wiring	Various	N/A	60
MHWP Heat Exchanger Bellows	Type 347 or 321 stainless steel	38-53	846	60
Fuel Rod Flask Donut - Shielding	Lead, paraffin wax-boron carbide mixture	heavy water cools to 30-50	60000	60
Fuel Rod Flask Bellows	Stainless Steel as per ASTM A240 Type 321 or 347	30 to 50	30000	N/A
MHWP Check Valves - Waukesha 88 Bushings	Waukesha alloys	38	846	N/A

Welds Between Different Alloys in NRU (out-of-core)

Weld location	Materials
U1 ends of Spool 129 (F1-1 and F1-2) **Main loop piping between mixer #2 and Inlet to mixer #1**	3” diameter Carbon steel (11.13 mm wall)/ 304 stainless steel (7.62 mm wall)
U1 inlet and outlet of the Loop Cooler (LC-1 and LC-2)	3” diameter Inconel (7.62 mm wall)/ 347 or 321 stainless steel (7.62 mm wall)
Steam Generator Inlet and outlet	4” diameter 304 stainless steel (13.49 mm)/ carbon steel (13.49 mm)
Main Heliflow Cooler Inlet and outlet, tube side	3” diameter 304 stainless steel (reducer 3” to 2.5” SCH 80)/Inconel 600 (7.62 mm) Main Heliflow Cooler: MAWP 2000 psig, Design Temperature 640°F
Auxiliary Heliflow cooler inlet and outlet	2” diameter 304 stainless steel (reducer 2” to 1” SCH 80)/Inconel 600 (1.5 mm) Auxiliary Heliflow Cooler: MAWP 2000 psig, Design Temperature 640°F

Timelines for Extraction of Artefacts from NRU



Key dates:

- Shutdown on March 31, 2018
- De-fuel ~41 days after shutdown
- De-water ~Sept 2018

Timelines for Extraction of Artefacts from NRU

Assembly	Current Location	Availability/Extraction
Loop pressure tubes **Zr-2.5Nb**	NRU Rod Bays 50216, 50218, 50219 in loops	Available now Removal after de-fuel, de-water.
Loop liner tubes **Zr-2.5Nb**	NRU Rod Bays	Available now
Control rod shroud tube **Zr-2 annealed tube, X-750 spring, 304 SS rings**	In-core	As early as FY19/20
Blowdown Test Facility pressure tube **347 stainless steel**	NRU Rod Bays	Available now
Lower header cups **304 stainless stee**	In-Core	After de-fuel but before de-water. ~June 2018
Vessel baffle plate **304 or 347 stainless steel**	In-core	Challenge but ideally after de-fuel, before de-water
Vessel bolts **Inconel X-750**	In-core	Extraction of a few bolts should be possible at any time following the reactor shutdown.
Loop fuel carriage tie rod **Inconel X-750**	NRU Rod Bays	Available now
Thermal column **Graphite**	In-service	~Sept 2019
Biological Shield/Interspace concrete **Heavy concrete**	In-service	Mid 2019 for the shield plug, dependent on replacement component.
Cables	In-service	End of 2018/early 2019

Discussion

- Are there any other irradiation damage or aging issues that were not discussed and should be considered for the artefact research project?
- Are there industry issues that can be resolved by performing research on these artefacts?
- Are there opportunities for collaboration?
- Should CNL store certain materials for later examination?

Follow-up

- COG specific
  - COG workpackage “Materials Studies of NRU Artefacts”
  - Follow up detailed technical meetings with working groups

- Outside of COG
  - Follow up on interest provided in the feedback forms

- Based on feedback on high-interest components, CNL will refine flux and fluence calculations; will develop extraction plans for in-core materials; and will identify sites for storage of artefacts.

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