From: Tregoning, Robert
Sent: Mon, 28 Aug 2017 11:07:25 +0000
To: Hiser, Matthew
Subject: RE: Ex-plant Materials Harvesting Workshop

Matt:

Can you give me until the end of this week?

Thanks,

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, Matthew
Sent: Friday, August 25, 2017 10:14 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Reminder to provide any comments by today before we finalize this meeting summary.

From: Hiser, Matthew
Sent: Thursday, August 17, 2017 12:31 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Hi Rob and Mita,

Here is the latest version of the workshop report. Please take a look and provide any feedback by next Friday, August 25 before I finalize it at the end of the month.

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, June 22, 2017 3:20 PM
To: 'Bernhoft, Sherry' <sbernhoft@epri.com>; 'Dyle, Robin' <rdyle@epri.com>; 'Jean Smith (jmsmith@epri.com)' <jmsmith@epri.com>; 'Ahluwalia, Kawaljit' <kahluwal@epri.com>; 'Richard Reister (Richard.Reister@nuclear.energy.gov)' <Richard.Reister@nuclear.energy.gov>; 'leonardk@ornl.gov' <leonardk@ornl.gov>; 'Rosseel, Thomas M.' <rosseeltm@ornl.gov>; 'William F Zipp (Generation - 4)' <william.f.zipp@dom.com>; 'Gerard P. Van Noordennen' <gpvannoordennen@energysolutions.com>; 'Ramuhalli, Pradeep (Pradeep.Ramuhalli@pnnl.gov)' <Pradeep.Ramuhalli@pnnl.gov>; 'daniel.tello@canada.ca' <daniel.tello@canada.ca>; 'Uwe.Jendrich@grs.de' <Uwe.Jendrich@grs.de>; 'rachid.chaouadi@sckcen.be' <rachid.chaouadi@sckcen.be>; 'arait@criepi.denken.or.jp' <arait@criepi.denken.or.jp>; 'alpanfa@westinghouse.com' <alpanfa@westinghouse.com>; 'sokolovm@ornl.gov' <sokolovm@ornl.gov>; 'desire.ndomba@canada.ca' <desire.ndomba@canada.ca>; 'khuynh@aecl.ca' <khuynh@aecl.ca>; 'higuchi@criepi.denken.or.jp' <higuchi@criepi.denken.or.jp>; 'kazunobu_sakamoto@nsr.go.jp' <kazunobu_sakamoto@nsr.go.jp>; 'chimi.yasuhiro@jaea.go.jp' <chimi.yasuhiro@jaea.go.jp>; 'Jackson, John Howard' <john.jackson@inl.gov>; 'Roussel Guy' <guy.roussel@Belv.be>; 'john.wagner@inl.gov' <john.wagner@inl.gov>; 'Riccardella, Pete' <Priccardella@Structint.com>; 'RICHTER, Mark' <mar@nei.org>; 'Amberge, Kyle' <kamberge@epri.com>; Moyer, Carol <Carol.Moyer@nrc.gov>; Oberson, Greg <Greg.Oberson@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>; Yoo, Mark <Mark.Yoo@nrc.gov>; Koshy, Thomas <Thomas.Koshy@nrc.gov>; Buford, Angela <Angela.Buford@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

I have received input from a couple participants. This is a gentle reminder to please provide any input on the report by next Friday, June 30.

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: Wednesday, May 31, 2017 4:21 PM
To: 'Bernhoft, Sherry' <sbernhoft@epri.com>; 'Dyle, Robin' <rdyle@epri.com>; 'Jean Smith (jmsmith@epri.com)' <jmsmith@epri.com>; 'Ahluwalia, Kawaljit' <kahluwal@epri.com>; 'Richard Reister (Richard.Reister@nuclear.energy.gov)' <Richard.Reister@nuclear.energy.gov>; 'leonardk@ornl.gov' <leonardk@ornl.gov>; 'Rosseel, Thomas M.' <rosseeltm@ornl.gov>; 'William F Zipp (Generation - 4)' <william.f.zipp@dom.com>; 'Gerard P. Van Noordennen' <gpvannoordennen@energysolutions.com>;

'Ramuhalli, Pradeep (Pradeep.Ramuhalli@pnnl.gov)' <Pradeep.Ramuhalli@pnnl.gov>; 'daniel.tello@canada.ca' <daniel.tello@canada.ca>; 'Uwe.Jendrich@grs.de' <Uwe.Jendrich@grs.de>; 'rachid.chaouadi@sckcen.be' <rachid.chaouadi@sckcen.be>; 'arait@criepi.denken.or.jp' <arait@criepi.denken.or.jp>; 'alpanfa@westinghouse.com' <alpanfa@westinghouse.com>; 'sokolovm@ornl.gov' <sokolovm@ornl.gov>; 'desire.ndomba@canada.ca' <desire.ndomba@canada.ca>; 'khuynh@aecl.ca' <khuynh@aecl.ca>; 'higuchi@criepi.denken.or.jp' <higuchi@criepi.denken.or.jp>; 'kazunobu_sakamoto@nsr.go.jp' <kazunobu_sakamoto@nsr.go.jp>; 'chimi.yasuhiro@jaea.go.jp' <chimi.yasuhiro@jaea.go.jp>; 'Jackson, John Howard' <john.jackson@inl.gov>; 'Roussel Guy' <guy.roussel@Belv.be>; 'john.wagner@inl.gov' <john.wagner@inl.gov>; 'Riccardella, Pete' <Priccardella@Structint.com>; 'RICHTER, Mark' <mar@nei.org>; 'Amberge, Kyle' <kamberge@epri.com>; Moyer, Carol <Carol.Moyer@nrc.gov>; Oberson, Greg <Greg.Oberson@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>; Yoo, Mark <Mark.Yoo@nrc.gov>; Koshy, Thomas <Thomas.Koshy@nrc.gov>; Buford, Angela <Angela.Buford@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Dear Workshop Participants:

I would like to share for your review and comment the workshop summary report (attached). In the report, we tried to capture as much of the discussion as possible, while focusing on the key takeaways that might be useful for all participants as they consider harvesting in the future. In particular, please review how your presentation and contribution to the discussion is characterized, in case you feel it should be clarified in any way. Feel free to provide additional references to previous research on harvested materials that should be captured in this report. Comments, edits, and suggestions on any other parts of the report are welcome.

Please provide your input by June 30 at the latest and we will try to finalize the report by sometime in July.

As indicated in action items 4 and 5, we will be pursuing further coordination efforts on data needs for harvesting and a sources of materials database and welcome any other parties that may be interested in participating in these discussions.

Thank you once again for your participation and engagement in this workshop!

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: Friday, March 17, 2017 8:39 AM
To: 'Bernhoft, Sherry' <sbernhoft@epri.com>; 'Dyle, Robin' <rdyle@epri.com>; 'Jean Smith (jmsmith@epri.com)' <jmsmith@epri.com>; 'Ahluwalia, Kawaljit' <kahluwal@epri.com>; 'Richard Reister (Richard.Reister@nuclear.energy.gov)' <Richard.Reister@nuclear.energy.gov>; 'leonardk@ornl.gov' <leonardk@ornl.gov>; 'Rosseel, Thomas M.' <rosseeltm@ornl.gov>; 'William F Zipp (Generation - 4)' <william.f.zipp@dom.com>; 'Gerard P. Van Noordennen' <gpvannoordennen@energysolutions.com>; 'Ramuhalli, Pradeep (Pradeep.Ramuhalli@pnnl.gov)' <Pradeep.Ramuhalli@pnnl.gov>; 'daniel.tello@canada.ca' <daniel.tello@canada.ca>; 'Uwe.Jendrich@grs.de' <Uwe.Jendrich@grs.de>; 'rachid.chaouadi@sckcen.be' <rachid.chaouadi@sckcen.be>; 'arait@criepi.denken.or.jp' <arait@criepi.denken.or.jp>; 'alpanfa@westinghouse.com' <alpanfa@westinghouse.com>; 'sokolovm@ornl.gov' <sokolovm@ornl.gov>; 'desire.ndomba@canada.ca' <desire.ndomba@canada.ca>; 'khuynh@aecl.ca' <khuynh@aecl.ca>; 'higuchi@criepi.denken.or.jp' <higuchi@criepi.denken.or.jp>; 'kazunobu_sakamoto@nsr.go.jp' <kazunobu_sakamoto@nsr.go.jp>; 'chimi.yasuhiro@jaea.go.jp' <chimi.yasuhiro@jaea.go.jp>; 'Jackson, John Howard' <john.jackson@inl.gov>; 'Roussel Guy' <guy.roussel@Belv.be>; 'john.wagner@inl.gov' <john.wagner@inl.gov>; 'Riccardella, Pete' <Priccardella@Structint.com>; 'RICHTER, Mark' <mar@nei.org>; 'Amberge, Kyle' <kamberge@epri.com>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Oberson, Greg <Greg.Oberson@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>; Yoo, Mark <Mark.Yoo@nrc.gov>; Koshy, Thomas <Thomas.Koshy@nrc.gov>; Buford, Angela <Angela.Buford@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Dear Workshop Participants:

I have attached a list of participants in last week's workshop, along with their email for contact.

Also, I have not received any concerns from the presenters regarding sharing slides, so feel free to share the slides, which are available on Google Drive:
https://drive.google.com/open?id=0B5DWMLch5YSXcnpZZ0JOS055QUU .

We hope to share a detailed workshop summary report in the next two months.

Thanks!
Matt

From: Hiser, Matthew
Sent: Friday, March 10, 2017 7:03 AM
To: 'Bernhoft, Sherry' <sbernhoft@epri.com>; 'Dyle, Robin' <rdyle@epri.com>; 'Jean Smith (jmsmith@epri.com)' <jmsmith@epri.com>; 'Ahluwalia, Kawaljit' <kahluwal@epri.com>; 'Richard Reister (Richard.Reister@nuclear.energy.gov)' <Richard.Reister@nuclear.energy.gov>; 'leonardk@ornl.gov' <leonardk@ornl.gov>; 'Rosseel, Thomas M.' <rosseeltm@ornl.gov>; 'William F Zipp (Generation - 4)' <william.f.zipp@dom.com>; 'Gerard P. Van Noordennen' <gpvannoordennen@energysolutions.com>; 'Ramuhalli, Pradeep (Pradeep.Ramuhalli@pnnl.gov)' <Pradeep.Ramuhalli@pnnl.gov>;

'daniel.tello@canada.ca' <daniel.tello@canada.ca>; 'Uwe.Jendrich@grs.de' <Uwe.Jendrich@grs.de>; 'rachid.chaouadi@sckcen.be' <rachid.chaouadi@sckcen.be>; 'arait@criepi.denken.or.jp' <arait@criepi.denken.or.jp>; 'alpanfa@westinghouse.com' <alpanfa@westinghouse.com>; 'sokolovm@ornl.gov' <sokolovm@ornl.gov>; 'desire.ndomba@canada.ca' <desire.ndomba@canada.ca>; 'khuynh@aecl.ca' <khuynh@aecl.ca>; 'higuchi@criepi.denken.or.jp' <higuchi@criepi.denken.or.jp>; 'kazunobu_sakamoto@nsr.go.jp' <kazunobu_sakamoto@nsr.go.jp>; 'chimi.yasuhiro@jaea.go.jp' <chimi.yasuhiro@jaea.go.jp>; 'Jackson, John Howard' <john.jackson@inl.gov>; 'Roussel Guy' <guy.roussel@Belv.be>; 'john.wagner@inl.gov' <john.wagner@inl.gov>; 'Riccardella, Pete' <Priccardella@Structint.com>; 'RICHTER, Mark' <mar@nei.org>; 'Amberge, Kyle' <kamberge@epri.com>; Hull, Amy <Amy.Hull@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>; Oberson, Greg <Greg.Oberson@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>; Yoo, Mark <Mark.Yoo@nrc.gov>; Koshy, Thomas <Thomas.Koshy@nrc.gov>; Buford, Angela <Angela.Buford@nrc.gov>; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Dear Workshop Participants:

Thank you for attending and participating in the workshop this week. I appreciate your active participation in what was a very interesting and informative discussion. I hope you were able to come away from the meeting with a better understanding of how to approach harvesting and what to expect in terms of cost, schedule, complexity, challenges, etc.

NRC will be developing a workshop summary report to be shared among meeting participants. We have also placed all of the presentations into a Google Drive folder for sharing among meeting participants (https://drive.google.com/open?id=0B5DWMLch5YSXcnpZZ0JOS055QUU).

I have laid out the action items and planned next steps to address each item below:

1. Sharing workshop slides (Ahluwalia)
    a. **Next step**: Presenters, please reply to this email if you have any concerns with meeting participants sharing your slides with colleagues or other organizations. If I don't hear from you, we'll assume you're OK with sharing.
2. MRP-320 (Product ID: 1022866) on harvesting from MRP-227 inspections
    a. Available to public for fee
3. Cable surveillance programs in Germany
    a. **Next step**: GRS (Jendrich) to inquire with cable colleagues and share
4. Sources of Materials database
    a. **Next step**: Opportunities presented in this meeting to be documented in workshop summary.
    b. **Next step**: AECL, CNSC, NRC, PNNL, INL NSUF interested in database development. Any other parties interested?
5. Prioritized data needs
    a. **Next step**: Smaller group meetings to prioritize data needs of interest
        i. Material / component of interest, purpose, intended outcome
    b. Idea: survey of participants at Environmental Degradation conference

6. EPRI report on SFP liner boric acid transport through concrete
    a. NRC (Sircar) to contact EPRI if needed
7. Harvested Materials Research Results
    a. **Next step:** A section of the workshop summary report to cover references from previous harvested materials research
    b. Use references from EMDA as starting point
    c. **Next step:** Please send any references to harvested materials research that should be included and its outcome to Matt Hiser.

Please feel free to contact me with any questions or suggestions for documenting the workshop and the next steps moving forward.

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: Friday, March 03, 2017 8:22 AM
To: 'Bernhoft, Sherry' <sbernhoft@epri.com>; 'Dyle, Robin' <rdyle@epri.com>; 'Jean Smith (jmsmith@epri.com)' <jmsmith@epri.com>; 'Ahluwalia, Kawaljit' <kahluwal@epri.com>; 'Richard Reister (Richard.Reister@nuclear.energy.gov)' <Richard.Reister@nuclear.energy.gov>; 'leonardk@ornl.gov' <leonardk@ornl.gov>; 'Rosseel, Thomas M.' <rosseeltm@ornl.gov>; 'William F Zipp (Generation - 4)' <william.f.zipp@dom.com>; 'Gerard P. Van Noordennen' <gpvannoordennen@energysolutions.com>; 'Ramuhalli, Pradeep (Pradeep.Ramuhalli@pnnl.gov)' <Pradeep.Ramuhalli@pnnl.gov>; 'daniel.tello@canada.ca' <daniel.tello@canada.ca>; 'Uwe.Jendrich@grs.de' <Uwe.Jendrich@grs.de>; 'rachid.chaouadi@sckcen.be' <rachid.chaouadi@sckcen.be>; 'arait@criepi.denken.or.jp' <arait@criepi.denken.or.jp>; 'alpanfa@westinghouse.com' <alpanfa@westinghouse.com>; 'sokolovm@ornl.gov' <sokolovm@ornl.gov>; 'desire.ndomba@canada.ca' <desire.ndomba@canada.ca>; 'khuynh@aecl.ca' <khuynh@aecl.ca>; 'higuchi@criepi.denken.or.jp' <higuchi@criepi.denken.or.jp>; 'kazunobu_sakamoto@nsr.go.jp' <kazunobu_sakamoto@nsr.go.jp>; 'chimi.yasuhiro@jaea.go.jp' <chimi.yasuhiro@jaea.go.jp>; Jackson, John Howard <john.jackson@inl.gov>; 'Roussel Guy' <guy.roussel@Belv.be>; 'john.wagner@inl.gov' <john.wagner@inl.gov>; 'Riccardella, Pete' <Priccardella@Structint.com>; 'RICHTER, Mark' <mar@nei.org>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: Ex-plant Materials Harvesting Workshop

Dear Harvesting Workshop Attendees:

You are receiving this email because I have you recorded as attending the upcoming Ex-plant Materials Harvesting Workshop on March 7-8 at USNRC headquarters in Rockville, MD. I have

attached the final workshop agenda as well as the workshop introduction slides that cover meeting logistics, motivation, approach, expected outcome, and session expectations. We are hoping these slides provide a common vision for the workshop that will allow for a focused, productive discussion.

The workshop will be held in NRC's Three White Flint North (3WFN) building, which is directly adjacent to the White Flint Metro station, in room 1C3 on the first floor. I have attached a map of the local area showing the Metro station and the 3WFN building.

The workshop is scheduled to start at 8:00 on Tuesday, March 7. I recommend planning to arrive at 3WFN around 7:30-7:45 in order to go through security to enter the building.

If you have not yet responded, please let me know if you plan to join for the dinner with other workshop participants, so I can make the appropriate reservation.

Thank you for your participation in the workshop. We are looking forward to the discussion and engagement and appreciate your contribution to a productive and interesting meeting!

Please let me know if you have any questions.

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: Fri, 19 May 2017 18:10:48 +0000
To: Hull, Amy
Cc: Moyer, Carol
Subject: RE: FYI, another idea for PLiM....: Reviewed with comments -- Harvesting Workshop summary Report draft abh 5-19-17-1pm

We could put in a paper for the harvesting effort. I think it's a good idea and would circulate this idea out to a wider audience. However, Carol is the lone person from RES that we're targeting to go to PLiM so she would need to present it.

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: Hull, Amy
Sent: Friday, May 19, 2017 1:57 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: Moyer, Carol <Carol.Moyer@nrc.gov>
Subject: FYI, another idea for PLiM....: Reviewed with comments -- Harvesting Workshop summary Report draft abh 5-19-17-1pm

---

From: Hull, Amy
Sent: Friday, May 19, 2017 1:48 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: Reviewed with comments -- Harvesting Workshop summary Report draft abh 5-19-17-1pm

Hi Matt,

This is lovely work and it was a very productive workshop.

I have another suggestion for you --- I think it would be a great idea to also have this as a presentation for IAEA PLiM this Fall. At the last SMIRT, there were summary papers of workshops like this that were very valuable. Condensing wisdom of many people into a short presentation – but you get a refereed

article out of it. I think the short abstracts have to be done soon (today?) so you might want to check with Rob or Carol about this.

From: Hiser, Matthew
Sent: Tue, 10 Oct 2017 16:52:51 -0400
To: Purtscher, Patrick
Subject: RE: Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Feel free to share with Pradeep….

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
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E-mail: Ki-Sig.KANG@iaea.org

From: Audrain, Margaret
Sent: Wed, 30 May 2018 14:10:46 +0000
To: Tregoning, Robert;Purtscher, Patrick;Hiser, Matthew
Subject: RE: harvesting report

Pat,

I'm working on putting together my site visit to PNNL in July. Do you think it'd be easiest to have Steve Bruemmer coordinate with Pradeep on timing/etc? Does Pradeep have the latest version of the spreadsheet to work with in advance of my coming there?

Thanks,

Meg

From: Tregoning, Robert
Sent: Tuesday, May 29, 2018 7:38 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: harvesting report

Pat:

Thanks, they have the slides and summary and we indicated during the meeting last week that the final report is largely consistent with that information. They obviously want the final report however because it will provide much more context and detail and also reflect at least some level of NRC review….

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: Purtscher, Patrick
Sent: Tuesday, May 29, 2018 7:34 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: harvesting report

All,

I will contact Pradeep today to see how the revision is coming. In fact, the slides and summary of the workshop (already available to EPRI) would be more valuable to industry than the report itself; these files include slides from Pradeep that reflect the report.

Pat

From: Hiser, Matthew
Sent: Thursday, May 24, 2018 12:09 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: RE: harvesting report

I agree it would be good to move the publishing of that report ahead expeditiously to help our coordination with EPRI. Last I heard Pat said PNNL was working on addressing NRR's comments – not sure what the timeline was for doing that though.

Thanks!
Matt

From: Tregoning, Robert
Sent: Thursday, May 24, 2018 8:37 AM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: harvesting report

All:

Yesterday, during Steve's presentation, EPRI (Dyle and Demma) expressed interest in getting the PNNL report once it's published. We're also planning to have some discussions with EPRI next week during the NRC/EPRI materials meeting to promote future collaboration on harvesting opportunities. Therefore, I think we should make publishing that report a higher priority and we can possibly use it in part to help frame our discussions with EPRI moving forward.

Thoughts?

Rob

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ph: 301-415-2324
fax: 301-415-6671

From: Tregoning, Robert
Sent: Wed, 18 Jan 2017 20:02:45 +0000
To: Hiser, Matthew;Purtscher, Patrick
Subject: RE: Harvesting service irradiated material from NPPs

Matt:

When we put together our high-priority needs for harvesting, we should have an internal meeting including Mita, Tom Koshy, and Darrell Murdock, at a minimum. They can add items related to concrete, I&C, and electrical. While we don't need to be comprehensive at this point, it would be good to have some examples…..

Cheers,

Rob

Robert Tregoning
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ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, January 18, 2017 11:53 AM
To: Sircar, Madhumita <Madhumita.Sircar@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: RE: Harvesting service irradiated material from NPPs

Hi Mita,

Yes, we're planning for March 7 and 8 in 3WFN. I've attached the meeting announcement and a draft agenda.

Thanks!
Matt

From: Sircar, Madhumita
Sent: Wednesday, January 18, 2017 11:51 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: Harvesting service irradiated material from NPPs

Matt,

Rob Tregoning suggested me to contact you regarding the meeting on harvesting service irradiated material from NPPs. Is the meeting in March?

Thanks,
Mita Sircar
Tel: 301-415-1804

From: Tregoning, Robert
Sent: Wed, 16 Mar 2016 13:21:37 +0000
To: McHale, John
Subject: RE: Harvesting WG

John:

(b)(6) Thanks for getting back to me on this. [redacted]
(b)(6) [redacted] Not a big deal as far as missing today's meeting. We'll get him up to speed, quickly.

Cheers,

Rob

Robert Tregoning
Technical Advisor for Materials
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11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
Blackberry: [redacted]
fax: 301-415-6671

From: McHale, John
Sent: Wednesday, March 16, 2016 8:46 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: Harvesting WG

Rob,

After our conversation yesterday, I did confirm with Jeff Poehler that he will be our rep on the
(b)(6) harvesting WG. [redacted]
(b)(6) [redacted] so he won't be able to make it in today for the meeting. I hope this will not be too much of an impact for today's meeting and we'll be able to support better the next time around.

Jack

From: Tregoning, Robert
Sent: Tue, 3 Jan 2017 12:54:26 +0000
To: 'Hojna Anna'
Subject: RE: Harvesting Workshop - U.S. NRC - March 2017

Dear Anna:

Thank you for your email and for your interest in our upcoming harvesting workshop. We are planning five unique sessions as part of the workshop. Each session has a specific theme, or objective, as outlined below (and in the agenda that you were sent previously).

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

The objective of the workshop is not to look for potential sponsors but to discuss better ways to plan and implement harvesting programs than has been done in the past. With this in mind, we are interested in learning about past experiences that organizations have had with harvesting programs and what has been learned from the program that could inform any future programs. This is the objective of Session 4. We're not so much interested in discussing the technical knowledge that has been gained from getting materials from decommissioned nuclear power plants, but in the practical aspects of running the program.

We are trying to keep the workshop participation relatively small so that we can have focused discussion and we are inviting the specific talks. Please let me know if you are interested in attending and if you also have a proposed talk that may fit within the objectives for any of the sessions I listed above. Please also let me know if you have any additional questions.

Warm regards,

Rob

From: Hojna Anna [mailto:Anna.Hojna@cvrez.cz]
Sent: Friday, December 23, 2016 7:30 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: [External_Sender] Harvesting Workshop - U.S. NRC - March 2017

Dear Rob Tregoning,
Could you be so kind and give me more information about the Harvesting workshop.
I heard about it, but I do know if the participation is only for invited people or if anybody can come.
I am working in CVR in Czech Republic, the research centre dealing with irradiated materials testing. In past I was responsible for the project on the irradiated internals material of the decommissioned NPP VVER 440 Nord I situated in Greifswald, Germany. I can share my experience with the testing.

However, it seems to me, that in the workshop you wish to look rather for potential sponsors than experimental labs.
Anyway, I would be glad to hear more about the event. Thanks.

With best regards
Anna Hojna

Centrum Vyzkumu Rez s.r.o.
Department 8590 VaV Generation IV
Rez 130
25068 Husinec
Czech Republic
http://cvrez.cz
Tel.: +420 2 6617 3549

From: Tregoning, Robert
Sent: Wed, 7 Dec 2016 21:07:09 +0000
To: Hiser, Matthew
Subject: RE: Harvesting Workshop Agenda Brainstorming

Matt:

Just got off the phone with Sherry and Rich. Let's talk about the agenda as soon as possible, either today or tomorrow morning.

Cheers,

Rob

Robert Tregoning
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ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, December 07, 2016 3:38 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: RE: Harvesting Workshop Agenda Brainstorming

<< File: NRC Harvesting Workshop Announcement 12-7-16.docx >>

Hi Rob,

Added some language to the announcement per suggestion from Allen. He suggested addressing whether presentations were open or solicited, as well as when more information on the workshop would be available:

"Workshop will consist of solicited presentations followed by discussion periods. Open attendance and participation in discussion is encouraged. Additional information to be provided by January 13, 2016."

Any thoughts? Look good to you?

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: Wednesday, December 07, 2016 2:08 PM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>
Subject: RE: Harvesting Workshop Agenda Brainstorming

Updated workshop announcement as requested with figures.

<< File: NRC Harvesting Workshop Announcement 12-7-16.docx >>

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: Wednesday, November 09, 2016 10:37 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>
Subject: FW: Harvesting Workshop Agenda Brainstorming

Just wanted to send a reminder for feedback / input on the workshop agenda.

Thanks!
Matt

_____
From: Hiser, Matthew
Sent: Friday, November 04, 2016 12:46 PM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>
Subject: RE: Harvesting Workshop Agenda Brainstorming

<< File: Workshop Agenda 11-4-16.docx >> << File: NRC Harvesting Workshop Announcement.docx >>

Hi Rob, Pat, and Jeff,

Please find attached my updates to the agenda based on our discussion yesterday. It may be somewhat premature, but I went ahead and tried to put times to the agenda, just to see how it might schedule out. Session 5 is probably the main area of uncertainty along with international presenters in general.

Please take a look and provide any comments or feedback by next Wednesday, so we can hopefully finalize this and share with DOE/EPRI very soon.

I also attached the latest version of the workshop announcement, which we plan to use to publicize to other attendees and presenters.

Thanks!
Matt

Original Appointment-----
From: Hiser, Matthew
Sent: Wednesday, November 02, 2016 2:34 PM
To: Hiser, Matthew; Purtscher, Patrick; Tregoning, Robert; Poehler, Jeffrey
Subject: Harvesting Workshop Agenda Brainstorming
When: Thursday, November 03, 2016 1:00 PM-2:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: HQ-TWFN-08C01-10p

Hi Rob, Jeff, Pat,

I've put together an outline of an agenda for this workshop on harvesting that we are planning for March. My first cut at it is attached. I'd like to use this meeting to brainstorm how to structure the workshop and, if possible, who to ask to present and on what topics.

Rob and I were discussing trying to selectively target participants and presentations to cover the topics we'd like, rather than simply asking DOE and EPRI and others for their take on "harvesting." I think if we plan this well, we can get an interesting and substantive discussion. If not, we may just get a rehash of SLR-type talks…

Thanks!
Matt

<< File: Agenda Outline.docx >>

From: Tregoning, Robert
Sent: Thu, 1 Dec 2016 15:53:18 +0000
To: Hiser, Matthew
Subject: RE: Harvesting Workshop Agenda

Thanks, I'll send the agenda to DOE/EPRI and start circulating the announcement as well….

Robert Tregoning
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fax: 301-415-6671

From: Hiser, Matthew
Sent: Thursday, December 01, 2016 10:37 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: Harvesting Workshop Agenda

Hi Rob,

I've incorporated the tweaks to the agenda that we discussed yesterday. We may want to try to schedule a meeting soon, given the rapidly approaching holidays. We should try to get aligned with DOE and EPRI before the holidays and firm up/contact the presenters. When everyone gets back in January, we'll be about 2 months from the workshop!

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: Fri, 21 Oct 2016 13:17:10 +0000
To: Hiser, Matthew;Iyengar, Raj
Subject: RE: Harvesting Workshop Announcement

Let's set the dates based on EPRI/DOE feedback and then I'll start sending internationally once we finalize the dates.

RT

Robert Tregoning
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Rockville, MD 20852-2738
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fax: 301-415-6671

From: Hiser, Matthew
Sent: Friday, October 21, 2016 9:05 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>
Subject: Harvesting Workshop Announcement

Hi Rob and Raj,

Please find attached the final version of the harvesting workshop announcement. If you could share this with your contacts at DOE/EPRI (Raj), and internationally (Rob), that would be great to begin to publicize this workshop and receive feedback on the preferred dates as well as those interested to present at the workshop.

Thanks!
Matt

From: Tregoning, Robert
Sent: Wed, 14 Dec 2016 23:21:11 +0000
To: Purtscher, Patrick
Subject: RE: Harvesting Workshop Plans

Tom Rossel I have his email if you need it trossel@ornl.gov. I may not have his name spelled correctly however

-------- Original Message --------
From: "Purtscher, Patrick" <Patrick.Purtscher@nrc.gov>
Date: Wed, December 14, 2016 10:13 AM -0500
To: "Tregoning, Robert" <Robert.Tregoning@nrc.gov>
Subject: RE: Harvesting Workshop Plans

Hi,

Do you have the contact info for the guy at ORNL who would have worked with Energy Solutions Zion?

Pat

From: Hiser, Matthew
Sent: Monday, December 12, 2016 2:44 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Cc: Poehler, Jeffrey <Jeffrey.Poehler@nrc.gov>; Hiser, Allen <Allen.Hiser@nrc.gov>
Subject: Harvesting Workshop Plans

Hi Rob and Pat,

Following our meeting last week, I made the appropriate updates to the workshop agenda and have attached it to this email. I have also attached a "condensed" workshop agenda that we can share with any interested attendees looking for a little more info.

We agreed that Rob will take the lead for organizing Sessions 1 and 5, Pat will take session 3, and I will take sessions 2 and 4.

Action items from that meeting are summarized below:

- Rob: send revised agenda to EPRI/DOE and ask for their leads for each session
- Rob: send announcement to CSNI and other international contacts
- Rob: contact MAI, JRC, JNRA, and IAEA for potential presentations
- Pat: contact decommissioning branch for contact at EnergySolutions for decommissioning presentation
- Matt: Contact Chuck Tomes at Dominion for U.S. utility talk

The list of international parties we think could be interested include:

- ENSI (Muhleberg in Switzerland)
- KINS/KAERI (Kori plant in Korea)
- SCK – RPV interest in Belgium
- MAI in France
- JRC in EU
- JNRA in Japan
- IAEA
- German decommissioning company

Thanks!
Matt

From: Tregoning, Robert
Sent: Wed, 31 Jan 2018 15:52:36 +0000
To: Hiser, Matthew
Cc: Purtscher, Patrick
Subject: RE: Harvesting Workshop Presentations

I'm going to send it to him under our umbrella agreement with CSN that covers information sharing but ask him not to distribute or share outside of his organization…..

Robert Tregoning
Technical Advisor for Materials
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fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, January 31, 2018 10:51 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop Presentations

I'm fine with it…

From: Tregoning, Robert
Sent: Wednesday, January 31, 2018 10:50 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop Presentations

Ah yes, I forgot you put them on google drive and when I scanned the summary report I didn't see a link. Do you see any problems with sending the summary and link to Carlos?

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fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, January 31, 2018 10:48 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop Presentations

Here's the final report – the presentations are on a folder in my Google Drive that is accessible via a private link (anyone with the link can access them, but otherwise no one can see them): https://drive.google.com/open?id=0B5DWMLch5YSXcnpZZ0JOS055QUU . This link is in the final report on page 17 under Action Items.

From: Tregoning, Robert
Sent: Wednesday, January 31, 2018 10:45 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop Presentations

Matt:

Thanks, that's what I thought but just wanted confirmation. I got a request from CSN (Carlos Castelao) about the workshop. I was planning on sending him the workshop summary. Are there any issues with this? I was also thinking about sending him the presentations. Thoughts? How did we ultimately send these to the workshop participants if they are just on the g:\?

Rob

Robert Tregoning
Technical Advisor for Materials
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11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, January 31, 2018 10:38 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop Presentations

Hi Rob,

They are not in ADAMS (since we were in this non-public working space, I never bothered). Here's their location on the G: drive: G:\DE\CMB\Harvesting Workshop Presentations .

Thanks!
Matt

From: Tregoning, Robert
Sent: Wednesday, January 31, 2018 8:38 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: Harvesting Workshop Presentations

Matt/Pat:

I'm assuming that we put all the presentations in ADAMS in a single package. Is this the case? Can you send me the ADAMS number?

Rob

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US Nuclear Regulatory Commission
Two White Flint North, M/S T-10 A36
11545 Rockville Pike
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fax: 301-415-6671

From: Tregoning, Robert
Sent: Mon, 1 May 2017 14:57:16 +0000
To: Hiser, Matthew
Cc: Purtscher, Patrick
Subject: RE: Harvesting Workshop Summary Report Draft

Matt:

Thanks, I'm pretty tied up again both this week and early next week (through Wednesday) but I'll do my best. Proceed if you don't hear from me by end of this week. We do need to keep the effort moving on developing wish lists and the sources database. I spoke with Kazu Sakamoto last week and he indicated that he's getting pressure from his bosses to do something in this area so he is now motivated more so than during the workshop to collaborate with us on this. I can provide more details….

Rob

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fax: 301-415-6671

From: Hiser, Matthew
Sent: Monday, May 01, 2017 10:45 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: Harvesting Workshop Summary Report Draft

Hi Rob,

I have started working on the workshop summary report (attached). I bounced this off of Pat last week and he and I are largely aligned in terms of scope and level of detail.

I have currently written up through the background / intro, session 1 and session 2. When you get a chance, please take a look and provide any feedback on the organization, scope, and level of detail. There is a high-level outline on the first page.

I am hoping to get to a complete first draft by the end of next week and then hopefully something ready to share with workshop participants by the end of May.

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: Tue, 17 Jan 2017 13:25:49 +0000
To: Hiser, Matthew;Purtscher, Patrick
Subject: RE: Harvesting Workshop

Matt:

I think your message is fine and it doesn't hurt to query CNSC a bit about possible contributions. We should, of course, keep in mind that there will likely be less interest in a CANDU-perspective/opportunities/issues since our focus is LWR components. However, maybe there are other components, like cables or concrete, where there is enough similarities in operating conditions and pedigree.

Rob

Robert Tregoning
Technical Advisor for Materials
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11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Tuesday, January 17, 2017 8:12 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop

It was a voicemail with a phone number left, so I was planning to call him back later this morning.

My plan was to deliver a similar message as you have to the Japanese: non-public workshop; we are inviting/soliciting presentations; their attendance and participation is welcome, but we are trying to keep it small and focused. Do you think CNSC could present in one of the yellow or red slots below?

Session	Topic	Organization	Speaker	Status
1	Why our organization is interested in harvesting	EPRI		
		DOE		
		NRC	Robert Tregoning	
		MAI or JRC		
		JNRA		
	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		
		MAI or JRC		SCK-CEN?
		JNRA		CRIEPI?
3	Available materials from decommissioning plants and past harvesting programs	NRC	Matt Hiser	
	Available materials from operating reactors and past harvesting programs	EPRI		
	Available materials at DOE labs from past harvesting programs	DOE (ORNL?)		
	International sources of materials	IAEA?		
4	Perspective on Harvesting Lessons Learned / Prior Experience	EPRI		
		DOE		
		NRC		
	Decommissioning process and harvesting: schedule, site-specific, timing for different components	Energy Solutions	Gerry van Noordennen	

	Utility-Owner perspective on harvesting and decommissioning	Dominion?		
	International decommissioning and harvesting experience	Germany?		
5	Technical information needed for informed harvesting decisions	PNNL (for NRC)	Pradeep Ramuhalli	
	Perspective on future harvesting planning	EPRI		
		DOE		
		NRC	Robert Tregoning	
		MAI or JRC		
		JNRA		
	PANEL DISCUSSION			
	Discussion of Next Steps / Actions			

Thanks!
Matt

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

From: Tregoning, Robert
Sent: Tuesday, January 17, 2017 8:05 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop

Are you responding to CNSC?

RT

Robert Tregoning
Technical Advisor for Materials
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11545 Rockville Pike
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ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Tuesday, January 17, 2017 7:27 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop

Hi Rob,

I think that is an excellent idea. I'll draft up a few slides and share with you two.

Also, I received a message on Friday from someone at CNSC indicating their interest in possibly sending a couple people to the workshop.

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: Thursday, January 12, 2017 4:22 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop

Guys:

We haven't explicitly talked about this but I think it would be good to have a 5 – 10 minute talk at the very beginning of the workshop to provide the overall workshop objectives, and discuss the objectives and format/approach of the individual sessions. Maybe it would also be good to put a few slides together now that we can send to participants so that people are as aligned as possible heading into the workshop.

Thoughts about this idea?

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, Matthew
Sent: Thursday, January 12, 2017 1:44 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: Harvesting Workshop

<< File: Workshop Planning.docx >>
Hi Rob and Pat,

Thanks for the productive meeting this morning. I've attached the latest version of the planning document.

Here were each of our action items:

Rob:

- Sessions 1/5 (mostly panel discussions)
- Contact international participants:
  - Oliver Martin – JRC
  - TG Lian – EPRI/MAI
  - JNRA/CRIEPI

Pat:

- Contact PNNL
- Session 2 – work with DOE (Keith Leonard) and EPRI to plan

Matt:

- Sessions 3/4 – work with DOE (Rosseel) and EPRI to plan
- Contact speakers:
  - EnergySolutions
  - Dominion/utility
  - IAEA/Krivanek
- Transcription/AV

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

-----Original Appointment-----
From: Hiser, Matthew
Sent: Monday, January 09, 2017 10:00 AM
To: Hiser, Matthew; Tregoning, Robert; Purtscher, Patrick
Subject: Harvesting Workshop
When: Thursday, January 12, 2017 8:00 AM-9:00 AM (UTC-05:00) Eastern Time (US & Canada).
Where: HQ-TWFN-10A73-8p

Can we move this a little earlier tomorrow since I now have a conflict at 9:00?

Here is a workshop planning document I've created with a list of contacts / expected attendees and a table laying out all the planned presentations and sessions to track confirmed speakers.

<< File: Workshop Planning.docx >>

From: Hiser, Matthew
Sent: Tue, 5 Dec 2017 19:40:07 +0000
To: Purtscher, Patrick
Subject: RE: Harvesting-TLR-final DRAFT-12_04_2017.docx

I think when we met last week we talked about having a meeting with the appropriate folks over there to explain this report and what is going on with harvesting, rather than just lobbing it over the fence… You might want to reach out to Bennett to figure out who would be the right staff in NRR to pull into such a meeting.

From: Purtscher, Patrick
Sent: Tuesday, December 05, 2017 2:27 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: FW: Harvesting-TLR-final DRAFT-12_04_2017.docx

Should I send this over to Bennett Brady too?

From: Purtscher, Patrick
Sent: Tuesday, December 05, 2017 8:20 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>
Subject: Harvesting-TLR-final DRAFT-12_04_2017.docx

Here is the final draft of the harvesting report.

Pat

From: Tregoning, Robert
Sent: Tue, 17 Jan 2017 13:04:02 +0000
To: Hiser, Matthew;Purtscher, Patrick
Subject: RE: Hi Matt. I understand that there will be a 2 day harvesting workshop the week before the RIC? If so can you send me a scheduler for the workshop?

Agreed….

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: Tuesday, January 17, 2017 7:25 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: FW: Hi Matt. I understand that there will be a 2 day harvesting workshop the week before the RIC? If so can you send me a scheduler for the workshop?

Got this from Bernie Litkett in DLR last week. We probably need to talk about how to communicate this workshop within NRC…

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: Litkett, Bernard
Sent: Thursday, January 12, 2017 2:30 PM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: Hi Matt. I understand that there will be a 2 day harvesting workshop the week before the RIC? If so can you send me a scheduler for the workshop?

Bernard Litkett
NRR/DLR/RSRG
Project Manager

0-11C5
301-415-3657
Bernard.Litkett@nrc.gov

Note to requester: The attachment is immediately following.

From: Tregoning, Robert
Sent: Thu, 30 Aug 2018 20:09:03 +0000
To: Audrain, Margaret
Cc: Hiser, Matthew;Purtscher, Patrick
Subject: RE: JNRA Meeting Sept 2018 Harvesting.pptx
Attachments: JNRA Meeting Sept 2018 Harvesting rlt.pptx

Meg, Matthew, Patrick:

Many thanks for your help with this. The presentation looks good and it will be useful for having a targeted discussion on the topic and hopefully we will see some interest from them in this area. I made a few simple formatting changes to a few slides so they all have similar fonts (see attached).

Could you also provide me a reference for the PNNL report (i.e., title and report number)? I'd specifically like to let them know about this report and let them know that we are planning to have it completed sometime in the fall. I'm going to add this as a bullet to one slide.

Matt:

Can I get you to add another slide which summarizes, at a high level the harvesting workshop and then has a reference to the workshop summary report? Basically just a reminder of dates, attendance, agenda/discussion topics, and then the reference to the report. Since Kazu attended the meeting I don't think there are any issues with giving them the summary. Do you agree?

Thanks again,

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: Audrain, Margaret
Sent: Thursday, August 30, 2018 2:22 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: JNRA Meeting Sept 2018 Harvesting.pptx

Rob,

Please see attached for the harvesting presentation. I added the harvesting needs slides, as discussed. Feel free to make edits or let me know if you want something changed.

Thanks,

Meg

Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

M. Audrain, M. Hiser, P. Purtscher, R. Tregoning

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

The views expressed in this presentation are those of the author, not necessarily those of the U.S. NRC.

Motivation

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

- US utilities are interested in extending operating lifespans from to 60-80 years:
  - Key technical areas for aging management:
    - RPV embrittlement, irradiation-assisted degradation of internals, concrete structures and containment, electrical cables
- Many plant shutdowns worldwide provide opportunities to harvest components during decommissioning
  - Harvesting can provide valuable information on aging mechanisms to increase confidence in aging management
- Limited budgets make cooperation for new research, including harvesting, essential:
  - Important to align interested parties
  - Leverage resources for maximum benefit

NRC Harvesting Experience

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

- NRC has participated in several programs:
  - RPV, CRDM penetrations, RCS piping, RPV internals, neutron absorbers, and cables
  - Materials harvested from unfinished, operating and decommissioning plants
  - US and international programs
- NRC experience is there is significant value in using harvested components to confirm data from other research programs

Lessons Learned

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

- Technical
  - Provides highly representative aged materials for research
  - Important to gain as much information as possible before committing to specific harvesting project

- Logistical
  - Expensive and time-consuming effort
  - Leveraging resources helps mitigate cost challenges
  - Transportation of irradiated materials is cumbersome and time-consuming

Current Work

U.S.NRC
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- Develop strategic approach to materials harvesting
  - Past efforts have been reactive to individual plants shutting down
  - Developing
- Prioritize data needs best addressed by harvesting, considering:
  - Applicability of harvested material for addressing gaps
  - Importance of harvested materials over laboratory aging
  - Fleet-wide vs plant-specific applicability of data
  - Regulatory considerations
  - Harvesting cost/complexity
- Database for Sources of Materials
  - Compilation of previously harvested materials available at US national labs as well as those available for future harvesting
  - NRC is interested in engaging with other organizations in developing the database

Needs - Metals

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- 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

Needs - Metals

U.S.NRC
United States Nuclear Regulatory Commission
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- 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

Needs - Electrical

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- 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.

Needs - Concrete

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- 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

Conclusion

U.S.NRC
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Protecting People and the Environment

- Harvesting can yield highly representative and valuable data on materials aging
- A focused approach to choosing harvested materials is necessary to get best outcomes
- NRC is working on a sources of materials database and prioritizing data needs based on relevant criteria to inform decisions on specific harvesting opportunities
- NRC welcomes opportunities for cooperation and leveraging with other interested research organizations

Discussion

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- Has the planned work on harvesting RPV materials and concrete from Hamaoka 1 been completed?
  - Can those results be shared with NRC?
- Does NRA/CRIEPI have any other harvesting programs in progress or planned?
  - If so, any information that can be shared?
  - If still being planned, is there interest in additional partners?
- Would there be interest in participating if a harvesting project was identified in the US or another country?
  - Should we reach out to NRA if other harvesting opportunities develop?

From: Tregoning, Robert
Sent: Mon, 19 Dec 2016 15:37:38 +0000
To: 'OlliVilhelm.NEVANDER@oecd.org'
Subject: RE: NRC Harvesting Workshop

Thanks, Olli. I greatly appreciate the help. I hope you and your family have a happy and healthy holidays and a prosperous New Year!

Rob

From: OlliVilhelm.NEVANDER@oecd.org [mailto:OlliVilhelm.NEVANDER@oecd.org]
Sent: Monday, December 19, 2016 9:02 AM
To: ajh@csn.es; alexander.price@onr.gov.uk; andrei.blahoianu@canada.ca; andrzej.kochmanski@udt.gov.pl; ari.koskinen@vtt.fi; b.martens@sckcen.be; bharat.patel@ec.europa.eu; bjorn.brickstad@ssm.se; borut.mavko@ijs.si; boylydell@msn.com; bruno.barthelet@edf.fr; car@csn.es; ccl@csn.es; ccueto@tecnatom.es; cecile.deust-dhaultfoeuille@irsn.fr; chris.belsham@onr.gov.uk; cik@kaeri.re.kr; ckr@kins.re.kr; corsi@casaccia.enea.it; daniel.kjellin@ssm.se; dietmar.kalkhof@ensi.ch; Hackett, Edwin <Edwin.Hackett@nrc.gov>; eric.meister@edf.fr; eric.van.walle@sckcen.be; francois.balestreri@irsn.fr; francois.tarallo@irsn.fr; frank.michel@grs.de; frederic.somville@tractebel.com; fredrik.forsberg@ssm.se; georges.van-goethem@ec.europa.eu; gillemot@sunserv.kfki.hu; giuseppe.pino@isprambiente.it; guillaume-gontrand.herve@edf.fr; hiroaki_yamazaki@nsr.go.jp; hiroshi_abe@nsr.go.jp; hoj@ujv.cz; igor.simonovski@ec.europa.eu; ilie.petre-lazar@edf.fr; incalcaterra@enea.it; isabelle.delvallee@irsn.fr; jan.borak@enel.com; jan.dotrel@ujv.cz; janosi@hu.inter.net; jari.puttonen@aalto.fi; jikim@kaeri.re.kr; jiri.zdarek@ujv.cz; jjchen@iner.gov.tw; jkgone@aec.gov.tw; jolana.rydlova@sujb.cz; Pires, Jose <Jose.Pires@nrc.gov>; jovica.riznic@canada.ca; jsc@csn.es; juergen.sievers@grs.de; jukka.mononen@stuk.fi; junekl@uam.cz; jure.skodlar@gov.si; jussi.solin@vtt.fi; k211ckk@kins.re.kr; k651pjs@kins.re.kr; karl-fredrik.nilsson@ec.europa.eu; karl-heinz.herter@mpa.uni-stuttgart.de; katsunori_sugaya@nsr.go.jp; kazunobu_sakamoto@nsr.go.jp; kensaku_arai@nsr.go.jp; kikuo_takeshima@nsr.go.jp; kisaburo_azuma@nsr.go.jp; klaus.germerdonk@ensi.ch; klaus.heckmann@grs.de; kostas.xanthopoulos@ssm.se; krajmer.imrich@ebo.seas.sk; l.francia@unesa.es; ladislav.pecinka@ujv.cz; lars.skanberg@ssm.se; laurent.foucher@asn.fr; laurent.streibig@asn.fr; leon.cizelj@ijs.si; lola.gomezbriceno@ciemat.es; louis.vanderwiel@minvrom.nl; ludovit.kupca@enel.com; lutz.lindhorst@anvs.nl; Sircar, Madhumita <Madhumita.Sircar@nrc.gov>; makio_nakano@nsr.go.jp; marc.petit@irsn.fr; masaaki_ishikawa@nsr.go.jp; masakuni_koyama@nsr.go.jp; mhlu@iner.gov.tw; michaela.weber@ensi.ch; michel.desmet@g dfsuez.com; mihdi.elmas@grs.de; miloslav.hrazsky@vuje.sk; ming.han@snclavalin.com; morishita.masaki@jaea.go.jp; mscibett@sckcen.be; Chokshi, Nilesh <Nilesh.Chokshi@nrc.gov>; nilgun.gerceker@taek.gov.tr; obushev@nikiet.ru; oliver.martin@ec.europa.eu; olli.nevander@oecd.org; onizawa.kunio@jaea.go.jp; panagiotis.manolatos@ec.europa.eu; paolo.contri@enel.com; paul.harrop@onr.gov.uk; pentti.varpasuo@partners.fortum.com; peter.haehner@ec.europa.eu; pfan@csn.es; pierre.labbe@edf.fr; pis@ujv.cz; potapov@vniiaes.ru; r.krivanek@iaea.org; rachel.vaucher@asn.fr; rauli.keskinen@stuk.fi; rob.jansen@anvs.nl; Tregoning, Robert <Robert.Tregoning@nrc.gov>; s.samaddar@iaea.org; sabhardwaj@npcil.co.in; sampsa.launiainen@fortum.com; shingo_nomura@nsr.go.jp; shirimp@kins.re.kr; shunsuke_ogiya@nsr.go.jp; sskang@kins.re.kr;

suzuki.masahide@jaea.go.jp; sychoi@kaeri.re.kr; syed.ali@nrc.gov; takuya_toriyama@nsr.go.jp; thierry.payen@irsn.fr; tomohiro_hojo@nsr.go.jp; toru_iijima@nsr.go.jp; tshoji@fri.niche.tohoku.ac.jp; vanderschaaf@nrg.eu; vincent.deledicque@belv.be; vivekb@barc.gov.in; vla dimir.jurco@enel.com; vladimir_magula@ibok.sk; yann.kayser@cea.fr; young@kins.re.kr
Subject: [External_Sender] NRC Harvesting Workshop

NRC harvesting workshop

On March 7 – 8, 2016, the U.S. NRC, in cooperation with the U.S. Department of Energy (DOE) and the Electric Power Research Institute (EPRI), is hosting an invited workshop on Material and Component Harvesting in Rockville, MD, USA. Harvesting is the extraction of materials, components, or structures from either operational or decommissioned nuclear plants. There is a long history of research programs using harvested materials. Often, these programs are complicated, costly, and risky, and there is a danger that the knowledge gained by the research is not justified by the effort and cost involved. In the near future, there will be more opportunities to obtain harvested materials from nuclear plants, both in the U.S. and internationally. The objective of the workshop is to identify technical needs best addressed by harvesting, identify possible sources of harvested materials, summarize lessons-learned and practical aspects of harvesting programs, and ultimately outline a process for developing a more efficient plan for harvesting materials.

An announcement for the workshop and a condensed agenda is attached. Please contact Rob Tregoning (rlt@nrc.gov), if you are interested in getting more information about the workshop or possibly contributing to the discussion.

Best regards
Olli

Olli Nevander
Nuclear Safety Specialist
Nuclear Safety Division
OECD Nuclear Energy Agency (NEA)
Tel.: +33 (0)1 45 24 10 58
(b)(6) Cell: [redacted]
e-mail: olli.nevander@oecd.org
www.oecd-nea.org
Follow the NEA on:

From: Tregoning, Robert
Sent: Wed, 11 Oct 2017 13:16:01 +0000
To: Hiser, Matthew
Cc: Moyer, Carol;Hull, Amy;Purtscher, Patrick
Subject: RE: NRC PLiM slides on Harvesting rlt).pptx

Matt:

Think slides look fine; pending additional comments from others on this email, I'm okay with moving to Steve/Brian for review.

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, Matthew
Sent: Wednesday, October 11, 2017 9:13 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>
Cc: Moyer, Carol <Carol.Moyer@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: NRC PLiM slides on Harvesting rlt).pptx

Hi Rob,

Thank you for reviewing and for your input. I greatly reduced the sub bullets and sub sub bullets as you suggested (moving info to the notes) and the slides are much cleaner now.

I also added a couple figures to improve the visual interest.

Thanks!
Matt

From: Tregoning, Robert
Sent: Wednesday, October 11, 2017 6:59 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Moyer, Carol <Carol.Moyer@nrc.gov>; Hull, Amy <Amy.Hull@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: NRC PLiM slides on Harvesting rlt).pptx

Matt:

I have only a few comments (attached). I think the key messages are on point. My only real quibble is stylistic. The slides are basically a ton of words. It would be nice to have some representative graphics or illustrations of some of the points just to break up the words. However, I know it can take time to develop/find good representative graphics and given our limited window, I don't know if you want to tackle this or not. At a minimum, I recommend eliminating many of the sub-bullets and sub-sub-bullets from the slides themselves and moving them to the talking points. This will help Allen out as well.

Good job with this on such short notice!

Rob

Robert Tregoning
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11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Tregoning, Robert
Sent: Wed, 22 Feb 2017 19:58:21 +0000
To: Hiser, Matthew;Purtscher, Patrick
Subject: RE: NRC Staff Attendance at Workshop

Matt:

I'm still a bit unclear on session 5. Maybe I'm being dense

PNNL (for NRC)	Pradeep Ramuhalli	Technical Information Needed for Informed Harvesting Decisions
EPRI	Sherry Bernhoft	
DOE	Rich Reister	
NRC	Robert Tregoning	NRC Perspective on Future Harvesting Planning
DISCUSSION		
Action Items and Closing Thoughts		

What specifically do we want Sherry and Rich to cover in their remarks? I thought we talked yesterday about EPRI, DOE, and NRC just providing some closing thoughts and then opening it up to the group. I envisioned that the session would look like this

1. Pradeep's talk
2. General Discussion using seeded questions.
3. Summary of action items
4. Closing thoughts about workshop and harvesting in general: first DOE, EPRI, and NRC and then open it up to the group.

While I'm not opposed to the above layout, I just want to make sure that we're clear what we want Sherry and Rich to communicate in their separate talks prior to the discussion.

On another note, I think it would be good to indicate specific times for each talk, especially within session 2 – 4 to reinforce the notion that each speaker only has been allotted that amount of time.

Otherwise, it looks good but I'd really like to get titles ☺

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, Matthew
Sent: Wednesday, February 22, 2017 1:27 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: NRC Staff Attendance at Workshop

Hi Rob,

I've attached the latest workshop attendee and webinar contact list. It's only a few external people. INL will be sending John Jackson who will give a brief talk on the NSUF sample library in session 3. Any other INL staff will participate via webinar.

I haven't heard back from EnBW, so I put together the agenda assuming they will not present. We could easily add them into session 4 if necessary. I've attached the final agenda. Please take a look and let me know what you guys think.

Thanks!

Matt

From: Tregoning, Robert
Sent: Wednesday, February 22, 2017 10:11 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: NRC Staff Attendance at Workshop

Matt:

Who's on the final webinar list? I think we have like 3 or 4 people correct? Do we have final confirmation that INL will just send one person? I think adding Mark is fine as long as we're right around 30 people.

Robert Tregoning
Technical Advisor for Materials
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11545 Rockville Pike
Rockville, MD 20852-2738
ph: 301-415-2324
fax: 301-415-6671

From: Hiser, Matthew
Sent: Wednesday, February 22, 2017 9:30 AM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: NRC Staff Attendance at Workshop

NRC	Pat Purtscher	NRC
	Rob Tregoning	NRC
	Matt Hiser	NRC
	Mita Sircar	NRC
	Tom Koshy	NRC
	NRR/DE	NRC
	NRR/DLR	NRC
	NRR concrete	NRC

Hi Rob and Pat,

This is the current list of NRC staff attending the workshop. Tom Koshy indicated a NRR electrical wouldn't be needed (or if NRR sent an electrical person then Tom wouldn't be needed), so I haven't included them on here. With these 8 NRC staff plus 23 external participants, we are at 31 total.

The other person that I have discussed this workshop with that has expressed strong interest in attending is Mark Kirk. Given the Belgian participation and interest in RPV topics, we might want to allow him to attend as well. That would put us at 32 total in the room. Thoughts?

Thanks!

Matt

From: Audrain, Margaret
Sent: Thu, 29 Mar 2018 20:13:05 +0000
To: Tregoning, Robert;Purtscher, Patrick
Subject: RE: ORNL visit

Yes, that's probably fine. I can explain to Steve the delay.

From: Tregoning, Robert
Sent: Thursday, March 29, 2018 2:30 PM
To: Audrain, Margaret <Margaret.Audrain@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: ORNL visit

Meg:

I have not heard back yet from pinging them again. Do you think you can wait until early next week for your travel or is that too late? If I don't get a reply back by Monday or Tuesday at the latest, we should call them.

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: Audrain, Margaret
Sent: Thursday, March 29, 2018 2:26 PM
To: Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: ORNL visit

Rob,

Have you heard from the folks at ORNL about visiting them April 20? I need to get my travel in ASAP.

Thanks,

Meg

From: Hiser, Matthew
Sent: Thu, 9 Nov 2017 08:01:06 -0500
To: Purtscher, Patrick
Subject: RE: phone call with INL

Hi Pat,

They've all accepted the meeting. I need to set up a bridge line, so you'll see an update to the scheduler…

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: Purtscher, Patrick
Sent: Thursday, November 09, 2017 8:00 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Subject: phone call with INL

What have you heard from INL about a phone call? I am working from home today but could call in.

Pat

From: Purtscher, Patrick
Sent: Wed, 27 Jun 2018 10:08:05 +0000
To: 'Ramuhalli, Pradeep'
Subject: RE: Phone call

That will be fine, try my office line first, 301-415-3942 and if I don't answer, call my cell (b)(6)

(b)(6)

Pat

From: Ramuhalli, Pradeep [mailto:Pradeep.Ramuhalli@pnnl.gov]
Sent: Wednesday, June 27, 2018 12:50 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: [External_Sender] Phone call

Patrick,

My apologies – the other phone call ran long and I completely forgot to give you a call afterwards. Can I call you in the morning tomorrow for a few minutes? Probably be around 9.30 or 10 am east coast time, if that is OK. I can call your office.

With best regards,

Pradeep

Pradeep Ramuhalli, PhD
Senior Research Scientist,
Applied Physics Group
Pacific Northwest National Laboratory
902 Battelle Blvd.
P.O.Box 999, MSIN K5-26
Richland, WA 99352
Tel: 509-375-2763
Email: pradeep.ramuhalli@pnnl.gov
http://www.pnnl.gov

Note to requester: The "INL NEID Material Library Search Result mah 1-26-18.xlsx" file is too large to import into the FOIA Team's redaction software. This file will be provided in its original format (Excel) as a seperate document in this interim response. The remaining attachments are immediately following.

From: Hiser, Matthew
Sent: Friday, January 26, 2018 3:59 PM
To: Purtscher, Patrick; Audrain, Margaret; Tregoning, Robert
Subject: Ex-Plant Harvesting Coordination Meeting
Attachments: INL NEID Material Library Search Result mah 1-26-18.xlsx; Harvesting Jan 25 Meeting Summary and Path Forward.docx; Harvesting Needs Prioritization 12-1-17.xlsx

Hi everyone,

Following up from our meeting yesterday, I have attached a meeting summary / path forward outline covering our current activities. I've also attached the latest version of the prioritization table as well as a modified version of the INL database as noted in the meeting summary document.

I appreciate you guys continuing to push forward on this effort in my absence and will hopefully be back in a few months to pick things back up.

Thanks!
Matt

Harvesting 1/25/2018 Meeting Summary / Path Forward

Harvesting

- Actions
  - ALL – do prioritization before next meeting: first ad hoc, then by using criteria
    - Next, socialize with NRR and NRO technical staff to solicit additional ideas for harvesting and a path to staff consensus on prioritized list
  - Pat - ANL spreadsheet
    - Send requested NRC revisions to ANL
    - Contact PNNL / Pradeep
  - Matt – columns in INL database
    - Identified corresponding columns in INL database to ANL spreadsheet - see column headings shaded green in attached Excel spreadsheet
    - Pat / Meg – follow-up with INL NFML as-needed
  - Pat / Meg – follow-up on RIC poster as needed (per forwarded emails)
- Boneyards
  - ANL – Pat and Meg
    - Visit complete, input complete pending tweaks to spreadsheet
  - PNNL – Pat coordinate with Pradeep
    - Meg and Eric to visit in spring during regular PWSCC meetings
    - Contacts: Pradeep Ramuhalli, Steve Doctor
  - ORNL – Meg
    - Meg to visit in April during ICG-EAC travel
    - Contacts: Mikhail Sokolov and Tom Rosseel
  - Battelle - Matt
    - Matt to visit in June during EWI training in Columbus
    - Contacts: Bruce Young, Paul Scott
- Prioritization table
  - Latest version attached to email. Use in advance of next meeting and determine future use of table/criteria for prioritization
  - Engage staff in NRR/NRO/RES for socialization / feedback
- RIC
  - E-Poster – with division management for approval (emails forwarded to Pat and Meg)
  - Bilaterals – how much to support each country?
- PNNL report
  - With NRR for review

Criteria Title	Description	Scoring Guidance	
Criticalness of Technical Gap Addressed	Harvesting to address critical gaps should be prioritized over less essential technical gaps	**H = high risk significance / little to no available data** **MH = Medium-high risk significance / limited data available** **M = Moderate risk significance / some data available** **ML = low to moderate risk signficance / sufficient data available for regulatory decisions** **L = Low risk significance / large amount of data available**	**H = High** **MH = Medium-high** **M = Medium** **ML = Medium-low** **L = Low**
Importance of Harvested Materials over Laboratory Aging	Key considerations are the ease of laboratory replication of aging mechanism and unique field aspects of the aging mechanism. 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. For unique field aspects, 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 with representative properties.	**H = Nearly impossible to replicate service enviroment / critically important to use harvested materials** **MH = Challenging to replicate service enviroment / important to use harvested materials** **M = Possible with some limitations to replicate service enviroment / moderately important to use harvested materials** **ML = Not challenging to replicate service enviroment / less important to use harvested materials** **L = Very easy to replicate service enviroment / not important to use harvested materials**	
Applicability to US Operating Fleet	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.	**H = All plants** **MH = All PWRs** **M = All BWRs or most PWRs** **ML = ~10-15 plants** **L = <5 plants**	
Regulatory Considerations Related to Inspections and AMPs	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.The less confidence that NRC staff has in the effectiveness of the relevant AMP, the higher priority for harvesting.	**H = No or very limited inspection methods available / low confidence in AMPs** **MH = Limited inspection methods available / low-to-moderate confidence in AMPs** **M = Some inspection methods available / moderate confidence in AMPs** **ML = Good inspection methods available / medium-high confidence in AMPs** **L = Effective, well-accepted inspection methods exist / high confidence in AMPs**	
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.	**H = Highly irradiated (>5 dpa)** **MH = Lightly irradiated / contaminated** **M = Minimal contamination or high effort unirradiated** **ML = Unirradiated, moderate effort expected** **L = Unirradiated, low effort expected**	
Timeliness of 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.		

	Basic Info		Technical Criteria										Cost / Complexity		Project Specific	
Need Description	Purpose / Testing Planned	Technical Knowledge Gained	Criticalness of Technical Gap Addressed		Importance of Harvested Materials over Laboratory Aging		Applicability to US Operating Fleet		Regulatory Considerations Related to Inspections and AMPs		Score Average	Basis for Priority			Timeliness of results	Availability of materials for harvesting
METALS			Score	Comment	Score	Comment	Score	Comment	Score	Comment			Score	Comment		
High fluence reactor internals	Void swelling, mechanical properties, IASCC	Likely extent of void swelling in PWRs during extended operation and impact on cracking													TBD	TBD
Thermally aged unirradiated CASS	Fracture toughness and microstructure	Fracture toughness data in real conditions to compare to accelerated aging data														
Moderate fluence (1-2 dpa) CASS	Fracture toughness and microstructure	Fracture toughness data near limit requiring further evaluation														
Metallic components with known flaws	NDE and destructive examination	Determine whether SCC mitigation methods are effective at preventing SCC; effectiveness of NDE at detection and sizing														
Metallic components with limiting fatigue life	NDE and destructive examination	Determine whether fatigue flaws are present in high usage locations														

Need Description	Purpose / Testing Planned	Technical Knowledge Gained	Benefit / Significance	Cost	Alternative to Harvesting?	Priority / Value	Basis for Priority	Unique aspects of harvested materials	ISI availablility?
METALS									
RPV - High fluence & high shift vessel with well-established unirradiated properties	Measure fluence, toughness, & chemistry as a function of through-thickness position	Through thickness section to validate fluence & attenuation models	Increases confidence in existing regulatory approach	High	No	**LOW**	High cost not justified by benefit given surveillance specimens and well-established emrittlement trend correlations	Vintage compositions and irradiation conditions	
RPV - Samples from virtually any vessel	Enable measurement of both the Charpy transition curve and master curve transition temperature T0	Provides data supporting evolution from the use of correlative (Charpy-based) to direct measurement (fracture toughness-based) approaches	Increases confidence in existing regulatory approach	High	No	**LOW**	High cost not justified by benefit given surveillance specimens and well-established emrittlement trend correlations	Vintage compositions and realistic irradiation conditions	

Need Description	Purpose / Testing Planned	Technical Knowledge Gained	Benefit / Significance	Cost	Alternative to Harvesting?	Priority / Value	Basis for Priority	Unique aspects of harvested materials	ISI availablility?
ELECTRICAL									
Low and medium voltage cables				Medium		**HIGH**			
Cables protected with fire retardant coating				Medium					
1E MOVs from harsh and mild environments				Medium					
1E Air operated valves; 4160									
1E breakers				Low					
1E Molded case breakers 480V, 250V DC, 125 VDC,				Low					
1E Relays from mild environment GE – HFA, Agastat timing relays, any from Westinghouse, Potter Brumfield, Stuthers Dunn etc.,				Low					
Batteries				Low					
Electrical penetrations									
Fire research interest									
Electrical enclosures									
Distribution: switchgear, MCCs, LCs | Control: Horseshoe, SSCP, ASP, etc.									

Need Description	Purpose / Testing Planned	Technical Knowledge Gained	Benefit / Significance	Cost	Alternative to Harvesting?	Priority / Value	Basis for Priority	Unique aspects of harvested materials	ISI availablility?
METALS									
CONCRETE									
Structures exposed to high radiation	Change in properties due to irradiation effects	Loss of strength due to irradiation	Fills data gap for extended plant operation	High		**HIGH**			
Post-tensioned structures				Medium		**LOW**			
Corrosion of reinforcing steel, tendon, liner, embedment				Medium		**LOW**			
Spent fuel pool and transfer canal-boric acid attack on concrete in PWRs				Medium		**LOW**			
Alkali Aggregate Reaction				Medium		**LOW**			
Large structural sections for testing	Effects of concrete aging on structural capacity		Validate assumptions of aging effects at larger scales	High		**LOW**			

From:	Ramuhalli, Pradeep
To:	Hiser, Matthew; Purtscher, Patrick
Cc:	Knobbs, Katie
Subject:	[External_Sender] Updated example
Date:	Tuesday, May 3, 2016 1:41:55 PM
Attachments:	Example-DM-rev1.docx

Note to requester: Attachment is immediately following.

Matt, Pat:

The updated document is attached. More to come with CASS and the harvesting plan in a week or so.

Pradeep Ramuhalli, PhD
Senior Research Scientist,
Applied Physics Group
Pacific Northwest National Laboratory
902 Battelle Blvd.
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Email: pradeep.ramuhalli@pnnl.gov
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Draft Examples of Harvesting Prioritization Process

1. Ex-plant Harvesting
    a. May help address knowledge gaps in cases where replacement/repair is not possible – i.e., all cases where the material is going to stay for the duration of the license extension; condition assessment (CA) may or may not be possible on these.
2. Harvesting
    a. Literature and Sources
        i. EMDA PIRT, LWRS, LTO, NRC-RES, EDF-MRI, harvesting requests to date
        ii. Materials divided up into piping and pressure boundary components (metal), cables, concrete – all non-replaceable
        iii. Collate information across these sources as a first cut at identifying harvesting priorities.
    b. Criteria for prioritizing harvesting: Initial criteria focus on the ability of harvested materials to address gaps in materials performance knowledge for SLR. Available documents from the EMDA assessment identify the susceptibility of various materials in relevant environments to a number of degradation mechanisms. In addition to the susceptibility, information is available on the knowledge and confidence in the available knowledge regarding this "Material, Degradation Mechanism, Environment" (<M,M,E>) combination. In parallel, information in the SLR guidance documents associate similar combinations with relevant AMPs, while other available documents provide insights into the specific knowledge gaps. Questions that would need to be answered in line with these general criteria are:
        i. Is the combination of <M,M,E> rated "High susceptibility" in the EMDA review? Note that the PIRT review documents for cables and concrete may not be readily available for answering this question.
        ii. Is the combination of <M,M,E> rated "Low knowledge" in the EMDA review?
        iii. How easy it is to simulate <M,M,E> in the lab?
            1. Of the environments of interest, radiation environments are likely to be the most challenging to duplicate in a lab environment. This is more so for low dose, long term irradiation and is a concern if dose rate effects exist that may influence the mechanism initiation and growth. Harvesting should focus on irradiated materials where possible.
        iv. Is there OE associated with the combination of <M,M,E>? If OE is available, especially for low susceptibility <M,M,E> (for instance, atmospheric SCC), it may be worth harvesting the material if possible.
        v. Expected benefits from harvested materials
            1. Can harvested materials be used to address a critical gap in knowledge? See item (iv) above as an example.
            2. How will materials be used to address critical gaps? In addition to lab studies using characterization tools, can the material be used in

degradation initiation and growth studies? In cables aging, such studies have been proposed (wear-out aging).

3. Which AMPs are applicable to address the combination of <M,M,E>? Does OE in particular point to additional AMPs that may be applicable?
4. Do ISI methods exist to reliably detect and size degradation in <M,M,E>? Can harvested material be used to develop/improve ISI for SLR?

Note: Incorporate NRC Safety/regulatory aspects/perspectives – regulatory benefit.

c. Examples – In the interests of developing the process for prioritizing harvesting further, several examples are being considered. The two listed below are being used to fine-tune the process. Both of these are considered low priority for harvesting (one because of low susceptibility, the other because of significant knowledge already available).

<M,M,E> = <82/182 Welds, SCC,[PWR Primary,borated demin water (normally stagnant),100F-150F,640 psia]>

Components: ECCS Accumulator Piping to Cold Leg

Criteria	Value	Additional Values for criteria, if any	Additional information	Comments
EMDA Susceptibility Score	Low-Medium			Temperatures considered too low for SCC to be concern. However, cracking is a generic concern for these materials.
EMDA Knowledge Score	Generally High			
Critical gaps in knowledge	Crack initiation time			Crack initiation probability considered low for the environment listed.
SLR GD	Nothing obvious listed for environment for this example.	AMP XI. M7, M1,M2,M19: SG, Water Chem., ISI		AMPs are for components similar to the one listed above.
OE?	No			Nothing was identified in LER searches to date
AMP Audit Info?	TBD			Need to determine if this stays as a criterion, or if it is dropped. The intent is to identify additional AMPs (or additional detail for existing AMPS) for the <M,M,E> combination.
ISI Capability for Detection/Sizing	Yes in pressure boundary components. VT for internals.			Detection and sizing capability TBD but generally capable of meeting acceptance

				criteria set in ASME BPV.
Unique Field Aspects, if any	Vintage material; cracking from OE if applicable.			
Ease of Lab Replication	Medium/High			
Applicability of Harvested Material for Addressing Critical Gaps	Material and environment can be duplicated in lab relatively easily. Unless there are other operational specific aspects (such as cracking OE, or irradiation, or water chemistry issues), likely that studies can be handled without harvesting.			
Availability of material for harvesting	TBD			Needs input from utilities
Condition Assessment/ISI Needs	SCC morphology (COD, shape)			Potential need to validate methods for simulating SCC. Condition assessment methods for SLR may be unconventional. Given low susceptibility, this may not be a major concern.

Example: <M,M,E> = <82/182 Welds, SCC,[PWR Primary,reactor water,653F,2250 psia]>

Components: RCS Pressurizer DM Welds, RPV DM welds, RCS SG, ECCS Accumulator piping to Cold Leg, ECCS CVCS Piping to RCS Cold Leg

Criteria	Value	Additional Values for criteria, if any	Additional information	Comments
EMDA Susceptibility Score	Generally High			
EMDA Knowledge Score	Generally High			
Critical gaps in knowledge	Crack growth rates, crack initiation time			Multiple studies available on SCC initiation and growth in nickel alloys and DM welds, mitigation proposals (overlay) also being studied.
SLR GD	Variety of structures and similar components identified, but no specifics on materials available	AMP XI. M7, M1,M2,M19: SG, Water Chem., ISI		
OE?	Yes			
AMP Audit Info?	TBD			
ISI Capability for Detection/Sizing	Yes in pressure boundary components. VT for internals.			Detection and sizing generally capable of meeting acceptance criteria set in ASME BPV.
Unique Field Aspects, if any	Vintage material, operational stress, flaws in weld from fabrication.			
Ease of Lab Replication	Medium/High			
Applicability of Harvested Material for Addressing Critical Gaps	TBD			

Availability of material for harvesting	TBD			Needs input from utilities
Condition Assessment/ISI	SCC morphology (COD, shape), accessibility for ISI			Potential need to validate methods for simulating SCC. Condition assessment methods for SLR may be unconventional. Access issues may dictate POD and sizing performance. Harvested materials useful to study issue and develop workarounds as needed.

From:	Ramuhalli, Pradeep
To:	Hiser, Matthew
Subject:	[External_Sender] RE: Synopsis on Harvesting for IAEA PLiM
Date:	Wednesday, May 24, 2017 4:21:40 PM
Attachments:	Harvesting IAEA PLim 2 page synopsis-pr.docx

Note to requester: Attachment is immediately following.

Matt,

This looks good overall. I just had a few edits/comments. Attached is a marked up version (using track changes).

With best regards,
Pradeep Ramuhalli, PhD
Tel: 509-375-2763
Email: pradeep.ramuhalli@pnnl.gov

From: Hiser, Matthew [mailto:Matthew.Hiser@nrc.gov]
Sent: Monday, May 22, 2017 12:19 PM
To: Ramuhalli, Pradeep <Pradeep.Ramuhalli@pnnl.gov>
Subject: FW: Synopsis on Harvesting for IAEA PLiM

Hi Pradeep,

In the last couple days, we've decided to throw in an abstract at PLiM on harvesting. Please take a look at what I attached and provide any feedback.

If you're planning to attend PLiM, I think it'd be best for you to give the talk. If not, another staff in our office, Carol Moyer, will be attending and can give the presentation.

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: Monday, May 22, 2017 2:47 PM
To: Hull, Amy <Amy.Hull@nrc.gov>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Moyer, Carol <Carol.Moyer@nrc.gov>
Cc: Frankl, Istvan <Istvan.Frankl@nrc.gov>
Subject: Synopsis on Harvesting for IAEA PLiM

I have attached a draft 2 page synopsis on harvesting for the IAEA PLiM conference. The plan will be for Carol to give the presentation at the conference, but we need to submit the abstract by this week if possible (deadline was last Friday).

If possible, please take a look and provide comments or edits to the abstract by Wednesday to support submission this week.

Thanks!

Matt

Matthew Hiser
Materials Engineer
US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research

Division of Engineering | Corrosion and Metallurgy Branch
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Harvesting of Aged Materials from Operating and Decommissioning Nuclear Power Plants

Matthew Hiser, Patrick Purtscher, Pradeep Ramuhalli, Amy Hull, Robert Tregoning, and Carol Moyer

In the U.S. and global nuclear industry, two recent developments include strong interest in extended plant operation and a number of nuclear power plants (NPPs) shutting down. In the U.S., there is strong interest in extending NPP lifespans through subsequent license renewal (SLR) from 60 to 80 years. 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 NRC have focused on aging in four key areas: the reactor pressure vessel (RPV), RPV internals and piping, concrete, and electrical components. Meanwhile, in recent years, a number of nuclear plants, 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 plants shutting down, these new developments provide opportunities for harvesting components that were aged in representative light water reactor (LWR) environments. In a related development, economic challenges for the nuclear industry 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.

Commented [RP1]: Should some reasons (economics, severe aging and degradation, etc.) be given for these decisions, given the earlier statement that there is a strong interest in NOT shutting down plants till they are 80?

NRC has recently undertaken an effort, with the assistance of Pacific Northwest National Lab (PNNL), to develop a strategic approach to harvesting of 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, 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 those high-priority data needs.

The first step in this strategic approach to harvesting is to prioritize data needs for harvesting. A data need describes a particular material-environment combination and should be ~~defined~~ as detailed 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 data needs for harvesting, including:

- Applicability of harvested material for addressing critical gaps
  - Prioritize harvesting for critical gaps over less essential ~~data needs~~technical gaps.
- Ease of laboratory replication of the environment-material combination
  - For example, simultaneous thermal and irradiation conditions may be difficult to replicate or a mechanism sensitive to dose rate may not be good for accelerated aging.
- Unique field aspects of degradation
  - For example, unusual operating experience or legacy materials (fabrication methods, composition, etc.) that may no longer be available.

- Fleet-wide vs. plant-specific applicability of data
    - There is generally greater value in addressing an issue applicable to a larger number of plants.
- Availability of reliable in-service inspection (ISI) techniques for the material / component
    - If inspection methods are mature and easy to apply to monitor and track degradation, perhaps the effort ~~of~~ for research with harvested materials is not needed.
- Availability of material for harvesting
    - The necessary materials / components must be available to be harvested.
- Harvesting cost and complexity
    - For example, harvesting unirradiated concrete or electrical cables should be less expensive and less complex than harvesting from the reactor internals or RPV.
- Timeliness of the expected research results relative to the objective.

These 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 perspective, 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.

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 important factors for decision-making. NRC is interested in engaging with other organizations to develop a database for sources of materials for harvesting.

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 plant from which harvesting will take place, are key~~s~~ to success. As specific harvesting opportunities are identified through this strategic approach to harvesting, NRC welcomes opportunities for cooperation and leveraging with other interested research organizations.

From:	Hiser, Matthew
To:	Ramuhalli, Pradeep
Cc:	Purtscher, Patrick; Audrain, Margaret; Lin, Bruce
Subject:	RE: RE: PNNL Visit
Date:	Thursday, August 2, 2018 4:25:00 PM
Attachments:	NRCI_Lin-Dunn_Agenda1.docx

Hi Pradeep,
Hope you are doing well! I will be visiting PNNL next week and hope we can find a little time to meet to discuss harvesting. I just spoke with Bruce about the agenda for our time there and it looks like maybe Monday morning or Tuesday afternoon might be good times for us to meet.
I also met with Meg and Pat this morning to hear about Meg's visit a couple weeks ago and the latest on the PNNL report. My thought was we could discuss a couple topics while we have the opportunity in-person:

- the latest on incorporating comments on the report (any questions you may have on how to best address the comments)
- the plans for an inventory of harvested materials at PNNL (I understand much of this is already being done for Carol Nove's contract)

Looking forward to seeing you next week!
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: Ramuhalli, Pradeep [mailto:Pradeep.Ramuhalli@pnnl.gov]
Sent: Wednesday, July 11, 2018 11:33 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Lin, Bruce <Bruce.Lin@nrc.gov>
Subject: [External_Sender] RE: PNNL Visit

Matt,
Excellent! Yes, currently I expect to be in town on those dates and should be available to meet. I will let you know if anything changes.

With best regards,
Pradeep Ramuhalli, PhD
Tel: 509-375-2763
Email: pradeep.ramuhalli@pnnl.gov

From: Hiser, Matthew [mailto:Matthew.Hiser@nrc.gov]
Sent: Tuesday, July 10, 2018 10:21 AM
To: Ramuhalli, Pradeep <Pradeep.Ramuhalli@pnnl.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Lin, Bruce <Bruce.Lin@nrc.gov>
Subject: PNNL Visit

Hi Pradeep,

I hope all is well with you. I know you've been in contact with Pat recently on finalizing the report and cataloguing the available materials at PNNL and Meg Audrain will be visiting next week.
I just wanted to let you know that I will be visiting PNNL (along with Bruce Lin and Darrell Dunn from NRC) on August 6-8 for a dry cask storage contract Bruce is managing at PNNL. If you are in town and available at all those dates, it may be a useful opportunity to meet and discuss the harvesting program, particularly any final tweaks to the report or follow-up from Meg's visit regarding the previously harvested materials at PNNL.
Looking forward to the visit next month and hope we will be able to find some time to meet while I'm there.
Thanks!
Matt

Matthew Hiser
Materials Engineer
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Phone: 301-415-2454 | *Office: TWFN 10D62*
Matthew.Hiser@nrc.gov

Inspection Technology Demonstration on PNNL Dry Storage Cask Mock-ups

Flaw Detection

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Dates: August 6-8, 2018

Host: Ryan Meyer

RTT: Jamie Beard, Andrew Bryant, Steve Glovsky
IOS: Max Wiedmann
EPRI: Jeremy Renshaw
NRC: Darrell Dunn, Bruce Lin, Matthew Hiser

DATE/TIME	TOPIC	LOCATION	PARTICIPANTS
MONDAY, August 6, 2018			
7:30 am – 8:00 am	Pick up Visitor Badges	Discovery Hall to 3440 Test Area	**PNNL**: Ryan Meyer, Sharon Bailey **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS:** Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser
8:00 am – 9:00 am	Pre-job Briefing	3440 Test Area	**PNNL**: Ryan Meyer, Sharon Bailey, Ron Mabry **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS**: Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser ***Optional (PNNL)**: Emily Schinell, Adrian McCall, Drue Collins, Laurie True, Donald Kelly*
9:00 am – 10:00 am	Unpack Equipment	3440 Test Area	**PNNL**: Ryan Meyer, Ron Mabry **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS**: Max Wiedmann **EPRI**: Jeremy Renshaw
MONDAY, August 6, 2018 (continued)			
10:00 am – 11:00 am	NDE Technology Electrical Safety Inspection Preview Mockups	3440 Test Area	**PNNL**: Ryan Meyer, Bobby Sparks **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS**: Max Wiedmann **EPRI**: Jeremy Renshaw

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DATE/TIME	TOPIC	LOCATION	PARTICIPANTS
11:00 am – 12:00 pm	Set-up and Testing on Horizontal Mock-up (RTT and EPRI)	3440 Test Area	**PNNL**: Ryan Meyer **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS:** Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser
12:00 pm – 1:00 pm	Working Lunch: Discuss Morning Progress/Challenges	TBD	
1:00 pm – 6:00 pm	Continue Testing on Horizontal Mock-up (RTT and EPRI)	3440 Test Area	
Tuesday, August 7, 2018			
7:30 am – 12:00 pm	Continue Testing on Horizontal Mock-up (RTT and EPRI)	3440 Test Area	**PNNL**: Ryan Meyer **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS:** Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser
12:00 pm – 1:00 pm	Working Lunch: Discuss Morning Progress, Review Remaining Testing	TBD	**PNNL**: Ryan Meyer **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS:** Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser
1:00 pm – 6:00 pm	Continue Testing on Horizontal Mock-up (RTT and EPRI)	3440 Test Area	
7:00 pm	Dinner	TBD	
Wednesday, August 8, 2018			
7:00 am – 9:00 am	Mock-up Re-orientation	3440 Test Area	
9:00 am – 12:00 pm	Testing on Vertical Mock-up (RTT, EPRI, and IOS) Testing on Plate Specimens (EPRI)	3440 Test Area	**PNNL**: Ryan Meyer **RTT**: Jamie Beard, Andrew Bryant, Steve Glovsky **IOS:** Max Wiedmann **EPRI**: Jeremy Renshaw **NRC**: Darrell Dunn, Bruce Lin, Matthew Hiser
12:00 pm – 1:00 pm	Working Lunch: Discuss Morning Progress, Review Remaining Testing	TBD	
1:00 pm – 6:00 pm	Continue Testing on Vertical Mock-up (RTT, EPRI, and IOS) Testing on Plate Specimens (EPRI)	3440 Test Area	

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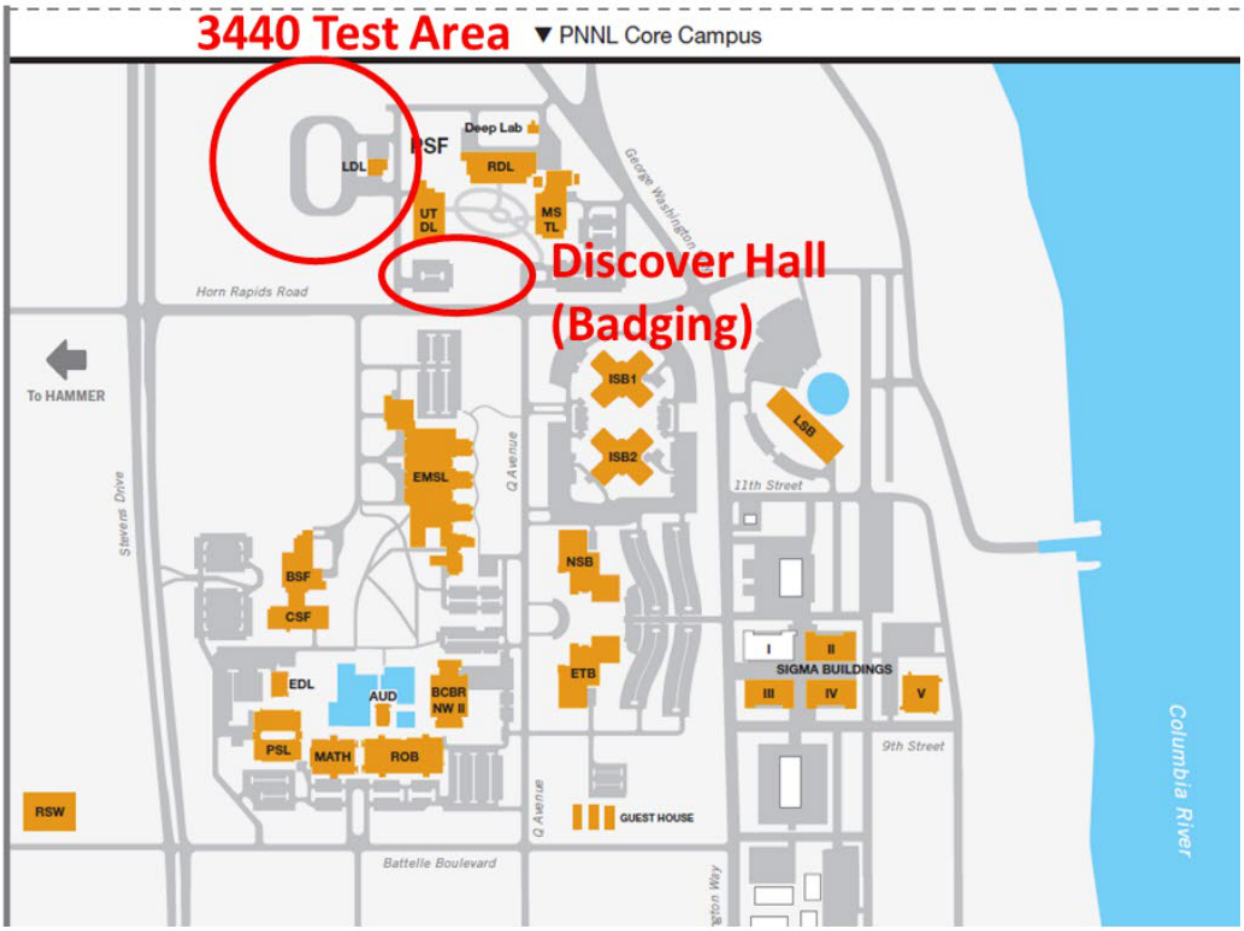

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Data Needs Best Addressed By Harvesting – Overview

Note to requester: This note for this slide did not transfer: "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."

Drivers

- Basic question for SLR: Is there adequate confidence that the material will be capable of meeting its functional goals through the end of SLR?
- (my opinion!) Defense in depth through SLR is likely to need
  - Demonstrate that the component will have limited degradation in function due to material aging past 60 physical years of operation (with reasonable confidence)
  - Implement program to ensure that components can be appropriately monitored to ensure timely detection and mitigation of any aging-related issues

Note to requester: This note for this slide did not transfer: "Left it in hidden mode for now (as a reminder of some of the drivers) – will delete before going final."

Several Sources of Literature are Available and Inform Data Needs

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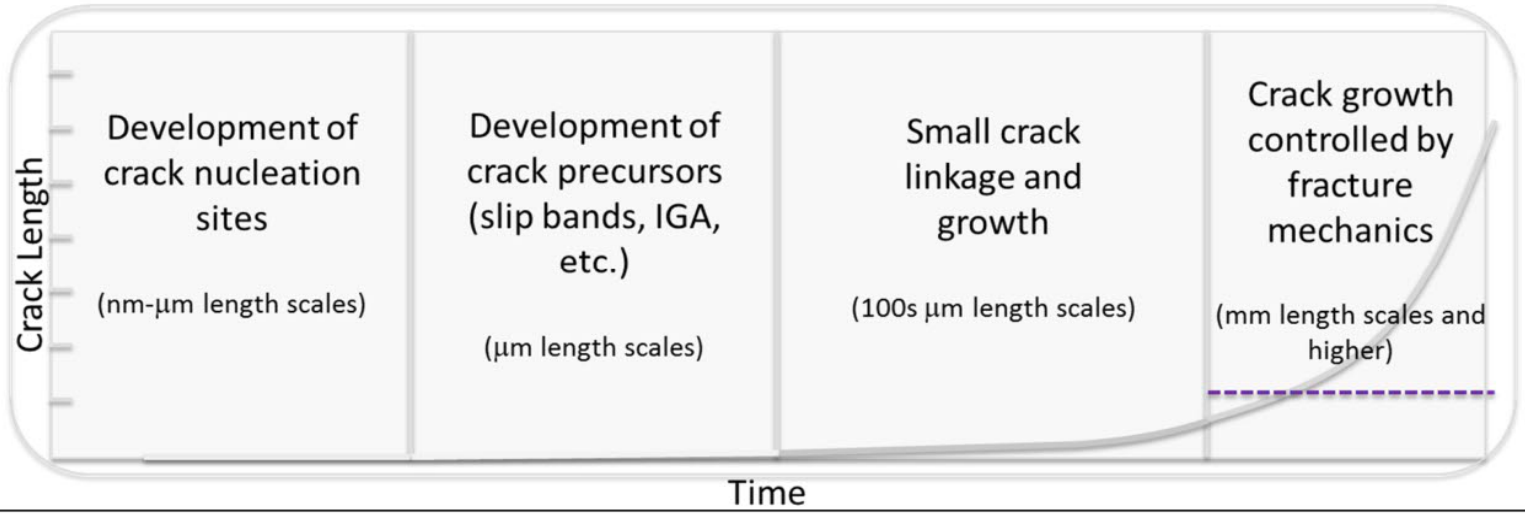
- EMDA/PMDA, GALL-SLR, Various NUREG/CR, DOE-LWRS, EPRI-LTO, IAEA-TECDOCs, Other DOE/EPRI publications…
- Key needs:
  - Understand materials degradation processes that contribute to degradation growth
  - Availability of adequate NDE and condition monitoring techniques



Key Idea: The two key needs highlighted above are related, and will need to be jointly addressed for long-term operation needs

Note to requester: This note for this slide did not transfer: "DOE includes national laboratory complex. Degradation – if not detected and mitigated – can lead to loss of structural integrity."

Literature Covers a broad range of materials and mechanisms for long term operation

- Level of specificity varies
  - Specific compositions vs generic alloys
  - Specific conditions vs generic drivers of degradation
- Increased emphasis on non-metallic materials
- Identified knowledge gaps in materials degradation and condition monitoring

Key finding: Certain materials and mechanisms, within the context of long term operation, may be considered a high priority for addressing technical gaps in degradation initiation, growth and detection.

Generic Data Needs for Material Aging Studies

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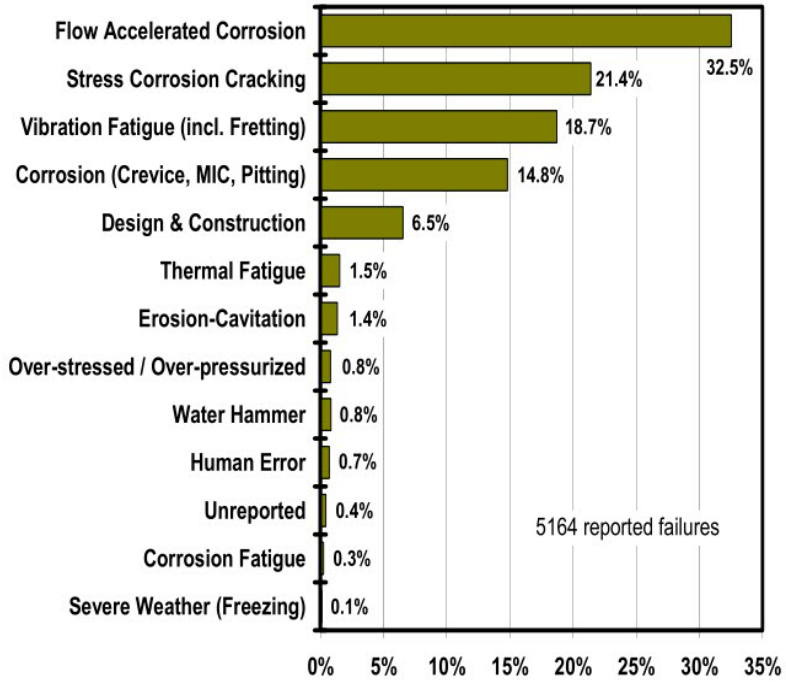
- Dominant effects and synergistic effects
  - Thermal, coolant, and neutron
  - A need for multiple classes of materials
- Dose, dose-rate, spectrum effects
  - Microstructural variations
  - Irradiation-assisted processes
- Degradation initiation and growth studies
  - Particularly metals
  - Residual stress
- Mechanical properties
- Mitigation actions
  - Annealing, peening,…



Lydell 2007 (US Pipe Failure Data by Degradation Mechanisms and Other Sources)

Key Insight: These data needs must be addressed for materials that exist in plants today

Generic Data Needs for Condition Monitoring

- Observables that result from aging of materials in real-world environments
  - Measurement targets for condition monitoring
  - Important for cables, concrete in particular
- Benchmarking of accelerated aging-produced degradation
  - Real-world degradation examples
  - Applicability of lab studies to quantify detectability
  - Detection and sizing limits under real-world conditions
- Field specimens – impact on detection and sizing
  - Vintage materials not always reproducible in the lab

Key Insight: These data needs must be addressed for materials that exist in plants today

New Degradation Processes Found in U.S. Nuclear Power Plants Roughly Every 7 Years (Wilkowski 2002)

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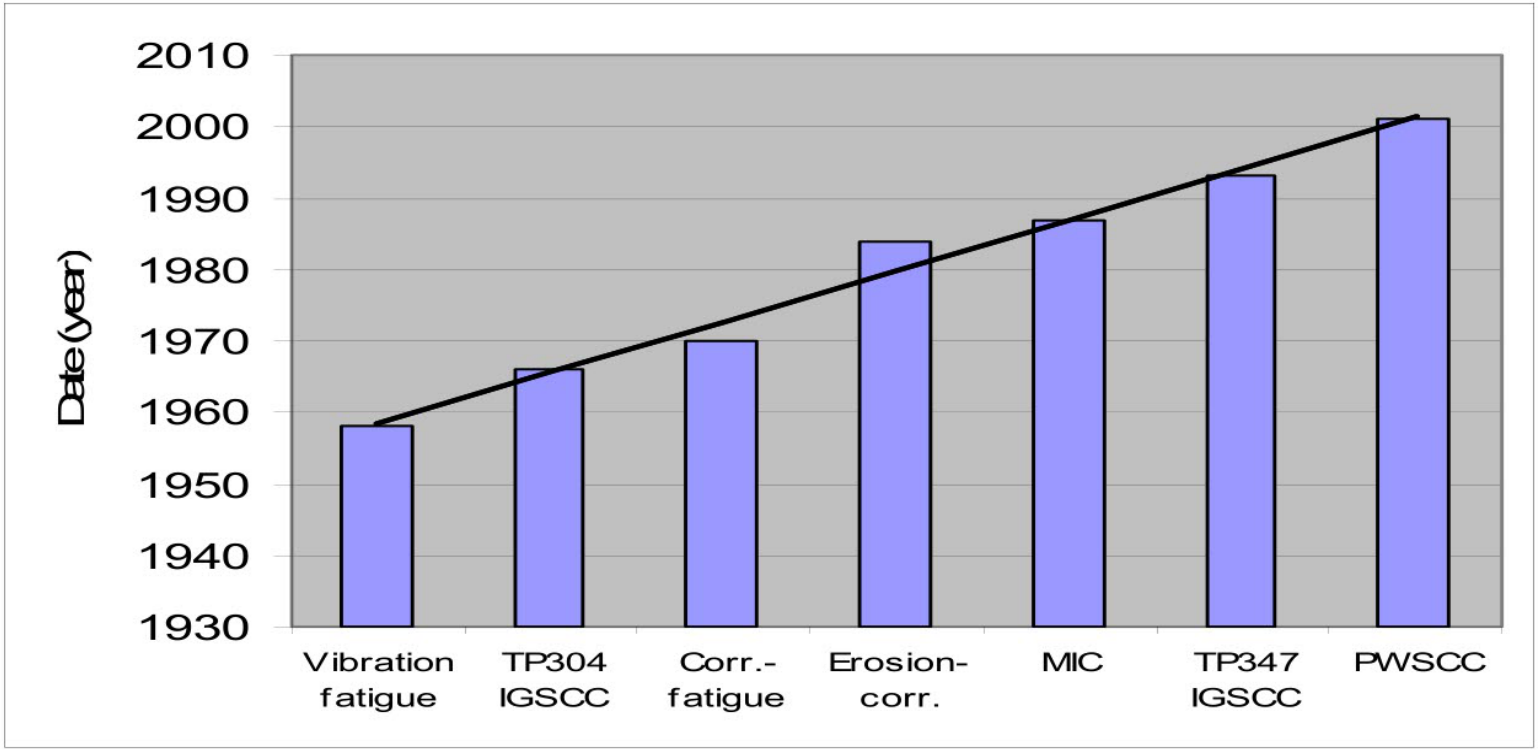

Note to requester: This note for this slide did not transfer: "Interesting graphic – not sure if this should be included in previous charts, or removed. Will discuss."

Where can harvesting help?

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- Benchmarking laboratory-scale studies on materials aging
- Identifying constraints on materials/components replacement in operating plants.
  - Understanding aging mechanisms and precise margins to failure
- Determining specific methods for condition assessment that may be applied to these components in the field, to assess component aging.

Answer questions that help bridge the gap from the laboratory to the real-world

Note to requester: This note for this slide did not transfer: "Essential to provide reasonable assurance that the materials/components will continue to provide adequate defense-in-depth through the end of life.Harvesting from closed plants, or during component maintenance/replacement activities."

Criteria for Harvesting

- Unique field aspects, if any, that drive the importance of harvesting the material
  - Unusual OE – harvest to better understand phenomena
- Ease of laboratory replication of material and environment combination
- Applicability of harvested material for addressing critical gaps (dose rate issues, etc., for instance)
- Availability of reliable ISI techniques for the material
- Availability of material for harvesting

Ultimately, harvesting decisions must tradeoff knowledge gain vs costs (including dose to workers)

Examples – Electrical Cables

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Criteria	Qualitative Assessment	Comments
Unique Field Aspects, if any	Vintage formulations, depending on manufacturer, real-world conditions.	10–12 manufacturers of vintage cable in U.S. fleet. Within a single plant, cable types and manufacturers can vary.
Ease of Laboratory Replication	Low-medium (long-term aging studies necessary)	
Applicability of Harvested Material for Addressing Critical Gaps	High - Wear-out aging a possibility	Requires knowledge on plant conditions
Condition Monitoring/ISI for detection and sizing	Low to medium. Unclear how well proposed techniques would perform for low dose rate, low temperature aging of insulation.	Access limited; long-range methods are not fully understood
Availability of Material for Harvesting	TBD	Needs input from utilities
EMDA Susceptibility Score	Generally High (2–3)	
EMDA Knowledge Score	Medium (mostly 2)	Some data exists on long-term aging. Inverse temperature and synergistic effects are a concern. Inverse temperature effects apply and CSPE is formulation-specific.
GALL-SLR	Documented as a potential issue	AMP updates ongoing
OE?	Yes	Documented in industry publications
Level of Understanding of Mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium	See knowledge gaps below
Options for Mitigation	Low	
Ease of Replacement	Medium	Possible but can get expensive depending on specific locations
Amount of Use (in a plant and fleet-wide)	High	LV and MV cables extensively used in plants
Critical Gaps in Knowledge	Contribution to data base for dominant effects, synergistic effects, dose rate effects for understanding accelerated aging vs. field aging, develop and qualify condition monitoring techniques	
HARVESTING PRIORITY	HIGH	

CASS? Internals? DMW SCC?

- Will discuss format and add.

Example: CASS, Reactor Internals

- CASS: Open questions for SLR
  - Loss of fracture toughness due to thermal aging
  - Unknown: How radiation interacts with thermal aging
  - Current programs – laboratory studies (accelerated aging) and simulations
  - Example of data Needs: Benchmarking accelerated aging studies, fracture toughness changes between 0.5 dpa and 5 dpa, interaction of neutron and thermal effects
- Internals: Open questions for SLR
  - Materials performance with irradiation
  - Crack initiation and growth (IASCC)
  - Current programs – studies on harvested materials (limited by available materials)
  - Example of data needs: factors contributing to crack initiation and growth, high-fluence effects on representative LWR components

Graphics TBD

Examples: Concrete, Cables

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- Concrete
  - Unknown: Inspection techniques for liner corrosion, ASR
  - Example of data needs: Critical flaw sizes, materials with aging-related degradation for benchmarking lab specimens
- Cables
  - Unknown: What observables may enable rapid assessment and localization of degradation, detection thresholds for field-aging
  - Example of data needs: Aged materials representing spectrum of material formulations, CM measurements on fielded cables (benchmark measurements from lab-aged specimens)

Note to requester: This note for this slide did not transfer: "Can add examples for CASS, etc."

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Technical Info Needed for Informed Harvesting Decisions

Note to requester: This note for this slide did not transfer: "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."

Harvesting Experience - Summary

- Multiple projects spanning cancelled, disconnected, SAFSTOR, DECON(?), etc. plants
  - Zion, Zorita, Crystal River 3, Shoreham, River Bend 2, Ginna, …
- Materials spanning RPV and piping (base metal and welds), cables, internals (baffle former bolts)
- General lessons learned
  - Uncertainty about operational environment for materials (especially for localized exposure)
  - Cost can be significant
  - Supporting resources may be scarce
  - Planning for harvesting must start significantly in advance of opportunity

Ultimately, harvesting decisions must tradeoff knowledge gain vs costs (including dose to workers)

General Needs for Informed Harvesting Decisions

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- Why – Technical gaps
  - Identify the knowledge gaps that will be addressed by this specific harvesting opportunity
- How – R&D plan
  - Clearly articulate how the harvested material will be used to address knowledge gaps
  - Determine resources (including funds) for R&D on harvested material
- Who and When – Resource availability and planning for harvesting
  - Secure necessary engineering and labor support – need to justify and prioritize harvesting
  - Timelines and schedule development
  - Can be the greatest challenge in developing informed harvesting decisions
- What – Availability
- Post-harvesting planning – should cover everything from shipping to receipt of material and handling for R&D purposes and waste disposal.

Much of this can be assembled prior to material becoming available, but may need to be modified to account for ground realities.

Specifics quantities that may need to be tracked as the plan comes together

- Clear identification of appropriate material – labels, tags, etc.
  - Critical when harvesting is being coordinated with other activities (maintenance, decommissioning, etc.)
- Operational environment documentation
  - General parameters (temperature, radiation)
  - Proximity to other components
  - Physical contamination
- Material condition (degradation and aging) and special features
  - Cracking or other unique degradation conditions
  - Welds, terminations, base metal,…

Detailed knowledge capture about component condition can simplify planning when material becomes available for harvesting.

Example

- Add Crystal River 3 documentation, Zion documentation and planning

Additional Recommended Information that would be helpful for planning, harvesting, and subsequent R&D

- Physical
  - Category, construction info, manufacturer, Material composition, dimensions, special features
- Service Info
  - System, service application, how often used, safety/maintenance rule significance, age in service
  - Installation location, connected components, supporting structures or conveyances
- Stressors
  - Installation stressors, in-service environmental, other
- OE
  - Testing history, failure or degradation

Note to requester: The attachment, "NRC_Materials_and_Component_Spreadsheet_of_Inventory_at_PNNL_Draft.xlsx" file is too large to import into the FOIA Team's redaction software. This file will be provided in its original format (Excel) as a seperate document in this interim response.

From: Lin, Bruce
Sent: Tue, 28 Aug 2018 16:03:59 +0000
To: Hiser, Matthew;Nove, Carol
Cc: Purtscher, Patrick;Audrain, Margaret
Subject: RE: inventory of ex-plant materials at PNNL

Matt,

Please see attached inventory list. PNNL also put together a presentation with photos. I have saved a copy at G:\DE\CIB\PNNL NDE Reports file name "NRC_Materials_and_Component_Inventory_at_PNNL_Draft.pptx"

Bruce

From: Hiser, Matthew
Sent: Tuesday, August 28, 2018 11:32 AM
To: Nove, Carol <Carol.Nove@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Lin, Bruce <Bruce.Lin@nrc.gov>
Subject: RE: inventory of ex-plant materials at PNNL

Thanks Carol!

It sounded like from our discussion with Pradeep that what they are putting together for you should "bound" what we are looking for. Can you share with us the inventory of materials whenever you receive it from PNNL?

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: Nove, Carol
Sent: Monday, August 06, 2018 8:55 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>; Lin, Bruce <Bruce.Lin@nrc.gov>
Subject: RE: inventory of ex-plant materials at PNNL

Hi Matt,

Feel free to talk to Pradeep about the inventory of materials being conducted under my program. If there is some other info you need, let me know so that I can ask them to include it.

Thanks,
Carol

From: Hiser, Matthew
Sent: Friday, August 03, 2018 8:55 AM
To: Nove, Carol <Carol.Nove@nrc.gov>
Cc: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>
Subject: FW: inventory of ex-plant materials at PNNL

Hi Carol,

I will be heading to PNNL next week for a trip focused on NMSS dry storage work there with Bruce and Darrell. However, while I'm there I'm planning to spend a little time meeting with Pradeep on the harvesting contract we have with them (Pat Purtscher is the COR; I am alt. COR).

One topic will be a report they're finalizing and addressing NRC comments on, while another will be their efforts to identify previously harvested materials at PNNL. I think they're already doing a large portion of that for you, which probably meets our needs as well. I just wanted to touch base with you on what they are doing under your contract and let you know I'll be there next week and might discuss that some with Pradeep (not give direction of course, just try to be clear on what they're doing for your contract and whether that covers everything we're looking at for harvesting).

Let me know if you have any questions or concerns with that and we can catch up the week of August 13…

Thanks!
Matt

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

From: Purtscher, Patrick
Sent: Thursday, August 02, 2018 11:26 AM
To: Hiser, Matthew <Matthew.Hiser@nrc.gov>; Audrain, Margaret <Margaret.Audrain@nrc.gov>
Subject: FW: inventory of ex-plant materials at PNNL

FYI

From: Nove, Carol
Sent: Thursday, August 02, 2018 10:17 AM
To: Purtscher, Patrick <Patrick.Purtscher@nrc.gov>
Subject: RE: inventory of ex-plant materials at PNNL

Pat,

I think it will be done before the end of the summer. I'll send it to you when I get it.

Carol

From: Purtscher, Patrick
Sent: Monday, July 30, 2018 9:31 AM
To: Nove, Carol <Carol.Nove@nrc.gov>
Subject: inventory of ex-plant materials at PNNL

Good morning,

Pradeep told me that PNNL is doing an inventory of ex-plant materials for you. Do you know when they will complete that task?

Pat

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US Nuclear Regulatory Commission | Office of Nuclear Regulatory Research
Division of Engineering | Corrosion and Metallurgy Branch
11545 Rockville Pike | Rockville, MD 20852-2738
Phone: 301-415-3942 | *Office: TWFN 10A49*
ptp1@nrc.gov

Note to requester: Attachment is immediately following.

From: Hiser, Matthew
Sent: Fri, 20 May 2016 00:33:09 +0000
To: Burke, John;Sircar, Madhumita
Cc: Frankl, Istvan
Subject: FW: 2018-2020 draft proposal, F&M
Attachments: HP-1490-Vol. 1, Proposal_2018-2020_Fuels_Materials_draft.pdf

Hi John and Mita,

Halden has included irradiated concrete work in their draft 2018-2020 proposal. It appears they have just the general idea of acquiring harvested concrete and irradiating it further in their JEEP-II reactor. Beyond that, there is not much specific in their proposal, so we could certainly help suggest approaches and specific activities of interest to us.

Halden will be visiting NRC on August 30 to discuss their 2018-2020 proposal. Following these so-called country visits, in late 2016 – early 2017 HRP members (including NRC) have the opportunity to rank and provide written feedback on research programs in the 2018-2020 proposal.

To summarize, there is no direct action right now needed from you, but please be aware of this and try to be available for the visit on August 30 if possible.

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: Turid Danielsen [mailto:Turid.Danielsen@ife.no]
Sent: Tuesday, April 19, 2016 10:30 AM
To: Alonso Pacheco, José Manuel <jap@enusa.es>; Alvestad, Anna (Anna.Alvestav@ssm.se) <Anna.Alvestav@ssm.se>; Amaya, Masaki <amaya.masaki@jaea.go.jp>; Austin, Robert <raustin@epri.com>; Bales, Michelle <Michelle.Bales@nrc.gov>; Boirel David (david.boirel@irsn.fr) <david.boirel@irsn.fr>; Boris Volkov <Boris.Volkov@ife.no>; Bossis, Philippe <philippe.bossis@cea.fr>; Breest, Axel <axel.breest@oecd.org>; Brown, Spencer <spencer.brown@fanr.gov.ae>; Busby, Jeremy <busbyjt@ornl.gov>; Cong Li (licong@snerdi.com.cn) <licong@snerdi.com.cn>; Dalleur Jean-Paul <jean-paul.dalleur@gdfsuez.com>; Danying Gu (gudanying@snerdi.com.cn) <gudanying@snerdi.com.cn>; Daum, Robert S. <rdaum@epri.com>; Delafoy, Christine (christine.delafoy@areva.com) <christine.delafoy@areva.com>; Dunavant, Randall <randall.dunavant@ge.com>; Faye, Helene (helene.faye@irsn.fr) <helene.faye@irsn.fr>; figedy@vuje.sk; Fiser, Vladimir (vladimir.fiser@ujv.cz) <vladimir.fiser@ujv.cz>; Fujii, Hajime (hajime_fujii@mnf.co.jp) <hajime_fujii@mnf.co.jp>; Garde, Anand <gardeam@westinghouse.com>; Gjerde, Ole <ole.gjerde@statnett.no>; Gorzel, Andreas <andreas.gorzel@ensi.ch>; Hales, Jason <Jason.Hales@inl.gov>; Hallbert, Bruce <Bruce.Hallbert@inl.gov>; Hartung, Jürgen <juergen.hartung@grs.de>; Herranz, Luis Enrique

<luisen.herranz@ciemat.es>; Hiser, Matthew <Matthew.Hiser@nrc.gov>; Hoffmann, Petra-Britt <petra-britt.hoffmann@areva.com>; Hollasky Nadine (nadine.hollasky@belv.be) <nadine.hollasky@belv.be>; Hózer, Zoltán (zoltan.hozer@energia.mta.hu) <zoltan.hozer@energia.mta.hu>; Jan Klouzal (Jan.Klouzal@ujv.cz) <Jan.Klouzal@ujv.cz>; Josefsson, Bertil (Bertil.Josefsson@vattenfall.com) <Bertil.Josefsson@vattenfall.com>; kita@criepi.denken.or.jp; Kjellin, Andreas <Andreas.Kjellin@ssm.se>; Koo, Yang-Hyun <yhkoo@kaeri.re.kr>; Kozine, Igor (igko@dtu.dk) <igko@dtu.dk>; Krause, Wolfgang <wolfgang.krause@areva.com>; Kulacsy, Katalin <kulacsy.katalin@energia.mta.hu>; Lavoil, Alexandre <alexandre.lavoil@edf.fr>; Lee, Hyun-Chul (leehc@kaeri.re.kr) <leehc@kaeri.re.kr>; Libing Zhu (zhulibing@snerdi.com.cn) <zhulibing@snerdi.com.cn>; Linder, Jan <jan.linder@ssm.se>; Lipcsei, Sándor <lipcsei.sandor@energia.mta.hu>; Masaaki, Ozawa <masaaki_ozawa@nsr.go.jp>; Morilhat, Patrick <patrick.morilhat@edf.fr>; Naser, Joseph <jnaser@epri.com>; Navas, Marta <m.navas@ciemat.es>; Nonon-Solaro, Chrystelle <chrystelle.nonon@cea.fr>; Novikov, Vladimir <novikov@bochvar.ru>; Barbara C. Oberländer <Barbara.Oberlander@ife.no>; Páleník Peter <peter.palenik@enel.com>; Paulik, Luboslav (luboslav.paulik@enel.com) <luboslav.paulik@enel.com>; PAULUS, Valerie <valerie.paulus@cea.fr>; PETIT, Marc <marc.petit@irsn.fr>; Pimenov, Yury (pimenov@tvel.ru) <pimenov@tvel.ru>; Pouchon, Manuel A. <manuel.pouchon@psi.ch>; Ravn, Ole (or@elektro.dtu.dk) <or@elektro.dtu.dk>; Reed Julie (reedji@westinghouse.com) <reedji@westinghouse.com>; Rossiter, Glyn <glyn.d.rossiter@nnl.co.uk>; Saito, Takehiko <takehiko.saito@fanr.gov.ae>; Santucci, Catherine (catherine.santucci@cea.fr) <catherine.santucci@cea.fr>; Scott, Harold <Harold.Scott@nrc.gov>; Simko, Juraj <juraj.simko@enel.com>; Szilard, Ronaldo <ronaldo.szilard@inl.gov>; Takakura, Kenichi <kenichi_takakura@nsr.go.jp>; Takita, Masami <masami_takita@nsr.go.jp>; Terrani, Kurt <terranika@ornl.gov>; Teshima, Hideyuki <hideyuki_teshima@mnf.co.jp>; Torralba, Belen <belen.torralba@ciemat.es>; Tregoning, Robert <Robert.Tregoning@nrc.gov>; Tulkki Ville (Ville.Tulkki@vtt.fi) <Ville.Tulkki@vtt.fi>; Valkonen Janne <Janne.Valkonen@vtt.fi>; Verwerft Marc (marc.verwerft@sckcen.be) <marc.verwerft@sckcen.be>; vinh.dang@psi.ch; Vinton, Steve <steve.nd.vinton@hse.gsi.gov.uk>; Vonkova Katerina (katerina.vonkova@cvrez.cz) <katerina.vonkova@cvrez.cz>; Wensauer, Andreas <andreas.wensauer@eon.com>; Wright, Jonathan (wrightj@westinghouse.com) <wrightj@westinghouse.com>; Xing, Jing <Jing.Xing@nrc.gov>; Xu, Peng <xup@westinghouse.com>; Yagnik, Suresh <SYAGNIK@epri.com>; Yakovlev V. V. (vladvas_irtm@mail.ru) <vladvas_irtm@mail.ru>; Yoji Minagawa <Yoji.Minagawa@ife.no>
Cc: Margaret McGrath <Margaret.McGrath@ife.no>; Jon Kvalem <Jon.Kvalem@ife.no>; Øivind Berg <Oivind.Berg@ife.no>; Jannicke Margrethe Neeb <jannicke.neeb@ife.no>
Subject: [External_Sender] 2018-2020 draft proposal, F&M

To the F&M Members of the HPG

Please find attached the Draft Proposal for the 2018-2020 Program. It is based on input I've been receiving since my email of February 20th, as well as other earlier discussions at the HPG, and of course the parts of the current Program that are likely to continue past the end of 2017. As usual at this stage the Draft Proposal contains more than we are likely to be able to do, and fitting the overall Program to the budget we can expect for 2018-2020 will have to be done as part of the process of progressing to the Final Proposal for approval by the Board in June 2017.

However, at this stage the main focus is on technical merit and we will have about one hour at the HPG meeting on Tuesday May 10th to discuss the Draft Proposal in outline, with new items being the highlight.

I hope you can take the time over the next 3 weeks to read through the Draft Proposal and be prepared for a short discussion on the new/newer items.

Best regards,
Margaret

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OECD HALDEN REACTOR PROJECT

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Fuels and Materials Proposal for the Three Year Period

2018-2020

OECD
Halden Reactor Project

F&M Draft proposal for the three year period 2015-2017

April 2016

CONTENTS **Page**

Introduction

This document contains proposals for items to be included in the programme to be carried out in the period 2018-2020 aimed at promoting participants' interests on safety and reliability of nuclear power plants. The Fuels & Materials research programme will be based on:

- work carried out in previous programme periods
- discussions in the Halden Programme Group
- input and feedback from member organisations
- guidelines given by the Halden Board of Management

In formulating the proposal, account will be taken of the continuity necessary to complete programme elements already started in the 2015-2017 period together with needs and priorities for both new long term activities and short-term deliverables.

This document is organised in two Chapters: Fuel Safety and Operational Margins; and Plant Ageing and Degradation.

The Fuels Chapter covers:

- Long and short-term fuel performance irradiations
- LOCA and transient studies
- Cladding performance and behaviour

The Materials Chapter covers:

- Irradiation assisted stress corrosion cracking studies
- Irradiation enhanced creep and stress relaxation
- Reactor pressure vessel (RPV) embrittlement
- Ageing of concrete

Development of instruments for improved robustness, use in more demanding conditions or for extended range of measurement will be included as and when needed to fulfil the scope of the programme.

1 Fuel Safety and Operational Margins

The safe and economical operation of nuclear power plants remains a priority for the nuclear industry. The availability of high performance, reliable fuels is essential for this goal and contributes to competitive electricity generation from nuclear power. New fuel and cladding materials have been and are being developed to support extended operation cycles, more flexible operation regimes, power up-rates and increased discharge burn-ups in some countries. As a consequence the performance of nuclear power plants has improved over the years; however, operational experience shows that unexpected deviations from normal fuel performance do occasionally occur in some conditions. Such deviations can limit plant operation or even lead to premature shut-down to discharge the affected fuel.

Counteractive measures to improve fuel reliability in a variety of demanding service conditions include fuel design modifications, development of new materials or changes to water chemistry. The success of these approaches is evidenced by a decreasing trend in fuel failure rates. However, for nuclear power to remain competitive and further approach the goal of zero failure, it is essential that the mechanisms responsible for challenging the fuel and weakening the cladding during exposure are well understood.

Increased utilisation of fuel provides challenges also in safety transients. Qualified models and codes are required to define the condition and properties of the fuel before the safety transient or accident scenario as well as its subsequent behaviour during the transient. It is therefore essential to establish a knowledge base for safety assessments and to demonstrate the capabilities at all exposure levels of fuel in off-normal situations. Since such situations are undesired and extremely rare by definition, data must be obtained by dedicated investigations conducted in test reactors with complementary work carried out in nuclear laboratories. In-reactor experiments should focus on issues that are essential to safety and that cannot otherwise be resolved.

There is consensus among HRP participants to continue experimental activities with the objective of generating new and improved data on fuel properties and fuel behaviour under relevant operational conditions, utilising fuels representative of the current and near-term expected industry standard (including burn-up levels). To that end this programme proposal deals with the following phenomena and operational conditions:

- Gas release under irradiation – fission gas release (FGR) behaviour, gas inventory increase
- Fuel thermal and mechanical performance - conductivity degradation, densification, swelling, fuel creep, pellet-clad-mechanical-interaction (PCMI)
- Fuel behaviour during transients and accident conditions – FGR and PCMI under power transient operation as well as dry-out (departure from nucleate boiling) and LOCA studies
- Cladding performance and behaviour - cladding creep, growth, corrosion and hydriding in-reactor and also under bounding dry storage conditions

These phenomena and operational conditions are addressed in long and short-term fuel performance irradiations and where several phenomena interact with each other in an integral manner as well as in studies where a phenomenon is observed as much as possible in isolation.

Participating organisations contribute to these investigations through providing relevant materials, and it is indispensable that fuel discharged from commercial nuclear power stations is also made available and can be re-fabricated and instrumented for further irradiation testing.

In most tests, the fuel rods and re-fabricated segments will be equipped with multiple instruments to study the interrelation between various performance parameters. The in-pile measurements and results will be complemented with post irradiation examinations at the Kjeller hot cell laboratories, and also by specialised PIE at participants' laboratories as needed.

Data evaluation is also essential in order to utilise the information generated from the experimental programme for gaining an as complete as possible understanding of fuel performance. This is a crucial step in supporting the development and validation of models and codes for safety assessments.

1.1 Long and Short-Term Fuel Performance Irradiations

Fuel behaviour is characterised by the complex interaction of many phenomena which develop and change with burn-up. Experiments are therefore required for generating data which include the effect of inter-dependencies and which can be used for assessing the capability of fuel modelling codes to render inter-dependencies correctly. Pertinent whole rod performance data are obtained from instrumented tests in the Halden reactor. The instrumentation provides information on a number of phenomena, separate and combined, which are essential for fuel performance assessments and safety analyses:

- The *fuel thermocouple* gives direct information on the fuel temperature and indirectly on fuel thermal conductivity and the changes induced by increasing burn-up.
- The *pressure transducer* provides data on the kinetics and amount of fission gas release under different operating conditions and how the threshold for fission gas release is reduced with burn-up. Fuel densification and swelling can also be deduced prior to the start of fission gas release.
- The *cladding extensometer* gives data on the axial stress induced by pellet-cladding interaction and the relaxation with time. Fuel swelling can also be deduced in the case of prevailing contact between fuel and cladding.
- The *fuel stack elongation detector* measures dimensional changes caused by fuel densification and fuel swelling.

The value of the data obtained with these instruments is enhanced by noise analysis and the evaluation of the transient response of the fuel temperature to reactor scrams.

It is envisaged for the 2018-2020 programme that integral rod behaviour data will mostly be generated from BWR, PWR and VVER types of fuel rods with standard and modified urania fuel. Other types can be included to the extent that such fuel is made available by participants. The Halden Reactor Project will seek to establish collaborative agreements with participants for providing suitable test material.

Experiments can start with fresh, zero burn-up fuels, or utilise pre-irradiated fuels retrieved from commercial nuclear power stations. The latter is especially important for studying the behaviour of high burn-up fuel. In either case, instrumentation is an essential requirement for obtaining in-core data on key performance parameters while phenomena develop. The re-instrumentation technique developed at Halden, and proved in many applications, enables mounting of several rod instruments onto pre-irradiated commercial fuel segments.

The experiments will operate in natural Halden reactor thermal hydraulic conditions (usually tests starting with fresh fuel) or make use of loop systems providing prototypical light water reactor thermal-hydraulic and water chemistry conditions (usually for pre-irradiated fuels from commercial nuclear power stations).

1.1.1 **Long-term irradiation of enhanced performance fuels**

– *Motivation and background*

Several long-term fuel irradiation experiments have been successfully carried out in the Joint Programme, most recently IFA-677, IFA-676, IFA-681 and IFA-716. A new irradiation of this type is due to start in the 2015-2017 programme period to study improved performance and advanced designs of fuel pellets including increased tolerance to accident conditions.

The main objective is to study the thermo-mechanical and FGR behaviour of different fuel types proposed as candidate fuels for accident tolerant fuel concepts, by irradiating 6 highly instrumented fuel rods under normal operating conditions in the Halden reactor (HBWR moderator/coolant). The focus is on the following parameters:

- Fuel thermal performance (fuel centre temperature)
- Fuel dimensional changes (densification and swelling)
- Fission gas release (FGR) behaviour

The fuels to be irradiated are:

- Variants with uranium nitride compounds, aimed at compensating for the expected cost penalty of moving to ATF cladding concepts by offering a fuel pellet featuring a higher density of uranium than conventional UO_2.
- Microcell UO_2 fuels with microstructures aimed at retaining fission gas products in the pellets during transients/accidents as well as having improved thermal conductivity (thereby reducing FG release).

– *Work scope*

The irradiation phase is due to start towards the end of the 2015-2017 period and is expected to continue throughout the 2018-2020 programme period. Each of the fuels being tested will have been characterised in its as-manufactured state and archive material will be kept for possible future examinations following the end of the irradiation phase and subsequent PIE.

There is also interest in studying the behaviour of IFBA (Integral Fuel Burnable Absorber) fuel under long-term steady-state irradiation to provide data to validate IFBA end of life rod internal pressure.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Obtain data on the thermo-mechanical performance of enhanced performance fuels
- Produce data on the fission gas release properties of enhanced performance fuels
- Provide long term measurements of PCMI behaviour and rod growth rate due to fuel swelling and fuel-clad bonding of enhanced performance fuels

1.1.2 **BeO doped UO_2 fuel**

– *Motivation and background*

The IFA-716 experiment from the 2015-2017 programme period was designed to address parameters influencing the fission gas release properties of doped, large grain fuel where the effect of increased diffusion length (large grains) competes with the negative influence arising from increases in the diffusion coefficients as a result of the dopants. To this end, the experiment contained large grain fuels with different dopant concentrations as well as standard reference fuel. An additional fuel type included in the test was UO_2 with BeO added to improve the thermal conductivity and thereby obtain lower fuel temperatures and consequently lower fission gas release.

– *Work scope*

The IFA-716 experiment completed its irradiation during the 2015-2017 period and the UO_2 / UO_2-BeO pair of rods (Rod 3 and Rod 4) is planned to be transferred to a new test rig for continued burn-up accumulation to prepare them for subsequent PCMI/FGR testing. The irradiation phase is due to start towards the end of the 2015-2017 period and is expected to be completed early within the 2018-2020 programme period, with subsequent PCMI/FGR testing being performed towards the end of the period (see 1.1.3).

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Generate more data on the thermo-mechanical performance of UO_2-BeO fuel
- Prepare UO_2-BeO fuel for subsequent studies of its fission gas release and PCMI properties

1.1.3 **Short-term irradiation of pre-irradiated fuel rods**

– *Motivation and background*

This is an experimental series utilising two types of test rig: IFA-629 (HBWR conditions) and IFA-720 (LWR loop conditions). The aim is to characterise medium to high burn-up fuel performance with respect to fuel thermal properties, fission gas release and pellet-clad-mechanical-interaction. The specific objective is to produce experimental data for understanding and modelling fuel behaviour by

the concurrent measurement of temperature, FGR and PCMI during power increments and holds. Additional knowledge on the rod dynamic response is obtained by analysis of scram and noise data. Irradiations in IFA-720 are done under prototypical LWR conditions, i.e. an LWR loop system is utilized, and start with irradiated fuel segments. The fuel is characterised prior to testing as part of collating the base irradiation information, and also after testing in the Halden reactor with the main purpose to confirm the in-pile observations of FGR.

– *Work scope*

It is planned to utilise IFA-629 (or a new test rig of the same design) to test four fuel segments (in two loadings) during the 2018-2020 programme period. While two rods from IFA-716 are already planned to be tested in this rig (IFA-629.10) towards the end of the 2015-2017 programme period (Rod 1, Cr-doped and Rod 5, non-doped), it is also proposed to test the UO_2 / UO_2-BeO pair of rods (Rod 3 and Rod 4) from IFA-716, for which burn-up extension is first planned (see 1.1.2). In addition, it is proposed to test the two 5%Gd-doped VVER fuel rods from IFA-676 (Rod 2 and Rod 5), for which the burn-up accumulation irradiation is planned to be completed during the 2015-2017 programme period. Further, it is proposed to test one of the two extended burn-up Loviisa fuel rods from IFA-789 (multilateral VVER fuel irradiation increment test to ~75 MWd/kgU) in the IFA-720 test rig.

It is expected that the sequence will be:

- *[Rod 1 and Rod 5 from IFA-716 (UO_2/Cr-doped UO_2 pairing) in IFA-629.10 – done 2015-2017]*
- Rod 2 and Rod 5 from IFA-676 (Gd-bearing VVER) in IFA-629.12 (or similar), early in period
- Rod 1 from IFA-789 (extended burn-up VVER) in IFA-720.5, middle of period
- Rod 3 and Rod 4 from IFA-716 (UO_2/UO_2-BeO pairing) in IFA-629.13 (or similar), end of period

There is also interest in subjecting pre-irradiated ATF rods to power transients when possible.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Expand the database of fuel thermal conductivity and its degradation with burn-up from different fuel types and burn-up levels
- Expand the database of PCMI behaviour of different fuels at different exposures
- Provide data on the fission gas release properties of different fuels (grain sizes, microstructures and other additives)
- Expand the database of fission gas release threshold behaviour of different fuel types and burn-up levels
- Provide more data on the behaviour of VVER Gd-UO_2 fuel
- Provide data on the behaviour of extended burn-up VVER fuel
- Provide more data on the behaviour of UO_2-BeO fuel

1.1.4 **Fission induced fuel creep**

– *Motivation and background*

The understanding of fuel behaviour requires knowledge on many phenomena. While all of these phenomena are present in integral fuel performance experiments, their development may be so weak as not to matter for the particular test, or instrumentation may not be present or too insensitive to detect their influence. Separate effect tests are therefore designed and executed for assessing specific phenomena with efficient methods, and the results are used for model development and verification. Separate effects tests can also go to conditions not normally found in LWR operation, generating data allowing model interpolation instead of extrapolation.

One such test approach has been developed at Halden to study irradiation creep of fuels below 1000°C i.e. fuel periphery temperatures. Creep behaviour is studied as a function of applied stress, with temperature and power density being controlled parameters. The fuel has the shape of disks which are stacked between molybdenum disks in order to obtain a more even temperature distribution in the fuel. A compressive load is applied via a bellows unit positioned at the top of the fuel / Mo disk stack. The stack length reduction is monitored by an LVDT, and in order to avoid significant creep of the Mo disks contributing to the integral measurement, the temperature of the disks must be kept below 1000°C. The instrumentation also generates data on fuel densification and swelling under controlled temperature.

The first such fission induced fuels creep test was successfully completed in IFA-701 with Cr-doped fuel and UO_2 reference fuel within the 2015-2017 programme period. It was then proposed to perform another two tests using the same experimental approach, but with gadolinia bearing fuel proposed to be supplied by ENUSA: an 8% and a 3% Gd_2O_3 bearing UO_2 fuel. The low temperatures achievable are relevant not only for the periphery of Gd_2O_3-UO_2 fuel pellets but also for the pellet centre temperature during normal BOL operation. As it is possible to obtain fuel densification data from the instrumentation during the initial phase of the test, running the test with Gd-fuel will thus enhance understanding of the densification kinetics differences associated with the addition of gadolinia to UO_2, complementing the observations made in IFA-636, IFA-676 and IFA-681, as well as characterizing the irradiation induced creep behaviour of gadolinia bearing fuel. This latter has been inferred as being approximately ten times higher in 8wt% Gd-bearing fuel than for UO_2 fuel (at a similar power level / fission rate) from cladding elongation data generated from the power transient, integral performance test, IFA-720.2. It is thus expected that despite the lower power level of Gd-bearing fuel compared to UO_2 under the same reactor conditions, that the creep rate of such fuel will be readily measureable using the “IFA-701 test approach”.

– *Work scope*

It is expected that the first test (in IFA-795) with 8% Gd_2O_3 bearing UO_2 fuel will be started during the 2015-2017 programme period and completed early in the 2018-2020 programme period, with the next test (in a new IFA) with 3% Gd_2O_3 bearing UO_2 fuel starting around the middle of the 2018-2020 period.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Produce direct measurements of in-pile fuel creep at two different levels of Gd-content
- Determine the densification of gadolinia bearing fuel at two irradiation temperatures

1.1.5 **High burn-up structure development**

– *Motivation and background*

There is interest in starting a *new test* in the 2018-2020 programme period to study the development of HBS in a variety of new fuels. For this new study it is planned to collaborate with the NFIR (Nuclear Fuel Industry Research) Group and coordinate with their plans for the NFIR-VII Program, which include the aim to study the properties and behaviour of high burn-up fuels of different types by post irradiation studies. One of the aims of studying these fuel types is to investigate the factors (especially impurities) that promote or delay HBS formation. Another goal is to investigate localization/trapping of volatile fission products by different additives.

On the condition that only one type of fuel is included in a fuel rod, the design of some of the fuel rods to be included in the experiment could also mirror that which was used for IFA-655 i.e. including gas flushing capabilities and fuel stack elongation detectors. This would enable the determination of S/V ratios at given burn-ups throughout the test (by analysis of the flushed out radioactive fission products) and thus monitoring of microstructural changes. Densification and swelling could also then be monitored online.

– *Work scope*

The study would involve performing a long-term irradiation to provide high burn-up fuel material for future fuel behaviour studies and property testing, most likely by utilising the fuel disc irradiation approach as used in IFA-655. However, there is also interest to generate HBS in non-disc set-ups i.e. small diameter fuel pellets in fuel rods operated at high power to accumulate burn-up more quickly than otherwise. Gas flushing and fuel stack elongation detectors could be added to single fuel type rods.

PIE of the fuel after the high burn-up irradiation would include HBS rim thickness values, FGR and retention characteristics, porosity and thermal characteristics. It is expected that participating laboratories would contribute to the PIE. Fuel rods of such HBS fuel discs or pellets would also be available for subsequent testing under power transient conditions such as was done with the IFA-655 fuel rods in IFA-629.

Ideas received so far for fuels to be irradiated as discs for future high burn-up properties studies (as well as some online measurements), are given below.

- Very high purity standard grain UO_2
- Very high purity standard grain UO_2 with intentionally added controlled impurities such as Fe for comparison

- Other commercially produced UO_2 with additive fuels
- UO_2 with ultra-small grain size
- UO_2 with ultra-large grain size
- UO_2 variants (normal impurities) small, standard, large grains but irradiated to even higher burn-ups than was possible in the IFA-649 disk irradiation for NFIR IV
- UO_2 with "centralized U-235 enrichment" to mitigate burn-up peaking at the rim
- Different fuel types (i.e. not UO_2 based) including "cold fuels": silicides, nitrides
- Thorium Fuel variants (Ref: OECD/NEA/Nuclear Science Report 2015)
- U-10Zr Metal Fuel (Ref: Terra Power's TWR Reactor)

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Generate high burn-up fuel material for future fuel behaviour and property testing
- Determine S/V ratios at selected burn-up levels from a range of fuel types
- Measure densification and swelling in a range of fuel types

1.2 Fuel Properties and Behaviour Related to Transient and Accident Conditions

1.2.1 Fuel behaviour under LOCA conditions

– *Motivation and background*

The introduction of new cladding materials and the move to higher burn-up have generated a need to re-examine the safety criteria for loss-of-coolant accidents (LOCA) and to verify their continued validity. As part of international efforts to this end, the Halden Project has implemented a test series (IFA-650) to study integral in-reactor fuel behaviour under expected and bounding LOCA conditions.

The Halden reactor is suited for integral in-pile testing of fuel behaviour under LOCA conditions using single fuel rods. The decay heat is simulated by a low level of nuclear heating which produces a temperature distribution in the fuel rod similar to the real case. Thus a more correct differential fuel-cladding thermal expansion is obtained compared to out-of-reactor tests where the cladding is heated from outside and more than the fuel.

The objectives of the HRP LOCA test series and the test execution conditions have been defined in close cooperation with the HPG and individual member organisations as:

1. Measure the extent of fuel (fragment) relocation into the ballooned region (determine packing fraction) and evaluate its effect on peak cladding temperature in the balloon zone and subsequent effect on oxidation.
2. Investigate the extent (if any) of "secondary transient hydriding" on the inner side of the cladding above and below the burst region.

3. Determine the extent of iodine release; this objective was added later and addressed in the most recent tests of the series.

The test carried out so far, with irradiated fuel segments in the burn-up range 40 – 92 MWd/kg, have given clear evidence of fuel fragmentation and relocation. The fragmentation propensity increases with increasing burn-up when a threshold of about 60 MWd/kg is exceeded, but is counteracted if the cladding keeps firm contact with the pellets. Some experiments have shown a slow depressurisation after burst, and it is not clear how this phenomenon influences the fuel's LOCA behaviour.

– *Work scope*

It is proposed to continue the HRP LOCA test series with the aim to implement, as far as possible and to the extent eventually agreed upon, some of the following experimental approaches:

- Further investigate any grid effect, especially using a grid cell. This is in line with the recommendation from the NEA-CSNI Working Group on Fuel Safety (WGFS) to determine the impact of axial gas transport on ballooning, e.g. by including a spacer grid between the upper plenum and the balloon area that would act as a prototypical distension restriction and cooling improvement similar to what can be expected in the real situation.
- Further study how large the gap between pellet and cladding must be before fragmentation occurs (loss of restraint).
- Develop instrumentation to record when fragmentation (and fission gas release) occurs.
- Quantify transient FGR under the LOCA heat-up.
- Simulate SB LOCA conditions (longer duration, lower temperature, higher outer pressure).
- Oxidation for longer time for oxygen and hydrogen pick-up study (burn-up 45 – 55 MWd/kg).
- Variation of rod pressure and free volume. This is in line with the recommendation from the WGFS to investigate fuel relocation as influenced by the driving force provided by the amount of gas available in the experiments.
- Position the plenum at the bottom of the rod (to check the fuel "lifting" and expulsion capabilities of gas coming from below the balloon/burst region).
- Include quenching at end of test.
- Axial constraint.

And the following fuel selection ideas:

- Testing of additive fuel segments (especially impact on FFRD behaviour)
- Testing of ATF fuel segments (especially impact on FFRD behaviour)
- Testing of UO_2-Gd_2O_3 fuel segments (especially impact on FFRD behaviour)
- Testing of fuels with modern cladding materials (M5, Optimized ZIRLO and M-MDA)

- Study the role of gas location within the fuel pellets on fragmentation behaviour: compare for example Cr_2O_3-doped fuels subjected first to different power ramps promoting different levels of intragranular gaseous precipitation
- Testing of commercially irradiated fuel that has received additional base irradiation to higher burn-up under prototypic LWR conditions in the Halden reactor. A specific example is: a VVER segment originally from Loviisa that has been irradiated under VVER conditions in the HBWR to an extended burn-up of ~75 MWd/kgU. Another example could be comparing two segments of the same burn-up, base irradiated in an NPP but with different final power periods applied in the HBWR.

The exact conditions for the tests, based on the bullet points above or other possible variants also discussed with the HPG such as tests complementary to those done within the SCIP program will be developed in HPG workshops and Expert Group discussions accompanying the test series.

It is mandatory to utilise fuel rods irradiated in commercial reactors to relevant burn-ups with a thorough characterisation regarding the state of the cladding and the bonding with the fuel. Participating organisations are requested to continue to provide fuel with the desired characteristics.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Execute three LOCA tests in the Halden reactor - the exact test programme will not only depend on the outcome of the in-core phase, but also on the results of accompanying PIE.
- The LOCA testing programme will be kept flexible in order to be able to address new questions and issues which may emerge as the experiment series and the understanding of phenomena advance.
- Measure and quantify the iodine released from the LOCA test fuel.

1.2.2 **Behaviour of HBS fuel during transients**

– *Motivation and background*

High-burn-up structure (HBS) fuel is formed in the outer parts of UO_2 fuel where epithermal energy neutrons are captured due to resonances in the ^{238}U absorption cross section, generating plutonium and a local power and burn-up peak. It plays an important role in both normal operation and accident conditions. In the LOCA test series for example, fragmentation of high-burn-up structure (HBS) fuel has proved to be important. Such HBS fuel with burn-up exceeding 120 MWd/kg has been produced in previous programme periods (in disc form) and is available for testing in order to shed more light on its behaviour when subjected to a temperature transient. It is also proposed to generate new high burn-up fuel materials with focus on advanced and “designer” fuel types (see Section 1.1.5).

– *Work scope*

Large amounts of HBS fuel (disks) have been produced in previous programme periods from irradiation in IFA-655.1 and IFA-655.2. The four test rods from IFA-655.1 have already been re-instrumented and tested in IFA-629.5, .6, .7 and .8 to study fission gas release of HBS fuel subjected to a relatively fast power and temperature up-rating. In addition, the first of the two rods irradiated to 180 MWd/kg in IFA-655.2 is also planned to be tested (in IFA-629.9) during the 2015-2017 programme period. The second of the two rods from IFA-655.2 is proposed to be tested in the same manner as the other five rods (in IFA-629.11 or a new test rig of the same design).

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Subject high-burn-up structure fuel (1 test segment) to a temperature transient and measure fission gas release and fuel swelling, then perform PIE.

1.2.3 **Transient fission gas release**

– *Motivation and background*

Anticipated operation occurrences (AOO) such as non-prompt power excursions can contribute to increases in fission gas inventory that are not always well accounted for in fuel performance models. Detailed data obtained from carefully controlled and monitored transients applied to medium to high burn-up fuel could be used to improve the accuracy of current predictions for how the fuel will respond to a defined transient.

– *Work scope*

As a continuation of the plans in the 2015-2017 programme, it is planned to subject commercially irradiated LWR fuel to specific power transients under prototypical LWR conditions to quantify transient or burst fission gas release under AOO conditions. Proposals for different fuel segments to be studied under specific conditions are invited from participants, but it is clear that there is high interest in testing fuel with modern cladding types (M5, Optimized ZIRLO, M-MDA) and pellets with additives as well as ATF. Detailed proposals will be presented to the HPG for discussion and their consideration for inclusion in the program. It is expected that 2-4 fuel segments could be studied in 1-2 loadings of the same test rig.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Subject medium to high burn-up fuel to a power transient (non-prompt power excursion) and measure FGR and fuel swelling

1.2.4 **Dry-out**

– *Motivation and background*

Light water reactor fuel may be subjected to thermal-hydraulic transients resulting in inadequate cooling for short periods of time. Inadequate cooling may occur in PWRs as departure from nucleate boiling (DNB) and in BWRs as short term dry-out. Operation criteria to assure fuel rod integrity in the event of off-normal transients which may lead to fuel dry-out imposed operating restrictions and may also limit the further use of fuel after dry-out. There is therefore interest in further assessing fuel performance under dry-out conditions in order to assess possible additional margins.

– *Work scope*

Of particular interest would be the accumulated effect of "less severe" dry-outs due to for example oscillating flow conditions. Otherwise, dry-outs resulting in cladding temperatures in the range 500 to 700°C being reached would be of interest (to fill the knowledge gap in behaviour "between normal conditions and LOCA"). Such a test could also be used to assess the FGR behaviour of the fuel during a dry-out transient as well as the behaviour and consequences for the cladding performance during for example continued operation. It is expected that 2-4 fuel segments could be studied in 1-2 loadings of the test rig.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Subject medium to high burn-up fuel to a dry-out transient(s) and determine the effects by post irradiation examination as well as online instrumentation such as cladding elongation and possibly pressure transducer

1.2.5 **Power cycling**

– *Motivation and background*

Nuclear power stations are more and more required to participate in power cycling and load follow. Concurrent with extended fuel utilization, this entails questions as to whether and how these modes of operation affect fuel performance. A related issue is the kinetics of conditioning / deconditioning / reconditioning of fuel and cladding. It is therefore of interest to verify that conventional fuel can sustain power cycling at any level of burn-up, and that new types of fuel and cladding have at least as good properties in that regard.

– *Work scope*

This testing would be aimed at defining fuel failure modes and operational limits for power cycling operations and would be informed by related work already done and experience gained in participating countries already operating with power cycling.

An idea is to compare the behaviour of "standard" fuel rods i.e. Zr-based cladding with UO_2 fuel against that of enhanced performance fuel rods (ATF or EATF), which are expected to have improved

behaviour under flexible operation schemes. Within the 2018-2020 programme period, it is possible that some low burn-up EATF rods could be sourced for such testing.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Subject medium to high burn-up fuel to power cycling protocols and determine the effects by both online measurements and post irradiation examinations

1.3 Cladding Performance and Behaviour

All in-core experiments involving the study of cladding behaviour make use of test loops that allow experiments to be performed under representative thermal-hydraulic and water chemistry conditions, i.e. coolant water pressure, temperature and chemistry. Since the fuel is also operated under representative linear powers, other parameters such as cladding mid-wall and surface temperatures are also representative. Fast flux levels are maximised where required by surrounding the test fuel with booster fuel rods. All tests are instrumented for measurement of neutron flux and coolant temperature, pressure and flow rate. Test rods are fitted with instrumentation appropriate to the objectives of the experiment.

The experiments related to cladding performance and behaviour considered for the next programme period are indicated in the following sections.

1.3.1 Cladding creep

– *Motivation and background*

After the fuel cladding has crept down onto the fuel pellet, which is concurrently swelling, and the initial fuel-clad gap is closed, a stress reversal occurs as fuel swelling starts to drive general clad creep-out. Subsequent fuel swelling, fission gas release and power variations affect the applied hoop stress on the cladding in terms of both magnitude and direction. At any given time the fuel-clad gap, an important parameter for determining the thermal performance of the fuel, is dependent on the creep of the cladding. In-pile, diametral creep behaviour of LWR fuel cladding under variable loading conditions is thus important and needs to be addressed in fuel performance codes. General discussion indicates that there are specific areas where modellers continue to require creep data on well characterised material tested under carefully defined in-pile testing conditions, such as primary creep following repeated stress increments and reversals, especially for modern cladding materials.

– *Work scope*

In-pile cladding creep is investigated using the dual principle of stress application by internal gas pressurisation of closed-end cladding tubes and diameter change measurement via a surface traversing 3-point contact diameter gauge. A wide range of compressive and tensile hoop stresses can be applied to the specimens, and on-line changes in stress level can be effected both rapidly and repeatedly. On-line monitoring of the changing segment outer diameter can be carried out frequently and to an accuracy of ±2 µm.

It is proposed to complete the test that was started in the 2012-2014 programme period (IFA-741) loaded with four test claddings (M5, M-MDA, E110-M and optimized ZIRLO) supplied by member organisations. Due to a diameter gauge failure, testing had to be continued with each double-segmented rodlet separately in series, which resulted in a delay to the overall test plan: the rodlet with E110-M and opt. ZIRLO (741-2) will complete testing in the middle of the 2015-2017 period and the rodlet with M5 and M-MDA (741-1) will start to be tested straight afterwards and is expected to complete testing about the middle of the 2018-2020 period. The test is conducted under representative PWR conditions.

On completion of the IFA-741 test, there is interest in starting a *new test* to study the creep behaviour of low-tin ZIRLO and Ziron.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Characterise creep behaviour of modern LWR cladding materials under a range of representative compressive and tensile hoop stress levels.

1.3.2 **Cladding corrosion under high Li conditions**

– *Motivation and background*

With the trend toward increased fuel cycle length and reactor core ratings, fuel can be challenged by the resulting high discharge burn-up and more aggressive thermal-hydraulic conditions (e.g. coolant temperature and void fraction) and water chemistry conditions. Longer fuel cycles together with power up-rates require higher boron concentrations for reactivity control, which, in turn, leads to the increased need of lithium to maintain the optimal water chemistry conditions. Such operation requires beginning of cycle LiOH concentrations above the current widespread industry limit of 3.5 ppm. PWR primary water chemistry is also being optimised to minimise corrosion product release from the surfaces of steam generators and thus out-of-core radiation fields and crud formation on fuel cladding surfaces. Elevated and constant coolant pH is one potential optimisation method. Operation with constant pH 7.3 or 7.4 (maximum lithium concentration 5-6 ppm) has been demonstrated in a commercial PWR; however before more demanding operation conditions can be implemented in PWRs, it is necessary to confirm that they do not have adverse effects on the corrosion and hydriding behaviour of the fuel claddings in use. One concern is to determine whether a so-called cliff edge exists, beyond which operation will be unacceptable.

– *Work scope*

It is proposed to complete the test that started in the 2015-2017 programme period (IFA-785) loaded with six test rods made with claddings supplied by member organisations: M5, M-MDA-SR and ZIRLO, together with alloys used in previous experiments and development alloys. The irradiation conditions (coolant mass evaporation rate and lithium concentration) were chosen to be more severe than those currently allowed in commercial PWRs. The irradiation phase will be completed by the end of the 2015-2017 period or early in the 2018-2020 programme period, and it is planned to perform PIE during the 2018-2020 period to complement the interim inspections made during reactor outages for

which oxide thickness was determined using an eddy current proximity probe. As part of the PIE, oxide thickness and morphology will be studied on metallography samples, which will also show hydride distributions, and hydrogen content will be determined by the hot extraction method.

There is interest to start a *new test* to study the corrosion behaviour of low-tin ZIRLO and Ziron.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Determine oxide thickness and hydrogen pick-up rates for modern PWR cladding materials under elevated Li water chemistry conditions (10 ppm Li, pH_{300} 7.4).

1.3.3 **Long-term irradiation of ATF cladding**

– *Motivation and background*

Most countries are involved in developing fuel with enhanced accident tolerance (EATF), where the enhanced tolerance is due mainly to advanced cladding designs. A specific objective is to reduce the hydrogen production associated with the Zircaloy–steam reaction at temperatures in excess of 900°C. It will also be a prerequisite that the performance of EATF claddings is not inferior to that of currently used claddings under normal reactor operation conditions. Thus the decision on whether enhanced accident tolerant fuel can be used in current LWRs will be in part based on its performance under normal reactor operation conditions.

– *Work scope*

It is proposed to continue the test that started in the middle of the 2015-2017 programme period (IFA-796) loaded with different UO_2 fuelled cladding sections (coated Zr-based claddings, a FeCrAl cladding, and Mo-based claddings) supplied by member organizations. The fuel rods are operated under PWR thermal-hydraulic and water chemistry conditions, with coating integrity and oxide thickness being determined annually during reactor outages, as well as cladding diameter and length measurements. The irradiation phase is expected to continue throughout the entire 2018-2020 programme period. Assuming this will be the case, post irradiation examinations will be made in the subsequent programme period to evaluate coating integrity, cladding creep, oxide thickness and morphology as well as hydrogen pick-up. Fuel segments will also then be available for additional testing such as under power or thermal-hydraulic transients or accident conditions.

– *Deliverables*

The aim for the 2018-2020 programme is to:

- Determine the corrosion, creep and growth behaviour of candidate accident tolerant fuel claddings under normal PWR operation conditions.

1.3.4 **Fuel cladding behaviour in interim dry storage**

– *Motivation and background*

Since many spent fuel pools at nuclear power plants are near capacity and there are no permanent spent fuel disposal facilities in operation, many countries are considering extending the capacity or duration of use of interim dry storage facilities for spent fuel. Storage periods of possibly up to 300 years are being considered. Decay heat keeps the cladding temperature elevated, but decreasing over time, and the combination of atmospheric storage pressure with high EOL internal gas pressure results in significant clad hoop stress, which also decreases over time. These conditions increase the possibility of fuel cladding embrittlement in the radial direction due to hydride reorientation (which can have consequences for later handling of the stored fuel) or even failure due to creep rupture. Dry storage conditions will also induce specific cladding microstructural changes and determine creep behaviour, such that the only way to determine the behaviour of fuel cladding in dry storage is to study it under specific dry storage conditions.

– *Work scope*

This project started during the 2015-2017 programme period to study the dimensional, microstructural, and mechanical properties changes occurring in different irradiated fuel rods during representative dry storage boundary conditions. It is planned to continue this project in order to complete a comparative study of fuel rod variables expected to influence the behaviour of cladding under dry storage conditions, as well as studying the effects of bounding and realistic conditions on commercially irradiated LWR fuel rods.

In addition, there is interest in adding to this project the possibility of quantifying alpha-decay fuel swelling and decay gas release.

– *Deliverables*

The aims for the 2018-2020 programme are to:

- Contribute to characterisation of cladding behaviour under interim dry storage conditions in particular for modelling purposes.

2 Plant Ageing and Degradation

The plant ageing and degradation programme is aimed at studying the effects of irradiation on reactor vessel internals as well as concrete containment buildings as the age of operating nuclear power plants increases. The studies address the following issues:

- Irradiation assisted stress corrosion cracking (IASCC) of core component structural materials
- Irradiation enhanced creep and stress relaxation
- Reactor pressure vessel (RPV) embrittlement
- Ageing of concrete

The experimental programme on IASCC is aimed at generating data that provide a fundamental mechanistic understanding of the phenomenon, predicting behaviour, in particular the cracking response of irradiated materials, assessing the benefits of countermeasures and determining the limits of operation for existing materials. An understanding of the processes is considered the key to effective ageing management (i.e. mitigation and / or repair). The majority of the IASCC investigations are performed in loops simulating light water reactor operating and water chemistry conditions.

Irradiation enhanced creep and stress relaxation are potential degradation mechanisms that may affect materials' long-term performance. An in-pile study aimed at assessing the effects of irradiation and applied load on creep / stress relaxation of new, accident tolerant fuel (ATF) cladding and improved radiation resistant materials that are being developed for LWRs, may be conducted under dry irradiation conditions.

For the RPV programme, the Halden Project is participating, in collaboration with VUJE, Slovakia, in studies that make use of the small punch test method for determining the basic mechanical properties of irradiated RPV materials.

An additional area of investigation for the Joint Programme in 2018-2020 is proposed to focus on the ageing of concrete. All nuclear power plants contain concrete structures that are essentially passive under normal operating conditions but play a key role in mitigating the impact of extreme/abnormal operations and environmental events. As NPPs age, assurances need to be provided that the concrete has not deteriorated unacceptably due to environmental effects such as exposure to a radiation environment.

2.1 Irradiation Assisted Stress Corrosion Cracking

– *Motivation and background*

Irradiation assisted stress corrosion cracking (IASCC) occurs under the combined effects of irradiation, stress and a corrosive environment. IASCC is a degradation mechanism that is of concern for core components as reactors age, and components from both BWRs and PWRs have experienced intergranular cracking attributed to IASCC.

The austenitic stainless steels and nickel based alloys that are used as structural materials for LWR internals are exposed to radiation environments over extended periods of time. The resultant increases in yield strength, radiation induced segregation, changes in the material microstructure, loss of ductility and fracture resistance are all important factors when addressing plant ageing and licence renewal issues. A better understanding of their manifestation can enable better planning of aging management strategies for power plants.

The IASCC programme focuses on crack growth rate and crack initiation studies.

2.1.1 **Crack growth rate studies**

- *Workscope*

Long-term crack growth rate (CGR) data from Compact Tension (CT) specimens prepared from irradiated core component materials will be generated in BWR and PWR environments. The specimens are instrumented with the reversing dc potential drop method for crack propagation monitoring and are equipped with bellows for variable load application. The crack growth rate studies are aimed at practical data generation as a function of temperature, corrosion potential / water chemistry, fast neutron flux and stress intensity (K) levels. Representative materials harvested from commercial power plant components (e.g. control blades, baffle bolts, top guide, core shroud) are employed, concentrating on crack growth rate (CGR) testing over a range of dose levels.

In addition to the comparatively high dose materials retrieved from, for example, control blades and baffle bolts, it is recognized that there is very limited crack growth rate data for weld and heat affected zone (HAZ) materials, in particular at the higher dose levels that are relevant for extended reactor operation. Participant organisations have therefore made available to the Joint programme both core barrel weld and HAZ material with doses of ~1 - 2 dpa, for further irradiation and testing. The materials have been machined into 8 ¼T CTs, 8 ½ T CTs and 8 tensile specimens. Irradiation to higher dose levels began in 2016 and will be continued in the 2018 – 2020 programme period. While the irradiation, as well as most of the testing, will take place within the Joint Programme, the results from specimens tested elsewhere will also be shared with HRP members.

It is expected that one BWR and one PWR crack growth test, each employing 6 CTs, will be conducted in the 2018-2020 programme period: the BWR study, IFA-791, began already in 2016. The materials in the IFA-791 test matrix include ~2 dpa weld and heat affected zone 304 SS, 35 dpa 304 SS5, 2 dpa 321 SS and 4 dpa CW 316 Ti SS. The effects of low ECP (hydrogen addition) as a means of mitigating crack growth rate will be evaluated. In addition, the effects of temperature on crack growth rate will also be studied. The materials and operating conditions for the PWR study, to be performed after the BWR test, have not yet been identified.

Post irradiation characterisation of the materials that are used in the crack growth rate (and also the crack initiation) tests is an important supplement to the in-pile data. PIE typically includes post irradiation examination of specimen fracture surfaces, hardness measurements and tensile testing. In addition, detailed TEM / FEG-STEM examination of the materials' microstructures and microchemistries is performed at participant laboratories.

Efforts are also made to obtain information on the flux, fluence and temperature to which the materials were exposed in the commercial nuclear power plants from which they were retrieved.

- *Deliverables*

The aims for the 2018 – 2020 programme are to:

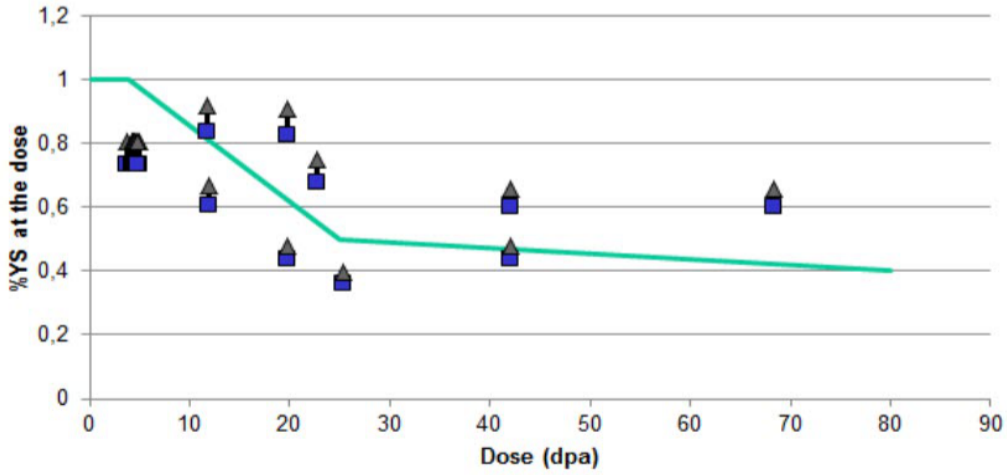
- Irradiate weld and HAZ specimens to higher dose levels representative of extended reactor operation for subsequent testing in PWR (and BWR) CGR investigations
- Generate crack growth rate data on irradiated CTs in BWR conditions with either 5 ppm O_2 or 2 ppm H_2 in the coolant and evaluate the effect of temperature on growth rate.
- Measure crack growth rates in irradiated CTs under PWR conditions
- Perform detailed post irradiation examination of selected test materials

2.1.2 **Crack initiation studies**

- *Workscope*

Two crack initiation studies that began in the 2015-2017 programme period will be continued in the 2018-2020 programme period.

The first study, performed under representative PWR conditions, addresses the effects of load transients on the initiation of cracks in tensile specimens prepared from ~4 to 25 dpa CW 316 SS and ~4 to 70 dpa SA 304 SS. The main objective will be to study a proposed engineering sensitivity threshold for crack initiation under transient load conditions. The specimens will be loaded to stress levels below the threshold curve and subjected to load transients above the threshold curve, as illustrated in the figure below.



It is proposed that 80 dpa CW 316 SS O-ring samples be included in a second loading of the test. O-ring samples prepared from the same material have already been tested out-of-core at a participant laboratory, thus enabling a comparison between in and out of core initiation data.

The second study addresses the initiation of cracks in Alloy 718, also in a simulated PWR environment.

Alloy 718 has shown exceptional mechanical properties and resistance to radiation degradation for certain material compositions and heat treatments. Outside this narrow area, studies have found that the material properties quickly degrade, and PWR operational experience has shown cracking and stress relaxation in a number of 718 components. In order to evaluate the factors affecting the material performance, the effects of stress, heat treatment, % cold work and alloy chemistry on crack initiation of alloy 718 are being assessed in the investigation.

The test was originally performed on a bilateral basis and was continued in the Joint Programme from mid-2016 when the bilateral study was concluded, granting Joint Programme members access to all results. In-pile testing will conclude at the end of 2017 and will be followed by PIE.

– *Deliverables*

The aims for the 2018–2020 programme are to:

- Assess the effect of load transients on the initiation of cracks in tensile and O-rings samples with different doses
- Perform PIE on the Alloy 718 specimens

2.2 Irradiation Enhanced Creep and Stress Relaxation

– *Motivation and background*

New accident tolerant fuel cladding materials as well as more radiation resistant alloys for core structural components are being developed in a number of countries. In addition to evaluating the potential application of these materials for fuel cladding and structural components by studying their corrosion performance, there is also a need to evaluate other performance aspects such as in-pile creep behaviour.

– *Workscope*

The design of the proposed test will be based on that of an earlier Joint Programme creep and stress relaxation test which was in operation for eight years in the period 2006-2014. Tensile samples are installed in instrumented units. Stress is applied to the specimens by means of bellows which are compressed by gas pressure that is introduced into the chamber housing the bellows, and sample elongation is measured by means of LVDTs. In order to measure creep rates at different stress levels (or to obtain stress relaxation data by maintaining constant displacement on the samples) the applied load may be decreased on-line, by reducing the pressure in the bellows housing units.

In addition to the bellows gas lines for load application, the test units are equipped with gas lines that enable control of the specimen temperatures by altering the composition of helium-argon gas mixture surrounding the specimens.

Materials of interest for inclusion in the study will be discussed with Project participants.

- *Deliverables*

The aims for the 2018–2020 programme are to:

- Provide baseline creep (and stress relaxation) data for new accident tolerant fuel cladding and candidate core component replacement materials.

2.3 Pressure Vessel Integrity Study

– *Motivation and background*

The pressure vessel integrity studies are aimed at evaluating the effects of neutron embrittlement on pressure vessel materials as well as on some core component materials. The limited amounts of available material for such tests are resolved through reconstitution techniques and miniaturisation of test specimens.

The use of the small punch test (SPT) method, which reduces the amount of material required to determine the basic mechanical properties of a material, was verified experimentally in the 2009 - 2011 and 2012 - 2014 programme periods in two investigations performed in collaboration with VÚJE, Slovakia.

– *Workscope*

A 3rd study, which began in the 2015 – 2017 programme period, will be concluded in 2018 -2020. The main objective is to compare the results obtained from surveillance specimen programmes at Slovakian power reactors with results obtained from specimens irradiated in the Halden reactor. Two sets of SPT and mini tensile specimens prepared from the same materials that are being used in the NPP surveillance programmes are currently being irradiated in the Halden reactor. The specimens are prepared from the RPV base and weld materials of the 3rd and 4th units of the NPP in Mochovce (EMO). The two units are currently under construction and the start of the operation is expected in 2016 (Unit 3) and in 2017 (Unit 4).

The specimens, comprising 180 SPT and 30 mini tensile specimens, are being irradiated at ~275 °C to 4 x 10^{19} and 1 x 10^{20} n/cm^2 (> 1MeV), equivalent to 1 and 3 campaigns in the power reactors. The irradiation will be completed in mid-2017, followed by mechanical testing.

The surveillance specimen programmes for the two Mochovce units also contain several sets of SPT specimens. The results from the Halden and NPP irradiation will be used in safety assessments for both units of the Mochovce NPP.

– *Deliverables*

The aim for the 2018 – 2020 programme is to:

- Complete mechanical testing and compare the results from the Slovakian power reactor specimen surveillance programmes with those obtained from Halden reactor.

2.4 Ageing of Concrete

- *Background and motivation*

Concrete is used in the construction of nuclear power plants, e.g. for the containment, the biological shield and the structures carrying the reactor pressure vessel. As the operation of NPPs extends over several decades, it is important to ensure that the concrete structure maintains adequate properties also in the long term, considering that such concrete structures are subjected to the damaging effects caused by neutron and gamma radiation.

- *Workscope*

The irradiation of concrete would be performed at the JEEP-II reactor at Kjeller, primarily because of the low operating temperature (55 °C) and the low gamma heat (0.1 W/g), which give representative irradiation conditions for concrete. Experience with concrete irradiation and testing has already been established at IFE through bilateral programmes.

While the scope and objective of the proposed experiment still need to be discussed further with Project participants, preliminary ideas include:

- Harvesting concrete samples from actual NNPs and irradiating the specimens up to a number of different neutron fluence levels, equivalent to various numbers of years of operation of an NPP.
- Doing a "systematic scientific study" to learn more about the effects of exposure on the behaviour of different cements/aggregates when exposed to a radiation environment.

The test assemblies that are irradiated in the Jeep II reactor are able to contain concrete specimens with a diameter of up to 5 cm. On-line measurements could include monitoring of temperature and gamma heat as well as monitoring the concrete samples' gas release (amount and composition), water release and dimensional changes (stack elongation).

Subsequent post irradiation measurements of the concrete samples could include some, or all, of the following:

- Change in mass and dimensions
- Elastic modulus
- Compressive and tensile strength
- Gamma scanning and neutron radiography
- LOM examination and SEM examination

- *Deliverables*

The aims for the 2018 -2020 programme are to:

- Initiate an investigation aimed at assessing the ageing of concrete as a result of exposure to neutron and gamma radiation

Note to requester: Attachment is immediately following.

From: Frankl, Istvan
Sent: Thu, 2 Feb 2017 07:56:17 -0600
To: Tregoning, Robert
Cc: Berrios, Ilka;Hiser, Matthew;Hull, Amy;Purtscher, Patrick
Subject: FW: Action: FANC Research on decommissioned RPV
Attachments: 16-105 Leaflet SCK FANC BELV.docx

Rob

Would FANC be a good candidate for the upcoming harvesting workshop?

Thanks,

Steve

From: Berrios, Ilka
Sent: Thursday, February 02, 2017 8:19 AM
To: Frankl, Istvan <Istvan.Frankl@nrc.gov>; Iyengar, Raj <Raj.Iyengar@nrc.gov>
Subject: FW: Action: FANC Research on decommissioned RPV

Please see below. Please let me know your thoughts.

Thanks,

Ilka
415-2404

From: Sangimino, Donna-Marie
Sent: Wednesday, February 01, 2017 5:10 PM
To: Berrios, Ilka <Ilka.Berrios@nrc.gov>
Cc: RES_International_Mailbox <RES_International_Mailbox@nrc.gov>
Subject: Action: FANC Research on decommissioned RPV

Hi Ilka,

OIP reached out regarding the email below and attached, asking if RES is interested in working with the Federal Agency for Nuclear Control (FANC) in Belgium on material properties of decommissioned RPV (no rush).

Thanks

Donna-Marie

From: VINCK Marion [mailto:Marion.VINCK@FANC.FGOV.BE]
Sent: Friday, December 02, 2016 8:18 AM
To: Holzman (Schwartzman), Jennifer <Jennifer.Schwartzman@nrc.gov>
Cc: van Walle Eric (eric.van.walle@sckcen.be) <eric.van.walle@sckcen.be>
Subject: [External_Sender] RE: Research on decommissioned RPV

Dear Jennifer,

Please find attached the requested leaflet.

Kind regards

Marion VINCK
Management Assistant to the DG
FANC-AFCN
Tel : +32 (0)2. 289.2100
Fax : +32 (0)2. 289.2103
(b)(6) Gsm : [redacted]
marion.vinck@fanc.fgov.be
http://www.fanc.fgov.be/

FANC
federal agency for nuclear control

From: Holzman (Schwartzman), Jennifer [mailto:Jennifer.Schwartzman@nrc.gov]
Sent: donderdag 1 december 2016 20:05
To: VINCK Marion
Subject: Research on decommissioned RPV

Dear Marion,

Greetings from the USNRC – I hope this message finds you well!

I am writing because, during Director General Bens' meeting with the USNRC delegation during the recent General Conference, he mentioned that FANC may be initiating a research project to examine the dismantled reactor pressure vessel of a decommissioned NPP. A brochure on the project was provided to our delegation. I was hoping that it might be possible to obtain an electronic copy of this information so we may share it with our technical experts. Your assistance is greatly appreciated.

Best regards,
Jennifer

Jennifer Schwartzman Holzman
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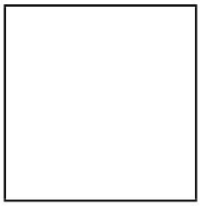
jennifer.schwartzman@nrc.gov



Note to requester: This empty box was in the original email record provided to the FOIA team, it links to the FANC web site, https://fanc.fgov.be/nl

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

FANC AFCN BEL V

Assessing actual material properties of decommissioned nuclear reactor vessels in comparison to prediction – an international programme

This project is aiming to extract irradiated reactor pressure vessel materials from one or more shutdown (decommissioned) nuclear power plants for testing in different laboratories in order to assess the actual measured properties of the vessel materials versus predicted values. The outcome of this research will improve our understanding of neutron-induced degradation of RPV materials from long-term radiation exposure, to compare them to accelerated material test reactor (MTR) irradiation enabling both the operators and the regulators evaluation of the reliability of the current procedures. It is a matter of fact that an incredible amount of valuable information can be extracted from the decommissioned vessels upon post-mortem tests by scientists from different organizations to deepen and understand material behavior that have operated under realistic conditions.

Several tens of nuclear power plants were shut down worldwide among which 37 reactors in the last decade. On the other hand, from the operating worldwide nuclear power reactor fleet, more than 60 reactors are at present more than 40 years old many reactors licenses will be renewed in the coming years for a further 20 (or even 40) years of operation. As a result, operators and regulators need additional information to understand, assess and manage the degradation of irradiated materials of nuclear pressure vessels.

Figure showing the BR3 reactor pressure vessel dismantling

Historical context

Testing irradiated materials from decommissioned vessels is not new. A number of individual initiatives can be found worldwide but the effort is quite limited because of funding constraints (see Table). Nevertheless, the outcomes from these individual projects were very pertinent and beneficial. BR3 post-mortem tests demonstrated the conservatism of the regulation. It is interesting to note that the BR3 vessel is very similar to the Yankee Rowe vessel that was shut down in 1991 after many discussions on vessel embrittlement. Chooz-A post-mortem tests proved the validity of the surveillance program.

Within the Gundremmingen-A reactor vessel test program, the mechanical properties of the different forging constituting the vessel were found to be different. However, the surveillance data as well as the regulatory approach remain conservative. The Greifswald post-mortem tests showed that the weld properties may significantly vary from one location to another, not always related to fluence level. The chemical composition through the weld thickness is found not constant. This was also observed on the Novovoronesh-1 reactor where phosphorus content is relatively high. The embrittlement based on regulatory approach is higher than expected but direct fracture toughness measurements are within the Russian code This brief overview, although modest in terms of efforts shows clearly that we need to reactivate such a program but this time in an international context with more extensive investigations.

Table : Reactor vessels on which post-mortem tests were performed

BR3	Belgium	PWR (11 MWe)	1963–1987
Chooz-A	France	PWR (305 MWe)	1967–1991
Gundremmingen-A	Germany	BWR (237 MWe)	1966–1977
Greifswald-1 to 4	Germany	VVER-440 (408 MWe)	1986–1991
Novovoronesh-1	Russia	VVER-440 (408 MWe)	1964–1984

The project

The proposed project is aiming to gathers several international organizations to assess the reactor vessel materials properties after long term operation conditions and to compare them to surveillance data (moderate lead factor) as well as material test reactor data (lead factor several orders of magnitude higher than the vessel). The final materials selection and test matrix will depend on organizations interests as well as funding. But the outcomes will clearly improve our understanding on materials behavior under neutron irradiation and would allow assessment of spectrum and flux effects, the final goal being the assessment of the regulatory procedures in place today. The results will benefit the worldwide utilities and regulators, and will also help to better evaluate long term operation programs aiming at a plant lifetime of more than 40 years.

To successfully execute this project, active participation of utilities, regulators and research organizations is a prerequisite. It is important that the utilities offer interesting vessel materials so that a number of issues can be investigated, in particular, material variability (chemical composition as well as mechanical properties), comparison to surveillance program, comparison to accelerated material test reactor data, regulatory-based assessment versus actual vessel properties, post-irradiation annealing behavior, ...

This project is open for international collaboration including the EU, USA, and Japan where a large number of decommissioned reactors are available. SCK•CEN together with the Belgian nuclear authorities FANC/AFCN and BEL V will act as the Belgian representatives.

Contact

FANC/AFCN Jan Bens, Director-General, Ravensteinstraat 36, 1000 Brussel, JAN.BENS@FANC.FGOV.BE
François Henry, Expert, Ravensteinstraat 36, 1000 Brussel, Francois.henry@fanc.fgov.be

SCK•CEN Eric van Walle, Director-General, Boeretang 200, 2400 Mol, eric.van.walle@sckcen.be
Rachid Chaouadi, Deputy Institute Manager NMS, Boeretang 200, 2400 Mol, rachid.chaouadi@sckcen.be