



2/16/11

Meeting with Representatives From the State of New York

March 22, 2011

Introductions

- **NRC Introductions**
- **New York State Introductions**
- **Opening Remarks**

Agenda

- **Status of Events in Japan**
- **Domestic Reactor Safety**
- **License Renewal Process**
- **GI-199**

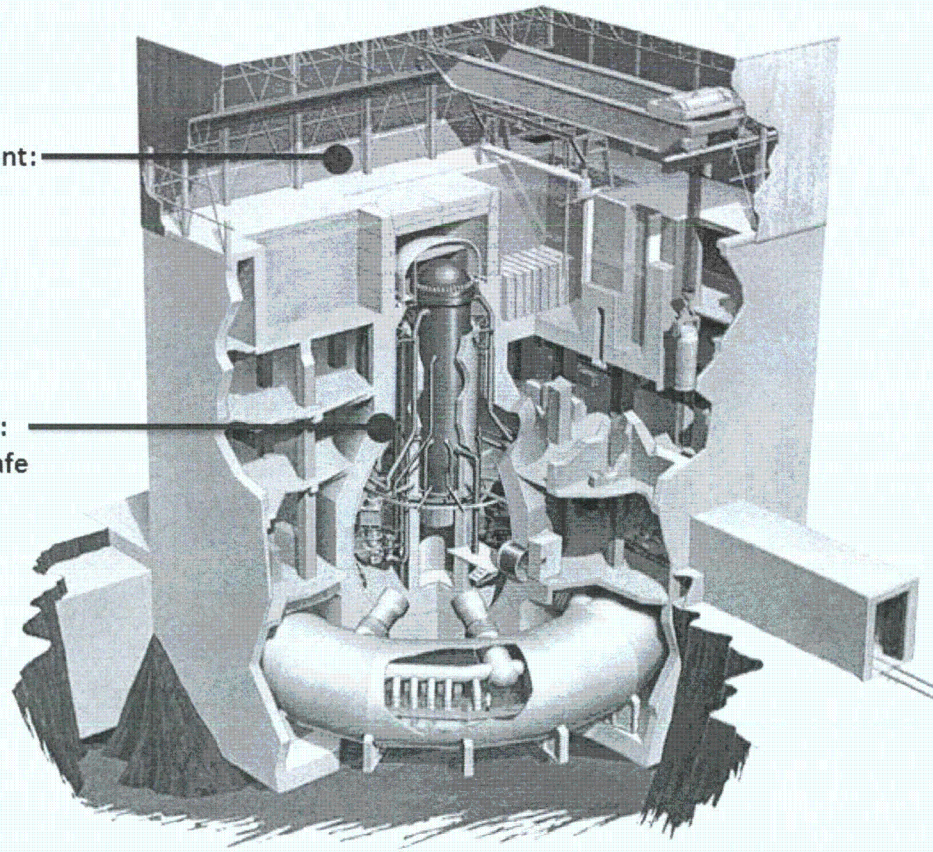
Status of Events in Japan

- **Status of reactor cores**
- **Status of spent fuel pools**
- **Protective actions**

BWR with Mark 1 Containment

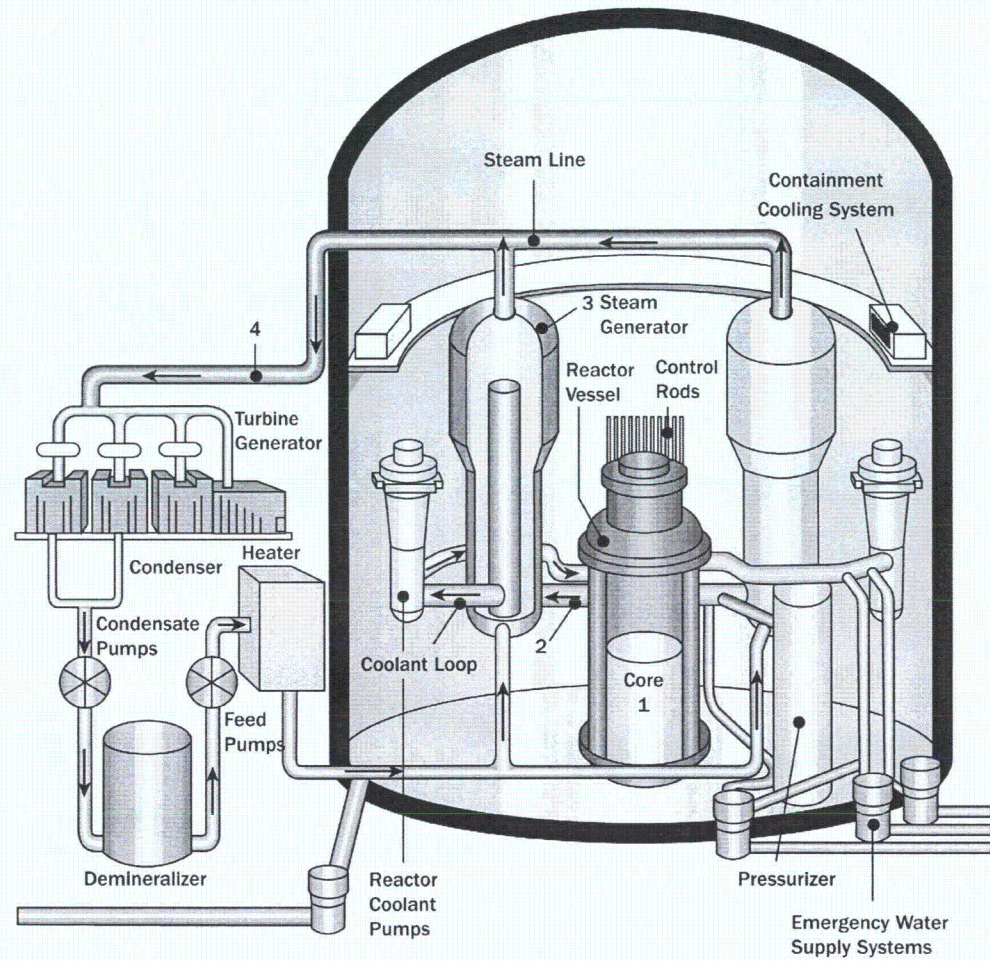
Secondary containment:
Area of explosion at
Fukushima Daiichi 1

Primary containment:
Remains intact and safe



Boiling Water Reactor Design

Typical Pressurized-Water Reactor



Source: U.S. Nuclear Regulatory Commission

Domestic Reactor Safety

- **NRC oversight of U.S. plant safety**
- **Continuous improvement based on operating experience**

License Renewal Process

- **Scope of review is focused on managing the effects of aging**
- **NRC also reviews environmental impacts**
- **All other issues are addressed through the day-to-day regulatory framework**

Overview of GI-199 Updated Seismic Hazard Estimates

Background: GI-199 Safety/Risk Assessment Context and Results

- **Generic Issues Program Stages**
 - **Identification – from Early Site Permit reviews**
 - **Acceptance**
 - **Screening**
 - **Safety/Risk Assessment**
 - **Regulatory Assessment**
- **Safety Risk Assessment Results**
 - **Operating power plants are safe.**
 - **Overall seismic risk estimates remain small**
 - **The new seismic data for some plants meet the criteria for further evaluation**

Conclusion

- **Indian Point plants meet NRC safety standards and no immediate actions are necessary**
- **Emergency preparedness for Indian Point meets Federal standards and no immediate actions are necessary**
- **NRC has a strong regulatory framework**
- **NRC will evaluate the Japanese event for lessons for U.S. reactors**
- **NRC will use the Generic Issues program to further evaluate seismic risk**
- **NRC will continue to maintain openness and involvement by stakeholders**

Landau, Mindy

From: Landau, Mindy
Sent: Tuesday, March 22, 2011 7:47 AM
To: Hayden, Elizabeth
Cc: Harrington, Holly; Brenner, Eliot
Subject: RE: Harrison Akins - U.S. Nuclear Infrastructure Council

I assume he's talking about the timeline for the report? Let's wait to respond until the Commission vote, tasking, etc., is released.

From: Hayden, Elizabeth
Sent: Monday, March 21, 2011 1:21 PM
To: Landau, Mindy
Cc: Harrington, Holly; Brenner, Eliot
Subject: FW: Harrison Akins - U.S. Nuclear Infrastructure Council

Can someone in the EDO's office give us a hand with this request?

Beth Hayden
Senior Advisor
Office of Public Affairs
U.S. Nuclear Regulatory Commission
--- Protecting People and the Environment
301-415-8202
elizabeth.hayden@nrc.gov

From: Harrington, Holly
Sent: Monday, March 21, 2011 12:35 PM
To: Hayden, Elizabeth; Brenner, Eliot
Subject: RE: Harrison Akins - U.S. Nuclear Infrastructure Council

Maybe someone in the EDO, as I believe they would have written his presentation?

From: Hayden, Elizabeth
Sent: Monday, March 21, 2011 12:32 PM
To: Harrington, Holly; Brenner, Eliot
Subject: RE: Harrison Akins - U.S. Nuclear Infrastructure Council

Anyone in the Ops Center available to provide?

Beth Hayden
Senior Advisor
Office of Public Affairs
U.S. Nuclear Regulatory Commission
--- Protecting People and the Environment
301-415-8202
elizabeth.hayden@nrc.gov

From: Harrington, Holly
Sent: Monday, March 21, 2011 12:18 PM
To: Brenner, Eliot; Hayden, Elizabeth
Subject: FW: Harrison Akins - U.S. Nuclear Infrastructure Council

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Not sure what to do with this request . . .

015 **From:** Ghneim, Munira
Sent: Monday, March 21, 2011 12:10 PM
To: Harrington, Holly
Subject: Harrison Akins - U.S. Nuclear Infrastructure Council

Organization – U.S. Nuclear Infrastructure Council

Contact – Harrison Akins

Phone – 202-450-8824

Email – hakins@nuclearinfrastructure.org

Request – Would like details of the timeline discussed in the staff briefing this morning.

Thank You
Munira Ghneim
Contract Secretary
Office of Information Services
301-415-1170

Landau, Mindy

From: Landau, Mindy
Sent: Tuesday, March 22, 2011 7:55 AM
To: Hayden, Elizabeth
Subject: RE: Comm Team Sitrep

For some reason, I only get sound – no picture. Can you view it?

From: Hayden, Elizabeth
Sent: Monday, March 21, 2011 5:01 PM
To: Landau, Mindy
Subject: RE: Comm Team Sitrep

OK. The video is up on the web.

Beth Hayden
Senior Advisor
Office of Public Affairs
U.S. Nuclear Regulatory Commission
--- Protecting People and the Environment
301-415-8202
elizabeth.hayden@nrc.gov

From: Landau, Mindy
Sent: Monday, March 21, 2011 4:54 PM
To: Hayden, Elizabeth
Subject: RE: Comm Team Sitrep

There were no prepared remarks. Most were just off the top of his head.... We need to wait for the transcript.

From: Hayden, Elizabeth
Sent: Monday, March 21, 2011 4:44 PM
To: Landau, Mindy
Subject: FW: Comm Team Sitrep

If the EDO's comments are given to Bob Nelson, can we get them too?

Beth Hayden
Senior Advisor
Office of Public Affairs
U.S. Nuclear Regulatory Commission
--- Protecting People and the Environment
301-415-8202
elizabeth.hayden@nrc.gov

From: Leeds, Eric
Sent: Monday, March 21, 2011 4:32 PM
To: Dean, Bill; Lew, David; McCree, Victor; Wert, Leonard; Pederson, Cynthia; West, Steven; Howell, Art; Collins, Elmo
Cc: Johnson, Michael; Wiggins, Jim; Sheron, Brian; Virgilio, Martin; Brenner, Eliot; Hayden, Elizabeth; Schmidt, Rebecca; Powell, Amy; Grobe, Jack; Uhle, Jennifer; Evans, Michele; Holahan, Gary
Subject: FYI: Comm Team Sitrep

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FYI – see below. Lots of progress. Lots more to do.

Eric J. Leeds, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
301-415-1270

From: Nelson, Robert
Sent: Monday, March 21, 2011 3:51 PM
To: Leeds, Eric; Boger, Bruce; Giitter, Joseph
Cc: Meighan, Sean; Nguyen, Quynh; Markley, Michael; Oesterle, Eric; Thomas, Eric
Subject: FYI: Comm Team Sitrep

1. The biggest advancement was the public version of Annie Kemmerer's Qs & As. Our team had little to do with this other than to ask for it.
2. We added numerous documents to our NRR internal website: <http://portal.nrc.gov/edo/nrr/default.aspx>. I've communicated this update to our regional POCs.
3. I prepared & forwarded to Eric a recommended communication to all NRR staff regarding that web site. Our staff is hungry for info.
4. We completed our compilation of OBE, SSE, Max Flooding Level and Protection Level for all of the plants based on info in the FSARs. This info is readily available when needed.
5. We'll begin our screening of potentially sensitive licensing actions tomorrow. I'll inform you of the results.
6. We working on some additional Qs & As but we've been impacted by the AP FOIA and did not make as much progress as we had hoped.
7. I've asked OEDO for the file of the EDO's opening remarks from today's meeting. We don't want to wait for the transcript. This is another source of info for Qs & As. No response yet.

NELSON

Landau, Mindy

From: Landau, Mindy
Sent: Tuesday, March 22, 2011 9:22 AM
To: Pedersen, Renee
Subject: RE: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website

Agreed...

From: Pedersen, Renee
Sent: Tuesday, March 22, 2011 9:06 AM
To: Landau, Mindy
Subject: RE: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website

Mindy,

This is the first one. I called the individual and left a message and thanked him for his suggestions, but let him know that this wasn't the right avenue and that I would help him forward his concerns to a more appropriate channel. (I always feel better about trying to talk to a person so it doesn't just feel like I'm dismissing their concern.)

Renée

From: Landau, Mindy
Sent: Tuesday, March 22, 2011 7:43 AM
To: Pedersen, Renee
Subject: RE: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website

Why don't you just forward them to me for now I and will figure something out. Have you been getting many of these?

From: Pedersen, Renee
Sent: Monday, March 21, 2011 2:29 PM
To: Landau, Mindy
Subject: FW: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website

Mindy,

Clearly these suggestions don't fall in my area. Any ideas where I can recommend that he send them? Ops Center, OPA, OEDO, suggestion program?

Renée

From: DifferingViews Resource
Sent: Friday, March 18, 2011 3:25 PM
To: Pedersen, Renee
Subject: FW: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website

From: Kidwell, Michael
Sent: Friday, March 18, 2011 3:24:44 PM
To: DifferingViews Resource

Subject: Two suggestions: No.1 for Fukushima plant; and No.2 for NRC website
Auto forwarded by a Rule

I didn't know quite where else to send these:

1. My idea involves the ability to get large quantities of water where it is needed. I have watched helplessly as the seemingly midget fire trucks fight valiantly to do the task. Could it be possible to use a different piece of equipment? The vehicle I am thinking of is a cement mixer truck with the long booms that they use to place concrete at many construction sites. When they clean out the mixer they use copious quantities of water and the boom could direct it onto the appropriate place in the reactor buildings or spent-fuel pools.
2. In a vein similar to one of the questions posed in today's all-hands meeting, I think our website might also include a place for the registration of suggestions (beyond the nuclear technical) that might aid or spawn others that will aid in solving the problems of how to get water into the target reactors and spent fuel pools in sufficient quantities. I know we lack much of the information that our technical teams and, of course, our Japanese brothers have but I would be remiss for not at least offering a small suggestion.

Best regards,

Mike Kidwell

Lee, Richard

From: Lee, Richard
Sent: Friday, March 25, 2011 8:49 AM
To: Salay, Michael; Wagner, Katie
Subject: RE: Fukushima DW/SP dose additional SA documents

Mike:

The SOW one, if you give us the tasks, we can have it done next week. Just give us the info. you got so far.

Richard

From: Salay, Michael
Sent: Friday, March 25, 2011 8:39 AM
To: Lee, Richard; Wagner, Katie
Subject: Fukushima DW/SP dose additional SA documents

Richard/Katie,

Two things:

A) I found confirmation of SP/DW doses in status doc - It looked like it was released by NISA. I saw it at home last night - i.e. from internet - i.e. publicly available. Although it was in Japanese DW, SP and dose units were clearly visible and consistent (though not exactly the same) with what I had mentioned. I didn't bring or email as it seemed to be the same table we already have. When I went to verify this morning when I got in I realized that it was not the same table. The table we received were estimated source terms. It seemed possible that this table may have been one of many. I'll try to remember to find and forward source URL when I get home. If available, we should collect these so that we can get dose trends.

B) Don Marksbury provided me (two days ago - haven't mentioned) the SA NUREGs that he collected. I haven't had a chance to go through. We should upload docs that we don't already have to the ST site. The disk is on my desk if either of you have time to look through and upload to SharePoint - or can find someone else to do so.

BTW: my priorities before leaving today:

- 1) collecting material necessary for trip
- 2) getting sgtr presentations transferred to Raj and others
- 3) getting text for SOW generated (support STEM BIP2 ARTIST SARNET) - got partway through a few weeks ago
- 4) I guess I have to ask about time - this is kind of messy as I was taking time off for contract and house inspection - I think I will just send hours to Larry Davidson.

Unfortunately I keep looking at Fukushima stuff so I haven't worked on foregoing. I'm not planning on looking at any more Fukushima stuff so I can hopefully complete the above items before going home today.

-Mike

Michael Salay
United States Nuclear Regulatory Commission Washington, DC 20555
MS: C3-C07M
michael.salay@nrc.gov<<mailto:mas10@nrc.gov>>

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tel: 301-251-7543

fax: 301-251-7436

Rihm, Roger

From: Rihm, Roger
Sent: Wednesday, March 23, 2011 1:07 PM
To: Boska, John
Subject: RE: ACTION: G20110195

Haven't started Lowey (thought I would steal from you!) Basically, she's going to get a response that has 2 parts. The first part (which I plan to start drafting this afternoon) is going to be an "interim response" we plan to send in response to multiple letters from various Members basically telling them what the impending SRM is going to have us do (near term and longer term analyses by senior level task force, etc.) and indicate we will give them more info as those activities progress. The other part was going to be my effort to ensure she receives the same info that we gave to the NY delegation yesterday, which I hoped to crib from some of the email summaries and talking with Brian Wittick (OEDO) who was there. If you get through with yours before I get to mine (she is not at the top of my list), then perhaps you might have some text I can lift....

-----Original Message-----

From: Boska, John
Sent: Wednesday, March 23, 2011 1:01 PM
To: Rihm, Roger
Subject: RE: ACTION: G20110195

I was at the meeting with the NY Lt Gov, and I have Annie's Q&A. I'll get Sherwin Turk on concurrence for the response. Are you answering Congresswoman Lowey's 3/15/11 letter (G20110181)? If you have a rough draft, that would be helpful. Did you request an extension to the 4/1/11 due date?

John Boska
Indian Point Project Manager, NRR/DORL
U.S. Nuclear Regulatory Commission
301-415-2901
email: john.boska@nrc.gov

-----Original Message-----

From: Rihm, Roger
Sent: Wednesday, March 23, 2011 12:50 PM
To: Boska, John
Cc: Turk, Sherwin; Landau, Mindy
Subject: RE: ACTION: G20110195

Thanks for being in touch. As you may or may not know, I am responsible for drafting correspondence to Congress, including responding to their Japan-related inquiries, so the point here is that we need to be sure we're speaking with one voice. The Indian Pt letter seems reasonably self contained, and I think it might be more efficient if you draft it in consultation with OGC rather than do this sequentially. Don't know who you might ordinarily deal with in OGC, but I know that Sherwin Turk has been assigned to work on all "Japan-related" correspondence, which this arguably is, so at a minimum, be sure to touch base with him.

I assume you are up to speed on the meeting here yesterday with the NY Lt Governor? (Maybe you were there!) If not, I can forward you some of the emails. Also, Annie Kammerer has been preparing seismic Qs and As that may be of some relevance (I've attached her latest should you not have them).

Please let me know if you have any questions or there is something I can do to help.

-----Original Message-----

From: Boska, John
Sent: Wednesday, March 23, 2011 9:08 AM
To: Rihm, Roger
Subject: FW: ACTION: G20110195
Importance: High

Roger, I have been assigned to draft the response to this letter from the New York Attorney General. The instructions say to coordinate with you, and that the EDO should coordinate the response with OGC. Do you want me to have OGC on concurrence prior to the response coming to the OEDO, or will you take care of the OGC review?

John Boska
Indian Point Project Manager, NRR/DORL
U.S. Nuclear Regulatory Commission
301-415-2901
email: john.boska@nrc.gov

-----Original Message-----

From: RidsNrrMailCenter Resource
Sent: Tuesday, March 22, 2011 12:24 PM
To: RidsNrrDorl Resource
Cc: Boska, John; Salgado, Nancy; Meighan, Sean
Subject: ACTION: G20110195

Attached is a green ticket assigned to NRR on Seismic Risk at Indian Point Nuclear Generating Stations, due 04/02/11.

I will issue the green ticket once the TAC number has been assigned.

Thanks,
Patti

-----Original Message-----

From: Clayton, Kathleen
Sent: Tuesday, March 22, 2011 10:47 AM
To: RidsNrrMailCenter Resource
Cc: RidsOgcMailCenter Resource; RidsRgn1MailCenter Resource; RidsNsrMailCenter Resource; Wittick, Brian; Rihm, Roger
Subject: ACTION: G20110195

Attached is a green ticket for NRR. The ADAMS version will be sent after DPC processes.

Andersen, James

From: Andersen, James
Sent: Wednesday, March 23, 2011 7:32 AM
To: Baval, Rochelle
Subject: RE: Scheduling Note for 4/14 Status of Japan Events-Radiological Consequence, Health Effects

I haven't talked to Greg this morning, I'll check.

From: Baval, Rochelle
Sent: Wednesday, March 23, 2011 7:14 AM
To: Andersen, James
Subject: Scheduling Note for 4/14 Status of Japan Events-Radiological Consequence, Health Effects

Jim,

Did you hear back from staff when they will get you the scheduling note for the 4/14 briefing on radiological consequence?

Rochelle

Andersen, James

From: Andersen, James
Sent: Wednesday, March 23, 2011 1:51 PM
To: Frazier, Alan
Subject: FW: Japan/SBO Scheduling Note
Attachments: 110428 Status on Japan and SBO.docx

Here is the latest version. I meet with the Chairman's office today, the Chairman tomorrow, and the Commission on March 31st before it will be final.

Jim A.

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SCHEDULING NOTE

Title: **BRIEFING ON THE JAPAN NUCLEAR EVENT: RADIOLOGICAL CONSEQUENCES AND POTENTIAL HEALTH EFFECTS (Public)**

Purpose: Provide the Commission an update of the Japan nuclear event with additional focus on radiological consequences and potential health effects and an opportunity to hear a representative sample of external stakeholder viewpoints.

Scheduled: **April TBD**
9:00am

Duration: Approx. 3 hours

Location: Commissioner's Hearing Room, 1st fl. OWFN

Participants:	Presentation
<u>NRC Staff</u>	50 mins.*
Bill Borchardt , Executive Director for Operations <u>Topic:</u> Opening Remarks and Event Status	10 mins.*
Charlie Tinkler , Senior Level Advisor, RES <u>Topic:</u> Source Term Determination	10 mins.*
Cynthia Jones , Technical Advisor, NSIR <u>Topic:</u> Dose Projections	15 mins.*
Patricia Milligan , Senior Level Advisor, NSIR <u>Topic:</u> Protective Actions and Health Effects	15 mins.*
Commission Q & A	50 mins.
BREAK	5 mins.
<u>Stakeholder Panel</u>	40 mins.*
David Bowman , DOE <u>Topic:</u> DOE Assets (AMS, NARAC, etc)	10 mins.*
Sarah Decair , EPA <u>Topic:</u> EPA Protective Action Guidelines	10 mins.*

TBD, FDA

Topic: FDA Derived Intervention Levels for Radionuclides in Food 10 mins.*

TBD, NR or DOD

Topic: Assets and Event Response for Military Personnel
10 mins.*

Commission Q & A

30 mins.

Discussion – Wrap-up

5 mins.

*For presentation only and does not include time for Commission Q & A's

Documents:

- TBD

- TBD

Staff background material due to SECY: Ten business days prior to the briefing.

Slides due to SECY: Five business days prior to the briefing.

Rihm, Roger

From: Rihm, Roger
Sent: Wednesday, March 23, 2011 3:08 PM
To: Williamson, Edward
Subject: RE: OGC Review of Staff Draft Responses to Congressional Inquiries Associated with Operating Reactors --- Japanese Event

Thanks, important clarification!

From: Williamson, Edward
Sent: Wednesday, March 23, 2011 3:07 PM
To: Rihm, Roger
Cc: Turk, Sherwin; Spencer, Mary
Subject: OGC Review of Staff Draft Responses to Congressional Inquiries Associated with Operating Reactors --- Japanese Event

Hi Roger,

I think Shep Turk who is in my OGC Operating Reactors (OR) Division recently sent you an e-mail indicating that he was the OGC point of contact (POC) for Congressional Correspondence on the Japanese events. I need to clarify and refine the intent of that message.

Shep will be the POC in the OGC OR Division with respect to legal review of staff responses to Congressional Inquires associated only with respect specifically to OR matters and the license renewal process for OR. Obviously, he would not be the OGC POC regarding Congressional Correspondence associated with rulemaking, materials, dosage-levels, security, waste disposal or new reactor program issues arising from the Japanese event. Those inquiries would be assigned to the cognizant OGC Division responsible for advising on those matters.

Ed

Edward L. Williamson
Assistant General Counsel for Operating Reactors
Office of the General Counsel
U.S. Nuclear Regulatory Commission

Phone 301 -415-1143

~~Official Use Only~~---Attorney-Client Privileged / Attorney Work Product Rule

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Landau, Mindy

From: Landau, Mindy
Sent: Wednesday, March 23, 2011 3:02 PM
To: Muessle, Mary
Subject: FW: Revised press release language
Attachments: japan task force.Press Release FINAL DRAFT (3).docx

Importance: High

Mary, assume you've seen this...

From: Loyd, Susan
Sent: Wednesday, March 23, 2011 3:00 PM
To: Landau, Mindy
Subject: FW: Revised press release language
Importance: High

Mindy:
FYI, since there is a quote from Bill.
S

Susan K. Loyd
Communications Director
Office of the Chairman
U.S. Nuclear Regulatory Commission
Tele: 301-415-1838
Susan.Loyd@nrc.gov

From: Loyd, Susan
Sent: Wednesday, March 23, 2011 2:59 PM
To: Burnell, Scott
Cc: Batkin, Joshua; Coggins, Angela; Brenner, Eliot
Subject: FW: Revised press release language
Importance: High

Here is the revised press release. The Chairman is getting ready to sign it. Please coordinate your release with SECY. Thanks.
Susan

Susan K. Loyd
Communications Director
Office of the Chairman
U.S. Nuclear Regulatory Commission
Tele: 301-415-1838
Susan.Loyd@nrc.gov

From: Burnell, Scott
Sent: Wednesday, March 23, 2011 2:51 PM
To: Batkin, Joshua; Loyd, Susan; Coggins, Angela
Cc: Brenner, Eliot
Subject: Revised press release language
Importance: High

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Josh, Angela, Susan;

I understand we're just about there on the voting. I can incorporate whatever changes you have quickly in order to have the press release ready to go as soon as the button is pushed. Thanks very much.

Scott

OPA-

PRESS RELEASE

(Source: CHRMN)

**NUCLEAR REGULATORY COMMISSION DIRECTS STAFF ON CONTINUING
AGENCY RESPONSE TO JAPAN EVENTS; ADJUSTS COMMISSION SCHEDULE**

The Nuclear Regulatory Commission has voted to launch a two-pronged review of U.S. nuclear power plant safety in the aftermath of the March 11 earthquake and tsunami and the resulting crisis at Japanese nuclear power plants.

Acting on a proposal from NRC Chairman Gregory B. Jaczko, the Commission supported the establishment of an agency task force, made up of current senior managers and former NRC experts with relevant experience. The task force will conduct both short- and long-term analysis of the lessons that can be learned from the situation in Japan, and the results of their work will be made public.

“Our focus is always on ensuring the health and safety of the American people through our licensing and oversight of plants and radioactive materials in this country,” Chairman Jaczko said. “Examining all the available information from Japan is essential to understanding the

event's implications for the United States. We will perform a systematic and methodical review to see if there are changes that should be made to our programs and regulations to further protect public health and safety.”

The Commission set an aggressive schedule for the task force to provide formal updates on the short-term effort in 30, 60 and 90 days. NRC senior technical staff provided the Commission a 90-minute briefing on Monday, as a first step. The staff reiterated their conclusions that the U.S. and its territories will avoid any harmful radiation levels as a result of the ongoing events at the Fukushima Daiichi plant damaged by the quake and subsequent tsunami.

NRC inspectors who are posted at every U.S. nuclear power plant will also support the task force's short-term effort, supplemented as necessary by experts from the agency's regional and headquarters offices.

“This work will help determine if any additional NRC responses, such as Orders requiring immediate action by U.S. plants, are called for, prior to completing an in-depth investigation of the information from events in Japan,” said NRC Executive Director for Operations Bill Borchardt.

The longer-term review will inform any permanent NRC regulation changes determined to be necessary. The Commission said it hopes the task force can begin the long-term evaluation

in no later than 90 days, and added that the task force should provide a report with recommended actions within six months of the beginning of that effort.

The Commission also decided to revise its schedule for meetings and briefings to allow ample focus on the agency's response to events in Japan. Open Commission meetings on the status of the NRC response to the Japan earthquake are scheduled for April 14 and 28, with a meeting on the staff's 30-day response planned for May 3. A revised Commission meeting schedule will be posted shortly on the NRC website.

###

Landau, Mindy

From: Landau, Mindy
Sent: Wednesday, March 23, 2011 2:17 PM
To: 'Gelsi, Steven'
Subject: RE: NRC Reply - Market Watch NY

I'm sorry but that is outside our jurisdiction, and we have no such information

Regards,
Mindy

From: Gelsi, Steven [mailto:SGelsi@marketwatch.com]
Sent: Wednesday, March 23, 2011 1:27 PM
To: Landau, Mindy
Subject: RE: NRC Reply - Market Watch NY

Hello Mindy

Is it possible to look up any proposed nuclear plants that have received an investment from Tokyo Electric Power? They had planned to invest in a plant being built by NRG and I wanted to see if there were any other. Thanks.

Steve Gelsi
Energy Reporter
MarketWatch
212 416 4659

From: Landau, Mindy [mailto:Mindy.Landau@nrc.gov]
Sent: Wednesday, March 16, 2011 4:18 PM
To: Gelsi, Steven
Subject: RE: NRC Reply - Market Watch NY

Steve, we have no confirmation of that.

Mindy Landau (assisting Public Affairs)

From: Gelsi, Steven <SGelsi@marketwatch.com>
To: Couret, Ivonne
Sent: Wed Mar 16 11:21:43 2011
Subject: RE: NRC Reply - Market Watch NY

Hello Ivonne

ABC news reported about two hours ago that a large American nuclear response team of hundreds of military and other folks is on its way to Japan.

I didn't see anything else about this on your web site? Could you confirm?

From: Couret, Ivonne [mailto:Ivonne.Couret@nrc.gov]
Sent: Monday, March 14, 2011 1:13 PM
To: Gelsi, Steven
Subject: RE: NRC Reply - Market Watch NY

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11:45a.m.

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs



(301) 415-8205

✉ ivonne.couret@nrc.gov

Visit our online photo gallery. Incorporate graphics and photographs to tell your story!
<http://www.nrc.gov/reading-rm/photo-gallery/>

2010-2011 Information Digest - Where you can find NRC Facts at a Glance
<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/>

NRC Employees can read interesting insight on the OPA Blog
<http://portal.nrc.gov/OCM/opa/blog/default.aspx>

Please consider the environmental impact before printing this email.

From: Gelsi, Steven [<mailto:SGelsi@marketwatch.com>]
Sent: Monday, March 14, 2011 1:11 PM
To: Couret, Ivonne
Subject: RE: NRC Reply - Market Watch NY

Thanks how long has this been out? Dow Jones Newswires just flashed headlines on it

From: Couret, Ivonne [<mailto:Ivonne.Couret@nrc.gov>]
Sent: Monday, March 14, 2011 1:08 PM
To: Gelsi, Steven
Subject: RE: NRC Reply - Market Watch NY

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs



(301) 415-8205

✉ ivonne.couret@nrc.gov

Visit our online photo gallery. Incorporate graphics and photographs to tell your story!
<http://www.nrc.gov/reading-rm/photo-gallery/>

2010-2011 Information Digest - Where you can find NRC Facts at a Glance
<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/>

NRC Employees can read interesting insight on the OPA Blog
<http://portal.nrc.gov/OCM/opa/blog/default.aspx>

Please consider the environmental impact before printing this email.

From: Gelsi, Steven [mailto:SGelsi@marketwatch.com]
Sent: Monday, March 14, 2011 1:06 PM
To: Couret, Ivonne
Subject: RE: NRC Reply - Market Watch NY

Hello could you please send over release ASAP about Japan formally asking US for help in cooling reactors? Thanks

STEVE GELSI

From: Couret, Ivonne [mailto:Ivonne.Couret@nrc.gov]
Sent: Sunday, March 13, 2011 1:00 PM
To: Gelsi, Steven
Subject: RE: NRC Reply - Market Watch NY

New Reactor Application under review - <http://www.nrc.gov/reactors/new-reactors/col.html> - There have been request from the licensee specifically talking about Vogtle Limited Work Authorization (LWA)

Limited work authority regulations to allow some preconstruction activities without NRC approval, such as site clearing, road building, and transmission line routing. Other activities require authorization by NRC. Thus applicants must place request for LWA. Does this help? Ivonne

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs




(301) 415-8205

ivonne.couret@nrc.gov

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<http://www.nrc.gov/reading-rm/photo-gallery/>

2010-2011 Information Digest - Where you can find NRC Facts at a Glance
<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/>

NRC Employees can read interesting insight on the OPA Blog
<http://portal.nrc.gov/OCM/opa/blog/default.aspx>

 Please consider the environmental impact before printing this email.

From: Gelsi, Steven [mailto:SGelsi@marketwatch.com]
Sent: Sunday, March 13, 2011 12:46 PM
To: Couret, Ivonne
Subject: RE: NRC Reply - Market Watch NY

Thanks – Ivonne, you said no construction permits have yet been issued, but there have been preliminary construction plants issued for at least one project.

From: Couret, Ivonne [mailto:Ivonne.Couret@nrc.gov]
Sent: Sunday, March 13, 2011 12:42 PM
To: Gelsi, Steven
Subject: NRC Reply - Market Watch NY

Steve -

Website link to BWR backgrounder – Diagrams hyperlinked
Information Digest provide summary of NRC regulatory activities is plain English - <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/>
Details of current operating commercial Nuclear Reactors – Appendix A (attached)

Another resource is NEI.org website at <http://www.nei.org/newsandevents/information-on-the-japanese-earthquake-and-reactors-in-that-region>
Trust this helps. Ivonne

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs




(301) 415-8205

ivonne.couret@nrc.gov

Visit our online photo gallery. Incorporate graphics and photographs to tell your story!
<http://www.nrc.gov/reading-rm/photo-gallery/>

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<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/>

NRC Employees can read interesting insight on the OPA Blog
<http://portal.nrc.gov/OCM/opa/blog/default.aspx>

 Please consider the environmental impact before printing this email.

Schaperow, Jason

From: Casey Wagner [kcw@dycoda.com]
Sent: Tuesday, March 15, 2011 11:23 AM
To: Schaperow, Jason
Cc: Tinkler, Charles; Chang, Richard
Subject: RE: telecon
Attachments: Table_3_3.pdf

Hi Jason,

I do not have a full offload ready but plan to estimate using Table 3.3 from the BWR SFP Spray Mitigation report.

Assumptions –

1. Scale decay heat to add 480 more assemblies.
2. It is too time-consuming to add all the core input for 480 assemblies, so I will just add the decay heat to the low powered assemblies in Rings 7 & 8.
3. Assume PB SFP, which is much bigger thermal power rating scales okay to Fukushima.

Call if you have any suggestions or corrections.

Thanks,
KC

From: Schaperow, Jason [mailto:Jason.Schaperow@nrc.gov]
Sent: Tuesday, March 15, 2011 9:09 AM
To: kcw@dycoda.com
Cc: Tinkler, Charles; Chang, Richard
Subject: telecon

Just to confirm our telecom that we had a few minutes ago...

Fukushima Daiichi unit 4 may be having a spent fuel pool meltdown.
Fukushima Daiichi unit 4 has a full core offload in its spent fuel pool.
We are planning to give to the NRC Chairman information on spent fuel pool boil-off times (and maybe spent fuel heatup times).

We need you to do boil-off calculations just like the attached, but for a full core offload into the pool. We need it for 3 decay times (20 days, 90 days, and 365 days). Also, if you could get it to run until the level reaches core mid-plane that would be even better.

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Table 3-3 Summary of Regions in the MELCOR Whole Pool Model.

Ring	Description	Decay Heat with 20 days Aging			Number	Total
		Peak	Average	Minimum		
1	High – Last offload	11.211	10.873	10.408	88	956.8
2	Lowest powered	0.176	0.137	0.072	352	48.2
3	Medium – Last offload	9.728	9.474	9.261	68	644.3
4	Lowest powered	0.176	0.137	0.072	272	37.3
5	Low – Last offload	8.305	4.958	3.048	128	634.6
6	Lowest powered	0.176	0.137	0.072	512	70.2
7	Next highest 787 assemblies	1.328	0.690	0.330	787	543.1
8	Remaining 787 assemblies	0.330	0.222	0.176	787	175.0
9	825 empty rack cells				825	0.0
					3819	3109.5

$\sum_{i=1,3,5} \text{Rings} = 284 \text{ assemblies}$

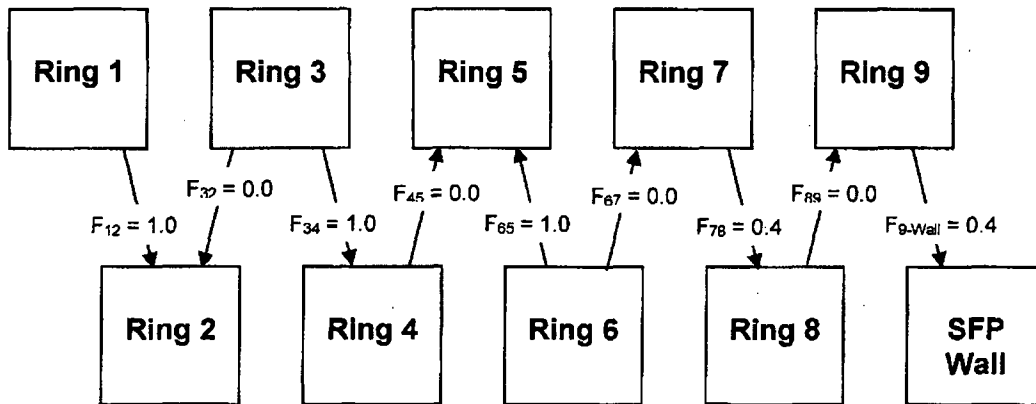


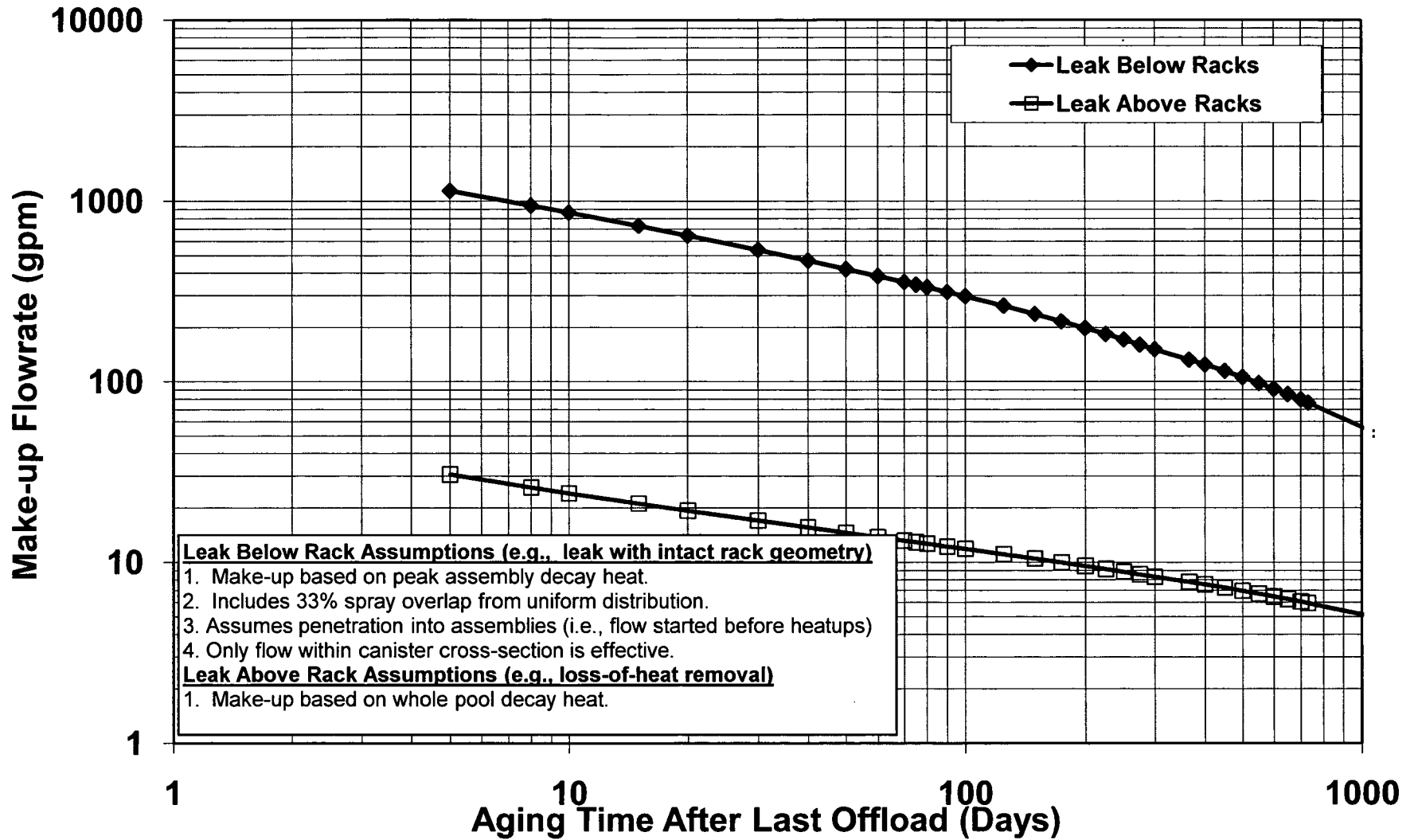
Figure 3-19 The Radial Coupling Scheme as Implemented in MELCOR SFP Model.

1. PB has 764 assemblies
2. full offload has $764 - 284 = 480$ more
3. I will add $480 * \text{Power of Average of Assemblies } 1, 3, \text{ \& } 5 \text{ at } 20d, 90d, \text{ \& } 365d$

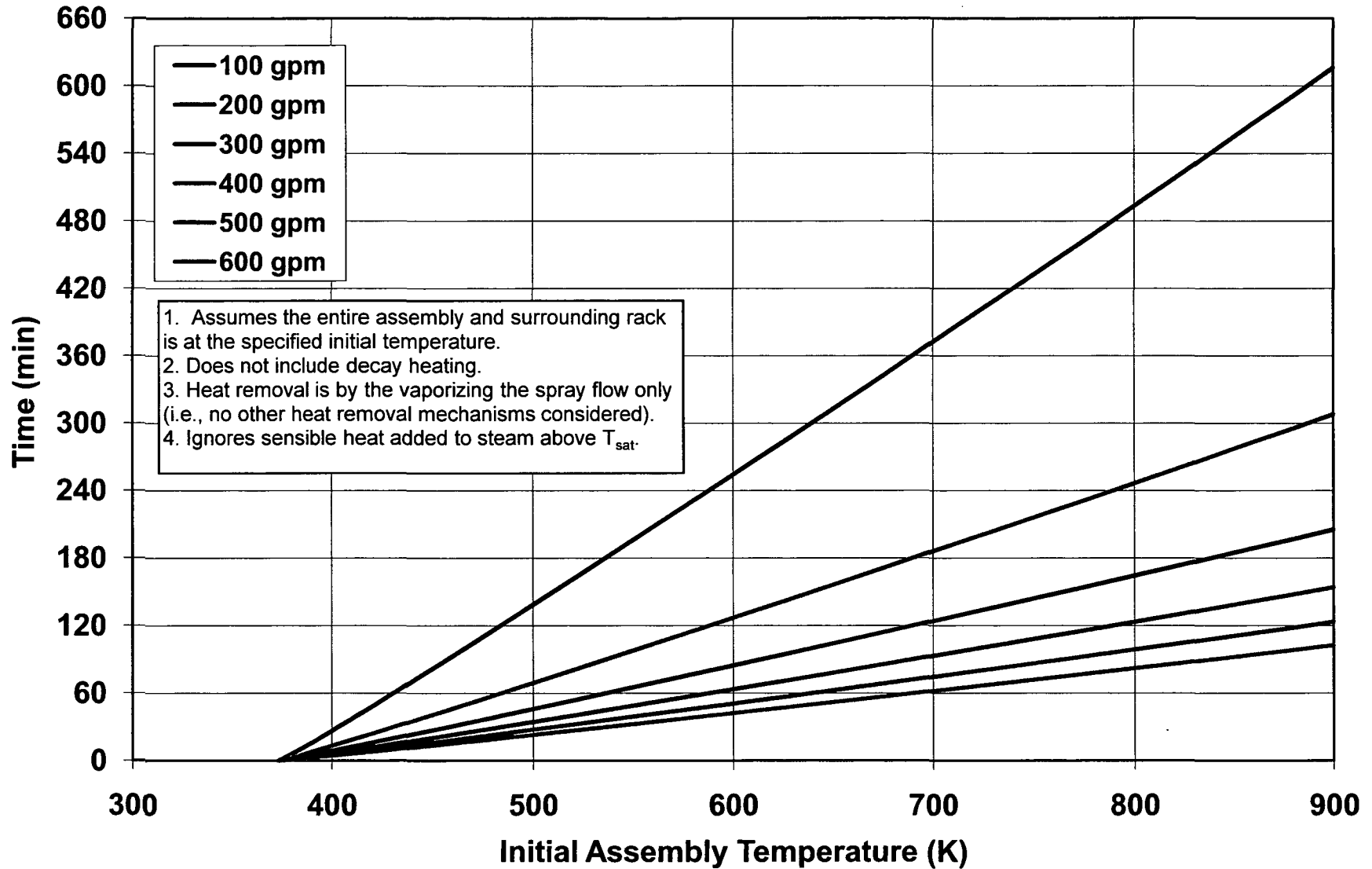
Schaperow, Jason

From: Casey Wagner [kcw@dycoda.com]
Sent: Tuesday, March 15, 2011 1:14 PM
To: Schaperow, Jason
Subject: Spray Make-up_
Attachments: BWR_Spray.xls

Make-up Flowrate for Reference BWR SFP



Spray Time to Remove Assembly Sensible Heat to $T_{sat} = 373$ K



Schaperow, Jason

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Tuesday, March 15, 2011 12:43 PM
To: Gauntt, Randall O; Schaperow, Jason; Tinkler, Charles
Cc: 'Ali.Tehrani@hse.gsi.gov.uk'; 'Kelly, John E (NE)'
Subject: RE: Pool Dose Rate Estimate for Uncovering SFP
Attachments: Mathcad - pool dose rate.pdf

Here is a more realistic calculation I did that takes into account the amount of the fuel still covered by water. Lower dose rate than the point source treatment.

Randy

From: Gauntt, Randall O
Sent: Tuesday, March 15, 2011 10:36 AM
To: 'Schaperow, Jason'; 'Tinkler, Charles'
Cc: 'Ali.Tehrani@hse.gsi.gov.uk'; 'Kelly, John E (NE)'
Subject: Pool Dose Rate Estimate for Uncovering SFP

<< File: Consider that a Spent Fuel Pool becomes uncovered.docx >>

Note that this assumes 1 billion curies. It's a rough order magnitude estimate.

Somewhere I did a more detailed analysis that considered the fraction of the fuel under water when the water falls below the top of the fuel assemblies.

Randy

Order of Magnitude Estimation of Dose Rate for an Accident

$$\text{Curies} := 3.7 \cdot 10^{10} \text{ sec}^{-1} \quad \text{MeV} := 3.83 \cdot 10^{-14} \text{ cal} \quad \text{Rad} := 100 \frac{\text{erg}}{\text{gm}}$$

$$\begin{aligned} \mu_a &:= 0.06 \frac{\text{cm}^2}{\text{gm}} & \rho_{\text{air}} &:= 1.2 \frac{\text{gm}}{1000 \text{cm}^3} & \rho_{\text{steel}} &:= 8 \cdot \frac{\text{gm}}{\text{cm}^3} & \rho_{\text{fuel}} &:= 6 \frac{\text{gm}}{\text{cm}^3} \\ & & \rho_{\text{concrete}} &:= 2.5 \frac{\text{gm}}{\text{cm}^3} & \rho_{\text{sand}} &:= 1 \frac{\text{gm}}{\text{cm}^3} & \rho_{\text{water}} &:= 1 \frac{\text{gm}}{\text{cm}^3} \end{aligned}$$

$$A_{\text{total}} := 2 \cdot 10^{19} \text{ Bq} \quad \text{Estimate of gamma dose}$$

Consider that a Spent Fuel Pool becomes uncovered

$$\Phi(A, L) := \frac{1}{4} \cdot \frac{A}{3 \cdot \text{m}} \cdot \frac{e^{-\mu_a \cdot \rho_{\text{water}} \cdot L}}{50 \text{ft} \cdot 100 \text{ft}} \cdot \int_{0 \text{m}}^{3 \text{m}} e^{-(3 \text{m} - z) \cdot \mu_a \cdot \rho_{\text{fuel}}} dz$$

$$E_{\gamma} := 1 \text{ MeV} \quad \mu := 0.03 \cdot \frac{\text{cm}^2}{\text{gm}}$$

$$A_{\text{total}} = 5.405 \times 10^8 \text{ Curies}$$

$$\text{Dose_Rate}(A, L) := \Phi(A, L) \cdot E_{\gamma} \cdot \mu$$

$$\Phi(1 \text{m}) = f(\text{Length}) \rightarrow \text{Length}^{-1}$$

$$A_{\text{total}} = 2 \times 10^{19} \frac{1}{\text{s}}$$

$$i := 1, 2 \dots 100$$

$$x_i := i \cdot \text{m}$$

$$\text{Dose_Rate}(A_{\text{total}}, 1 \text{m}) = 42.784 \frac{\text{Rad}}{\text{hr}}$$

$$\left(1 - e^{-\mu_a \cdot \rho_{\text{fuel}} \cdot 2 \text{cm}} \right) = 0.513$$

$$\int_{0 \text{m}}^{3 \text{m}} e^{-(3 \text{m} - z) \cdot \mu_a \cdot \rho_{\text{fuel}}} dz = 0.028 \text{ m}$$

$$\text{day5} := 7.3 \cdot 10^{17} \text{ Bq} \quad \text{day10} := 5.44 \cdot 10^{17} \text{ Bq}$$

$$\text{day60} := 2.9 \cdot 10^{17} \text{ Bq} \quad \text{day300} := 1.4 \cdot 10^{17} \text{ Bq}$$

$$\text{day300} = 3.784 \times 10^6 \text{ Curies}$$

$$\text{day5} = 1.973 \times 10^7 \text{ Curies}$$

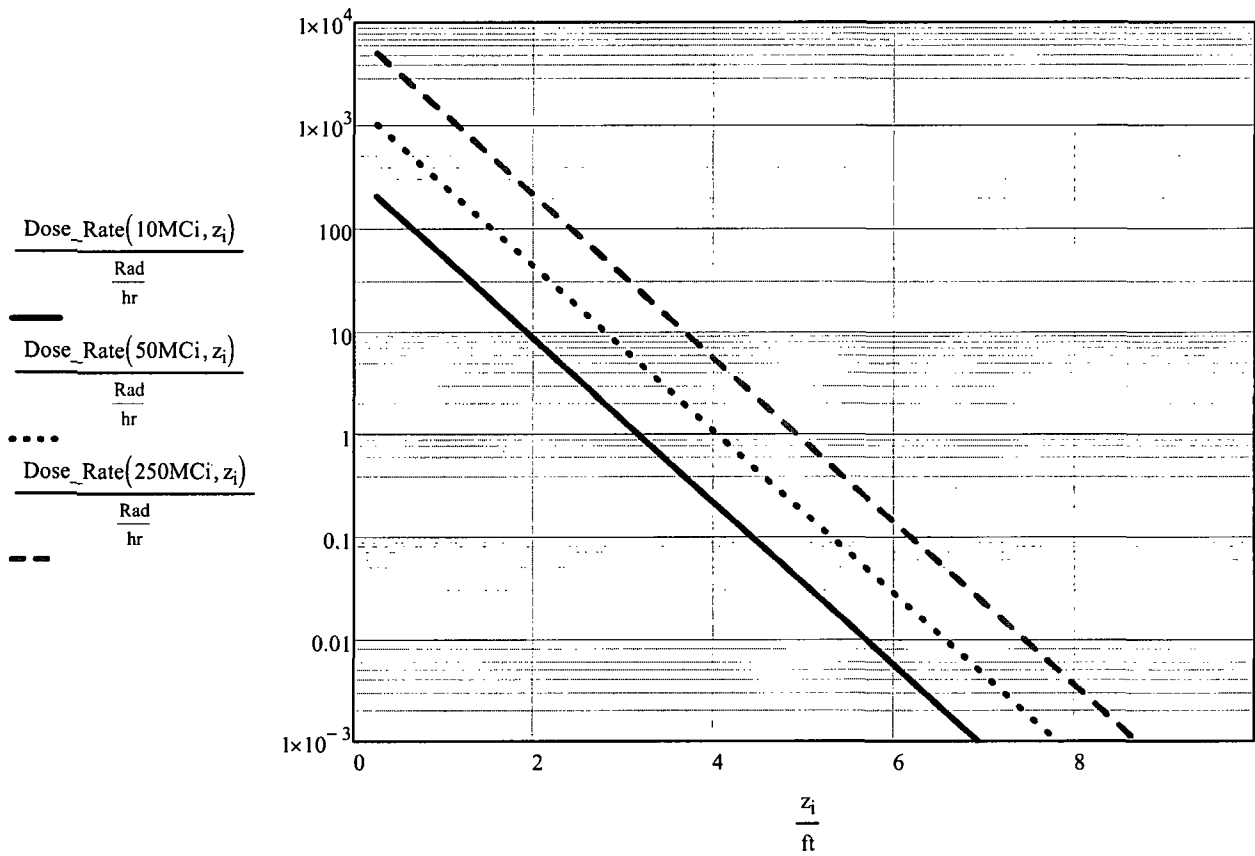
$$i := 1, 2 \dots 160$$

$$z_i := .25 \cdot i \cdot \text{ft}$$

$$A_{\text{total}} = 5.405 \times 10^8 \text{ Curies}$$

$$\text{day60} = 7.838 \times 10^6 \text{ Curies}$$

$$\text{MCi} := 10^6 \text{ Curies}$$



Assuming the top of the fuel is 40 feet below the pool surface, the graph below estimates the dose rate at the top of the pool as the water layer over the fuel falls. When the water depth above the top of the fuel falls below 8 feet, doses in the mR/hr range are encountered. Less than 2 ft of shielding gives 100 R/hr dose, so something must be done to cover the fuel before the shield depth falls below 6 ft.

$\frac{\text{Dose_Rate}(10\text{MCi}, z_i)}{\text{hr}}$	$\frac{\text{Dose_Rate}(50\text{MCi}, z_i)}{\text{hr}}$	$\frac{\text{Dose_Rate}(250\text{MCi}, z_i)}{\text{hr}}$	$z_i =$
$2.021 \cdot 10^2$	$1.011 \cdot 10^3$	$5.054 \cdot 10^3$	0.25
$1.28 \cdot 10^2$	$6.398 \cdot 10^2$	$3.199 \cdot 10^3$	0.5
$8.101 \cdot 10^1$	$4.051 \cdot 10^2$	$2.025 \cdot 10^3$	0.75
$5.128 \cdot 10^1$	$2.564 \cdot 10^2$	$1.282 \cdot 10^3$	1
$3.247 \cdot 10^1$	$1.623 \cdot 10^2$	$8.116 \cdot 10^2$	1.25
$2.055 \cdot 10^1$	$1.028 \cdot 10^2$	$5.138 \cdot 10^2$	1.5
$1.301 \cdot 10^1$	$6.505 \cdot 10^1$	$3.253 \cdot 10^2$	1.75
$8.237 \cdot 10^0$	$4.118 \cdot 10^1$	$2.059 \cdot 10^2$	2
$5.214 \cdot 10^0$	$2.607 \cdot 10^1$	$1.304 \cdot 10^2$	2.25
$3.301 \cdot 10^0$	$1.65 \cdot 10^1$	$8.252 \cdot 10^1$	2.5
$2.09 \cdot 10^0$	$1.045 \cdot 10^1$	$5.224 \cdot 10^1$	2.75
$1.323 \cdot 10^0$	$6.614 \cdot 10^0$	$3.307 \cdot 10^1$	3
$8.374 \cdot 10^{-1}$	$4.187 \cdot 10^0$	$2.094 \cdot 10^1$	3.25
$5.301 \cdot 10^{-1}$	$2.651 \cdot 10^0$	$1.325 \cdot 10^1$	3.5
$3.356 \cdot 10^{-1}$	$1.678 \cdot 10^0$	$8.39 \cdot 10^0$...
...

ft

Schaperow, Jason

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Tuesday, March 15, 2011 12:36 PM
To: Schaperow, Jason; Tinkler, Charles
Cc: 'Ali.Tehrani@hse.gsi.gov.uk'; 'Kelly, John E (NE)'
Subject: Pool Dose Rate Estimate for Uncovering SFP
Attachments: Consider that a Spent Fuel Pool becomes uncovered.docx

Note that this assumes 1 billion curies. It's a rough order magnitude estimate.

Somewhere I did a more detailed analysis that considered the fraction of the fuel under water when the water falls below the top of the fuel assemblies.

Randy

Consider that a Spent Fuel Pool becomes uncovered
 R. Gauntt – Sandia National Laboratories

$$\rho_{\text{water}} := 1 \frac{\text{gm}}{\text{cm}^3}$$

$$\phi(r, \delta z_{\text{water}}) := \frac{A_{\text{total}}}{4 \cdot \pi \cdot r^2} \cdot e^{-\mu_a \cdot \rho_{\text{water}} \cdot \delta z_{\text{water}}}$$

$$\text{Dose_Rate}(r, \delta z_{\text{water}}) := \phi(r, \delta z_{\text{water}}) \cdot E_{\gamma} \cdot \mu$$

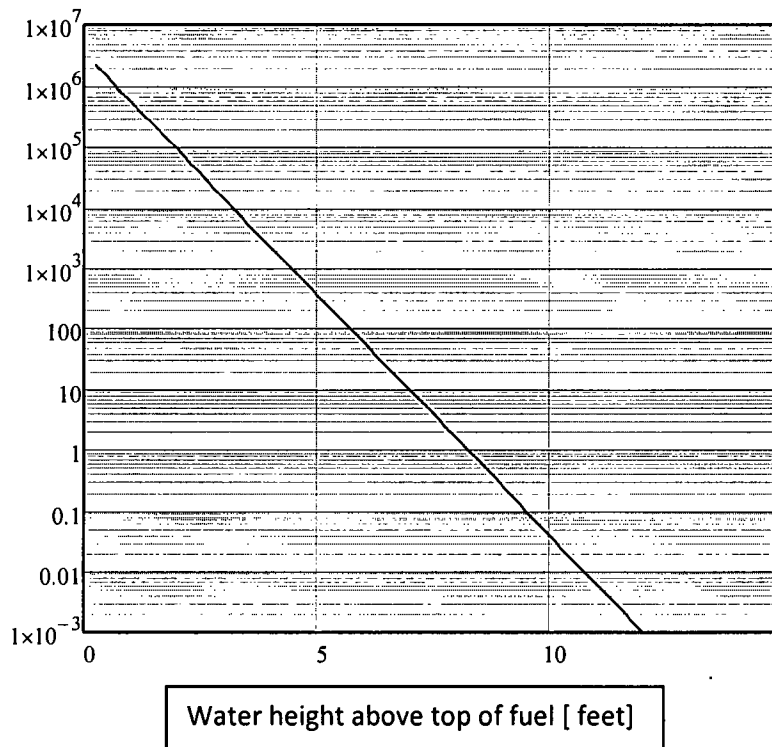
$$i := 1, 2..160$$

$$z_1 := .25 \cdot i \cdot \text{ft}$$

$$A_{\text{total}} = 1 \times 10^9 \text{ Curies}$$

Assuming the top of the fuel is 40 feet below the pool surface, the graph below estimates the dose rate at the top of the pool as the water layer over the fuel falls. When the water depth above the top of the fuel falls below 12 feet, doses in the mR/hr range are encountered. Less than 6 ft of shielding gives 100 R/hr dose, so something must be done to cover the fuel before the shield depth falls below 6 ft.

Dose_Rate(40ft, z_i)
 Rad
 hr



Cassidy, John

From: Conatser, Richard
Sent: Thursday, March 24, 2011 7:03 AM
To: Cassidy, John
Subject: RE: IMMEDIATE ACTION NEEDED

John,

Here's some additional information. Positive results from REMP samples are required to be reported in the Annual REMP Report. If plant-related activity exceeds the NRC's reporting levels (as specified in the licensee's ODCMs), the licensee must take the actions listed in their ODCM, which may include a Special Report to the NRC within 30 days. These are the licensing requirements. See my earlier email on this. It is my understanding the NRC management is asking licensees to take additional actions, but I have not heard what those actions are.

Some REMP samples will show positive results from Fukushima at many, if not all US facilities. These indications are expected and are a demonstration of the extremely sensitive detection capabilities the NRC requires from the licensees' REMPs. The amount of materials detected in the US thus far are extremely small, and the levels are expected to be reduced with time. Analysis of rainwater samples have indicated positive for I-131 in some locations in the US, and analysis of cow's milk is a much more sensitive technique since iodine is concentrated in cow's milk. As a result, we should expect to see I-131 in cow's milk at some locations. Other sampling media may see other nuclides, and we may see in some locations, the plume may be elevated but may be brought to ground by rain or other meteorological conditions. As a result, some variability in the sample results is expected. In all cases, the results are expected to be at extremely low levels, which are not linked to health effects. The dose to a typical member of the public is less than that received from a dental x-ray, or from living in a brick home, or from having granite kitchen countertops. No health effects have ever been linked to radioactive materials at the very low levels that are being seen in the US from the Fukushima event.

Richard

From: Conatser, Richard
Sent: Thursday, March 24, 2011 5:58 AM
To: Cassidy, John
Cc: Shoop, Undine
Subject: RE: IMMEDIATE ACTION NEEDED

John,

I read the emails. Give me a call so we can talk about I can provide any assistance.

Thanks,

Richard

From: Cassidy, John
Sent: Wednesday, March 23, 2011 5:49 PM
To: Phalen, Martin; Mitchell, Mark; Go, Tony; Myers, Valerie; Dickson, Billy
Cc: Conatser, Richard
Subject: RE: IMMEDIATE ACTION NEEDED

Sample Media	Sample	Sample	Sample Results	MDA	Comments /	Station
--------------	--------	--------	----------------	-----	------------	---------

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	Location	Date	List Each Isotope Separately		Insights	Contact (Phone Number)
Drinking Water						
Non-Drinking Water (Wells, Rain Water, Surface Water, etc.)						
Air (Particulate and Cartridge)						
Milk (If not on stock)						
Other – As necessary						

I talked the RETS-REMP guy here at Byron (Jeff Golich). Exelon held a fleet call yesterday to discuss their response to the Japanese events and it appears that the NRC has already requested this type of info from Exelon.

Exelon is changing their REMP frequencies to collect milk as if livestock were out to pasture. This means milk will be collected every 2 weeks as opposed every month for this time of year. Additionally, they have/will start a rain collection to look for I-131. All results will be routed to Exelon Corporate (Ron Chrzanowski) where the data will be compiled, evaluated, and distributed to external sources.

Byron has not identified any activity on REMP samples – BUT – results often take ~1month to get back to the plant from the vendor. Jeff is concerned about how to handle any positive results.

From: Phalen, Martin
Sent: Wednesday, March 23, 2011 11:03 AM
To: Mitchell, Mark; Go, Tony; Cassidy, John
Cc: Dickson, Billy; Reynolds, Steven
Subject: IMMEDIATE ACTION NEEDED
Importance: High

Guys,

As per the direction of senior management, we need to contact our assigned plants ASAP and get from them their latest REMP sample results no later than early next week. Specifically, what we are looking for is:

Sample Media	Sample Location	Sample Date	Sample Results List Each Isotope Separately	MDA	Comments / Insights	Station Contact (Phone Number)
Drinking Water						
Non-Drinking Water (Wells, Rain Water, Surface Water, etc.)						

Air (Particulate and Cartridge)						
Milk (If not on stock)						
Other – As necessary						

Additionally, we should ask each licensee if there have been any changes to the sampling frequencies, post Fukushima, and remind them that their ODCMs may not list all isotopes that they may now want to analyze for (Cs, Sr, Nb, Ce, etc.)

Another heads up is that unique isotopes may now be showing up in unusual places, such as the intake filters on the Main Control Room Radiation Monitors.

Thanks.

Marty

PS I will collate this data once I am back in the office next Wednesday.

Additionally, the below e-mail may be of help / interest....marty

From: Dickson, Billy
Sent: Monday, March 21, 2011 12:58 PM
To: Go, Tony; Phalen, Martin; Mitchell, Mark; Cassidy, John
Subject: FW: REMP Reporting Levels and Fukushima

FYI

From: Conatser, Richard
Sent: Monday, March 21, 2011 12:18 PM
To: Werner, Greg; Henderson, Pamela; Dickson, Billy; Bonser, Brian
Cc: Garry, Steven; Pedersen, Roger; Jimenez, Manuel; Clemons-Webb, Candace; Shoop, Undine
Subject: REMP Reporting Levels and Fukushima

All,

You may want to pass this along to your Inspectors who will be on inspections during the next couple of months.

The NRC's REMP REPORTING LEVELS may be exceeded as a result of plumes from Fukushima passing over REMP sampling stations. This email contains some unit conversions for your use. The table below shows the default NRC REPORTING LEVEL for I-131 in REMP samples listed in NUREG-1301 (PWRs) and NUREG-1302 (BWRs). It also converts the REPORTING LEVELS to those units commonly used at the plant sites.

I-131 Reporting Level in NUREG 1301 and NUREG-1302

	I-131	Units	I-131	Units
Drinking Water	2	pCi/L	2E-09	uCi/ml
Non-Drinking Water	20	pCi/L	2E-08	uCi/ml

Air | 0.9 pCi/m³ 9E-13 uCi/cc

These are default values, and the site-specific values will be in the licensees' ODCMs. The REMP REPORTING LEVELS may be exceeded as a result of plumes from Fukushima passing over REMP sampling stations. The REMP results may vary as various puffs/plumes traverse the US. If a nuclide concentration exceeds the REPORTING LEVES (averaged over a calendar quarter), the licensee may be required to report the data to the NRC within 30 days. The licensee should take the actions listed in their ODCM.

Because the I-131 (and possibly other radionuclides) from Fukushima will elevate the "background," it will reduce the licensee's ability to differentiate releases from their site. Strong data evaluation and analyses are appropriate at all times, and are particularly applicable at this time. This is also a good verification of licensee analytical detection capabilities.

Best Regards,

Richard L. Conatser

Health Physicist

Nuclear Regulatory Commission

301-415-4039

Richard.Conatser@NRC.gov

Killian, Lauren

From: Killian, Lauren
Sent: Wednesday, March 16, 2011 4:13 PM
To: Beasley, Benjamin
Cc: Kauffman, John
Subject: RE: As per MSNBC investigative reporter
Attachments: ML08185047719.docx

As requested, here is the part in the GI-199 Communication Plan that discusses the "aggregate" use of plant specific results in GI-199:

(FYI – the most recent GI-199 Communication Plan from ADAMS is also attached)

Q23. Will the NRC release the results of the Safety/Risk Assessment? If so, will plant-specific results be included?

A23. The Safety/Risk Assessment report will be made available on the public NRC Generic Issues Program (GIP) website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>), on the internal NRC GIP website (<http://www.internal.nrc.gov/RES/projects/GIP/>), and in the NRC Agencywide Document Access and Management System (ADAMS) under Accession No. ML100270582.

Regarding the plant-specific results, they are included in the Safety/Risk Assessment report (in appendix D), and have been used in the aggregate for the determination that further, plant-specific information and analysis is needed to investigate possible plant-specific improvements. (See the last section, "Safety/Risk Assessment Results - Plants in the GIP "Continue Region," of this Communication Plan.)

Note: Results of the Safety/Risk Assessment confirm that currently operating plants have adequate protection against seismic hazards; however, the results also indicated that GI-199 meets the NRC Generic Issues Program numerical risk threshold for an issue to continue to be evaluated for possible regulatory action (see answer A13). The Safety/Risk Assessment utilized simplifying methods and assumptions to produce plant-specific results to determine trends, not to finalize which plants will or will not be further analyzed.

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Safety/Risk Assessment Results - Plants in the GIP "Continue Region"

Plant-specific results are included in the Safety/Risk Assessment report (in appendix D) and have been used in the aggregate to determine that further, plant-specific information and analysis is needed to investigate possible plant-specific improvements. Listed below are plants that are currently above the Generic Issues Program (GIP) numerical risk threshold for an issue to continue to be evaluated for possible regulatory action (see answers A13 and A23). (Note that the plants are listed in alphabetical order by NRC region.) During the analysis, this group of plants was referred to as the "plants in the *continue region*."

As more information becomes available and more detailed analysis is performed, this group of plants *will* change. As discussed in answer A4, generic communications on this issue will be addressed to all operating power plants in the United States. More detailed, plant-specific analysis of all plants will allow NRC staff to prioritize plants that may be considered for regulatory action. The need to continue evaluating GI-199 is based on the collective results, not the results for any particular plant.

Region I

Indian Point 2
Indian Point 3
Limerick 1
Limerick 2
Peach Bottom 2
Peach Bottom 3
Seabrook 1

Region II

Crystal River 3
Farley 1
Farley 2
North Anna 1
North Anna 2
Oconee 1
Oconee 2
Oconee 3
Saint Lucie 1
Saint Lucie 2
Sequoyah 1
Sequoyah 2
Summer
Watts Bar 1

From: Beasley, Benjamin
Sent: Wednesday, March 16, 2011 3:35 PM
To: Killian, Lauren
Cc: Kauffman, John
Subject: FW: As per MSNBC investigative reporter

Lauren,

Is there a Q&A in the Comm Plan that addresses Doug's question?

Ben

From: Tift, Doug
Sent: Wednesday, March 16, 2011 3:24 PM
To: Manoly, Kamal; Scales, Kerby
Cc: Wilson, George; Munson, Clifford; Beasley, Benjamin; Chokshi, Nilesh; Nguyen, Quynh; McNamara, Nancy; Gray, Mel
Subject: RE: As per MSNBC investigative reporter

Thanks, that helps.

But is the reporters statement that our data shows that Indian Point Unit 3 is the plant in the US with the highest risk of suffering core damage from an earthquake an accurate conclusion from our data?

I seem to recall discussions where it was mentioned that the GI-199 data is only valid in aggregate for the nuclear industry, and is not enough data to draw any conclusion about any one reactor site. Is that true?

-Doug

From: Manoly, Kamal
Sent: Wednesday, March 16, 2011 3:19 PM
To: Scales, Kerby
Cc: Wilson, George; Munson, Clifford; Beasley, Benjamin; Chokshi, Nilesh; Nguyen, Quynh; Tift, Doug; McNamara, Nancy
Subject: RE: As per MSNBC investigative reporter

Kerby,
The list in GI-199 Comm Plan (Q/A23) identifies the plants by name only that are in the continue category for GI-199 (Delta CDF) to request additional information via a generic communication. The GI-199 applies only to plants in Eastern and Central US. The list provided for the top 10 contains interpretation of **total** CDF based on information provided to the reporter concerning all plants in the US. That is why you see Diablo in the list of 10 even though Diablo is not a GI-199 plant.
Kamal

From: Scales, Kerby
Sent: Wednesday, March 16, 2011 1:47 PM
To: Manoly, Kamal
Cc: Wilson, George; Munson, Clifford; Beasley, Benjamin; Chokshi, Nilesh
Subject: FW: As per MSNBC investigative reporter

Kamal,
Can you review the list below and respond back to George and copy me?

Thanks,

From: Nguyen, Quynh
Sent: Wednesday, March 16, 2011 1:39 PM
To: Scales, Kerby
Cc: Tift, Doug; Meighan, Sean
Subject: FW: As per MSNBC investigative reporter

Can you get somebody to check this quickly?

Thanks,
Q

From: Tift, Doug
Sent: Wednesday, March 16, 2011 12:56 PM
To: OST05 Hoc; LIA04 Hoc; Nguyen, Quynh
Cc: McNamara, Nancy
Subject: FW: As per MSNBC investigative reporter

Please see below list. I think this is referring to GI 199, but the list of plants is completely different from the list in our GI 199 Comm Plan. Did the reporter mis-interpret the GI 199 documents? If so, where did they go wrong?

See Q23:
http://www.internal.nrc.gov/communications/plans/active/CommPlan_Generic_Issue199.pdf

-Doug

From: Giarrusso, John (CDA) [mailto:John.Giarrusso@state.ma.us]

Sent: Wednesday, March 16, 2011 11:48 AM

To: McNamara, Nancy; Tiff, Doug

Subject: Fw: As per MSNBC investigative reporter

From: DeNicola, Fran (CDA) [mailto:Fran.Denicola@state.ma.us]

Sent: Wednesday, March 16, 2011 11:00 AM

To: john.giarrusso@state.ma.us <John.Giarrusso@state.ma.us>; Viveiros, John L. (CDA)

<John.L.Viveiros@state.ma.us>; peter.judge@state.ma.us <Peter.Judge@state.ma.us>; linda.lecuyer@state.ma.us

<Linda.Lecuyer@state.ma.us>

Subject: As per MSNBC investigative reporter

The top 10

Here are the 10 nuclear power sites with the highest risk of suffering core damage from an earthquake, showing their NRC risk estimates based on 2008 and 1989 geological data. (The full list of 104 reactors is below.)

1. Indian Point 3, Buchanan, N.Y.: 1 in 10,000 chance each year. Old estimate: 1 in 17,241. Increase in risk: 72 percent.
2. Pilgrim 1, Plymouth, Mass.: 1 in 14,493. Old estimate: 1 in 125,000. Increase in risk: 763 percent.
3. Limerick 1 and 2, Limerick, Pa.: 1 in 18,868. Old estimate: 1 in 45,455. Increase in risk: 141 percent.
4. Sequoyah 1 and 2, Soddy-Daisy, Tenn.: 1 in 19,608. Old estimate: 1 in 102,041. Increase in risk: 420 percent.
5. Beaver Valley 1, Shippingport, Pa.: 1 in 20,833. Old estimate: 1 in 76,923. Increase in risk: 269 percent.
6. Saint Lucie 1 and 2, Jensen Beach, Fla.: 1 in 21,739. Old estimate: N/A.
7. North Anna 1 and 2, Louisa, Va.: 1 in 22,727. Old estimate: 1 in 31,250. Increase in risk: 38 percent.
8. Oconee 1, 2 and 3, Seneca, S.C.: 1 in 23,256. Old estimate: 1 in 100,000. Increase in risk: 330 percent.
9. Diablo Canyon 1 and 2, Avila Beach, Calif.: 1 in 23,810. Old estimate: N/A.

10. Three Mile Island, Middletown, Pa.: 1 in 25,000. Old estimate: 1 in 45,455. Increase in risk: 82 percent.

Briefing on GI-199
for New York State
Lt. Gov. Robert J. Duffy

March 22, 2011

Introduce people (as appropriate):

- Marty Stutzke – Senior Advisor for PRA, RES
- Doug Coe – Deputy Director of Division of Risk Analysis, RES
- Pat Hiland – Director of the Division of Engineering, NRR
- Kamal Manoly – Senior Advisor in Structural Engineering, NRR

GI-199:

•Generic Issue 199 is “Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants”

•Identified by NRO when reviewing applications for new plants that use recent seismic hazard data

Agenda

- Background
 - Context and Results
 - Conclusions
 - Assumptions
 - Limitations
 - Approach to Resolution
 - Communication of Results
-

Background: GI-199 Context and Results

- **Generic Issues Program Stages**
 - Identification
 - Acceptance
 - Screening
 - **Safety/Risk Assessment**
 - Regulatory Assessment
- **Generic Issue 199 Results**
 - Operating power plants are safe.
 - Overall seismic risk estimates remain small in an absolute sense
 - The new seismic data for some plants meet the criteria for further evaluation

3

Generic Issues Program:

- GI v.s. GSI (historically referred to as GSI)

Results:

- Adequate protection is presumed based on criteria in NRR Office Instruction LIC-504.
- No evidence that plants do not meet design basis. Have evidence that there is margin beyond design basis.
- The new seismic risk results give changes for some plants that meet the numerical risk criteria for an issue to proceed to regulatory analysis, which is the next stage of the Generic Issue process. A regulatory analysis would consider cost beneficial changes to individual plants.

Details If Requested:

- All operating plants in the CEUS have seismic core-damage frequency (SCDF) less than or equal to $10E-4$ /year.
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Background: GI-199 Conclusions

- Pursue plant-specific improvements to seismic safety
- Additional information and methods are needed to consider plant-specific cost beneficial changes

4

•To perform the regulatory analysis, we need more information from each plant. (amplification functions, fragility, significant contributors)

•For some of the plants, we need to develop an approach to conduct the analysis.

Note:

There is a back-up slide on information needed

Background: GI-199 Assumptions

- Results were a conservative, screening-level assessment to evaluate if further investigations are warranted.
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 - The nature of the information used (seismic hazard data, plant-level fragility information) make these estimates useful only as a screening tool.

5

Note:

- OPA answer about rankings is below
- Report page on assumptions and limitations is below

Quotes:

From OPA (seismic FAQs link from press release)
<http://www.nrc.gov/japan/faqs-related-to-japan.pdf>

“17) Does GI-199 provide rankings of US nuclear plants in terms of safety?

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Quote from Report (a full page of the “assumptions and limitations”):

“5. DISCUSSION AND CONCLUSIONS

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 - **Data Limitations**
 - IPEEE data from late 1980s
 - USGS intended for local building codes, not nuclear power plants, so many adjustment made
 - **Analytical Limitations**
 - Simplified approach
 - Sensitive to some seismic modeling assumptions
- **Report did not focus on plant specific results because of the assumptions and limitations in the analyses**

6

(see notes for previous slide)

Approach to Resolution

- Issued an Information Notice to inform plants of the GI-199 Safety/Risk Assessment results. (September 2010)
- NRR is developing a generic communication to request needed data. (2011)
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8

Note - Public Meeting Notice: mailed 9/8/10 to Andrew Cuomo (NY State Attorney General at the time, now NY State Governor)

Documents:

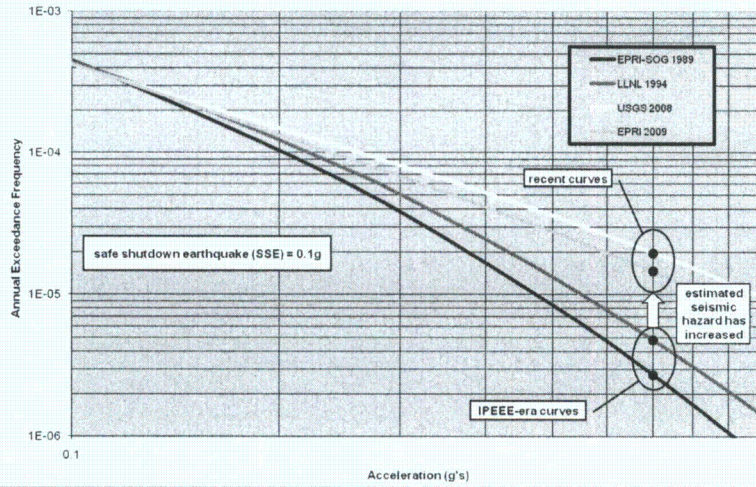
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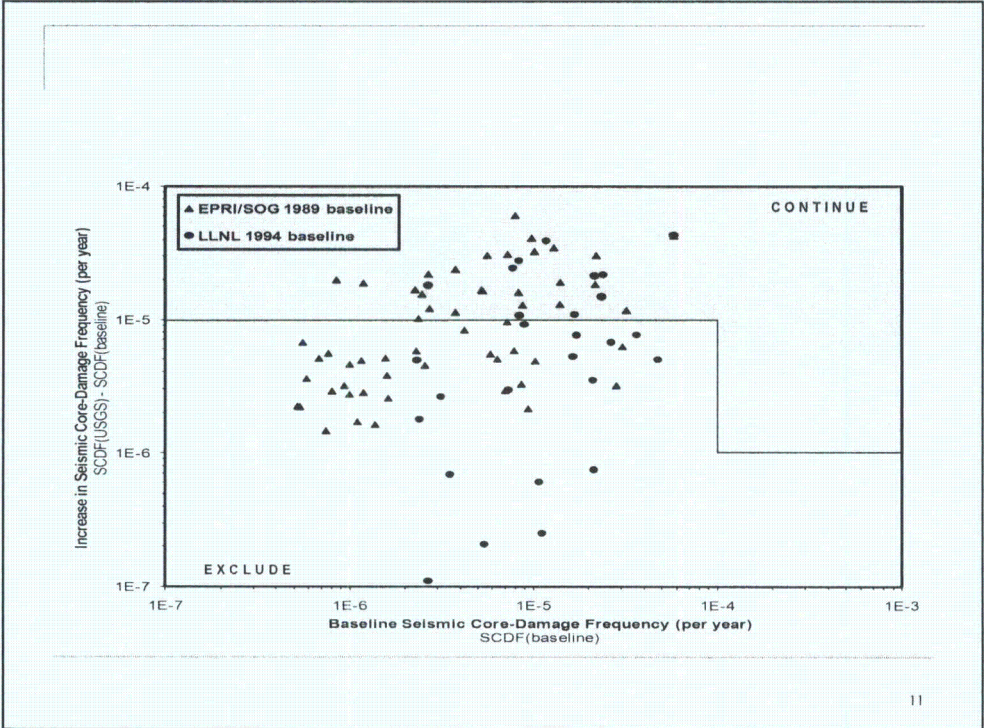
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Back-up Material

Example - Comparison of Seismic Hazard Curves
(Peak Ground Acceleration)





Needed for GI-199 Regulatory Analysis

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Generic Issues Process

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Acceptance review by Generic Issue Program staff – issue not accepted if it clearly does not meet one or more of the criteria

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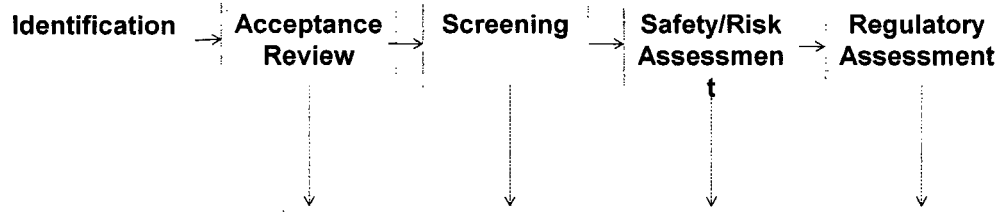
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Handwritten: 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Killian, Lauren

From: Killian, Lauren
Sent: Monday, March 21, 2011 3:09 PM
To: Beasley, Benjamin
Cc: Kauffman, John
Subject: Briefing on GI-199 for NY Delegation_March 22 2011_1.05.pptx
Attachments: Briefing on GI-199 for NY Delegation_March 22 2011_1.05.pptx

Briefing on GI-199
for New York State
Lt. Gov. Robert J. Duffy

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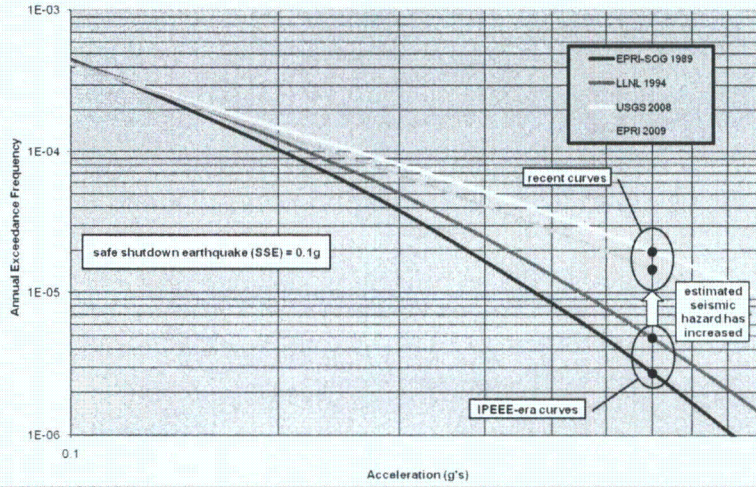
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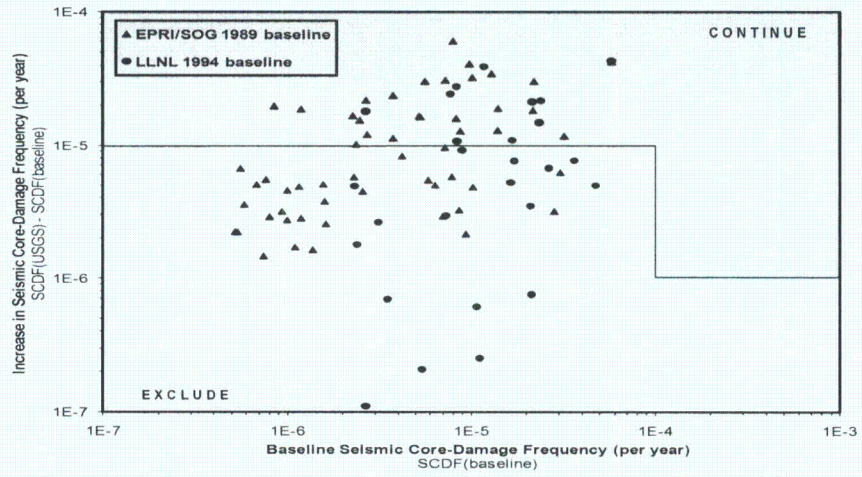
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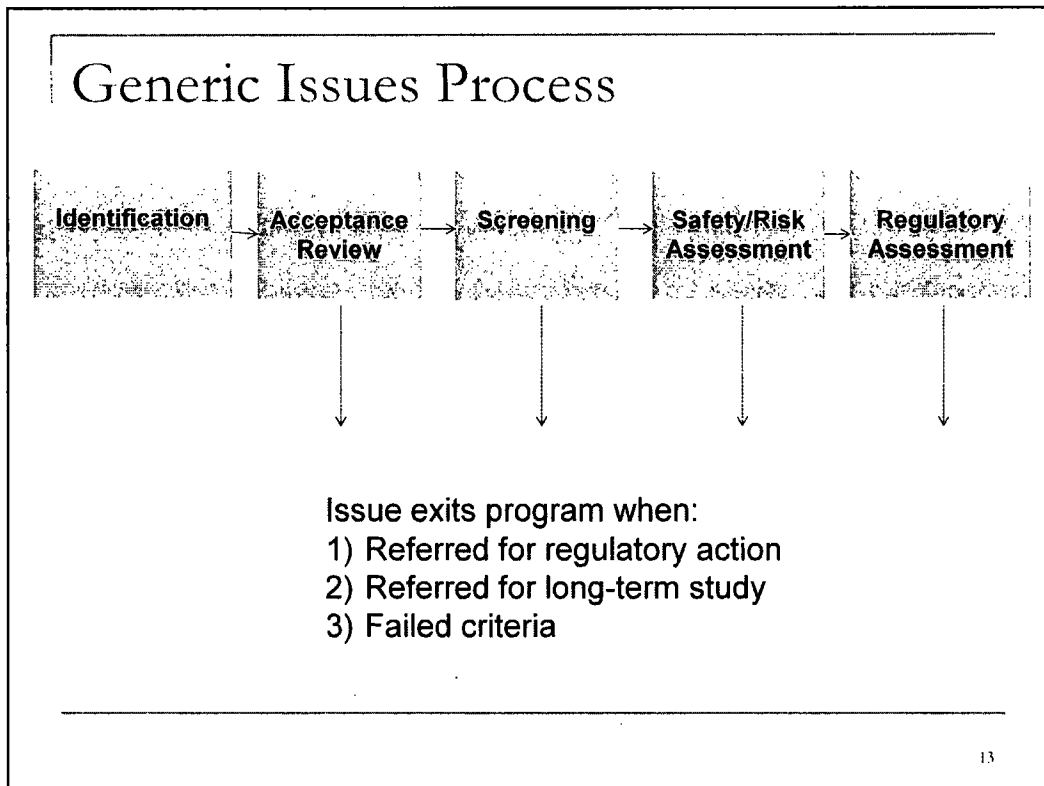
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COMMUNICATION PLAN FOR GENERIC ISSUE 199

September 14, 2010
(ML081850477)

Goal

This plan will guide staff communications and activities with internal and external stakeholders of the United States Nuclear Regulatory Commission (NRC) as they relate to Generic Issue 199 (GI-199), "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants."

Key Messages

The key messages to be communicated to stakeholders are as follows:

- (1) **Operating nuclear power plants are safe:** Plants have adequate safety margin for seismic issues. The NRC's Safety/Risk Assessment confirms that overall *seismic risk* estimates remain small and that adequate protection is maintained.
- (2) **Though still small, some seismic hazard estimates have increased:** Updates to seismic data and models indicate increased *seismic hazard* estimates for some operating nuclear power plant sites in the Central and Eastern United States.
- (3) **Assessment of GI-199 will continue:** Plants are safe (see key message 1), but the NRC has separate criteria for evaluating whether plant improvements may be imposed. The NRC's Safety/Risk Assessment used readily available information and found that for about one-quarter of the currently operating plants, the estimated *core damage frequency* change is large enough to warrant further attention. Action may include obtaining additional, updated information and developing methods to determine if plant improvements to reduce seismic risk are warranted.

Background

This issue was proposed as a Generic Issue in May 2005 after NRC staff's review of updates to the seismic source and ground motion models provided by applicants in support of early site permits for new reactors. The updated seismic information included new Electric Power Research Institute (EPRI) models to estimate earthquake ground motion and updated models for earthquake sources in seismic regions such as eastern Tennessee, and around both Charleston, South Carolina and New Madrid, Missouri. The new data and models resulted in increased estimates of the seismic hazards for some plants in the Central and Eastern United States (CEUS). The staff evaluated this new information along with preliminary results from a 2004 U.S. Geological Survey (USGS) letter report regarding seismic hazard estimates. From this review the staff concluded that the likelihood of exceeding the seismic hazard values, used in plant design and in previous evaluations (such as the Individual Plant Examination of External Events (IPEEE) Program), may be higher than previously understood for some currently operating CEUS sites.

The staff compared the new seismic hazard data with the earlier evaluations conducted as a part of the IPEEE Program. From this comparison, the staff determined that the seismic designs of operating plants in the CEUS still provide adequate safety margins. At the same time, the staff also recognized that the new seismic data and models could reduce available safety margins due to increased estimates of the probability associated with seismic hazards at some of the currently operating sites in the CEUS.

The licensing basis for currently operating plants is based on deterministic analysis of design basis loads from the maximum earthquake level determined from historical data. The licensing basis does not include a probabilistic assessment of seismic hazards or probabilistic assessment of their potential impact on plant structures, systems, and components.

To maintain consistency with the performance-based approach for assessing seismic hazards for new reactors, the staff determined that the screening analysis should consider seismic hazard data and models besides those available from the USGS. This determination was based on the staff's ongoing interactions with stakeholders to develop a new performance-based approach for assessing seismic hazards for new reactors, as described in a memorandum to the Commission, "A Performance-Based Approach to Define the Safe Shutdown Earthquake Ground Motion," dated July 26, 2006 (ADAMS Accession No. ML052360044). The NRC staff held a public meeting, in February 2008, to engage external stakeholders. During the meeting, the representative from the Nuclear Energy Institute (NEI) expressed their willingness to support a collaborative approach to GI-199. This led to a Seismic Risk Memorandum of Understanding Addendum between EPRI and NRC.

The staff collected and analyzed seismic hazard information from the USGS and from other sources, and seismic risk information from IPEEE analyses. EPRI reported that they calculated mean seismic hazard results for all nuclear power plant sites in the CEUS and used these results to perform an independent evaluation of the implications of changes in seismic hazard estimates. The staff completed the review and analysis of seismic data in support of the Safety/Risk Assessment in June 2009.

Audience and Stakeholders

Internal

Internal stakeholders include the Commission, Office of the Executive Director for Operations (OEDO), Office of Nuclear Regulatory Research (RES), Office of Nuclear Reactor Regulation (NRR), Office of New Reactors (NRO), Office of Nuclear Material Safety and Safeguards (NMSS), Office of Federal and State Materials and Environmental Management Programs (FSME), Region I, Region II, Region III, Region IV, Office of Public Affairs (OPA), Advisory Committee on Reactor Safeguards (ACRS), Office of International Programs (OIP), Office of Congressional Affairs (OCA). (See the "Communications Team" section for a list of specific Communication Team members.)

External

External stakeholders include licensees, EPRI, Nuclear Energy Institute, Congressional members, public interest groups, media, and the public.

Communication Timeline

Detailed Activities to Support Release of the GI-199 Safety/Risk Assessment Report				
Stakeholder Group	Specific Audience	Tool	Lead	Date
Internal	Regional Offices	Brief	RES-Kauffman	May 12, 2010 (c)
	NRR Office Director	Brief	RES-Kauffman	May 12, 2010 (c)
	NRO Office Director	Brief	RES-Beasley	May 19, 2010 (c)
	Region I Management	Brief	RES-Kauffman	June 3, 2010 (c)
	EDO, Deputy EDOs	Brief	RES-Kauffman	June 22, 2010 (c)
	Commission offices	Technical Assistants Brief	RES-Kauffman	July 8, 2010 (c)
	NRC Chairman	Brief	RES-Kauffman	August 23, 2010
	Commission offices	EDO Daily Note (with link to documents)	RES-Killian	T* (September 1, 2010)
	EDO	Issue Safety/Risk Assessment Report (goes public after 5 working days)	RES-Sheron	T
External	General Public	Safety/Risk Assessment Report made public in ADAMS		T + 6 days (September 7, 2010)
	General Public	Press Release	OPA-Burnell	T + 6 days (September 7, 2010)
	Public and Licensees	Information Notice	NRR-Manoly	T + 6 days (September 7, 2010)
	Congressional Members/staff (as appropriate)	Phone Calls	OCA-Riley	T + 6 days (September 7, 2010)
	International contacts (as appropriate)	Phone Calls	OIP	T + 6 days (September 7, 2010)
	State/local governments (as appropriate)	Phone Calls	Regional State Liaison Officers Region I- McNamara/Tiff Region II – Trojanowski Region III – Barker Region IV - Maier	T + 6 days (September 7, 2010)

	USGS	Phone Call	OCA-Riley	T + 6 days (September 7, 2010)
	General Public	Public Meeting	RES-Beasley	T + [1 month]
	General Public	Seismic Fact Sheet Update	RES-Killian OPA-Burnell	August 26, 2010

* "T" refers to the time that the Director, RES endorses the Safety/Risk Assessment panel recommendation.

Communication Team

Name	Office	Telephone Number	Email ID
Contacts in RES Operating Experience and Generic Issues Branch			
Benjamin Beasley	RES	301-251-7676	Benjamin.Beasley@nrc.gov
John Kauffman		301-251-7465	John.Kauffman@nrc.gov
Lauren Killian		301-251-7475	Lauren.Killian@nrc.gov
Contacts in NRR Division of Engineering			
Patrick Hiland	NRR	301-415-3298	Patrick.Hiland@nrc.gov
Kamal Manoly		301-415-2765	Kamal.Manoly@nrc.gov
George Wilson		301-415-1711	George.Wilson@nrc.gov
Contact in NRO Division of Site and Environmental Reviews			
Nilesh Chokshi	NRO	301-415-1634	Nilesh.Chokshi@nrc.gov
Contact in NMSS Division of Fuel Cycle Safety and Safeguards			
Marissa Bailey	NMSS	301-492-3264	Marissa.Bailey@nrc.gov
Contacts in NRC Regional Offices			
Wayne Schmidt	Region I	601-337-5315	Wayne.Schmidt@nrc.gov
Robert Carrion	Region II	404-562-4522	Robert.Carrion@nrc.gov
Vijay Meghani	Region III	630-829-9751	Vijay.Meghani@nrc.gov
Thomas Farnholtz	Region IV	817-860-8243	Thomas.Farnholtz@nrc.gov
Communications Assistant in OPA			
Scott Burnell	OPA	301-415-8204	Scott.Burnell@nrc.gov
Contact in OCA			
Tim Riley	OCA	301-415-8492	Tim.Riley@nrc.gov

Additional Communication Tools

The NRC has an internal Generic Issues Program (GIP) website (<http://www.internal.nrc.gov/RES/GIP/index.html>) and a public GIP website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>). These websites include program information and documents, background and historical information, generic issue status information, and links to related programs.

The staff created a Seismic Issue Fact Sheet (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-seismic-issues.html>).

Questions and Answers

Background

Q1. What is the NRC Generic Issues Program?

A1. The Nuclear Regulatory Commission (NRC) Generic Issues Program (GIP) evaluates technical issues that apply to two or more facilities and that may not be covered by existing regulatory processes or criteria. Issues are evaluated for their effect on safety, security, and/or the environment. The GIP is a program by which these issues can be formally assessed to see if they can be dispositioned by existing regulatory processes or if not, to determine their safety and/or risk significance and how best to treat them. Information on the program is available on the public NRC GIP website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>); information is also available to NRC staff on the NRC internal GIP website (<http://www.internal.nrc.gov/RES/projects/GIP/>). Management Directive (MD) 6.4, "Generic Issues Program," contains GIP guidance (available at <http://www.nrc.gov/about-nrc/regulatory/gen-issues/policy-procedures.html>). MD 6.4 was updated in November 2009 to incorporate program changes described in SECY-07-0022 (available at <http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2007/>).

Q2. What is Generic Issue 199 about?

A2. Generic Issue 199 investigates the safety and risk implications of updated earthquake-related data and models. These data and models suggest that the probability for earthquake ground shaking above the seismic design basis (see answers A8, A9, and A10) for some nuclear power plants in the Central and Eastern United States is still low, but larger than previous estimates (see answer A12).

Q3. Where can I get current information about Generic Issue 199?

A3. The public NRC Generic Issues Program (GIP) website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>) contains program information and documents, background and historical information, generic issue status information, and links to related programs. The GI-199 section of the NRC internal GIP website (<http://www.internal.nrc.gov/RES/projects/GIP/Individual%20GIs/GI-0199.html>) contains additional information about Generic Issue 199 (GI-199) and is available to NRC staff. The latest Generic Issue Management Control System quarterly report, which has regularly updated GI-199 information, is publicly available at <http://www.nrc.gov/reading-rm/doc-collections/generic-issues/quarterly/index.html>. Additionally, the U.S. Geological Survey data is publicly available at <http://earthquake.usgs.gov/hazards/products/conterminous/2008/>.

Q4. Are all U.S. plants being evaluated as a part of Generic Issue 199?

A4. The scope of the Generic Issue 199 (GI-199) Safety/Risk Assessment is limited to all plants in the Central and Eastern United States. Although plants at the Columbia, Diablo Canyon, Palo Verde, and San Onofre sites are not included in the GI-199 Safety/Risk Assessment, the Information Notice on GI-199 is addressed to all operating power plants in the U.S. (as well as all independent spent fuel storage installation licensees). The staff will also consider inclusion

of operating reactors in the Western U.S. in its future generic communication information requests.

Q5. Does GI-199 affect license renewal?

A5. No. The NRC's regulations for license renewal (10 CFR Part 54) require licensees to manage age-related degradation to ensure that systems, structures, and components (SSCs) will fulfill their safety-related functions, as specified in the current licensing basis, for the period of extended operation. The aging management review conducted by license renewal applicants specifically addresses the impact of age-related degradation on SSC seismic capacity. It should be noted that a plant's licensing basis, including its seismic design basis, is established outside of the license renewal process during initial plant licensing and subsequent license amendments. In addition, the NRC has processes to evaluate the adequacy of plant licensing bases (e.g., the Generic Issues Program) based on new information or operating experience and, if necessary, improve safety (e.g., require plant improvements through the backfit process).

Note: Related to license renewal, the County Executive of Westchester County (New York) and groups from New Jersey submitted a petition for rulemaking on license renewal, including a seismic-related aspect. NRC denied this petition. The petitioners then filed suit in the U.S. Court of Appeals Second Circuit and the court upheld the NRC's position. Details are available on the internal webpage of the Office of General Counsel (under Law Library, Summary of AEC-NRC Litigation, "Spano v. NRC" (2d Cir. 2009): http://www.internal.nrc.gov/ogc/internal/AEC-NRC_Cases.pdf.)

Q6. Are the implications of new seismic hazard estimates being considered for the storage of spent fuel?

A6. Yes, while the GI-199 Safety/Risk Assessment focused solely on operating power reactors in the Central and Eastern U.S., spent fuel storage has been considered by NRC.

The NRC Office of Nuclear Materials Safety and Safeguards (NMSS) was informed of GI-199 and a preliminary screening review was performed in November, 2008 by the NMSS Division of Spent Fuel Storage and Transportation. There is a total of 40 operating independent spent fuel storage installations (ISFSIs) in the Central and Eastern U.S. (CEUS). Except for a wet storage facility at G. E. Morris located in Illinois, the ISFSIs are co-located at the operating and permanently shutdown reactor sites. A review of design earthquakes (DE) used at the existing ISFSI locations in CEUS indicated that the safety margin (defined for ISFSIs as the ratio of DE/SSE, where SSE is the *safe shutdown earthquake* discussed in answer A8) for the cask designs were in the range of 1.20 ~ 3.90. Therefore, NMSS considers that there is significant margin built into the existing designs and has confidence that the ISFSIs can continue to operate safely while the licensees' investigate this issue using their site specific information. Even so, holders of operating license for ISFSIs are included among addressees in the Information Notice on GI-199.

Spent fuel pools (SFPs) were not specifically evaluated as part of GI-199. However, based on their design attributes (as follows), SFPs remain safe. SFPs are constructed of reinforced concrete, several feet thick, with a stainless steel liner to prevent leakage and maintain water quality. Due to their configuration, SFPs are inherently structurally-rugged and are designed to the same seismic requirements as the nuclear plant.

Note: Typically, SFPs are about 40 feet deep and vary in width and length. The fuel is stored in stainless steel racks and submerged with approximately 23 feet of water above the top of the stored fuel. Each plant has a preferred SFP make-up water source (the refueling water storage tank for pressurized water reactors and the condensate storage tank for boiling water reactors). SFPs have alternate means of make-up such as service water systems and the fire water system. SFPs are also typically designed (e.g. with anti-siphon check valves) and instrumented such that leakage is minimized and promptly detected.

Q7. Are the implications of new seismic hazard estimates being considered for fuel cycle facilities?

A7. Yes, while the GI-199 Safety/Risk Assessment focused solely on operating power reactors in the Central and Eastern U.S., fuel cycle facilities have been considered by NRC. Based on preliminary reviews of the updated seismic hazard estimates, NRC staff in the Office of Nuclear Material Safety and Safeguards concluded that, for the fuel cycle facilities within the CEUS, there is no immediate safety concern.

Existing facilities (uranium enrichment, fuel fabrication [high and low enriched]) were mostly built to local building codes. These facilities demonstrate compliance with the performance requirements in 10 CFR 70.61 through their Integrated Safety Analyses (ISAs). 10 CFR Part 70 licensees are required to perform an ISA in which seismic events are addressed (through a combination of design and preventive/mitigative actions). To demonstrate compliance with Part 70, licensees must limit the risk of high and intermediate consequence events, by limiting the likelihood or consequence. It is expected that, in view of this new data, existing facilities will consider the updated information as it relates to the performance requirements and see if additional safety controls are necessary.

In addition to the ISA requirements, new facilities have to meet the even higher baseline design criteria (BDC), which requires the design to provide adequate protection against natural phenomena with consideration of the most severe documented historical events for the site. Three new facilities (LES, USEC ACP, and MOX) are undergoing construction. Conservatism was built into the design of these facilities (i.e., design code factors of safety, elasticity in the structures, and conservatism in the design evaluation) resulting in additional safety margin. All new facilities and new processes at existing facilities are required to meet 10 CFR 70.64(a)(2), which requires adequate protection against natural phenomena.

Note: Regarding some particular facilities, the Paducah Gaseous Diffusion Plant (a 10 CFR Part 76 facility) was designed to meet local building codes at the time of its construction in the early 1950s. Later in the late 1990s, as part of the Certification process, the Paducah plant was evaluated and reinforced to meet a 250 year return earthquake. Honeywell's construction was also consistent with the local building codes when it was built 50 years ago. Later during the 1990s, structural modifications were performed at Honeywell to upgrade the plant so it could withstand a 475-yr recurrence site-specific earthquake.

Q8. How can I learn more about earthquakes?

A8. A fact sheet on seismic issues for existing nuclear power plants is available on the NRC public website at <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-seismic-issues.html>. Background information on earthquakes can also be obtained at the U.S. Geological Survey website at <http://earthquake.usgs.gov/>.

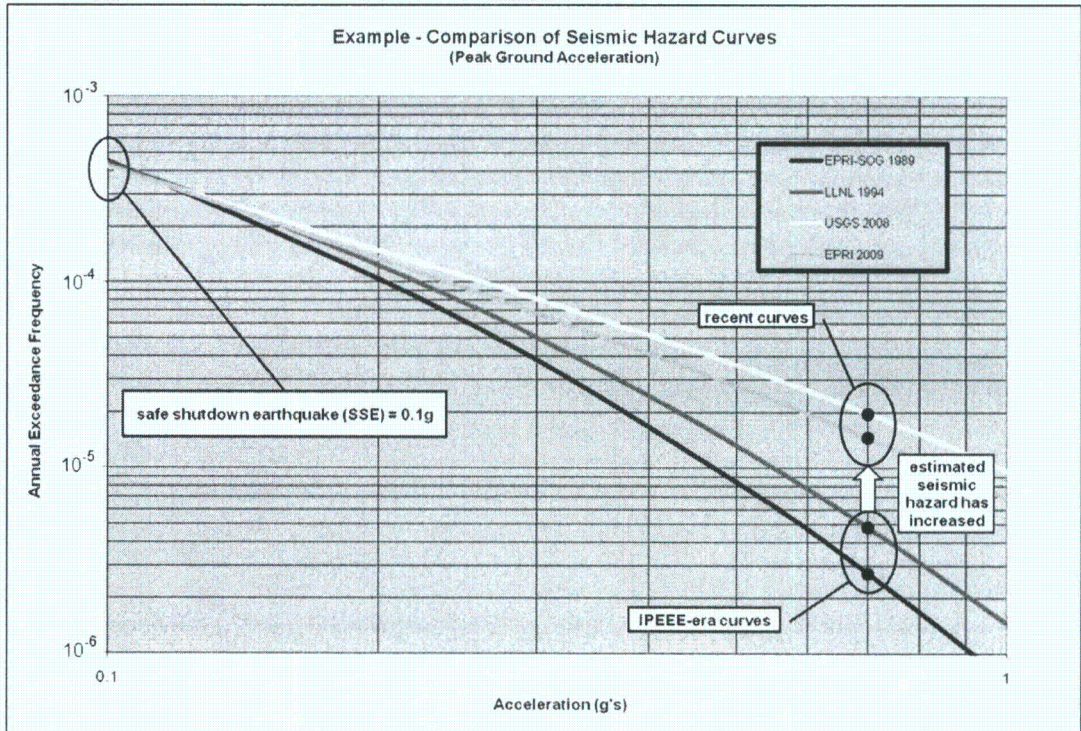
Q9. What do the following terms mean?

- **Annual exceedance frequency**
- **Core damage frequency**
- **Design basis earthquake or safe shutdown earthquake**
- **Ground acceleration**
- **High confidence of low probability of failure capacity**
- **Large early release frequency**
- **Seismic hazard**
- **Seismic margin**
- **Seismic risk**

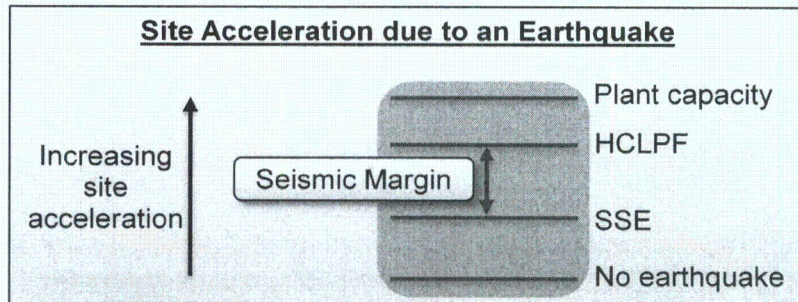
A9. The terms are defined as follows:

- **Annual exceedance frequency (AEF)** – Number of times per year that a site's ground motion is expected to exceed a specified acceleration.
- **Core damage frequency (CDF)** – Expected number of core damage events per unit of time. *Core damage* refers to the uncovering and heat-up of the reactor core, to the point that prolonged oxidation and severe fuel damage are not only anticipated but also involve enough of the core to result in off-site public health effects if released. *Seismic core damage frequency* refers to the component of total CDF that is due to seismic events.
- **Design basis earthquake or safe shutdown earthquake (SSE)** – A *design basis earthquake* is a commonly employed term for the *safe shutdown earthquake (SSE)*; the SSE is the earthquake ground shaking for which certain structures, systems, and components are designed to remain functional. In the past, the SSE has been commonly characterized by a standardized spectral shape associated with a peak *ground acceleration* value.
- **Ground acceleration** – Acceleration produced at the ground surface by seismic waves, typically expressed in units of *g*, the acceleration of gravity at the earth's surface.
- **High confidence of low probability of failure (HCLPF) capacity** – A measure of *seismic margin*. In *seismic risk* assessment, *HCLPF capacity* is defined as the earthquake motion level, at which there is high confidence (95%) of a low probability (at most 5%) of failure of a structure, system, or component.
- **Large early release frequency (LERF)** – The expected number of large early releases per unit of time. A *large early release* is the rapid, unmitigated release of airborne fission products from the containment building to the environment, occurring before the effective implementation of off-site emergency response and protective actions, such that there is a potential for early health effects. *Seismic large early release frequency* refers to the component of total LERF that is due to seismic events.
- **Seismic hazard** – Any physical phenomenon, such as ground motion or ground failure, that is associated with an earthquake and may produce adverse effects on human activities (such as posing a risk to a nuclear facility).

For the representative plant in the chart below, the *annual exceedance frequency* for a 0.7g acceleration (e.g., for a large, but highly improbable earthquake) has increased from approximately one in 250,000 years (for IPEEE-era curves) to approximately one in 60,000 years (for recent *seismic hazard* curves). (In other words, the annual exceedance frequency for a 0.7g acceleration has increased from about 4×10^{-6} (0.000004) per year for IPEEE-era curves to about 1.8×10^{-5} (0.000018) per year for recent seismic hazard curves.) Note that the curves in this example are virtually indistinguishable at the SSE (design basis) level, but this is not always the case. Ultimately, GI-199 is about understanding the impact of these seismic hazard changes on reactor risk.



- **Seismic margin** – The difference between a plant’s *HCLPF* capacity and its seismic design basis (*safe shutdown earthquake, SSE*), as shown in the figure below. (Note that the “plant capacity” label in this figure is the acceleration expected to result in core damage half of the time.) (Also see answer A11.)



- **Seismic risk** – The risk (frequency of occurrence multiplied by its consequence) of severe earthquake-initiated accidents at a nuclear power plant. A severe accident is an accident that causes core damage, and, possibly, a subsequent release of radioactive materials into the environment. Several risk metrics may be used to express *seismic risk*, such as *seismic core damage frequency* and *seismic large early release frequency*.

Safety

Q10. How was the seismic design basis for an existing nuclear power plant established?

A10. The seismic ground motion used for the design basis was determined from the evaluation of the maximum historic earthquake within 200 miles of the site, without explicitly considering the time spans between such earthquakes; safety margin was then added beyond this maximum historic earthquake to form a hypothetical *design basis earthquake* (see answer A9). The relevant regulation for currently operating plants is 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" (<http://www.nrc.gov/reading-rm/doc-collections/cfr/part100/part100-appa.html>).

Q11. Is there margin above the design basis?

A11. Yes, there is margin beyond the design basis (see answer A9). In the mid to late 1990s, NRC staff reviewed the plants' assessments of potential consequences of severe earthquakes (earthquakes well beyond the safety margin included in each plant's design basis), which licensees performed as part of the Individual Plant Examination of External Events program. From this review, the staff determined that seismic designs of operating plants in the Central and Eastern United States have considerable safety margins, for withstanding earthquakes, built into the designs.

Q12. What do you mean by "increased estimates of seismic hazards" at nuclear power plant sites?

A12. *Seismic hazard* (earthquake hazard) represents the chance (or probability) that a specific level of ground shaking could be observed or exceeded at a given location. Our estimates of seismic hazard at some Central and Eastern United States locations have changed based on results from recent research, indicating that earthquakes occurred more often in some locations than previously estimated. Our estimates of seismic hazard have also changed because the models used to predict the level of ground shaking, as caused by a specific magnitude earthquake at a certain distance from a site, changed. The increased estimates of seismic hazard at some locations in the Central and Eastern United States were discussed in a memorandum to the Commission, dated July 26, 2006. (The memorandum is available in the NRC Agencywide Documents Access and Management System [ADAMS] under Accession No. ML052360044).

Q13. What has the Safety/Risk Assessment found and what does it mean for Generic Issue 199?

A13. Results of the Safety/Risk Assessment confirm that currently operating plants have adequate protection against *seismic hazards* (see Safety/Risk Assessment report transmittal

memorandum). However, based on a separate criterion in the Generic Issues Program, the estimated *core damage frequency* change is still large enough to warrant further attention regarding the possible imposition of plant improvements. Action could include obtaining information and developing methods to complete plant-specific value-impact analyses.

RES staff developed a methodology and implemented it to assess the risk associated with this issue. Overall *seismic risk* estimates remain small in an absolute sense. All operating plants in the Central and Eastern United States have seismic core damage frequency (SCDF) less than or equal to 10^{-4} (0.0001) per year, which is considered safe (see answer to A15). The SCDF changes (the difference in SCDFs calculated using the old and new seismic hazard information) for a number of plants lie in the range of 10^{-4} to 10^{-5} (0.0001 to 0.00001) per year, which meets the NRC Generic Issues Program numerical risk threshold for an issue to continue to be evaluated for possible regulatory action.

Q14. Are the plants safe? If you are not sure they are safe, why are they not being shut down? If you are sure they are safe, why are you continuing evaluations related to this generic issue?

A14. Yes, currently operating nuclear plants in the Central and Eastern United States remain safe, with no need for immediate action. This determination is based on NRC staff reviews associated with Early Site Permits, the conclusions of the Generic Issue 199 Screening Panel (comprised of technical experts), and the conclusions of the Safety/Risk Assessment Panel (also comprised of technical experts).

No immediate action is needed because: (1) existing plants were designed to withstand anticipated earthquakes with substantial design margins, as confirmed by the results of the Individual Plant Examination of External Events; (2) the probability of exceeding the *safe shutdown earthquake* ground motion (see answer A9) may have increased at some sites, but only by a relatively small amount; (3) the increased probability is primarily in the high structural response frequencies, so buildings and equipment should not be affected (seismic amplitudes at lower frequencies are the primary contributors to building and equipment damage); and (4) the Safety/Risk Assessment Stage results indicate that the probabilities of seismic core damage are lower than the guidelines for taking immediate action.

Even though the staff has determined that existing plants remain safe, the Generic Issues Program criteria direct staff to continue their analysis to determine whether any cost-justified plant improvements can be identified to make plants even safer.

Q15. How do you know the plants are safe?

A15. The Safety/Risk Assessment results confirm that plants are safe. The relevant risk criterion for GI-199 is total *core damage frequency* (CDF). The threshold for taking immediate regulatory action (found in NRR Office Instruction LIC-504, see below) is a total CDF greater than or on the order of 10^{-3} (0.001) per year. For GI-199, the staff calculated seismic CDFs of 10^{-4} (0.0001) per year and below for nuclear power plants operating in the Central and Eastern U.S. (CEUS) (based on the new U.S. Geological Survey seismic hazard curves). The CDF from internal events (estimated using the staff-developed Standardized Plant Analysis of Risk models) and fires (as reported by licensees during the IPEEE process and documented in NUREG-1742), when added to the seismic CDF estimates results in the total risk for each plant to be, at most, 4×10^{-4} (0.0004) per year or below. This is well below the threshold (a CDF of

10⁻³ [0.001] per year) for taking immediate action. Based on the determination that there is no need for immediate action, and that this issue has not changed the licensing basis for any operating plant, the CEUS operating nuclear power plants are considered safe. In addition, as detailed in the GI-199 Safety/Risk Assessment and answers A13 and A14 above, there are additional, qualitative considerations that provide further support to the conclusion that plants are safe.

Note: The NRC has an integrated, risk-informed decision-making process for emergent reactor issues (NRR Office Instruction LIC-504, ADAMS Accession No. ML100541776 [not publically available]). In addition to deterministic criteria, LIC-504 contains risk criteria for determining when an emergent issue requires regulatory action to place or maintain a plant in a safe condition.

Despite NRC's determination that plants are safe to operate, MD 6.4, "Generic Issues Program," contains quantitative risk guidelines that place GI-199 into the category of continued evaluation to determine if cost-beneficial backfits can be justified at any plants.

Note: Also, New U.S. Geological Survey seismic hazard information provides ground acceleration likelihoods at each power plant site for both design basis and beyond design basis earthquakes. This seismic hazard information was combined with an estimate of each plant's resistance to earthquakes (seismic fragility) to produce an estimate of the frequency of damage to the reactor core due to earthquakes. This seismic core damage frequency (SCDF) was combined with estimates of the core-damage frequency (CDF) for internal events and fires, and the total CDF was then compared to risk thresholds used by the NRC to assess and assure that nuclear power plants are operated safely. The frequency calculated for all operating nuclear power plants in the CEUS is in the range considered safe.

Q16. Why are new nuclear plants being built to different seismic design requirements than existing nearby plants? Why are the currently operating plants not required to meet the new standards?

A16. Currently operating plants have been determined to adequately protect the public; new plants are designed to different requirements in order to meet the Nuclear Regulatory Commission's expectation that the new plants will provide enhanced margins of safety (see "Regulation of Advanced Nuclear Power Plants; Statement of Policy" 59 FR 35461 at <http://www.nrc.gov/reading-rm/doc-collections/commission/policy/#power>). There are two primary ways of determining safety: deterministic assessments (based on past events and engineering judgment) and probabilistic assessments. New plants employ probabilistic methods. Existing plants were built to older standards, based on deterministic assessments. Those standards have been monitored, and were found to be sufficient and appropriate. In order to impose new requirements on existing plants, the NRC must be able to justify the new requirements in accordance with the "Backfit Rule" (10 CFR 50.109, available at <http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0109.html>). The NRC needs additional information to justify any new requirements, and the Safety/Risk Assessment Panel recommended taking action to acquire the information.

Q17. How does the occurrence of a new earthquake in the Central or Eastern United States affect Generic Issue 199?

A17. The effect of a single earthquake is small on the estimated *seismic hazard* (defined in answer A9) and hence on Generic Issue 199, unless it occurs in an area not previously recognized as being capable of producing earthquakes, or is larger than previously believed possible in a region. In a seismic hazard study, the seismic source zones are specifically delineated to include a sufficient number of earthquakes to provide a stable estimate of the seismicity rate and are thus relatively insensitive to the addition of a single earthquake. If an earthquake does occur in an area not previously recognized as being capable of producing earthquakes or if an earthquake occurs that is larger than previously believed possible in a region, changes to the seismic hazard model used to develop seismic hazard estimates would be required.

Note: The magnitude 5.2 earthquake that occurred on April 18, 2008 in southeastern Illinois provides a good example of the potential impact of a single earthquake. This earthquake occurred in an area recognized as being capable of producing significant earthquakes (the Wabash Valley seismic source zone) and was smaller than the maximum magnitude event defined for the zone based on geologic investigations (maximum magnitude of 7-7.5). The addition of a single event of this magnitude to the earthquake database for this area would likely change the activity rate by less than a few percent and thus have a very small impact on the estimated seismic hazard at any of the nuclear facilities in the area.

Schedule

Q18. What has been done about this issue since it was identified as a generic issue in the Generic Issues Program?

A18. The following summarizes what has been done on Generic Issue 199 (GI-199):

Prioritization and Screening

- *June 2005:* The issue was logged into the Generic Issues Program (GIP) and, based on the NRC determination that the seismic design of plants in the Central and Eastern United States still provided an adequate level of protection, the Agency decided that this issue was a relatively low priority.
- *November 2005 – February 2007:* The Agency awarded a contract to screen this issue and determine whether it should continue to be evaluated under the GIP. In 2006, the contractor notified RES of problems obtaining information that the contractor wanted to perform its task.
- *April 2007:* The NRC decided to use Agency staff to complete the screening analysis using guidance provided in Management Directive (MD) 6.4 and SECY-07-0022, "Status Report on Proposed Improvements to the Generic Issues Program," dated January 30, 2007. MD 6.4 outlines the seven GIP criteria for use in determining whether proposed generic issues should be designated generic issues (the screening process) and proceed to the Safety/Risk Assessment Stage of the GIP.
- *September 2007:* An initial screening analysis was completed.
- *October 2007:* For consistency with the performance-based approach for assessing *seismic hazards* for new reactors, the staff determined that the screening analysis should consider seismic hazard data and models besides those available from the U.S.

Geological Survey.

- *February 2008:* The NRC completed the GIP screening with the GI-199 Screening Panel concluding that the issue should proceed to the Safety/Risk Assessment Stage under the GIP. The NRC staff held a public meeting to engage external stakeholders. During the meeting, the representative from NEI expressed their willingness to support a collaborative approach to GI-199. (This led to a Seismic Risk Memorandum of Understanding Addendum between the Electric Power Research Institute and the NRC Office of Nuclear Regulatory Research (RES).)

Safety/Risk Assessment Stage

- GI-199 then entered the Safety/Risk Assessment Stage of the GIP. RES staff collected and analyzed seismic hazard information from the U.S. Geological Survey and other sources, and *seismic risk* information from Individual Plant Examination of External Events analyses.
- *November 2008:* The NRC Office of Nuclear Material Safety and Safeguards (NMSS) performed a preliminary review related to independent spent fuel storage installations (ISFSIs). A review of design earthquakes (DE) used at the existing ISFSI locations in Central and Eastern U.S., indicated that there is significant margin built into the existing designs and NMSS determined that they have confidence that the ISFSIs can continue to operate safely while GI-199 is processed.
- *June 2009:* In support of the Safety/Risk Assessment, the staff completed the review and detailed analysis of seismic data for 96 plants.
- *July 2009 – March 2010:* Several Safety/Risk Assessment Panel meetings were held to determine recommendations in light of stakeholder input that was received.
- *April 2010 – August 2010:* The Safety/Risk Assessment report is finalized. Internal briefings and communications are carried out (to build NRC consensus and to prepare for the release of the Safety/Risk Assessment report and associated public meeting).
- During the process of resolving GI-199, staff responded to Freedom of Information Act requests and held numerous meetings with internal and external stakeholders.

Q19. Why is it taking the NRC so long to process Generic Issue 199?

A19. This is a complicated issue involving the intersection of the probabilistic risk analysis and seismic disciplines. Obtaining data, developing methods, and performing analyses are all required to address the issue. Analyzing a few representative plants for this issue (as is normally done in the Generic Issues Program) is inappropriate because the *seismic hazard* and associated impact to the power plant are very site-specific; so analysis for 96 separate plants is required. (Refer to A14 for a summary of what has been done on GI-199 since it was first identified.) GI-199 has also been a communication-intensive generic issue because it affects many parts of the NRC and industry, and because it is important to NRC and all stakeholders that the Safety/Risk Assessment results are properly conveyed.

Q20. What will happen next regarding Generic Issue 199?

A20. The next step is for the staff to complete the Safety/Risk Assessment Stage of the Generic Issues Program (GIP). The Safety/Risk Assessment report will soon be published, followed by an information notice being sent to all licensees of nuclear power reactors and independent spent fuel storage installations. A public meeting will be held to discuss the results of the Safety/Risk Assessment and the next steps for GI-199. After the Safety/Risk Assessment

Stage, further action regarding GI-199 will be pursued (such as obtaining more detailed, plant-specific information and performing analysis to determine whether plant-specific improvements are warranted). NRC staff will also make presentations to the Advisory Committee on Reactor Safeguards.

Q21. Aside from evaluations for GI-199, what is the NRC's expectation regarding the use of updated probabilistic seismic hazard information in regulatory applications?

A21. It is expected that all NRC licensees that are required to analyze risks and hazards impacting their operations will use the most current seismic hazard information.

Regarding currently operating nuclear power plants, there is no requirement that the plants re-evaluate their seismic design basis (10 CFR 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants"), but plants do need to use the most updated information available in the case of risk-informed licensing amendments.

Note: The NRC guidance for using probabilistic risk assessment (PRA) in risk-informed decisions on plant-specific changes to the licensing basis is provided in RG 1.174. The scope, level of detail, and technical acceptability of the PRA are to be commensurate with the application for which it is intended and the role that the PRA results play in the integrated decision process. One over-riding requirement is that the PRA should realistically reflect the actual design, construction, operational practices, and operational experience of the plant and its owner. RG 1.200 provides further guidance concerning the technical adequacy of PRAs and states that seismic hazard analysis should include current information. Consistent with this guidance, the staff expects that licensees will use the most recent seismic hazard information available for risk-informed regulatory applications.

Regarding seismic requirements for dry cask storage systems and independent spent fuel storage installations (ISFSIs), the staff also expects that licensees will use the most recent seismic hazard information available for risk-informed regulatory applications.

Note: NRC regulations (in 10 CFR Part 72) require licensees to perform written evaluations to establish that, for their site-specific conditions, the conditions set forth in the Certificate of Compliance (CoC) have been met. They must also perform evaluations showing that cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction as well as soil liquefaction potential or other soil instability due to vibratory ground motion.

Stakeholder Interest

Q22. Has the NRC received any requests from government officials regarding seismic issues?

A22. Yes. On November 15, 2007, the NRC received a letter (available in the NRC Agencywide Documents Access and Management System, ADAMS, under Accession No. ML0732500954) from the Attorneys General of six states (Connecticut, Delaware, Illinois, Kentucky, New York, and Vermont). The letter encouraged the NRC to consider siting and safety requirements, including geographic and seismic issues, in the regulatory process for license renewal. The NRC reviewed this letter and responded that the items of concern are

addressed in “ongoing regulation [that]... occurs throughout the life of the license... [and that] expand[ing] the scope of license renewal to cover... [the] issues raised in [the] letter... [would be] duplicating the Commission’s responsibilities...” (ADAMS Accession No. ML073400603). Additionally, several Freedom of Information Act requests were received, and NRC staff responded to the requests; the U.S. Geological Survey data related to these requests is publicly available under ADAMS Accession No. ML072880133.

Also, the County Executive of Westchester County (New York) and groups from New Jersey submitted a petition for rulemaking on license renewal, including a seismic-related aspect. The NRC denied this petition. The petitioners then filed suit in the U.S. Court of Appeals Second Circuit and the court upheld the NRC position. Details are available on the internal webpage of the NRC Office of General Counsel (under Law Library, Summary of AEC-NRC Litigation, “Spano v. NRC” (2d Cir. 2009): http://www.internal.nrc.gov/ogc/internal/AEC-NRC_Cases.pdf.)

Q23. Will the NRC release the results of the Safety/Risk Assessment? If so, will plant-specific results be included?

A23. The Safety/Risk Assessment report will be made available on the public NRC Generic Issues Program (GIP) website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>), on the internal NRC GIP website (<http://www.internal.nrc.gov/RES/projects/GIP/>), and in the NRC Agencywide Document Access and Management System (ADAMS) under Accession No. ML100270582.

Regarding the plant-specific results, they are included in the Safety/Risk Assessment report (in appendix D), and have been used in the aggregate for the determination that further, plant-specific information and analysis is needed to investigate possible plant-specific improvements. (See the last section, “Safety/Risk Assessment Results - Plants in the GIP “Continue Region,” of this Communication Plan.)

Note: Results of the Safety/Risk Assessment confirm that currently operating plants have adequate protection against seismic hazards; however, the results also indicated that GI-199 meets the NRC Generic Issues Program numerical risk threshold for an issue to continue to be evaluated for possible regulatory action (see answer A13). The Safety/Risk Assessment utilized simplifying methods and assumptions to produce plant-specific results to determine trends, not to finalize which plants will or will not be further analyzed.

Safety/Risk Assessment Results - Plants in the GIP "Continue Region"

Plant-specific results are included in the Safety/Risk Assessment report (in appendix D) and have been used in the aggregate to determine that further, plant-specific information and analysis is needed to investigate possible plant-specific improvements. Listed below are plants that are currently above the Generic Issues Program (GIP) numerical risk threshold for an issue to continue to be evaluated for possible regulatory action (see answers A13 and A23). (Note that the plants are listed in alphabetical order by NRC region.) During the analysis, this group of plants was referred to as the "plants in the *continue region*."

As more information becomes available and more detailed analysis is performed, this group of plants *will* change. As discussed in answer A4, generic communications on this issue will be addressed to all operating power plants in the United States. More detailed, plant-specific analysis of all plants will allow NRC staff to prioritize plants that may be considered for regulatory action. The need to continue evaluating GI-199 is based on the collective results, not the results for any particular plant.

Region I

Indian Point 2
Indian Point 3
Limerick 1
Limerick 2
Peach Bottom 2
Peach Bottom 3
Seabrook 1

Region II

Crystal River 3
Farley 1
Farley 2
North Anna 1
North Anna 2
Oconee 1
Oconee 2
Oconee 3
Saint Lucie 1
Saint Lucie 2
Sequoyah 1
Sequoyah 2
Summer
Watts Bar 1

Region III

Dresden 2
Dresden 3
Duane Arnold
Perry 1

Region IV

River Bend 1
Wolf Creek 1

Q24. There was a recent Part 21 (60-Day Interim Report) Notification concerning seismic input for control rods that might lead to a failure to scram at Boiling Water Reactors (BWRs). Was this information included in the GI-199 Safety/ Risk Assessment (S/RA)? Could this information change the results of the S/RA?

A24. On September 3, 2010, General Electric Hitachi (GEH) Nuclear Energy submitted a 10CFR50 Part 21 Notification regarding a failure to include seismic input in reactor control blade customer guidance for BWRs. BWRs remain safe because (1) control rods are expected to fully or partially insert even with channel-control rod interference, (2) operators will still have the ability to manually scram partially inserted rods, and (3) the limited time spent at conditions where the failure to scram could occur (low reactor pressure). NRR has been following this Part 21 issue and has determined that the GEH has provided effective interim guidance to the affected licensees that experience channel-control rod interference, and that additional guidance detailed in the Part 21 notice, provides licensees with conservative strategies to assist in the insertion of control rods under low reactor pressure conditions.

The GI-199 S/RA was completed in August, prior to the Part 21 notice. Considering the above, information from the new Part 21 notice would not be expected to change the conclusions of the GI-199 S/RA. Information from this Part 21 Notification will be considered in future efforts to address GI-199.

Killian, Lauren

From: Killian, Lauren
Sent: Monday, March 21, 2011 12:11 PM
To: Beasley, Benjamin; Stutzke, Martin
Cc: Kauffman, John
Subject: draft slides for NY delegation meeting
Attachments: Briefing on GI-199 for NY Delegation_March 22 2011_1.01.pptx

Here is our draft so far. The notes need work, but we wanted to send them out and get your comments sooner rather than later.

Thanks,
Lauren
John K

Briefing on GI-199 for New York State Delegation

March 22, 2011

Introduce pit crew:

Marty Stutzke – Senior Advisor for PRA, RES

Dr. Jon Ake – Senior Seismologist, RES

Doug Coe – Deputy Director of Division of Risk Analysis, RES

Pat Hiland – Director of the Division of Engineering, NRR

Kamal Manoly – Senior Advisor in Structural Engineering, NRR

Generic Issue 199 is “Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants”

Identified by NRO when reviewing applications for new plants that use recent seismic hazard data

Agenda

- **Background**
 - Context and Results
 - Conclusions
- **Approach to Resolution**
- **Communication of Results**
 - Overview
 - Public Meeting Purposes
- **Discussion of Results**

Background: GI-199 Context and Results

- Generic Issues Program Stages
 - Identification
 - Acceptance
 - Screening
 - **Safety/Risk Assessment**
 - Regulatory Assessment
- Generic Issue 199 Results
 - Overall seismic risk estimates remain small in an absolute sense
 - The new seismic data for some plants meet the criteria for further evaluation

3

GI-199 is about: updated seismic hazard estimates/information for Central and Eastern U.S. and their implications for applicable nuclear power plants

GI/GSI (historically referred to as GSI)

Old notes:

Info on slide

Adequate protection is presumed based on criteria in NRR Office Instruction LIC-504.

No evidence that plants do not meet design basis. Have evidence that there is margin beyond design basis.

The new seismic hazard curves give changes for some plants that meet the numerical risk criteria for an issue to proceed to regulatory analysis, which is the next stage of the Generic Issue process. A regulatory analysis will consider cost beneficial changes to individual plants.

Background:

Safety / Risk Assessment Conclusions

- Established the need to continue to regulatory analysis.
- Additional information and methods are needed to consider plant-specific cost beneficial changes

4

Old notes:

Info on slide

To perform the regulatory analysis, we need more information from each plant.
(amplification functions, fragility, significant contributors)

For some of the plants, we need to develop an approach to conduct the analysis.

Approach to Resolution

- Issued an Information Notice to inform plants of the GI-199 Safety/Risk Assessment results.
- NRR is developing a generic communication to request needed data.
- Work with EPRI on method for plants that used Seismic Margins Analysis (SMA)

5

Old Notes:

SMA - because SMA does not provide the component level insights needed to identify significant risk contributors

70% of plants have SMA

30% have a seismic PRA

Communication of Results: Overview

- Safety/Risk Assessment Report Publicly Released
- Outreach to Stakeholder (Regional State Liaisons, Congressional Affairs, International Programs)
- Information Notices
- Press Release
- Public Meeting
- Routine Reports: GIMCS Quarterly Reports, Semi-Annual Report to Congress (all publicly available)

6

Note - Public Meeting Notice: mailed 9/8/10 to Andrew Cuomo (NY State Attorney General at the time, now NY State Governor)

Old Notes:

S/RA report

A clear context for the safety / risk assessment will be provided when releasing the Safety/Risk Assessment Report. (where we are in the process and what comes next)

Collective results rather than individual plant results:

- Simplified method, assumptions, and data not sufficient to perform regulatory analyses
- Results are sensitive to inputs with significant uncertainties
- Need plant specific insight into what SSCs are important to seismic risk

Communication of Results: Public Meeting Purposes

- Provided status update
- Communicated where in GIP process
- Discussed path forward and items needed to move ahead
- Solicited information needed for regulatory analysis from industry
- Provided opportunity for public participation

7

Old Notes:

- Over 2 years since last meeting on this issue
- Get the safety / risk assessment results and current status out
- Re-engage industry

Target for public meeting is late September.

Discussion of Results:

Overview of Assessment Results

- Operating power plants are safe
- Though still small, some seismic hazard estimates have increased
- Assessment of GI-199 will continue
 - Information is needed to perform regulatory assessments
 - NRC will request the needed information

8

•“Earthquakes greater than the seismic design basis do not necessarily lead to core damage or containment release”

Discussion of Results: Assumptions

- Results were a conservative, screening-level assessment to evaluate if further investigations are warranted.
 - The results should not be interpreted as definitive estimates of plant-specific seismic risk because some analyses were very conservative making the calculated risk higher than in reality.
 - The nature of the information used (seismic hazard data, plant-level fragility information) make these estimates useful only as a screening tool.
- Report did not rank nuclear plants by seismic risk because assumptions and limitations in the analyses.

17) Does GI-199 provide rankings of US nuclear plants in terms of safety?

The objective of the GI-199 Safety/Risk Assessment was to perform a conservative, screening-level assessment to evaluate if further investigations of seismic safety for operating reactors in the central and eastern US (CEUS) are warranted, consistent with NRC directives. The results of the GI-199 safety risk assessment should not be interpreted as definitive estimates of plant-specific seismic risk because some analyses were very conservative making the calculated risk higher than in reality. The nature of the information used (both seismic hazard data and plant-level fragility information) make these estimates useful only as a screening tool.

Quote from Report (a full page of the "assumptions and limitations"):

"5. DISCUSSION AND CONCLUSIONS

5.1 Discussion

The preceding sections summarize the analyses conducted for the Safety/Risk Assessment

phase of the Generic Issues Process. It has been necessary to make a number of assumptions

to perform these analyses. Prior to developing any conclusions, it is appropriate to specifically

state some of the **assumptions and limitations** in the analyses as they impact

Discussion of Results: Limitations

- Conservative, simplified screening analysis
 - Data Limitations
 - Old, IPEEE data from late 1980s
 - USGS intended for local building codes, not nuclear power plants, so many adjustments made
 - Analytical Limitations
 - Simplified approach
 - Sensitive to some seismic modeling assumptions
- Overall – We did not rank plants because the nature of the information used makes these estimates useful only as screening tool.

10

17) Does GI-199 provide rankings of US nuclear plants in terms of safety?

The objective of the GI-199 Safety/Risk Assessment was to perform a conservative, screening-level assessment to evaluate if further investigations of seismic safety for operating reactors in the central and eastern US (CEUS) are warranted, consistent with NRC directives. The results of the GI-199 safety risk assessment should not be interpreted as definitive estimates of plant-specific seismic risk because some analyses were very conservative making the calculated risk higher than in reality. The nature of the information used (both seismic hazard data and plant-level fragility information) make these estimates useful only as a screening tool.

Quote from Report (a full page of the “assumptions and limitations”):

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The preceding sections summarize the analyses conducted for the Safety/Risk Assessment

phase of the Generic Issues Process. It has been necessary to make a number of assumptions

to perform these analyses. Prior to developing any conclusions, it is appropriate to specifically

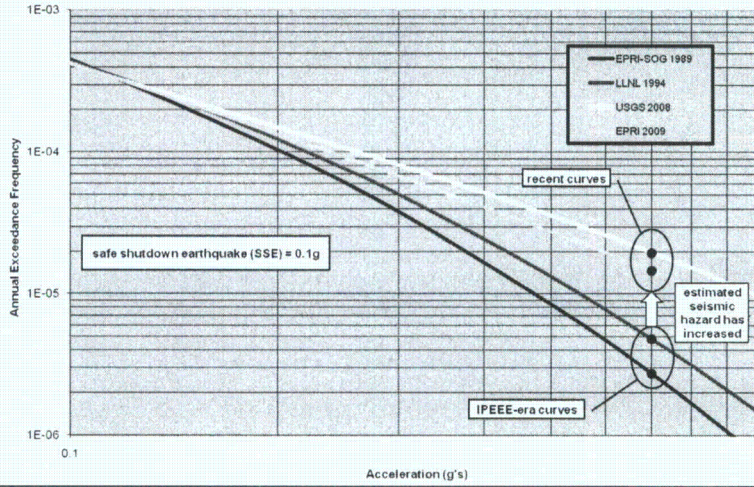
state some of the **assumptions and limitations** in the analyses as they impact

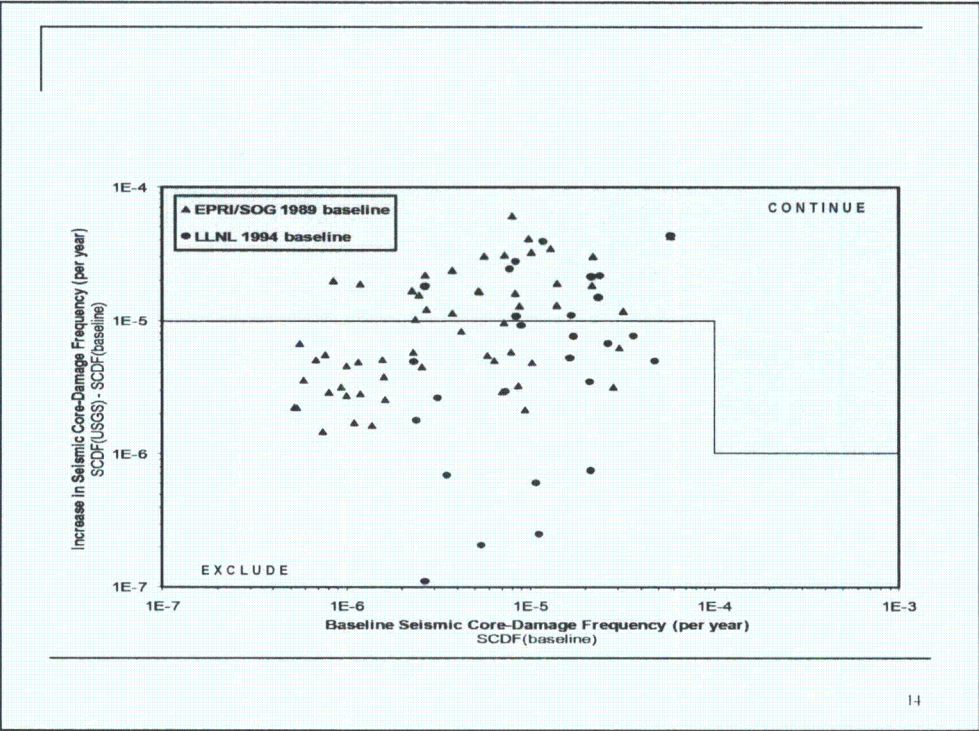
Back-up Material

Recent GI-199 Activities

- Panel Chair discussed GI-199 information topics with NEI (2/24/2010)
- Division Director Alignment Meeting (3/30/2010)
- Office Director Alignment Meeting (5/12/2010)
- Briefing of all regions (5/12/2010)
- RI Management Briefing (6/3/2010)
- EDO Briefing (6/22/2010)
- Briefing to Commission TAs (7/8/2010)

Example - Comparison of Seismic Hazard Curves
(Peak Ground Acceleration)





Needed for GI-199 Regulatory Analysis

- Updated site specific hazard curves
- Frequency dependent, site specific amplification functions
- Plant level fragility information
- Plant specific contributors to seismic risk
 - Can be produced for plants with seismic PRA
 - Will need method developed for plants with SMA
- Need repeatable approach for evaluating new seismic hazard information being developed

15

OLD NOTES:

Site-specific, updated EPRI hazard curves used to evaluate plant seismic risk in the recent study conducted by EPRI for industry.

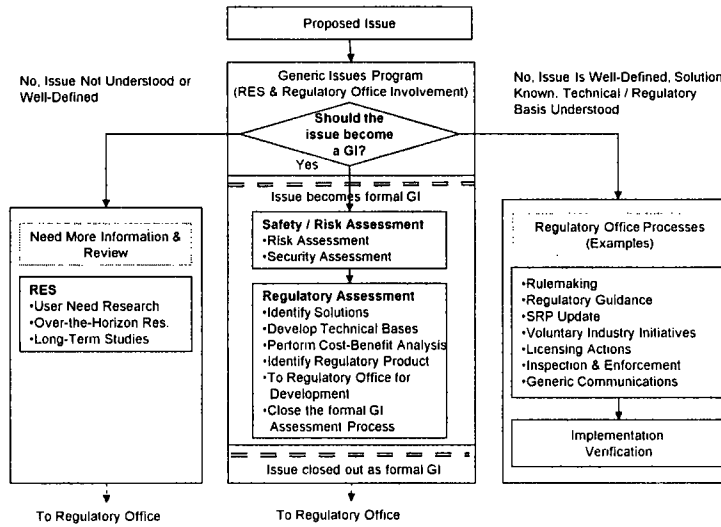
Frequency dependent, site-specific amplification functions used to translate seismic motions from hard rock conditions to appropriate surface conditions. These functions should be consistent with the recent seismic evaluation performed by EPRI using updated seismic hazard results.

Plant-level fragility information used in the recent study conducted by EPRI. Specific information needed includes the median seismic capacity (C50), the composite logarithmic standard deviation (*bC*), and spectral ratios (relative to PGA) for 1, 5, and 10 Hz, representative of the currently operated plant.

Plant-specific significant contributors to seismic risk. Identify the SSCs that are significant contributors to seismic risk and the approach used to identify them.

We are working with DOE, USGS, and EPRI on new consensus seismic hazard estimates that will become available around the end of the year. This underscores the need to develop a regulatory mechanism to routinely and promptly evaluate new seismic hazard information as it becomes available. We want to avoid repeat GI-199s.

GIP in Perspective with Other Regulatory Programs and Processes



16

16

Killian, Lauren

This whole document is exempt under
Exemption 5 "predecisional information"
because the attachment is a draft presentation

From: Killian, Lauren
Sent: Monday, March 21, 2011 2:59 PM
To: Beasley, Benjamin
Cc: Kauffman, John
Subject: Briefing on GI-199 for NY Delegation_March 22 2011_1.04.pptx
Attachments: Briefing on GI-199 for NY Delegation_March 22 2011_1.04.pptx

Rihm, Roger

From: Rihm, Roger
Sent: Thursday, March 24, 2011 7:54 AM
To: Clayton, Kathleen
Cc: Barkley, Richard
Subject: FW: Incoming Correspondence
Attachments: Galef --NY Assembly 03-22-11.pdf

Thanks, Kathy. Good to know, but I assume this letter (coming from a state assembly member and asking for a public meeting) will probably be assigned to Reg I for response.

From: Clayton, Kathleen
Sent: Thursday, March 24, 2011 7:34 AM
To: Rihm, Roger
Subject: FW: Incoming Correspondence

FYI

From: Champ, Billie
Sent: Wednesday, March 23, 2011 4:15 PM
To: Batkin, Joshua; Reddick, Darani; Sharkey, Jeffry; Sosa, Belkys; Bubar, Patrice; Nieh, Ho; Burns, Stephen
Cc: Jaegers, Cathy; Clayton, Kathleen; Vietti-Cook, Annette; McKelvin, Sheila; Mike, Linda; Bovol, Rochelle
Subject: Incoming Correspondence

I have attached for your information a letter from Sandra Galef—NY State Assembly dated 3/22/11..re; Status of seismic risk at Indian Pointrequest a public meeting concerning Indian Point

Billie A. C-Lopes

2/183



THE ASSEMBLY
STATE OF NEW YORK
ALBANY

CHAIR
Real Property Taxation
COMMITTEES
Corporations, Authorities and Commissions
Election Law
Governmental Operations
Health

SANDRA R. GALEF
Assemblywoman 90th District

March 22, 2011

Gregory Jaczko
Chairman
U. S. Nuclear Regulatory Commission
11555 Rockville Pike, Mail Stop O-16G4
Rockville, MD 20852

Dear Chairman Jaczko,

As you continue to evaluate the catastrophic damage from which Japan is trying to recover, I understand you are also evaluating lessons for the U.S., specifically how the impact of natural disasters relates to emergency plans for our own nuclear power plants. The power plant in our country which your organization has rated most at risk for core damage from an earthquake, Indian Point, sits squarely in the center of the 90th New York State Assembly District, which I represent.

I have already placed a call to the Commission asking for a meeting with elected officials in the area. Now I would also respectfully request that you organize a public meeting in my area to address some of the questions that are arising as the disaster in Japan continues to play out. These questions include:

- What is the status of the seismic risk at Indian Point? I understand it has changed, so I would like to know what potential impact the two fault lines that are now known to be there could have in a worst case scenario, and if the power plant is prepared for such a disaster.
- What, if any, are the risks of a tsunami in the area? What would the impact be on Indian Point?
- What type of protection of the spent fuel rod pools is there at Indian Point? What kind of an emergency could compromise that protection?
- I understand the electricity responsible for cooling the spent fuel rod pools is dependent on the electrical grid? Should there be a requirement that it have independent back up as well?
- Where are we in terms of a timeline to eventually rid the Buchanan site of these rods?
- In the interim, are we at greater risk because we are trying to maximize use of the small space that is available for the spent fuel rods? Is the cask plan an effective interim?
- How many hours of back up do we have in the event of an electrical outage?
- How many hours of independent protection can the plant offer?
- What is the condition of the underground pipes that supply Indian Point? What effect have minor quakes had on those pipes, and what would happen in the event of a worse quake?
- How would an evacuation plan of a 50 mile radius around Indian Point be realized if we are not even sure that the plan for a 10 mile radius is feasible?
- What are we learning about our own evacuation plans as we evaluate Japan?

I look forward to the NRC responding to these questions, as well as hearing back from you in response to my request for a public meeting to address these and other safety concerns. Thank you for your kind attention to my requests.

Sincerely,

Sandy Galef, NYS Assemblywoman, 90th A.D.

ALBANY OFFICE: Room 641, Legislative Office Building, Albany, New York 12248, (518) 455-5348, FAX (518) 456-6728
DISTRICT OFFICE: 2 Church Street, Ossining, New York 10582, (814) 941-1111, FAX (514) 841-0132
E-MAIL: galefs@assembly.state.ny.us WEBSITE: www.assembly.state.ny.us



SANDRA R. GALEF
Assemblywoman 80th District

**THE ASSEMBLY
STATE OF NEW YORK
ALBANY**

CHAIR
Real Property Taxation

COMMITTEES
Corporations, Authorities and Commissions
Election Law
Governmental Operations
Health

cc:

Andrew Cuomo, Governor of New York
Chuck Schumer, U.S. Senator
Kirsten Gillibrand, U.S. Senator
Nita Lowey, U.S. Congresswoman
Nan Hayworth, U.S. Congresswoman

Andersen, James

From: Golder, Jennifer
Sent: Friday, March 25, 2011 3:34 PM
To: McDonald, Christine
Cc: Dyer, Jim; Brown, Milton; Allwein, Russell; Peterson, Gordon
Subject: Japan Funding Tracker Update
Attachments: Japan 2011 Incident Funding Tracker NRC - March 17 2011 (2).xlsx

Hi Christine,

Here is our latest.

Jennifer Golder

Budget Director
Office of the Chief Financial Officer
United States Nuclear Regulatory Commission

INTERNAL USE ONLY

Agency	Account	Fiscal Year	Committed to Date (dollars in thousands)	Of which is Reimbursable	Name of Agency Reimbursing	Authorized Cap	Agency Authorities to Transfer \$	Description of assistance (e.g., non-food commodities, medical supplies, search and rescue, airlift)
Corp Support/ADM Services		2011	6.00					Clearances to support international travel for 12 NRC staff traveling
Corp Support/IT		2011	17.20					IT support (international Blackberries, phone cards, laptops) for 12 NRC staff
Travel		2011	36.00					Travel, lodging, and per diem for 2 employees paid by NRC; does not include the 10 employees paid by USAID.
Salaries and Benefits		2011	84.20					S&B's for 12 employees
Incident Response Center		2011	1,731.00					Marginal costs associated with staffing Ops Center
Operating Reactors/International Activities		2011	50.00					Translation services
NRC Total			1,924.40	0.00				
GRAND TOTAL				0.00				

Lee, Richard

From: Lee, Richard
Sent: Friday, March 25, 2011 8:00 AM
To: Farmer, Mitchell T.
Subject: RE: Results of Nuclide Analysis

Mitch,

Dana was asking for isotopic data (I-131, I-129, Cs, Ru, ...etc.,) gather around the site and from these data, he will try to discern release from the core vs. from the pool. If you have them, please send to Randy Gauntt (rogaunt@sandia.gov) and to Dana at his home (powerss@crossnet.org)

Please forward your e-mail to Randy. Randy and Dana is still at the NRC PDC teaching the Reactor Safety Course until noon today.

Thanks, Richard

From: Farmer, Mitchell T. [farmer@anl.gov]
Sent: Friday, March 25, 2011 7:42 AM
To: binderJL@ornl.gov; johnE.Kelly@nuclear.energy.gov; McCaughey, Bill; Miller, Tom
Cc: Douglas E Burns; Phillip J Finck; Connell, Elizabeth; Basu, Sudhamay; Tinkler, Charles; Lee, Richard; 'Michael Corradini'; Flanagan, George F.
Subject: FW: Results of Nuclide Analysis

You should probably take a look at this. They are even detecting noble metals around the site (La, Ru) which are indicative of fuel melting. I'd ask Dana Powers to have a 5 minute look at these if you could Richard/Charlier/Sud; we need his opinion. Maybe he can tell from the La/Ru ratio whether there has been air ingress (if not, I think the ratio should be about what it is in irradiated fuel in general; if so, I'd expect Ru to be high as RuOx is quite volatile).

I also don't like the 0.355 MPa pressure reading on unit 1 yesterday that we talked about. Can't be much water going in as that's about the head the fire pump pushes. It might have stopped pressurizing because the core uncovered and so there's no more steam production?? Or leak rate of containment has matched steam production at pressure (don't containments usually leak 0.5 % /day at pressure).

These are some questions, none of them good.

Thanks
Mitr

From: Grandy, Christopher
Sent: Friday, March 25, 2011 12:04 AM
To: Farmer, Mitchell T.
Cc: Taiwo, Temitope A.; Yang, Won Sik
Subject: FW: Results of Nuclide Analysis

They are also seeing Ru isotope in the seawater and in the air now.

Chris

2/185

From: Yang, Won Sik
Sent: Thursday, March 24, 2011 5:57 PM
To: Taiwo, Temitope A.
Cc: Grandy, Christopher
Subject: Results of Nuclide Analysis

Temi,

More results of nuclide analysis are in page 11 to 16. They have detected even La isotopes, indicating fuel melting according the correlation of group release and fuel temperature.

Won Sik

From: Taiwo, Temitope A.
Sent: Thursday, March 24, 2011 5:34 PM
To: Yang, Won Sik; Hoffman, Edward A.; Kim, Taek K.; Adduci, Joseph J.
Subject: FW: Check out these photos
FYI.

Temitope Taiwo
Argonne National Laboratory
9700 S. Cass Avenue,
Argonne, IL 60439-4842, U.S.A.
Taiwo@anl.gov<<mailto:Taiwo@anl.gov>>
(630) 252 1387

From: Grandy, Christopher
Sent: Thursday, March 24, 2011 2:51 PM
To: Taiwo, Temitope A.; Sofu, Tanju; Seidensticker, Ralph W.; Farmer, Mitchell T.
Subject: Check out these photos

Lee, Richard

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Friday, March 25, 2011 8:02 AM
To: Binder, Jeffrey L.
Cc: 'farmer@anl.gov'; 'johnE.Kelly@nuclear.energy.gov'; 'Bill.McCaughey@nuclear.energy.gov'; 'TOM.MILLER@nuclear.energy.gov'; 'Douglas.Burns@inl.gov'; 'Phillip.Finck@inl.gov'; 'elizabeth.connell@inl.gov'; Basu, Sudhamay; Tinkler, Charles; Lee, Richard; Flanagan, George F.
Subject: RE: Results of Nuclide Analysis

These reports have been consistently conflicting.

For example, Unit#2 has been reported as near zero gage (+/-) for many days.

--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Binder, Jeffrey L." <binderjl@ornl.gov>:

> Mitch
>
> Have you seen the various containment reports? They are bit
> conflicting. There also was a report last that one of the RPV
> pressures was sub atmospheric.
>
> I will call you in a bit.
>
> Jeff
>
> -----Original Message-----
> From: Farmer, Mitchell T. [<mailto:farmer@anl.gov>]
> Sent: Friday, March 25, 2011 07:42 AM Eastern Standard Time
> To: Binder, Jeffrey L.; johnE.Kelly@nuclear.energy.gov; McCaughey,
> Bill; Miller, Tom
> Cc: Douglas E Burns; Phillip J Finck; Connell, Elizabeth; Basu,
> Sudhamay; 'Tinkler, Charles'; 'Lee, Richard'; 'Michael Corradini';
> Flanagan, George F.
> Subject: FW: Results of Nuclide Analysis
>
> You should probably take a look at this. They are even detecting
> noble metals around the site (La, Ru) which are indicative of fuel
> melting. I'd ask Dana Powers to have a 5 minute look at these if you
> could Richard/Charlier/Sud; we need his opinion. Maybe he can tell
> from the La/Ru ratio whether there has been air ingress (if not, I
> think the ratio should be about what it is in irradiated fuel in
> general; if so, I'd expect Ru to be high as RuOx is quite volatile).
>
> I also don't like the 0.355 MPa pressure reading on unit 1 yesterday

2/186

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> teh head teh head teh fire pump pushes. It might have stopped
> pressurizing because teh core uncovered and so there's no more steam
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> at pressure).

> These are some questions, none of them good.

> Thanks
> Mitchr

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> Sent: Friday, March 25, 2011 12:04 AM
> To: Farmer, Mitchell T.
> Cc: Taiwo, Temitope A.; Yang, Won Sik
> Subject: FW: Results of Nuclide Analysis

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> From: Yang, Won Sik
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> Cc: Grandy, Christopher
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> Won Sik

> From: Taiwo, Temitope A.
> Sent: Thursday, March 24, 2011 5:34 PM
> To: Yang, Won Sik; Hoffman, Edward A.; Kim, Taek K.; Adduci, Joseph J.
> Subject: FW: Check out these photos

>
> FYI.
>
>
>
> Temitope Taiwo
> Argonne National Laboratory
> 9700 S. Cass Avenue,
> Argonne, IL 60439-4842, U.S.A.
> Taiwo@anl.gov
> (630) 252 1387
>
>
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> From: Grandy, Christopher
> Sent: Thursday, March 24, 2011 2:51 PM
> To: Taiwo, Temitope A.; Sofu, Tanju; Seidensticker, Ralph W.;
> Farmer, Mitchell T.
> Subject: Check out these photos
>
>
>
>
>
>

Lee, Richard

From: Lee, Richard
Sent: Friday, March 25, 2011 8:07 AM
To: Salay, Michael; Wagner, Katie
Subject: RE: RST Requested Evaluations to be Performed by RES

Mike:

DOE through ANL (Mitch Farmer) is doing the MCCI analysis. Mitch has a stand-alone model to do the analysis. Take to Sud if you needed to.

Sud and I had already on 3/23, ask Mike Corradini to start FCI analysis (with the cavity flooded), based on the discussion we had with Dana.

Richard

From: Salay, Michael
Sent: Friday, March 25, 2011 8:05 AM
To: Lee, Richard; Wagner, Katie
Subject: RE: RST Requested Evaluations to be Performed by RES

Katie/Richard,

FYI: I uploaded these documents to the EOC network two nights ago when I was there. Even though I mentioned it, the director on duty did not have time to respond and perhaps not process due to the high activity level. That didn't seem to be an effective communication pathway so officially they may be unaware. It is definitely good if they are communicated "officially".

The three documents are on the EOC network at M:/Shared/MCCI. There is an indication that the documents are restricted.

-Mike

Michael Salay
United States Nuclear Regulatory Commission Washington, DC 20555
MS: C3-C07M
michael.salay@nrc.gov<<mailto:mas10@nrc.gov>>
tel: 301-251-7543
fax: 301-251-7436

From: Lee, Richard
Sent: Wednesday, March 23, 2011 5:43 PM
To: Wagner, Katie
Cc: Salay, Michael
Subject: FW: RST Requested Evaluations to be Performed by RES

Katie:

This complete the RES/DSA response to this request. On item 4, we provided 2 documents on OECD-MCCI2 and Research Information Letter 0601 by Sud Basu

Richard

From: Lee, Richard

2/187

Sent: Wednesday, March 23, 2011 5:41 PM
To: RST01 Hoc
Cc: Wagner, Katie
Subject: RE: RST Requested Evaluations to be Performed by RES

Additional info. on OECD MCCI2 project.

4. NISA is interested to obtain any reference material regarding core-concrete interaction (not because they think they have a current issue but against that eventuality) including the conditions under which that occurs and any associated data.

Please note that Japan is one of the participants of OECD MCCI2 project.

Richard

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 5:39 AM
To: Lee, Richard
Cc: Gibson, Kathy; RST01 Hoc
Subject: FW: RST Requested Evaluations to be Performed by RES

From: Hoc, RST16
Sent: Wednesday, March 23, 2011 5:37 AM
To: RST01 Hoc
Subject: RST Requested Evaluations to be Performed by RES

RST Coordinator,

Please forward the e-mail text below to Richard Lee and cc: Kathy Gibson from RES.

Thank you,

RST Communicator

Dear Mr. Lee,

The Reactor Safety Team (RST) in the Operations Center has been given your name as the lead Point of Contact (POC) for the Office of Research to manage all incoming requests from the RST.

As such, here is a request to investigate the topics related to queries 1, 3, and 4 from our Site Team located over in Japan. FYI, this request was entered into the WEB EOC Task Tracker software as Record # 2098 on 3/22/2011 @ 11:42 AM. Items 2 and 5 have been evaluated by our team and other sources and have been determined to be complete and require no further action.

Per Site Team e-mail, they would like RST to provide input on the following:

1. Sea water injection continues to reactors 1-3. NISA is concerned about the radiolytic disassociation of H2 and O2. NISA would like NRC's perspective on the significance of this concern and how to treat this concern as they transition to freshwater injection.

2. At what point does salt deposits become a problem for flow during pending freshwater injection?
3. NISA is conducting simulations to project the extent of damage to fuel in the reactors. Has NRC developed any views on the extent of fuel damage?
4. NISA is interested to obtain any reference material regarding core-concrete interaction (not because they think they have a current issue but against that eventuality) including the conditions under which that occurs and any associated data.
5. In addition to the H₂/O₂ disassociation in item 1 above, they are concerned that there may be residual H₂ in the containments and welcome NRC's thoughts on how to treat such a condition.

The RST requests an progress update via e-mail, at least once daily in order for us to be able to track your progress for each of the three issues.

Thank you for your time and consideration.

Bill Roggenbrodt
RST Communicator
301-816-5504

Lee, Richard

From: Basu, Sudhamay
Sent: Friday, March 25, 2011 4:34 PM
To: Lee, Richard
Subject: FW: mark 1 containment - drywell
Attachments: Fukushima-FCl.ppt

Here it is - it is actually addressed to you.

-----Original Message-----

From: Michael Corradini [mailto:corradini@engr.wisc.edu]
Sent: Friday, March 25, 2011 12:00 AM
To: RICHARD Y LEE
Cc: Basu, Sudhamay
Subject: Re: mark 1 containment - drywell

Richard - Thanks for the schematic. I completed the nominal calcs.
Weak explosion

--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "RICHARD Y LEE" <rylm@cavtel.net>:

> Mike:
>
> Please see if the attached figure provides dimension info. on Fukushima.
>
> Richard
>

Lee, Richard

From: Basu, Sudhamay
Sent: Friday, March 25, 2011 5:02 PM
To: 'corradin@cae.wisc.edu'
Cc: Lee, Richard
Subject: RE: Re:

I will look for info.

-----Original Message-----

From: Michael Corradini [mailto:corradini@engr.wisc.edu]
Sent: Friday, March 25, 2011 4:27 PM
To: Basu, Sudhamay
Cc: Lee, Richard
Subject: RE: Re:

I am doing parametrics now. Kevin is helping Mitch. I agree that subcooled is not useful but the real effect on structure needs us to get the structural integrity of the pedestal and the drywell liner.

Any help there from others? I know this was done in the past - has Dana popped up? I was trying to reach him

--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Basu, Sudhamay" <Sudhamay.Basu@nrc.gov>:

> Mike - the presentation sent at 12:00 a.m.? Yes, I saw. Are you
> doing any parametric variation? For example, increasing the pool
> depth, increasing the melt mass (release diameter), increasing the
> superheat, etc. I suppose, the pool is at saturated condition - there
> is no point doing any subcooling variation or is there? For the base
> calculation, how did you get 0.6% efficiency? I suppose that is the
> ratio of kinetic energy (from impulse) to thermal energy. And the
> thermal energy is based on predominantly or entirely metallic melt
> (stainless steel) - is that right?

>
>

> -----Original Message-----

> **From:** Michael Corradini [mailto:corradini@engr.wisc.edu]
> **Sent:** Friday, March 25, 2011 4:03 PM
> **To:** Basu, Sudhamay
> **Subject:** Re:

>

> did you see my presentation i sent this morning? call if you'd like !!

> --

>

> Michael Corradini, Chair

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> Engineering Physics
> University of Wisconsin
> (608)263-1648 [Fax: 3-7451]
> corradini@engr.wisc.edu
> http://www.engr.wisc.edu/ep
>
>
> Quoting "Basu, Sudhamay" <Sudhamay.Basu@nrc.gov>:
>
>> Mike,
>>
>> Some drawings with dimension for Peach Bottom that I found in FSAR.
>> Hope this helps.
>>
>> Sud
>>
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>

Lee, Richard

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Friday, March 25, 2011 5:16 PM
To: Lee, Richard
Cc: Basu, Sudhamay
Subject: RE: Re:

thanks
--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

> Mike:
>
> Dana is on his way home after finishing teaching the course at NRC PDC.
>
> Richard
>
> -----Original Message-----
> From: Michael Corradini [mailto:corradini@engr.wisc.edu]
> Sent: Friday, March 25, 2011 4:27 PM
> To: Basu, Sudhamay
> Cc: Lee, Richard
> Subject: RE: Re:
>
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> subcooled is not useful but the real effect on structure needs us to
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> Michael Corradini, Chair
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> University of Wisconsin
> (608)263-1648 [Fax: 3-7451]
> corradini@engr.wisc.edu
> <http://www.engr.wisc.edu/ep>
>
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>> the base calculation, how did you get 0.6% efficiency? I suppose
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>> -----Original Message-----
>> From: Michael Corradini [mailto:corradini@engr.wisc.edu]
>> Sent: Friday, March 25, 2011 4:03 PM
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>> Subject: Re:
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>> Michael Corradini, Chair
>> Engineering Physics
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>> (608)263-1648 [Fax: 3-7451]
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>> Quoting "Basu, Sudhamay" <Sudhamay.Basu@nrc.gov>:
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>>> Mike,
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>>> Some drawings with dimension for Peach Bottom that I found in FSAR.
>>> Hope this helps.
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>>> Sud
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Lee, Richard

From: Basu, Sudhamay
Sent: Friday, March 25, 2011 5:51 PM
To: 'corradin@cae.wisc.edu'
Cc: Lee, Richard
Subject: SE impulse loading

Mike,

I was concentrating thus far on the liner. You brought up the subject of pedestal. Would you be able to convert your pressure plots to impulse and see what kind of impulse load you get. Pedestals cannot generally support large impulse load so toppling of the vessel may be a concern. On a separate note, your base case pool depth is 3 meter. I have seen some old calculations with 7 meter depth. This could be parameter variation as I previously suggested. Please take a look at the drawing I sent you today and see what is the maximum depth that can be accommodated without submerging the release point into water. My thinking is submerged release scenario may not produce a strong explosion but I may be wrong. Thanks for your help.

Sud

BTW – earlier reference I had seen indicates the pedestal will fail at about 125 kPa-s impulse. I am also looking for a paper Wiktor Frid presented years ago on structural integrity (perhaps at a meeting in Japan). Can't seem to find it now.

Andersen, James

From: Bowman, Gregory
Sent: Friday, March 25, 2011 5:13 PM
To: Baval, Rochelle; Laufer, Richard
Cc: Andersen, James
Subject: Scheduling Notes for Level III PRA and April 14 Japan Meeting
Attachments: Status on Japan Scheduling Note 03252011.docx; Draft Level 3 PRA Commission Meeting Scheduling Note 03252011.docx

Rochelle and Rich,

I attached the revised draft scheduling notes for the April 14 meeting on Japan and the July 28 meeting on Level III PRA.

For the Japan meeting, this will be slightly different than what was discussed at the meeting with the Chairman yesterday. Rob Lewis has been discussing this meeting with the Chairman's office, so the scheduling note has been refined a little based on those discussions. Rob spoke with Annette about this earlier today.

If you have any comments or questions, please let me know. Sorry for the delay in getting these to you – I know RES was working really hard on getting them both wrapped up as soon as they could.

Greg

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SCHEDULING NOTE

Title: BRIEFING ON THE STATUS OF EVENTS IN JAPAN AND DISCUSSION ON U.S. RADIATION PROTECTION STRATEGY IN EMERGENCY SITUATIONS (Public)

Purpose: Provide the Commission an update of the Japanese nuclear event, discuss NRC's radiation protection strategies in emergency situations, and hear a representative sample of external stakeholder viewpoints.

Scheduled: April 14, 2011
9:00am

Duration: Approx. 3 hours

Location: Commission Hearing Room, 1st fl. OWFN

<u>Participants:</u>	<u>Presentation</u>
<u>NRC Staff Panel</u>	30 mins.*
Robert Lewis , Acting Director, Division of Materials Safety and State Agreements, FSME <u>Topics:</u> <ul style="list-style-type: none">• Opening Remarks and Status of the Japanese Event• Overall Strategy of Radiation Protection in the United States<ul style="list-style-type: none">-Normal and Accident Conditions-NRC's Response to a Radiological Event-Use of Models and Source Term Determinations-Protective Action Strategies	30 mins.*
Commission Q & A	50 mins.
BREAK	5 mins.
<u>Stakeholder Panel</u>	40 mins.*
Edward Maher , President, Health Physics Society <u>Topic:</u> U.S. Response from an HPS Perspective	10 mins.*
John Boice , Scientific Director of the International Epidemiology Institute <u>Topic:</u> Epidemiological Consequences of Emergency Situations	10 mins.*

Richard Toohey, Oak Ridge Associate Universities <u>Topic:</u> TBD	10 mins.*
National Council on Radiation Protection and Measurements <u>Topic:</u> U.S. Response in Emergency Situations	10 mins.*
Commission Q & A	50 mins.
Discussion – Wrap-up	5 mins.

*For presentation only and does not include time for Commission Q & A's

Documents:

- TBD

Staff background material due to SECY: March 31, 2011.

Slides due to SECY: April 7, 2011.

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 9:09 AM
To: Gibson, Kathy
Subject: Sharing info. with DOE Science Council

Dear Kathy:

Sud and I had asked Mike Corradini to perform an assessment on Fuel coolant interaction analysis using the NRC TEXAS code. The base calculation (which Randy, Dana, Mike Salay, Sud and I) think could be perhaps the worst case scenario of melt (with stainless steel) coming out of one control rod drive (CRD) hole into a saturated pool of water about 6-7ft from the melt expelling from the CRD hole. The load calculated is not showing a problem in breaching the primary containment structure (for e.g, the liner - assuming that it is still in reasonable condition). Additional parametric studies are ongoing. I have provided the preliminary assessment to Mike Salay and Hossein already.

This is the case where the water did not completely flooded the reactor cavity. If the cavity is completely flooded, the FCI will not be an issue. I think, flooding the reactor cavity is being considered. I know MCCI analysis been carried out by Mitch Farmer (ANL) - which is a DOE directed analysis.

Your advise (and Brian Sheron one if you need to consult with him) is sought for us to share this FCI analysis with the Science Council through John Kelly This will give us some visibility on the pro-active analyses that are on-going at different labs directed by DOE.

Richard

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Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 3:25 PM
To: Esmaili, Hossein; Salay, Michael; 'mike.salay@gmail.com'
Subject: FW: Mark I failure

fyi

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 1:47 PM
To: Lee, Richard
Subject: Fw: Mark I failure

From: Tinkler, Charles
To: Gibson, Kathy
Sent: Sat Mar 26 13:23:10 2011
Subject: RE: Mark I failure

There was speculation that hydrogen explosion in the reactor building may have damaged the torus/suppression pool.

However, as I have noted and discussed with RST, the unit 3 torus pressure is 2 bar. So, it may be relatively minor damage since the pressure reading is above atmospheric. Leakage may be high on the torus. Alternatively, they may have had trouble closing a vent valve and that is what caused pressure to drop after explosion.

Evidence also suggests unit 3 containment may be flooded up to the drywell – maybe up as high as the RPV lower head. Drywell pressure is 1 bar and torus pressure is a little less than 2 bar. (suggests flooding). Other measurement also suggested flooding. Again we discussed with RST (I talked to Don Helton yesterday before he went on RST shift and he passed it along for their telecom to Japan) View was discussed with ET as well.

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 1:06 PM
To: Tinkler, Charles
Subject: Re: Mark I failure

What is the breach is in the suppression pool like they were saying for I think Unit 3 hydrogen explosion?

From: Tinkler, Charles
To: Gibson, Kathy
Sent: Sat Mar 26 13:03:47 2011
Subject: RE: Mark I failure

Sure, I will set up briefing

More background : Mark I liner failure during severe accidents is a longstanding issue going back 20 years (some plants made changes to reduce risk by adding curbs, others did not – risk was low enough. But it is the sort of thing that is likely to highlighted these days.

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Again, SOARCA has shown n that releases are not extreme because of fission products are deposited in suppression pool.

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 12:54 PM
To: Tinkler, Charles
Subject: Re: Mark I failure

Can you set up a briefing next week with me and Brian (and Jennifer if she's in) on accident progression in BWRs. I've had BWR training and was inspector at Hope Creek (and Brian has some BWR background) but a refresher of Mark I and severe accidents etc would be helpful - especially for all these Congressional calls Brian is doing. Thanks

From: Tinkler, Charles
To: Gibson, Kathy
Sent: Sat Mar 26 12:42:22 2011
Subject: Mark I failure

The Mark I containment is relatively vulnerable to drywell shell/liner melt thru – if the reactor vessel fails and if the drywell floor is dry (not flooded). It also depends if the drywell pedestal region has a large sump or if there are curbs. (design details)

Peach Bottom is fairly vulnerable , for SBO, if the RPV fails then the containment fails but most of the fission products are deposited in the suppression pool so the containment integrity is not so important at that stage.

SOARCA models containment failure but the fission product release is still relatively small because the fp's go to the pool.

Charles Tinkler
Charles.Tinkler@nrc.gov

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 8:53 AM
To: powerss@crossnet.org
Subject: FW: DW/SP dose information

Hi, Dana:

The info. we spoke about on isotopic measurements.

Richard

From: Salay, Michael
Sent: Saturday, March 26, 2011 6:25 AM
To: Lee, Richard
Cc: Wagner, Katie; dapower@sandia.gov
Subject: RE: DW/SP dose information

Note that this site also provides limited sampling info - I haven't seen gamma spectra or isotopic composition on the outside but it does provide isotopic concentration in the stagnant water on the basement floor of the turbine building of Unit 1 of Fukushima Dai-ichi Nuclear Power Station:

Radioactive Nuclide Concentration (Bq/cm³)

Cl-38 1.6×10⁶
As-74 3.9×10²
Y-91 5.2×10⁴
I-131 2.1×10⁵
Cs-134 1.6×10⁵
Cs-136 1.7×10⁴
Cs-137 1.8×10⁶
La-140 3.4×10²

From: Salay, Michael
Sent: Saturday, March 26, 2011 6:05 AM
To: Lee, Richard
Cc: Wagner, Katie
Subject: DW/SP dose information

I think I mentioned in one of my emails that I would provide dose information that I found. I believe it came from NISA. I didn't keep searching because they have since been releasing this information in English.

<http://www.nisa.meti.go.jp/english/index.html>

This is linked on the Fukushima SharePoint site.

-Mike

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Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:10 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council
Attachments: Fukushima-FCI.ppt

Brian:

Attached is the preliminary FCI analysis that would like to provide to NRC Op Center in case question on FCI is received. If you are at the Op Center, please provide to them.

Shortly, thereafter I will provide it to John Kelly.

Thanks, Richard

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:06 PM
To: Gibson, Kathy; Lee, Richard
Cc: Uhle, Jennifer
Subject: RE: Sharing info. with DOE Science Council

Richard, I agree with Kathy.

-----Original Message-----

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 10:35 AM
To: Lee, Richard
Cc: Sheron, Brian; Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Richard,

In general, if information is not proprietary or safeguards or otherwise restricted, we should share whatever information we have with those who can make use of it in the interest of site recovery and radiological safety. In this case, it can be shared. Also make sure Ops Center RST has whatever we have for their assessments. They can pass along to the site team whatever they think is useful.

Thanks,
Kathy

----- Original Message -----

From: Lee, Richard
To: Gibson, Kathy
Sent: Sat Mar 26 09:09:19 2011
Subject: Sharing info. with DOE Science Council

Dear Kathy:

Sud and I had asked Mike Corradini to perform an assessment on Fuel coolant interaction analysis using the NRC TEXAS code. The base calculation (which Randy, Dana, Mike Salay, Sud and I) think could be perhaps the worst case scenario of melt (with stainless steel) coming out of one control rod drive (CRD) hole into a saturated pool of water about 6-7ft from the

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melt expelling from the CRD hole. The load calculated is not showing a problem in breaching the primary containment structure (for e.g, the liner - assuming that it is still in reasonable condition). Additional parametric studies are ongoing. I have provided the preliminary assessment to Mike Salay and Hossein already.

This is the case where the water did not completely flooded the reactor cavity. If the cavity is completely flooded, the FCI will not be an issue. I think, flooding the reactor cavity is being considered. I know MCCI analysis been carried out by Mitch Farmer (ANL) - which is a DOE directed analysis.

Your advise (and Brian Sheron one if you need to consult with him) is sought for us to share this FCI analysis with the Science Council through John Kelly This will give us some visibility on the pro-active analyses that are on-going at different labs directed by DOE.

Richard

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:29 PM
To: Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

Thx, Kathy.
Richard

-----Original Message-----

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 4:18 PM
To: Lee, Richard; Sheron, Brian
Cc: Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Richard, you can send it. Email address is RST01.hoc@nrc.gov

----- Original Message -----

From: Lee, Richard
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Sent: Sat Mar 26 16:09:36 2011
Subject: RE: Sharing info. with DOE Science Council

Brian:

Attached is the preliminary FCI analysis that would like to provide to NRC Op Center in case question on FCI is received. If you are at the Op Center, please provide to them.

Shortly, thereafter I will provide it to John Kelly.

Thanks, Richard

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:06 PM
To: Gibson, Kathy; Lee, Richard
Cc: Uhle, Jennifer
Subject: RE: Sharing info. with DOE Science Council

Richard, I agree with Kathy.

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From: Gibson, Kathy
Sent: Saturday, March 26, 2011 10:35 AM
To: Lee, Richard
Cc: Sheron, Brian; Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Richard,

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2/197

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Thanks,
Kathy

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From: Lee, Richard

To: Gibson, Kathy

Sent: Sat Mar 26 09:09:19 2011

Subject: Sharing info. with DOE Science Council

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Richard

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:44 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

No impact of salt. Because, 30 years ago, FCI experiments with ejection into salt water was conducted at SNL (because of floating NPPs been considered at that time).. No affect were found between salt water and clean water.

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:40 PM
To: Lee, Richard
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

Remember that the lower head is filled with sea salt. Thus, the melt that relocates to the lower head will be mixed with a lot of sea salt. Do we understand what impact the salt has (or doesn't have) on steam explosion dynamics?

-----Original Message-----

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:10 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

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-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:06 PM
To: Gibson, Kathy; Lee, Richard
Cc: Uhle, Jennifer
Subject: RE: Sharing info. with DOE Science Council

Richard, I agree with Kathy.

-----Original Message-----

From: Gibson, Kathy
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To: Lee, Richard
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Subject: Re: Sharing info. with DOE Science Council

Richard,

2/198

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Kathy

----- Original Message -----

From: Lee, Richard
To: Gibson, Kathy
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Subject: Sharing info. with DOE Science Council

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Richard

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:46 PM
To: 'Kelly, John E (NE)'
Cc: 'Adams, Ian'; Wagner, Katie
Attachments: Fukushima-FCI.ppt

Dear John:

Attached is VGs discussing a question that may arise from flooding the Fukushima reactor cavity with water, and potential fuel coolant interaction may occur if melt breached the RPV and enter the reactor cavity.

As requested by NRC/RES, Prof. Mike Corradini had performed fuel coolant interaction analysis using the NRC TEXAS code. The base calculation we think could be perhaps the worst case scenario of melt (with stainless steel) coming out of one control rod drive (CRD) hole into a saturated pool of water about 6-7ft from the melt expelling from the CRD hole. The load calculated is not showing a problem in breaching the primary containment structure (for e.g, the liner - assuming that it is still in reasonable condition). Additional parametric studies are ongoing. This is the case where the water did not completed flooded the reactor cavity.

If the cavity is completely flooded, the FCI will not be an issue.

Impact of FCI in salt: NONE!!. Because, 30 years ago, FCI experiments with ejection into salt water was conducted at SNL (because of floating NPPs been considered at that time). No affect were found between salt water and clean water.

Richard

P.S. Our NRC FCI expert is Dr. Sud Basu (301-251- 7521)

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Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:56 PM
To: 'Dana Powers'
Subject: FW: Sharing info. with DOE Science Council

He's worry about the mixture containing salt, Do you think salt penetrate the molten melt?

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:54 PM
To: Lee, Richard
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

I'm not talking about ejecting melt into sea water. I'm saying that when the melt relocates from the core to the lower head it will encounter a lower head filled with sea salt as a result of cooling the core with sea water. Thus, the volume of salt mixing with the molten core material will be significant. This will affect the composition of the "corium" that is ejected.

-----Original Message-----

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:44 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

No impact of salt. Because, 30 years ago, FCI experiments with ejection into salt water was conducted at SNL (because of floating NPPs been considered at that time).. No affect were found between salt water and clean water.

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:40 PM
To: Lee, Richard
Cc: Uhle, Jennifer; Gibson, Kathy
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-----Original Message-----

From: Lee, Richard
Sent: Saturday, March 26, 2011 4:10 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

Brian:

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Z/200

Shortly, thereafter I will provide it to John Kelly.

Thanks, Richard

-----Original Message-----

From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:06 PM
To: Gibson, Kathy; Lee, Richard
Cc: Uhle, Jennifer
Subject: RE: Sharing info. with DOE Science Council

Richard, I agree with Kathy.

-----Original Message-----

From: Gibson, Kathy
Sent: Saturday, March 26, 2011 10:35 AM
To: Lee, Richard
Cc: Sheron, Brian; Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Richard,

In general, if information is not proprietary or safeguards or otherwise restricted, we should share whatever information we have with those who can make use of it in the interest of site recovery and radiological safety. In this case, it can be shared. Also make sure Ops Center RST has whatever we have for their assessments. They can pass along to the site team whatever they think is useful.

Thanks,
Kathy

----- Original Message -----

From: Lee, Richard
To: Gibson, Kathy
Sent: Sat Mar 26 09:09:19 2011
Subject: Sharing info. with DOE Science Council

Dear Kathy:

Sud and I had asked Mike Corradini to perform an assessment on Fuel coolant interaction analysis using the NRC TEXAS code. The base calculation (which Randy, Dana, Mike Salay, Sud and I) think could be perhaps the worst case scenario of melt (with stainless steel) coming out of one control rod drive (CRD) hole into a saturated pool of water about 6-7ft from the melt expelling from the CRD hole. The load calculated is not showing a problem in breaching the primary containment structure (for e.g, the liner - assuming that it is still in reasonable condition). Additional parametric studies are ongoing. I have provided the preliminary assessment to Mike Salay and Hossein already.

This is the case where the water did not completely flooded the reactor cavity. If the cavity is completely flooded, the FCI will not be an issue. I think, flooding the reactor cavity is being considered. I know MCCI analysis been carried out by Mitch Farmer (ANL) - which is a DOE directed analysis.

Your advise (and Brian Sheron one if you need to consult with him) is sought for us to share this FCI analysis with the Science Council through John Kelly This will give us some visibility on the pro-active analyses that are on-going at different labs directed by DOE.

Richard

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 6:16 PM
To: 'Dana Powers'
Subject: FW: SUMMARY NOTES to ORNL

fyi

-----Original Message-----

From: Michael Corradini [<mailto:corradini@engr.wisc.edu>]
Sent: Saturday, March 26, 2011 6:06 PM
To: Lee, Richard
Subject: RE: SUMMARY NOTES to ORNL

This will not likely generate a more energetic effect. It will be a dilution to the melt composition and energy. Think of this like any solid that must be melted and mixes with the melt. So no effect there.

So if it does stop the melt there with in-vessel retention (which I suspect it would), it would add to the melt volume as it remelts and mixes and dilutes the corium.

I would then expect it to lower the solidus temperature of the mixture. How much, I do not know, but we can see the effect on energetics by altering the solidus. Remember that the if we assume triggering (which we always do), steam explosions are a thermodynamic phenomenon altered minimally by local ht. transf.

--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

> Mike:
>
>
>
> Brian is asking about salt on the molten core materials, as stated
> below,
>
>
>
> I'm not talking about ejecting melt into sea water. I'm saying that
> when the melt relocates from the core to the lower head it will
> encounter a lower head filled with sea salt as a result of cooling the
> core with sea water. Thus, the volume of salt mixing with the molten
> core material will be significant. This will affect the composition of
> the "corium" that is ejected.
>
> Richard
>
>

Z/201

> From: Michael Corradini [<mailto:corradin@cae.wisc.edu>]
> Sent: Saturday, March 26, 2011 4:43 PM
> To: Lee, Richard
> Cc: Basu, Sudhamay
> Subject: SUMMARY NOTES to ORNL
>
>
>

Lee, Richard

From: Lee, Richard
Sent: Saturday, March 26, 2011 7:54 PM
To: Michael Corradini
Cc: Basu, Sudhamay
Subject: RE: FCI Parametric Analysese

Thx, Mike:
Richard

From: Michael Corradini [corradin@cae.wisc.edu]
Sent: Saturday, March 26, 2011 7:30 PM
To: Lee, Richard
Cc: Basu, Sudhamay
Subject: FCI Parametric Analysese

Gentlemen - Here is the latest with my parametrics. My conclusions stand. Mike

2/202

Lee, Richard

From: Lee, Richard
Sent: Sunday, March 27, 2011 5:13 PM
To: 'Dana Powers'
Subject: question

Hi, Dana:
Did you call in?
Richard

Z / 203

Andersen, James

From: Evans, Michele
Sent: Sunday, March 27, 2011 7:22 PM
To: Merzke, Daniel; Virgilio, Martin; Weber, Michael; Ash, Darren
Cc: Borchardt, Bill; Muessle, Mary; Andersen, James
Subject: RE: Draft Note to Chairman on Recommended Staffing for Japan Event

Dan,

Some general comments:

- I think we need clearer definition of what our role is. I get the impression that managers on shift may interpret the broader statements differently.
- Whichever option is taken for Ops Center staffing, I'd recommend going to 2 shifts, 10 hours each, to reduce the number of shifts and turnovers needed. Hours could be 4 pm to 2 am and 2 am to noon. This would match up with Japan work time. However, would leave no one for the Chairman to call between noon and 4 pm, but this should be manageable.
- If we use the option of "Expanded" ET functions as a coordination center, is it really feasible to have this staffed by DEDO or OD? I'd recommend identifying 4 individuals (DEDO, OD or deputy OD) who can do this for two weeks as their primary jobs. This would reduce the change in leadership and enable better consistency.
- The note from the chairman asked for short and long term options for task team staffing. Task team staffing is not addressed in this paper.

Michele

From: Merzke, Daniel
Sent: Friday, March 25, 2011 3:29 PM
To: Virgilio, Martin; Weber, Michael; Ash, Darren; Evans, Michele
Cc: Borchardt, Bill; Muessle, Mary; Andersen, James
Subject: Draft Note to Chairman on Recommended Staffing for Japan Event

The Chairman requested a paper by COB on Monday with options and recommendations for short- and long-term staffing of the site team and Operations Center supporting the Fukushima event. Attached is a first draft. If you can, please review and provide any comments to me Monday morning. Thank you.

Dan

Lee, Richard

From: Lee, Richard
Sent: Sunday, March 27, 2011 6:58 PM
To: 'Kelly, John E (NE)'
Subject: missed the firts few mintues of US - Japan disussions

John:

I missed the first few minutes of the conference call since the call in number was changed. I got in the end of where Dr. Kondo was going through a list of proprieties that they are addressing. Please let me know what they are.

Thanks,
Richard

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 9:32 AM
To: 'Dana Powers'; 'Powers, Dana A'
Subject: FW: reactor#3 and others

So, when does the RPV will disappear? Soon!!

-----Original Message-----

From: Per F. Peterson [mailto:peterson@nuc.berkeley.edu]
Sent: Sunday, March 27, 2011 5:25 PM
To: DL-NITSolutions
Subject: Fwd: reactor#3 and others

I am forwarding this email from Professor Tom Devine, a colleague in Materials Science and Engineering at UC Berkeley who has extensive experience in corrosion processes in light water reactor systems. He expresses strong concern about the likelihood of very rapid stress corrosion cracking in the reactor primary system (0.8 cm/day), given the high concentration of chloride in the reactor coolant. He believes that it is urgent to begin flushing salt water out of these systems. I think that it is worthwhile to take this concern seriously.

-Per

>Date: Fri, 25 Mar 2011 09:57:48 -0700
>Subject: reactor#3 and others
>From: devine@berkeley.edu
>To: Peterson@nuc.Berkeley.edu

>
>-----

>Per,

>
>I'm troubled by the report I just heard on CNN, which indicated that Co
>was in the ocean adjacent to the plant and in the water that burned the
>three workers. Apparently the workers were exposed to Co-containing
>water while in the turbine room. The presence of Co at these two
>locations suggests that water from the core is releasing into the ocean
>and into the turbine room.

>
>The cause of the leak(s) might be pipes that were cracked during the
>hydrogen explosions. Alternatively, the leak(s) might be due to
>corrosion and/or stress corrosion cracking. The possibility of
>corrosion and scc must be urgently addressed.

>
>The email that I sent to you one week
>ago was prompted by our parking-lot discussion in which you mentioned
>the amount of salt water that was being used to cool the reactors. My
>concern then was that the chloride would cause stress corrosion
>cracking of the stainless steel cladding that coats the inside of the
>RPV and of stainless steel piping that is part of the cooling system.
>I indicted that an upper limit SCC velocity of about 0.8 cm/day in
>stainless steel exposed to hot aqueous chloride. Hot aqueous chloride
>would severely corrode, and possibly crack, low alloy steel and carbon
>steel, especially if oxygen (from air) is also present.

Z/206

>The only sure way of stopping SCC is to remove the stress. In this
>case removing the stress might not be possible because the highest
>stresses are most likely residual. Furthermore, the carbon steel and
>low alloy steel are susceptible to very high corrosion rates in high
>temperature aqueous chloride, so if cracks have penetrated the RPV
>cladding then corrosion of the low alloy steel is as much of a potential problem as is SCC.
>
>The steam lines going from the RPV to the turbine are carbon steel, so
>hot aqueous chloride can be expected to severely corrode and possibly
>crack the steam lines.
>
>At this point the best remedial action to take is to get rid of the salt.
>Probably the only way to do it is by dilution: flooding the reactor
>with salt-free water. In my view it is extremely urgent that the
>chloride be removed asap. Can you communicate this message to someone in authority?
>
>Tom

--

Per F. Peterson
Professor and Chair
Department of Nuclear Engineering
University of California
4153 Etcheverry Hall
Berkeley, California 94720-1730
peterson@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 9:34 AM
To: 'Binder, Jeffrey L.'
Subject: RE: Diagram of Fukushima No. 1

Jeff;
Thanks for all the transmittal. Appreciate it.
Richard

-----Original Message-----

From: Binder, Jeffrey L. [mailto:binderjl@ornl.gov]
Sent: Sunday, March 27, 2011 5:06 PM
To: Kelly, John E (NE); Connell, Elizabeth; Lee, Richard
Cc: Peltz, James; tom.miller@hq.doe.gov
Subject: RE: Diagram of Fukushima No. 1

Richard:

I am going to send you a bunch of drawings that Tom Miller was able to obtain. There will be a series of emails.

Jeff

From: Kelly, John E (NE) [JohnE.Kelly@Nuclear.Energy.Gov]
Sent: Sunday, March 27, 2011 4:54 PM
To: Connell, Elizabeth; Binder, Jeffrey L.
Cc: Peltz, James
Subject: FW: Diagram of Fukushima No. 1

if we have this can one of you take care of it

From: Lee, Richard (NRC)
Sent: Friday, March 25, 2011 5:33 PM
To: Kelly, John E (NE)
Subject: Diagram of Fukushima No. 1

John:

We would like to get details electronics drawings of plant and the spent fuel pools of all 4 units.

Thanks, Richard

2/207

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 11:02 AM
To: 'Binkley, Steve'
Cc: 'Adams, Ian'
Subject: FW: Accident Scenarios During Recovery - Fire

Hi, Steve:

Please forward the following message to the DOE Science Council members. Appreciate it.

Best regards,
Richard

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Monday, March 28, 2011 10:55 AM
To: Lee, Richard; Kelly, John E (NE)
Subject: Accident Scenarios During Recovery - Fire

Richard, John,

An important scenario to consider in the recovery of Fukushima with all the ad hoc activity underway is the possibility of fire in electrical equipment that initiates "hot shorts" and spurious actuation of equipment. This could include plant equipment not being used in the recovery process. I think it will be very important for TEPCO to establish a fire marshal and carefully consider scenarios with spurious actuations of equipment. This will not happen in the normal course of events. Dana

2/208

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 11:07 AM
To: RST01 Hoc
Cc: Wagner, Katie; Gibson, Kathy; Scott, Michael; Elkins, Scott; Hoxie, Chris
Subject: FW: Accident Scenarios During Recovery - Fire

Please note the following concerns that we should advise TEPCO on.

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Monday, March 28, 2011 10:55 AM
To: Lee, Richard; Kelly, John E (NE)
Subject: Accident Scenarios During Recovery - Fire

Richard, John,

An important scenario to consider in the recovery of Fukushima with all the ad hoc activity underway is the possibility of fire in electrical equipment that initiates "hot shorts" and spurious actuation of equipment. This could include plant equipment not being used in the recovery process. I think it will be very important for TEPCO to establish a fire marshal and carefully consider scenarios with spurious actuations of equipment. This will not happen in the normal course of events. Dana

21 / 209

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 11:13 AM
To: 'Dana Powers (Home)'; 'Dana Powers (SNL)'
Subject: FW: Results of Nuclide Analysis

Dana:

I think you have seen this. Any comments?

Richard

-----Original Message-----

From: Binder, Jeffrey L. [<mailto:binderjl@ornl.gov>]
Sent: Friday, March 25, 2011 7:48 AM
To: 'farmer@anl.gov'; 'johnE.Kelly@nuclear.energy.gov'; 'Bill.McCaughey@nuclear.energy.gov'; 'TOM.MILLER@nuclear.energy.gov'
Cc: 'Douglas.Burns@inl.gov'; 'Phillip.Finck@inl.gov'; 'elizabeth.connell@inl.gov'; Basu, Sudhamay; Tinkler, Charles; Lee, Richard; 'corradin@cae.wisc.edu'; Flanagan, George F.
Subject: RE: Results of Nuclide Analysis

Mitch

Have you seen the various containment reports? They are bit conflicting. There also was a report last that one of the RPV pressures was sub atmospheric.

I will call you in a bit.

Jeff

-----Original Message-----

From: Farmer, Mitchell T. [<mailto:farmer@anl.gov>]
Sent: Friday, March 25, 2011 07:42 AM Eastern Standard Time
To: Binder, Jeffrey L.; johnE.Kelly@nuclear.energy.gov; McCaughey, Bill; Miller, Tom
Cc: Douglas E Burns; Phillip J Finck; Connell, Elizabeth; Basu, Sudhamay; 'Tinkler, Charles'; 'Lee, Richard'; 'Michael Corradini'; Flanagan, George F.
Subject: FW: Results of Nuclide Analysis

You should probably take a look at this. They are even detecting noble metals around the site (La, Ru) which are indicative of fuel melting. I'd ask Dana Powers to have a 5 minute look at these if you could Richard/Charlier/Sud; we need his opinion. Maybe he can tell from the La/Ru ratio whether there has been air ingress (if not, I think the ratio should be about what it is in irradiated fuel in general; if so, I'd expect Ru to be high as RuOx is quite volatile).

I also don't like the 0.355 MPa pressure reading on unit 1 yesterday that we talked about. Can't be much water going in as that's about the head the fire pump pushes. It might have stopped pressurizing because the core uncovered and so there's no more steam production?? Or leak rate of containment has matched steam production at pressure (don't containments usually leak 0.5 % /day at pressure).

These are some questions, none of them good.

Thanks
Mitchr

Z/210

From: Grandy, Christopher
Sent: Friday, March 25, 2011 12:04 AM
To: Farmer, Mitchell T.
Cc: Taiwo, Temitope A.; Yang, Won Sik
Subject: FW: Results of Nuclide Analysis

They are also seeing Ru isotope in the seawater and in the air now.

Chris

From: Yang, Won Sik
Sent: Thursday, March 24, 2011 5:57 PM
To: Taiwo, Temitope A.
Cc: Grandy, Christopher
Subject: Results of Nuclide Analysis

Temi,

More results of nuclide analysis are in page 11 to 16. They have detected even La isotopes, indicating fuel melting according the correlation of group release and fuel temperature.

Won Sik

From: Taiwo, Temitope A.
Sent: Thursday, March 24, 2011 5:34 PM
To: Yang, Won Sik; Hoffman, Edward A.; Kim, Taek K.; Adduci, Joseph J.
Subject: FW: Check out these photos

FYI.

Temitope Taiwo
Argonne National Laboratory
9700 S. Cass Avenue,
Argonne, IL 60439-4842, U.S.A.
Taiwo@anl.gov
(630) 252 1387

From: Grandy, Christopher
Sent: Thursday, March 24, 2011 2:51 PM
To: Taiwo, Temitope A.; Sofu, Tanju; Seidensticker, Ralph W.; Farmer, Mitchell T.
Subject: Check out these photos

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 11:16 AM
To: Esmaili, Hossein; 'Gauntt, Randy (home)'; 'Randy Gauntt (SNL)'; Salay, Michael
Subject: FW: Cutaway of Mark I and RHR System
Attachments: Oyster Creek Cutaway.pdf; Hatch1RHRSpecs.pdf

fyi

From: Elizabeth A Connell [<mailto:Elizabeth.Connell@inl.gov>]
Sent: Friday, March 25, 2011 7:07 PM
To: DL-NITsolutions@nnsa.doe.gov
Subject: Cutaway of Mark I and RHR System

Attached please find the cutaway of the Mark I and information on the RHR system.

2/211

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 12:09 PM
To: 'Powers, Dana A'
Subject: RE: Input to DOE science council

Thx, Dana:
Richard

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Monday, March 28, 2011 12:02 PM
To: Lee, Richard
Subject: RE: Input to DOE science council

Richard, This looks fine. Dana

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Monday, March 28, 2011 7:04 AM
To: Powers, Dana A; Dana Powers
Subject: Input to DOE science council

Dear Dana:

Please review and revise the attached note so I can offer our input to the ongoing discussions.

Thanks, Richard

Z/212

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 12:22 PM
To: Basu, Sudhamay
Subject: FW: Brian's Q

fyi

-----Original Message-----

From: Lee, Richard
Sent: Sunday, March 27, 2011 6:44 PM
To: Gibson, Kathy
Subject: RE: Brian's Q

Sure as long as they burn for long time.

-----Original Message-----

From: Gibson, Kathy
Sent: Sunday, March 27, 2011 6:20 PM
To: Lee, Richard
Subject: Re: Brian's Q

Should I bring you aromatherapy candles? :-)

----- Original Message -----

From: Lee, Richard
To: Gibson, Kathy
Sent: Sun Mar 27 17:00:00 2011
Subject: RE: Brian's Q

Thanks, Kathy.

We are about to start the conference call with DOE. I am in my office and the overhead light does not work.

Richard

I need to bring in candles in case the conference call is later

-----Original Message-----

From: Gibson, Kathy
Sent: Sunday, March 27, 2011 4:56 PM
To: Lee, Richard
Subject: Fw: Brian's Q

Fyi - I've been sending so much stuff to Brian I think he loses track of where it came from. ;-)

----- Original Message -----

From: Sheron, Brian
To: Gibson, Kathy
Cc: Tinkler, Charles
Sent: Sun Mar 27 15:56:05 2011
Subject: RE: Brian's Q

Thanks.

-----Original Message-----

2/2/13

From: Gibson, Kathy
Sent: Sunday, March 27, 2011 10:41 AM
To: Sheron, Brian
Cc: Tinkler, Charles
Subject: Fw: Brian's Q

----- Original Message -----

From: Lee, Richard
To: Hoxie, Chris; Uhle, Jennifer
Cc: Gibson, Kathy
Sent: Sun Mar 27 10:35:35 2011
Subject: RE: Brian's Q

Consulted both Mike and Dana on the matter - Salt effects on molten core materials:

From Mike Corradini:

This will not likely generate a more energetic effect. It will be a dilution to the melt composition and energy. Think of this like any solid that must be melted and mixes with the melt. So no effect there. So if it does stop the melt there with in-vessel retention (which I suspect it would), it would add to the melt volume as it remelts and mixes and dilutes the corium.

I would then expect it to lower the solidus temperature of the mixture. How much, I do not know, but we can see the effect on energetics by altering the solidus. Remember that the if we assume triggering (which we always do), steam explosions are a thermodynamic phenomenon altered minimally by local heat transfer.

From: Dana Powers

Core debris will hit the salt and cause it to melt and vaporize. Some fraction of it will be incorporated into the core debris, but much will vaporize - removing heat from the core debris. Vaporized salt will condense on upper internals of the BWR vessel. Salt in the core debris will cause some vaporization of materials - including some fission products - as chlorides, but I would not expect the effect to be especially significant. Again vaporized chlorides will condense on upper internal surfaces.

From: Hoxie, Chris
Sent: Saturday, March 26, 2011 9:41 PM
To: Uhle, Jennifer
Cc: Lee, Richard; Gibson, Kathy
Subject: Brian's Q

In regards to Brian's question about how salt water may influence the dynamics of a fuel coolant interaction:

Here are two references:

http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/42/006/42006251.pdf

On page 396, states that pure water vs. salt water made no difference in an experiment designed to measure peak pressures for fuel coolant interactions in a lab setting.

• Reference 2:

Although it might not be one-for-one, here is a reference to research that indicates the salt might actually dampen the steam explosion (or at least it does maybe when lava hits sea water...)

Caveats: This reference 2 is not nuclear oriented. Not specific to the Japan case. This is really complex and should be answered by an expert. Depends so much on the actual conditions in the Japan plants...

At least I did not find anything that says salt makes things worse!

Impure coolants and interaction dynamics of phreatomagmatic eruptions

James D. L. White E-mail The Corresponding Author, *

Geology Department, University of Otago P.O. Box 56, Dunedin 9015, New Zealand

Received 12 January 1996;

revised 18 June 1996;

accepted 18 June 1996. ;

Available online 26 February 1999.

Abstract

Phreatomagmatic eruptions resulting from interaction of magma with groundwater are common in many terrestrial settings, and their explosivity is widely accepted to result from fuel-coolant interaction (FCI) processes. Relatively little attention has been given to the precise nature of the volcanic settings in which phreatomagmatic FCI's take place, but several lines of evidence indicate that they almost inevitably involve mixing of magma with impure, sediment-laden water. Consideration of the effects of these impure coolants on the fuel-coolant interaction process suggests that: (1) impure coolants enhance the ability of magma to mix with large volumes of coolant; and (2) maximum unit-volume explosivity of FCI's is damped relative to interactions with pure water. It is probably unrealistic to back-calculate water-magma mass ratios for most, if not all, phreatomagmatic eruptions because: (1) effects of impure coolants on fragmentation efficiency and eruption explosivity are not yet known; and (2) aspects of the vent environments in which phreatomagmatism occurs may influence fragmentation processes, explosive efficiency, and resultant particle populations as or more strongly than water-magma mass ratios. To estimate mass ratios for individual bursts, or for eruptions as a whole, one must distinguish particle populations resulting from many different processes in phreatomagmatic vents, including primary fragmentation, induced fragmentation, vent-wall collapse and pyroclast recycling. Incorporation of accidental blocks beyond the zone of phreatomagmatic interaction and ejection of unvaporized water further complicate efforts at reconstruction.

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 3:06 PM
To: 'Powers, Dana A'
Subject: RE: Salt Beds and Core Melts

Please send bill for psychologist consultation. And, our contract people will reject the payment requested.

Alternative: Have Richard Garwin talk to you for an hour?

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Monday, March 28, 2011 3:03 PM
To: Lee, Richard
Subject: RE: Salt Beds and Core Melts

Cry!?! No, I will need immediate therapy by overpriced psychologists of international reputation. Dana

-----Original Message-----

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Monday, March 28, 2011 1:00 PM
To: Powers, Dana A
Subject: RE: Salt Beds and Core Melts

No call today. I know you going to cry!

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Monday, March 28, 2011 2:52 PM
To: Lee, Richard
Subject: RE: Salt Beds and Core Melts

I'm sure pictures have suffered the fate of the Dodo bird, since the test was done back in the CRBR days. I think we gave a conference paper on the test. I will look, but it may take a while.

Did I understand correctly that we are NOT doing the call-in today?
Dana

-----Original Message-----

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Monday, March 28, 2011 10:56 AM
To: Powers, Dana A
Subject: RE: Salt Beds and Core Melts

Dana:

Do you have summary documents and pictures from these test? If you can compose a page or 2, I can send it to the DOE Science Council. Thx.

Richard

2/2/14

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]

Sent: Monday, March 28, 2011 12:34 PM

To: Lee, Richard

Subject: Salt Beds and Core Melts

Richard, A usual core melt scenario for a BWR has individual assemblies slumping into the lower head where they quench because of all the water and steel structures (CRDs and instrument tubes) in the lower head. Then, if coolability cannot be maintained there is remelting beginning with the metals (stainless steel alloyed with residual cladding and channel box alloys). It is this metal melt that attacks the lower head usually at an instrumentation tube.

The presence of a large salt bed might alter this. Salt melts at a relatively low temperature with a middle of the road heat of fusion. The molten salt would act as a working fluid to dissipate the decay heat. We did a fairly large scale test of this type with borax (sodium borate) rather than salt. We got beautiful Bernard convection cells - lovely pentagrams. The steel within the molten borax had a solid crust and was molten within this crust. Wonder if the same behavior would be realized in salt? Dana

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 7:55 PM
To: Gauntt, Randall O
Subject: RE: NRC source term estimates (Japan response)

O.K. Thanks.

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Monday, March 28, 2011 7:50 PM
To: Lee, Richard
Subject: RE: NRC source term estimates (Japan response)

I was talking mostly to Jason Schaperow but Michelle Hart was also there. There was a Rascal person who I don't know who was actually entering the data. They were running RASCAL I understand and said something about sending to NARAC as well.

Randy

-----Original Message-----
From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Monday, March 28, 2011 5:47 PM
To: Gauntt, Randall O
Subject: RE: NRC source term estimates (Japan response)

Randy:

Who is "they?" You meant the RST team!

Have you shown the new calculations to RST (Steve, Michelle,,), or only to Charlie and Jason?

Richard

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Monday, March 28, 2011 7:45 PM
To: Lee, Richard
Subject: RE: NRC source term estimates (Japan response)

Richard,
I think that Steve's reference to "supercore" is a source term that they constructed based on 1) the MELCOR Peach Bottom LTSBO source terms (scaled for Fukushima core) and 2) a MELCOR Peach Bottom Spent Fuel Pool boil down source terms, again scaled for the Fukushima pools. I believe that they used these to hypothesize what if they have a reactor source term and in addition superimposed subsequent source terms for several pools having uncovering accidents spaced maybe a day apart. We provided isotope inventories based on Unit 4 pool having both 105 day and 300 day offload fuel, and the other SFP have only 300+ day offload fuels.

We now have updated SFP analysis for the unit 4 pool.

Randy

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Monday, March 28, 2011 11:53 AM
To: Gauntt, Randall O
Subject: FW: NRC source term estimates (Japan response)

2/215

Please explain when you have a chance. Thx.

From: Arndt, Steven
Sent: Monday, March 28, 2011 1:29 PM
To: Tinkler, Charles
Cc: Lee, Richard; Schaperow, Jason; Marksberry, Don
Subject: FW: NRC source term estimates (Japan response)

Charley,

It looks like we are playing phone tag. I think the e-mail update from the PMT, below, resolves the issue I was trying to run down for the ET. I would like to have a short discussion with you (and the others) to make sure, we are all on the same page.

Please e-mail me when and where to call to have this short discussion.

Thanks,

Steven

From: PMT11 Hoc
Sent: Monday, March 28, 2011 12:54 PM
To: narac@11nl.gov; cmht@nnsa.doe.gov; FOIA Response.hoc Resource
Cc: PMT11 Hoc; PMT02 Hoc; PMT09 Hoc; PMT11 Hoc; Batkin, Joshua; Arndt, Steven
Subject: NRC source term estimates (Japan response)

--- THIS IS A MONITORING OPERATION FOR THE FUKUSHIMA REACTOR IN JAPAN ---

On 3/17 and 3/18, NRC provided NARAC with a source term that came to be known as "supercore." This source term included contributions from the Unit 2 reactor, and releases from the Unit 3 and Unit 4 spent fuel pools.

With regard to the Unit 4 spent fuel pool, the NRC had been provided information that the fuel in the Unit 4 pool had only decayed for about 30 days. This assumption was used in generating the supercore source term. The NRC subsequently learned from another source that the fuel had about 105 days of decay. As a result of the shorter decay period, the inventory of short term radionuclides in the Unit 4 SPF would have been greater than necessary, a conservative situation. To put this into perspective, I-131 has a 8.5 day half-life. In thirty days, there would have been about four half-lives, compared to about 13 half-lives for 105 days.

This discrepancy does not affect the plausible realistic case source term sent to NARAC on 3/24/2011 since the fuel pools were not included in that case.

Accordingly, the supercore source term should not be used for analyses moving forward. Since the plausible realistic case source term replaces the supercore, it should be used for analyses moving forward. NRC is not planning to revise the supercore source term.

Stephen F. LaVie
Radiological Assessment Assistant Director Protective Measures Team U.S. Nuclear Regulatory Commission.

This is a MONITORING OPERATION FOR THE JAPAN EARTHQUAKE TSUNAMI AFTERMATH.

Please reply to this email to acknowledge receipt.

This information should not be released at this time.

--- THIS IS A MONITORING OPERATION FOR THE FUKUSHIMA REACTOR IN JAPAN ---

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 1:52 PM
To: Esmaili, Hossein; Salay, Michael
Subject: FW: NRC source term estimates (Japan response)

fyi

From: Arndt, Steven
Sent: Monday, March 28, 2011 1:29 PM
To: Tinkler, Charles
Cc: Lee, Richard; Schaperow, Jason; Marksberry, Don
Subject: FW: NRC source term estimates (Japan response)

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To: narac@llnl.gov; cmht@nnsa.doe.gov; FOIA Response.hoc Resource
Cc: PMT11 Hoc; PMT02 Hoc; PMT09 Hoc; PMT11 Hoc; Batkin, Joshua; Arndt, Steven
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2/216

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Radiological Assessment Assistant Director
Protective Measures Team
U.S. Nuclear Regulatory Commission.

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--- THIS IS A MONITORING OPERATION FOR THE FUKUSHIMA REACTOR IN JAPAN ---

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 2:43 PM
To: Sheron, Brian
Subject: subsequent telecon with Japan ~~000~~

Brian:

After yesterday teleconference with the DOE Science Council, at the request of Dr. Holdrens (White House Science Advisor), a conference call to Japan was placed. The purpose (as I understood) of the U.S. and Japan conference call is to open a channel to make technical inquiries to a few key persons in Japan to gather information on Fukushima. The information gathered is to assist the on-going technical discussions among DOE Science Council members. This daily conference call is scheduled for ½ hour.

On the U.S. side, Secretary Chu with a few members of his team at DOE Headquarter, Dr. Holdrens, and NRC (Brain McDermott, Richard Lee). On the Japanese side, I only heard Dr. Shunsuke Kondo, Chairman of the Japan Atomic Energy Commission. Steve Chu asked Prof. Kondo on who else from Japan should participate. He recommended to include Commissioner Omoto (of JAEC, I think that what he said) and will think of who else should participate.

U.S. asked in case the radiation level is so high that on-site work cannot be carried out, is there "remote monitor and control panel" at Fukushima plants. Prof. Kondo said he has already asked the same question, but have not received an answer! During further discussion, Prof. Kondo said Unit 2 & 3, the primary containment were breached (inferred from the atmospheric pressure measurements), thereby allowing radionuclides leakage to the turbine building. Leakage into the turbine building is worst for Unit 2 as compared to Unit 3.

Kondo mentioned that he going to advise the Japanese PM to consider the "final plan" (which I do not know what it is) in case the situation get worst. I understood the Japanese PM called Secretary Chu yesterday (apparently discussed long term recovery issues).

Two main things resulting from the conference call – U.S. to (a) formulate SFP water level measurement and replenishment, (b) provide waste storage tanks.

Prof. Kondo concurred with U.S. pursuing these 2 items.

Next call: Tomorrow – right after the DOE Science Council conference call.

Richard

2/2/17

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 2:50 PM
To: 'Binder, Jeffrey L.'
Subject: RE: Diagram of Fukushima No. 1

Thx, Jeff.
Richard

-----Original Message-----

From: Binder, Jeffrey L. [<mailto:binderjl@ornl.gov>]
Sent: Monday, March 28, 2011 2:48 PM
To: Lee, Richard
Subject: RE: Diagram of Fukushima No. 1

I checked, I think I sent everything I got. I will send on as I get.

From: Lee, Richard [Richard.Lee@nrc.gov]
Sent: Monday, March 28, 2011 2:46 PM
To: Binder, Jeffrey L.
Subject: RE: Diagram of Fukushima No. 1

Great, thanks.

-----Original Message-----

From: Binder, Jeffrey L. [<mailto:binderjl@ornl.gov>]
Sent: Monday, March 28, 2011 2:08 PM
To: Lee, Richard
Subject: RE: Diagram of Fukushima No. 1

some are, some are not. I would not assume at least it says explicitly F1. They are either Unit 1 or 2, these are the only ones GE designed.

I think there may be more - that i will send now.

From: Lee, Richard [Richard.Lee@nrc.gov]
Sent: Monday, March 28, 2011 1:11 PM
To: Binder, Jeffrey L.
Subject: RE: Diagram of Fukushima No. 1

Jeff:

I assume these diagrams and specs. are applicable to Fukushima. Am I correct?

Richard

-----Original Message-----

From: Binder, Jeffrey L. [<mailto:binderjl@ornl.gov>]
Sent: Sunday, March 27, 2011 5:06 PM
To: Kelly, John E (NE); Connell, Elizabeth; Lee, Richard
Cc: Peltz, James; tom.miller@hq.doe.gov
Subject: RE: Diagram of Fukushima No. 1

2/218

Richard:

I am going to send you a bunch of drawings that Tom Miller was able to obtain. There will be a series of emails.

Jeff

From: Kelly, John E (NE) [JohnE.Kelly@Nuclear.Energy.Gov]
Sent: Sunday, March 27, 2011 4:54 PM
To: Connell, Elizabeth; Binder, Jeffrey L.
Cc: Peltz, James
Subject: FW: Diagram of Fukushima No. 1

if we have this can one of you take care of it

From: Lee, Richard (NRC)
Sent: Friday, March 25, 2011 5:33 PM
To: Kelly, John E (NE)
Subject: Diagram of Fukushima No. 1

John:

We would like to get details electronics drawings of plant and the spent fuel pools of all 4 units.

Thanks, Richard

Lee, Richard

From: Lee, Richard
Sent: Monday, March 28, 2011 9:22 PM
To: danapowers@msn.org; dapower@sandia.gov
Subject: FW: Re: Salt water corrosion

Dana:

At this rate, the vessel should disappear soon!!

Richard

From: Per F. Peterson [peterson@nuc.berkeley.edu]
Sent: Monday, March 28, 2011 7:59 PM
To: SCHU; Garwin, Dick (IBM); Binkley, Steve; Brinkman, Bill; Binder, Jeff; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; Connell, Elizabeth; McFarlane, Harold; 'Harold Denton'; Adams, Ian; John Holdren; 'JOE H. PAYER'; Kelly, John E (NE); Grossenbacher, John (INL); Owens, Missy; Peterson, Per; Lyons, Peter; Finck, Phillip; Garwin, Dick (EOP); Lee, Richard; Budnitz, Bob; Szilard, Ronaldo; Aoki, Steven; Koonin, Steven; Steve Fetter; Binkley, Steve; DAgostino, Thomas
Subject: Fwd: Re: Salt water corrosion

As a follow-up to Steve Chu's note on oxygen, Tom Devine at UC Berkeley also identifies oxygen as a key problem for accelerated corrosion. Corrosion will emerge as the most important longer-term risk factor, since integrity of the reactor containment is essential to maintaining flooding of the drywell and heat removal from the reactor vessel.

Now that the transition to fresh water has been achieved (something we identified early on as an important risk-reduction step), one of the most important risk-reduction opportunities now available is to expedite the installation of equipment to strip oxygen from water injected into the reactor vessels and primary containments.

I note an important in Tom's email, that CO₂ can have a beneficial and protective effect for corrosion. This suggests that it would be better to use CO₂ as an inerting agent to inject into the reactor feedwater, rather than nitrogen. CO₂ can serve as an inerting agent, but also should have useful effects in inhibiting corrosion.

-Per

>Date: Mon, 28 Mar 2011 08:07:02 -0700
>Subject: Re: Salt water corrosion
>From: devine@berkeley.edu
>To: "Per F. Peterson" <peterson@nuc.berkeley.edu>

>
>Per,
>
>The critical parameters that will determine the appropriate material
>for storing aqueous waste are: the water's: dissolved oxygen concentration,
>temperature, pH and chloride ion concentration. For example, carbon
>steel can be protected against corrosion in 65°C water that contains
>0.4M chloride (i.e., greater than sea water) and is saturated with CO₂
>(so it is acidic). However, in this case it is critically important
>that the water is free of oxygen (as it is saturated with CO₂) and
>organic corrosion inhibitors have been added. This example illustrates

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>the interplay between the environment's chemistry (in this case, the
>absence of dissolved oxygen permits the use of carbon steel along with
>corrosion inhibitors, despite the presence of high chloride
>concentration and a pH of about 5), the appropriate material and the
>required protective measure (organic inhibitors).
>
>As you have pointed out, titanium would be a good choice. In over 70
>years of use of titanium in a range of environments and applications
>there has never been a single reported instance of crevice corrosion or
>pitting corrosion of titanium at temperatures below 80°C.
>
>The family of Ni-Cr alloys should be considered. Recall that Alloy C22
>(a Ni-Cr-Mo alloy) was selected by DOE for long-term storage of waste
>at Yucca Mtn. Cobalt-chromium alloys would also be effective, but
>should be ruled out on the basis of cost/availability.
>
>Depending on the storage time, there are stainless steels that should
>also be considered.
>
>In summary, there are a number of options available. IN particular,
>there are a number of corrosion-resistant alloys that should be
>considered as well as carbon steel that is protected by organic
>inhibitors, or cathodic protection. I can suggest specific alloys
>and/or methods of protecting carbon steel once I know the chemistry of the water.
>
>Tom
>
>> Tom,
>>
>> One of the major elements of remediating the reactors at Fukushima
>> will involve flushing high activity, corrosive fluids out of the
>> reactor vessel into some type of storage tank(s), with an evaporator
>> system to concentrate the fluids and to recycle the condensate for
>> further flushing.
>>
>> Currently the turbine condensers are being used for storage of
>> low-activity fluids (see below).
>>
>> The storage tanks for high activity fluids will need to have life
>> spans of at least a few years. This raises the question of what
>> materials can be used an how corrosion can be managed. Commonly for
>> salt water service one would use coatings, but I expect that these
>> would not survive well in a high radiation environment. Titanium has
>> excellent salt-water resistance, but I'm not sure if it is a
>> practical material to use to use for tanks that need to be acquired
>> on an expedited basis. An alternative is to attempt to use existing
>> tanks at the site; these might be carbon steel or stainless steel.
>>
>> Could you provide advice on potential materials to use for such
>> storage tanks? If carbon steel or stainless steel end up being the
>> only practical options, are there methods that might be used to
>> mitigate corrosion (e.g., cathodic protection), and what would the
>> thickness need to be to assure several years of service life?
>>
>> -Per
>>
>>

>>
>>>Date: Sun, 27 Mar 2011 20:50:09 -0700
>>>To: "Gehin, Jess C." <gehinc@ornl.gov>
>>>From: "Per F. Peterson" <peterson@nuc.berkeley.edu>
>>>Subject: Re: Hydrogen
>>>
>>>Jess,
>>>
>>>Below is my assessment of the major actions needed to remediate these
>>>reactors. Getting the refueling crane out of the way in Unit
>>>3 will be important (I'm pretty sure that the 100 ton reactor crane
>>>would not have been parked above the pool). Hopefully the pool is
>>>not leaking and can be refilled enough to reduce radiation levels to
>>>assist with the effort to remove this debris, including cutting up
>>>the crane system so it can be lifted out.
>>>
>>>The turbine condensers are an ok place to flush low-activity fluids
>>>to. In the longer term evaporators will be needed to concentration
>>>these solutions and produce condensate that can be used in additional
>>>flushing operations. Shielded tanks (probably new) will be needed
>>>for high activity fluids flushed out of the reactors and
>>>containments.
>>>
>>>-Per
>>>
>>>
>>>
>>>Initial remediation efforts will involve flushing corrosive and
>>>radioactive fluids out of the primary systems and containments into
>>>storage tanks (potentially new tanks, similar to the waste tanks at
>>>Hanford and SRS), and the use of evaporators to concentrate this salt
>>>solution in the tanks and return condensate for additional
>>>flushing. Later on the salts can be processed into suitable waste
>>>forms using similar technologies to those used for the supernate
>>>fluids in U.S. defense waste tanks.
>>>
>>>In parallel remotely operated construction cranes will be used to
>>>remove debris from above and around spent fuel pools, and then the
>>>cranes will be used to transfer the fuel assemblies into lightly
>>>shielded baskets to be lowered into shielded casks on the ground.
>>>
>>>Once the spent fuel is moved and the systems have been extensively
>>>flushed to reduce radiation levels and to remove mobile
>>>contamination, core debris will be removed as was done at TMI.
>>>
>>>Currently this is my best projection of the sequence of actions
>>>needed to remediate these reactors.
>>>
>>>-
>>>
>>>>Per,
>>>>
>>>>Interesting theory. I happen to be watching NHK right now and there
>>>>seems to be a lot of discussion by a government official (chief
>>>>cabinet secretary Edano) about when the venting was ordered and when
>>>>it occurred. I was looking at the timelines on the BBC and
> >>>OECD sites and they indicate that there was venting before the

>>>>explosion in unit 1 and unit 3.
>>>>
>>>>He is also saying that the leak of the water to the TG building was
>>>>a "one-time" event. They are working to pump the water into the
>>>>condensers, but for unit 1 and 2 the condensers are full and they
>>>>need to dump them first.
>>>>
>>>>They have a university of tokyo professor that says the crane in
>>>>unit 3 has fallen into the pool and may have damaged some fuel.
>>>>They have some close-up video and images from what looks to be a
>>>>helicopter with a good zoom lens.
>>>>
>>>> -- Jess
>>>>
>>
>> --
>>
>> -----
>> Per F. Peterson
>> Professor and Chair
>> Department of Nuclear Engineering
>> University of California
>> 4153 Etcheverry Hall
>> Berkeley, California 94720-1730
>> peterson@nuc.berkeley.edu
>> Office: (510) 643-7749 Fax: (510) 643-9685
>> http://www.nuc.berkeley.edu/People/Per_Peterson
>> -----
>>

--

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Rihm, Roger

From: Rihm, Roger
Sent: Monday, March 28, 2011 12:32 PM
To: Barkley, Richard
Subject: RE: Heads Up on Bill's Testimony - This was Just Posted on EPA's Website Yesterday

Thanks. Consistent with what I've been hearing.

From: Barkley, Richard
Sent: Monday, March 28, 2011 12:21 PM
To: Rihm, Roger
Subject: Heads Up on Bill's Testimony - This was Just Posted on EPA's Website Yesterday
Importance: High

<http://www.epa.gov/japan2011/>

As a result of the incident with the Fukushima nuclear plant in Japan, several EPA air monitors have detected very low levels of radioactive material in the United States consistent with estimates from the damaged nuclear reactors. These detections were expected and the levels detected are far below levels of public-health concern.

Elevated levels of radioactive material in rainwater have been expected as a result of the nuclear incident after the events in Japan since radiation is known to travel in the atmosphere. There have been reports received that the states of Pennsylvania and Massachusetts have seen elevated levels of radiation in recent precipitation events. EPA is reviewing this data - however, in both cases these are levels above the normal background levels historically reported in these areas.

While short-term elevations such as these do not raise public health concerns - and the levels seen in rainwater are expected to be relatively short in duration - the U.S. EPA has taken steps to increase the level of nationwide monitoring of precipitation, drinking water, and other potential exposure routes to continue to verify that.

EPA's only recommendation to state and local governments is to continue to coordinate closely with EPA, CDC and FDA - EPA will continue to communicate our nationwide sampling results as they come in.

I don't know if you were aware of this announcement.

From: Rihm, Roger
Sent: Monday, March 28, 2011 11:42 AM
To: Barkley, Richard
Subject: RE: COMMISSION E-READER....MONDAY, MARCH 28, 2011

Here's where his testimony stands right now. Unless something big happens in Japan (or the Commission dramatically changes the statement for the record), I don't think it will change.

From: Barkley, Richard
Sent: Monday, March 28, 2011 11:38 AM
To: Rihm, Roger
Subject: RE: COMMISSION E-READER....MONDAY, MARCH 28, 2011
Importance: High

Z/220

No – Thanks very much. My Regional Administrator needed that for his meeting Wednesday.

Any chance I can see a copy of Bill's testimony tomorrow? Thanks!

From: Rihm, Roger
Sent: Monday, March 28, 2011 11:31 AM
To: Barkley, Richard
Subject: FW: COMMISSION E-READER....MONDAY, MARCH 28, 2011

Have you seen Tab E?

From: Champ, Billie
Sent: Monday, March 28, 2011 11:29 AM
To: E-Reader Distribution
Subject: COMMISSION E-READER....MONDAY, MARCH 28, 2011

INTERNAL USE ONLY
Some of the information contained in the
Reader is not publicly available.
If there are any questions, please contact SECY.

READING FILE

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March 28, 2011

INCOMING CORRESPONDENCE

- Tab "A" 03/25/11 -- Letter from Sen. Dianne Feinstein, invites Commission testimony before the Senate Appropriations Subcommittee on Energy and Water Development regarding nuclear safety.**
- Tab "B" 03/24/11 -- Email from Daria Neal-DOJ, concerns FY 2009 & 2010 Information and Reporting Requirements for Agencies that Administer Federally Assisted Programs Subject to Executive Order 12250.**
- Tab "C" 03/23/11-- Letter from Said Abdel-Khalik, ACRS, concerns Point Beach nuclear plant, units 1 and 2, extended power uprate applications.**
- Tab "D" 03/23/11 -- Letter from Said Abdel-Khalik, ACRS, concerns status of groundwater protection task force efforts.**
- Tab "E" 03/21/11 -- Letter from Therese Murray and Martha Coakley , MA-AG, concerns storage of spent nuclear fuel.**

Rihm, Roger

From: Rihm, Roger
Sent: Monday, March 28, 2011 3:09 PM
To: Milligan, Patricia
Cc: Landau, Mindy
Subject: RE: Draft Weber Testimony Sent to Commission

Turns out OCA put it where I had inserted the placeholder originally, not where you had actually placed the text when you returned it to us. Since it has gone to the Commission for review this way, the staffer will have to get back to me on our ability to move it after she talks to her management. I would hope that just moving it around won't be an issue....

From: Milligan, Patricia
Sent: Monday, March 28, 2011 2:47 PM
To: Rihm, Roger; Weber, Michael
Cc: Landau, Mindy
Subject: RE: Draft Weber Testimony Sent to Commission

They need to move it. It is the important point and really the reason for the Wed discussion.

From: Rihm, Roger
Sent: Monday, March 28, 2011 2:44 PM
To: Milligan, Patricia; Weber, Michael
Cc: Landau, Mindy
Subject: RE: Draft Weber Testimony Sent to Commission

I noticed that OCA did not have it in where you had placed it and agree with you. I'll check to see why they put it there and discuss moving it.

From: Milligan, Patricia
Sent: Monday, March 28, 2011 2:35 PM
To: Rihm, Roger; Weber, Michael
Cc: Landau, Mindy
Subject: RE: Draft Weber Testimony Sent to Commission

I think this massaged draft needs to be rearranged a bit. I purposely chose to discuss the emergency planning drills, exercises, etc before the planning zones to link together the 10 and 50 mile EPZs and their basis for expansion as conditions warrant to the actual discussion that recommends the 50 mile evacuation. It makes the point a bit better that expanding an evacuation is consistent with our EP framework. I don't think we want to bury that point... I think it needs to be highlighted and the dots connected. I have attached the original version I sent along with the OCA massaged version. Please consider rearranging it so that this point is not lost.

Happy to discuss if you want.

Trish

From: Rihm, Roger
Sent: Monday, March 28, 2011 12:03 PM
To: Weber, Michael
Cc: Landau, Mindy; Milligan, Patricia
Subject: Draft Weber Testimony Sent to Commission

2/221

Attached is OCA's slightly massaged version of Trish's draft that was sent (by OCA) to the Commission this morning for review.

Rihm, Roger

From: Rihm, Roger
Sent: Monday, March 28, 2011 2:46 PM
To: Shane, Raeann
Subject: FW: Draft Weber Testimony Sent to Commission
Attachments: Testimony_EPP_March 30 2011.docx; Congressional Hearing March 30 2011.docx

Per my voice mail message.

From: Milligan, Patricia
Sent: Monday, March 28, 2011 2:35 PM
To: Rihm, Roger; Weber, Michael
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Z/222

**STATEMENT
BY MIKE WEBER, DEPUTY EXECUTIVE DIRECTOR FOR
MATERIALS, WASTE, RESEARCH, STATE, TRIBAL AND COMPLIANCE PROGRAMS
UNITED STATES NUCLEAR REGULATORY COMMISSION
TO THE
HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE**

MARCH 30, 2011

Good morning, Mr. Chairman and members of the Subcommittee. I am pleased to appear before you on behalf of the United States Nuclear Regulatory Commission to discuss our emergency planning and preparedness programs at nuclear power facilities in the United States, and to discuss the protective action guidance recently issued by the U.S. Ambassador to American citizens in Japan in response to the events at the Fukushima 1 nuclear power plant site.

NRC's primary mission is to regulate nuclear reactors, materials, and waste facilities in a manner that protects the health and safety of the public and promotes the common defense and security. Emergency preparedness is a key element of the "defense in depth" safety philosophy we employ for nuclear power plants. This philosophy ensures high quality in design, construction, and operation of nuclear power plants; requires redundant safety systems that reduce the chances that malfunctions will lead to accidents; and recognizes that in spite of all these precautions, unforeseen events could occur. Through emergency planning and preparedness, mechanisms are in place to protect the public in the unlikely event that these barriers fail.

For planning purposes, we define two planning zones around nuclear power plant sites. The first zone is an area covering a 10 mile radius around a nuclear power plant. This is the area with the greatest potential for exposure from a release. Planning for this area is comprehensive

and includes such protective actions as evacuation, sheltering, and potassium iodide, as appropriate, for members of the public.

Consideration of these protective actions is prompted at very low projected dose levels. A second extended planning zone of about 50 miles is also established around each plant to deal with potential lower-level, long-term risks primarily due to exposure from consumption of contaminated food, milk, and water. This comprehensive planning within the 10 and 50 mile EPZ provides a substantial basis for expansion of response efforts in the event that this is necessary. The NRC emergency preparedness and planning regulations are extensive and require the licensee to develop and demonstrate an effective emergency plan prior to initial startup. The nuclear power plant operator is required to provide extensive emergency response training to emergency plant workers; for example, severe accident management training to control room operators, and demonstrate personnel response in a rigorous drill and exercise program. This program includes an every-other-year full participation exercise that engages both the onsite and offsite response organizations which include state and local responders as well as FEMA. These exercises are evaluated by both FEMA (offsite) and NRC (onsite) staff. In addition, the NRC performs periodic emergency preparedness inspections of the facility. NRC resident inspectors also observe licensee on-site emergency drills and exercises. It is safe to say that over the 30 plus years of operating history and in 104 operating nuclear power plants, there have been thousands of drills and exercises designed to ensure optimum response to abnormal and emergency conditions.

Let me now address the NRC's recent protective action recommendation for U.S citizens in Japan to evacuate out to 50 miles from the Fukushima Daiichi site. That decision was based on the best information available during an evolving event. NRC began monitoring the event when the tsunami warning was issued for Hawaii and the west coast of the United States. The

information flow from the Fukushima site was often confusing and conflicting. In order to provide timely information to the U.S. Ambassador to Japan, and to best protect the health and safety of U.S. citizens in Japan, we based our assessment on the conditions as we understood them. This is a 6 unit site and 4 of the units were facing extraordinary challenges. Units 1, 2, and 3 appeared to have suffered significant damage as a result of reported hydrogen explosions. We knew that the concrete containment buildings were severely damaged and unable to perform their function of stopping the release of radiation. Unit 4 was in a refueling outage and its entire core had been transferred to the spent fuel pool a little more than 3 months earlier. This means that there was fresh fuel in the spent fuel pool that was in danger of overheating if the water level dropped, and there were indications that was happening. Additionally, radiation monitors were showing very high levels of radiation on the plant site, which would pose challenges to plant crew attempting to stabilize the reactors, and there were offsite readings indicating that fuel damage had occurred. This situation was unprecedented.

In order to determine the proper evacuation distance, the staff performed a series of calculations using our RASCAL computer code to assess possible offsite consequences. These calculations demonstrated that the Environmental Protection Agency's Protective Action Guidelines would be exceeded at a distance of 50 miles from the Fukushima site. We understood that some of our assumptions were conservative, but believed that it was better to err on the side of overprotection, especially in the case of a seemingly rapidly deteriorating situation.

If this situation had occurred in the United States, the NRC has resident inspector staff at the plants that can report back to the Region and Headquarters on conditions as they are evolving. In addition, we are able to readily access "live-time" plant parameters and radiation monitors, as well as talk directly to our licensee and emergency management officials allowing us to refine

our understanding and consequence assessments. The licensee would then make a recommendation to State officials on what protective actions to take. With the Fukushima event we had to make our best decision with what we had available. The Emergency Preparedness framework provides for the expansion of the emergency planning zones as conditions require. Acting in accordance with this framework and with the best information available at the time, the NRC determined that evacuation out to 50 miles for U.S. citizens was an appropriate course of action.

Good afternoon, Mr./Ms Chairman and members of the Subcommittee. I am pleased to appear before you on behalf of the United States Nuclear Regulatory Commission (NRC) to discuss our emergency planning and preparedness programs at nuclear power facilities in the United States and to discuss the protective action guidance recently issued by the NRC to American citizens in Japan in response to the serious problems at the Fukushima 1 nuclear power plant site.

NRC's primary mission is to regulate nuclear reactors, materials and waste facilities in a manner that protects the health and safety of the public and promotes the common defense and security. Emergency preparedness is a key element of the "defense in depth" safety philosophy we employ for nuclear power plants. This philosophy: ensures high quality in design, construction, and operation of nuclear power plants; requires redundant safety systems that reduce the chances that malfunctions will lead to accidents; and recognizes that in spite of all these precautions, accidents could occur. That is why, for example, containment structures and other safety features are required to minimize the potential for the release of fission products off site. Through emergency planning and preparedness, additional mechanisms are in place to protect the public in the unlikely event that these barriers were to fail.

The NRC emergency preparedness and planning regulations are extensive and require the licensee to develop and demonstrate an effective emergency plan prior to initial startup. The

nuclear power plant operator is required to provide extensive emergency response training to emergency plant workers; for example, severe accident management training to control room operators, and demonstrate personnel response in a rigorous drill and exercise program. This program includes an every other year full participation exercise that engages both the offsite and onsite response organizations. These exercises are evaluated by both FEMA (offsite) and NRC (onsite) staff. In addition, the NRC performs periodic emergency preparedness inspections of the facility. NRC resident inspectors also observe licensee on-site emergency drills and exercises. It is safe to say that over the 30 plus years of operating history and in 104 operating nuclear power plants, there have been thousands of drills and exercises designed to ensure optimum response to abnormal and emergency conditions.

For planning purposes, we define two planning zones around nuclear power plant sites. The planning zones are based on a study of accidents, known as the WASH 1400 report, that examined a range of events from design basis accidents to catastrophic severe accidents.

The study made a number of very conservative assumptions regarding the performance of safety equipment, the radionuclides in the core that could be released as well as the timing of the release. The first zone is an area covering about 10 miles in all directions around nuclear power plants where the greatest potential for radiological effects from a release

exists. Planning for this area is comprehensive and includes such protective actions as evacuation, sheltering and potassium iodide, as appropriate, for members of the public. Consideration of these protective actions is prompted at very low projected dose levels. A second extended planning zone of about 50 miles is also established around each plant to deal with potential lower-level, long-term risks primarily due to exposure from consumption of contaminated food, milk, and water. This comprehensive planning within the 10 and 50 mile EPZ provides a substantial basis for expansion of response efforts in the event that this is necessary.

Let me now address the NRC's recent protective action recommendation for U.S citizens in Japan evacuate out to 50 miles from the Fukushima Daiichi site. That decision was based on best information available at that time. The information flow from the Fukushima site was often confusing and conflicting. The NRC was receiving its information from the same open sources available to everyone; such as CNN. We based our assessment on the conditions as we were able to determine; Units 1, 2, and 3 appeared to have suffered significant damage as a result of reported hydrogen explosions, Unit 4 was in a refueling outage and its entire core had been transferred to the spent fuel pool a little more than 3 months earlier so there was fresh fuel in the spent fuel pool that was in danger of overheating if level dropped, and there were

indications that was happening. Additionally, there were some radiation monitors that were showing very high levels of radiation on the plant site which would pose challenges to plant crew attempting to stabilize the reactors and there were some offsite readings indicating that fuel damage had occurred. This situation was unprecedented. This is a 6 unit site and 4 of the units were facing extraordinary challenges. The staff performed a series of calculations to assess possible offsite consequences. We understood that some of our assumptions were conservative. However, we were unable to discuss or verify our assumptions with the licensee or our Japanese counterparts. In the United States, the NRC has resident inspector staff at the plants that can report back to the Region and Headquarters on conditions as they are evolving, we are able to readily access "live-time" plant parameters and radiation monitors, as well as talk directly to plant staff and emergency management officials which enables us to refine our understanding and consequence assessments. With the Fukushima event we had to make our best decision with what we had available. The Emergency Preparedness framework provides for the expansion of the emergency planning zones as conditions require. Acting in accordance with this framework and with the limited information available at the time, the NRC determined that evacuation out to 50 miles for U.S. Citizens was an appropriate course of action.

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 9:41 PM
To: Kelly, John E (NE)
Subject: RE: Telephone Discussion

John, thanks.
Appreciate it.
Richard

From: Kelly, John E (NE) [JohnE.Kelly@Nuclear.Energy.Gov]
Sent: Tuesday, March 29, 2011 9:35 PM
To: Lee, Richard
Subject: FW: Telephone Discussion

I think this is what you asked for

-----Original Message-----

From: 尾本 彰 [<mailto:akira.omoto@mac.com>]
Sent: Tuesday, March 29, 2011 9:09 AM
To: Kelly, John E (NE)
Cc: Kondo Shunsuke.; SCHU; Binkley, Steve; Aoki, Steven; Adams, Ian; Lyons, Peter
Subject: Telephone Discussion

Dear John,

I am sending the following information that may benefit tomorrow morning's conference call. Since I did not participate in the last Monday morning's conference call, I am afraid I might be addressing a different and too much technical issue.

In my view, key technical issues would be;

- 1) Avoiding spill-over of contaminated water to the sea by inventory control in feed & bleed operation and others,
- 2) Avoiding hydrogen explosion in the reactor and containment (Sandia paper helps),
- 3) Assessment of damage status of Spent Fuel Pool (1F3 and 4), and finally
- 4) Establishing long-term stable condition, especially for cooling.

On the last topic, I had intensive discussion twice today in TEPCO, the first one by participation of Prof. Kondo.

Please refer to my slides (attached), though I am afraid they may not be self-explanatory. According to an analysis by Hitachi, natural heat dissipation could be established in a matter of another 1-2 months, though meanwhile overhead spray followed by external cooling of containment will be required for core heat removal.

Best,
akira OMOTO (Commissioner, AEC)

2/223

Lee, Richard

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Tuesday, March 29, 2011 12:46 PM
To: Lee, Richard
Cc: Basu, Sudhamay
Subject: RE: FCI analysis for Fukushima

Yes - but Sud just called to have me verify by a concrete wall strength calc
--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

> Hence, your conclusion from the FCI load is confined to the structural
> failure in the pedestal area. Hence, the structure supporting the RPV
> will not collapse - Am I correct?

>
> -----Original Message-----
> From: Michael Corradini [<mailto:corradini@engr.wisc.edu>]
> Sent: Tuesday, March 29, 2011 10:56 AM
> To: Lee, Richard
> Cc: Basu, Sudhamay
> Subject: RE: FCI analysis for Fukushima

>
> Richard - You are asking a good question but now we need to couple the
> dynamic pressure load we are computing with the structural member that
> may fail. Since the explosion (if melt pour occurs) would likely occur
> within the pedestal region - one would have to consider the
> propagation of the pressure wave from the mixture region and how it
> propagates to the pedestal wall then beyond to the bellows. I really
> think this is a SMALL probability event but the calc is much more
> complex. I hesitate to bound it with the local explosion pressure
> since that is way too conservative. Does that make sense?

> --
>
> Michael Corradini, Chair
> Engineering Physics
> University of Wisconsin
> (608)263-1648 [Fax: 3-7451]
> corradini@engr.wisc.edu
> <http://www.engr.wisc.edu/ep>

> Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

>
>> It makes sense from the water level point of view wrt to FCI load.
>>
>> From the FCI loading on the containment structure, will the resulting

Z/224

>> pressure load cause a larger leakage? For example, if either of the
>> bellows is compromised. This is more of a structure question.

>>
>> From: Basu, Sudhamay
>> Sent: Tuesday, March 29, 2011 10:23 AM
>> To: Lee, Richard; Michael Corradini
>> Subject: RE: FCI analysis for Fukushima

>>
>> If there is a leakage path, I would expect the pool depth to be less
>> than say the baseline. Since Mike ran parametric on pool depth, I
>> imagine that point is covered. If the leakage is excessive (I
>> suspect not from the bellow configuration), the pool will be shallow
>> and the steam explosion potential and energetic will be even less.
>> Am I making any sense?

>>
>> From: Lee, Richard
>> Sent: Tuesday, March 29, 2011 9:57 AM
>> To: Michael Corradini
>> Cc: Basu, Sudhamay
>> Subject: FCI analysis for Fukushima

>>
>> Mike:
>>
>> Will you assessment on FCI on containment failure change giving the
>> assumption that there is an existing leakage path in the primary
>> containment (e.g., a bellow is broken). Attached is a paper on BWR
>> Mark 1 bellows.

>>
>> Appreciate your assessment.
>>
>> Thanks, Richard

>>
>
>
>
>

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 11:27 AM
To: Esmaili, Hossein; 'Gauntt, Randy (home)'; 'Randy Gauntt (SNL)'; Salay, Michael; Aissa, Mourad
Subject: FW: Presentation to NE (and AREVA brief by Dr. Matthias Braun)
Attachments: Fukuchima_eng_20110320 2.pps

See questions raised by Dick Garwin. FYI only. Do not join in on the e-mail thread!

From: Richard L Garwin [<mailto:rlg2@us.ibm.com>]
Sent: Tuesday, March 29, 2011 11:16 AM
To: Larzelere, Alex
Cc: DL-NITsolutions@nnsa.doe.gov
Subject: Re: Presentation to NE (and AREVA brief by Dr. Matthias Braun)

Thanks, Alex.

A question I asked yesterday at Millstone relates to the times shown on your Slide 11,

► Reactor Isolation pump stops

- ◆ Friday 3/11 16:36 in Unit 1
(Batteries empty)
- ◆ Monday 3/14 13:25 in Unit 2
(Pump failure)
- ◆ Sunday 3/13 2:44 in Unit 3
(Batteries empty)

The tsunami struck 3/11 at 15:41, so Unit 1 lost battery power after 55 minutes. How could the batteries be drained in such a short time?

Unit 3 drained its batteries in 35 hours. How could they last so long?

Unit 2 still had battery power after 70 hours. How could they last so long?

I understand that the steam driven isolation pump needs battery power to keep the valves open along that path. How does this work, exactly? For the most part, these motor-driven valves will stay in their position if power is removed.

Finally, there are no FOUO markings or other limitations on your presentation. Also none on the presentation by Matthias Braun of AREVA (not "Dr. Matthias of AREVA"), which I attach.

Dick Garwin

2/225

From: "Larzelere, Alex" <alex.larzelere@nuclear.energy.gov>
To: DL-NITsolutions <DL-NITsolutions@nnsa.doe.gov>
Date: 03/29/2011 09:53 AM
Subject: Presentation to NE

Everyone,

Attached is a presentation I gave yesterday at the NE All Hands meeting that you might find useful. As you will see, it provides a pretty good chronology of events for the accident at Fukushima Daiichi. This information was put together by Dr. Mattias of AREVA. I have not gone back and verified every number but I am pretty confident that they are mostly correct.

Please let me know if you have any questions or comments.

Regards,

Alex

Alex R. Larzelere
*Director, Advanced Modeling and Simulation Office
Office of Nuclear Energy (NE-71)
U.S. Department of Energy
202-586-1906
Alex.Larzelere@nuclear.energy.gov*

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 12:59 PM
To: 'Dana Powers (Home)'; 'Dana Powers (SNL)'
Subject: FW: Bisconti TDY-Tokyo

Fyi

Dana: Lesson-learned from Russian wrt entombment?
Thx.

-----Original Message-----

From: Bisconti, Giulia [<mailto:Giulia.Bisconti@nuclear.energy.gov>]
Sent: Tuesday, March 29, 2011 12:26 PM
To: PWG; DL-NITsolutions
Cc: Bisconti, Giulia
Subject: Bisconti TDY-Tokyo

Dear all:

As requested, this is an update of how I am helping in Tokyo for the week. My main duty is to be embedded with the NRC team at the Embassy. I am also performing other duties where I can be helpful to Ron and Aleshia. They have both been very welcoming.

Giulia

Here are some items of interest:

- Two PNNL experts to visit Japan (at the request of Japan) to help on water decontamination and storage issues.
- Japanese government is seeking private sector experts on fuel rod/pool issues with hands-on TMI experience (per NRC meetings).
- Japanese government is thrilled with NNSA's airborne monitoring cooperation (I joined MOFA/MEXT meeting with Alan).
- Met with Toshiba and B&W. Toshiba has hundreds of employees at the accident site and the TEPCO emergency control room. Toshiba is deploying equipment and resources. Toshiba and Hitachi are both in the emergency control room, and TEPCO is heavily relying on them. Toshiba offered to be an information resource to our specialists.
- 6.3 quake in Northeastern Japan today--no damage reported to facilities.
- Aleshia and I met today with METI Vice Minister Okada (at his invitation). Okada mentioned that Japan is thinking about a "cover" for the Fukushima plants in the coming months. He and his colleagues expressed very deep appreciation for assistance from DOE and its National labs and everyone's hard work and long hours. They appreciated DOE recommendations on the salt/fresh water issue. Okada offered to personally work with DOE on any matter related to the Fukushima response and to help overcome any barrier. Although, he mentioned that information flow is much better now (the government is better organized to receive and respond to inquiries) and the mechanisms seem to be working. He noted that Japan will be looking for assistance-including on the issue of water decontamination (10,000 tons ? of contaminated water). He said that the Japanese government would seek input from DOE and its labs, including PNNL, Idaho, Livermore, others...
- Participated in NRC meeting. Issues: remove heat from the reactor. Structural concerns for the pools. Controlling releases. Water management is a big issue. Are the Japanese workers wearing adequate protective clothing? Flooding--continued leakages? Need to establish the water level of the pools--want to get water above the rods, maybe 3-4 feet above.

3/22/11

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 1:55 PM
To: Hoxie, Chris; Wagner, Katie
Subject: FW: Bisconti TDY-Tokyo

FYI.

Since you were asked on PNNL staff travel to Japan.

-----Original Message-----

From: Bisconti, Giulia [<mailto:Giulia.Bisconti@nuclear.energy.gov>]
Sent: Tuesday, March 29, 2011 12:26 PM
To: PWG; DL-NITsolutions
Cc: Bisconti, Giulia
Subject: Bisconti TDY-Tokyo

Dear all:

As requested, this is an update of how I am helping in Tokyo for the week. My main duty is to be embedded with the NRC team at the Embassy. I am also performing other duties where I can be helpful to Ron and Aleshia. They have both been very welcoming.

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2/227

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 1:24 PM
To: Tinkler, Charles
Cc: Esmaili, Hossein; Salay, Michael; Schaperow, Jason
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Charlie:

Randy's offhand response was this. I think the concern is on additional loading that the containment may have to subject to in case of after-shock?

We have not ask SNL to do anything about this for IAEA.

Richard

-----Original Message-----

From: Gauntt, Randall O [mailto:rogaunt@sandia.gov]
Sent: Thursday, March 24, 2011 4:05 PM
To: Petti, Jason P; Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane
Subject: Re: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Seems to me he is confusing atm with MPa - the graph indicates about 50 psi - his e-mail says 3.8 MPa . Ultimate strength is around 150 psi not considering heating of drywell head bolts. Just an initial reaction.

----- Original Message -----

From: Petti, Jason P
Sent: Thursday, March 24, 2011 01:13 PM
To: 'Richard.Lee@nrc.gov' <Richard.Lee@nrc.gov>
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMs Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D

2/228

Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico
Phone: 505-284-8574
Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]

Sent: Thursday, March 24, 2011 11:53 AM

To: Petti, Jason P

Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?

2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.

How can maintain or decrease pressure of containment in current situation without venting ?

3. What is the maximum operating pressure according to your judgement ?

4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796
Fax: +43 1 2600 29598
E-mail: Ki-Sig.KANG@iaea.org

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]
Sent: Thursday, 24 March 2011 17:44
To: KANG, Ki-Sig
Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis. You might contact Jason Petti (jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm).

Can I ask you the important questions ?

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2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material. How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and

containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

[cid:3383815441_5634291]

Ki- Sig KANG

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

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Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 1:56 PM
To: Sheron, Brian
Subject: RE: 4:45 Conference Call

No problem. I will call in.

From: Sheron, Brian
Sent: Tuesday, March 29, 2011 1:41 PM
To: Lee, Richard
Subject: 4:45 Conference Call

Can you take it today? I have to be at a meeting in WF from 4-5 pm, so I won't get back here until 5:30 pm or so. If they come up with any more helpful hints from Heloise for the Japanese, please remind them any recommendations need to be vetted and agreed upon among the various governmental and industry organizations. Thanks.

2/229

Lee, Richard

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Tuesday, March 29, 2011 2:18 PM
To: Lee, Richard
Cc: Basu, Sudhamay
Subject: Re: FCI analysis for Fukushima

Richard - Sorry I missed this email. This leakage will only change the water depth and we have considered how that will affect the energetics parametrically

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

> Mike:
>
> Will you assessment on FCI on containment failure change giving the
> assumption that there is an existing leakage path in the primary
> containment (e.g., a bellows is broken). Attached is a paper on BWR
> Mark 1 bellows.
>
> Appreciate your assessment.
>
> Thanks, Richard
>

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Lee, Richard

From: Farmer, Mitchell T. [farmer@anl.gov]
Sent: Tuesday, March 29, 2011 3:01 PM
To: Lee, Richard
Cc: 'Michael Corradini'; Basu, Sudhamay; Gavrilas, Mirela; Robb, Kevin Richard
Subject: FW: COMMENTS on SUMMARY SLIDES
Attachments: UW Fukushima MCCI Summ rev3.ppt

Hi Richard,

I believe Mike has forwarded these corquench and melcor ex-vessel analyses on to you earlier. Would it be possible to forward these on to John Kelly? If possible, could you also cc Jeff Binder as John's email is being overwhelmed and Jeff is helping him on managing information. Jeff's email is: binderjl@ornl.gov

Thank you,
Mitch

-----Original Message-----

From: Kevin Robb [mailto:krrobb@wisc.edu]
Sent: Saturday, March 26, 2011 9:02 PM
To: Michael Corradini; Farmer, Mitchell T.
Subject: Re: COMMENTS on SUMMARY SLIDES

Hello,
Attached is updated calcs from me.

CORQUENCH predicts anchoring but there's uncertainty in that.
Anchoring allowed - slide 15: 50-100% melts all do not quench in 5 days but ablation is very slow (<0.4 cm/hr), ablation on the order of 1m
Anchoring not allowed - slide 16: 50-100% melts quenches in several to tens of hrs, ablation on the order of 0.5m
100's - 1500 kg of H2 is produced I'm not sure about the MELCORE predictions - higher ablation rate (2x), odd spikes in upward/downward heat transfer

I'll try some hand calcs tomorrow about steaming rate & non-condensable pressurization.

Kevin

On 03/26/11, Michael Corradini wrote:
>
>

r 2/231

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 4:45 PM
To: 'Powers, Dana A'
Subject: RE: Re: Salt water corrosion

o.k.

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Tuesday, March 29, 2011 4:12 PM
To: Lee, Richard
Subject: RE: Re: Salt water corrosion

I think the accelerated corrosion is actually fatigue corrosion cracking in pressure vessel steel. I have stuff on that. I'll put something together. Dana

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Monday, March 28, 2011 7:22 PM
To: danapowers@msn.org; Powers, Dana A
Subject: FW: Re: Salt water corrosion

Dana:

At this rate, the vessel should disappear soon!!

Richard

From: Per F. Peterson [peterson@nuc.berkeley.edu]
Sent: Monday, March 28, 2011 7:59 PM
To: SCHU; Garwin, Dick (IBM); Binkley, Steve; Brinkman, Bill; Binder, Jeff; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; Connell, Elizabeth; McFarlane, Harold; 'Harold Denton'; Adams, Ian; John Holdren; 'JOE H. PAYER'; Kelly, John E (NE); Grossenbacher, John (INL); Owens, Missy; Peterson, Per; Lyons, Peter; Finck, Phillip; Garwin, Dick (EOP); Lee, Richard; Budnitz, Bob; Szilard, Ronaldo; Aoki, Steven; Koonin, Steven; Steve Fetter; Binkley, Steve; DAgostino, Thomas
Subject: Fwd: Re: Salt water corrosion

As a follow-up to Steve Chu's note on oxygen, Tom Devine at UC Berkeley also identifies oxygen as a key problem for accelerated corrosion. Corrosion will emerge as the most important longer-term risk factor, since integrity of the reactor containment is essential to maintaining flooding of the drywell and heat removal from the reactor vessel.

Now that the transition to fresh water has been achieved (something we identified early on as an important risk-reduction step), one of the most important risk-reduction opportunities now available is to expedite the installation of equipment to strip oxygen from water injected into the reactor vessels and primary containments.

I note an important in Tom's email, that CO2 can have a beneficial and protective effect for corrosion. This suggests that it would be better to use CO2 as an inerting agent to inject into the reactor feedwater, rather than nitrogen. CO2 can serve as an inerting agent, but also should have useful effects in inhibiting corrosion.

-Per

2/232

>Date: Mon, 28 Mar 2011 08:07:02 -0700
>Subject: Re: Salt water corrosion
>From: devine@berkeley.edu
>To: "Per F. Peterson" <peterson@nuc.berkeley.edu>

>
>Per,
>
>The critical parameters that will determine the appropriate material
>for storing aqueous waste are: the water's: dissolved oxygen concentration,
>temperature, pH and chloride ion concentration. For example, carbon
>steel can be protected against corrosion in 65°C water that contains
>0.4M chloride (i.e., greater than sea water) and is saturated with CO2
>(so it is acidic). However, in this case it is critically important
>that the water is free of oxygen (as it is saturated with CO2) and
>organic corrosion inhibitors have been added. This example illustrates
>the interplay between the environment's chemistry (in this case, the
>absence of dissolved oxygen permits the use of carbon steel along with
>corrosion inhibitors, despite the presence of high chloride
>concentration and a pH of about 5), the appropriate material and the
>required protective measure (organic inhibitors).

>
>As you have pointed out, titanium would be a good choice. In over 70
>years of use of titanium in a range of environments and applications
>there has never been a single reported instance of crevice corrosion or
>pitting corrosion of titanium at temperatures below 80°C.

>
>The family of Ni-Cr alloys should be considered. Recall that Alloy C22
>(a Ni-Cr-Mo alloy) was selected by DOE for long-term storage of waste
>at Yucca Mtn. Cobalt-chromium alloys would also be effective, but
>should be ruled out on the basis of cost/availability.

>
>Depending on the storage time, there are stainless steels that should
>also be considered.

>
>In summary, there are a number of options available. IN particular,
>there are a number of corrosion-resistant alloys that should be
>considered as well as carbon steel that is protected by organic
>inhibitors, or cathodic protection. I can suggest specific alloys
>and/or methods of protecting carbon steel once I know the chemistry of the water.

>
>Tom

>
>> Tom,
>>

>> One of the major elements of remediating the reactors at Fukushima
>> will involve flushing high activity, corrosive fluids out of the
>> reactor vessel into some type of storage tank(s), with an evaporator
>> system to concentrate the fluids and to recycle the condensate for
>> further flushing.

>>
>> Currently the turbine condensers are being used for storage of
>> low-activity fluids (see below).

>>
>> The storage tanks for high activity fluids will need to have life
>> spans of at least a few years. This raises the question of what

>> materials can be used and how corrosion can be managed. Commonly for
>> salt water service one would use coatings, but I expect that these
>> would not survive well in a high radiation environment. Titanium has
>> excellent salt-water resistance, but I'm not sure if it is a
>> practical material to use for tanks that need to be acquired
>> on an expedited basis. An alternative is to attempt to use existing
>> tanks at the site; these might be carbon steel or stainless steel.

>>
>> Could you provide advice on potential materials to use for such
>> storage tanks? If carbon steel or stainless steel end up being the
>> only practical options, are there methods that might be used to
>> mitigate corrosion (e.g., cathodic protection), and what would the
>> thickness need to be to assure several years of service life?

>>
>> -Per

>>
>>
>>

>>>Date: Sun, 27 Mar 2011 20:50:09 -0700
>>>To: "Gehin, Jess C." <gehinjc@ornl.gov>
>>>From: "Per F. Peterson" <peterson@nuc.berkeley.edu>
>>>Subject: Re: Hydrogen

>>>
>>>Jess,

>>>
>>>Below is my assessment of the major actions needed to remediate these
>>>reactors. Getting the refueling crane out of the way in Unit
>>>3 will be important (I'm pretty sure that the 100 ton reactor crane
>>>would not have been parked above the pool). Hopefully the pool is
>>>not leaking and can be refilled enough to reduce radiation levels to
>>>assist with the effort to remove this debris, including cutting up
>>>the crane system so it can be lifted out.

>>>
>>>The turbine condensers are an ok place to flush low-activity fluids
>>>to. In the longer term evaporators will be needed to concentrate
>>>these solutions and produce condensate that can be used in additional
>>>flushing operations. Shielded tanks (probably new) will be needed
>>>for high activity fluids flushed out of the reactors and
>>>containments.

>>>
>>>-Per

>>>
>>>
>>>

>>>Initial remediation efforts will involve flushing corrosive and
>>>radioactive fluids out of the primary systems and containments into
>>>storage tanks (potentially new tanks, similar to the waste tanks at
>>>Hanford and SRS), and the use of evaporators to concentrate this salt
>>>solution in the tanks and return condensate for additional
>>>flushing. Later on the salts can be processed into suitable waste
>>>forms using similar technologies to those used for the supernate
>>>fluids in U.S. defense waste tanks.

>>>
>>>In parallel remotely operated construction cranes will be used to
>>>remove debris from above and around spent fuel pools, and then the
>>>cranes will be used to transfer the fuel assemblies into lightly
>>>shielded baskets to be lowered into shielded casks on the ground.

>>>
>>>Once the spent fuel is moved and the systems have been extensively
>>>flushed to reduce radiation levels and to remove mobile
>>>contamination, core debris will be removed as was done at TMI.
>>>
>>>Currently this is my best projection of the sequence of actions
>>>needed to remediate these reactors.
>>>
>>>-
>>>
>>>>Per,
>>>>
>>>>Interesting theory. I happen to be watching NHK right now and there
>>>>seems to be a lot of discussion by a government official (chief
>>>>cabinet secretary Edano) about when the venting was ordered and when
>>>>it occurred. I was looking at the timelines on the BBC and
> >>>OECD sites and they indicate that there was venting before the
>>>>explosion in unit 1 and unit 3.
>>>>
>>>>He is also saying that the leak of the water to the TG building was
>>>>a "one-time" event. They are working to pump the water into the
>>>>condensers, but for unit 1 and 2 the condensers are full and they
>>>>need to dump them first.
>>>>
>>>>They have a university of Tokyo professor that says the crane in
>>>>unit 3 has fallen into the pool and may have damaged some fuel.
>>>>They have some close-up video and images from what looks to be a
>>>>helicopter with a good zoom lens.

>>>>
>>>> -- Jess

>>>>
>>
>> --
>>
>> -----
>> Per F. Peterson
>> Professor and Chair
>> Department of Nuclear Engineering
>> University of California
>> 4153 Etcheverry Hall
>> Berkeley, California 94720-1730
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>> Office: (510) 643-7749 Fax: (510) 643-9685
>> http://www.nuc.berkeley.edu/People/Per_Peterson
>> -----
>>

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Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 5:31 PM
To: 'Adams, Ian'; 'Binkley, Steve'
Subject: When do we have a conference call with Japan

Hi, Steve and Ian:

Please let me know when the call to Japan will take place.

Richard

2/233

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 5:50 PM
To: 'Binkley, Steve'
Subject: RE: When do we have a conference call with Japan

Thanks, Steve.
Richard

From: Binkley, Steve [<mailto:Steve.Binkley@science.doe.gov>]
Sent: Tuesday, March 29, 2011 5:50 PM
To: Lee, Richard
Subject: Re: When do we have a conference call with Japan

6:00 pm, same number as for the call we just completed.

Steve Binkley

From: Lee, Richard <Richard.Lee@nrc.gov>
To: Adams, Ian; Binkley, Steve
Sent: Tue Mar 29 17:31:11 2011
Subject: When do we have a conference call with Japan

Hi, Steve and Ian:

Please let me know when the call to Japan will take place.

Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 5:49 PM
To: Kelly, John E (NE)
Subject: Call to Japan today

John:

Is the call to Japan will take place at 6:00pm?

Richard

Z/235

Lee, Richard

From: Lee, Richard
Sent: Tuesday, March 29, 2011 6:40 PM
To: 'Kelly, John E (NE)'; 'Binkley, Steve'
Subject: Questions and handouts

Hi, John and Steve:

Please send me the questions/materials that you received from Japan that was mentioned in today conference call.

I have a hard time hearing when the other side spoke. Please let me know what he said about the means of providing cooling water to the 4 SFP units.

Thanks, Richard

7/6 | 236

Bozin, Sunny

From: Franovich, Mike
Sent: Tuesday, March 29, 2011 3:27 PM
To: Ostendorff, William
Cc: Nieh, Ho; Kock, Andrea; Zorn, Jason
Subject: AWARENESS: 50 Mile Evacuation Zone and Reentry Guidance for Temporary Access
Attachments: 3 28 11 Re-Entry Guidance FINAL.docx

Below is the NRC feedback to inquiries from the Ministry of Foreign Affairs (MOFA) regarding the 50 mile radius evacuation zone recommendation for US citizens/residents.

Attached are the re-entry criteria for limited time/access to 50 mile evacuation zone. EPA did comment on the proposed guidelines. The final guidelines were sent to the White House.

From: LIA03 Hoc
Sent: Monday, March 28, 2011 11:07 AM
To: takashi.inutsuka@mofa.go.jp
Cc: Doane, Margaret; Mamish, Nader; LIA02 Hoc; LIA08 Hoc; Borchardt, Bill; LIA03 Hoc
Subject: 50 Mile EPZ justification response

On behalf of Bill Borchardt, we are responding to your questions:

1. In the NRC NEWS, March 16, 2011, there are attachments of the results of two sets of computer calculations. One, 15 March 2010 02:51am (EDT), has a hypothetical, single-reactor site, 2350 Mwt, Boiling Water Reactor. On the other hand, 16 March 2010 12:24pm (EDT), has a hypothetical, four-reactor site. But in these attachments there is no detailed assumption for calculations about

(1) the power and type of reactor for the four-reactor site,
(2) weather, wind direction and speed, and the status of the problem at the reactors (for example: Source Term).

Q1: Are these sentences correct?

A1: These sentences are correct. Although the press release identified one of the computer calculations being based on a hypothetical four-reactor site, the source term used in the calculation was the approximate activity available for release from one reactor and two spent fuel pools.

Q2: Have you ever explained these detailed assumptions to the public?

A2: The assumptions have been generally described in press releases, interviews, and congressional testimony.

Q3: Could you explain the relation between the number of Total EDE and 1rem (PAGs)? For example 8.1rem (15 March calculation) and 9.9rem (16 March calculation), 50 mi, and 1rem? Could you also explain the relation between the number of Thyroid CDE and 5rem (PAGs)? For example 23rem (15 March calculation) and 48rem (16 March calculation), 50 mi, and 5rem? Is there no need to calculate this for distances greater than 50 mi?

A3: As stated in the press release, these two computer calculations are hypothetical, rough estimates that would not necessarily characterize an actual release. Although the calculation references have TEDE and CDE doses exceeding PAGs beyond 50 miles, these were only two of several cases run. Given that other cases projected PAG doses less than 50 miles

Z/237

and there would be time to extend our recommendations beyond 50 miles, if necessary, the 50 mile recommendation was considered appropriate to protect US citizens.

2. At the White House Regular Briefing, March 17, 2011, Chairman Jaczko said, "We have a team of 11, some of our best technical experts in Tokyo, and they are working with counterparts from the utility in Tokyo as well as other individuals with the government. So that is one of the sources. We are collecting data from as many places as we can to make the best judgments we can with the information available. But I would stress that this is a very difficult situation. There is often conflicting information. And so we made what we thought was a prudent decision."

Q4: Does this statement accurately reflect the NRC's decisionmaking process that led to the recommendation (50 miles)?

A4: Yes.

Q5: Did NRC have evidence to suggest that radiation levels around Fukushima were higher than what Japanese officials had said?

A5: No. The NRC had very limited radiation level information at this time. The computer calculations and subsequent protective action decisions were based on conservative assumptions based on limited information and the deteriorating state of several reactors and spent fuel pools.

3. At the meeting of NRC, March 21, 2011, you said, "the situation that led to the 50 mile guidance in Japan was based upon what we understood and still believe had existed that there were degraded conditions in two spent-fuel pools at the site and, in all likelihood, some core damage in three of the reactor units. Based on the situation as we understood it at that time, we thought it was prudent to provide the recommendation to the ambassador to evacuate out to 50 miles in Japan."

Q6: Does this statement accurately reflect the NRC's decisionmaking process that led to the recommendation (50 miles)?

A6: Yes.

Q7: There are some differences on the basis for making recommendation between 1. and 3. Could you explain the basis for making the recommendation (50 miles) again?

A7: The comments made by NRC Chairman Jaczko and Mr. Borchardt were consistent in that seriously degrading conditions at several Daiichi units supported a need to take pre-emptive protective action. The computer calculations helped to provide perspective on possible impacts.

Q8: I understand the recommendation is prudent. How do you define "prudent" in the assumptions for your calculations? in the decision about the distance?

A8: Since communications were limited and there was a large degree of uncertainty about plant conditions at the time, it was difficult to accurately assess the radiological hazard. Computer models used meteorological model data appropriate for the Fukushima Daiichi vicinity. Source terms were based on hypothetical, but not unreasonable estimates of fuel damage, containment, and other release conditions. Subsequent modeling can be correlated with the ground deposition as observed in flyover and other monitoring data. Therefore, prudent (reasonable conservative protective actions made with a predictive approach to limit radiation exposure to US citizens) can be substantiated based on the conditions present and the information known at the time.

If you have additional questions please contact Mr. Borchardt at the email address above.

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 10:06 AM
To: Uhle, Jennifer
Cc: Gibson, Kathy; Armstrong, Kenneth
Subject: RE: Action: Question from the Chairman's Office (COB today)

Greg called and confirmed that the info. did get to the Chairman office yesterday.

From: Uhle, Jennifer
Sent: Wednesday, March 30, 2011 9:43 AM
To: Lee, Richard
Cc: Gibson, Kathy; Armstrong, Kenneth
Subject: RE: Action: Question from the Chairman's Office (COB today)

OK great. J

From: Lee, Richard
Sent: Wednesday, March 30, 2011 9:42 AM
To: Uhle, Jennifer
Cc: Gibson, Kathy; Armstrong, Kenneth
Subject: FW: Action: Question from the Chairman's Office (COB today)

Jennifer:
We believe EDO deliver it to the Chairman office yesterday. Ken also called Greg to confirm Richard

From: Bowman, Gregory
Sent: Wednesday, March 30, 2011 8:25 AM
To: Aissa, Mourad
Cc: Gibson, Kathy; Lee, Richard; Armstrong, Kenneth
Subject: RE: Action: Question from the Chairman's Office (COB today)

Thanks so much for the help in getting us this information with such a quick turnaround. I'm sure it will turn out to be very useful for the Chairman, Bill, and Mike during their testimony today and tomorrow, along with any future requests we get to talk to Congress. Thanks again!

From: Aissa, Mourad
Sent: Tuesday, March 29, 2011 7:08 PM
To: Armstrong, Kenneth
Cc: Lee, Richard; Hoxie, Chris; Bowman, Gregory; Frazier, Alan; Weber, Michael; Sheron, Brian; Gibson, Kathy
Subject: RE: Action: Question from the Chairman's Office (COB today)
Importance: High

Ken,
Attached is the requested information. After we iterated, the request has been clarified as having to do to with a plutonium question to the EDO and the impact of MOX fuel. Attached is a summary of information on the impact of MOX. Thanks
Mourad

Mourad Aissa, PhD
Senior Criticality Analysis and Reactor Physics Engineer

Z/238

Office of Nuclear Regulatory Research
Mail Stop CSB-3A07M
US Nuclear Regulatory Commission
Washington, DC 20555-0001
Phone: (301) 251-7511

From: Armstrong, Kenneth
Sent: Tuesday, March 29, 2011 3:04 PM
To: Esmaili, Hossein; Salay, Michael; Aissa, Mourad; Hudson, Nathanael; Yarsky, Peter
Cc: Algama, Don; Lee, Richard; Hoxie, Chris
Subject: Action: Question from the Chairman's Office (COB today)
Importance: High

Please let me know if you have any input into the request below?

From: Bowman, Gregory
Sent: Tuesday, March 29, 2011 2:51 PM
To: Armstrong, Kenneth
Subject: Question from the Chairman's Office
Importance: High

Like we discussed...

We got an information request to help prepare the Chairman for Congressional testimony tomorrow. The Chairman is interested in knowing how the isotopic composition of fuel changes over life of the core (from BOL, after each cycle, to EOL). The Chairman's office is looking for something by 5:30 this evening.

I realize this is difficult question with a lot of different variables. We're really looking for a more general response, and because the Chairman's office is using it to prepare for Congressional testimony, it would be better to avoid anything highly technical.

NMSS/SFST was also asked to help with a response, but we were thinking RES might have expertise in this area, as well, and might be better suited to help.

Greg

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 9:23 AM
To: Graves, Herman
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA
Attachments: image.png; A reinforced concrete wall is 123 to 185 Cm thick.docx

Herman:

Does it worthwhile to ask SNL to respond?

Thx, Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]
Sent: Thursday, March 24, 2011 3:14 PM
To: Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMs Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D
Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico
Phone: 505-284-8574
Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]
Sent: Thursday, March 24, 2011 11:53 AM
To: Petti, Jason P
Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?
2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.
How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796
Fax: +43 1 2600 29598
E-mail: Ki-Sig.KANG@iaea.org

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]
Sent: Thursday, 24 March 2011 17:44
To: KANG, Ki-Sig
Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis. You might contact Jason Petti (jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai Ichi Npp containment.

The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm).

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

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How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

[cid:3383815441_5634291]

Ki- Sig KANG

Technical Head (PLiM/LTO)
Nuclear Power Engineering Section

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Tel: +43 1 2600 22796
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E-mail: Ki-Sig.KANG@iaea.org

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Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 9:50 AM
To: Wagner, Katie
Cc: Gibson, Kathy
Subject: FW: ACTION: DRAFT PMT request to RES-RST
Attachments: PMT Draft Request to RES-RST.docx

Importance: High

Katie:

Please log in. This is a high priority item that we need to respond to.

Thanks, Richard

From: PMT01 Hoc
Sent: Wednesday, March 30, 2011 9:39 AM
To: Esmaili, Hossein; Tinkler, Charles; Lee Col
Cc: Lee, Richard; Hoc, PMT12; PMT01 Hoc; PMT11 Hoc; PMT02 Hoc
Subject: ACTION: DRAFT PMT request to RES-RST
Importance: High

Attached for your comment.
Request input ASAP.

Contacts:
Tony Huffert
Rich Clement
PMT – NRC Ops Center
301-816-5402

2/240

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 9:13 AM
To: Basu, Sudhamay
Subject: FW: COMMENTS on SUMMARY SLIDES

Please ask Mitch and we can finalize it. Thx.

-----Original Message-----

From: Tinkler, Charles
Sent: Wednesday, March 30, 2011 9:02 AM
To: Lee, Richard
Subject: RE: COMMENTS on SUMMARY SLIDES

I have 2 comments - #1 - do we want to opine on likelihood of crust anchoring?

And #2 - do we need to say more about radial versus axial ablation for siliceous concrete?

-----Original Message-----

From: Lee, Richard
Sent: Wednesday, March 30, 2011 8:01 AM
To: Salay, Michael; Esmaili, Hossein; Tinkler, Charles; Schaperow, Jason; Helton, Donald
Subject: FW: COMMENTS on SUMMARY SLIDES

FYI.

I will be forwarding this calculations to Op Center (since last week the NRC Team in Tokyo was asking for MCCI info. per Japanese request) to transmit to Tokyo NRC team.

Richard

-----Original Message-----

From: Farmer, Mitchell T. [mailto:farmer@anl.gov]
Sent: Tuesday, March 29, 2011 3:01 PM
To: Lee, Richard
Cc: 'Michael Corradini'; Basu, Sudhamay; Gavrilas, Mirela; Robb, Kevin Richard
Subject: FW: COMMENTS on SUMMARY SLIDES

Hi Richard,

I believe Mike has forwarded these corquench and melcor ex-vessel analyses on to you earlier. Would it be possible to forward these on to John Kelly? If possible, could you also cc Jeff Binder as John's email is being overwhelmed and Jeff is helping him on managing information. Jeff's email is: binderjl@ornl.gov

Thank you,
Mitch

-----Original Message-----

From: Kevin Robb [mailto:krrobb@wisc.edu]
Sent: Saturday, March 26, 2011 9:02 PM
To: Michael Corradini; Farmer, Mitchell T.
Subject: Re: COMMENTS on SUMMARY SLIDES

Hello,

Z/241

Attached is updated calcs from me.

CORQUENCH predicts anchoring but there's uncertainty in that.

Anchoring allowed - slide 15: 50-100% melts all do not quench in 5 days but ablation is very slow (<0.4 cm/hr), ablation on the order of 1m Anchoring not allowed - slide 16: 50-100% melts quenches in several to tens of hrs, ablation on the order of 0.5m 100's - 1500 kg of H₂ is produced I'm not sure about the MELCORE predictions - higher ablation rate (2x), odd spikes in upward/downward heat transfer

I'll try some hand calcs tomorrow about steaming rate & non-condensable pressurization.

Kevin

On 03/26/11, Michael Corradini wrote:

>
>

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 10:57 AM
To: Basu, Sudhamay
Subject: FW: COMMENTS on SUMMARY SLIDES

FYI

-----Original Message-----

From: Tinkler, Charles
Sent: Wednesday, March 30, 2011 9:02 AM
To: Lee, Richard
Subject: RE: COMMENTS on SUMMARY SLIDES

I have 2 comments - #1 - do we want to opine on likelihood of crust anchoring?

And #2 - do we need to say more about radial versus axial ablation for siliceous concrete?

-----Original Message-----

From: Lee, Richard
Sent: Wednesday, March 30, 2011 8:01 AM
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Subject: FW: COMMENTS on SUMMARY SLIDES

FYI.

I will be forwarding this calculations to Op Center (since last week the NRC Team in Tokyo was asking for MCCI info. per Japanese request) to transmit to Tokyo NRC team.

Richard

-----Original Message-----

From: Farmer, Mitchell T. [mailto:farmer@anl.gov]
Sent: Tuesday, March 29, 2011 3:01 PM
To: Lee, Richard
Cc: 'Michael Corradini'; Basu, Sudhamay; Gavrilas, Mirela; Robb, Kevin Richard
Subject: FW: COMMENTS on SUMMARY SLIDES

Hi Richard,

I believe Mike has forwarded these corquench and melcor ex-vessel analyses on to you earlier. Would it be possible to forward these on to John Kelly? If possible, could you also cc Jeff Binder as John's email is being overwhelmed and Jeff is helping him on managing information. Jeff's email is: binderjl@ornl.gov

Thank you,
Mitch

-----Original Message-----

From: Kevin Robb [mailto:krrobb@wisc.edu]
Sent: Saturday, March 26, 2011 9:02 PM
To: Michael Corradini; Farmer, Mitchell T.
Subject: Re: COMMENTS on SUMMARY SLIDES

Hello,

2/242

Attached is updated calcs from me.

CORQUENCH predicts anchoring but there's uncertainty in that.

Anchoring allowed - slide 15: 50-100% melts all do not quench in 5 days but ablation is very slow (<0.4 cm/hr), ablation on the order of 1m Anchoring not allowed - slide 16: 50-100% melts quenches in several to tens of hrs, ablation on the order of 0.5m 100's - 1500 kg of H₂ is produced I'm not sure about the MELCORE predictions - higher ablation rate (2x), odd spikes in upward/downward heat transfer

I'll try some hand calcs tomorrow about steaming rate & non-condensable pressurization.

Kevin

On 03/26/11, Michael Corradini wrote:

>
>

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 12:20 PM
To: 'Powers, Dana A'
Subject: RE: Isotopes in MOX and LEU

He was looking for the isotopic composition of fuel changes over life of the core (from BOL, after each cycle, to EOL).

I think the next question is from a SA release point of view, what is the differences between the two - LEU vs. LEU/MOX.release for the NUREG-1465 classes of release.

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 11:31 AM
To: Lee, Richard
Subject: Isotopes in MOX and LEU

Richard, I have the Origen outputs for the MOX and LEU fuel for fresh, 1, 2, and 3 cycles, Output includes fuel isotopes, fission products, and activation products. What is it that we need for the Chairman? Dana

Z/243

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 12:48 PM
To: Wagner, Katie
Subject: FW: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run

Katie:
Same as #60 on the sharepoint

From: PMT02 Hoc
Sent: Wednesday, March 30, 2011 12:41 PM
To: Tinkler, Charles; Esmaili, Hossein; PMT01 Hoc; PMT01 Hoc
Cc: Lee, Richard; Schaperow, Jason
Subject: FW: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run

Please see recent email for your information.

Tony Huffert
Rich Clement
PMT NRC Operations Center
301-816-5402

From: Hoc, PMT12
Sent: Wednesday, March 30, 2011 12:37 PM
To: Julie_A._Bentz@nss.eop.gov; Fetter, Steve
Cc: OST02 HOC; Blount, Tom; Miller, Marie; Jackson, Todd; Cool, Donald; Boger, Bruce; FOIA Response.hoc Resource; Holahan, Vincent; LIA01 Hoc; NITOPS; 'narc@llnl.gov'; Hoc, PMT12; PMT02 Hoc; David.Bowman@nnsa.doe.gov
Subject: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run

The U.S. Ambassador in Japan has requested modeling to support decisions on the return of individuals who were voluntarily evacuated. NRC was informed of this request through members of our team in Japan, for a modeling run for a "Pessimistic Case" of future releases from the Fukushima plants. We understand that the Ambassador requested that this product be completed by Wednesday April 6, with a draft available on Sunday April 3.

The case, as we understand it, would involve a set of events, starting on April 15, 2011. This date was selected because the Ambassador is planning for individuals to return to Tokyo around that time. Our understanding is that the case should include new energetic event in the Unit 1 reactor core, followed by an additional event 24 hours later at the Unit 4 spent fuel pool.

We are currently in the process of developing a radiological source term for this assessment. We plan to include more specific considerations of the timing of events since March 11th and take into account the radiological decay of short half-life fission products. Assumptions on meteorology conditions would include representative conditions and winds moving toward Tokyo from the Fukushima site. We will be prepared to interact directly with DOE, the NIT, and with NARAC, once this tasking has been agreed by the NTAG and the White House, and a tasking established to NARAC for the modeling to support the Ambassador request.

We understand that this request may also being brought forward through other pathways.

We await White House agreement and tasking to move forward to meet the Ambassador's request.

3/244

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 4:03 PM
To: Gibson, Kathy
Cc: Santiago, Patricia; Chang, Richard; Armstrong, Kenneth
Subject: RE: SOARCA study put on hold for Japan reviews?

Our conversation with Susan Pickering this morning is to keep the work at the current pace.

From: Gibson, Kathy
Sent: Wednesday, March 30, 2011 3:45 PM
To: Uhle, Jennifer; Santiago, Patricia; Chang, Richard
Cc: Sheron, Brian; Lee, Richard
Subject: Re: SOARCA study put on hold for Japan reviews?

Perfect.

Richard Chang, Pat, Tina, are still working mostly SOARCA, SNL has some new staff working it. Ken Armstrong is rotating to SPB to help out as well as an MA. I'm trying to maintain some semblance of momentum so we can complete it as soon as possible. There will be heightened interest...

From: Uhle, Jennifer
To: Gibson, Kathy; Santiago, Patricia; Chang, Richard
Cc: Sheron, Brian; Lee, Richard
Sent: Wed Mar 30 15:37:02 2011
Subject: RE: SOARCA study put on hold for Japan reviews?

Okay, I did not think anyone was left...

How about:

NRC is continuing its efforts on the State of the Art Reactor Consequence Analysis (SOARCA) project at a reduced pace since many of the staff and contractors working on SOARCA are assisting NRC's efforts regarding the Fukushima event. The NRC has not yet determined the length of the project's delay.

From: Gibson, Kathy
Sent: Wednesday, March 30, 2011 3:32 PM
To: Uhle, Jennifer; Santiago, Patricia; Chang, Richard
Cc: Sheron, Brian; Lee, Richard
Subject: Re: SOARCA study put on hold for Japan reviews?

We have NOT put SOARCA on hold. We and SNL are working it with staff not completely consumed by Japan support and main staff (charlie, jason, randy gauntt) as they can. This will certainly delay SOARCA but have not yet assessed the length of the delay since Japan support is fluid. Yes delayed, NOT on hold.

From: Uhle, Jennifer
To: Santiago, Patricia; Gibson, Kathy; Chang, Richard
Cc: Sheron, Brian
Sent: Wed Mar 30 15:24:54 2011
Subject: RE: SOARCA study put on hold for Japan reviews?

This is what I would say about SOARCA delays

Z/245

NRC's efforts on the State of the Art Reactor Consequence Analysis (SOARCA) are currently on hold because the NRC staff and contractors working on SOARCA are assisting NRC's efforts regarding the Fukushima event.

Do you agree?

From: Hayden, Elizabeth
Sent: Wednesday, March 30, 2011 3:04 PM
To: Uhle, Jennifer
Cc: Sheron, Brian
Subject: FW: SOARCA study put on hold for Japan reviews?

Can someone help us out in Scott Burnell's absence?

Thanks,

Beth

From: Dolley, Steven [mailto:Steven_Dolley@platts.com]
Sent: Wednesday, March 30, 2011 2:56 PM
To: OPA Resource
Cc: Hayden, Elizabeth
Subject: RE: SOARCA study put on hold for Japan reviews?

Could someone please confirm or disconfirm Neil's statement that the NRC Soarca study is on hold pending the Japan reviews? I'm not sure why he can't, but he referred me to HQ.

Thanks,
Steve

Steven Dolley
Managing Editor, Inside NRC
Platts Nuclear
202-383-2166 Office
202-383-2187 Fax

From: Sheehan, Neil [mailto:Neil.Sheehan@nrc.gov]
Sent: Wednesday, March 30, 2011 2:51 PM
To: Dolley, Steven
Cc: Burnell, Scott
Subject: FW: SOARCA study put on hold for Japan reviews?

Steve,

I would refer you to Scott Burnell on this. He may be out today.

Neil
NRC Public Affairs
(610) 337-5331

From: Dolley, Steven [mailto:Steven_Dolley@platts.com]
Sent: Wednesday, March 30, 2011 2:49 PM
To: Sheehan, Neil
Subject: SOARCA study put on hold for Japan reviews?

Neil, Can you confirm this? If so, how long will the Soarca review be on hold?

Thanks, Steve

That study has been put on hold, though, because the NRC is busy reviewing facilities to make sure vulnerabilities identified from what happened in Japan after the March 11 earthquake and tsunami are not found in U.S. plants, Sheehan said.

http://www.timesonline.com/news/figures-showing-high-risk-of-meltdown-at-beaver-valley-outdated/article_2b061d5c-5a5a-11e0-b6b3-0017a4a78c22.html

Steven Dolley
Managing Editor, Inside NRC
Platts Nuclear
202-383-2166 Office
202-383-2187 Fax

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Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 1:40 PM
To: 'Dana Powers (Home)'; 'Dana Powers (SNL)'
Subject: FW: Processes to remove radiocesium from salt solutions

Dana:

Ion-exchange to remove Cs, Sr and actinides....

Richard

-----Original Message-----

From: Per F. Peterson [mailto:peterson@nuc.berkeley.edu]
Sent: Wednesday, March 30, 2011 1:20 PM
To: Brinkman, Bill; 'Binder, Jeffrey L.'; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; 'Elizabeth.Connell@inl.gov'; 'Harold McFarlane'; 'Harold Denton'; Adams, Ian; 'John Holdren'; 'JOE H. PAYER'; Kelly, John E (NE); 'John Grossenbacher'; Owens, Missy; 'Per Peterson'; Lyons, Peter; 'Phil Finck'; 'Dick Garwin'; Lee, Richard; 'Bob Budnitz'; 'Rolando Szilard'; SCHU; Aoki, Steven; Koonin, Steven; 'Steve Fetter'; Binkley, Steve; DAgostino, Thomas
Subject: Processes to remove radiocesium from salt solutions

I have attached below references to four National Academy reports on methods to remove radiocesium and other water-soluble radionuclides from sodium salt solutions.

I would point in particular to the ion exchange options for removal of strontium and actinides, and removal of cesium. Cesium was separated from tank wastes at Hanford and is now in storage at Hanford, and has also been studied extensively for use at SRS, INL, and Hanford, for example:

"Alternatives for High-Level Waste Salt Processing at the Savannah River Site," Chapters on "Strontium and Actinide Removal (35-42)" and "Crystalline Silicotitanate Ion Exchange (pp. 55-64)."

In discussion with Terry Todd at INL, one of the most promising ion exchange materials may be crystalline silicotitanate (CST), developed by Sandia National Laboratory and Texas A&M University. It has high selectivity for cesium in solutions that have high concentrations of sodium. It also can recover strontium, although the use of monosodium titanate (MST) may be more effective in stripping strontium and actinides. A mixed bed of MST and CST might be best.

CST and MST are also appropriate materials to feed into waste glass, so this would provide a path to get cesium and strontium from Fukushima incorporated into waste glass that could be produced at Rokkashomura.

I think that the goal for using ion exchange should be to achieve 90 to 99% reductions in radioactivity levels in the salt solutions, to reduce the shielding and reliability requirements for tanks and evaporator equipment. If ion exchange columns are set up in series, even higher decontamination is possible. Radiation monitoring on the outlet of the lead column can be used to determine when it is saturated, and it can then be valved out and the next column in the series can become the lead column. Further clean up and processing of these lower activity salt solutions coming out of the ion exchange can be deferred while attention is focused on remediation of the reactors.

I do remain concerned about the longer-term integrity of the primary containment vessels, since they are only 3-cm of carbon steel and are subjected to a very corrosive environment.

A substantial leak in the torus of a reactor containment would make it impossible to maintain flooding of the bottom of the reactor vessels and would challenge the coolability of the reactor cores, inviting further damage and relocation of core material. It is important to note that the addition of caustic to reduce the pH of the salt solutions has been suggested to reduce corrosion rates, and that reducing the pH will also improve the effectiveness of the ion exchange.

Flushing the reactor vessels and primary containments can reduce corrosion rates, and it also reduces the source term for fluid that could be discharged into the reactor building if the primary containment leaks. Flushing also prepares the reactors to reestablish residual heat removal and for removal of the damaged fuel in the cores.

In parallel with flushing, cranes need to be used to remove debris from above and around the spent fuel pools and reactor refueling cavities. Flooding of the reactor cavities, once debris is gone, can allow the reactor vessel heads to be removed and core debris transferred into baskets and then into shielded casks. The heads are heavy, so the crane capability to make these transfers is an issue.

There is discussion of reenclosing the reactor buildings, but some hatches are needed above the reactor cavity to allow an external crane to be used.

To estimate the amount of CST and MST needed to clean up the reactors, it's probably reasonable to assume that 30 to 90 percent of the cesium and strontium that was in the reactor cores is now in the salt solutions. The total inventory of cesium and strontium can be estimated based upon the integrated power production that has occurred with the fuel in the reactors. Fairly quickly, it will be important to get some estimates of how much ion exchange material would be needed to clean up the reactors, and to begin addressing the engineering and logistical challenges of setting up an ion exchange system at Fukushima. It may also be necessary to increase the rate of commercial production of these ion exchange materials. This is something that merits a near-term scoping study by INL and SRL.

-Per

Alternatives for High-Level Waste Salt Processing at the Savannah River Site, National Academy Press, 2000.

http://www.nap.edu/catalog.php?record_id=9959

Also

Research and Development on a Salt Processing Alternative for High-Level Waste at the Savannah River Site, National Academy Press, 2001.

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Evaluation of Criteria for Selecting a Salt Processing Alternative for High-Level Waste at the Savannah River Site: Interim Report, National Academy Press, 2001.

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Interim Report -- Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, National Academy Press, 1999.

http://www.nap.edu/catalog.php?record_id=9703

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Per F. Peterson
Professor and Chair
Department of Nuclear Engineering

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Berkeley, California 94720-1730
peterson@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 4:53 PM
To: 'Binkley, Steve'
Subject: RE: Mar 30 S-1 Science Council

Steve:

I cannot open the document on DOE perspective on corrosion. Please send again. Sorry.
Richard

From: Binkley, Steve [mailto:Steve.Binkley@science.doe.gov]
Sent: Wednesday, March 30, 2011 4:45 PM
To: Adams, Ian; Aoki, Steven; Binkley, Steve; Bob Budnitz; Sheron, Brian; Brinkman, Bill; DAgostino, Thomas; Dick Garwin; Dick Garwin; Harold Denton; Harold McFarlane; Hurlbut, Brandon; JOE H. PAYER; John Grossenbacher; John Holdren; Kelly, John E (NE); Koonin, Steven; Lyons, Peter; Owens, Missy; Per Peterson; Phil Finck; Poneman, Daniel; Lee, Richard; Rolando Szilard; SCHU; Steve Fetter
Subject: FW: Mar 30 S-1 Science Council

Science Call briefing materials attached

From: Larzelere, Alex
Sent: Wednesday, March 30, 2011 4:42 PM
To: DL-NITsolutions
Subject: Mar 30 S-1 Science Council

Everybody,

Attached are the slides and document for discussion at today's Science Council meeting.

Regards,

Alex

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 5:01 PM
To: 'Powers, Dana A'
Subject: RE: Mar 30 S-1 Science Council

No. I just ask for another copy.

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 4:56 PM
To: Lee, Richard
Subject: RE: Mar 30 S-1 Science Council

Do you know how to open the file entitled DOE Perspective on Corrosion?

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 2:45 PM
To: Dana Powers (Home); Powers, Dana A
Subject: FW: Mar 30 S-1 Science Council

fyi

From: Binkley, Steve [mailto:Steve.Binkley@science.doe.gov]
Sent: Wednesday, March 30, 2011 4:45 PM
To: Adams, Ian; Aoki, Steven; Binkley, Steve; Bob Budnitz; Sheron, Brian; Brinkman, Bill; DAgostino, Thomas; Dick Garwin; Dick Garwin; Harold Denton; Harold McFarlane; Hurlbut, Brandon; JOE H. PAYER; John Grossenbacher; John Holdren; Kelly, John E (NE); Koonin, Steven; Lyons, Peter; Owens, Missy; Per Peterson; Phil Finck; Poneman, Daniel; Lee, Richard; Rolando Szilard; SCHU; Steve Fetter
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Alex

Z/248

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 5:37 PM
To: 'Binder, Jeffrey L.'
Subject: FW: Processes to remove radiocesium from salt solutions

Jeff:

John Kelly's e-mails must be overwhelmed now. Please distributed for record. Dana mentioned this during today DOE Science Council conference call today.

Richard

I have spoken to Nenoff about the use of crystalline silicon titanates for separation of cesium from salt solution. She does not think that they actually tested seawater, but she thinks that the material has the needed selectivity for cesium. She look further at her notes. Dana

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 4:30 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

Hanford and Savannah River folks have a lot more experience with ion exchange than I do. I think it is tricky to do in this situation because you have micromolar quantities of cesium and half molar sodium ions. You really have to have a lot of selectivity to overcome the concentration difference. But the Hanford and savannah river wastes had equally high concentrations of sodium nitrate. You also have a substantial amount of divalent cations in the salt water that love to grab onto resins. Crystalline silicontitanates seem to perform well. You do have to figure out what to do with it all. Nenoff was the developer of this method. She is still here at Sandia. I will send her a note and see what she thinks. Dana

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From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 11:40 AM
To: Dana Powers (Home); Powers, Dana A
Subject: FW: Processes to remove radiocesium from salt solutions

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Sent: Wednesday, March 30, 2011 1:20 PM
To: Brinkman, Bill; 'Binder, Jeffrey L.'; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; 'Elizabeth.Connell@inl.gov'; 'Harold McFarlane'; 'Harold Denton'; Adams, Ian; 'John Holdren'; 'JOE H. PAYER'; Kelly, John E (NE); 'John Grossenbacher'; Owens, Missy; 'Per Peterson';

Z/249

Lyons, Peter; 'Phil Finck'; 'Dick Garwin'; Lee, Richard; 'Bob Budnitz'; 'Rolando Szilard'; SCHU; Aoki, Steven; Koonin, Steven; 'Steve Fetter'; Binkley, Steve; DAgostino, Thomas
Subject: Processes to remove radiocesium from salt solutions

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Per F. Peterson
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Berkeley, California 94720-1730
peterson@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Brookhaven National Laboratory (BNL) Site Visit and Audit Regarding Maximum Extended Load Line Limit Analysis Plus (MELLLA+) Anticipated Transient Without SCRAM (ATWS) Calculation Agenda

Time: Monday April 18, 2011 through Wednesday April 20, 2011

Topics:

Resolution of seven audit open items from the February site visit
Modeling of feedwater control during manual operator level control
Standby liquid control system tank inventory and boron content
Review of Channel Generating Script update to incorporate channel box heat transfer
Discussion of PARCS related code issues
Preliminary analysis results for large ATWS with instability (ATWSI) model
Discussion of emergency depressurization results and code issues
Discussion of schedule impacts and expectations

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 5:01 PM
To: 'Powers, Dana A'
Subject: RE: Processes to remove radiocesium from salt solutions

I will do so later today.

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 4:57 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

sure

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 2:42 PM
To: Powers, Dana A
Subject: RE: Processes to remove radiocesium from salt solutions

Dana:

Do you want me to send your message to the DOE Science CXoincil?

Richard

-----Original Message-----

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Sent: Wednesday, March 30, 2011 4:30 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

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Sent: Wednesday, March 30, 2011 11:40 AM
To: Dana Powers (Home); Powers, Dana A
Subject: FW: Processes to remove radiocesium from salt solutions

Dana:

Ion-exchange to remove Cs, Sr and actinides....

Richard

Z/250

-----Original Message-----

From: Per F. Peterson [mailto:peterson@nuc.berkeley.edu]

Sent: Wednesday, March 30, 2011 1:20 PM

To: Brinkman, Bill; 'Binder, Jeffrey L.'; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; 'Elizabeth.Connell@inl.gov'; 'Harold McFarlane'; 'Harold Denton'; Adams, Ian; 'John Holdren'; 'JOE H. PAYER'; Kelly, John E (NE); 'John Grossenbacher'; Owens, Missy; 'Per Peterson'; Lyons, Peter; 'Phil Finck'; 'Dick Garwin'; Lee, Richard; 'Bob Budnitz'; 'Rolando Szilard'; SCHU; Aoki, Steven; Koonin, Steven; 'Steve Fetter'; Binkley, Steve; DAgostino, Thomas
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"Alternatives for High-Level Waste Salt Processing at the Savannah River Site," Chapters on "Strontium and Actinide Removal (35-42)" and "Crystalline Silicotitanate Ion Exchange (pp. 55-64)."

In discussion with Terry Todd at INL, one of the most promising ion exchange materials may be crystalline silicotitanate (CST), developed by Sandia National Laboratory and Texas A&M University. It has high selectivity for cesium in solutions that have high concentrations of sodium. It also can recover strontium, although the use of monosodium titanate (MST) may be more effective in stripping strontium and actinides. A mixed bed of MST and CST might be best.

CST and MST are also appropriate materials to feed into waste glass, so this would provide a path to get cesium and strontium from Fukushima incorporated into waste glass that could be produced at Rokkashomura.

I think that the goal for using ion exchange should be to achieve 90 to 99% reductions in radioactivity levels in the salt solutions, to reduce the shielding and reliability requirements for tanks and evaporator equipment. If ion exchange columns are set up in series, even higher decontamination is possible. Radiation monitoring on the outlet of the lead column can be used to determine when it is saturated, and it can then be valved out and the next column in the series can become the lead column. Further clean up and processing of these lower activity salt solutions coming out of the ion exchange can be deferred while attention is focused on remediation of the reactors.

I do remain concerned about the longer-term integrity of the primary containment vessels, since they are only 3-cm of carbon steel and are subjected to a very corrosive environment. A substantial leak in the torus of a reactor containment would make it impossible to maintain flooding of the bottom of the reactor vessels and would challenge the coolability of the reactor cores, inviting further damage and relocation of core material. It is important to note that the addition of caustic to reduce the pH of the salt solutions has been suggested to reduce corrosion rates, and that reducing the pH will also improve the effectiveness of the ion exchange.

Flushing the reactor vessels and primary containments can reduce corrosion rates, and it also reduces the source term for fluid that could be discharged into the reactor building if the primary containment leaks. Flushing also prepares the reactors to reestablish residual heat removal and for removal of the damaged fuel in the cores.

In parallel with flushing, cranes need to be used to remove debris from above and around the spent fuel pools and reactor refueling cavities. Flooding of the reactor cavities, once

- debris is gone, can allow the reactor vessel heads to be removed and core debris transferred into baskets and then into shielded casks. The heads are heavy, so the crane capability to make these transfers is an issue.

There is discussion of reenclosing the reactor buildings, but some hatches are needed above the reactor cavity to allow an external crane to be used.

To estimate the amount of CST and MST needed to clean up the reactors, it's probably reasonable to assume that 30 to 90 percent of the cesium and strontium that was in the reactor cores is now in the salt solutions. The total inventory of cesium and strontium can be estimated based upon the integrated power production that has occurred with the fuel in the reactors. Fairly quickly, it will be important to get some estimates of how much ion exchange material would be needed to clean up the reactors, and to begin addressing the engineering and logistical challenges of setting up an ion exchange system at Fukushima. It may also be necessary to increase the rate of commercial production of these ion exchange materials. This is something that merits a near-term scoping study by INL and SRL.

-Per

Alternatives for High-Level Waste Salt Processing at the Savannah River Site, National Academy Press, 2000.

http://www.nap.edu/catalog.php?record_id=9959

Also

Research and Development on a Salt Processing Alternative for High-Level Waste at the Savannah River Site, National Academy Press, 2001.

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Evaluation of Criteria for Selecting a Salt Processing Alternative for High-Level Waste at the Savannah River Site: Interim Report, National Academy Press, 2001.

http://www.nap.edu/catalog.php?record_id=10088

Interim Report -- Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, National Academy Press, 1999.

http://www.nap.edu/catalog.php?record_id=9703

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Per F. Peterson
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Berkeley, California 94720-1730
peterson@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 5:50 PM
To: 'Powers, Dana A'
Subject: RE: Processes to remove radiocesium from salt solutions

Any proof?

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 5:43 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

Everyone knows more the Per

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 3:42 PM
To: Powers, Dana A
Subject: RE: Processes to remove radiocesium from salt solutions

Sounds good! She knows more than Per?

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 5:40 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

Sounds like they have a functioning system for cleaning up things.

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 3:16 PM
To: Powers, Dana A
Subject: RE: Processes to remove radiocesium from salt solutions

Dana:

It appears that the lady speaking today knows of Hanford and Savannah River capability.
Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 4:57 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

sure

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 2:42 PM
To: Powers, Dana A

Z/251

Subject: RE: Processes to remove radiocesium from salt solutions

Dana:

Do you want me to send your message to the DOE Science CXoincil?

Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 4:30 PM
To: Lee, Richard
Subject: RE: Processes to remove radiocesium from salt solutions

Hanford and Savannah River folks have a lot more experience with ion exchange than I do. I think it is tricky to do in this situation because you have micromolar quantities of cesium and half molar sodium ions. You really have to have a lot of selectivity to overcome the concentration difference. But the Hanford and savannah river wastes had equally high concentrations of sodium nitrate. You also have a substantial amount of divalent cations in the salt water that love to grab onto resins. Crystalline silicotitanates seem to perform well. You do have to figure out what to do with it all. Nenoff was the developer of this method. She is still here at Sandia. I will send her a note and see what she thinks. Dana

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 11:40 AM
To: Dana Powers (Home); Powers, Dana A
Subject: FW: Processes to remove radiocesium from salt solutions

Dana:

Ion-exchange to remove Cs, Sr and actinides....

Richard

-----Original Message-----

From: Per F. Peterson [mailto:peter@nuc.berkeley.edu]
Sent: Wednesday, March 30, 2011 1:20 PM
To: Brinkman, Bill; 'Binder, Jeffrey L.'; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; 'Elizabeth.Connell@inl.gov'; 'Harold McFarlane'; 'Harold Denton'; Adams, Ian; 'John Holdren'; 'JOE H. PAYER'; Kelly, John E (NE); 'John Grossenbacher'; Owens, Missy; 'Per Peterson'; Lyons, Peter; 'Phil Finck'; 'Dick Garwin'; Lee, Richard; 'Bob Budnitz'; 'Rolando Szilard'; SCHU; Aoki, Steven; Koonin, Steven; 'Steve Fetter'; Binkley, Steve; DAgostino, Thomas
Subject: Processes to remove radiocesium from salt solutions

I have attached below references to four National Academy reports on methods to remove radiocesium and other water-soluble radionuclides from sodium salt solutions.

I would point in particular to the ion exchange options for removal of strontium and actinides, and removal of cesium. Cesium was separated from tank wastes at Hanford and is now in storage at Hanford, and has also been studied extensively for use at SRS, INL, and Hanford, for example:

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Also

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Evaluation of Criteria for Selecting a Salt Processing Alternative for High-Level Waste at the Savannah River Site: Interim Report, National Academy Press, 2001.
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Interim Report -- Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, National Academy Press, 1999.
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Per F. Peterson
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Berkeley, California 94720-1730
peterston@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 6:26 PM
To: Graves, Herman
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Thanks, Herman.
Richard

-----Original Message-----

From: Graves, Herman
Sent: Wednesday, March 30, 2011 6:25 PM
To: Lee, Richard
Cc: Pires, Jose; Candra, Hernando
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard,

As discussed we do not believe that it is necessary to ask SANDIA to do more on this request.

The units used by Ki Sig Kang, IAEA are off by a factor of 10 [design pressure is about 0.37-0.41 MPa not 3.84 MPa; the thickness of the carbon steel plate varies from about 3/4 in -1 3/4 in not 6 mm]. Also, from Mirela's and Jose review we have the following information:

"Two pressures are of interest when considering venting: leakage pressure and rupture pressure. According to NUREG/CR- 6920, the leakage pressure for the wetwell is around 0.8 MPa (116 psi) and for the drywell it is around 1.0 MPa (145 psi). The rupture pressure is about 1.0-1.2 MPa, which is consisted to 2.5-3x design pressure. Note that these pressures are also temperature dependent, but that dependency is weak until about 200 deg. C (400 deg. F).

While carbon steel is not highly vulnerable to cracking, the salt can increase the crevice/pitting corrosion so some degradation of the values listed above can be expected. The once you have the conditions for localized corrosion, the rate can be as high as 10 cm/year (4 in/year). The containment shell thickness for MK-Is varies from 0.75-1.75 in (1.9-4.5 cm) at various locations. NUREG/CR-6920 estimates that localized corrosion of up to 50% of the thickness reduces the leakage and rupture pressure by 10-20%."

<<Herman>>
<<301.251.7625>>
mail to: Herman.Graeves@nrc.gov

-----Original Message-----

From: Lee, Richard
Sent: Wednesday, March 30, 2011 10:07 AM
To: Graves, Herman
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Great, Thanks.
Richard

-----Original Message-----

From: Graves, Herman
Sent: Wednesday, March 30, 2011 10:06 AM
To: Lee, Richard
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard,

I believe staff here can respond to the request for information but let me check to see. I will get back to you I about an hour.

<<Herman>>
<<301.251.7625>>
mail to: Herman.Graves@nrc.gov

-----Original Message-----

From: Lee, Richard
Sent: Wednesday, March 30, 2011 9:23 AM
To: Graves, Herman
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Herman:

Does it worthwhile to ask SNL to respond?

Thx, Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]
Sent: Thursday, March 24, 2011 3:14 PM
To: Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMS Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D
Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico

Phone: 505-284-8574
Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]
Sent: Thursday, March 24, 2011 11:53 AM
To: Petti, Jason P
Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?
2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.
How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796

Fax: +43 1 2600 29598

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

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]
Sent: Thursday, 24 March 2011 17:44
To: KANG, Ki-Sig
Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis. You might contact Jason Petti (jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai Ichi Npp containment.

The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm).

Can I ask you the important questions ?

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Thanks for your reply in advance.

[cid:3383815441_5634291]

Ki- Sig KANG

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

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Lee, Richard

From: Lee, Richard
Sent: Wednesday, March 30, 2011 6:30 PM
To: 'Binkley, Steve'
Subject: RE: PDF of Lab Corrosion Document 3-30

Thx, Steve: Sorry about this.
Richard

From: Binkley, Steve [<mailto:Steve.Binkley@science.doe.gov>]
Sent: Wednesday, March 30, 2011 6:26 PM
To: Adams, Ian; Aoki, Steven; Binkley, Steve; Bob Budnitz; Sheron, Brian; Brinkman, Bill; DAgostino, Thomas; Dick Garwin; Dick Garwin; Harold Denton; Harold McFarlane; Hurlbut, Brandon; JOE H. PAYER; John Grossenbacher; John Holdren; Kelly, John E (NE); Koonin, Steven; Lyons, Peter; Owens, Missy; Per Peterson; Phil Finck; Poneman, Daniel; Lee, Richard; Rolando Szilard; SCHU; Steve Fetter
Subject: FW: PDF of Lab Corrosion Document 3-30

PDF version of 2nd document.

Steve Binkley

From: Elizabeth A Connell [<mailto:Elizabeth.Connell@inl.gov>]
Sent: Wednesday, March 30, 2011 6:25 PM
To: Binkley, Steve
Subject: PDF of Lab Corrosion Document 3-30

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 6:32 PM
To: 'Powers, Dana A'
Subject: RE: Uranium, Plutonium and Neptunium Isotopes in MOX and LEU Fuel

Thx, Dana. If you have the tabulated values handy, we would like to get it.
Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Thursday, March 31, 2011 6:23 PM
To: Lee, Richard
Subject: Uranium, Plutonium and Neptunium Isotopes in MOX and LEU Fuel

Richard, attached are the plots of inventories for MOX and LEU fuel in a PWR. Do you need the tabulated values? Dana

Z/254

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 10:20 PM
To: Binder, Jeffrey L.
Subject: RE: SFP at Unit 3

Jeff:

As of 1800 03/31/2011, we understood Unit 3 pool is getting fresh water injection via the cooling and purification line. Did something happen?

Richard

From: Binder, Jeffrey L. [binderjl@ornl.gov]
Sent: Thursday, March 31, 2011 4:59 PM
To: Lee, Richard
Subject: SFP at Unit 3

Richard:

Do you know anything about the status?

Jeff

Z/255

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 3:05 PM
To: Tinkler, Charles; Schaperow, Jason
Cc: Wagner, Katie
Subject: FW: Research Look into Worse Case, what if ...

Gentlemen:

Your view on this is sought.

Thanks, Richard

From: RST01 Hoc
Sent: Thursday, March 31, 2011 2:48 PM
To: Gibson, Kathy; Lee, Richard
Subject: Research Look into Worse Case, what if ...

Please take a look at this first cut by RST and Please Add To or Refine as necessary to answer the following (RST Task # 3491):

Make determinations (time and measures) that would result in an energetic release no longer being a realistic possibility. How long until decay heat is not a factor?

Thank you,
RST Coordinator

Z/256

Dose calculations that supported the March 16 press release and calculations sent to NARAC

Data as of 03/31/2011

Dose calculations that supported the March 16 press release and calculations sent to NARAC										
Data as of 03/28/2011										
Date sent	Name of case	Fuel Melt (FM) and containment release (%/Day) assumed			Fuel Pool inventory released				NARAC Summary	Note
		U1 Core	U2 Core	U3 Core	U1 SFP	U2 SFP	U3 SFP	U4 SFP		
3/15/2011	Attachment 1 to March 16 Protective Action Press Release		100% FM 100%/day						N/A	RASCAL run, not sent to NARAC.
3/16/2011	Attachment 2 to March 16 Protective Action Press Release		33% FM 100%/day	33% FM, 100%/day				100% released	N/A	RASCAL run, not sent to NARAC. Adjusted U2 power to approximate source term from assumed damage.
3/17 - 3/18/2011	"Super Core" Trans- Pacific NOTE: This source term is not to be used going forward due to error in offload timing for SPF #4. E-mail sent 3/28/2011 @12:54 to NARAC		33% FM 100%/day				50% release in 14 days	3 fresh batches + 4 old batches 100%/14 days	N/A	NARAC to use this source term to determine impacts to U.S. west coast
3/19/2011	MELCOR Assessment - Long Term Station Blackout (LTSBO)	1/2 hour release duration based on a containment failure shortly after Reactor Pressure Vessel (RPV) breach			500 day off loaded fuel 16-hour release duration			mix of 100 & 500 day fuel 8-hour release	N/A	"Worst-Case" scenario using best estimate accident progression assumptions
?	Plausible Realistic Scenario	33% FM 0.5%/Day	33% FM 0.5%/Day	33% FM 0.5%/Day	No Fuel Pool release assessed in this scenario				>1 rem TEDE 7.8 km 14:33 UTC March 24, 2011	Source Term from conference call with OSTP (Japan), DOE, NARAC and NRC
3/24/2011	Plausible Realistic Case PRC-V3	70% FM 10%/day	33% FM 5 in ² hole 60 psi internal pressure	33% FM 100%/day	No Fuel Pool release assessed in this scenario				>1 rem TEDE 12.6 km 16:00 UTC March 25, 2011	Source term info from Japan 3/21/2011 Analysis Team
3/26/2011	Intermediate Phase Supercore NOTE: This source term is not to be used going forward due to error in offload timing for SPF #4. E-mail sent 3/28/2011 @12:54 to NARAC		33% FM 100%/day				50% release in 14 days	3 fresh batches + 4 old batches 100%/14 days	N/A	DOE was directed by the White House to generate report

DOE

157
2

Dose calculations that supported the March 16 press release and calculations sent to NARAC

Data as of 03/31/2011

3/30/2011	Pessimistic Source Term for US Embassy in Tokyo	70% FM, some ex- vessel, drywell venting						3 fresh batches offloaded on 12/01/10, 7 old batches	Request from Japan Team
4/6/2011	MELCOR version of "Plausible Realistic Case"	70% FM 10%/day	33% FM 5 in ² hole 60 psi internal pressure	33% FM 100%/day	No Fuel Pool release assessed in this scenario				To re-evaluate 50- mile evacuation

RASCAL run to justify expansion to 50 mile EPZ

ex 5

Refer to NSIR

Summary Report

Case description: Fukushima Unit 2 mid day release 15MAR
 Run date/time: 2011/03/15 02:56

Maximum Dose Values (rem) - Close-In

Dist from release miles (kilometers)	0.5 (0.8)	1. (1.61)	1.5 (2.41)	2. (3.22)	3. (4.83)	5. (8.05)	7. (11.27)	10. (16.09)
Total EDE	<u>4.1E+03</u>	<u>1.7E+03</u>	<u>1.0E+03</u>	<u>7.2E+02</u>	<u>4.4E+02</u>	<u>8.7E+01</u>	<u>4.5E+01</u>	<u>4.1E+00</u>
Thyroid CDE	<u>9.9E+03</u>	<u>2.9E+03</u>	<u>1.4E+03</u>	<u>8.2E+02</u>	<u>4.4E+02</u>	<u>1.0E+02</u>	<u>6.2E+01</u>	<u>7.2E+00</u>
Inhalation CEDE	1.2E+03	3.3E+02	1.5E+02	8.7E+01	4.4E+01	8.8E+00	4.8E+00	4.7E-01
Cloudshine	8.4E+00	3.1E+00	1.5E+00	7.5E-01	2.9E-01	2.0E-01	1.4E-01	5.8E-02
4-day Groundshine	2.9E+03	1.4E+03	8.6E+02	6.3E+02	3.9E+02	7.8E+01	4.0E+01	3.6E+00
Inter Phase 1st Yr	<u>4.5E+04</u>	<u>2.1E+04</u>	<u>1.3E+04</u>	<u>9.9E+03</u>	<u>6.1E+03</u>	<u>1.2E+03</u>	<u>6.1E+02</u>	<u>5.4E+01</u>
Inter Phase 2nd Yr	<u>2.2E+04</u>	<u>1.1E+04</u>	<u>6.6E+03</u>	<u>4.9E+03</u>	<u>3.0E+03</u>	<u>5.9E+02</u>	<u>3.0E+02</u>	<u>2.6E+01</u>

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

Maximum Dose Values (rem) - To 50 mi

Dist from release miles (kilometers)	15 (24.1)	20 (32.2)	30 (48.3)	40 (64.4)	50 (80.5)
Total EDE	<u>2.1E+00</u>	<u>2.8E+00</u>	<u>2.7E+00</u>	5.6E-01	1.7E-01
Thyroid CDE	<u>2.0E+01</u>	<u>1.7E+01</u>	<u>1.1E+01</u>	<u>5.0E+00</u>	3.5E+00
Inhalation CEDE	1.3E+00	1.0E+00	6.2E-01	2.0E-01	1.4E-01
Cloudshine	2.9E-02	2.5E-02	1.7E-02	8.1E-03	5.8E-03
4-day Groundshine	1.6E+00	2.5E+00	2.0E+00	3.6E-01	3.7E-02
Inter Phase 1st Yr	<u>2.5E+01</u>	<u>3.8E+01</u>	<u>2.3E+01</u>	<u>2.1E+00</u>	3.2E-01
Inter Phase 2nd Yr	<u>1.2E+01</u>	<u>1.9E+01</u>	<u>1.0E+01</u>	<u>6.6E-01</u>	1.2E-01

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine
 - Total Acute Bone = Bone Inhalation + Cloudshine + Period Groundshine

Case Summary

Event Type Nuclear Power Plant

Location
 Name: Fukushima Unit 2
 City, county, state: <undefined>, <undefined>, <undefined>
 Lat / Long / Elev: 37.4214° N, 141.0325° E, 0 m
 Time zone: <undefined>
 Population: not available

Reactor Parameters

Summary Report

Reactor power: 2350 MWt
Average fuel burn-up: 30000 MWD / MTU
Containment type: BWR Mark I
Containment volume: 2.50E+05 ft³
Design pressure: 60 lb/in²
Design leak rate: 0.54 %/d
Coolant mass: 1.25E+05 kg
Assemblies in core: 550

Source Term

Type: Time Core Is Uncovered
Shutdown: 2011/03/11 14:46
Core uncovered: 2011/03/15 00:00
Core recovered: No

Release Pathway

Type: BWR - Release Through Dry Well
via direct, unfiltered pathway
Description: Unit 2 mid-day release 3-15-11
Release height: 10. m

Release events

2011/03/15 00:00 Sprays Off
2011/03/15 11:45 Leak rate (% vol) Total failure

Meteorology

Type: Actual Observations
Dataset name: Fukushima 2011 03-14 1600
Dataset desc: Obs/fcsts for Fukushima Unit 1

Summary of data at release point:	Type	Dir deg	Speed m/s	Stab class	Precip	Temp °C
2011/03/12 14:00	Obs	265	1.0	B	?	
2011/03/12 15:00	Obs	265	1.0	B	?	
2011/03/12 16:00	Obs	277	1.3	B	?	
2011/03/12 17:00	Obs	260	2.4	B	?	
2011/03/12 18:00	Obs	241	1.4	E	?	
2011/03/12 19:00	Obs	236	2.1	E	?	
2011/03/12 20:00	Obs	239	2.1	E	?	
2011/03/12 21:00	Obs	229	3.8	E	?	
2011/03/12 22:00	Obs	224	5.1	E	?	
2011/03/12 23:00	Obs	226	3.9	E	?	
2011/03/13 00:00	Obs	228	4.1	E	?	
2011/03/13 01:00	Obs	235	2.6	E	?	
2011/03/13 02:00	Obs	233	3.9	E	?	
2011/03/13 03:00	Obs	225	1.8	E	?	
2011/03/13 04:00	Obs	225	1.3	E	?	
2011/03/13 05:00	Obs	225	2.2	E	?	
2011/03/13 06:00	Obs	225	2.2	E	?	
2011/03/13 07:00	Obs	248	2.7	E	?	
2011/03/13 08:00	Obs	248	2.7	E	?	
2011/03/13 09:00	Obs	270	3.1	E	?	
2011/03/13 12:00	Obs	271	7.4	D	?	
2011/03/13 13:00	Obs	276	6.2	D	?	
2011/03/13 14:00	Obs	312	2.8	B	?	
2011/03/14 18:00	Obs	258	4.8	unk	?	
2011/03/14 19:00	Obs	268	5.0	unk	?	

Summary Report

2011/03/14 20:00	Obs	330	2.2	unk	?
2011/03/14 21:00	Fcst	337	4.6	unk	?
2011/03/14 22:00	Fcst	323	7.2	unk	?
2011/03/14 23:00	Fcst	305	6.6	unk	?
2011/03/15 00:00	Fcst	015	8.6	unk	?
2011/03/15 02:00	Fcst	002	7.5	unk	?
2011/03/15 03:00	Fcst	347	5.2	E	None
2011/03/15 04:00	Fcst	332	5.6	E	None
2011/03/15 05:00	Fcst	332	4.0	E	None
2011/03/15 06:00	Fcst	344	3.5	E	Lgt rain
2011/03/15 07:00	Fcst	026	3.8	E	Lgt rain
2011/03/15 08:00	Fcst	044	4.4	E	Lgt rain
2011/03/15 09:00	Fcst	020	4.2	E	Lgt rain
2011/03/15 10:00	Fcst	010	3.4	E	None
2011/03/15 11:00	Fcst	030	3.5	D	Lgt rain
2011/03/15 12:00	Fcst	027	3.0	D	Lgt rain
2011/03/15 13:00	Fcst	037	3.4	D	Lgt rain
2011/03/15 14:00	Fcst	053	3.7	B	None
2011/03/15 15:00	Fcst	058	3.7	B	None
2011/03/15 16:00	Fcst	067	3.2	C	Lgt rain
2011/03/15 17:00	Fcst	081	3.9	C	Lgt rain
2011/03/15 18:00	Fcst	089	4.7	B	None
2011/03/15 19:00	Fcst	085	4.4	B	None
2011/03/15 20:00	Fcst	083	4.4	B	Lgt rain
2011/03/15 21:00	Fcst	074	4.6	C	Lgt rain
2011/03/15 22:00	Fcst	054	5.0	D	Lgt rain
2011/03/15 23:00	Fcst	029	5.6	D	Rain
2011/03/16 00:00	Fcst	011	5.1	D	Lgt rain
2011/03/16 01:00	Fcst	346	4.3	C	Lgt rain
2011/03/16 02:00	Fcst	350	5.3	D	Lgt rain
2011/03/16 03:00	Fcst	323	5.6	D	Lgt rain
2011/03/16 04:00	Fcst	316	5.4	D	None
2011/03/16 05:00	Fcst	298	4.8	D	None
2011/03/16 06:00	Fcst	314	5.6	D	None
2011/03/16 07:00	Fcst	312	4.7	D	None
2011/03/16 08:00	Fcst	331	4.9	D	None
2011/03/16 09:00	Fcst	353	4.1	D	None

Dataset options: Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

Calculations

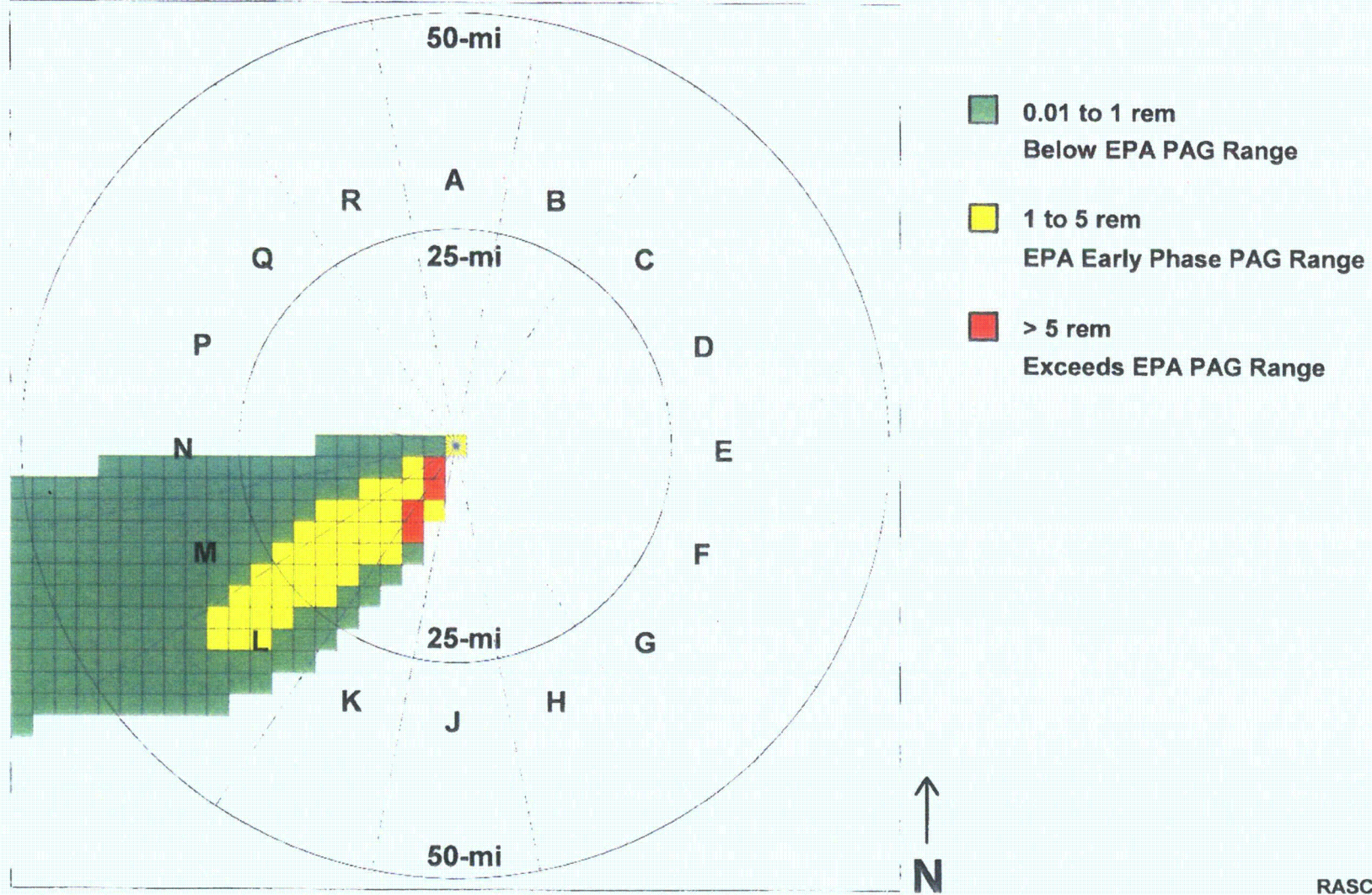
Case description: Fukushima Unit 2 mid day release 15MAR
End of calculations: 2011/03/16 03:45
Start of release to atmosphere + 16 h
Distance of calculation: Close-in + to 50 miles
Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

Total Effective Dose Equivalent

Accumulated between 2011/03/15 11:45 and 2011/03/16 03:45

Fukushima Unit 2 mid day release 15MAR

Fukushima Unit 2



Re-run of 3/15/11 2:51 run found in press release. Ignore run date/time on this copy.

Summary Report

Case description: Fukushima Unit 2 mid night release 14MAR
 Run date/time: 2011/03/15 03:04

Maximum Dose Values (rem) - Close-In

Dist from release miles (kilometers)	0.5 (0.8)	1. (1.61)	1.5 (2.41)	2. (3.22)	3. (4.83)	5. (8.05)	7. (11.27)	10. (16.09)
Total EDE	<u>5.4E+03</u>	<u>2.0E+03</u>	<u>1.2E+03</u>	<u>8.2E+02</u>	<u>4.8E+02</u>	<u>2.4E+02</u>	<u>1.6E+02</u>	<u>9.5E+01</u>
Thyroid CDE	<u>2.8E+04</u>	<u>1.1E+04</u>	<u>6.2E+03</u>	<u>4.3E+03</u>	<u>2.5E+03</u>	<u>1.3E+03</u>	<u>8.4E+02</u>	<u>5.1E+02</u>
Inhalation CEDE	<u>3.7E+03</u>	<u>1.4E+03</u>	<u>8.0E+02</u>	<u>5.6E+02</u>	<u>3.3E+02</u>	<u>1.7E+02</u>	<u>1.1E+02</u>	<u>6.7E+01</u>
Cloudshine	<u>1.9E+01</u>	<u>9.3E+00</u>	<u>5.8E+00</u>	<u>4.1E+00</u>	<u>2.5E+00</u>	<u>1.4E+00</u>	<u>9.7E-01</u>	<u>6.2E-01</u>
4-day Groundshine	<u>1.7E+03</u>	<u>6.5E+02</u>	<u>3.8E+02</u>	<u>2.6E+02</u>	<u>1.5E+02</u>	<u>7.3E+01</u>	<u>4.6E+01</u>	<u>2.8E+01</u>
Inter Phase 1st Yr	<u>2.4E+04</u>	<u>9.3E+03</u>	<u>5.4E+03</u>	<u>3.8E+03</u>	<u>2.2E+03</u>	<u>1.0E+03</u>	<u>6.6E+02</u>	<u>3.9E+02</u>
Inter Phase 2nd Yr	<u>1.1E+04</u>	<u>4.4E+03</u>	<u>2.6E+03</u>	<u>1.8E+03</u>	<u>1.0E+03</u>	<u>4.9E+02</u>	<u>3.1E+02</u>	<u>1.8E+02</u>

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

Maximum Dose Values (rem) - To 50 mi

Dist from release miles (kilometers)	15 (24.1)	20 (32.2)	30 (48.3)	40 (64.4)	50 (80.5)
Total EDE	<u>8.6E+01</u>	<u>6.3E+01</u>	<u>3.7E+01</u>	<u>1.8E+01</u>	<u>8.1E+00</u>
Thyroid CDE	<u>3.3E+02</u>	<u>2.7E+02</u>	<u>1.3E+02</u>	<u>5.9E+01</u>	<u>2.5E+01</u>
Inhalation CEDE	<u>3.9E+01</u>	<u>3.1E+01</u>	<u>1.3E+01</u>	<u>4.4E+00</u>	<u>1.3E+00</u>
Cloudshine	<u>4.5E-01</u>	<u>3.8E-01</u>	<u>1.7E-01</u>	<u>7.4E-02</u>	<u>2.9E-02</u>
4-day Groundshine	<u>4.7E+01</u>	<u>3.2E+01</u>	<u>2.4E+01</u>	<u>1.3E+01</u>	<u>6.7E+00</u>
Inter Phase 1st Yr	<u>7.1E+02</u>	<u>4.7E+02</u>	<u>3.8E+02</u>	<u>2.2E+02</u>	<u>1.3E+02</u>
Inter Phase 2nd Yr	<u>3.4E+02</u>	<u>2.3E+02</u>	<u>1.8E+02</u>	<u>1.1E+02</u>	<u>6.9E+01</u>

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine
 - Total Acute Bone = Bone Inhalation + Cloudshine + Period Groundshine

Case Summary

Event Type Nuclear Power Plant

Location

Name: Fukushima Unit 2
 City, county, state: <undefined>, <undefined>, <undefined>
 Lat / Long / Elev: 37.4214° N, 141.0325° E, 0 m
 UTC Offset: 9 hours
 Population: not available

Reactor Parameters

Summary Report

Reactor power: 2350 MWt
Average fuel burn-up: 30000 MWD / MTU
Containment type: BWR Mark I
Containment volume: 2.50E+05 ft³
Design pressure: 60 lb/in²
Design leak rate: 0.54 %/d
Coolant mass: 1.25E+05 kg
Assemblies in core: 550

Source Term

Type: Time Core Is Uncovered
Shutdown: 2011/03/11 14:46
Core uncovered: 2011/03/15 00:00
Core recovered: No

Release Pathway

Type: BWR - Release Through Dry Well
via direct, unfiltered pathway
Description: Unit 2 mid-night release 3-14-11
Release height: 10. m

Release events

2011/03/15 00:00 Sprays Off
2011/03/15 00:00 Leak rate (% vol) Total failure

Meteorology

Type: Actual Observations
Dataset name: Fukushima 2011 03-14 1600
Dataset desc: Obs/fcsts for Fukushima Unit 1

Summary of data at release point:	Type	Dir deg	Speed m/s	Stab class	Precip	Temp °C
2011/03/12 14:00	Obs	265	1.0	B	?	
2011/03/12 15:00	Obs	265	1.0	B	?	
2011/03/12 16:00	Obs	277	1.3	B	?	
2011/03/12 17:00	Obs	260	2.4	B	?	
2011/03/12 18:00	Obs	241	1.4	E	?	
2011/03/12 19:00	Obs	236	2.1	E	?	
2011/03/12 20:00	Obs	239	2.1	E	?	
2011/03/12 21:00	Obs	229	3.8	E	?	
2011/03/12 22:00	Obs	224	5.1	E	?	
2011/03/12 23:00	Obs	226	3.9	E	?	
2011/03/13 00:00	Obs	228	4.1	E	?	
2011/03/13 01:00	Obs	235	2.6	E	?	
2011/03/13 02:00	Obs	233	3.9	E	?	
2011/03/13 03:00	Obs	225	1.8	E	?	
2011/03/13 04:00	Obs	225	1.3	E	?	
2011/03/13 05:00	Obs	225	2.2	E	?	
2011/03/13 06:00	Obs	225	2.2	E	?	
2011/03/13 07:00	Obs	248	2.7	E	?	
2011/03/13 08:00	Obs	248	2.7	E	?	
2011/03/13 09:00	Obs	270	3.1	E	?	
2011/03/13 12:00	Obs	271	7.4	D	?	
2011/03/13 13:00	Obs	276	6.2	D	?	
2011/03/13 14:00	Obs	312	2.8	B	?	
2011/03/14 18:00	Obs	258	4.8	unk	?	
2011/03/14 19:00	Obs	268	5.0	unk	?	

Summary Report

2011/03/14 20:00	Obs	330	2.2	unk	?
2011/03/14 21:00	Fcst	337	4.6	unk	?
2011/03/14 22:00	Fcst	323	7.2	unk	?
2011/03/14 23:00	Fcst	305	6.6	unk	?
2011/03/15 00:00	Fcst	015	8.6	unk	?
2011/03/15 02:00	Fcst	002	7.5	unk	?
2011/03/15 03:00	Fcst	347	5.2	E	None
2011/03/15 04:00	Fcst	332	5.6	E	None
2011/03/15 05:00	Fcst	332	4.0	E	None
2011/03/15 06:00	Fcst	344	3.5	E	Lgt rain
2011/03/15 07:00	Fcst	026	3.8	E	Lgt rain
2011/03/15 08:00	Fcst	044	4.4	E	Lgt rain
2011/03/15 09:00	Fcst	020	4.2	E	Lgt rain
2011/03/15 10:00	Fcst	010	3.4	E	None
2011/03/15 11:00	Fcst	030	3.5	D	Lgt rain
2011/03/15 12:00	Fcst	027	3.0	D	Lgt rain
2011/03/15 13:00	Fcst	037	3.4	D	Lgt rain
2011/03/15 14:00	Fcst	053	3.7	B	None
2011/03/15 15:00	Fcst	058	3.7	B	None
2011/03/15 16:00	Fcst	067	3.2	C	Lgt rain
2011/03/15 17:00	Fcst	081	3.9	C	Lgt rain
2011/03/15 18:00	Fcst	089	4.7	B	None
2011/03/15 19:00	Fcst	085	4.4	B	None
2011/03/15 20:00	Fcst	083	4.4	B	Lgt rain
2011/03/15 21:00	Fcst	074	4.6	C	Lgt rain
2011/03/15 22:00	Fcst	054	5.0	D	Lgt rain
2011/03/15 23:00	Fcst	029	5.6	D	Rain
2011/03/16 00:00	Fcst	011	5.1	D	Lgt rain
2011/03/16 01:00	Fcst	346	4.3	C	Lgt rain
2011/03/16 02:00	Fcst	350	5.3	D	Lgt rain
2011/03/16 03:00	Fcst	323	5.6	D	Lgt rain
2011/03/16 04:00	Fcst	316	5.4	D	None
2011/03/16 05:00	Fcst	298	4.8	D	None
2011/03/16 06:00	Fcst	314	5.6	D	None
2011/03/16 07:00	Fcst	312	4.7	D	None
2011/03/16 08:00	Fcst	331	4.9	D	None
2011/03/16 09:00	Fcst	353	4.1	D	None

Dataset options: Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

Calculations

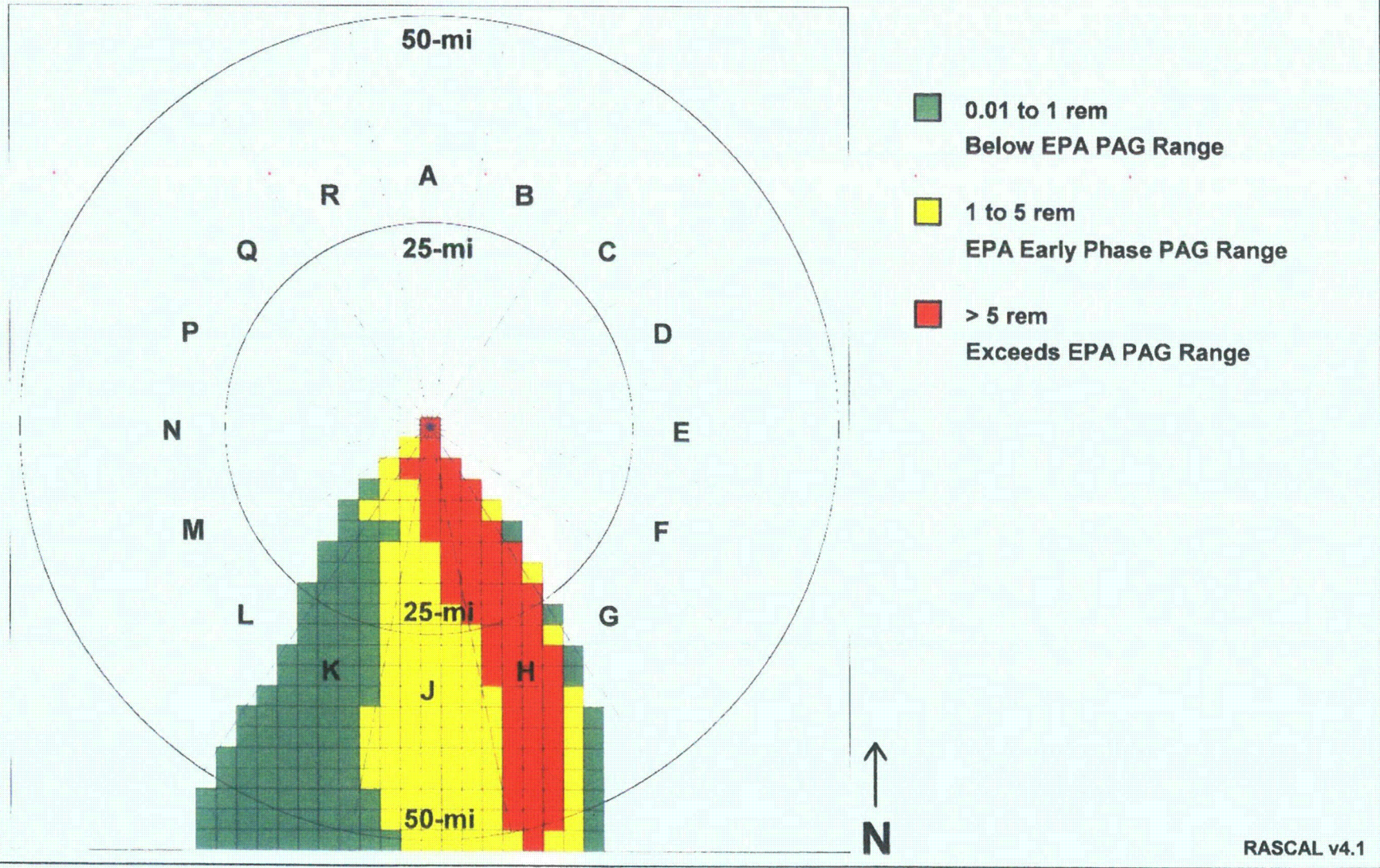
Case description: Fukushima Unit 2 mid night release 14MAR
End of calculations: 2011/03/15 16:00
Start of release to atmosphere + 16 h
Distance of calculation: Close-in + to 50 miles
Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

Total Effective Dose Equivalent

Accumulated between 2011/03/15 00:00 and 2011/03/15 16:00

Fukushima Unit 2 mid night release 14MAR

Fukushima Unit 2



ex 3

Re-run of 3/16/11 run @ 12:24pm
found in press release. Ignore run date /
time on this copy

Summary Report

Case description: Fukushima U2, U3 and U4 SFP approximate site release
Run date/time: 2011/03/17 08:48

Maximum Dose Values (rem) - Close-In

Dist from release miles (kilometers)	0.5 (0.8)	1. (1.61)	1.5 (2.41)	2. (3.22)	3. (4.83)	5. (8.05)	7. (11.27)	10. (16.09)
Total EDE	<u>5.4E+03</u>	<u>1.5E+03</u>	<u>6.7E+02</u>	<u>3.9E+02</u>	<u>1.8E+02</u>	<u>7.5E+01</u>	<u>4.0E+01</u>	<u>1.4E+01</u>
Thyroid CDE	<u>2.9E+04</u>	<u>7.9E+03</u>	<u>3.6E+03</u>	<u>2.1E+03</u>	<u>9.6E+02</u>	<u>4.0E+02</u>	<u>2.1E+02</u>	<u>7.5E+01</u>
Inhalation CEDE	<u>3.8E+03</u>	<u>1.0E+03</u>	<u>4.8E+02</u>	<u>2.8E+02</u>	<u>1.3E+02</u>	<u>5.4E+01</u>	<u>2.9E+01</u>	<u>1.0E+01</u>
Cloudshine	<u>2.2E+01</u>	<u>8.0E+00</u>	<u>3.9E+00</u>	<u>2.3E+00</u>	<u>8.0E-01</u>	<u>2.6E-01</u>	<u>2.1E-01</u>	<u>1.1E-01</u>
4-day Groundshine	<u>1.5E+03</u>	<u>4.1E+02</u>	<u>1.9E+02</u>	<u>1.1E+02</u>	<u>5.0E+01</u>	<u>2.1E+01</u>	<u>1.1E+01</u>	<u>4.4E+00</u>
Inter Phase 1st Yr	<u>2.6E+04</u>	<u>7.0E+03</u>	<u>3.2E+03</u>	<u>1.9E+03</u>	<u>8.5E+02</u>	<u>3.5E+02</u>	<u>1.9E+02</u>	<u>7.5E+01</u>
Inter Phase 2nd Yr	<u>1.3E+04</u>	<u>3.5E+03</u>	<u>1.6E+03</u>	<u>9.2E+02</u>	<u>4.2E+02</u>	<u>1.8E+02</u>	<u>9.5E+01</u>	<u>3.8E+01</u>

Notes:

- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

Maximum Dose Values (rem) - To 50 mi

Dist from release miles (kilometers)	15 (24.1)	20 (32.2)	30 (48.3)	40 (64.4)	50 (80.5)
Total EDE	<u>1.5E+01</u>	<u>1.3E+01</u>	<u>1.1E+01</u>	<u>1.0E+01</u>	<u>9.9E+00</u>
Thyroid CDE	<u>8.6E+01</u>	<u>7.0E+01</u>	<u>5.2E+01</u>	<u>4.9E+01</u>	<u>4.8E+01</u>
Inhalation CEDE	<u>1.1E+01</u>	<u>9.2E+00</u>	<u>7.7E+00</u>	<u>7.6E+00</u>	<u>7.3E+00</u>
Cloudshine	<u>1.2E-01</u>	<u>9.7E-02</u>	<u>7.3E-02</u>	<u>7.0E-02</u>	<u>6.6E-02</u>
4-day Groundshine	<u>4.1E+00</u>	<u>3.4E+00</u>	<u>2.8E+00</u>	<u>2.7E+00</u>	<u>2.5E+00</u>
Inter Phase 1st Yr	<u>7.1E+01</u>	<u>6.0E+01</u>	<u>4.7E+01</u>	<u>4.5E+01</u>	<u>4.3E+01</u>
Inter Phase 2nd Yr	<u>3.6E+01</u>	<u>3.0E+01</u>	<u>2.3E+01</u>	<u>2.2E+01</u>	<u>2.1E+01</u>

Notes:

- Doses exceeding PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine
- Total Acute Bone = Bone Inhalation + Cloudshine + Period Groundshine

Case Summary

Event Type Nuclear Power Plant

Location
 Name: Fukushima U4
 City, county, state: <undefined>, <undefined>, <undefined>
 Lat / Long / Elev: 37.4214° N, 141.0325° E, 0 m
 UTC Offset: 9 hours
 Population: not available

Reactor Parameters

Summary Report

Reactor power: 3760 MWt
Average fuel burn-up: 30000 MWD / MTU
Containment type: BWR Mark I
Containment volume: 2.50E+05 ft³
Design pressure: 60 lb/in²
Design leak rate: 0.54 %/d
Coolant mass: 1.25E+05 kg
Assemblies in core: 917

Source Term

Type: Time Core Is Uncovered
Shutdown: 2011/03/11 14:46
Core uncovered: 2011/03/16 19:50
Core recovered: No

Release Pathway

Type: BWR - Release Through Dry Well
via direct, unfiltered pathway
Description: Fukushima - U2, U3 and U4 SFP release approximation
Release height: 10. m

Release events

2011/03/16 19:50 Leak rate (% vol) Total failure
2011/03/16 19:50 Sprays Off

Meteorology

Type: Actual Observations
Dataset name: Fukushima 2011-03-16 0935
Dataset desc: Obs/fcsts for Fukushima Unit 1

Summary of data at release point:	Type	Dir deg	Speed m/s	Stab class	Precip	Temp °C
2011/03/12 14:00	Obs	265	1.0	B	?	
2011/03/12 15:00	Obs	265	1.0	B	?	
2011/03/12 16:00	Obs	277	1.3	B	?	
2011/03/12 17:00	Obs	260	2.4	B	?	
2011/03/12 18:00	Obs	241	1.4	E	?	
2011/03/12 19:00	Obs	236	2.1	E	?	
2011/03/12 20:00	Obs	239	2.1	E	?	
2011/03/12 21:00	Obs	229	3.8	E	?	
2011/03/12 22:00	Obs	224	5.1	E	?	
2011/03/12 23:00	Obs	226	3.9	E	?	
2011/03/13 00:00	Obs	228	4.1	E	?	
2011/03/13 01:00	Obs	235	2.6	E	?	
2011/03/13 02:00	Obs	233	3.9	E	?	
2011/03/13 03:00	Obs	225	1.8	E	?	
2011/03/13 04:00	Obs	225	1.3	E	?	
2011/03/13 05:00	Obs	225	2.2	E	?	
2011/03/13 06:00	Obs	225	2.2	E	?	
2011/03/13 07:00	Obs	248	2.7	E	?	
2011/03/13 08:00	Obs	248	2.7	E	?	
2011/03/13 09:00	Obs	270	3.1	E	?	
2011/03/13 12:00	Obs	271	7.4	D	?	
2011/03/13 13:00	Obs	276	6.2	D	?	
2011/03/13 14:00	Obs	312	2.8	B	?	
2011/03/14 18:00	Obs	258	4.8	unk	?	
2011/03/14 19:00	Obs	268	5.0	unk	?	

Summary Report

2011/03/14 20:00	Obs	330	2.2	unk	?
2011/03/14 21:00	Fcst	337	4.6	unk	?
2011/03/14 22:00	Fcst	323	7.2	unk	?
2011/03/14 23:00	Fcst	305	6.6	unk	?
2011/03/15 00:00	Fcst	015	8.6	unk	?
2011/03/15 02:00	Fcst	002	7.5	unk	?
2011/03/15 03:00	Fcst	347	5.2	E	None
2011/03/15 04:00	Fcst	332	5.6	E	None
2011/03/15 05:00	Fcst	332	4.0	E	None
2011/03/15 06:00	Fcst	344	3.5	E	Lgt rain
2011/03/15 07:00	Fcst	026	3.8	E	Lgt rain
2011/03/15 08:00	Fcst	044	4.4	E	Lgt rain
2011/03/15 09:00	Fcst	020	4.2	E	Lgt rain
2011/03/15 10:00	Fcst	010	3.4	E	None
2011/03/15 11:00	Fcst	030	3.5	D	Lgt rain
2011/03/15 12:00	Fcst	027	3.0	D	Lgt rain
2011/03/15 13:00	Fcst	037	3.4	D	Lgt rain
2011/03/15 14:00	Fcst	053	3.7	B	None
2011/03/15 15:00	Fcst	058	3.7	B	None
2011/03/15 16:00	Fcst	067	3.2	C	Lgt rain
2011/03/15 17:00	Fcst	081	3.9	C	Lgt rain
2011/03/15 18:00	Fcst	089	4.7	B	None
2011/03/15 19:00	Fcst	085	4.4	B	None
2011/03/15 20:00	Fcst	083	4.4	B	Lgt rain
2011/03/15 21:00	Fcst	074	4.6	C	Lgt rain
2011/03/15 22:00	Fcst	054	5.0	D	Lgt rain
2011/03/15 23:00	Fcst	029	5.6	D	Rain
2011/03/16 00:00	Fcst	011	5.1	D	Lgt rain
2011/03/16 01:00	Fcst	346	4.3	C	Lgt rain
2011/03/16 02:00	Fcst	350	5.3	D	Lgt rain
2011/03/16 03:00	Fcst	323	5.6	D	Lgt rain
2011/03/16 04:00	Fcst	316	5.4	D	None
2011/03/16 05:00	Fcst	298	4.8	D	None
2011/03/16 06:00	Fcst	314	5.6	D	None
2011/03/16 07:00	Fcst	312	4.7	D	None
2011/03/16 08:00	Fcst	331	4.9	D	None
2011/03/16 09:00	Fcst	299	4.2	D	None
2011/03/16 10:00	Fcst	312	5.4	C	None
2011/03/16 11:00	Fcst	309	7.5	C	None
2011/03/16 12:00	Fcst	304	7.2	C	None
2011/03/16 13:00	Fcst	314	8.8	C	None
2011/03/16 14:00	Fcst	325	10.4	C	None
2011/03/16 15:00	Fcst	324	12.3	C	None
2011/03/16 16:00	Fcst	304	14.7	D	None
2011/03/16 17:00	Fcst	299	14.2	D	None
2011/03/16 18:00	Fcst	297	11.3	D	None
2011/03/16 19:00	Fcst	316	9.8	D	None
2011/03/16 20:00	Fcst	309	9.4	D	None
2011/03/16 21:00	Fcst	294	9.5	D	None
2011/03/16 22:00	Fcst	299	7.6	D	None
2011/03/16 23:00	Fcst	300	9.7	D	None
2011/03/17 00:00	Fcst	294	5.0	D	None
2011/03/17 01:00	Fcst	286	7.0	D	None
2011/03/17 02:00	Fcst	287	6.6	D	None
2011/03/17 03:00	Fcst	293	6.5	D	None
2011/03/17 04:00	Fcst	300	6.3	D	None
2011/03/17 05:00	Fcst	311	5.9	D	None
2011/03/17 06:00	Fcst	295	7.4	D	None

Summary Report

2011/03/17 07:00	Fcst	303	8.4	C	None
2011/03/17 08:00	Fcst	333	4.8	C	None
2011/03/17 09:00	Fcst	321	5.9	C	None
2011/03/17 10:00	Fcst	307	5.0	C	None
2011/03/17 11:00	Fcst	292	8.4	C	None
2011/03/17 12:00	Fcst	315	9.3	C	None
2011/03/17 13:00	Fcst	299	11.1	C	None
2011/03/17 14:00	Fcst	292	11.8	C	None
2011/03/17 15:00	Fcst	286	10.7	C	None
2011/03/17 16:00	Fcst	298	9.3	D	None
2011/03/17 17:00	Fcst	286	8.5	D	None
2011/03/17 18:00	Fcst	285	10.6	D	None
2011/03/17 19:00	Fcst	288	11.1	D	None
2011/03/17 20:00	Fcst	301	11.3	D	None
2011/03/17 21:00	Fcst	311	10.1	D	None
2011/03/17 22:00	Fcst	307	8.4	D	None
2011/03/17 23:00	Fcst	303	8.7	D	None
2011/03/18 00:00	Fcst	311	7.1	D	None
2011/03/18 01:00	Fcst	316	3.4	D	None
2011/03/18 02:00	Fcst	310	6.0	D	None
2011/03/18 03:00	Fcst	319	7.4	D	None
2011/03/18 04:00	Fcst	316	6.3	D	None
2011/03/18 05:00	Fcst	307	4.9	D	None
2011/03/18 06:00	Fcst	311	4.4	D	None
2011/03/18 07:00	Fcst	326	5.1	C	None
2011/03/18 08:00	Fcst	343	5.4	C	None
2011/03/18 09:00	Fcst	344	6.1	C	None

Dataset options: Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

Calculations

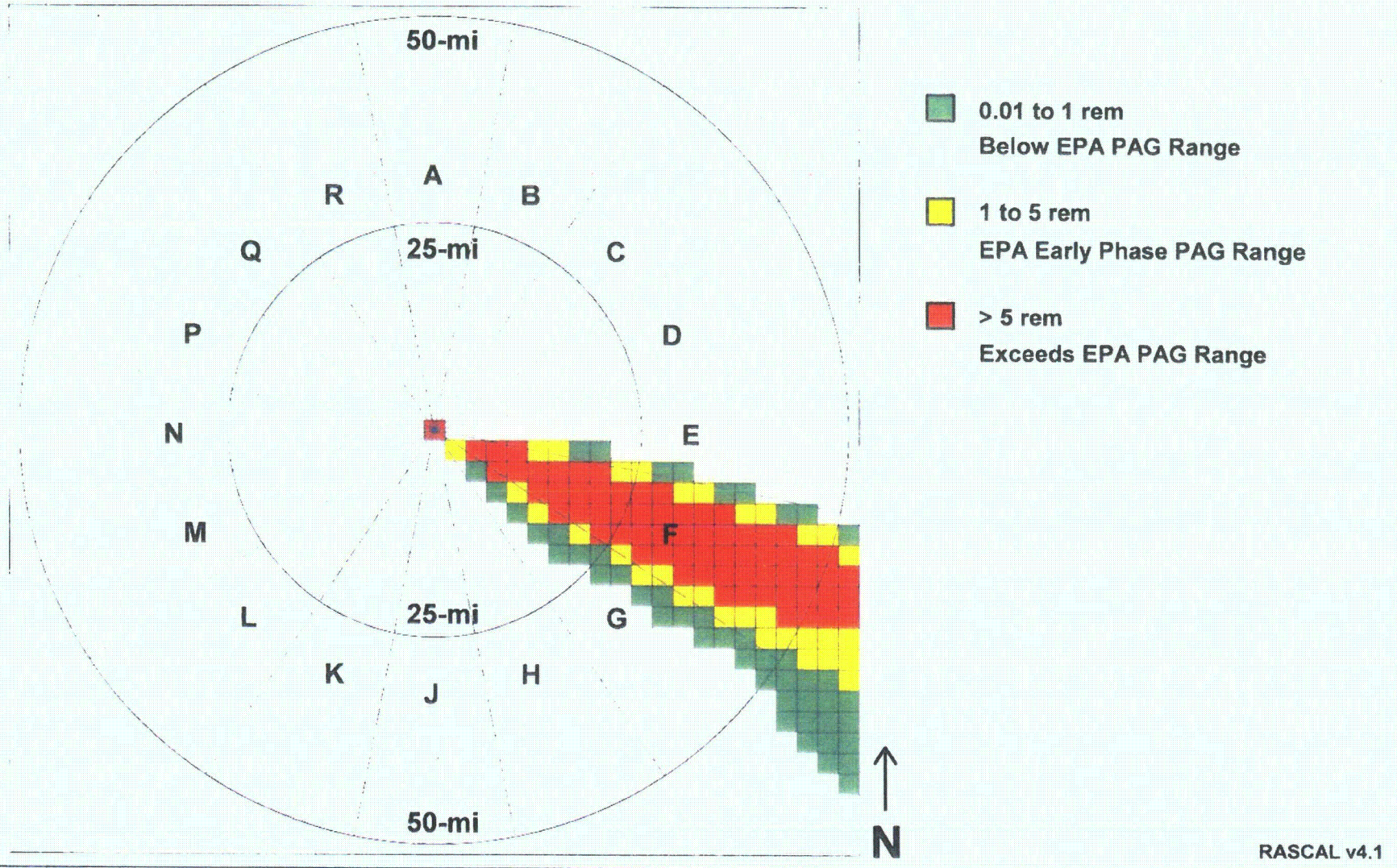
Case description: Fukushima U2, U3 and U4 SFP approximate site release
End of calculations: 2011/03/17 10:50
Start of release to atmosphere + 15 h
Distance of calculation: Close-in + to 50 miles
Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

Total Effective Dose Equivalent

Accumulated between 2011/03/16 19:50 and 2011/03/17 10:50

Fukushima U2, U3 and U4 SFP approximate site release

Fukushima U4



E*5

Re-run of 3/16/11 run @ 12:24pm
 found in press release. Ignore run date /
 time on this copy

Summary Report

Case description: Fukushima U2, U3 and U4 SFP approximate site release
 Run date/time: 2011/03/17 08:48

Maximum Dose Values (rem) - Close-In

Dist from release miles (kilometers)	0.5 (0.8)	1. (1.61)	1.5 (2.41)	2. (3.22)	3. (4.83)	5. (8.05)	7. (11.27)	10. (16.09)
Total EDE	<u>5.4E+03</u>	<u>1.5E+03</u>	<u>6.7E+02</u>	<u>3.9E+02</u>	<u>1.8E+02</u>	<u>7.5E+01</u>	<u>4.0E+01</u>	<u>1.4E+01</u>
Thyroid CDE	<u>2.9E+04</u>	<u>7.9E+03</u>	<u>3.6E+03</u>	<u>2.1E+03</u>	<u>9.6E+02</u>	<u>4.0E+02</u>	<u>2.1E+02</u>	<u>7.5E+01</u>
Inhalation CEDE	<u>3.8E+03</u>	<u>1.0E+03</u>	<u>4.8E+02</u>	<u>2.8E+02</u>	<u>1.3E+02</u>	<u>5.4E+01</u>	<u>2.9E+01</u>	<u>1.0E+01</u>
Cloudshine	2.2E+01	8.0E+00	3.9E+00	2.3E+00	8.0E-01	2.6E-01	2.1E-01	1.1E-01
4-day Groundshine	1.5E+03	4.1E+02	1.9E+02	1.1E+02	5.0E+01	2.1E+01	1.1E+01	4.4E+00
Inter Phase 1st Yr	<u>2.6E+04</u>	<u>7.0E+03</u>	<u>3.2E+03</u>	<u>1.9E+03</u>	<u>8.5E+02</u>	<u>3.5E+02</u>	<u>1.9E+02</u>	<u>7.5E+01</u>
Inter Phase 2nd Yr	<u>1.3E+04</u>	<u>3.5E+03</u>	<u>1.6E+03</u>	<u>9.2E+02</u>	<u>4.2E+02</u>	<u>1.8E+02</u>	<u>9.5E+01</u>	<u>3.8E+01</u>

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase EPA PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = Inhalation CEDE + Cloudshine + 4-Day Groundshine

Maximum Dose Values (rem) - To 50 mi

Dist from release miles (kilometers)	15 (24.1)	20 (32.2)	30 (48.3)	40 (64.4)	50 (80.5)
Total EDE	<u>1.5E+01</u>	<u>1.3E+01</u>	<u>1.1E+01</u>	<u>1.0E+01</u>	<u>9.9E+00</u>
Thyroid CDE	<u>8.6E+01</u>	<u>7.0E+01</u>	<u>5.2E+01</u>	<u>4.9E+01</u>	<u>4.8E+01</u>
Inhalation CEDE	1.1E+01	9.2E+00	7.7E+00	7.6E+00	7.3E+00
Cloudshine	1.2E-01	9.7E-02	7.3E-02	7.0E-02	6.6E-02
4-day Groundshine	4.1E+00	3.4E+00	2.8E+00	2.7E+00	2.5E+00
Inter Phase 1st Yr	<u>7.1E+01</u>	<u>6.0E+01</u>	<u>4.7E+01</u>	<u>4.5E+01</u>	<u>4.3E+01</u>
Inter Phase 2nd Yr	<u>3.6E+01</u>	<u>3.0E+01</u>	<u>2.3E+01</u>	<u>2.2E+01</u>	<u>2.1E+01</u>

- Notes:
- Doses exceeding PAGs are underlined.
 - Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
 - Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
 - *** indicates values less than 1 mrem
 - To view all values - use Detailed Results | Numeric Table
 - Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine
 - Total Acute Bone = Bone Inhalation + Cloudshine + Period Groundshine

Case Summary

Event Type Nuclear Power Plant

Location
 Name: Fukushima U4
 City, county, state: <undefined>, <undefined>, <undefined>
 Lat / Long / Elev: 37.4214° N, 141.0325° E, 0 m
 UTC Offset: 9 hours
 Population: not available

Reactor Parameters

Summary Report

Reactor power: 3760 MWt
Average fuel burn-up: 30000 MWD / MTU
Containment type: BWR Mark I
Containment volume: 2.50E+05 ft³
Design pressure: 60 lb/in²
Design leak rate: 0.54 %/d
Coolant mass: 1.25E+05 kg
Assemblies in core: 917

Source Term

Type: Time Core Is Uncovered
Shutdown: 2011/03/11 14:46
Core uncovered: 2011/03/16 19:50
Core recovered: No

Release Pathway

Type: BWR - Release Through Dry Well
via direct, unfiltered pathway
Description: Fukushima - U2, U3 and U4 SFP release approximation
Release height: 10. m

Release events

2011/03/16 19:50 Leak rate (% vol) Total failure
2011/03/16 19:50 Sprays Off

Meteorology

Type: Actual Observations
Dataset name: Fukushima 2011-03-16 0935
Dataset desc: Obs/fcsts for Fukushima Unit 1

Summary of data at release point:	Type	Dir deg	Speed m/s	Stab class	Precip	Temp °C
2011/03/12 14:00	Obs	265	1.0	B	?	
2011/03/12 15:00	Obs	265	1.0	B	?	
2011/03/12 16:00	Obs	277	1.3	B	?	
2011/03/12 17:00	Obs	260	2.4	B	?	
2011/03/12 18:00	Obs	241	1.4	E	?	
2011/03/12 19:00	Obs	236	2.1	E	?	
2011/03/12 20:00	Obs	239	2.1	E	?	
2011/03/12 21:00	Obs	229	3.8	E	?	
2011/03/12 22:00	Obs	224	5.1	E	?	
2011/03/12 23:00	Obs	226	3.9	E	?	
2011/03/13 00:00	Obs	228	4.1	E	?	
2011/03/13 01:00	Obs	235	2.6	E	?	
2011/03/13 02:00	Obs	233	3.9	E	?	
2011/03/13 03:00	Obs	225	1.8	E	?	
2011/03/13 04:00	Obs	225	1.3	E	?	
2011/03/13 05:00	Obs	225	2.2	E	?	
2011/03/13 06:00	Obs	225	2.2	E	?	
2011/03/13 07:00	Obs	248	2.7	E	?	
2011/03/13 08:00	Obs	248	2.7	E	?	
2011/03/13 09:00	Obs	270	3.1	E	?	
2011/03/13 12:00	Obs	271	7.4	D	?	
2011/03/13 13:00	Obs	276	6.2	D	?	
2011/03/13 14:00	Obs	312	2.8	B	?	
2011/03/14 18:00	Obs	258	4.8	unk	?	
2011/03/14 19:00	Obs	268	5.0	unk	?	

Summary Report

2011/03/14 20:00	Obs	330	2.2	unk	?
2011/03/14 21:00	Fcst	337	4.6	unk	?
2011/03/14 22:00	Fcst	323	7.2	unk	?
2011/03/14 23:00	Fcst	305	6.6	unk	?
2011/03/15 00:00	Fcst	015	8.6	unk	?
2011/03/15 02:00	Fcst	002	7.5	unk	?
2011/03/15 03:00	Fcst	347	5.2	E	None
2011/03/15 04:00	Fcst	332	5.6	E	None
2011/03/15 05:00	Fcst	332	4.0	E	None
2011/03/15 06:00	Fcst	344	3.5	E	Lgt rain
2011/03/15 07:00	Fcst	026	3.8	E	Lgt rain
2011/03/15 08:00	Fcst	044	4.4	E	Lgt rain
2011/03/15 09:00	Fcst	020	4.2	E	Lgt rain
2011/03/15 10:00	Fcst	010	3.4	E	None
2011/03/15 11:00	Fcst	030	3.5	D	Lgt rain
2011/03/15 12:00	Fcst	027	3.0	D	Lgt rain
2011/03/15 13:00	Fcst	037	3.4	D	Lgt rain
2011/03/15 14:00	Fcst	053	3.7	B	None
2011/03/15 15:00	Fcst	058	3.7	B	None
2011/03/15 16:00	Fcst	067	3.2	C	Lgt rain
2011/03/15 17:00	Fcst	081	3.9	C	Lgt rain
2011/03/15 18:00	Fcst	089	4.7	B	None
2011/03/15 19:00	Fcst	085	4.4	B	None
2011/03/15 20:00	Fcst	083	4.4	B	Lgt rain
2011/03/15 21:00	Fcst	074	4.6	C	Lgt rain
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2011/03/15 23:00	Fcst	029	5.6	D	Rain
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2011/03/16 01:00	Fcst	346	4.3	C	Lgt rain
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2011/03/16 04:00	Fcst	316	5.4	D	None
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2011/03/16 07:00	Fcst	312	4.7	D	None
2011/03/16 08:00	Fcst	331	4.9	D	None
2011/03/16 09:00	Fcst	299	4.2	D	None
2011/03/16 10:00	Fcst	312	5.4	C	None
2011/03/16 11:00	Fcst	309	7.5	C	None
2011/03/16 12:00	Fcst	304	7.2	C	None
2011/03/16 13:00	Fcst	314	8.8	C	None
2011/03/16 14:00	Fcst	325	10.4	C	None
2011/03/16 15:00	Fcst	324	12.3	C	None
2011/03/16 16:00	Fcst	304	14.7	D	None
2011/03/16 17:00	Fcst	299	14.2	D	None
2011/03/16 18:00	Fcst	297	11.3	D	None
2011/03/16 19:00	Fcst	316	9.8	D	None
2011/03/16 20:00	Fcst	309	9.4	D	None
2011/03/16 21:00	Fcst	294	9.5	D	None
2011/03/16 22:00	Fcst	299	7.6	D	None
2011/03/16 23:00	Fcst	300	9.7	D	None
2011/03/17 00:00	Fcst	294	5.0	D	None
2011/03/17 01:00	Fcst	286	7.0	D	None
2011/03/17 02:00	Fcst	287	6.6	D	None
2011/03/17 03:00	Fcst	293	6.5	D	None
2011/03/17 04:00	Fcst	300	6.3	D	None
2011/03/17 05:00	Fcst	311	5.9	D	None
2011/03/17 06:00	Fcst	295	7.4	D	None

Summary Report

2011/03/17 07:00	Fcst	303	8.4	C	None
2011/03/17 08:00	Fcst	333	4.8	C	None
2011/03/17 09:00	Fcst	321	5.9	C	None
2011/03/17 10:00	Fcst	307	5.0	C	None
2011/03/17 11:00	Fcst	292	8.4	C	None
2011/03/17 12:00	Fcst	315	9.3	C	None
2011/03/17 13:00	Fcst	299	11.1	C	None
2011/03/17 14:00	Fcst	292	11.8	C	None
2011/03/17 15:00	Fcst	286	10.7	C	None
2011/03/17 16:00	Fcst	298	9.3	D	None
2011/03/17 17:00	Fcst	286	8.5	D	None
2011/03/17 18:00	Fcst	285	10.6	D	None
2011/03/17 19:00	Fcst	288	11.1	D	None
2011/03/17 20:00	Fcst	301	11.3	D	None
2011/03/17 21:00	Fcst	311	10.1	D	None
2011/03/17 22:00	Fcst	307	8.4	D	None
2011/03/17 23:00	Fcst	303	8.7	D	None
2011/03/18 00:00	Fcst	311	7.1	D	None
2011/03/18 01:00	Fcst	316	3.4	D	None
2011/03/18 02:00	Fcst	310	6.0	D	None
2011/03/18 03:00	Fcst	319	7.4	D	None
2011/03/18 04:00	Fcst	316	6.3	D	None
2011/03/18 05:00	Fcst	307	4.9	D	None
2011/03/18 06:00	Fcst	311	4.4	D	None
2011/03/18 07:00	Fcst	326	5.1	C	None
2011/03/18 08:00	Fcst	343	5.4	C	None
2011/03/18 09:00	Fcst	344	6.1	C	None

Dataset options:

Est. missing stability using: Wind speed, time of day, etc.
Adjust stability for consistency: No
Modify winds for topography: Yes

Calculations

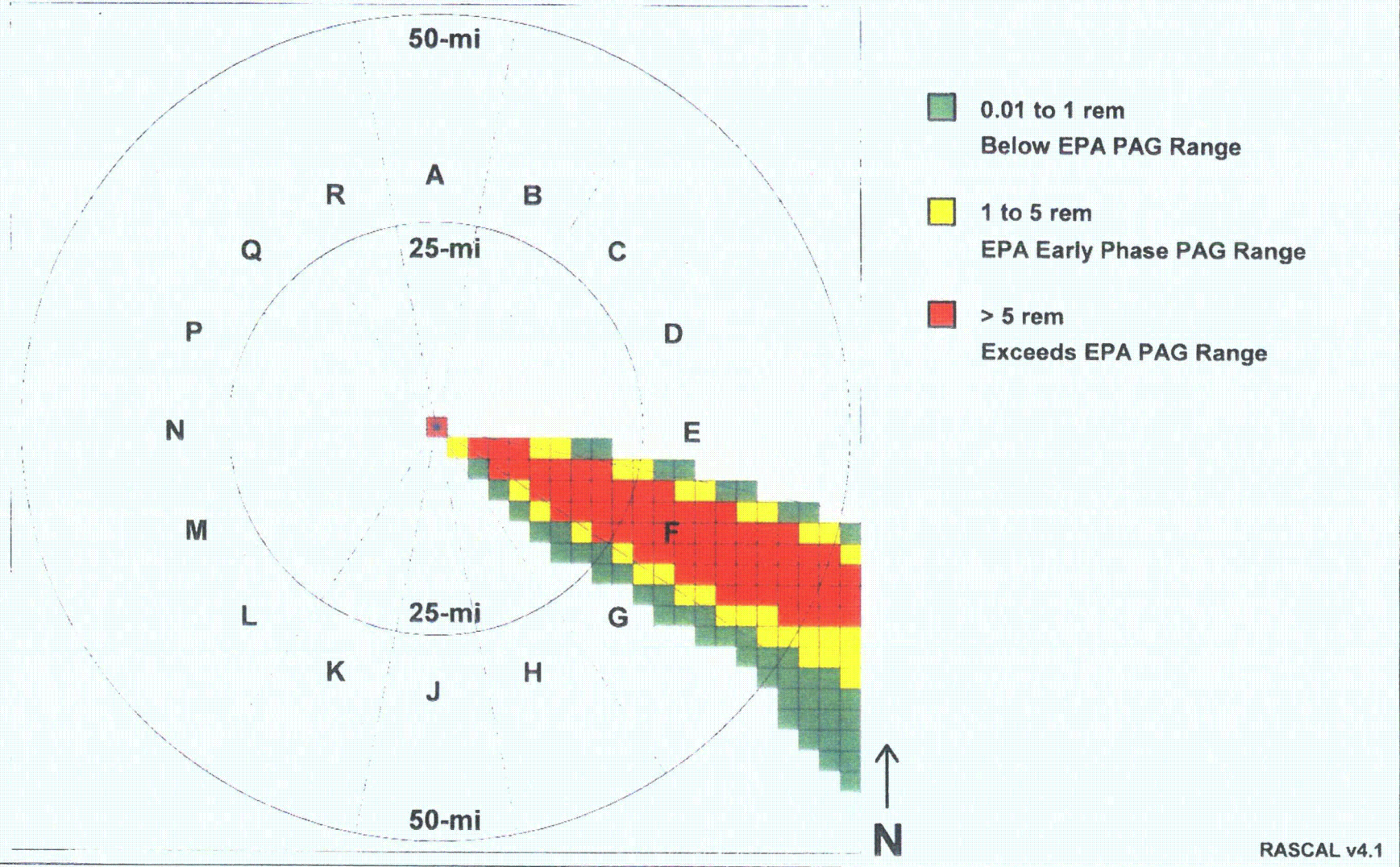
Case description: Fukushima U2, U3 and U4 SFP approximate site release
End of calculations: 2011/03/17 10:50
Start of release to atmosphere + 15 h
Distance of calculation: Close-in + to 50 miles
Close-in distances: 0.5, 1.0, 1.5, 2.0, 3.0, 5.0, 7.0, 10.0 miles

Total Effective Dose Equivalent

Accumulated between 2011/03/16 19:50 and 2011/03/17 10:50

Fukushima U2, U3 and U4 SFP approximate site release

Fukushima U4



Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 3:13 PM
To: Basu, Sudhamay; Michael Corradini
Subject: RE: Research Look into Worse Case, what if ...

That's the same impression I had when I saw "energetic RELEASE." I will ask.

From: Basu, Sudhamay
Sent: Thursday, March 31, 2011 3:11 PM
To: Lee, Richard; Michael Corradini
Subject: RE: Research Look into Worse Case, what if ...

Making sure RST is not talking about HPME and DCH when they say "energetic RELEASE". At low pressures, the potential for explosion should be less.

From: Lee, Richard
Sent: Thursday, March 31, 2011 3:04 PM
To: Michael Corradini; Basu, Sudhamay
Subject: FW: Research Look into Worse Case, what if ...

Mike & Sud:

Your view on this. Units 2 and 2 are 1 atms, and Unit 1 is between 2 to 3 atms.

Thanks, Richard

From: RST01 Hoc
Sent: Thursday, March 31, 2011 2:48 PM
To: Gibson, Kathy; Lee, Richard
Subject: Research Look into Worse Case, what if ...

Please take a look at this first cut by RST and Please Add To or Refine as necessary to answer the following (RST Task # 3491):

Make determinations (time and measures) that would result in an energetic release no longer being a realistic possibility. How long until decay heat is not a factor?

Thank you,
RST Coordinator

2/258

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 3:36 PM
To: Basu, Sudhamay; Michael Corradini
Subject: FW: Research Look into Worse Case, what if ...

No answer received!

From: Lee, Richard
Sent: Thursday, March 31, 2011 3:15 PM
To: RST01 Hoc
Cc: Gibson, Kathy; Tinkler, Charles; Schaperow, Jason
Subject: RE: Research Look into Worse Case, what if ...

What do meant by "energetic release?" Energetic release as in high pressure melt ejection in consideration of direct containment heating?

From: RST01 Hoc
Sent: Thursday, March 31, 2011 2:48 PM
To: Gibson, Kathy; Lee, Richard
Subject: Research Look into Worse Case, what if ...

Please take a look at this first cut by RST and Please Add To or Refine as necessary to answer the following (RST Task # 3491):

Make determinations (time and measures) that would result in an energetic release no longer being a realistic possibility. How long until decay heat is not a factor?

Thank you,
RST Coordinator

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 5:53 PM
To: Wagner, Katie
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Complete

From: Wagner, Katie
Sent: Thursday, March 31, 2011 5:03 PM
To: Lee, Richard
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard,

I see you are in a telecom right now, is the following item "Pending" or "Complete"?

45	3/24/2011	Jason Petti of Sandia for IAEA	jppet@sandia.gov	Richard Lee x7526 Charlie Tinkler x7496	FSTB/DSA	Request for Sandia staff help with questions relating to containment integrity and using sea water to cool systems. ***Update as of 3/30***: DE was asked to lead, also SNL asked B. Sheron for information.	Determine if Sandia should help answer IAEA's questions. ***Update as of 3/30***: DE was asked to lead, also SNL asked B. Sheron for information.	Pending
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Thanks,

Katie

-----Original Message-----

From: Petti, Jason P [mailto:jppet@sandia.gov]
Sent: Thursday, March 31, 2011 11:30 AM
To: Lee, Richard
Cc: Pickering, Susan Y; Wagner, Katie; Khalil, Imane
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

Thanks for getting back to me. I just wanted to clarify something. Are we allowed to add any thoughts/concerns to the staff's response when replying to the IAEA?

Jason

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 9:03 AM
To: Petti, Jason P
Cc: Pickering, Susan Y; Wagner, Katie
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Hi, Jason:

Z/260

The following is the response that I got from RES Division of Engineering staff who specialized in containment structure.

Please feel free to share it with IAEA. You do not need to do further evaluation on this.

"Two pressures are of interest when considering venting: leakage pressure and rupture pressure. According to NUREG/CR- 6920, the leakage pressure for the wetwell is around 0.8 MPa (116 psi) and for the drywell it is around 1.0 MPa (145 psi). The rupture pressure is about 1.0-1.2 MPa, which is consisted to 2.5-3x design pressure. Note that these pressures are also temperature dependent, but that dependency is weak until about 200 deg. C (400 deg. F).

While carbon steel is not highly vulnerable to cracking, the salt can increase the crevice/pitting corrosion so some degradation of the values listed above can be expected. The once you have the conditions for localized corrosion, the rate can be as high as 10 cm/year (4 in/year). The containment shell thickness for MK-Is varies from 0.75-1.75 in (1.9-4.5 cm) at various locations. NUREG/CR-6920 estimates that localized corrosion of up to 50% of the thickness reduces the leakage and rupture pressure by 10-20%."

Best regards,
Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]

Sent: Thursday, March 24, 2011 3:14 PM

To: Lee, Richard

Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O

Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMs Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D

Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico

Phone: 505-284-8574

Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]

Sent: Thursday, March 24, 2011 11:53 AM

To: Petti, Jason P

Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?
2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.

How can maintain or decrease pressure of containment in current situation without venting ?

3. What is the maximum operating pressure according to your judgement ?

4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796

Fax: +43 1 2600 29598

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

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]

Sent: Thursday, 24 March 2011 17:44

To: KANG, Ki-Sig

Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis
You might contact Jason Petti
(jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated
analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai
Ichi Npp containment.

The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel
plate (6 mm).

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is
4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to
suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

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should release pressure through venting system, but it is very difficult to release pressure to environment due
to radiation material.
How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your
judgement ?
4. If Japan insert sea water to dry well to cool down RPV and
containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them
to me.

Thanks for your reply in advance.

[cid:3383815441_5634291]

Ki- Sig KANG

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

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Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 6:08 PM
To: Tinkler, Charles
Subject: RE: ACTION: DRAFT PMT request to RES-RST

Thanks, Charlie.
Richard

From: Tinkler, Charles
Sent: Thursday, March 31, 2011 6:02 PM
To: Lee, Richard
Subject: FW: ACTION: DRAFT PMT request to RES-RST
Importance: High

From: Schaperow, Jason
Sent: Thursday, March 31, 2011 3:38 PM
To: RST01 Hoc; RST07 Hoc; RST08 Hoc; PMT01 Hoc; Hoc, PMT12
Cc: Tinkler, Charles; Uhle, Jennifer; Gibson, Kathy; Sheron, Brian
Subject: RE: ACTION: DRAFT PMT request to RES-RST
Importance: High

The attached information is provided by RES in response to a PMT request of 3/30/11 to provide a realistic, up-to-date estimation of source terms for dose projections to address future potential radiological releases from the Fukushima Unit 1 reactor and the Unit 4 spent fuel pool.

From: Tinkler, Charles
Sent: Wednesday, March 30, 2011 10:10 AM
To: Schaperow, Jason
Subject: FW: ACTION: DRAFT PMT request to RES-RST
Importance: High

From: PMT01 Hoc
Sent: Wednesday, March 30, 2011 9:39 AM
To: Esmaili, Hossein; Tinkler, Charles; Lee Col
Cc: Lee, Richard; Hoc, PMT12; PMT01 Hoc; PMT11 Hoc; PMT02 Hoc
Subject: ACTION: DRAFT PMT request to RES-RST
Importance: High

Attached for your comment.
Request input ASAP.

Contacts:
Tony Huffert
Rich Clement
PMT – NRC Ops Center
301-816-5402

Z/261

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 6:21 PM
To: PMT02 Hoc
Cc: Schaperow, Jason; Tinkler, Charles; Esmaili, Hossein; PMT01 Hoc; PMT01 Hoc; Salay, Michael; Gibson, Kathy; Wagner, Katie
Subject: RE: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run
Attachments: source term in response to PMT on 3-30.2011 pre-decisional.doc

The attached is RES response to the request to provide a realistic, up-to-date estimation of source terms for dose projections to address future potential radiological releases from the Fukushima Unit 1 reactor and the Unit 4 spent fuel pool.

From: PMT02 Hoc
Sent: Wednesday, March 30, 2011 12:41 PM
To: Tinkler, Charles; Esmaili, Hossein; PMT01 Hoc; PMT01 Hoc
Cc: Lee, Richard; Schaperow, Jason
Subject: FW: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run

Please see recent email for your information.

Tony Huffert
Rich Clement
PMT NRC Operations Center
301-816-5402

From: Hoc, PMT12
Sent: Wednesday, March 30, 2011 12:37 PM
To: Julie_A._Bentz@nss.eop.gov; Fetter, Steve
Cc: OST02 HOC; Blount, Tom; Miller, Marie; Jackson, Todd; Cool, Donald; Boger, Bruce; FOIA Response.hoc Resource; Holahan, Vincent; LIA01 Hoc; NITOPS; 'narmac@llnl.gov'; Hoc, PMT12; PMT02 Hoc; David.Bowman@nnsa.doe.gov
Subject: Draft: Request from U.S. Ambassador in Japan for Pessimistic Case Modeling Run

The U.S. Ambassador in Japan has requested modeling to support decisions on the return of individuals who were voluntarily evacuated. NRC was informed of this request through members of our team in Japan, for a modeling run for a "Pessimistic Case" of future releases from the Fukushima plants. We understand that the Ambassador requested that this product be completed by Wednesday April 6, with a draft available on Sunday April 3.

The case, as we understand it, would involve a set of events, starting on April 15, 2011. This date was selected because the Ambassador is planning for individuals to return to Tokyo around that time. Our understanding is that the case should include new energetic event in the Unit 1 reactor core, followed by an additional event 24 hours later at the Unit 4 spent fuel pool.

We are currently in the process of developing a radiological source term for this assessment. We plan to include more specific considerations of the timing of events since March 11th and take into account the radiological decay of short half-life fission products. Assumptions on meteorology conditions would include representative conditions and winds moving toward Tokyo from the Fukushima site. We will be prepared to interact directly with DOE, the NIT, and with NARAC, once this tasking has been agreed by the NTAG and the White House, and a tasking established to NARAC for the modeling to support the Ambassador request.

We understand that this request may also be brought forward through other pathways.

We await White House agreement and tasking to move forward to meet the Ambassador's request.

Protective Measures Team
Nuclear Regulatory Commission

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 12:20 PM
To: Wagner, Katie
Subject: RE: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

As far as DSA is concerned, it is completed (2 out of the 4 questions were assigned and answered by Mourad).

From: Wagner, Katie
Sent: Thursday, March 31, 2011 11:40 AM
To: Lee, Richard
Subject: RE: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Is this "Complete" or "Pending"?

From: Lee, Richard
Sent: Thursday, March 31, 2011 8:22 AM
To: Wagner, Katie
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

Pls. log in.

Provide response to EDO on Comm, Ostedorff's office questions on MOX (indirectly related to the use of MOX in Fukushima)

Thx

From: Aissa, Mourad
Sent: Thursday, March 31, 2011 7:02 AM
To: Armstrong, Kenneth
Cc: Gibson, Kathy; Lee, Richard; Hoxie, Chris
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

Ken,
Would you please forward our response. The MOX information provided to the Chairman on Tuesday should answer these questions. I added specific details in red below.

Thanks
Mourad

Mourad Aissa, PhD
Senior Criticality Analysis and Reactor Physics Engineer
Office of Nuclear Regulatory Research
Mail Stop CSB-3A07M
US Nuclear Regulatory Commission
Washington, DC 20555-0001
Phone: (301) 251-7511

2/263

From: Bowman, Gregory
Sent: Wednesday, March 30, 2011 2:20 PM
To: Gibson, Kathy; Lee, Richard; Aissa, Mourad
Cc: Armstrong, Kenneth
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

The questions below were sent to Ken Armstrong a minute ago, but I wanted to make sure you were aware of them (I tried calling Ken, but I missed him). Like the questions you worked on yesterday, these are related to MOX. Commissioner Ostendorff's office is asking for a response by COB tomorrow.

I think the answers you provided yesterday evening cover these questions, as well, but I wanted to give you a chance to add anything you think might be important that you didn't have time to address yesterday. The responses to these questions will end up being sent to all the Commission offices. If you're okay with what was sent yesterday, we can simply forward that on and consider the two RES questions addressed.

Thanks again for all the help with this. If you need any clarification or anything like that, please let me know.

From: Frazier, Alan
Sent: Wednesday, March 30, 2011 2:12 PM
To: Meighan, Sean; Nguyen, Quynh; Armstrong, Kenneth; Shropshire, Alan; Deegan, George
Cc: Wittick, Brian; Andersen, James; Merzke, Daniel; OST01 HOC; OST02 HOC; Rini, Brett; Bowman, Gregory; Brock, Kathryn; Muessle, Mary; Layton, Michael
Subject: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

All,

Commissioner Ostendorff would like additional information regarding the article below that was in the "NRC in the News" yesterday. Below are the Commissioner's specific questions and proposed office leads. **Please respond if possible by Thursday, March 31.** If you need more time, please let me know so I can inform the Commissioner's office. Please send responses to Alan Frazier and Brian Wittick for consolidation.

1. Specifically, has the NRC staff verified the claim that Reactor 3 at Fukushima contains MOX fuel, and if so, has the fact that some of the fuel is MOX posed any safety challenges during the event? RES (note that RES provided information on MOX yesterday, to help prepare the Chairman for today's hearing, which may be sufficient to answer questions 1 and 2)

.NRC staff currently in Japan confirmed that 32 MOX assemblies were loaded in Unit 3.

2. Has the staff evaluated the concerns that MOX fuel poses greater safety concerns? RES

NRC did its own evaluations of MOX fuel and presented its findings during a hearing in front of the Atomic Safety Licensing Board (ASLB). NRC concluded that the design basis accidents consequences were still within the acceptance criteria and the differences between MOX and uranium fuel were within the dose consequences calculation uncertainties. Based on staff evaluations, NRC allowed Catawba nuclear plant in South Carolina to load 4 MOX assemblies in one its reactors for testing purposes a few years ago.

3. Has the staff evaluated the concerns that MOX fuel poses greater security concerns? NSIR
4. I understand that the staff completed a safety assessment of the use of MOX fuel for Catawba and the Browns Ferry. Can you provide a summary of the dose/health consequence analysis and a synopsis of the staff's evaluation of any public health risk from the use of MOX? NRR lead, FSME support.

ARTICLE: **Mixed Oxide Nuclear Fuel Raises Safety Questions.** The Scientific American (3/25, Matson) reported that reactor No. 3 at the troubled Fukushima Daiichi power station in Japan "has one characteristic that differentiates it from its neighboring reactors and from any operating reactor in the US" Among the "hundreds of standard nuclear fuel assemblies in its core... are some that contain a mix of uranium and plutonium," or MOX. The use of MOX is controversial, and some "critics say that MOX is riskier than standard fuel and that there are better ways to dispose of excess plutonium." Notably, "the federally owned Tennessee Valley Authority (TVA), which operates the Browns Ferry Nuclear Plant and two other nuclear facilities, has expressed some interest in trying MOX and may step up to take fuel from" the Mixed Oxide Fuel Fabrication Facility (MFFF) in South Carolina.

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 2:34 PM
To: Scott, Harold
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Harold:
The reason the LTAs were removed due to.....??
Richard

From: Voglewede, John
Sent: Thursday, March 31, 2011 2:29 PM
To: Lee, Richard
Subject: Re: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Yes, 2 cycles. See Harold.

Sent from NRC Blackberry
John Voglewede

From: Lee, Richard
To: Voglewede, John
Sent: Thu Mar 31 13:16:39 2011
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

John:

I thought it stayed in for 2 cycles. I forgot the reason they did not stay in more, and it has nothing to do with been MOX.

Richard

From: Armstrong, Kenneth
Sent: Thursday, March 31, 2011 12:51 PM
To: Gibson, Kathy
Cc: Hoxie, Chris; Aissa, Mourad; Lee, Richard
Subject: RE: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Kathy,

Greg is collecting the information for questions 3 and 4 directly from the offices. We feel very confident that Catawba was the only facility to put LTAs through a cycle, but we are confirming with NRR/NMSS.

Thanks,
Kenneth

From: Gibson, Kathy
Sent: Thursday, March 31, 2011 11:47 AM
To: Armstrong, Kenneth
Cc: Hoxie, Chris; Aissa, Mourad; Lee, Richard
Subject: RE: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

2/264

This looks very good, nice work Mourad! What are we doing to get and add the answers to questions 3 and 4?

From: Armstrong, Kenneth
Sent: Thursday, March 31, 2011 10:22 AM
To: Gibson, Kathy
Cc: Hoxie, Chris; Aissa, Mourad; Lee, Richard
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Kathy,

We received some additional clarification questions from Commissioner Ostendorff's office from our recent summary of MOX fuel. Mourad has addressed these questions below (in red). We have also incorporated the responses into the attached document.

Please review and let me know if you have any comments. Would you like me to run this by Brian/Jennifer?

Thanks,
Kenneth

From: Aissa, Mourad
Sent: Thursday, March 31, 2011 6:58 AM
To: Bowman, Gregory
Cc: Armstrong, Kenneth
Subject: RE: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

Ken,
Would you please forward our response. The MOX information provided to the Chairman on Tuesday should answer these questions. I added specific details in **red** below.
Thanks
Mourad

Mourad Aissa, PhD
Senior Criticality Analysis and Reactor Physics Engineer
Office of Nuclear Regulatory Research
Mail Stop CSB-3A07M
US Nuclear Regulatory Commission
Washington, DC 20555-0001
Phone: (301) 251-7511

From: Bowman, Gregory
Sent: Wednesday, March 30, 2011 2:20 PM
To: Gibson, Kathy; Lee, Richard; Aissa, Mourad
Cc: Armstrong, Kenneth
Subject: FW: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel
Importance: High

The questions below were sent to Ken Armstrong a minute ago, but I wanted to make sure you were aware of them (I tried calling Ken, but I missed him). Like the questions you worked on yesterday, these are related to MOX. Commissioner Ostendorff's office is asking for a response by COB tomorrow.

I think the answers you provided yesterday evening cover these questions, as well, but I wanted to give you a chance to add anything you think might be important that you didn't have time to address yesterday. The responses to these questions will end up being sent to all the Commission offices. If you're okay with what was sent yesterday, we can simply forward that on and consider the two RES questions addressed.

Thanks again for all the help with this. If you need any clarification or anything like that, please let me know.

From: Frazier, Alan

Sent: Wednesday, March 30, 2011 2:12 PM

To: Meighan, Sean; Nguyen, Quynh; Armstrong, Kenneth; Shropshire, Alan; Deegan, George

Cc: Wittick, Brian; Andersen, James; Merzke, Daniel; OST01 HOC; OST02 HOC; Rini, Brett; Bowman, Gregory; Brock, Kathryn; Muessle, Mary; Layton, Michael

Subject: ACTION DUE by 3/31 COB: Questions on the use of MOX fuel

Importance: High

All,

Commissioner Ostendorff would like additional information regarding the article below that was in the "NRC in the News" yesterday. Below are the Commissioner's specific questions and proposed office leads. **Please respond if possible by Thursday, March 31.** If you need more time, please let me know so I can inform the Commissioner's office. Please send responses to Alan Frazier and Brian Wittick for consolidation.

1. Specifically, has the NRC staff verified the claim that Reactor 3 at Fukushima contains MOX fuel, and if so, has the fact that some of the fuel is MOX posed any safety challenges during the event? RES (note that RES provided information on MOX yesterday, to help prepare the Chairman for today's hearing, which may be sufficient to answer questions 1 and 2)

NRC staff currently in Japan confirmed that 32 MOX assemblies were loaded in Unit 3. We do not expect significant safety related issues with respect to the MOX fuel.

2. Has the staff evaluated the concerns that MOX fuel poses greater safety concerns? RES

NRC did its own evaluations of MOX fuel and presented its findings during a hearing in front of the Atomic Safety and Licensing Board (ASLB). NRC concluded that the design basis accidents consequences were still within the acceptance criteria and the differences between MOX and uranium fuel were within the dose consequences calculation uncertainties. Based on staff evaluations, NRC allowed Catawba nuclear plant in South Carolina to load 4 MOX assemblies in one its reactors for testing purposes a few years ago.

3. Has the staff evaluated the concerns that MOX fuel poses greater security concerns? NSIR
4. I understand that the staff completed a safety assessment of the use of MOX fuel for Catawba and the Browns Ferry. Can you provide a summary of the dose/health consequence analysis and a synopsis of the staff's evaluation of any public health risk from the use of MOX? NRR lead, FSME support.

Alan

ARTICLE: **Mixed Oxide Nuclear Fuel Raises Safety Questions.** The [Scientific American](#) (3/25, Matson) reported that reactor No. 3 at the troubled Fukushima Daiichi power station in Japan "has one characteristic that differentiates it from its neighboring reactors and from any operating reactor in the US" Among the "hundreds of standard nuclear fuel assemblies in its core... are some that contain a mix of uranium and

plutonium," or MOX. The use of MOX is controversial, and some "critics say that MOX is riskier than standard fuel and that there are better ways to dispose of excess plutonium." Notably, "the federally owned Tennessee Valley Authority (TVA), which operates the Browns Ferry Nuclear Plant and two other nuclear facilities, has expressed some interest in trying MOX and may step up to take fuel from" the Mixed Oxide Fuel Fabrication Facility (MFFF) in South Carolina.

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 12:21 PM
To: 'Petti, Jason P'
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Jason:

Sure, if you want to. Please keep you effort to a minimum. .

Thx, Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]
Sent: Thursday, March 31, 2011 11:30 AM
To: Lee, Richard
Cc: Pickering, Susan Y; Wagner, Katie; Khalil, Imane
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

Thanks for getting back to me. I just wanted to clarify something. Are we allowed to add any thoughts/concerns to the staff's response when replying to the IAEA?

Jason

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 9:03 AM
To: Petti, Jason P
Cc: Pickering, Susan Y; Wagner, Katie
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Hi, Jason:

The following is the response that I got from RES Division of Engineering staff who specialized in containment structure. Please feel free to share it with IAEA. You do not need to do further evaluation on this.

"Two pressures are of interest when considering venting: leakage pressure and rupture pressure. According to NUREG/CR- 6920, the leakage pressure for the wetwell is around 0.8 MPa (116 psi) and for the drywell it is around 1.0 MPa (145 psi). The rupture pressure is about 1.0-1.2 MPa, which is consisted to 2.5-3x design pressure. Note that these pressures are also temperature dependent, but that dependency is weak until about 200 deg. C (400 deg. F).

While carbon steel is not highly vulnerable to cracking, the salt can increase the crevice/pitting corrosion so some degradation of the values listed above can be expected. The once you have the conditions for localized corrosion, the rate can be as high as 10 cm/year (4 in/year). The containment shell thickness for MK-Is varies from 0.75-1.75 in (1.9-4.5 cm) at various locations. NUREG/CR-6920 estimates that localized corrosion of up to 50% of the thickness reduces the leakage and rupture pressure by 10-20%."

2/265

Best regards,
Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]
Sent: Thursday, March 24, 2011 3:14 PM
To: Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMs Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D
Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico
Phone: 505-284-8574
Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]
Sent: Thursday, March 24, 2011 11:53 AM
To: Petti, Jason P
Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?
2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.
How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796
Fax: +43 1 2600 29598
E-mail: Ki-Sig.KANG@iaea.org

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]
Sent: Thursday, 24 March 2011 17:44
To: KANG, Ki-Sig
Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis. You might contact Jason Petti (jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai Ichi Npp containment.

The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm).

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

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1. What are the major elements to keep the containment integrity ?
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How can maintain or decrease pressure of containment in current situation without venting ?
3. What is the maximum operating pressure according to your judgement ?
4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

[cid:3383815441_5634291]

Ki- Sig KANG

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

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Lee, Richard

From: Powers, Dana A [dapower@sandia.gov]
Sent: Thursday, March 31, 2011 12:22 PM
To: Lee, Richard
Subject: RE: white smoke

I'm working up the isotopes now. I only have a few points Mox to about 37 GWd/t and LEU to 58 GWd/t. Dana

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 10:16 AM
To: Powers, Dana A
Subject: RE: white smoke

Thanks, Dana.
I will add these to our archive folder
Richard

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Thursday, March 31, 2011 11:50 AM
To: Lee, Richard
Subject: RE: white smoke

Richard, I suspect the white "smoke" is indeed steam. Real smoke from cable fires can vary from an off-white to rather dark as shown in the attached photos. Dana

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Wednesday, March 30, 2011 4:16 PM
To: Dana Powers (Home); Powers, Dana A
Subject: white smoke

Dana:

From the daily DOE situation report:

Do you have any idea what these white smoke continues to see coming from Unit 1, 2 & 3, and Unit 4 spent fuel pool? Is it just steam? The weather is still cold there.

Richard

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 1:14 PM
To: Gibson, Kathy
Cc: Wagner, Katie
Subject: RE: Proposed Task Tracker

It has been logged in since yesterday.

From: Gibson, Kathy
Sent: Thursday, March 31, 2011 12:57 PM
To: Lee, Richard; Wagner, Katie
Subject: FW: Proposed Task Tracker

Pretty sure you already have this.

From: Correia, Richard
Sent: Thursday, March 31, 2011 12:48 PM
To: Coe, Doug; Cheok, Michael; Drouin, Mary; Demoss, Gary; Gibson, Kathy; Tinkler, Charles; Harrison, Donnie
Subject: FW: Proposed Task Tracker

FYI

Richard Correia, PE
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
US NRC

richard.correia@nrc.gov

From: Brown, Frederick
Sent: Thursday, March 31, 2011 9:35 AM
To: RST01 Hoc
Cc: RST06 Hoc; Ruland, William; Hackett, Edwin; Correia, Richard; Cheok, Michael; Gibson, Kathy; McDermott, Brian; Hoc, PMT12
Subject: Proposed Task Tracker

Peter,

There are two items being worked outside the Ops Center for the RST. The ET is aware of both, but they are not currently being tracked (or were not last night).

You may want to add the following two items to the task tracker so that everyone knows what has actually been requested, and who is working it. Also, if the tasks are reshaped, there will be a way of making the redirection visible to the ET and others.

Background e-mails are on the RST01 and RST06 systems from the last two evenings, subject: "Request for Ops Center RTS support"

Fred

Z/267

Task 1:

Given the known, or assumed, status of the three units and four pools, what realistic scenarios exist for energetic dispersion of high quantities of radioactive material that would result in mobile plumes? The point of this question is that there are many clear scenarios that present significant near-area radiological challenges, but given the time since shutdown (for the operating units) and age of much of the fuel (in the SFPs) what are the remaining scenarios of concern with respect to more distant locations (Tokyo with a large concentration of US citizens, Alaska, Hawaii, etc).

Objective for first question (energetic release potential): this information is important to the Ambassador in Japan and the US military command that would be responsible for movement of US citizens who were ordered to be evacuated from any locations in the Pacific. In fact, the Pacific Command asked the same question of the NRC at today's Deputies Meeting that is attended by the Chairman. The answer to this question may also impact when we as the NRC ramp down our activities? **We should attempt to address this by Friday (4/1).**

This task was accepted by RES, and I understand that Kathy Gibson's Division (RES/DSA) has the lead supported by NRR/DE.

Task 2:

Given the assumed condition of the three units and four pools, can we generate basic event trees for the coming weeks/months? The point would be to identify key success criteria and to help identify key decision points/risk factors to be balanced (qualitative not quantitative analysis). For instance, take two units, each with significant core damage and prior release of volatile fission products, each with primary and secondary containment failure, but one with an intact RPV and the other with a breach of RPV - would there be a difference in potential releases that would lead to different strategies for flooding the primary containment of these two units? This question will make more sense if you look at the assumed conditions below and the attached assessment document where we recommend that TEPCO utilize the SAMG recommendation to flood all 3 units' containments.

Objective for the second question is to support multiple questions/actions. There have been many requests of the PMT for "realistic" dose models. The RST Assessment document (original e-mail was supposed to have it attached, but I've added to this incase it did not go out the first time) also contains recommended actions for the Japanese to consider. These recommendations are based on the SAMGS, which all are intended to protect primary containment. Since primary containment is damaged on at least two units, we need to assess whether there may be new considerations/priorities that are not captured by the SAMGs. Also, the product of this effort helps us better clarify the assessment of potential energetic releases, along with identifying the best strategies to ensure that they don't happen. **This item does not have as short a deliverable date unless the PMT has one that I'm not aware of, but is still very significant in terms of our recommendations. Can we complete by Monday (4/4)?**

Once NRC staff validates this concept, and creates a framework for the event trees, we may be able to turn it over to INPO/GEH for completion.

This task has also been accepted by RES, and Rich Correia's Division (RES/DRA) has the lead, with support from NRR/DE.

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 12:23 PM
To: Wagner, Katie
Subject: RE: draft a response to Robert Caron on using liquid helium cooling

Request came from the EDO to draft a response for the Chairman. I don't have the covered sheet. Please check with Michelle.

Thx,

From: Wagner, Katie
Sent: Thursday, March 31, 2011 11:24 AM
To: Lee, Richard
Subject: RE: draft a response to Robert Caron on using liquid helium cooling

Richard,

Who requested that RES respond to this? The letter from R. Caron is addressed to President Obama. My best guess is that the Chairman's office requested a response to this . . .

Thanks,
Katie

From: Lee, Richard
Sent: Thursday, March 31, 2011 8:16 AM
To: Wagner, Katie
Cc: Flanagan, Michelle
Subject: FW: draft a response to Robert Caron on using liquid helium cooling

Katie:

Please log in on our sharepoint site.

Received: 03/30

Assigned to Michelle Flanagan

Draft response letter has been written 03/30

Carol Greenwood is putting the draft into the correct format for Chairman to send a response back to Robert Caron.

Thx, Richard

From: Flanagan, Michelle
Sent: Wednesday, March 30, 2011 4:35 PM
To: Greenwood, Carol
Cc: Lee, Richard
Subject: FW: draft a response to Robert Caron on using liquid helium cooling

Carol,

Attached is a draft letter (letter.doc) for the Chairman to Robert Caron in response to his letter of 3/21/2011 (also attached). I'm not sure how to format the headers for correspondence from the chairman, nor am I certain how to form the concurrence block, but Richard told me the concurrence should be: MFlanagan, KGibson, BSheron, MWeber, BBorchard, Chairman

Will you prepare a concurrence package for this response letter?

2/268

Thank you!
-Michelle

From: Lee, Richard
Sent: Wednesday, March 30, 2011 1:49 PM
To: Flanagan, Michelle
Subject: draft a response to Robert Caron on using liquid helium cooling

Michelle:

Please draft a letter for the Chairman to Robert Caron in response to his letter built around the following points.

Thank you for your suggestion of using liquid helium as a coolant for the reactors and spent fuel pools at Fukushima. Whereas liquid helium has a very low heat temperature, it has a very small heat capacity and the heat of vaporization (84.5 Joules per mole) is modest. It would require, then, quite a lot of liquid helium on a continuing basis to first cool the fuel and then to prevent decay energy from reheating the fuel. We estimate that each megawatt of decay heat would require 47 kg of liquid helium every second, or about 4 million kg per day. This might well tax the transport ability to the site. As a long term strategy, it might tax the ability to supply liquid helium. We will continue to look for opportunities to utilize your suggestion. Thank you very much.

Thanks, Richard

Concurrence: MFlanagan, KGibson, BSheron, MWeber, BBorchard, Chairman

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 7:43 AM
To: 'Michael Corradini'
Cc: Basu, Sudhamay; 'Powers, Dana A'
Subject: RE: Failure Criteria for Concrete

Hi, Mike:

Thanks for your great efforts.

I know that, since you do not know as much as Per (UCB-the #1 Nucl. Engr. School in U.S.), it takes you much longer to do this. (Remember: I am always nice to you)

See you next week at the ACRS meetings.

Best regards,
Richard

-----Original Message-----

From: Michael Corradini [<mailto:corradin@cae.wisc.edu>]
Sent: Thursday, March 31, 2011 12:43 AM
To: Basu, Sudhamay; Lee, Richard
Subject: Failure Criteria for Concrete

Folks -

I asked a colleague about the failure criterion for the concrete pedestal wall. After a whole day of discussing and investigating properties... etc... it is not straightforward.

Based on the schematics from the Fukushima schematics, the pedestal has an inner diameter of 7meters and a wall thickness of a meter. If I neglect the manway into the region from the outer drywell region and assume it is unanchored, then one can estimate its natural frequency (about 35 Hz - so characteristic time is 30ms). If the pressure pulse is substantially below this, then one can assume its an impulsive load (wall would be much stronger - since it would not even feel the pulse.

If the pressure pulse is substantially longer than this, its a static pressure load. The explosion pulse is about 5-6msec. So its smaller but not an order of magnitude.

If I conservatively assume a static load, then I compare the peak pressure (20MPa) as a static load to the yield stress for prestressed concrete (40MPa). Given the geometry and that it is a thick wall member, the stress in the wall from the pressure pulse is about 10MPa => $10 < 40$ MPa..... so we are conservatively OK.

Mike

Z/269

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 7:43 AM
To: 'Dana Powers (Home)'; 'Dana Powers (SNL)'
Subject: FW: Failure Criteria for Concrete
Attachments: pastedGraphic.pdf; ATT00001.txt

FYI. I have complimented him in an earlier e-mail.

-----Original Message-----

From: Michael Corradini [<mailto:corradin@cae.wisc.edu>]
Sent: Thursday, March 31, 2011 12:43 AM
To: Basu, Sudhamay; Lee, Richard
Subject: Failure Criteria for Concrete

Folks -

I asked a colleague about the failure criterion for the concrete pedestal wall. After a whole day of discussing and investigating properties... etc... it is not straightforward.

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Mike

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 8:16 AM
To: Wagner, Katie
Cc: Flanagan, Michelle
Subject: FW: draft a response to Robert Caron on using liquid helium cooling
Attachments: letter from Robert Caron to NRC on liquid helium to cool Fukushima reactors.pdf; letter.doc

Katie:
Please log in on our sharepoint site.
Received: 03/30
Assigned to Michelle Flanagan
Draft response letter has been written 03/30
Carol Greenwood is putting the draft into the correct format for Chairman to send a response back to Robert Caron.

Thx, Richard

From: Flanagan, Michelle
Sent: Wednesday, March 30, 2011 4:35 PM
To: Greenwood, Carol
Cc: Lee, Richard
Subject: FW: draft a response to Robert Caron on using liquid helium cooling

Carol,

Attached is a draft letter (letter.doc) for the Chairman to Robert Caron in response to his letter of 3/21/2011 (also attached). I'm not sure how to format the headers for correspondence from the chairman, nor am I certain how to form the concurrence block, but Richard told me the concurrence should be: MFlanagan, KGibson, BSheron, MWeber, BBorchard, Chairman

Will you prepare a concurrence package for this response letter?

Thank you!
-Michelle

From: Lee, Richard
Sent: Wednesday, March 30, 2011 1:49 PM
To: Flanagan, Michelle
Subject: draft a response to Robert Caron on using liquid helium cooling

Michelle:

Please draft a letter for the Chairman to Robert Caron in response to his letter built around the following points.

Thank you for your suggestion of using liquid helium as a coolant for the reactors and spent fuel pools at Fukushima. Whereas liquid helium has a very low heat temperature, it has a very small heat capacity and the heat of vaporization (84.5 Joules per mole) is modest. It would require, then, quite a lot of liquid helium on a continuing basis to first cool the fuel and then to prevent decay energy from reheating the fuel. We estimate that each megawatt of decay heat would require 47 kg of liquid helium every second, or about 4 million kg per day. This might well tax the transport ability to the site. As a long term strategy, it might tax the ability to supply liquid helium. We will continue to look for opportunities to utilize your suggestion. Thank you very much.

3/27/11

Thanks, Richard

Concurrence: MFlanagan, KGibson, BSheron, MWeber, BBorchard, Chairman

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 10:08 AM
To: Marksberry, Don
Subject: RE: Fukushima Daiichi Chronology (03-31-2011)....(Unofficial)

Thx, Don.
Richard

From: Marksberry, Don
Sent: Thursday, March 31, 2011 9:59 AM
To: Tinkler, Charles; Esmaili, Hossein; Helton, Donald; Arndt, Steven; Drouin, Mary; Salay, Michael; Schaperow, Jason
Cc: Lee, Richard; Demoss, Gary; Coyne, Kevin; Salley, MarkHenry; Correia, Richard
Subject: Fukushima Daiichi Chronology (03-31-2011)....(Unofficial)

RESENT – Wrong date on the file name.

All

Chronologies (Units 1, 2, 3) and parameters (Units 1, 2) tables are under construction---entries have not been checked.
Please read the notes on each spreadsheet.

Parameter table for Unit 3 should be completed tonight.

Don

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Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 10:25 AM
To: 'Dana Powers (Home)'; 'Dana Powers (SNL)'
Subject: FW: Recommendation

fyi

-----Original Message-----

From: Per F. Peterson [mailto:peterson@nuc.berkeley.edu]
Sent: Wednesday, March 30, 2011 11:49 PM
To: Brinkman, Bill; Binder, Jeff; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; Connell, Elizabeth; McFarlane, Harold; 'Harold Denton'; Adams, Ian; John Holdren; 'JOE H. PAYER'; Kelly, John E (NE); Grossenbacher, John (INL); Owens, Missy; Peterson, Per; Lyons, Peter; Finck, Phillip; Garwin, Dick (EOP); Lee, Richard; Budnitz, Bob; Szilard, Ronaldo; Aoki, Steven; Koonin, Steven; Steve Fetter; Binkley, Steve; DAGostino, Thomas
Subject: Fwd: Recommendation

Following up on Steve Chu's email on commercial equipment that can remove oxygen from boiler feedwater, this note from Tom Devine in our Materials Science and Engineering department also identifies the reduction of oxygen in feedwater as the single most effective step that can be taken to reduce corrosion of stainless and carbon steel in the reactor vessels and primary containment.

Given this information, it would appear to be prudent to move now to procure commercial equipment to strip oxygen from the water being injected into the Fukushima reactors (probably using the commercial membrane equipment is better than using hydrazine, an option that Tom mentions). The equipment might be installed at the dam that is currently providing the fresh water supply, since the conditions are less challenging there and access should be easier to get the equipment set up.

One way of looking at this problem is that essentially all of the oxygen that is injected into these reactors will end up reacting with and corroding metal structures. Just as stopping the flow of salt into the reactors was an important action to take on an expedited basis, now stopping the injection of oxygen is likely to also be a prudent measure. (Once recycled condensate is available from evaporators, it will also have relatively low oxygen content, but this will not be available for weeks to a few months).

-Per

>
>Date: Wed, 30 Mar 2011 14:19:08 -0700
>Subject: Recommendation
>From: devine@berkeley.edu
>To: peterson@nuc.berkeley.edu
>
>Per,
>
>The following is my recommendation (and explanation) of what should be
>done regarding treatment of water inside the reactors at Fukushima. In
>brief, my specific recommendation is to add sulfite or hydrazine to the
>water inside the reactors. My explanation is as follows.
>
>At present, seawater inside the reactor is saturated with air. The

Z/273

>combination of a high water temperature, a high chloride ion
>concentration (i.e., that of sea water or higher), and dissolved oxygen
>provides a very corrosive electrolyte to stainless steel (e.g., cooling
>pipelines and cladding on the RPV), and to the nonstainless steels, consisting of carbon
>steel (steam lines), and low alloy steel (RPV). In the present state of
>affairs inside the reactors, stainless steel is susceptible to
>localized corrosion, such as pitting corrosion and crevice corrosion
>(also intergranular corrosion if the stainless steel is sensitized,
>which might be the case for a region close to a weld). Because of
>residual stresses, the stainless steel components are also susceptible
>to environmentally assisted cracking, such as stress corrosion cracking
>(SCC). Non-stainless steel components are susceptible to general corrosion.

>
>Generally, increases in temperature, dissolved oxygen concentration,
>and chloride ion concentration increase the general corrosion rate of
>nonstainless steels and increase the probability of localized corrosion
>of stainless steels. However, there is a limit to how aggressive the
>water can become because the three factors of temperature, chloride ion
>concentration and dissolved oxygen concentration are interdependent.
>Specifically, in an open system the concentration of oxygen that is
>dissolved in water initially increases with increasing temperature, but
>it reaches a maximum value at about 80°C. As temperature increases
>above 80°C, the dissolved oxygen concentration decreases. As a result,
>the corrosion rate in boiling water (not seawater) is about the same as
>the corrosion rate at 30°C. Sodium chloride also limits the amount of
>oxygen that can be dissolved in the water. As the concentration of
>salt dissolved in the water increases, the solubility of oxygen decreases.

>
>The corrosion rate of nonstainless steels when the rate determining
>step is oxygen diffusion approximately doubles for every 30°C increase
>in temperature (this is likely the case inside the reactors). Thus,
>the corrosion rate in seawater at 65°C is approximately 0.12 mm/y. So,
>an approximate value of the maximum corrosion rate of a nonstainless
>steel in high temperature (80°C) seawater is about 0.24 mm/y.

>
>The main risk to stainless steel components is crevice corrosion and
>stress corrosion cracking. If the stainless steel is galvanically
>coupled to nonstainless steel, then the stainless steel is unlikely to
>fail by pitting corrosion but might be susceptible to hydrogen assisted
>cracking if the electrolyte in contact with the stainless steel is in
>an occluded volume.

>
>What is to be done?

>
>Undoubtedly, the most effective action that can be taken to lower the
>probability of a corrosion-related failure inside the reactors is to
>lower the water's dissolved oxygen concentration. This can be achieved
>by adding hydrazine to the water:

>
>
$$\text{N}_2\text{H}_4 + \text{O}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}.$$

>
>Alternatively, sodium sulfite (esp in the presence of a cobaltous salt
>as
>catalyst) can be added as an oxygen scavenger:

>
>
$$2\text{SO}_3^{2-} + \text{O}_2 \rightarrow 2\text{SO}_4^{2-}.$$

>

>Hydrazine is a toxic, flammable liquid at room temperature (boiling
>point is 114°C) and is sometimes employed as a rocket fuel. However,
>nuclear plant operators might be familiar with handling and using
>hydrazine to deoxygenate water (hydrazine is employed in the procedure
>known as Hydrogen-Water Chemistry, which is employed by some operators of BWRs).
>The products of the hydrazine deoxygenation reaction are benign, while
>the sulfate products of the sulfite deoxygenation reaction might
>contribute to corrosion. However, the corrosive effect of sulfate is
>greatly outweighed by the decrease in dissolved oxygen concentration.

>
>Corrosion inhibitors act either to passivate the nonstainless steel, or
>to diminish the rate of the reduction reaction. Passivating
>nonstainless steel components (e.g., by adding nitrite or phosphate)
>inside the reactors runs the risk of the steel subsequently failing by
>localized corrosion, such as pitting corrosion. In my view, the better
>approach is to try to lower the corrosion rate by inhibiting against
>the electrochemical reduction reaction.

>
>Corrosion is the most likely cause of failure of nonstainless steel
>components. In the near term, the greatest risk to the stainless steel
>components is some form of environmentally assisted cracking. The
>susceptibility of the stainless steel components to SCC is a
>consequence of the high temperature and high chloride ion
>concentrations, as well as the dissolved oxygen concentration.
>Deoxygenating the water will lower the susceptibility to SCC.

>
>In summary, the greatest benefit to both stainless steel and
>nonstainless steel components will be derived from deoxygenating the
>water (such as by the addition of hydrazine or sulfite). In addition,
>you might also consider the addition of an inhibitor that will act to
>lower the rate of the reduction reaction. I'll recommend specific
>inhibitors in a separate message.

>
>Best regards,
>Tom

--

Per F. Peterson
Professor and Chair
Department of Nuclear Engineering
University of California
4153 Etcheverry Hall
Berkeley, California 94720-1730
peterson@nuc.berkeley.edu
Office: (510) 643-7749 Fax: (510) 643-9685
http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 12:06 PM
To: 'Powers, Dana A'
Subject: RE: Recommendation

Dana:

You can communicate with the lady who spoke yesterday. I do not know who she is. I can ask.

Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Thursday, March 31, 2011 11:31 AM
To: Lee, Richard
Subject: RE: Recommendation

I cannot help but wonder if the oxygen removal they seek to reduce corrosion will not be frustrated by the radiolytic formation of hypochlorate ion - an oxidant of well known power. It may be that the ambient hydrogen partial pressure suppresses hypochlorate formation which would be good. I need to get a radiolysis model set up and check this. Dana

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 8:25 AM
To: Dana Powers (Home); Powers, Dana A
Subject: FW: Recommendation

fyi

-----Original Message-----

From: Per F. Peterson [mailto:peterson@nuc.berkeley.edu]
Sent: Wednesday, March 30, 2011 11:49 PM
To: Brinkman, Bill; Binder, Jeff; Hurlbut, Brandon; Sheron, Brian; Poneman, Daniel; Connell, Elizabeth; McFarlane, Harold; 'Harold Denton'; Adams, Ian; John Holdren; 'JOE H. PAYER'; Kelly, John E (NE); Grossenbacher, John (INL); Owens, Missy; Peterson, Per; Lyons, Peter; Finck, Phillip; Garwin, Dick (EOP); Lee, Richard; Budnitz, Bob; Szilard, Ronaldo; Aoki, Steven; Koonin, Steven; Steve Fetter; Binkley, Steve; DAgostino, Thomas
Subject: Fwd: Recommendation

Following up on Steve Chu's email on commercial equipment that can remove oxygen from boiler feedwater, this note from Tom Devine in our Materials Science and Engineering department also identifies the reduction of oxygen in feedwater as the single most effective step that can be taken to reduce corrosion of stainless and carbon steel in the reactor vessels and primary containment.

Given this information, it would appear to be prudent to move now to procure commercial equipment to strip oxygen from the water being injected into the Fukushima reactors (probably using the commercial membrane equipment is better than using hydrazine, an option that Tom mentions). The equipment might be installed at the dam that is currently providing the fresh water supply, since the conditions are less challenging there and access should be easier to get the equipment set up.

One way of looking at this problem is that essentially all of the oxygen that is injected into these reactors will end up reacting with and corroding metal structures. Just as stopping the flow of salt into the reactors was an important action to take on an expedited basis, now stopping the injection of oxygen is likely to also be a prudent measure. (Once recycled condensate is available from evaporators, it will also have relatively low oxygen content, but this will not be available for weeks to a few months).

-Per

>

>Date: Wed, 30 Mar 2011 14:19:08 -0700

>Subject: Recommendation

>From: devine@berkeley.edu

>To: peterson@nuc.berkeley.edu

>

>Per,

>

>The following is my recommendation (and explanation) of what should be done regarding treatment of water inside the reactors at Fukushima. In brief, my specific recommendation is to add sulfite or hydrazine to the water inside the reactors. My explanation is as follows.

>

>At present, seawater inside the reactor is saturated with air. The combination of a high water temperature, a high chloride ion concentration (i.e., that of sea water or higher), and dissolved oxygen provides a very corrosive electrolyte to stainless steel (e.g., cooling pipelines and cladding on the RPV), and to the nonstainless steels, consisting of carbon steel (steam lines), and low alloy steel (RPV). In the present state of affairs inside the reactors, stainless steel is susceptible to localized corrosion, such as pitting corrosion and crevice corrosion (also intergranular corrosion if the stainless steel is sensitized, which might be the case for a region close to a weld). Because of residual stresses, the stainless steel components are also susceptible to environmentally assisted cracking, such as stress corrosion cracking (SCC). Non-stainless steel components are susceptible to general corrosion.

>

>Generally, increases in temperature, dissolved oxygen concentration, and chloride ion concentration increase the general corrosion rate of nonstainless steels and increase the probability of localized corrosion of stainless steels. However, there is a limit to how aggressive the water can become because the three factors of temperature, chloride ion concentration and dissolved oxygen concentration are interdependent. Specifically, in an open system the concentration of oxygen that is dissolved in water initially increases with increasing temperature, but it reaches a maximum value at about 80°C. As temperature increases above 80°C, the dissolved oxygen concentration decreases. As a result, the corrosion rate in boiling water (not seawater) is about the same as the corrosion rate at 30°C. Sodium chloride also limits the amount of oxygen that can be dissolved in the water. As the concentration of salt dissolved in the water increases, the solubility of oxygen decreases.

>

>The corrosion rate of nonstainless steels when the rate determining step is oxygen diffusion approximately doubles for every 30°C increase in temperature (this is likely the case inside the reactors). Thus, the corrosion rate in seawater at 65°C is approximately 0.12 mm/y. So, an approximate value of the maximum corrosion rate of a nonstainless

>steel in high temperature (80°C) seawater is about 0.24 mm/y.

>

>The main risk to stainless steel components is crevice corrosion and
>stress corrosion cracking. If the stainless steel is galvanically
>coupled to nonstainless steel, then the stainless steel is unlikely to
>fail by pitting corrosion but might be susceptible to hydrogen assisted
>cracking if the electrolyte in contact with the stainless steel is in
>an occluded volume.

>

>What is to be done?

>

>Undoubtedly, the most effective action that can be taken to lower the
>probability of a corrosion-related failure inside the reactors is to
>lower the water's dissolved oxygen concentration. This can be achieved
>by adding hydrazine to the water:

>

> $\text{N}_2\text{H}_4 + \text{O}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}$.

>

>Alternatively, sodium sulfite (esp in the presence of a cobaltous salt
>as

>catalyst) can be added as an oxygen scavenger:

>

> $2\text{SO}_3^{2-} + \text{O}_2 \rightarrow 2\text{SO}_4^{2-}$.

>

>Hydrazine is a toxic, flammable liquid at room temperature (boiling
>point is 114°C) and is sometimes employed as a rocket fuel. However,
>nuclear plant operators might be familiar with handling and using
>hydrazine to deoxygenate water (hydrazine is employed in the procedure
>known as Hydrogen-Water Chemistry, which is employed by some operators of BWRs).
>The products of the hydrazine deoxygenation reaction are benign, while
>the sulfate products of the sulfite deoxygenation reaction might
>contribute to corrosion. However, the corrosive effect of sulfate is
>greatly outweighed by the decrease in dissolved oxygen concentration.

>

>Corrosion inhibitors act either to passivate the nonstainless steel, or
>to diminish the rate of the reduction reaction. Passivating
>nonstainless steel components (e.g., by adding nitrite or phosphate)
>inside the reactors runs the risk of the steel subsequently failing by
>localized corrosion, such as pitting corrosion. In my view, the better
>approach is to try to lower the corrosion rate by inhibiting against
>the electrochemical reduction reaction.

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>Corrosion is the most likely cause of failure of nonstainless steel
>components. In the near term, the greatest risk to the stainless steel
>components is some form of environmentally assisted cracking. The
>susceptibility of the stainless steel components to SCC is a
>consequence of the high temperature and high chloride ion
>concentrations, as well as the dissolved oxygen concentration.
>Deoxygenating the water will lower the susceptibility to SCC.

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>In summary, the greatest benefit to both stainless steel and
>nonstainless steel components will be derived from deoxygenating the
>water (such as by the addition of hydrazine or sulfite). In addition,
>you might also consider the addition of an inhibitor that will act to
>lower the rate of the reduction reaction. I'll recommend specific
>inhibitors in a separate message.

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>Best regards,
>Tom

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Per F. Peterson
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peterson@nuc.berkeley.edu
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http://www.nuc.berkeley.edu/People/Per_Peterson

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 12:13 PM
To: 'Powers, Dana A'
Subject: RE: NRC response to - Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dana:

I our discussion, the guys from DE know the leakage path you mentioned. As a matter of fact, there are other corrosion points on the outer part of primary containment shell that would enhance leakages.

Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Thursday, March 31, 2011 11:29 AM
To: Lee, Richard
Subject: RE: NRC response to - Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

I think the response does not recognize the degradation of the silicon rubber head seal on the dry well that has taken place in the elevated temperature and dose of the accident. I would suspect, though I surely do not know, that this degradation would enhance leakage rates at elevated pressure. An area of corrosion to consider is the bolting that holds the head on. I do not know whether the bolting on the Japanese plants is like that of Peach Bottom or the more robust bolting of Browns Ferry (See enclosed diagram.) Dana

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 9:04 AM
To: Dana Powers (Home); Powers, Dana A
Subject: NRC response to - Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

fyi

-----Original Message-----

From: Lee, Richard
Sent: Thursday, March 31, 2011 11:03 AM
To: 'Petti, Jason P'
Cc: 'Pickering, Susan Y'; Wagner, Katie
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Hi, Jason:

The following is the response that I got from RES Division of Engineering staff who specialized in containment structure. Please feel free to share it with IAEA. You do not need to do further evaluation on this.

"Two pressures are of interest when considering venting: leakage pressure and rupture pressure. According to NUREG/CR- 6920, the leakage pressure for the wetwell is around 0.8 MPa (116 psi) and for the drywell it is around 1.0 MPa (145 psi). The rupture pressure is

2/275

about 1.0-1.2 MPa, which is consisted to 2.5-3x design pressure. Note that these pressures are also temperature dependent, but that dependency is weak until about 200 deg. C (400 deg. F).

While carbon steel is not highly vulnerable to cracking, the salt can increase the crevice/pitting corrosion so some degradation of the values listed above can be expected. The once you have the conditions for localized corrosion, the rate can be as high as 10 cm/year (4 in/year). The containment shell thickness for MK-Is varies from 0.75-1.75 in (1.9-4.5 cm) at various locations. NUREG/CR-6920 estimates that localized corrosion of up to 50% of the thickness reduces the leakage and rupture pressure by 10-20%."

Best regards,
Richard

-----Original Message-----

From: Petti, Jason P [mailto:jppetti@sandia.gov]
Sent: Thursday, March 24, 2011 3:14 PM
To: Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

The email Susan Pickering and I described to you on the phone from the IAEA is attached, and includes their requests for information/opinions.

Our potential plan would be to consult with Sandia staff members (Mike Hessheimer, Randy Gauntt) to provide a quick opinion based on past work on similarly designed US plants (2-3 hours of time).

Past/current work in structural response of containments has been performed for NRC/Research under Rosemary Hogan's branch with the PMS Herman Graves and Jose Pires.

Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D
Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico
Phone: 505-284-8574
Email: jppetti@sandia.gov

-----Original Message-----

From: K-S.Kang@iaea.org [mailto:K-S.Kang@iaea.org]
Sent: Thursday, March 24, 2011 11:53 AM
To: Petti, Jason P
Subject: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Dear Dr. Jason Petti,

I got you name through Dr. Naus from ORNL. Can I ask your engineering judgement to Fukushima Dai Ichi nuclear power plant containment ?

I have very very urgent issues related to Fukushima Dai Ichi Npp containment. The thickness of reinforced concrete containment is from 1.2 to 1.6 M and containment has a carbon steel plate (6 mm). (see attached file)

Can I ask you the important questions ?

Containment design pressure of Fukushima Dai Ichi Npp unit 1 is 3.84 MPa and the Max. operation pressure is 4.27 MPa..

Due to reactor temperature high of unit 1, Japan released high steam from reactor pressure vessel to suppression pool and then containment pressure was increased from 3.2 to 3.8 Mpa.

My Questions are :

1. What are the major elements to keep the containment integrity ?

2. To keep containment integrity under design pressure, Japan should release pressure through venting system, but it is very difficult to release pressure to environment due to radiation material.

How can maintain or decrease pressure of containment in current situation without venting ?

3. What is the maximum operating pressure according to your judgement ?

4. If Japan insert sea water to dry well to cool down RPV and containment, is this good suggestion ?

Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

Ki- Sig KANG

Technical Head (PLiM/LTO)

Nuclear Power Engineering Section
Division of Nuclear Power
International Atomic Energy Agency

Tel: +43 1 2600 22796

Fax: +43 1 2600 29598

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

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]

Sent: Thursday, 24 March 2011 17:44

To: KANG, Ki-Sig

Subject: Re: Containment integrity from Ki Sig Kang, IAEA

Hi Ki-Sig,

Unfortunately I can not answer your questions because my background is materials and not structural analysis You might contact Jason Petti

(jppetti@snl.gov) at Sandia as they have done the model tests of containment vessels for NRC and correlated analyses of the tests.

Use of seawater definitely makes steel corrosion an issue.

Best regards,

dan

On 3/24/11 11:27 AM, "K-S.Kang@iaea.org" <K-S.Kang@iaea.org> wrote:

Hello Naus,

Long time I do not have any communication with you. I have very very urgent issues related to Fukushima Dai Ichi Npp containment.

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Thanks for your reply in advance.

[cid:3383815441_5634291]

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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Rihm, Roger

From: Rihm, Roger
Sent: Thursday, March 31, 2011 11:27 AM
To: Oesterle, Eric
Subject: RE: electronic versions of what I gave you attached

And an outstanding response it is!

From: Oesterle, Eric
Sent: Thursday, March 31, 2011 11:24 AM
To: Rihm, Roger
Subject: RE: electronic versions of what I gave you attached

Roger,

Odd how things come full circle! I wrote the response to the following:

*** Do you believe there is value in having an independent assessment of nuclear power safety in the United States?**

The NRC continues working in its mission to license, regulate the Nation's use of byproduct, source, and special nuclear materials in order to protect public health and safety, promote the common defense and security, and protect the environment. I am confident that the NRC's regulatory regime, inspection and oversight, and the proactive efforts of the industry through organizations like INPO will continue to ensure that this nation's reactors are operated safely.

The events in Japan are still unfolding as we speak and, I believe, it will still take some time before we know the full details of the event progression for each unit at the Fukushima Dai-ichi facility, the full extent of damage to structures, systems, and components, and the availabilities, capabilities, and responses of structures, systems and components to the earthquake and resultant tsunami. Until we know the full extent of what happened at the Fukushima Dai-ichi plant in Japan, I believe that it is premature to comment on whether or not there would be value in having an independent assessment of nuclear power safety in the U.S.

Eric

Eric R. Oesterle
NRR Communications Team
Senior Policy Analyst (NRO/DNRL)
U.S. Nuclear Regulatory Commission
301-415-1365

From: Rihm, Roger
Sent: Thursday, March 31, 2011 11:12 AM
To: Oesterle, Eric
Subject: electronic versions of what I gave you attached

These have not gone thru OPA. Use as you like!

I checked, and we did not prepare Qs and As for 3/16 hearing thru this office.

Roger S. Rihm

Communications and Performance Improvement Staff

Office of the Executive Director for Operations

US NRC

301.415.1717

roger.rihm@nrc.gov

Lee, Richard

From: Petti, Jason P [jppetti@sandia.gov]
Sent: Thursday, March 31, 2011 11:30 AM
To: Lee, Richard
Cc: Pickering, Susan Y; Wagner, Katie; Khalil, Imane
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

Thanks for getting back to me. I just wanted to clarify something. Are we allowed to add any thoughts/concerns to the staff's response when replying to the IAEA?

Jason

-----Original Message-----

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Thursday, March 31, 2011 9:03 AM
To: Petti, Jason P
Cc: Pickering, Susan Y; Wagner, Katie
Subject: RE: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

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To: Lee, Richard
Cc: Pickering, Susan Y; Khalil, Imane; Gauntt, Randall O
Subject: FW: Fukushima Dai Ichi Nuclear Power Plant containment integrity from Ki Sig Kang, IAEA

Richard

2/277

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Please let me know if you need more information.

Jason

Jason P. Petti, Ph.D
Structural & Thermal Analysis Department 6233 Sandia National Laboratories, Albuquerque, New Mexico
Phone: 505-284-8574
Email: jppetti@sandia.gov

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Based on your knowledge and profession, please reply and if you have any reference documents, send them to me.

Thanks for your reply in advance.

Note : Thanks Dan for your recommendation.

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

-----Original Message-----

From: nausdj@ornl.gov [mailto:nausdj@ornl.gov]

Sent: Thursday, 24 March 2011 17:44

To: KANG, Ki-Sig

Subject: Re: Containment integrity from Ki Sig Kang, IAEA

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[cid:3383815441_5634291]

Ki- Sig KANG

Technical Head (PLiM/LTO)
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Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 8:58 PM
To: Gauntt, Randall O
Subject: RE: An Upper Pool in U4!

O.K. Will ask Oyster Creek PM on Monday.

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Friday, April 01, 2011 8:49 PM
To: Lee, Richard; kcw@dycoda.com; Tinkler, Charles
Subject: RE: An Upper Pool in U4!

Report says that Oyster creek has the same design.

From: Gauntt, Randall O
Sent: Friday, April 01, 2011 6:48 PM
To: richard.lee@nrc.gov; kcw@dycoda.com; charles.tinkler@nrc.gov
Subject: FW: An Upper Pool in U4!

Richard,

Do you know anything about an upper pool in SFP?

Someone was looking for drawings of pool.

Randy

From: Gauntt, Randall O
Sent: Friday, April 01, 2011 4:36 PM
To: kcw@dycoda.com; charles.tinkler@nrc.gov; Lachance, Jeffrey Lynn
Subject: FW: An Upper Pool in U4!

Jeff,

We should bring this up as it ios a possible explanation for a small amount of fuel involved in a fire as opposed to the whole pool. This "upper" pool is a temporary holding tank I guess.

Randy

From: Joy L Rempe [Joy.Rempe@inl.gov]
Sent: Friday, April 01, 2011 4:32 PM
To: Gauntt, Randall O
Cc: Powers, Dana A; kcw@dycoda.com
Subject: Re: An Upper Pool in U4!

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Randy,

I copied you on an email to Jess . He's been looking into it. Bottom line, we just don't know. I'd think someone in Japan would know.

So, Dana, if you out there, are you going to have input on the C-SGTR stuff next week? Will you even be at ACRS?

Joy
[cid:_2_071EAA84071EA4CC007BD78387257865]

"Gauntt, Randall O" <rogaunt@sandia.gov>

04/01/2011 04:26 PM

To
"Joy L Rempe" <Joy.Rempe@inl.gov> cc
"kcw@dycoda.com" <kcw@dycoda.com>, "Powers, Dana A" <dapower@sandia.gov> Subject
An Upper Pool in U4!

Joy, this is intereresting, and the kind of information that could clarify the whole mess of inconsistencies.

I am forwarding this to me SFP analyst to see what he thinks. Is this another explanation for the explosion aside from the acetylene throry?

randy

From: Joy L Rempe [Joy.Rempe@inl.gov]
Sent: Friday, April 01, 2011 4:11 PM
To: Gauntt, Randall O
Subject: RE: Conference Call at 1:00 EDT Today

Randy,

Any chance that this guy, Murray Miles, knows something? He's ex-Rickover...here are paragraphs of interest (but the complete presentation is also attached). I'm just surprised that he'd claim that there was fuel in the upper pool if he knew nothing...

Joy

Quote from Murray Miles:

You need to hear one more complication in the design. The fuel pool is really two pools separated by a gate. Fuel removed from the reactor goes first into the small, upper pool which is only 20 or 25 feet deep. Later they move the fuel to the big, deep pool. There was apparently only a little fuel in this upper pool at the time of the quake.

This UPPER pool broke. The three-eighths inch steel liner is cracked and will not hold water. The concrete wall in front of this upper pool fell off. Fuel was severely damaged probably by explosion. Temperature profiles measured by helicopters show clumps of hot stuff that must be fuel scattered around the floor area. This scenario is consistent with the numerous reports of fire in unit 4.

This is a real nightmare. But the main fuel pool in unit 4 appears intact and full of water. The spread of radioactivity came fortunately from a small amount of fuel.

[cid:_2_071E62E4071E5428007BD78387257865]

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 10:01 AM
To: Wagner, Katie
Subject: FW:

From: Gibson, Kathy
Sent: Friday, April 01, 2011 9:58 AM
To: Correia, Richard; Marksberry, Don
Cc: Coe, Doug; Cheok, Michael; Lee, Richard
Subject: Re:

And Richard Lee please. We are keeping a Sharepoint site to track all our Japan-related requests. Thx

From: Correia, Richard
To: Marksberry, Don
Cc: Coe, Doug; Cheok, Michael; Gibson, Kathy
Sent: Fri Apr 01 08:03:34 2011
Subject: RE:

Thanks Don. I know Donnie Harrison is supporting our efforts. Once we have a product you, Mary & Donnie are satisfied with, please cc Mike Cheok, Kathy Gibson and me on emails/deliveries to the RST (Fred Brown/RST01Hoc@nrc.gov).

thanks

Richard Correia, PE
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
US NRC

richard.correia@nrc.gov

From: Marksberry, Don
Sent: Friday, April 01, 2011 7:41 AM
To: Correia, Richard
Subject: RE:

Mary has been working late at night. I will check when she gets into the office. Don

From: Correia, Richard
Sent: Friday, April 01, 2011 7:40 AM
To: Drouin, Mary; Marksberry, Don
Cc: Coe, Doug
Subject:

Mary, Don,

How are you progressing on the special project for the IRC?

2/279

Richard Correia, PE
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
US NRC

richard.correia@nrc.gov

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 2:58 PM
To: Basu, Sudhamay
Subject: FW: Request for Briefing on SFP Study

fyi

From: Tinkler, Charles
Sent: Friday, April 01, 2011 11:24 AM
To: Gibson, Kathy; Lee, Richard
Cc: Correia, Richard; Sheron, Brian; Uhle, Jennifer
Subject: RE: Request for Briefing on SFP Study

The study Brian is referring to is most likely NUREG-1738, Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants. the work was done between 1998? and late 2000. (date published Feb 2001, had a public comment issuance)

At that time myself and Jason Schaperow were the most heavily involved from research, I wrote the report section on Zr- fires with assistance from Sud Basu,, Jason and I developed, with NRR, source terms and performed offsite consequence calculations (Jason did the calcs in-house). Chris Boyd performed CFD calcs on fuel heatup using the assumptions provided by NRR..

Jason, myself, and Farouk Eltawila also sent a letter at the time advising NRR that the analyses were very conservative and that a more realistic treatment of zirc fires and source terms was needed. NRR response was that the conservative answers were sufficient for the purpose of the study.

The Commission heavily criticized the study as overly conservative and talked for a while of withdrawing the study. Study was not withdrawn but Chairman Diaz frequently criticized the study.

We subsequently performed more realistic analyses of spent fuel pools as part of the post 9/11 security assessment and have repeatedly stated in public that the "new security analyses" indicate pool vulnerability (and risk) is lower than previously estimated. In earlier studies such as NUREG-1738. Most recently in response to rulemaking petitions the study was discussed in Federal court by OGC. Bob Palla (now retired) and myself worked with OGC.

From: Gibson, Kathy
Sent: Friday, April 01, 2011 10:39 AM
To: Lee, Richard; Tinkler, Charles
Cc: Correia, Richard
Subject: Fw: Request for Briefing on SFP Study

Who was involved in the study Brian is referring to?

From: Correia, Richard
To: Gibson, Kathy; Cheok, Michael
Sent: Fri Apr 01 10:29:58 2011
Subject: FW: Request for Briefing on SFP Study

FYI. Brian's recollections on SFP accident risk studies.

Z/280

Richard Correia, PE
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
US NRC

richard.correia@nrc.gov

From: Sheron, Brian
Sent: Friday, April 01, 2011 10:25 AM
To: Correia, Richard; Uhle, Jennifer
Subject: RE: Request for Briefing on SFP Study

The only SFP risk study I recall was done in the 1999-2000 time frame. There was a question raised as to whether decommissioned plants that only had fuel in their SFPs could reduce their insurance requirements, their security requirements, and their EPZs. I was the Associate Director at the time, and DSA had the lead. Gary Holahan was honchoing the effort. I seem to recall that the analysis done only calculated down to top of active fuel, and we did not calculate consequences once the fuel uncovered, but I also seem to recall that we could not rule out a release. However, I think the answer was that that the probability of reaching fuel uncover was below the Commission's safety goals, so we didn't do any analyses of uncover. We were packaging up the results to send to the Commission, and then 9/11 happened, and the whole effort was shelved. There was also a lot of criticism of the study, and we pushed back because we kept saying we were only doing a bounding study.

Gary probably has a better memory about this than I do.

From: Correia, Richard
Sent: Friday, April 01, 2011 9:36 AM
To: Sheron, Brian; Uhle, Jennifer
Subject: FW: Request for Briefing on SFP Study

Brian, Jennifer,

DRA will support this Commissioner A. request. I am looking for the right person(s) to support. I'll keep you informed as we progress.

Richard Correia, PE
Director, Division of Risk Analysis
Office of Nuclear Regulatory Research
US NRC

richard.correia@nrc.gov

From: Cheok, Michael
Sent: Friday, April 01, 2011 9:30 AM
To: Correia, Richard; Coe, Doug
Cc: Bahadur, Sher; Ruland, William; Lee, Samson; Harrison, Donnie; Wertz, Trent
Subject: FW: Request for Briefing on SFP Study

Rich, Doug – Does RES want to take the lead on this and for us to support? (Or we can reverse this if you like) I kinda remember a SFP risk study back in the 90's. Not sure if there is a more recent one.

Mike

From: Wertz, Trent
Sent: Friday, April 01, 2011 9:11 AM
To: Cheok, Michael
Subject: FW: Request for Briefing on SFP Study

Mike,

Here's the request. I'll see if I can pin down when they want the briefing.

Trent

From: Williams, Shawn
Sent: Thursday, March 31, 2011 8:01 PM
To: Williams, Donna; Wertz, Trent
Cc: Wittick, Brian; Bowman, Gregory
Subject: FW: Request for Briefing on SFP Study

Is this request an NRR Lead, or NRO Lead, or maybe even Research? I would think NRR.

From: Snodderly, Michael
Sent: Thursday, March 31, 2011 7:01 PM
To: Williams, Shawn
Cc: Sosa, Belkys; Davis, Roger; Castleman, Patrick; Blake, Kathleen
Subject: Request for Briefing on SFP Study

Shawn,

Commissioner Apostolakis would like to request a briefing from the staff on the generic study of spent fuel pool accident risk. The Commissioner would like to have a better understanding of the risk from spent fuel pools including the risk due to fire and seismic. The Commissioner is aware of an adjudicatory issue associated with Diablo Canyon. So please avoid any discussion of SFP risk at Diablo Canyon. Commissioner Apostolakis plans to invite Commissioner Svinicki if she is interested. Please contact Kathleen Blake to schedule the briefing. Contact me if you have any questions concerning this matter.

Thanks,

Mike Snodderly
Technical Assistant for Reactors
to Commissioner Apostolakis
U. S. Nuclear Regulatory Commission

Phone: 301-415-2241
Email: michael.snodderly@nrc.gov

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 3:12 PM
To: Esmaili, Hossein; Salay, Michael; 'mike.salay@gmail.com'
Subject: FW: what can happen next
Attachments: What can happen next.docx

fyi

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Friday, April 01, 2011 1:44 PM
To: Lee, Richard; Kelly, John E (NE)
Subject: what can happen next

This is by no means a complete list, but here are some thoughts on issues that may arise in the ongoing recovery at Fukushima. These are just issues that come promptly to mind. I'm sure with further discussion, other ideas will come to mind.

If, indeed, there is a thick salt bed in the bottom of the pressure vessel (I have seen no proof of this), and we can avoid air ingress, I am less concerned about vessel melt thru. The salt bed along with the considerable mass of control drive mechanisms steel in the lower head will substantially delay melting and attack on the head. The melting salt will provide a heat sink and it will distribute heat over a very large area of the head. There are, however, other mechanisms to get to equally drastic events.

Dana

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Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 3:19 PM
To: Wagner, Katie
Subject: FW: ACTION: DRAFT PMT request to RES-RST

This is action for Op Center to send the source term info. (Charlie Tinkler and Jason completed yesterday in respond to PMT/Fred Brown #1 item on 3/30/2011) to NARAC.

From: Gibson, Kathy
Sent: Friday, April 01, 2011 1:50 PM
To: RST01 Hoc; RST07 Hoc; PMT01 Hoc; Hoc, PMT12
Cc: Tinkler, Charles; Schaperow, Jason; Lee, Richard
Subject: Re: ACTION: DRAFT PMT request to RES-RST

Please verify that this source term was received. Also was it sent to NARAC or actually used for any dose projections by PMT or NARAC? We would be interested in the results. Thanks.

From: Schaperow, Jason
To: RST01 Hoc; RST07 Hoc; RST08 Hoc; PMT01 Hoc; Hoc, PMT12
Cc: Tinkler, Charles; Uhle, Jennifer; Gibson, Kathy; Sheron, Brian
Sent: Thu Mar 31 15:37:59 2011
Subject: RE: ACTION: DRAFT PMT request to RES-RST

The attached information is provided by RES in response to a PMT request of 3/30/11 to provide a realistic, up-to-date estimation of source terms for dose projections to address future potential radiological releases from the Fukushima Unit 1 reactor and the Unit 4 spent fuel pool.

From: Tinkler, Charles
Sent: Wednesday, March 30, 2011 10:10 AM
To: Schaperow, Jason
Subject: FW: ACTION: DRAFT PMT request to RES-RST
Importance: High

From: PMT01 Hoc
Sent: Wednesday, March 30, 2011 9:39 AM
To: Esmaili, Hossein; Tinkler, Charles; Lee Col
Cc: Lee, Richard; Hoc, PMT12; PMT01 Hoc; PMT11 Hoc; PMT02 Hoc
Subject: ACTION: DRAFT PMT request to RES-RST
Importance: High

Attached for your comment.
Request input ASAP.

Contacts:
Tony Huffert
Rich Clement
PMT – NRC Ops Center
301-816-5402

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Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 3:30 PM
To: Esmaili, Hossein; 'Gauntt, Randy'; 'Gauntt, Randy (home)'; Salay, Michael
Cc: Farmer, Mitchell T.; 'Michael Corradini'
Subject: FW: MCCI Releases

fyi

-----Original Message-----

From: Basu, Sudhamay
Sent: Friday, April 01, 2011 3:25 PM
To: 'Powers, Dana A'
Cc: Lee, Richard
Subject: RE: MCCI Releases

Thank you Dana.

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Friday, April 01, 2011 3:18 PM
To: Basu, Sudhamay
Subject: MCCI Releases

Sud, Assume that all noble gases, iodine and cesium have been released from the fuel prior to the start of melt concrete interactions. Assume the accident is roughly equivalent of a long term station blackout with eventual battery depletion. Then assuming a siliceous concrete, the types of radionuclide release during melt-concrete interactions would be:

Tellurium group:	0.0085 to 0.013	fraction of initial core inventory
Ba/Sr group:	0.023 to 0.044	"
Molybdenum:	~ 0.02	"
Lanthanides:	~ 4×10^{-5}	"
Cerium group:	~0.0025	"

These numbers were derived from equivalent calculations for Peach Bottom and are intended to only give an order of magnitude feel for the results. No doubt they would be different were we to model the details of the Fukushima reactors. The intense period of attack lasts for about 6 hours though attack continues for days at a slow rate with low levels of release. The release fractions would be greatly attenuated by the presence of a water pool overlying the core debris. Dana

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 4:20 PM
To: 'Powers, Dana A'
Cc: Basu, Sudhamay
Subject: RE: Draft sumamry on MCCI ST

Thx, Dana.

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Friday, April 01, 2011 4:19 PM
To: Lee, Richard
Subject: RE: Draft sumamry on MCCI ST

I think this is a pretty accurate estimate of things given the assumptions. Dana

From: Lee, Richard [mailto:Richard.Lee@nrc.gov]
Sent: Friday, April 01, 2011 2:16 PM
To: Powers, Dana A
Cc: Basu, Sudhamay
Subject: FW: Draft sumamry on MCCI ST

Dana: Attached is my summary of the conversation on MCCI ST. Please review and revise
Thx

From: Lee, Richard
Sent: Friday, April 01, 2011 4:14 PM
To: 'Powers, Dana A'
Cc: Basu, Sudhamay
Subject: Draft sumamry on MCCI ST

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 4:45 PM
To: 'Adams, Ian'
Subject: RE: Regalabuto Presentation
Attachments: image001.jpg

Thx, Ian:
Richard

From: Adams, Ian [mailto:Ian.Adams@Hq.Doe.Gov]
Sent: Friday, April 01, 2011 4:40 PM
To: Lee, Richard; Powers, Dana A
Subject: FW: Regalabuto Presentation

Here you are.

From: Larzelere, Alex
Sent: Friday, April 01, 2011 4:11 PM
To: DL-NITsolutions
Subject: Regalabuto Presentation

Everyone,

Here is the presentation for this afternoon's conversation.

Regards,

Alex

Alex R. Larzelere
*Director, Advanced Modeling and Simulation Office
Office of Nuclear Energy (NE-71)
U.S. Department of Energy
202-586-1906
Alex.Larzelere@nuclear.energy.gov*



Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 5:19 PM
To: 'Powers, Dana A'
Subject: RE: part b and final part of april 1 briefing package

From UC Berkeley: Objection, Objection! No basis!!

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Friday, April 01, 2011 5:17 PM
To: Lee, Richard
Subject: RE: part b and final part of april 1 briefing package

And much better!

-----Original Message-----

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Friday, April 01, 2011 2:54 PM
To: Powers, Dana A
Subject: RE: part b and final part of april 1 briefing package

Thx, Dana.
Richard

It appears that Monica is talking more than Per!!

-----Original Message-----

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Friday, April 01, 2011 4:52 PM
To: Lee, Richard
Subject: part b and final part of april 1 briefing package

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 5:47 PM
To: RST09 Hoc; Arndt, Steven
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Steve:

Dana reviewed it already. Looks good.

Richard

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Friday, April 01, 2011 11:43 AM
To: Lee, Richard
Subject: RE: TASKING FROM RST

Richard, I am not immediately finding information on Kuricoat. I think it a polyamide, but that is more guess than knowledge. I do know that there was extensive use of sprayed polymers at the Chernobyl site for exactly the same reason. I think the overall experience with the polymer – I don't know what was used – was positive. Dose rates in the region of proposed spray will not adversely affect most polymers greatly – there will be some hydrogen production, but it will not be of great importance. I am unaware of difficulties encountered in the Chernobyl operation with mechanical equipment in the vicinity of the sprayed material – robotic or otherwise. There were great difficulties with robotics at Chernobyl but this had more to do with lack of radiation hardening of the electronics than any sprayed material. Dana

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Friday, April 01, 2011 6:15 AM
To: Dana Powers; Powers, Dana A
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Dana:

Same item

From: RST09 Hoc
Sent: Friday, April 01, 2011 5:07 AM
To: Lee, Richard
Cc: RST01 Hoc
Subject: FW: TASKING FROM RST

Update to the below TASKING

- 1) There is less urgency on this than was originally thought. Response by 1400, 4 April 1, 2011 (EST) is acceptable.
- 2) More clarification. The review should confirm the INPO assessment, and provide additional information on specifically what issues (heat transfer, clogging, degradation of the material, etc.) might be caused by using this material in such a way that it might get into the spent fuel pool.

Provide information to RST at RST01.hoc@nrc.gov

Steven Arndt

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Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 3:34 PM
To: 'corradin@cae.wisc.edu'
Subject: RE: FW: Fukushima - help needed

I guess you like this part.

(I think this is nonsense. The combination of radiolysis and corrosion
> probably means the net flux of oxygen is into the water and not out of
> it, plus the seawater also carries a heavy load of dissolved carbon
> dioxide that is fully capable of inerting a hydrogen-oxygen mixture.
> Whether there is enough CO2 to inert, I don't know, yet.)

Richard

-----Original Message-----
From: Michael Corradini [mailto:corradini@engr.wisc.edu]
Sent: Friday, April 01, 2011 3:33 PM
To: Lee, Richard
Subject: Re: FW: Fukushima - help needed

I was called privately by John Kelly and expressed similar points of view.

But of course Dana's chemistry expertise really adds meat to my meager bones
--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Lee, Richard" <Richard.Lee@nrc.gov>:

> FYI only
>
> From: Basu, Sudhamay
> Sent: Friday, April 01, 2011 2:28 PM
> To: Lee, Richard
> Subject: FW: Fukushima - help needed
>
>
> From: Powers, Dana A [mailto:dapower@sandia.gov]
> Sent: Friday, April 01, 2011 2:13 PM
> To: Basu, Sudhamay
> Subject: RE: Fukushima - help needed
>
> Sud, I think I can explain this, but I am by no means a believer.
> The concern as I understand this is that seawater pumped into the
> vessel is saturated in oxygen. The seawater gets hot if not boiled and
> oxygen is expelled. To be sure some seawater is leaked into the
> drywell through the recirculation pump seals where it also gets hot.

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> Up to some temperature near the boiling point of water, the solubility
> of oxygen decreases with temperature so there is an accumulation of
> oxygen, hydrogen and steam in the drywell head space. It is thought
> now that this mixture is "steam inerted" so it cannot deflagrate or
> detonate. If cold water is injected, the steam will condense and this
> will leave a combustible mixture of hydrogen and oxygen in the head
> space. They fear a deflagration that would overpressure the drywell.
> (I think this is nonsense. The combination of radiolysis and corrosion
> probably means the net flux of oxygen is into the water and not out of
> it, plus the seawater also carries a heavy load of dissolved carbon
> dioxide that is fully capable of inerting a hydrogen-oxygen mixture.
> Whether there is enough CO2 to inert, I don't know, yet.) At any rate,
> they have been hesitant to inject cold water. They have been content
> up until now to allow flooding of the drywell by leakage through the
> recirculation pump seals. My understanding is that they are getting
> more concerned about melting, so they are revising positions to
> advocate cold flooding of the drywell. I'm much less concerned about
> melting within the reactor pressure vessel for reasons outlined in my
> previous missive. Dana

>
> From: Basu, Sudhamay [mailto:Sudhamay.Basu@nrc.gov]
> Sent: Friday, April 01, 2011 11:32 AM
> To: Powers, Dana A
> Cc: Lee, Richard
> Subject: RE: Fukushima - help needed

>
> Thanks Dana for your thoughts and trust me, every bit helps now. I
> would like to pursue couple of things further. When we did Mark I
> liner failure study, we used a bounding estimate of 30 w/o unoxidized
> Zr (exceeding that is physically unreasonable a la Theo).
> According to APRIL calculation, you could get 100 w/o metal (Zr and
> SS) initially out of RPV and according to MAAP, the other extreme of
> fully oxidized core. Say we get 30 w/o unoxidized metal, what sort of
> radionuclide release can we expect in case there is a breach creating
> a release path. The other thing is attenuation by an overlying water
> pool. Scrubbing is real and my understanding is BWR SAMG recommends
> flooding for, if nothing else, that reason. Yet, I read in some
> communication that the NRC team is debating whether drywell flooding
> should be recommended at this stage of the accident because of the
> prospect of noncondensable generation and fear of potential explosion.
> Given the decay heat, if we keep the core debris just submerged, it is
> not clear to me that the noncondensable
> inventory would be so large as to the potential for an explosion.
> Can you shed any light on this?

>
> From: Powers, Dana A [mailto:dapower@sandia.gov]
> Sent: Friday, April 01, 2011 12:44 PM
> To: Basu, Sudhamay
> Cc: Lee, Richard
> Subject: RE: Fukushima - help needed

>
> Sud, If indeed there is a large bed of precipitated salt in the lower
> head of the pressure vessel, this bed coupled with the dense forest of
> steel control rod drives will greatly slow any progression of the
> melting of the lower head of the pressure vessel. Should the accident
> progress so that molten core debris can penetrate the reactor vessel
> and molten core debris cascade into the drywell, I would expect flow

> to the vessel wall and attack on the wall unless there is sufficient
> cooling to prevent this ala Theophanous. Attack on the concrete will
> depend critically on the amount of unoxidized zirconium in the core
> debris. Ordinarily, in accident that we calculate, there is quite a
> lot of unreacted zirconium. The accident at Fukushima is of course
> quite different than a typical station blackout accident and I do not
> now have a good feeling for the amount of unreacted zirconium present.
> The unreacted zirconium in the core debris will react with gaseous
> product of concrete decomposition to produce an energetic transient in
> the debris. (Any prediction of quenching of the core debris by water
> is predicated on the complete oxidation of zirconium in the core
> debris.) Erosion of concrete will eventually collapse the pedestal
> typically between 1 and 5 days. This will cause the vessel to drop and
> will tear open penetration and create a pathway to reactor building.
> The pathway will be high in the building so there will be very little
> natural attenuation of aerosol releases that escape into the reactor
> building.
> I suspect that events of the accident as well as further events that
> lead to the penetration of the vessel will largely rid the core debris
> of volatile radionuclides (Cs, I, noble gases) prior to interactions
> with the concrete. There may be some Te available for slow release.
> Any high temperature transient during the core debris interactions
> with the concrete will lead to the release of barium and strontium.
> There will be a mechanical release of droplets of core debris (1-5
> micrometers in size) that will contain the radionuclides at the bulk
> core debris concentration. A bounding estimate of this release is
> 0.0001 times the mass of gas sparged through the core debris during
> the attack on the concrete. It is not a large source of release, but
> it is persistent. Water overlying the core debris while it attacks the
> concrete will greatly attenuate the radionuclide release. Our past
> experiments with as little as a foot of water depth largely snuffed
> the production of aerosols through a combination of crust formation
> and gas bubble scrubbing by the water. As the water gets contaminated
> there will be a slow release of radionuclides suspended in the water
> by the bubble bursting
> mechanism. Hope this helps. Dana

>

> From: Basu, Sudhamay [mailto:Sudhamay.Basu@nrc.gov]
> Sent: Friday, April 01, 2011 9:34 AM
> To: Powers, Dana A; Powers, Dana
> Subject: Fukushima - help needed

>

> Hi Dana,

>

> Richard asked me to forward the attachment to you and ask you for some
> help. The attachment is CORQUENCH calculations for ex-vessel
> coolability performed by Kevin Robb at UW and Mitch farmer at ANL.
> I believe Richard sent the information to John Kelly already. The
> question is given the melt mass in the cavity and assuming the
> containment is breached, how much fission product inventory will
> likely get out in the environment - also keeping in mind the 21-day
> (from the start of accident) decay of some isotopes. Richard is
> asking you to do some calculations in that respect and advise us of
> the outcome. I believe Kevin did some parametric on the core
> inventory that will be relocated to the cavity. If you wish, you can
> build on that for your calculations. I am trying to get in touch with
> Mitch in case we need some clarification. His number is 630 252 4539

.
> in case you need to get in touch him. Thanks for your help.

>

> Sud

>

>

Lee, Richard

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Friday, April 01, 2011 6:14 PM
To: Gauntt, Randall O
Cc: Lee, Richard; Esmaili, Hossein; Gauntt, Randy (home); Salay, Michael; Farmer, Mitchell T.
Subject: RE: Fukushima - help needed

I agree with Randy that can we do a coherent picture - since H2 detonation is extreme in my mind with spray cooling of the drywell

--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
<http://www.engr.wisc.edu/ep>

Quoting "Gauntt, Randall O" <rogaunt@sandia.gov>:

> The explanation offered by Dana is exactly what is needed right now
> to spin down this dread of drywell h2 explosion. The NRC team wants to
> back off from recommending drywell flooding owing to the fear of
> detonation. I am not sure that there would be a lot of airborne to
> escape the drywell, anyway. But a fear is that if therer is another
> explosion accompanied by a large releasr the people will leave the
> site and things will progress as nature dictates.

>
>
>

> Could the chemistry proposed chemistry be argued convincingly?

>
>
>

> randy

>
>

> From: Lee, Richard [Richard.Lee@nrc.gov]
> Sent: Friday, April 01, 2011 1:22 PM
> To: Esmaili, Hossein; Gauntt, Randall O; Gauntt, Randy (home); Salay,
> Michael; Michael Corradini; Farmer, Mitchell T.
> Subject: FW: Fukushima - help needed

>
>

> FYI only

>
>

> From: Basu, Sudhamay
> Sent: Friday, April 01, 2011 2:28 PM
> To: Lee, Richard
> Subject: FW: Fukushima - help needed

>
>

> From: Powers, Dana A [mailto:dapower@sandia.gov]
> Sent: Friday, April 01, 2011 2:13 PM
> To: Basu, Sudhamay

2/289

> Subject: RE: Fukushima - help needed

>
> Sud, I think I can explain this, but I am by no means a believer.
> The concern as I understand this is that seawater pumped into the
> vessel is saturated in oxygen. The seawater gets hot if not boiled and
> oxygen is expelled. To be sure some seawater is leaked into the
> drywell through the recirculation pump seals where it also gets hot.
> Up to some temperature near the boiling point of water, the solubility
> of oxygen decreases with temperature so there is an accumulation of
> oxygen, hydrogen and steam in the drywell head space. It is thought
> now that this mixture is "steam inerted" so it cannot deflagrate or
> detonate. If cold water is injected, the steam will condense and this
> will leave a combustible mixture of hydrogen and oxygen in the head
> space. They fear a deflagration that would overpressure the drywell.
> (I think this is nonsense. The combination of radiolysis and corrosion
> probably means the net flux of oxygen is into the water and not out of
> it, plus the seawater also carries a heavy load of dissolved carbon
> dioxide that is fully capable of inerting a hydrogen-oxygen mixture.
> Whether there is enough CO2 to inert, I don't know, yet.) At any rate,
> they have been hesitant to inject cold water. They have been content
> up until now to allow flooding of the drywell by leakage through the
> recirculation pump seals. My understanding is that they are getting
> more concerned about melting, so they are revising positions to
> advocate cold flooding of the drywell. I'm much less concerned about
> melting within the reactor pressure vessel for reasons outlined in my
> previous missive. Dana

>
> From: Basu, Sudhamay [mailto:Sudhamay.Basu@nrc.gov]
> Sent: Friday, April 01, 2011 11:32 AM
> To: Powers, Dana A
> Cc: Lee, Richard
> Subject: RE: Fukushima - help needed

>
> Thanks Dana for your thoughts and trust me, every bit helps now. I
> would like to pursue couple of things further. When we did Mark I
> liner failure study, we used a bounding estimate of 30 w/o unoxidized
> Zr (exceeding that is physically unreasonable a la Theo).
> According to APRIL calculation, you could get 100 w/o metal (Zr and
> SS) initially out of RPV and according to MAAP, the other extreme of
> fully oxidized core. Say we get 30 w/o unoxidized metal, what sort of
> radionuclide release can we expect in case there is a breach creating
> a release path. The other thing is attenuation by an overlying water
> pool. Scrubbing is real and my understanding is BWR SAMG recommends
> flooding for, if nothing else, that reason. Yet, I read in some
> communication that the NRC team is debating whether drywell flooding
> should be recommended at this stage of the accident because of the
> prospect of noncondensable generation and fear of potential explosion.
> Given the decay heat, if we keep the core debris just submerged, it is
> not clear to me that the noncondensable
> inventory would be so large as to the potential for an explosion.
> Can you shed any light on this?

>
> From: Powers, Dana A [mailto:dapower@sandia.gov]
> Sent: Friday, April 01, 2011 12:44 PM
> To: Basu, Sudhamay
> Cc: Lee, Richard
> Subject: RE: Fukushima - help needed

>
> Sud, If indeed there is a large bed of precipitated salt in the lower
> head of the pressure vessel, this bed coupled with the dense forest of
> steel control rod drives will greatly slow any progression of the
> melting of the lower head of the pressure vessel. Should the accident
> progress so that molten core debris can penetrate the reactor vessel
> and molten core debris cascade into the drywell, I would expect flow
> to the vessel wall and attack on the wall unless there is sufficient
> cooling to prevent this ala Theophanous. Attack on the concrete will
> depend critically on the amount of unoxidized zirconium in the core
> debris. Ordinarily, in accident that we calculate, there is quite a
> lot of unreacted zirconium. The accident at Fukushima is of course
> quite different than a typical station blackout accident and I do not
> now have a good feeling for the amount of unreacted zirconium present.
> The unreacted zirconium in the core debris will react with gaseous
> product of concrete decomposition to produce an energetic transient in
> the debris. (Any prediction of quenching of the core debris by water
> is predicated on the complete oxidation of zirconium in the core
> debris.) Erosion of concrete will eventually collapse the pedestal
> typically between 1 and 5 days. This will cause the vessel to drop and
> will tear open penetration and create a pathway to reactor building.
> The pathway will be high in the building so there will be very little
> natural attenuation of aerosol releases that escape into the reactor
> building.

> I suspect that events of the accident as well as further events that
> lead to the penetration of the vessel will largely rid the core debris
> of volatile radionuclides (Cs, I, noble gases) prior to interactions
> with the concrete. There may be some Te available for slow release.
> Any high temperature transient during the core debris interactions
> with the concrete will lead to the release of barium and strontium.
> There will be a mechanical release of droplets of core debris (1-5
> micrometers in size) that will contain the radionuclides at the bulk
> core debris concentration. A bounding estimate of this release is
> 0.0001 times the mass of gas sparged through the core debris during
> the attack on the concrete. It is not a large source of release, but
> it is persistent. Water overlying the core debris while it attacks the
> concrete will greatly attenuate the radionuclide release. Our past
> experiments with as little as a foot of water depth largely snuffed
> the production of aerosols through a combination of crust formation
> and gas bubble scrubbing by the water. As the water gets contaminated
> there will be a slow release of radionuclides suspended in the water
> by the bubble bursting
> mechanism. Hope this helps. Dana

>
> From: Basu, Sudhamay [mailto:Sudhamay.Basu@nrc.gov]
> Sent: Friday, April 01, 2011 9:34 AM
> To: Powers, Dana A; Powers, Dana
> Subject: Fukushima - help needed

>
> Hi Dana,
>
> Richard asked me to forward the attachment to you and ask you for some
> help. The attachment is CORQUENCH calculations for ex-vessel
> coolability performed by Kevin Robb at UW and Mitch farmer at ANL.
> I believe Richard sent the information to John Kelly already. The
> question is given the melt mass in the cavity and assuming the
> containment is breached, how much fission product inventory will

> likely get out in the environment - also keeping in mind the 21-day
> (from the start of accident) decay of some isotopes. Richard is
> asking you to do some calculations in that respect and advise us of
> the outcome. I believe Kevin did some parametric on the core
> inventory that will be relocated to the cavity. If you wish, you can
> build on that for your calculations. I am trying to get in touch with
> Mitch in case we need some clarification. His number is 630 252 4539
> in case you need to get in touch him. Thanks for your help.

>
> Sud
>
>

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 8:06 PM
To: RST09 Hoc
Subject: RE: TASKING FROM RST

Don:

Will do.

Richard

From: RST09 Hoc
Sent: Friday, April 01, 2011 7:36 PM
To: Lee, Richard
Subject: RE: TASKING FROM RST

Richard,

Thanks, and pass along our appreciation to Dana.

Don Helton
On-Shift SA analyst

From: Lee, Richard
Sent: Friday, April 01, 2011 5:47 PM
To: RST09 Hoc; Arndt, Steven
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Steve:

Dana reviewed it already. Looks good.

Richard

From: Powers, Dana A [\[mailto:dapower@sandia.gov\]](mailto:dapower@sandia.gov)
Sent: Friday, April 01, 2011 11:43 AM
To: Lee, Richard
Subject: RE: TASKING FROM RST

Richard, I am not immediately finding information on Kuricoat. I think it a polyamide, but that is more guess than knowledge. I do know that there was extensive use of sprayed polymers at the Chernobyl site for exactly the same reason. I think the overall experience with the polymer - I don't know what was used - was positive. Dose rates in the region of proposed spray will not adversely affect most polymers greatly - there will be some hydrogen production, but it will not be of great importance. I am unaware of difficulties encountered in the Chernobyl operation with mechanical equipment in the vicinity of the sprayed material - robotic or otherwise. There were great difficulties with robotics at Chernobyl but this had more to do with lack of radiation hardening of the electronics than any sprayed material.
Dana

From: Lee, Richard [\[mailto:Richard.Lee@nrc.gov\]](mailto:Richard.Lee@nrc.gov)
Sent: Friday, April 01, 2011 6:15 AM

2/290

To: Dana Powers; Powers, Dana A
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Dana:

Same item

From: RST09 Hoc
Sent: Friday, April 01, 2011 5:07 AM
To: Lee, Richard
Cc: RST01 Hoc
Subject: FW: TASKING FROM RST

Update to the below TASKING

- 1) There is less urgency on this than was originally thought. Response by 1400, 4 April 1, 2011 (EST) is acceptable.
- 2) More clarification. The review should confirm the INPO assessment, and provide additional information on specifically what issues (heat transfer, clogging, degradation of the material, etc.) might be caused by using this material in such a way that it might get into the spent fuel pool.

Provide information to RST at RST01.hoc@nrc.gov<mailto:RST01.hoc@nrc.gov>

Steven Arndt

From: RST09 Hoc
Sent: Friday, April 01, 2011 12:33 AM
To: Lee, Richard
Cc: RST01 Hoc
Subject: TASKING FROM RST

Richard,

Please find attached two documents from the site team in Japan. Tepco is planning to use a chemical "fix-it" to various surfaces at the site (building walls, ground, etc.) to prevent dispersion of contamination. The site team and the RST are concerned the material might end up in the spent fuel pools and cause potentially significant issues (with heat transfer, clogging, degradation of the material, etc.).

Additionally, find attached the assessment of this issue done by INPO.

ACTION: Please get the INPO recommendation peer reviewed (perhaps by Dana Powers or someone else that has been looking at the sump clogging issues), and provide peer review comments and recommendations, if any to RST by 1800, 1 April 2011 (EDT).

Steven Arndt
RST

Lee, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 8:09 PM
To: danapowers@msn.org; dapower@sandia.gov
Subject: FW: TASKING FROM RST

Dear Dana:

Don wants to make sure that your comments is on the Japanese proposal to use the chemical spray and to the best of your assessment it is O.K.

Thanks, Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 8:07 PM
To: RST09 Hoc
Subject: RE: TASKING FROM RST

Don:

I will ask Dana again to ascertain that what he says is with the Japanese proposal.

Richard

From: RST09 Hoc
Sent: Friday, April 01, 2011 7:54 PM
To: Lee, Richard
Subject: RE: TASKING FROM RST

Hey Richard,

I've now actually had a moment to look at the incoming, and it isn't clear where Dana stands on the actual INPO assessment. The Japanese proposed using a certain chemical, the INPO assessments suggests issues with doing that, and then Dana reflects on Chernobyl experience that seems to suggest (but doesn't say) that the original proposal should be fine and that INPO may be making too much out of their concerns.

Any thoughts?

Don

From: Lee, Richard
Sent: Friday, April 01, 2011 5:47 PM
To: RST09 Hoc; Arndt, Steven
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Steve:

Dana reviewed it already. Looks good.

Richard

2/29/11

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Friday, April 01, 2011 11:43 AM
To: Lee, Richard
Subject: RE: TASKING FROM RST

Richard, I am not immediately finding information on Kuricoat. I think it a polyamide, but that is more guess than knowledge. I do know that there was extensive use of sprayed polymers at the Chernobyl site for exactly the same reason. I think the overall experience with the polymer - I don't know what was used - was positive. Dose rates in the region of proposed spray will not adversely affect most polymers greatly - there will be some hydrogen production, but it will not be of great importance. I am unaware of difficulties encountered in the Chernobyl operation with mechanical equipment in the vicinity of the sprayed material - robotic or otherwise. There were great difficulties with robotics at Chernobyl but this had more to do with lack of radiation hardening of the electronics than any sprayed material.
Dana

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Friday, April 01, 2011 6:15 AM
To: Dana Powers; Powers, Dana A
Cc: Wagner, Katie
Subject: FW: TASKING FROM RST

Dana:

Same intem

From: RST09 Hoc
Sent: Friday, April 01, 2011 5:07 AM
To: Lee, Richard
Cc: RST01 Hoc
Subject: FW: TASKING FROM RST

Update to the below TASKING

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Provide information to RST at RST01.hoc@nrc.gov<<mailto:RST01.hoc@nrc.gov>>

Steven Arndt

From: RST09 Hoc
Sent: Friday, April 01, 2011 12:33 AM
To: Lee, Richard
Cc: RST01 Hoc
Subject: TASKING FROM RST

Richard,

Please find attached two documents from the site team in Japan. Tepco is planning to use a chemical "fix-it" to various surfaces at the site (building walls, ground, etc.) to prevent dispersion of contamination. The site team and the RST are concerned the material might end up in the spent fuel pools and cause potentially significant issues (with heat transfer, clogging, degradation of the material, etc.).

Additionally, find attached the assessment of this issue done by INPO.

ACTION: Please get the INPO recommendation peer reviewed (perhaps by Dana Powers or someone else that has been looking at the sump clogging issues), and provide peer review comments and recommendations, if any to RST by 1800, 1 April 2011 (EDT).

Steven Arndt
RST

Rihm, Roger

From: Rihm, Roger
Sent: Friday, April 01, 2011 2:36 PM
To: Cianci, Sandra
Subject: RE: Response: Marty will brief House subcommittee

I know nothing more really – you'll have to get details from OCA. I have seen email indicating that committee might ask Marty to bring Don Cool (FSME) with him, but, again, we'll have to take our direction from OCA. At a minimum, someone from OCA will accompany Marty.

Marty is acting for Bill next week, so be sure you're coordinating with Renee about EDO-related meetings that might conflict with this.

From: Cianci, Sandra
Sent: Friday, April 01, 2011 2:32 PM
To: Rihm, Roger
Cc: Belmore, Nancy; Decker, David; Quesenberry, Jeannette; Powell, Amy
Subject: RE: Response: Marty will brief House subcommittee

Roger,

Do you have logistical information? Also, anyone else attending with Marty?

Sandy Cianci

*Administrative Assistant to Marty Virgilio, DEDR
Office of the Executive Director for Operations
O-17 H13
301-415-1714
sandra.cianci@nrc.gov*

From: Rihm, Roger
Sent: Thursday, March 31, 2011 9:06 AM
To: Cianci, Sandra
Subject: FW: Response: Marty will brief House subcommittee

Make sure this gets in Marty's calendar – essentially all morning Weds April 6

From: Powell, Amy
Sent: Thursday, March 31, 2011 8:35 AM
To: Leeds, Eric; Schmidt, Rebecca
Cc: Virgilio, Martin; Weber, Michael; Cianci, Sandra; Rihm, Roger
Subject: Re: Response: Marty will brief House subcommittee

Thanks Eric and Marty -

2/292

The hearing is April 6th with House Energy and Commerce, Subcommittee on Oversight and Investigations. Given that the focus is same as the Senate Energy event that Bill did this week, we asked Roger to refresh Bill's statement to serve as written testimony for this hearing.

Thanks,
Amy

Amy Powell
Associate Director
Office of Congressional Affairs
U. S. Nuclear Regulatory Commission
Phone: 301-415-1673

Sent from my Blackberry

From: Leeds, Eric
To: Powell; Amy; Schmidt, Rebecca
Cc: Virgilio, Martin; Weber, Michael; Cianci, Sandra
Sent: Thu Mar 31 08:32:14 2011
Subject: Response: Marty will brief House subcommittee

Amy -

Marty has been designated to brief the House Energy & Environment (?) subcommittee on oversight and investigation next Wednesday. I'm the installed spare!

Please let me know if we need to prepare a statement.

Eric J. Leeds, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
301-415-1270

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 4:26 PM
To: Case, Michael
Subject: Congressman Waxman's staff inquiry FW: Risk Informed Assessment of Degraded Containment Vessels

Importance: High

Mike:

I think we need to decide as soon as possible. Or, have this been done?
Richard

From: Lee, Richard
Sent: Friday, April 01, 2011 3:07 PM
To: Case, Michael
Cc: Graves, Herman; Gibson, Kathy; Wagner, Katie
Subject: FW: Risk Informed Assessment of Degraded Containment Vessels

Hi, Mike:

Do you like SNL to address this or NRC to handle this?

Thanks, Richard

From: Petti, Jason P [mailto:jppet@sandia.gov]
Sent: Friday, April 01, 2011 12:16 PM
To: Lee, Richard
Subject: FW: Risk Informed Assessment of Degraded Containment Vessels

Richard

I have another request for you to advise on. Ben Spencer was contacted by a staffer for Congressman Waxman regarding a NUREG Ben and I authored (NUREG/CR-6920). They were requesting to speak with someone about the findings. Again, Herman Graves in NRC/Research was the NRC PM for this NUREG. Please advise as how to proceed.

Jason

From: "Cassady, Alison" <Alison.Cassady@mail.house.gov>
Date: March 31, 2011 1:21:50 PM MDT
To: "bwspenc@sandia.gov" <bwspenc@sandia.gov>
Subject: Risk Informed Assessment of Degraded Containment Vessels

Hello,

My colleagues and I are interested in speaking with someone about the findings of the 2006 Sandia report entitled "Risk-Informed Assessment of Degraded Containment Vessels." I saw your name as one of the authors. Are you the best person to speak to this report's findings?

Thanks,

Alison Cassady

Alison Cassady
Senior Professional Staff
Committee on Energy and Commerce
U.S. House of Representatives
Rep. Henry A. Waxman, Ranking Member
(202) 226-3400

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 4:26 PM
To: 'Katie Wagner'
Subject: FW: ACTION: PMT request for MELCOR source term (Fukushima)
Attachments: RES request for MELCOR run 4-4-2011.doc

Katie:

Please log in.
Thx, Richard

From: PMT11 Hoc
Sent: Monday, April 04, 2011 3:14 PM
To: Lee, Richard
Cc: Hoc, PMT12; PMT02 Hoc; PMT11 Hoc; Tinkler, Charles; Schaperow, Jason; Gibson, Kathy; Gibson, Kathy; Gavrilas, Mirela
Subject: ACTION: PMT request for MELCOR source term (Fukushima)

Richard,

This email follows up on our conversation earlier today, and previous emails from the Protective Measures Team, for RES to review a specific RASCAL case (plausible release case no. PRC-V3) using MELCOR. Attached is a Word document that that provides details on this request.

This request was approved by the Executive Team this afternoon.

If possible, the PMT would like to meet with RES staff and representatives of the Reactor Safety Team tomorrow (before 2:00 PM) to discuss this request.

Tony
PMT Dose Assessment

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 5:39 PM
To: 'Larzelere, Alex'; 'Adams, Ian'
Subject: FW: handouts for today conf. call

Hi, Alex & Ian:

The file may be too large for NRC e-mail system to accept. Can break it up into a few files may help with the sending.

Thx, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 5:05 PM
To: 'Larzelere, Alex'
Subject: handouts for today conf. call

Hi, Alex:

I have not received the handout for today conference call.

Richard

2/295

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 5:02 PM
To: 'Adams, Ian'
Subject: handsout for today meeting

Hi, Adams:

Is there a handout?

Richard

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 6:06 PM
To: Esmaili, Hossein
Subject: RE: 04-04 RST Watch Bill to get us through April 15th

Hossein:

What is the best address to send an e-mail to Ops center. RST01 Hoc?

Richard

From: Esmaili, Hossein
Sent: Monday, April 04, 2011 5:54 PM
To: Flanagan, Michelle
Cc: Lee, Richard
Subject: RE: 04-04 RST Watch Bill to get us through April 15th

Michelle,

I just talked to Brett who is the coordinator now. He feels that no special requirements are necessary - you just to make sure other people get the information as it comes on like emailing to other people on team and respond to requests by the RST director.

Send an email to Rick hasselberg and Jerry Dozier and let them know what time and date you are interested in.

-hossein

From: Flanagan, Michelle
Sent: Monday, April 04, 2011 3:47 PM
To: Esmaili, Hossein
Cc: Lee, Richard
Subject: RE: 04-04 RST Watch Bill to get us through April 15th

Hossein,

Richard thought I should ask you about the appropriateness of my requested position for "RST Coordinator." What do you know that they are responsible for? Is it a position that can be filled by someone with my background and skill set?

-Michelle

From: Flanagan, Michelle
Sent: Monday, April 04, 2011 3:06 PM
To: Lee, Richard
Cc: Esmaili, Hossein
Subject: RE: 04-04 RST Watch Bill to get us through April 15th

Richard,

I would like to get trained to assist and assist at the OpCenter. I see the schedule for the Watch bill through the 15th has some open slots. There's an open slot for "RST Coordinator" on Monday 4/11 from 7am - 3pm. Is this a position I can fill following a little shadowing training or is it a complicated role? I'm assuming that I

should shadow someone one for at least one time before I take a shift, and I could do that this Friday (4/8) when Mark Orr and Joelle Starfos are scheduled for this position.

Does this sound like an acceptable thing for me to pursue??

Thank you,
Michelle

From: Esmaili, Hossein
Sent: Monday, April 04, 2011 2:27 PM
To: Flanagan, Michelle
Subject: FW: 04-04 RST Watch Bill to get us through April 15th

From: Alter, Peter
Sent: Monday, April 04, 2011 1:32 PM
To: Holian, Brian; Boyce, Tom (RES); Richards, Stuart; Dudes, Laura; Ruland, William; Hackett, Edwin; Case, Michael; Brown, Frederick; Hiland, Patrick; Rini, Brett; Morlang, Gary; Collins, Frank; Schoenebeck, Greg; Alter, Peter; Hasselberg, Rick; Orr, Mark; Starefos, Joelle; Kavanagh, Kerri; Bukharin, Oleg; Thomas, Eric; Gavrilas, Mirela; Esmaili, Hossein; Zoulis, Antonios; Gilmer, James; Fuller, Edward; Wong, See-Meng; Skarda, Raymond; Koshy, Thomas; Beasley, Benjamin; Marshall, Shawn; Velazquez-Lozada, Alexander; Iyengar, Raj; Criscione, Lawrence; Ward, Leonard; Caruso, Mark; Ferrante, Fernando; Brown, Michael; Norton, Charles; Brown, Eva; Vick, Lawrence; Kolb, Timothy; Williams, Donna; Thorp, John; Berry, Rollie; Padovan, Mark; Kugler, Andrew; Bloom, Steven; Jervey, Richard; Reeves, Rosemary; Thompson, Jon; Ramadan, Liliana; Isom, James; Roggenbrodt, William; Kotzalas, Margie
Cc: Gray, Kathy; Dozier, Jerry
Subject: 04-04 RST Watch Bill to get us through April 15th

All,

Here's the April 4th Watch Bill for the extended period to April 15th.

There are a lot of holes for RST Coordinator and some for BWR Analyst, especially Saturday 4/9 Midnights (2300 – 0700)

Kathy Gray fills in the RST Director Spots.

Jerry Dozier fills in the Accident Analysts spots.

Please do not use TAC ZG0061 after March 26, 2011. Starting Sunday, March 27th (Pay Period 8), the TAC is ZG0063 – "Japan Event HQ Operations Watchstanders. This TAC is to be used to record hours worked when employees are working in the Operations Center. This is for employees who are working directly on activities that are supporting the Japan events relating to the earthquake and tsunami and who did not travel to Japan." [See NRMSBulletin Resources email 04/01/11 1:59 pm, "NEW TAC'S ASSOCIATED WITH SUPPORTING THE EVENTS IN JAPAN."]

Thanks for volunteering,
Peter & Rick

OLD Updated Information – The Chairman has directed us to continue with the same level of responder staffing until 4/15. If you could please e-mail me and Peter Alter your availability to participate on the RST during the week of 4/9 to 4/15, we will start assembling that watch bill. Thanks in advance.

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 6:24 PM
To: RST01 Hoc
Cc: Wagner, Katie
Subject: N2 Inerting of Fukushima Unit 1

This is to let you know that the N2 inerting system has been delivered to the Fukushima site (Monday – Japanese time), and that TEPCO will begin inerting the drywell of the Fukushima Unit 1 commencing Tuesday (Japanese time). SOURCE (Japan Atomic Energy Commission)

Mike Salay (in Japan) confirmed that TEPCO plans to do this today.

Lee, Richard

From: Lee, Richard
Sent: Monday, April 04, 2011 9:03 PM
To: vfs@ibrae.ac.ru
Subject: inquiry on the use of organic resin spray at Chernobyl site

Importance: High

Dear Valery:

There is a proposal to use Kuricoat C720<https://webmail.nrc.gov/owa/?ae=Item&t=IPM.Note&a=New&AuthResend1908BC2350124b5095AB75012FA405BA#> green (a water soluble organic resin) to spray on contaminated surfaces at the Fukushima sites. Dana recalled that at Chernobyl polymer resins was used successfully to spray down contaminants. He did not know what type of resins. Appreciate it if you can find out what was used at Chernobyl. What ever used at Chernobyl, to the best of your knowledge, what are the downside of using it (from the perspective of immediate negative impacts it had on the surfaces, and future removal and cleanup operation).

Look forward to hearing from you.

Best regards,
Richard

P.S. Have you start to compile the lessons-learned on the re-mediation work related to Chernobyl. The Japanese needs all the help it can get further down the road on managing the site.

Andersen, James

From: Merzke, Daniel
Sent: Monday, April 04, 2011 7:46 AM
To: Andersen, James
Subject: FW: CRS draft document on Japanese event - for your awareness
Attachments: CRS Report 110331 Japan reactor v2.pdf

Jim, this appears to be a draft document, which is little more than Radiation 101. Cyndi suggested I share it with the CAs, but I'm not sure it merits their attention. What do you think?

Dan

From: Jones, Cynthia
Sent: Friday, April 01, 2011 1:10 PM
To: Merzke, Daniel
Subject: FW: CRS draft document on Japanese event - for your awareness

Dan- I realize you are out today, but suggest you send this to the Commission TAs for their awareness.

Thanks
Cyndi

From: Jones, Cynthia
Sent: Friday, April 01, 2011 1:00 PM
To: Wiggins, Jim; Evans, Michele; Rothschild, Trip; Brenner, Eliot; Hayden, Elizabeth; Leeds, Eric; Boger, Bruce; Uhle, Jennifer; Sheron, Brian; Droggitis, Spiros; Merzke, Daniel; Virgilio, Martin; Weber, Michael; Burnell, Scott; McDermott, Brian; Morris, Scott
Subject: CRS draft document on Japanese event - for your awareness

FYI-

Last weekend amongst all the other requests, we (PMT and myself) were requested to review and assist the Congressional Research Service (CRS) on their draft document on the Japanese event. I just rec'd a copy from them, for your awareness.

The RST (Rx Safety Team) had no comments, but we had a lot, and I think it showed an improved production in this version. Please share with your staff (I already passed along to RST & PMT).

I expect that CRS will share with Congress shortly.

Cyndi

From: Jonathan Medalia [<mailto:JMEDALIA@crs.loc.gov>]
Sent: Friday, April 01, 2011 12:01 PM
To: Jones, Cynthia
Subject: RE: your phone message on CRS draft document

I'm updating the report to add an appendix with useful links, and of course have included a couple from NRC. Thanks again for your good work.
Jon

>>> "Jones, Cynthia" <Cynthia.Jones@nrc.gov> 4/1/2011 11:59 AM >>>

Thanks Jon

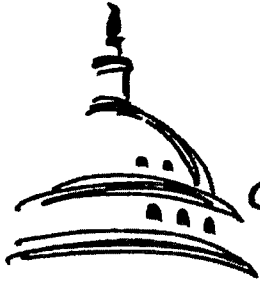
From: Jonathan Medalia [<mailto:JMEDALIA@crs.loc.gov>]
Sent: Thursday, March 31, 2011 6:31 PM
To: Jones, Cynthia
Cc: Sun, Casper; LIA06 Hoc; Hoc, PMT12
Subject: Re: your phone message on CRS draft document

Hi Cyndi, Casper, et al.,

Thanks for your comments on my report, Cyndi. I have worked through them and now have the report in good shape. I'll be in touch if I have further questions, but for now I think I'm ok. I've attached the report. You will notice that I acknowledge assistance from NRC, which I greatly appreciate. I will update the report from time to time, so let me know if you have any thoughts, esp. things to add.

Best,
Jon

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**Congressional
Research
Service**

The Japanese Nuclear Incident: Technical Aspects

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CRS Report for Congress

Prepared for Members and Committees of Congress

Summary

Japan's nuclear incident has engendered much public and congressional concern about the possible impact of radiation on the Japanese public, as well as possible fallout on U.S. citizens. This report provides information on technical aspects of the nuclear incident, with reference to human health.

While some radioactive material from the Japanese incident may reach the United States, it appears most unlikely that this material will result in harmful levels of radiation. In traveling thousands of miles between the two countries, some radioactive material will decay, rain will wash some out of the air, and its concentration will diminish as it disperses.

Many atoms are stable; they remain in their current form indefinitely. Other atoms are unstable, or radioactive. They "decay" or "disintegrate," emitting energy through various forms of radiation. Each form has its own characteristics and potential for human health effects.

Nuclear reactors use uranium or mixed oxides (uranium oxide and plutonium oxide, or MOX) for fuel. Uranium and plutonium atoms fission, or split, releasing neutrons that cause additional fissions in a chain reaction, and also releasing energy. A nuclear reactor's core consists of fuel rods made of uranium or MOX encased in zirconium, and neutron-absorbing control rods that are removed or inserted to start or stop the chain reaction. This assembly is placed underwater to carry off excess heat. The incident at the Fukushima Daiichi Nuclear Power Plant prevented water from circulating in the core of several reactors, causing water to evaporate and temperature to rise. High heat could melt the fuel rods and lead to a release of radioactive material into the air.

When uranium and plutonium fission, they split into smaller atoms that are highly radioactive and generate much heat; indeed, fuel rods that have just been removed from a reactor are much more radioactive, and hotter, than fuel rods before they have been inserted into a reactor. After fuel rods can no longer efficiently produce energy, they are considered "spent" and are placed in cooling pools of water for several years to keep them from overheating while the most radioactive materials decay. A concern about the spent fuel pool at reactor 4 is that it may have lost most or all of its water, yet it has more fuel rods than pools at the other five reactors, as it contains all the active fuel rods that were temporarily removed from the reactor core in November 2010 to permit plant maintenance in addition to spent fuel rods.

A nuclear reactor cannot explode like an atomic bomb because the concentration of the type of uranium or plutonium that fissions easily is too low to support a runaway chain reaction, and a nuclear weapon requires one of two configurations, neither of which is present in a reactor.

Some types of radiation have enough energy to knock electrons off atoms, creating "ions" that are electrically charged and highly reactive. Ionizing radiation is thus harmful to living cells. It strikes people constantly, but in doses low enough to have negligible effect. A concern about the reactor incident is that it will release radioactive materials that pose a danger to human health. For example, cesium-137 emits gamma rays powerful enough to penetrate the body and damage cells. Ingesting iodine-131 increases the risk of thyroid cancer. Potassium iodide tablets protect the thyroid, but there is no need to take them absent an expectation of ingesting iodine-131.

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Introduction

The Japanese earthquake and tsunami of March 2011 caused extensive damage to the Fukushima Daiichi Nuclear Power Plant (NPP). This damage has released some radioactive materials, and there are widespread fears about the health effects of current and possible future releases. These fears, and public concern about radiation in general, have attracted the world's attention. This report presents scientific and technical aspects of these issues in order to provide a basis for understanding the risks associated with this event.

Could Harmful Levels of Fallout Reach the United States?¹

To monitor radiation in the United States, the Environmental Protection Agency (EPA) operates RadNet, which "is a national network of monitoring stations that regularly collect air, precipitation, drinking water, and milk samples for analysis of radioactivity. The RadNet network, which has stations in each state, has been used to track environmental releases of radioactivity from nuclear weapons tests and nuclear accidents."² EPA has an online map of these stations,³ and provides updates on the results of its air monitoring as relates to the Japanese nuclear incident.⁴

Whether harmful levels of radioactive material from the incident reach the United States depends on many factors:

- Particle size: Tiny particles are more readily carried by the wind and can travel farther than large particles, which fall to Earth more rapidly.
- Wind patterns.
- Amount of material released: The more material released, the more likely some of it is to travel long distances.
- Melt vs. burn: If nuclear fuel rods (fresh or spent) melt and form a pool of very hot, highly radioactive liquid, that liquid might be contained by a containment structure. If it melts through that structure, it might contaminate groundwater. If the fuel rods burn, the fire would loft radioactive material into the air. The larger and hotter the fire, and the longer it burns, the more material would be injected into the air.
- Travel time: The longer radioactive material is in the air, the more of it will decay.
- Distance: The farther radioactive material travels, the greater the volume of air in which the material disperses, diluting it.

¹ This section was written by Jonathan Medalia, Specialist in Nuclear Weapons Policy, Foreign Affairs, Defense, and Trade Division.

² U.S. Environmental Protection Agency. "RadNet—Tracking Environmental Radiation Nationwide," <http://www.epa.gov/nare1/radnet/>.

³ U.S. Environmental Protection Agency. "RadNet Map View," <https://cdxnode64.epa.gov/radnet-public/showMap.do>.

⁴ U.S. Environmental Protection Agency. "Japanese Nuclear Emergency: EPA's Radiation Air Monitoring," <http://www.epa.gov/japan2011/>.

- Rain and snow: Precipitation washes some particles out of the air.

The first four of these factors depend on circumstances; the other three would reduce the amount of material reaching the United States under any circumstances.

According to U.S. nuclear authorities, the reactor incident does not appear to pose an immediate threat to the United States. On March 13, the Nuclear Regulatory Commission (NRC) stated, "Given the thousands of miles between the two countries [United States and Japan], Hawaii, Alaska, the U.S. Territories and the U.S. West Coast are not expected to experience any harmful levels of radioactivity."⁵ On March 18, EPA and the Department of Energy stated that a monitoring station in Sacramento "today ... detected minuscule quantities of iodine isotopes and other radioactive particles that pose no health concern at the detected levels," and that between March 16 and 17, a detector in Washington state detected "trace amounts of Xenon-133, which is a radioactive noble gas produced during nuclear fission that poses no concern at the detected level."⁶ In a briefing to the Nuclear Regulatory Commission on March 21, Bill Borchardt, NRC Executive Director for Operations, said, "natural background from things like ... rocks, sun, buildings, is 100,000 times more than any level that has been detected to date. We feel confident in our conclusion that there is no reason for concern in the United States regarding radioactive releases from Japan."⁷ A press report of March 22 stated that equipment in Charlottesville, VA, detected radiation from the reactor incident, but that "health experts said that the plume's radiation had been diluted enormously in its journey of thousands of miles and that—at least for now, with concentrations so low—its presence will have no health consequences in the United States."⁸

It is useful to put these doses in perspective. Using the figure that natural sources provide 100,000 times the dose recorded in California and Washington state, it is possible to calculate a rough approximation of the dose from the Japanese incident, using the improbable assumption that the dose persists at the detected rate for an entire year. As discussed later, a report estimates that the average American receives a dose of 310 millirem (mrem) per year from natural sources. (Units of radiation dose are discussed under "Health Effects of Ionizing Radiation.") NRC requires its licensees to "limit maximum radiation exposure to individual members of the public" to 100 mrem per year. One one hundred thousandth of 310 mrem per year is a dose of 0.00310 mrem per year. At that rate, it would take 32,258 years to accumulate a dose of 100 mrem; over a 70-year lifespan, the cumulative dose at this rate would amount to 0.22 mrem.

⁵ U.S. Nuclear Regulatory Commission. "NRC Sees No Radiation at Harmful Levels Reaching U.S. from Damaged Japanese Nuclear Power Plants," press release no. 11-046, March 13, 2011, <http://pbadupws.nrc.gov/docs/ML1107/ML110720002.pdf>.

⁶ U.S. Department of Energy and Environmental Protection Agency. "Joint EPA/DOE Statement: Radiation Monitors Confirm That No Radiation Levels of Concern Have Reached the United States," press release, March 18, 2011, <http://www.energy.gov/news/10190.htm>.

⁷ U.S. Nuclear Regulatory Commission. "Briefing on NRC Response to Recent Nuclear Events in Japan," public meeting, March 21, 2011, p. 13, <http://www.nrc.gov/reading-rm/doc-collections/commission/tr/2011/20110321.pdf>.

⁸ William Broad, "Radiation over U.S. Is Harmless, Officials Say," *New York Times*, March 22, 2011, p. 6.

What Is Radiation?⁹

Many atoms are stable: they will remain in their current form indefinitely. Some atoms are unstable, or radioactive. They “decay” or “disintegrate,” often transforming into atoms of a different element, such as through emission of radiation, which permits the atom to reach a more stable state.¹⁰ The most common types of radiation emitted in decay, and their characteristics, are:

- Alpha particles are two protons plus two neutrons. They are electrically charged and massive by subatomic standards, and travel relatively slowly, so they lose energy quickly in matter. They travel only an inch in air, and are stopped by a sheet of paper or the dead outer layers of skin.
- Beta particles (an electron or positron¹¹) are electrically charged, so are readily absorbed by matter, but are much less massive than alpha particles or neutrons. Depending on their energy, some are stopped by outer layers of skin, while others can penetrate several millimeters. They can travel up to several feet in air.
- Neutrons are typically emitted by heavy atoms like uranium and plutonium. They have no electrical charge and may be highly penetrating, depending on their speed. They can travel tens of meters in air; energetic neutrons can penetrate the body. They can be slowed down by hydrogen-containing material like water.
- Gamma rays are photons released during radioactive decay. Photons may be thought of as packets of electromagnetic energy; radio waves, light, and x-rays are less-energetic photons. Gamma ray energies vary widely. Those of medium to high energies are highly penetrating and can travel hundreds of meters in air. Stopping them requires a thick layer of a dense material like lead.

Several measurements are useful in discussing radioactivity. Radioactivity is measured in units of curies (Ci), where $1 \text{ Ci} = 3.7 \times 10^{10}$ disintegrations per second, or becquerels (Bq), where $1 \text{ Bq} = 1$ disintegration per second. (The curie is widely used in the United States; the Becquerel is more widely used internationally.) Specific activity—curies per gram—measures how radioactive a material is. Half-life is the time for half the atoms in a mass of particular type of radioactive material to decay. Specific activity is inversely related to half-life. For example, radioactive iodine-131 is intensely radioactive. It has a specific activity of 124,000 curies per gram and a half-life of 8 days; in 10 half-lives (80 days), 99.9 percent of the iodine-131 created at a given time will have decayed. In contrast, uranium-235 has a specific activity of 0.000002 curies per gram and a half-life of 700 million years; it would take 7 billion years (10 half-lives) for 99.9 percent of it to decay.¹² According to Richard Firestone, staff scientist, Lawrence Berkeley

⁹ This section was written by Jonathan Medalia, Specialist in Nuclear Weapons Policy, Foreign Affairs, Defense, and Trade Division.

¹⁰ For descriptions of radiation, see Roger Eckhardt, “Ionizing Radiation—It’s Everywhere,” *Los Alamos Science*, no. 23, 1995, <http://www.fas.org/sgp/othergov/doe/lanl/00326627.pdf>, and U.S. Environmental Protection Agency, “Radiation: Ionizing and Non-Ionizing,” <http://www.epa.gov/radiation/understand/index.html>.

¹¹ A positron is a positively-charged electron.

¹² For data on half-lives and other characteristics of radionuclides, see Lawrence Berkeley National Laboratory, “Exploring the Table of Isotopes,” <http://ie.lbl.gov/education/isotopes.htm>, and U.S. Department of Energy, Office of Environmental Management, “Table B.1. Characteristics of important radionuclides,” http://www.orau.org/ptp/PTP%20Library/library/DOE/Misc/Table%20B_1_%20Characteristics%20of%20Important%20Radionuclides.htm.

National Laboratory, uranium-235 emits so little radiation that “holding a piece in the hand would cause negligible radiation exposure.”¹³

Energy released per decay is measured differently. A standard measure is the electron volt or, more commonly, thousands of electron volts (keV).¹⁴ The penetrating power of gamma rays, and thus their threat to human health, increases as their energy increases.

Each radioactive atom, or “radionuclide,” decays in a specific way. For example, when uranium-235 decays,¹⁵ it emits gamma rays, most of which are of 186 keV (a low energy) or less, and alpha particles; cesium-137 emits gamma rays, virtually all of which are of 662 keV, a medium energy, and beta particles. Each radionuclide that emits gamma rays does so in a unique pattern, or “spectrum,” of energies that is the primary characteristic used to identify many radionuclides.

Radioactivity and Nuclear Reactors^{16,17}

Some heavy atoms, such as uranium-235 and plutonium-239, “fission” when struck by a neutron. In fission, an atom typically (1) splits into two lighter atoms, called “fission products”; (2) releases two or three neutrons; and (3) emits vast quantities of radiation. Fission products are often highly radioactive, such as cesium-137, iodine-131, and strontium-90.

Uranium-235 and plutonium-239 can support a nuclear chain reaction: to oversimplify, one neutron fissions one atom, which releases two neutrons that fission two atoms, releasing four neutrons that fission four atoms, and so on. Neutrons thus drive chain reactions; this is a key concept for understanding nuclear reactors. A supercritical mass supports an increasing rate of fission; fission diminishes in a subcritical mass; and fission proceeds at a constant rate in a critical mass. In an atomic bomb, a supercritical mass of uranium or plutonium supports a chain reaction that proceeds in a tiny fraction of a second, releasing vast quantities of energy. A nuclear reactor is designed to maintain a constant rate of fission. If fission proceeds too quickly, it gets out of control, in which case the fuel rods generate so much heat that they melt. When control rods are inserted into the reactor core, individual atoms continue to fission but the chain reaction stops. Control rods typically contain boron or cadmium because they are efficient neutron absorbers. (Because boron absorbs neutrons, it was added to cooling water in the Fukushima Daiichi NPP incident to prevent inadvertent criticality.) Fission that proceeds at the desired rate releases energy over several years from one load of fuel. The energy heats water to generate steam that spins turbines to generate electricity.

¹³ Personal communication, March 30, 2011.

¹⁴ “An electron volt is a measure of energy. An electron volt is the kinetic energy gained by an electron passing through a potential difference of one volt.” Fermi National Accelerator Laboratory, “How Big Is an Electron Volt?,” <http://www-bd.fnal.gov/public/electronvolt.html>.

¹⁵ The number following the name of an element is the number of protons plus neutrons in the nucleus.

¹⁶ This section was written by Jonathan Medalia, Specialist in Nuclear Weapons Policy, Foreign Affairs, Defense, and Trade Division, and Mark Holt, Specialist in Energy Policy, Resources, Science, and Industry Division. See also CRS Report R41694, *Fukushima Nuclear Crisis*, by Richard J. Campbell and Mark Holt.

¹⁷ For the status of each reactor, see “Status of the Nuclear Reactors at the Fukushima Daiichi Power Plant,” *New York Times*, <http://www.nytimes.com/interactive/2011/03/16/world/asia/reactors-status.html>, and Japan, Nuclear and Industrial Safety Agency, <http://www.nisa.meti.go.jp/english/>.

A nuclear reactor cannot explode like an atomic bomb because the fuels and configurations differ. In nature, uranium is 99.3 percent uranium-238 and 0.7 percent uranium-235. Only the latter is “fissile,” that is, it will fission when struck by neutrons moving at relatively slow speeds. To make fuel for a bomb or a reactor, the fraction of uranium-235 must be increased through “enrichment.”¹⁸ An atomic bomb uses uranium enriched to about 90 percent uranium-235 (“highly enriched uranium,” HEU), while nuclear reactor fuel is typically enriched to less than 5 percent (“low enriched uranium,” LEU). LEU does not have enough uranium-235 to support a chain reaction of the sort found in an atomic bomb. In addition, a bomb must be configured in one of two ways to create a large enough mass to support a runaway chain reaction; reactors are arranged in an entirely different configuration.

A nuclear reactor uses pellets of LEU or mixed oxides (MOX, i.e., uranium oxide and plutonium oxide) for fuel. Fuel rods—thin zirconium tubes typically between 12 and 15 feet long—hold the fuel. According to one report,

Zirconium is the metal of choice in this application because it absorbs relatively few of the neutrons produced in a fission reaction and because the metal is highly resistant to both heat and chemical corrosion.

Low neutron absorption is vital to any structural material used in a nuclear reactor because large numbers of neutrons produced by the reaction must be free to interact simultaneously with all the nuclear fuel confined inside hundreds of fuel rods. This interaction sustains the necessary chain reaction throughout the reactor’s core.¹⁹

Even with control rods fully inserted to halt the nuclear chain reaction, the radioactive decay of the fuel rods (primarily from fission products) generates heat, which must be dissipated. At the Fukushima Daiichi NPP, cooling was done by pumping cool water into the reactor. If the heat is not dissipated, the rods become so hot that they melt or burn. A fire would loft particles of radioactive material into the air. If fuel rods become too hot, their zirconium cladding may also react with water and produce hydrogen. The Fukushima Daiichi NPP primary containments used inert nitrogen gas to preclude hydrogen ignition. However, the operators had to vent the primary containment to relieve pressure, introducing hydrogen into the secondary containment, which is believed to have caused the explosions at reactor units 1-3.²⁰ This explains the urgency of the efforts to keep the fuel rods cool, and why the reactors suffered major damage when backup cooling systems failed.

In order to cool the fuel rods, personnel have been spraying huge amounts of seawater into the reactors and spent fuel pools. However, when seawater boils away from the heat of the fuel rods, it leaves behind large quantities of salt:

The big question is how much of that salt is still mixed with water, and how much now forms a crust on the reactors’ uranium fuel rods. Chemical crusts on uranium fuel rods have been a problem for years at nuclear plants.

¹⁸ For information on the enrichment process, see U.S. Nuclear Regulatory Commission. “Fact Sheet on Uranium Enrichment,” May 15, 2009, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/enrichment.html>.

¹⁹ “Zirconium: Covering for Fuel Rods,” *New York Times*, June 9, 1995, <http://www.nytimes.com/1995/06/09/nyregion/zirconium-covering-for-fuel-rods.html>.

²⁰ Information provided by Nuclear Regulatory Commission, personal communication, March 25, 2011.

Crusts insulate the rods from the water and allow them to heat up. If the crusts are thick enough, they can block water from circulating between the fuel rods. As the rods heat up, their zirconium cladding can ignite, which may cause the uranium inside to melt and release radioactive material.²¹

To alleviate this problem, workers have begun using fresh water instead of seawater.²²

As the fuel fissions in a reactor, the fraction of fission products in fuel rods increases. When the ratio of fission products to fissile material rises to the point at which a fuel rod can no longer efficiently maintain a chain reaction, it is referred to as spent fuel. “Spent” seems to imply that the fuel has been used up, and is therefore less dangerous, than fresh uranium fuel, but this is not necessarily the case. When fuel rods are first removed from a nuclear reactor, they have a high level of short-lived radionuclides, unlike new fuel rods, so they are intensely radioactive. This radioactivity generates intense heat, so spent fuel rods are placed in pools of water to cool them, typically for several years, until most of the short-lived radionuclides decay. The water also provides shielding against any radioactive release into the air, and the spent fuel pools have no hardened containment structure that would protect against radiation release. If a pool is drained, the fuel rods would heat up, melt, and perhaps burn. This possibility led to concern about the spent fuel rods at Fukushima Daiichi NPP reactor 4:

The spent fuel pools can be even more dangerous than the active fuel rods, as they are not contained in thick steel containers like the reactor core. As they are exposed to air, the zirconium metal cladding on the rods can catch fire, and a deadly mix of radioactive elements can spew into the atmosphere. ...

According to Tokyo Electric [Power Company]’s data, the spent fuel pool at the No. 4 reactor contains 548 fuel assemblies that were in use at the reactor until last November, when they were moved to the storage pool on the site. That means that the fuel rods were only recently taken out of active use and that their potential to burn and release radioactivity is higher than spent fuel in storage for a longer period.²³

Another danger comes from the potential release of plutonium from the MOX fuel used at reactor 3. Even very small amounts of plutonium, if inhaled, can potentially cause lung cancer. This explains the concern about that reactor, as it is the only one that uses MOX fuel, although irradiation of uranium fuel also creates plutonium. Water is being pumped into the spent fuel pools at the Fukushima Daiichi NPP reactors as well to cool the fuel rods and prevent additional radiation release.

²¹ Keith Bradsher, “New Problems at Japanese Plant Subdue Optimism and Present a Risky Agenda,” *New York Times*, March 24, 2011, p. 11.

²² David Nakamura and Steven Mufson, “Japan Urges More to Evacuate,” *Washington Post*, March 26, 2011, p. 1, and “Nuclear Energy—Crisis in Japan,” *New York Times*, update of March 30, 2011.

²³ David Sanger, Matthew Wald, and Hiroko Tabuchi, “U.S. Sees ‘Extremely High’ Radiation Level at Plant, Focusing on Spent Fuel’s Impact,” *New York Times*, March 17, 2011, p. 13.

Health Effects of Ionizing Radiation²⁴

Humans are continuously exposed to significant amounts of ionizing radiation from various naturally occurring and manmade sources. Because of its relatively high energy level, ionizing radiation is capable of producing significant biological change. Ionizing radiation gets its name from the fact that it causes ionization—ejection of electrons—when it interacts with atoms in the molecules that constitute cells and tissue. This process creates charged, often unstable, and highly reactive entities. The ensuing reactions may result in permanent molecular damage. Radiation disrupts cell division, which is why the most sensitive tissues are those in which cells frequently divide, such as skin, hair, bone marrow (where precursor cells give rise to new blood cells), and the cells that line the stomach and small intestine. Ionizing radiation may also damage DNA in chromosomes, resulting in mutations that are responsible for long-term effects such as the development of cancer.

Sources of Radiation Exposure

Naturally occurring sources of ionizing radiation to which all humans are exposed include cosmic radiation from outer space and terrestrial radiation from radioactive materials in rock deposits and soil. The Earth's atmosphere acts as a shield against cosmic radiation, so exposure levels increase with altitude (especially when flying). The most important source of terrestrial exposure is the inhalation of radon, which is produced by the radioactive decay of naturally occurring uranium.

In the United States, radiation exposure as a result of medical practice has increased significantly over the past 25 years as a result of the growing use of CT scans and nuclear medicine procedures to diagnose and treat disease. Other manmade sources of radiation account for a relatively small fraction of the U.S. population's total exposure. Those sources include consumer products (e.g., cigarettes, building materials, appliances); industrial, security, educational, and research activities, including nuclear power generation; and various types of occupational exposure.

Measuring Exposure: Absorbed Dose v. Equivalent Dose

Human exposure is measured by the amount of energy that ionizing radiation deposits in a unit mass of tissue. This is called the *absorbed dose*. The international unit for the absorbed dose is the gray (Gy), which replaced an earlier unit of dose, the rad (short for “radiation absorbed dose”). One gray equals 100 rad. The biological impact of ionizing radiation, however, depends not just on the absorbed dose (i.e., the amount of energy absorbed) but on the type of radiation. For example, an alpha particle is more damaging to biological tissue than a beta particle or gamma radiation because of its mass, electrical charge, and slow speed. Alpha particles lose their energy much more densely along the relatively short path they travel through biological tissue. Thus, 1 Gy of alpha radiation is more harmful than 1 Gy of beta or gamma radiation.

Radiation scientists use another quantity, called *equivalent dose*, which allows them to measure all types of exposure on an equal basis. Equivalent dose is equal to the absorbed dose multiplied by a factor that takes into account the relative effectiveness of each type of radiation to cause harm. For beta particles and gamma radiation, the factor is set at 1; that is, the absorbed dose

²⁴ This section was written by Jonathan Medalia, Specialist in Nuclear Weapons Policy, Foreign Affairs, Defense, and Trade Division, and C. Stephen Redhead, Specialist in Health Policy, Domestic Social Policy Division.

equals the equivalent dose. For alpha particles the factor is set at 20, which means that the equivalent dose is 20 times the absorbed dose. This reflects the fact that alpha radiation is more harmful than beta and gamma radiation. The international unit for the equivalent dose is the sievert (Sv). So, 1 Sv of alpha radiation to the lung would create the same risk of lung cancer as 1 Sv of beta radiation. The sievert is a large unit relative to common exposures, so the more common unit is the millisievert (mSv), which is one-thousandth of a sievert. The sievert replaced an earlier unit of equivalent dose, the rem, which is still widely used in the United States. One sievert = 100 rem; 1 mSv = 100 millirem (mrem).

The National Council on Radiation Protection and Measurement (NCRP) estimates that the *average annual equivalent dose* to an individual in the United States is 6.2 mSv (620 mrem).²⁵ Of that amount, 3.1 mSv (310 mrem) is from natural background sources, primarily inhalation of radon and its decay products, and 3.0 mSv (300 mrem) is from diagnostic and therapeutic medical procedures. The remaining 0.1 mSv (10 mrem) is from consumer products, industrial activities, and occupational exposure, among other sources. For comparison, the radiation dose from a jet airplane flight is 0.5 millirems (mrem) per hour in the air; from a chest x-ray, 6 mrem; and from living at an altitude of one mile, about 50 mrem/year.²⁶ **Table 1** shows various doses and their health consequences or regulatory limits.

²⁵ National Council on Radiation Protection and Measurement, "Ionizing Radiation Exposure of the Population of the United States," report no. 160, 2009.

²⁶ American Nuclear Society, "Radiation Dose Chart," <http://www.ans.org/pi/resources/dosechart/>. This interactive chart permits the user to adjust values to find an approximation of his or her total annual dose.

Table I. Radiation Dose Levels

Dose, mSv	Dose, rem	Source	Comments
1/yr	0.1/yr	(2)	NRC requires its licensees to "limit maximum radiation exposure to individual members of the public" to this level.
6.2/yr	0.62/yr	(1)	Average U.S. individual's total effective radiation dose in 2006; half is from natural background and half is from medical uses and other human activities.
20	2	(7)	Federal Emergency Management Agency and Environmental Protection Agency recommend relocating the public from an area if the expected dose in the first year after a radiological incident is above this level.
50/yr	5/yr	(2)	NRC requires its licensees to "limit occupational radiation exposure to adults working with radioactive materials" to this level.
100	10	(6)	A National Research Council committee defines "low dose" of certain types of ionizing radiation, such as gamma rays, as this level or below.
0-250	0-25	(3)	For an "acute" (i.e., received over a short time) whole-body external dose of ionizing radiation, "No detectable clinical effects; small increase in risk of delayed cancer and genetic effects."
250	25	(4)	Japan raised the permitted dose for emergency workers at the Fukushima Daiichi NPP from 100 mSv/10 rem to this level.
500	50	(5)	For an acute whole-body external dose of ionizing radiation, "blood count changes."
1,000-2,000	100-200	(3)	For an acute whole-body external dose of ionizing radiation, "Minimal symptoms; nausea and fatigue with possible vomiting; reduction in [certain white blood cells], with delayed recovery."
2,000-3,000	200-300	(3)	For an acute whole-body external dose of ionizing radiation, "Nausea and vomiting on first day; following latent period of up to 2 weeks, symptoms (loss of appetite and general malaise) appear but are not severe; recovery likely in about 3 months unless complicated by previous poor health."
3,200-3,600	320-360	(5)	Half the population exposed to an acute whole-body external dose of ionizing radiation will die within 60 days despite receiving minimal supportive care.
3,500-5,000	350-500	(2)	NRC believes that half the population receiving this dose in a few hours or less would die within 30 days.
8,000	800	(5)	100% mortality, despite best available treatment, for people receiving this external dose of whole-body ionizing radiation.

Sources: (1) National Council on Radiation Protection and Measurement, "Ionizing Radiation Exposure of the Population of the United States," report no. 160, 2009, p. 11. (2) U.S. Nuclear Regulatory Commission. "Fact Sheet on Biological Effects of Radiation," January 2011, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html>, and 10 CFR 20. (3) Dade Moeller, *Environmental Health*, revised edition, Cambridge, Harvard University Press, 1997, p. 250. (4) Keith Bradsher and Hiroko Tabuchi, "50 Workers Bravely Stay at Troubled Japan Reactors," *New York Times*, March 16, 2011. (5) Princeton University, Environmental Health and Safety. "Open Source Radiation Safety Training, Module 3: Biological Effects," <http://web.princeton.edu/sites/ehs/osradtraining/biological-effects/page.htm>, adapted from National Council on Radiation Protection and Measurements, Report No. 98, "Guidance on Radiation Received in Space Activities," Bethesda, MD, 1989. (6) National Research Council, Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, "Health Risks from Exposure to Low Levels of Ionizing Radiation," BEIR [Biological Effects of Ionizing Radiation] VII Phase 2, p. 2, http://www.nap.edu/openbook.php?record_id=11340&page=1 and click on PDF Summary. (7) U.S. Environmental Protection Agency. Office of Radiation Programs. *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, revised 1991 (second printing, May 1992), p. 4-4, <http://www.epa.gov/radiation/docs/er/400-r-92-001.pdf>, and Federal Emergency Management Agency, "Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents," 73 *Federal Register* 45034, August 1, 2008.

External v. Internal Exposure: Effective Dose

The health risks of ionizing radiation can occur as a result of both external and internal exposure. External exposure is almost exclusively from radioactive material that emits gamma radiation, which is very penetrating and, at higher energies, can only be stopped by a thick layer of lead or concrete. External sources of gamma radiation produce a whole-body exposure. Importantly, the level of exposure to gamma radiation falls off sharply with distance from the source. Cesium-137 (^{137}Cs), which has a half-life of 30 years, is the most common source of gamma radiation from nuclear weapons tests and reactor accidents.

Alpha and beta particles outside the body are typically not a source of external exposure. Alpha particles travel only a few centimeters through the air and cannot penetrate clothing or the outermost dead layer of skin. Beta particles, composed of electrons or positrons, can travel at most several feet through the air and penetrate to the live layer of skin causing burns (as happened to workers at Chernobyl). But they too are blocked by radiation suits.

Internal radiation exposure occurs through the inhalation of airborne radioactive material or the ingestion of contaminated food and drink. The potential for harm depends on the type and quantities of radioactive material taken in and the length of time they remain in the body. As already noted, isotopes that emit alpha particles present a greater hazard than those that emit beta particles and gamma radiation. In addition, the fate of the radioactive material depends on its chemical identity. For example, Strontium-90 (^{90}Sr), which is chemically similar to calcium and emits beta particles, accumulates in bone and can cause leukemia and bone cancer.

Iodine-131 (^{131}I), another beta emitter, tends to accumulate in the thyroid gland, where it is used in the synthesis of thyroid hormones. Beta radiation from iodine-131 damages the surrounding cells and increase the risk of non-malignant thyroid disease and thyroid cancer. Iodine-131 from radioactive fallout accumulates on grass and leafy crops and becomes concentrated in the milk of cows and goats that feed on the contaminated vegetation. Children who drink the contaminated milk are especially at risk because they are still growing and their thyroid glands are very active. However, iodine-131 has a half-life of only 8 days, so it decays relatively quickly on the ground, in the food chain, and in the body.

Iodine-131 posed the most important health risk following the incident at the Chernobyl nuclear power plant in 1986. According to the International Atomic Energy Agency:

The main consequence of the Chernobyl accident is thyroid cancer in children, some of whom were not yet born at the time of the accident. Following the vapour [sic] explosion and fire at the Chernobyl reactor, radioactive iodine was released and spread in the surrounding area. Despite measures taken, children in southern Belarus and northern Ukraine, were exposed to radiation in the weeks following the accident, particularly by consuming milk from pastured cows and leafy vegetables that had been contaminated with radioactive iodine.²⁷

Unlike whole-body external exposures, the exposure from ingested or inhaled radioactive material is often limited to certain parts of the body or even specific organs. Radiation scientists

²⁷ International Atomic Energy Agency, "Thyroid Cancer Effects in Children," staff report, August 2005, <http://www.iaea.org/newscenter/features/chernobyl-15/thyroid.shtml>.

are able to calculate a whole-body equivalent dose, or *effective dose*, for partial-body exposures. These amounts can be summed with external exposure to calculate a total dose.

Acute Health Effects v. Long-Term Cancer Risk

The health effects of ionizing radiation exposure depend on the total dose and dose rate. Radiation health experts distinguish between (1) acute, or short-term, effects such as radiation sickness that are associated with relatively high doses over a short period; and (2) long-term effects such as increased lifetime cancer risk that result from chronic exposure to low-levels of radiation. Short-term health effects are typically seen in workers and others in close proximity to nuclear weapons tests and accidents, while the long-term cancer risks apply to the general population. Scientists calculate the cancer risk from radiation exposure using data from epidemiological and other studies, such as those following the health outcomes of the Japanese atomic bomb survivors. According to the International Commission on Radiological Protection (ICRP), the lifetime risk of contracting a fatal cancer from chronic exposure to low-level radiation exposure is 0.05 per sievert, or 1 in 20 per sievert (i.e., 1 in 2,000 per rem). The ICRP and NCRP both recommend an annual exposure limit of 1 mSv (100 mrem) for members of the general population. An individual that received that much annual exposure over a 70-year lifetime (a total of 70 mSv, or 7 rem) would, as a result, have an increased risk of cancer death of approximately 1 in 300.

Table 1 summarizes the health effects of exposure to various acute doses of ionizing radiation. For comparison, the table also includes the current exposure standards for the general public and workers, and the average background radiation exposure in the United States.

Potassium Iodide

There is considerable interest in potassium iodide (also referred to by its chemical formula, KI) tablets to protect against thyroid cancer. These tablets contain non-radioactive iodine-127, the same type used in iodized table salt, to saturate the thyroid with iodine. Once the thyroid is saturated, it cannot absorb more of any isotope of iodine, including iodine-131. As a result, potassium iodide tablets, taken shortly *before* exposure to iodine-131, offer protection from thyroid cancer. The protection is of limited duration, however, and potassium iodide protects only the thyroid only against radioactive iodine. It does not protect against any other radioactive material or against radiation in general. Nor is there value in taking potassium iodide as a precautionary measure unless iodine-131 is expected to be present. As the next section of this report discusses, the amount of radioactive material that has reached the United States from the Japanese nuclear reactor incident is minuscule. Accordingly, the website of the Centers for Disease Control and Prevention, accessed on March 22, said, "At this time, CDC does not recommend that people in the United States take KI or iodine supplements in response to the nuclear power plant explosions in Japan. You should only take KI on the advice of emergency management officials, public health officials, or your doctor. There are health risks associated with taking KI."²⁸ Further, "Some general side effects caused by KI may include intestinal upset, allergic reactions (possibly severe), rashes, and inflammation of the salivary glands."²⁹

²⁸ U.S. Department of Health and Human Services. Centers for Disease Control and Prevention. "Emergency Preparedness and Response: Radiation and Potassium Iodide (KI)," <http://www.bt.cdc.gov/radiation/japan/ki.asp>.

²⁹ U.S. Department of Health and Human Services. Centers for Disease Control and Prevention. "Emergency (continued...)"

The Japanese Situation

Understanding dose and its health effects casts light on the Japanese situation. The (U.S.) Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation of the National Research Council reported on the health risks from a certain type of radiation that includes gamma rays and x-rays. It considered doses below about 100 mSv (10 rem) to be low doses. The committee found that many factors “make it difficult to characterize the effects of ionizing radiation at low levels,” and that “at doses less than 40 times the average yearly background exposure (100 mSv), statistical limitations make it difficult to evaluate cancer risk in humans.” To develop an estimate of risk, the committee constructed a “lifetime risk model [that] predicts that approximately 1 person in 100 would be expected to develop cancer (solid cancer or leukemia) from a dose of 0.1 Sv [10 rem] above background.” For comparison, about 42 percent of the population will be diagnosed with cancer in their lifetimes.³⁰ At Fukushima Daiichi NPP,

The workers are being asked to make escalating—and perhaps existential—sacrifices that so far are being only implicitly acknowledged: Japan’s Health Ministry said Tuesday that it was raising the legal limit on the amount of radiation exposure to which each worker could be exposed, to 250 millisieverts from 100 millisieverts, five times the maximum exposure permitted for nuclear plant workers in the United States.

The change means that workers can now remain on site longer, the ministry said. “It would be unthinkable to raise it further than that, considering the health of the workers,” the health minister, Yoko Komiyama, said at a news conference.³¹

An acute dose of 250 mSv (25 rem) is the upper threshold at which dose is unlikely to cause noticeable health effects, but it increases the risk of cancer. Based on the National Research Council report, 25 of 1,000 people would be expected to develop solid cancers or leukemia as a result of receiving this dose. Workers exposed to this dose will probably not be allowed to be exposed to additional radiation above background for at least a year to give their bodies time to repair cell damage.

Beyond the Fukushima Daiichi NPP, the external doses reported fall far below the low-dose threshold of the U.S. Nuclear Regulatory Commission (NRC). Japan’s Ministry of Education, Culture, Sports, Science and Technology reported dose readings from 80 monitoring stations between 25 and 60 km from the Fukushima Daiichi NPP.³² On March 20, almost all the readings were less than 15 microsieverts per hour. (One millisievert = 1,000 microsieverts; 1 microsievert = 0.1 millirem.) At a rate of 15 microsieverts per hour, it would take 278 days to accumulate a dose of 10 rem. At the highest rate reported, 110 microsieverts per hour, it would take 38 days to accumulate that dose. Staying inside an uncontaminated building would reduce exposure

(...continued)

Preparedness and Response: Potassium Iodide (KI),” <http://emergency.cdc.gov/radiation/ki.asp#med>.

³⁰ National Research Council. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation. *Health Risks from Exposure to Low Levels of Ionizing Radiation*, Washington, National Academies Press, 2006, pp. 1, 2, 7, 8, http://www.nap.edu/openbook.php?record_id=11340&page=1, and click on “pdf summary.”

³¹ Keith Bradsher and Hiroko Tabuchi, “50 Workers Bravely Stay at Troubled Japan Reactors,” *New York Times*, March 16, 2011.

³² Japan. Ministry of Education, Sports, Culture, Science and Technology (MEXT), “Readings at Monitoring Post out of 20 Km Zone of Fukushima Dai-ichi NPP [Nuclear Power Plant],” news release, as of 19:00 March 20, 2011, http://www.mext.go.jp/component/english/_icsFiles/afieldfile/2011/03/20/1303972_2019.pdf.

considerably, and short-lived radionuclides like iodine-131 (half-life, 8 days) would decay significantly during a month or more, sharply reducing the dose they produce. On the other hand, a larger release of radionuclides would be expected to increase dose, and cesium-137 (half-life, 30 years) decays much more slowly than iodine-131, so it would contribute to dose for many decades.

Given the increase in thyroid cancer as a result of the Chernobyl disaster, a major concern in Japan is minimizing the risk of thyroid cancer. This is especially important for children. At Chernobyl, as noted earlier, ingestion of radioactive iodine-131 resulted mainly from drinking milk from cows that ate contaminated feed, and from eating leafy greens. Accordingly, Japanese authorities have tested spinach, other vegetables, and milk for iodine-131, and found elevated levels. In response, on March 23 Prime Minister Naoto Kan restricted the distribution and consumption of spinach, cabbage, broccoli, and other vegetables in Fukushima Prefecture, and restricted the distribution of fresh raw milk and parsley produced in Ibaraki Prefecture.³³ In addition, authorities have reportedly found traces of radioactive iodine in drinking water in Tokyo. On March 23,

Ei Yoshida, head of water purification for the Tokyo water department, said ... that infants in Tokyo and surrounding areas should not drink tap water. He said iodine-131 had been detected in water samples at a level of 210 becquerels per liter, about a quart. The recommended limit for infants is 100 becquerels per liter. For adults, the recommended limit is 300 becquerels. ... The Health Ministry said in a statement that it was unlikely that there would be negative consequences to infants who did drink the water, but that it should be avoided if possible and not be used to make infant formula.³⁴

However, by March 24 the level was reported to be 79 becquerels per liter, and by March 27 had diminished to the point where two readings showed no radiation and one showed 27 becquerels per liter.³⁵

Author Contact Information

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jmedalia@crs.loc.gov, 7-7632

³³ Japan. Policy Planning and Communication Division. Inspection and Safety Division. Department of Food Safety. "Restriction of Distribution and/or Consumption of Foods Concerned in Fukushima and Ibaraki Prefectures (in Relation to the Accident at Fukushima Nuclear Power Plant)," March 23, 2011, <http://www.mhlw.go.jp/stf/houdou/2r98520000015wun-att/2r98520000015xym.pdf>.

³⁴ David Jolly and Denise Grady, "Tokyo Says Radiation in Water Puts Infants at Risk," *New York Times*, March 23, 2010.

³⁵ David Jolly, "Radiation in Tokyo's Water Has Dropped, Japan Says," *New York Times*, March 24, 2011, and David Jolly, Hiroko Tabuchi, and Keith Bradsher, "High Radiation Found in Water at Japan Plant," *New York Times*, March 28, 2011, p. 11.

Acknowledgments

The Nuclear Regulatory Commission provided technical comments on this report.

Rihm, Roger

From: Rihm, Roger
Sent: Monday, April 04, 2011 3:07 PM
To: Milligan, Patricia
Subject: RE: KI Question

Well, what could I reasonably get from you this afternoon? A few Qs and As? A one pager? The expansion to 20 is a key point to address. Thank you!

From: Milligan, Patricia
Sent: Monday, April 04, 2011 3:02 PM
To: Rihm, Roger
Subject: RE: KI Question

Too bad for Marty.. Congressman Markey is likely to hammer that point home about KI and expanding to 20 along with a lot of questions about the NRC KI program or lack thereof in his opinion. How much background do you want?

From: Rihm, Roger
Sent: Monday, April 04, 2011 2:59 PM
To: Marshall, Jane; Milligan, Patricia
Subject: KI Question
Importance: High

I am putting together background materials for Marty's appearance before a House subcommittee on Weds. Markey is on the Subcommittee. Do we (you) have (or can I get) some sort of Q&A that would address Markey's current interest in expanding KI out to 20 miles (as I understand it)?

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 8:34 AM
To: Esmaili, Hossein; 'Randy Gauntt (SNL)'; Salay, Michael
Subject: FW: ACTION: PMT request for MELCOR source term (Fukushima)
Attachments: RES request for MELCOR run 4-4-2011.doc

FYI

From: PMT11 Hoc
Sent: Monday, April 04, 2011 3:14 PM
To: Lee, Richard
Cc: Hoc, PMT12; PMT02 Hoc; PMT11 Hoc; Tinkler, Charles; Schaperow, Jason; Gibson, Kathy; Gibson, Kathy; Gavrilas, Mirela
Subject: ACTION: PMT request for MELCOR source term (Fukushima)

Richard,

This email follows up on our conversation earlier today, and previous emails from the Protective Measures Team, for RES to review a specific RASCAL case (plausible release case no. PRC-V3) using MELCOR. Attached is a Word document that that provides details on this request.

This request was approved by the Executive Team this afternoon.

If possible, the PMT would like to meet with RES staff and representatives of the Reactor Safety Team tomorrow (before 2:00 PM) to discuss this request.

Tony
PMT Dose Assessment

2/302

Lee, Richard

From: Salay, Michael
Sent: Tuesday, April 05, 2011 8:44 AM
To: Lee, Richard
Cc: Esmaili, Hossein
Subject: Re: ACTION: PMT request for MELCOR source term (Fukushima)

I forgot to mention on call. I've put today's summary on g:/dsa/fstb/fukushima. I'll keep putting stuff there.

From: Lee, Richard
To: Esmaili, Hossein; Randy Gauntt (SNL) <rogaunt@sandia.gov>; Salay, Michael
Sent: Tue Apr 05 08:34:29 2011
Subject: FW: ACTION: PMT request for MELCOR source term (Fukushima)

FYI

From: PMT11 Hoc
Sent: Monday, April 04, 2011 3:14 PM
To: Lee, Richard
Cc: Hoc, PMT12; PMT02 Hoc; PMT11 Hoc; Tinkler, Charles; Schaperow, Jason; Gibson, Kathy; Gibson, Kathy; Gavrilas, Mirela
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Tony
PMT Dose Assessment

2/303

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 8:59 AM
To: 'Binder, Jeffrey L.'
Subject: request

Hi, Jeff:

Please send me the VGs from yesterday DOE Science Council meeting. There is a size limit of 10MB on attachment to e-mail for NRC. If it is too big, please break it up into smaller file(s) as needed.

Thanks, Richard

2/304

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 9:07 AM
To: Huffert, Anthony
Cc: PMT09 Hoc; PMT02 Hoc; PMT11 Hoc; Tinkler, Charles; Schaperow, Jason
Subject: Charlie and Jason

Tony:

Charlie and Jason are in. Please call Charlie to arrange to talk about your request yesterday.

Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 1:01 PM
To: Gauld, Ian C.
Subject: RE: Peach Bottom pool analysis slides

Dear Ian:

Just need to check with you that when the 600 assemblies left in the pool, an increase in water volume due to removal of the unloaded assemblies is used in the boil down analysis.

Richard

From: Gauld, Ian C. [<mailto:gauldi@ornl.gov>]
Sent: Wednesday, March 23, 2011 9:04 AM
To: Lee, Richard; Aissa, Mourad
Cc: Parks, Cecil V.
Subject: Peach Bottom pool analysis slides

As requested, with OUD marking.

Thanks

Ian

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 3:40 PM
To: 'Adams, Ian'
Subject: RE: today DOE Science Council and call to Japan

Thx, Ian:

Don't worry. I will ask John Kelly. Have a nice trip.

Richard

From: Adams, Ian [<mailto:Ian.Adams@Hq.Doe.Gov>]
Sent: Tuesday, April 05, 2011 2:23 PM
To: Lee, Richard
Subject: RE: today DOE Science Council and call to Japan

Hi Richard,

I'm in UAE this week so not currently tracking when the call with Kondo is but I will try to track that down.

Ian

From: Lee, Richard (NRC)
Sent: Tuesday, April 05, 2011 9:02 AM
To: Adams, Ian; Larzelere, Alex
Cc: Kelly, John E (NE)
Subject: today DOE Science Council and call to Japan

Dear Ian and Alex:

I believe the Science Council call is at 5:00pm for today and tomorrow. I do not when the call to Japan will take place for today and tomorrow. Please let me know.

Thx, Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 4:55 PM
To: 'Kelly, John E (NE)'
Subject: RE: Call to Japan

Thx, John:
Please let me know future ones?

From: Kelly, John E (NE) [<mailto:JohnE.Kelly@Nuclear.Energy.Gov>]
Sent: Tuesday, April 05, 2011 4:13 PM
To: Lee, Richard
Subject: Re: Call to Japan

No calls scheduled
John E Kelly

From: Lee, Richard (NRC)
To: Kelly, John E (NE)
Sent: Tue Apr 05 15:41:15 2011
Subject: Call to Japan

Hi, John:

Do you a call to Japan today?. If yes, what time is it scheduled for?

Thx, Richard

2/308

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:12 PM
To: 'Kelly, John E (NE)'
Cc: 'Binder, Jeffrey L.'
Subject: handsout for today meeting

Hi John or Jeff:

Please send me the VGs for today conf. call.

Thx, Richard

2/309

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:24 PM
To: Powers, Dana
Subject: RE: Japanese test on reactor head seal

Thx, Dana.
Richard
Did you receive any handout for today conf. call?

From: Powers, Dana
Sent: Tuesday, April 05, 2011 5:23 PM
To: Lee, Richard
Subject: RE: Japanese test on reactor head seal

I have it in my office. I will try to find it here. Dana

From: Lee, Richard
Sent: Monday, April 04, 2011 5:20 PM
To: Powers, Dana A; Powers, Dana
Subject: Japanese test on reactor head seal

Dear Dana:

You told us that the Japanese had performed testing (steam and pressure) on the reactor head seal and found that it will fail from temp. and steam before radiation (1 Grad dose) will cause it to fail. Do you know who did the experiments? Do you have the Japanese study?

Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:32 PM
To: Esmaili, Hossein; 'Gauntt, Randy (home)'; 'Randy Gauntt (SNL)'; Salay, Michael
Subject: FW: sand vs. air

Fyi

It appears that the sand option for the SFP is been considered as a recommendation today by the consortium (INPO, EPRI, GE, etc.,).

Richard

From: Powers, Dana A [<mailto:dapower@sandia.gov>]
Sent: Friday, March 18, 2011 11:01 AM
To: Lee, Richard
Subject: RE: sand vs. air

Richard, Sand will be a powdered insulation limiting heat transfer from rods with internal heat generation of ~0.03 W/g. Temperatures will rise until the sand and the zirconium cladding can react. AT some point in the heat up, the cladding will balloon and rupture. This will release the noble gases and fission products in the gap region. We really have not done the experiment with sand. So I cannot comment on rates with any authority. The overall reaction depends a bit on environment. Roughly it is $Zr + SiO_2 = ZrO_2 + Si + \text{heat}$. The reaction will drive the temperature up so rates will get fast.. I would suspect that what will limit the temperature is either the melting of the clad or the evolution of SiO gas. The essential point is that we do not want to limit the heat transfer from the rods by packing them in an insulating bed. In principle, cesium and barium can react with the sand to form silicates. There will not be similar reactions of other radionuclides. The sand could filter out some aerosol. Still, you will get a lot of radioactive material escaping the bed.
Dana

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Friday, March 18, 2011 5:47 AM
To: Powers, Dana A
Subject: sand vs. air

Dear Dana:

I forgot to ask you information (e.g., oxidation as a function of temperature, the exothermic reactions rates, etc.) related to air vs. sand oxidation of Zr.

Thanks,
Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:39 PM
To: Powers, Dana
Subject: RE: per strikes

Do you want to know who else I tune off too?

From: Powers, Dana
Sent: Tuesday, April 05, 2011 5:38 PM
To: Lee, Richard
Subject: RE: per strikes

Now we are seriously discussing using shaped charges in the vicinity of the head – madness. Dana

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:37 PM
To: Powers, Dana
Subject: RE: per strikes

I have automatically tuned off as soon as Per starts talking.

From: Powers, Dana
Sent: Tuesday, April 05, 2011 5:35 PM
To: Lee, Richard
Subject: RE: per strikes

No, stopping if they try to cool the outside of the drywell. In fact, the AP1000 flow even with the engineering stripes and you get streaks of wet and dry – without the engineering you will get a bunch of uneven streaks with low heat transfer. Dana

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:33 PM
To: Powers, Dana
Subject: RE: per strikes

You are talking about sand vs. water. Correct?

From: Powers, Dana
Sent: Tuesday, April 05, 2011 5:28 PM
To: Lee, Richard
Subject: per strikes

Once again, Per can find fault with any suggestion. I think he is right in this case. dana

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:43 PM
To: Powers, Dana
Subject: RE: per strikes

Let's send some of the DOE Sci. Council advisors to have this done. I have at least 2 suggestions!

From: Powers, Dana
Sent: Tuesday, April 05, 2011 5:41 PM
To: Lee, Richard
Subject: RE: per strikes

The rarefaction off the backside of the concrete is the way we kill people inside bunkers. Dana

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:39 PM
To: Powers, Dana
Subject: RE: per strikes

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Once again, Per can find fault with any suggestion. I think he is right in this case. dana

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 5:40 PM
To: 'Kelly, John E (NE)'
Subject: RE: handsout for today meeting

Yes, Thanks.
Richard

From: Kelly, John E (NE) [<mailto:JohnE.Kelly@Nuclear.Energy.Gov>]
Sent: Tuesday, April 05, 2011 5:39 PM
To: Lee, Richard
Subject: Re: handsout for today meeting

Did you get them
John E Kelly

From: Lee, Richard (NRC)
To: Kelly, John E (NE)
Cc: Binder, Jeff
Sent: Tue Apr 05 17:12:17 2011
Subject: handsout for today meeting

Hi John or Jeff:

Please send me the VGs for today conf. call.

Thx, Richard

Lee, Richard

From: Lee, Richard
Sent: Tuesday, April 05, 2011 10:48 PM
To: Powers, Dana A
Subject: RE: Some comments on the strategy

Dana:

I will convey this to DOE ahead of our conf. call tomorrow. On Monday conf. call, I mentioned the likelihood of drywell head seal failure, and that the Japanese had done experiments under radiation and high temperature steam environment and found that this combination will cause seal failure. Dick Garwin got very excited and asked John to get the experimental results from the Japanese as soon as possible. That's why I asked you about the Japanese experiment on head seal.

On Monday morning, Don Marksberry mentioned to me that the Japanese believes that one of Unit (which I forgot which one) drywell upper head had a breach.

Richard

From: Powers, Dana A [dapower@sandia.gov]
Sent: Friday, April 01, 2011 5:35 PM
To: Lee, Richard
Subject: Some comments on the strategy

I made some markups in red on the strategy. Dana

2/3/5

Lee, Richard

From: Lee, Richard
Sent: Wednesday, April 06, 2011 7:40 AM
To: 'Gauntt, Randall O'
Cc: Salay, Michael
Subject: RE: Fukushima Drawings

Randy:
I will ask John Kelly for it.
Richard

From: Gauntt, Randall O [<mailto:rogaunt@sandia.gov>]
Sent: Wednesday, April 06, 2011 1:56 AM
To: Lee, Richard
Cc: Salay, Michael
Subject: Fukushima Drawings

Richard,
Earlier several weeks ago, you sent me a zip file with lots of drawings of Fukushima plants and P&ID drawings. There was no drawings of the spent fuel pools however. I wonder if there are any drawings of the reactor building and the spent fuel pools to see their dimensions and layouts?

Randy

Lee, Richard

From: Lee, Richard
Sent: Wednesday, April 06, 2011 7:43 AM
To: 'Kelly, John E (NE)'
Subject: Drawings of reactor building and spent fuel pool

Importance: High

Hi, John:

By any chance, do you have drawings of the Fukushima reactor buildings and spent fuel pool for Unit 1 to 4? If you do, can you have someone send it by zipping the files and send to me.

Appreciate it.

Best,
Richard

2/3/17

Lee, Richard

From: Lee, Richard
Sent: Wednesday, April 06, 2011 9:17 AM
To: Case, Michael
Cc: Wagner, Katie
Subject: RE: Sandia Report

I think it is the same thing from Congressman Waxman office.

From: Case, Michael
Sent: Tuesday, April 05, 2011 4:17 PM
To: Lee, Richard
Subject: FW: Sandia Report

Hey Richard. Is this the same request you were asking about?

From: Richards, Stuart
Sent: Tuesday, April 05, 2011 12:55 PM
To: Hogan, Rosemary; Graves, Herman
Cc: Case, Michael
Subject: FW: Sandia Report

See below - Stu

From: Dacus, Eugene
Sent: Tuesday, April 05, 2011 10:56 AM
To: Gibson, Kathy; Richards, Stuart
Cc: Uhlé, Jennifer; Sheron, Brian; Case, Michael; Scott, Michael
Subject: RE: Sandia Report

Kathy

The request is on hold. See response below. I'll let you know if and when it resurfaces.

Gene

No need to worry about it in the short term. We'll check back in at a later date if we still need it.

Alison Cassady
Senior Professional Staff
Committee on Energy and Commerce
Rep. Henry A. Waxman, Ranking Member
(202) 226-3400

From: Dacus, Eugene [<mailto:Eugene.Dacus@nrc.gov>]
Sent: Monday, April 04, 2011 4:02 PM
To: Cassady, Alison; Powell, Amy
Subject: RE: Sandia Report

2/3/8

Alison,

I've been informed that the staff members knowledgeable about this report are, as you might anticipate, involved in a number of other Japan event related requests and would need to review the report themselves before doing a briefing. How soon do you need this briefing?

Gene

From: Gibson, Kathy
Sent: Friday, April 01, 2011 5:14 PM
To: Richards, Stuart; Dacus, Eugene
Cc: Uhle, Jennifer; Sheron, Brian; Case, Michael; Scott, Michael
Subject: Re: Sandia Report

Gene,
Herman Graves (RES/DE) and Charlie Tinkler (RES/DSA) are the knowledgeable staff for this report. As you might anticipate, they are involved in a number of other Japan event related requests. They will want to review the report themselves before doing a briefing. What timeframe were you looking for?

From: Sheron, Brian
To: Gibson, Kathy; Case, Michael; Richards, Stuart
Cc: Uhle, Jennifer
Sent: Fri Apr 01 15:51:18 2011
Subject: FW: Sandia Report

See the request below. Who is the best, most knowledgeable person to discuss this report with the hill staffers?

From: Dacus, Eugene
Sent: Friday, April 01, 2011 3:37 PM
To: Uhle, Jennifer; Sheron, Brian
Cc: Powell, Amy; Schmidt, Rebecca
Subject: FW: Sandia Report

Brian,

Can you support this request?

Gene

From: Cassidy, Alison
Sent: Tuesday, March 29, 2011 4:07 PM
To: 'Powell, Amy'; Dacus, Eugene
Subject: Sandia Report

Amy & Gene,

Jeff Baran and I are interested in speaking with someone who can brief us on a report Sandia prepared for NRC, entitled *Risk Informed Assessment of Degraded Containment Vessels*, and its conclusions about the Mark 1's vulnerability to containment failure in the event of a core-melt accident.

Can you help us out?

Thanks,

Alison Cassady

Alison Cassady
Senior Professional Staff
Committee on Energy and Commerce
Rep. Henry A. Waxman, Ranking Member
(202) 226-3400

Andersen, James

From: Weber, Michael
Sent: Wednesday, April 06, 2011 3:21 PM
To: Campbell, Andy
Cc: Wiggins, Jim; Dyer, Jim; Zimmerman, Roy; Muessle, Mary; Andersen, James
Subject: RESPONSE - Call from Christine McDonald, OMB, RE: agency Japan activities and costs

Let Jim Dyer handle this call. If he needs assistance, we can provide the information that he needs.

From: Campbell, Andy
Sent: Wednesday, April 06, 2011 2:02 PM
To: Zimmerman, Roy
Cc: Wiggins, Jim; Dyer, Jim; Weber, Michael
Subject: Call from Christine McDonald, OMB, RE: agency Japan activities and costs

Roy,

Christine McDonald from OMB called for you (given your role at the Ops Center), regarding the agencies activities related to nuclear events in Japan and the costs of those activities. Specifically OMB is interested to know what NRC is doing?, what NRC has been asked to do by various entities (particularly by Japan)?, what are the total costs the agency is incurring?, and what if anything would be reimbursable by Japan?

OMB is organizing a teleconference for sometime Thursday. NRC will need to be represented by two people: 1) a program person who can speak to our activities and 2) a CFO person regarding agency costs for these activities.

Christine's phone number is 202-395-6944.

Andy

Andrew C. Campbell, Ph.D.
Deputy Director
Office of Enforcement
mail stop O4-H5
US Nuclear Regulatory Commission
Rockville, MD 20852

email: Andy.Campbell@nrc.gov
phone: 301-415-7566

2/3/19

Merzke, Daniel

From: Merzke, Daniel
Sent: Thursday, April 07, 2011 8:59 AM
To: Andersen, James
Subject: FW: Proposed HOC Transition Plan
Attachments: Proposed HOC Transition Plan.docx

Importance: High

Jim, I just got this, with a recommendation from Jim Wiggins that we meld the two plans together. I talked to Michele, and neither of us think that we should change the original plan at this point, but an ex-Ops Center team dedicated to supporting the site team might not be a bad idea. I was thinking of forwarding it to Marty as something to think about.

Dan

From: Morris, Scott
Sent: Thursday, April 07, 2011 8:18 AM
To: Merzke, Daniel
Subject: FW: Proposed HOC Transition Plan
Importance: High

FYI

From: Morris, Scott
Sent: Thursday, April 07, 2011 8:09 AM
To: Wiggins, Jim; Evans, Michele
Cc: Lubinski, John; Dudes, Laura; Johnson, Michael; Marshall, Jane; Grant, Jeffery; Gott, William; McDermott, Brian
Subject: Proposed HOC Transition Plan
Importance: High

Jim/Michele:

Last night Mike Johnson, Laura Dudes, John Lubinski and I spent some time developing the attached proposal ... we were hoping to get your blessing on it and get in up to OEDO today, if possible ...

If the proposal is not sufficiently self-explanatory, please let me know and I will attempt to explain our logic.

Thanks!

Scott

2/320

**Proposed NRC Headquarters Operations Center Transition Plan
- Response to Fukushima Daiichi Reactor Events -**

Currently the Headquarters Operations Center (HOC) is staffed 24/7 with approximately 25 individuals per shift serving in various capacities. Based on the nature of ongoing HOC work activities, and concerns raised by both HOC and NRC Site Team staff, the Office of Nuclear Security and Incident Response is proposing this transition plan.

Ongoing HOC priorities include:

- Assessing radiological conditions, dose projections and protective action recommendations.
- Providing technical assistance to the U.S. Ambassador in Japan and the Japanese Government.
- Coordinating with other U.S. Departments and Agencies, the Institute of Nuclear Power Operations (INPO), Bechtel, General Electric Hitachi (GEH), Tokyo Electric Power Company (TEPCO), and the Japanese military.

Current status:

The Fukushima Daiichi reactors and spent fuel pools appear to be approaching a static condition, and TEPCO is working aggressively to achieve long term stability.

The industry consortium (INPO, GeH, EPRI) has established direct communication with TEPCO and has embedded personnel in the WANO Tokyo Center and the TEPCO organization (TEPCO Emergency Response Center).

Recommendation:

Transition the current HOC Response Organization to a dedicated team established as an element of the NRC line organization (e.g., NSIR).

This team should consist of:

- A Team Lead with demonstrated strong organizational and communication skills
- A Senior Project Manager with strong organizational skills and experience managing complex projects, along with good communication skills
- Several staff with selected expertise (e.g., severe accident mitigation, dose assessment, protective measures, interagency/intergovernment liaison, etc.)
- An administrative assistant

Any additional specific technical expertise beyond the selected individuals could be obtained from one of the NRC line organizations through formally managed, high priority taskings.

The activities of this team would include (not limited to):

- Establishing a daily call with the NRC Site Team to align on support requests and priorities

- Participating in the daily call with the industry consortium to ensure awareness of their activities with TEPCO
- Tracking requested information serving as the single NRC headquarters point of contact for all documents/products developed in support of the Fukushima response/recovery effort
- Providing daily status summaries and/or briefings for NRC line management
- Establishing points of contact within NISA for continued assistance (as needed) once the NRC Site Team has been disestablished.

The Team Lead should be immediately available during the normal work hours of the NRC Site Team, and should also be reachable by phone during all other times.

Rationale:

Even with recent improvements in HOC turnover documentation, the fact that several different individuals are serving (or have served) in the various response positions creates a degree of inconsistency in situational awareness that the Site Team and others sometimes find frustrating, and leads to inefficiencies and reduced support effectiveness.

In addition, many of the ongoing and new work items being assigned to the HOC staff are either:

- Focused on longer-term efforts (vice being of an “immediate response” nature),
- Better suited for the line organization,
- Involve response to inquiries from external stakeholders, or are
- Related to intergovernmental/international coordination.

In other words, many of current tasks are not associated with time-sensitive “response” activities but rather are more focused on more routine communication, coordination and “recovery” efforts.

Finally, the NRC Site Team has indicated that no additional PMT support or actions are likely needed in the near term (e.g., offsite radiological assessments, RASCAL source term updates, etc.).

Note that several staff support positions in the HOC have already been reduced or eliminated to account for a lack of support needs (e.g., LT Director on midnight shift).

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 8:08 AM
To: Salay, Michael
Cc: Esmaili, Hossein
Subject: RE: SNL SFP4 MELCOR Calculation

Mikey-san:

I see a lot of plots, except the MELCOR markup of the SFP. Please send me a figure on MELCOR markup of the pool when you have a chance.

Thx, Richard

From: Salay, Michael
Sent: Thursday, April 07, 2011 4:26 AM
To: Lee, Richard
Subject: FW: SNL SFP4 MELCOR Calculation

From: Salay, Michael
Sent: Thursday, April 07, 2011 4:25 AM
To: RST01 Hoc
Cc: Giessner, John; Taylor, Robert; Bernhard, Rudolph; Blamey, Alan
Subject: SNL SFP4 MELCOR Calculation

The results of the preliminary SNL SFP4 MELCOR calculations assuming that the water drains from pool through fuel pool gates during earthquake are attached. Note that significant hydrogen generation is predicted to start 8 days after earthquake. Comments by SNL below.

-Mike

The problem was initiated with a starting water level drained down to 1-m above the fuel racks. This seems not quite enough initial draindown to explain the observed timing of explosion, but is getting close.

The calculation indicates a large Cs release.

Note that if this was the initial condition required to cause pool dryout at the time observed, then they should be having trouble keeping the pool covered at this point as the way I see it, the leak must be just above the top of the fuel.

We should keep asking the question, what is the water level in the SFP?

If the water level is very low, then the gamma shine above the pool should be remarkable.

If the water level is very high, then we have no way to explain the timing of pool dryout and fire that is assumed to have taken place on the 15th.

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:46 PM
To: Powers, Dana
Cc: 'Gauntt, Randy'
Subject: RE: yesterday DOE conf.call hndsout

Randy:

Your answer?

Richard

-----Original Message-----

From: Powers, Dana
Sent: Thursday, April 07, 2011 5:44 PM
To: Lee, Richard
Subject: RE: yesterday DOE conf.call hndsout

I'm pretty sure codes and the DF4 test suggested that the shrouds on BWR assemblies go before cladding following clad ballooning. We might confirm with Gauntt on that because I'm operating from memory right now. Dana

-----Original Message-----

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:39 PM
To: Powers, Dana
Subject: RE: yesterday DOE conf.call hndsout

No!

-----Original Message-----

From: Powers, Dana
Sent: Thursday, April 07, 2011 5:38 PM
To: Lee, Richard
Subject: RE: yesterday DOE conf.call hndsout

Will sand never die?

-----Original Message-----

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:09 PM
To: Powers, Dana
Subject: RE: yesterday DOE conf.call hndsout

Haven't got today one. I sent an e-mail to John Kelly and asking for it.

-----Original Message-----

From: Powers, Dana
Sent: Thursday, April 07, 2011 5:07 PM
To: Lee, Richard
Subject: RE: yesterday DOE conf.call hndsout

thanks

2/322

-----Original Message-----

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:06 PM
To: Powers, Dana; 'dapower@sandia.gov'
Subject: FW: yesterday DOE conf.call hndsout

Yesterday VGs

-----Original Message-----

From: Busby, Jeremy T. [<mailto:busbyjt@ornl.gov>]
Sent: Thursday, April 07, 2011 9:59 AM
To: Binder, Jeffrey L.; Lee, Richard
Cc: 'Doug Burns'
Subject: RE: yesterday DOE conf.call hndsout

Hi Richard,

We'll get you added. Here are the slides from yesterday.

Best regards,
Jeremy

From: Binder, Jeffrey L.
Sent: Thursday, April 07, 2011 9:47 AM
To: 'Richard.Lee@nrc.gov'
Cc: 'Doug Burns'; Busby, Jeremy T.
Subject: RE: yesterday DOE conf.call hndsout

Doug/Jeremy

Can you get Richard on the list? Thanks.

Jeff

-----Original Message-----

From: Lee, Richard [<mailto:Richard.Lee@nrc.gov>]
Sent: Thursday, April 07, 2011 09:43 AM Eastern Standard Time
To: Binder, Jeffrey L.
Subject: yesterday DOE conf.call hndsout

Jeff:

Do you have VGS from yesterday DOE Sci. Council. Conf. call? I do not know what distribution list DOE is using to distribute them ahead of the conf. call. I am not getting it.

Thanks, Richard

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 6:10 PM
To: 'alex.larzelere@nuclear.energy.gov'
Subject: FW: VGs

Hi, Alex:

Trying again.

Richard

From: System Administrator
Sent: Thursday, April 07, 2011 6:06 PM
To: Lee, Richard
Subject: Undeliverable: VGs

Your message did not reach some or all of the intended recipients.

Subject: VGs
Sent: 4/7/2011 6:06 PM

The following recipient(s) cannot be reached:

'Larzelere, Alex ' on 4/7/2011 6:06 PM
None of your e-mail accounts could send to this recipient.

2/323

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 12:15 AM
To: Gauntt, Randall O
Subject: RE: inquiry

yes!

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Wednesday, April 06, 2011 11:21 PM
To: Lee, Richard
Subject: RE: inquiry

Are you still awake?

From: Lee, Richard [Richard.Lee@nrc.gov]
Sent: Wednesday, April 06, 2011 8:54 PM
To: Gauntt, Randall O
Subject: RE: inquiry

Randy:

Another question is the remaining source term in Unit 4 spent fuel pool. If condition deteriorates, what will be the source term coming out of the Unit 4 SFP. Are you doing this analysis as well? Dr. Peter Lyons is in Tokyo. Have you run into him?

What is Mikey-san doing? Do you work closely with him throughout the day? NRC is asking for volunteer for the next group of staff to dispatch. Does Mike wants to stay longer? If you stay longer he might incline to stay.

Do you think the team dispatch by DOE compliment the NRC team?

Richard

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Wednesday, April 06, 2011 9:49 PM
To: Lee, Richard
Subject: RE: inquiry

Not sure.

Looking for an exit point.

Will need to check with John Kelly and our NNSA - but we have mostly been supporting the local NRC team while at the same time gathering what is known about accidents and data. This material may be hard to find later.

Our near term deliverable for NRC is some kind of source term for the reactors in case they have to leave the site unattended.

What is on your mind?

Randy

2/324

From: Lee, Richard [Richard.Lee@nrc.gov]
Sent: Wednesday, April 06, 2011 7:34 PM
To: Gauntt, Randall O
Subject: inquiry

Randy:

When will you be returning to U.S.?

Richard

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 8:20 AM
To: Powers, Dana
Subject: RE: IAEA Position "Never again: An Essential Goal for Nuclear Safety"

Dana:
Thanks, for your advice.
Richard

From: Powers, Dana
Sent: Thursday, April 07, 2011 8:07 AM
To: Lee, Richard
Subject: IAEA Position "Never again: An Essential Goal for Nuclear Safety"

Richard, If I were the Japanese, I would be absolutely hysterical over the IAEA statement entitled, "NEVER AGAIN: An Essential Goal for Nuclear Safety". They trolled the "old folks" homes for the authorship of this statement. The draft seems to imply that the Japanese were complacent. The operators were not adequately trained and that a better "safety culture" would have spared Fukushima from the tsunami. I don't think NRC wants to associate itself with this statement. Dana

2/325

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 1:09 PM
To: 'Kelly, John E (NE)'
Subject: RE: Drawings of reactor building and spent fuel pool

John:

I understood where you are with e-mails. That's why I tried to contact Jeff Binders and others to ask before I bother you.

Richard

From: Kelly, John E (NE) [<mailto:JohnE.Kelly@Nuclear.Energy.Gov>]
Sent: Thursday, April 07, 2011 12:46 PM
To: Lee, Richard
Subject: RE: Drawings of reactor building and spent fuel pool

sorry Richard, but I've reached the point where I can't keep up with email. Not sure at this point what we have. here's what I have, faxed from Japan

From: Lee, Richard (NRC)
Sent: Wednesday, April 06, 2011 7:43 AM
To: Kelly, John E (NE)
Subject: Drawings of reactor building and spent fuel pool
Importance: High

Hi, John:

By any chance, do you have drawings of the Fukushima reactor buildings and spent fuel pool for Unit 1 to 4? If you do, can you have someone send it by zipping the files and send to me.

Appreciate it.

Best,
Richard

2/32-6

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 1:12 PM
To: Gibson, Kathy
Cc: Santiago, Patricia; Wagner, Katie
Subject: FW: Casto Briefing Sheet -4249 1043 4-07.doc
Attachments: Casto Briefing Sheet -4249 1043 4-07.doc

Kathy:

Kathy:

Charlie needs to weigh in on this one. Casto needs it to brief the U.S. Ambassador.

Thanks, Richard

From: RST09 Hoc
Sent: Thursday, April 07, 2011 12:40 PM
To: Lee, Richard; Tinkler, Charles
Subject: Casto Briefing Sheet -4249 1043 4-07.doc

Richard/Charlie,

Can you please give a quick look to the attached document to see if it is consistent with the discussions on 3/18? If you could send it back to RST09 before 2:00 p.m. with your comments and suggestions, I'd greatly appreciate it. If you cannot review it by 2:00, please let me know so I can include it in the turn-over.

Thanks,
Mirela

2/327

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 2:14 PM
To: Powers, Dana
Subject: RE: Urgent request for review

Great! Thx. Richard

From: Powers, Dana
Sent: Thursday, April 07, 2011 1:41 PM
To: Lee, Richard
Subject: RE: Urgent request for review

Richard, it looks okay to me. Dana

From: Lee, Richard
Sent: Thursday, April 07, 2011 12:53 PM
To: Powers, Dana
Subject: Urgent request for review

Dana:

Please take a quick look at the attached. I need to get back with comments to Op Center by 2:00pm.
Thx, Richard

2/328

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:08 PM
To: 'Kelly, John E (NE)'
Subject: today's handout

John:

I have not been receiving any VGs before the meeting for today and the same problems for the previous days. Appreciate it if you can ask someone to send it. This morning, Jeremy sent me the one from yesterday.

Richard

2/329

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 5:36 PM
To: Sheron, Brian
Subject: VGs for today conf. call

Brian:

Did you get today VGs? I didn't.

Richard

2/330

Lee, Richard

From: Lee, Richard
Sent: Thursday, April 07, 2011 6:06 PM
To: 'Larzelere, Alex '
Cc: Sheron, Brian
Subject: VGs

Alex:

I do not know what the problem with my e-mail. It appears to be working. Sorry with all the trouble.

Richard

2/331

Merzke, Daniel

From: Merzke, Daniel
Sent: Thursday, April 07, 2011 8:26 AM
To: Morris, Scott
Subject: RE: Proposed HOC Transition Plan
Attachments: Japan Event Staffing.docx

Thanks, Scott. Marty is meeting with the Chairman today to discuss. I've attached a one-pager with our proposal on reducing the Ops Center staffing. It's not too dissimilar to what you're proposing. I'm revising a couple of things based on Marty's comments, but nothing substantial. One of the key assumptions is that the Chairman wants someone senior enough running the team to be aware of political and international sensitivities.

Dan

From: Morris, Scott
Sent: Thursday, April 07, 2011 8:18 AM
To: Merzke, Daniel
Subject: FW: Proposed HOC Transition Plan
Importance: High

FYI

From: Morris, Scott
Sent: Thursday, April 07, 2011 8:09 AM
To: Wiggins, Jim; Evans, Michele
Cc: Lubinski, John; Dudes, Laura; Johnson, Michael; Marshall, Jane; Grant, Jeffery; Gott, William; McDermott, Brian
Subject: Proposed HOC Transition Plan
Importance: High

Jim/Michele:

Last night Mike Johnson, Laura Dudes, John Lubinski and I spent some time developing the attached proposal ... we were hoping to get your blessing on it and get in up to OEDO today, if possible ...

If the proposal is not sufficiently self-explanatory, please let me know and I will attempt to explain our logic.

Thanks!

Scott

2/332

SUBJ: JAPAN EVENT STAFFING

Purpose: The purpose is to provide a plan for reducing the Operations Center staffing responding to the event at the Fukushima Daiichi nuclear facility.

Background: The Operations Center has been staffed with an event response team consisting of three shifts since March 11th. Operations Center staff members are supporting the site team, responding to Commission questions, and maintaining liaison with other federal agencies responding to the event.

The site team consists of nine staff members, led by Chuck Casto. The most recent team was dispatched during the week of April 4th.

The NRC has three roles in our event response: to support the Japanese government and NISA, to gather and assess any information to determine what implications the event has for U.S. licensees, and to support the U.S. Ambassador in Japan.

Discussion:

Capabilities Required

- Ability to have effective management interaction (and push back as appropriate) with other U.S. government entities and the consortium.
- Ability to provide timely response to the site team.

Future Staffing

Future staffing of the site team and Operations Center will be dependent on our assessment of plant conditions and the needs of the team in Japan and the U.S. Government. As the response of NISA and TEPCO moves from mitigation of the event to stabilization/recovery, the NRC response would be expected to be reduced, and other U.S. Government agencies would be expected to take on a leadership role. The recovery phase would be identified by restoration of AC power to all affected units, re-establishment of sustainable cooling for the reactors and spent fuel pools, and stabilization of plant conditions. Stabilization of plant conditions would be defined by maintaining sufficient water inventory in all spent fuel pools and/or cooling capacity to each pool, adequate long-term cooling established to each reactor core, and radioactivity releases have been terminated or the source of radioactivity release is under control.

Recommendations

- Establish one team directed by one ET member, consisting of two members from RST, one member of PMT, and one member of LT to provide immediate support to site team, and one assistant to the ET director. The team would be supplemented as necessary based on workload, and line organizations would be tapped for support as needed. (Need to decide if additional functions needed, such as chronologist.)
- Reduce the PMT to one member of the core team (other federal agencies have assumed lead for data collection, analysis, dose assessments and protective measures.)
- Reduce the LT to one member of the core team (line organizations capable of fulfilling functions as directed by remaining member of LT)
- As of 4/18, in the event of a government shutdown, the team would be on a shift work rotation, with 5 ET members identified as available team directors (Office Directors and above).
- Site team – Chuck Casto has indicated that he needs another team to replace the current team after two weeks in Japan, with strengths in dose assessment, protective measures, health physics, and/or severe accident mitigation.

Lee, Richard

From: Lee, Richard
Sent: Thursday, March 31, 2011 11:09 AM
To: 'Powers, Dana A'
Subject: RE: Isotopes in MOX and LEU

Hi, Dana:

Looks like that this issue is not going away any time soon. When you have a chance, please generate the table and perhaps plots showing some key nuclides comparison between LEU and MOX/LEU core.

Thanks, Richard

-----Original Message-----

From: Powers, Dana A [mailto:dapower@sandia.gov]
Sent: Wednesday, March 30, 2011 11:31 AM
To: Lee, Richard
Subject: Isotopes in MOX and LEU

Richard, I have the Origen outputs for the MOX and LEU fuel for fresh, 1, 2, and 3 cycles, Output includes fuel isotopes, fission products, and activation products. What is it that we need for the Chairman? Dana

Lee, Richard

From: Lee, Richard
Sent: Friday, April 08, 2011 2:40 PM
To: Marksberry, Don
Subject: RE: Plant Status Chronologies of Units 1, 2, and 3

Don:

It appears that your compilation is more comprehensive than the one I saw from Joy Rempe.

Richard

From: Marksberry, Don
Sent: Friday, April 08, 2011 8:00 AM
To: RST01 Hoc; Thorp, John; Tinkler, Charles; Schaperow, Jason; Arndt, Steven; Esmaili, Hossein; Helton, Donald
Cc: Lee, Richard; Demoss, Gary; Coyne, Kevin; Stutzke, Martin; Salley, MarkHenry; Siu, Nathan
Subject: Plant Status Chronologies of Units 1, 2, and 3

Here is this morning's edition of plant status chronology and data tables for Units 1, 2, and 3 that we are maintaining informally in RES. It does not include radiological information.

Please note that the info sources are official press releases from TEPCO and NISA. No other sources or speculations were included.

Don

Don Marksberry

Division of Risk Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
21 Church Street
Rockville, Maryland 20850-4207

Phone: 301-251-7593
E-mail: Don.Marksberry@nrc.gov

USPS & Express Mail Address:
Mail Stop: C-4C07M
Washington, D.C. 20555-0001

2/334

Lee, Richard

From: Lee, Richard
Sent: Friday, April 08, 2011 3:27 PM
To: Sheron, Brian
Subject: RE: QUESTION

We do.

From: Sheron, Brian
Sent: Friday, April 08, 2011 3:08 PM
To: Lee, Richard
Subject: FW: QUESTION

Richard, please respond to Roger. Remind him that all fuel that has been burned has Plutonium in it.

From: Rihm, Roger
Sent: Friday, April 08, 2011 9:37 AM
To: Aissa, Mourad
Cc: Uhle, Jennifer; Sheron, Brian
Subject: QUESTION

Mourad, are you in today (I called but you were not at your desk). I'm contacting you because I have seen your name on MOX information previously provided to the chairman.

We are rushing today to wrap up some Qs and As for Senator Boxer. One question we had was the following: What increased risk is associated with exposure to MOX? At 10PM last night, the best answer we could come up with was the following:

Mixed oxide (MOX) fuel involves the use of plutonium as a fuel, in addition to enriched uranium. Plutonium is a long-lived alpha emitter, which presents different risks than those presented by uranium fission products. Regarding exposure to mixed oxide fuel, in Japan, prompt evacuation has minimized radiation exposure to the public, so long-term public health consequences from radiation exposure resulting from the events, whether due to MOX or uranium fuel, are expected to be small. Also, given the small number of MOX fuel assemblies at Fukushima Daiichi Unit 3 at the time of the event, coupled with the short time of irradiation of the MOX fuel, it is likely that the MOX fuel has had and will have no perceptible impact on any consequences from the event.

Do you have corrections/edits/additions to suggest for this response? Need to wrap this up by about 11AM. Thank you.

Roger S. Rihm
Communications and Performance Improvement Staff
Office of the Executive Director for Operations
US NRC
301.415.1717
roger.rihm@nrc.gov

2/335

Raione, Richard

From: Munson, Clifford
Sent: Monday, March 14, 2011 9:41 AM
To: Karas, Rebecca; Chokshi, Nilesh; Flanders, Scott
Cc: Raione, Richard; Cook, Christopher; Ake, Jon; Kammerer, Annie; Jones, Henry; Li, Yong
Subject: Communication Plans for Tsunami, GI-199, Shoreline Fault (Diablo) plus EDO and Comm. TA briefings on Tsunami
Attachments: Tsunami%20Plan.pdf; Communication Plan_GI199_Mar 27 2009_for ADAMS ML081850477.pdf; Diablo COMMUNICATION PLAN 3-23-09Final.doc; edo tsunami briefing2.ppt; Complete Tsunami Presentation1-17-07.ppt

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COMMUNICATION PLAN FOR GENERIC ISSUE 199

March 27, 2009
(ML081850477)

Goals

This plan will guide staff communications and activities with internal and external stakeholders of the U.S. Nuclear Regulatory Commission (NRC), as they relate to Generic Issue (GI) 199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants."

Background

In support of early site permits for new reactors, the NRC staff reviewed updates to seismic source and ground motion models provided by applicants. The seismic update information included new models to estimate earthquake ground motion and updated models for earthquake sources in seismic regions such as eastern Tennessee, and around both Charleston, South Carolina, and New Madrid, Missouri. The new data and models resulted in increased estimates of the seismic hazards for plants in the Central and Eastern United States (CEUS), but these estimates remain small in an absolute sense. The staff reviewed and evaluated this new information along with similar U.S. Geological Survey (USGS) seismic hazard estimates, used for building code applications (as opposed to nuclear power plant licensing). From this review, the staff identified that the estimated seismic hazard levels at some current CEUS operating sites might be higher than seismic hazard values used in design and previous evaluations.

The staff of the NRC's Office of Nuclear Reactor Regulation (NRR) compared the new seismic hazard data with the earlier evaluations conducted by the NRC staff as part of the Individual Plant Examination of External Events (IPEEE) Program. From this comparison, the staff determined that seismic designs of operating plants in the CEUS still provide adequate safety margins. At the same time, the staff also recognized that the new seismic data and models could reduce available safety margins due to increased estimates of the probability associated with seismic hazards at some of the currently operating sites in the CEUS. The licensing basis for these plants does not include a probabilistic assessment of seismic hazards or a probabilistic assessment of their potential impact on plant structures, systems, and components. Rather, the licensing basis for these plants is based on deterministic analysis for design basis loads from the maximum earthquake level that is determined from historical data. To help assess potential reduction in available safety margins using a probabilistic approach, the staff of NRR issued a memorandum, dated May 26, 2005, recommending that the new data and models on CEUS seismic hazards be examined under the Generic Issues Program (GIP). This memorandum is available in the NRC's Agency-wide Documents Access and Management System (ADAMS), under Accession No. ML051450456.

The NRC's Office of Nuclear Regulatory Research (RES) reviewed the information in NRR's memorandum, and identified the issue as GI-199, as described in the RES response, dated June 9, 2005 (ADAMS Accession No. ML051600272). Given NRR's determination that seismic designs of operating plants in the CEUS still provide an adequate level of protection, RES determined that this issue was lower priority than some of the other issues already being

evaluated under the GIP. On November 7, 2005, RES assigned a contractor to perform the initial screening analysis of GI-199 in accordance with the guidelines outlined in Management Directive (MD) 6.4, "Generic Issues Program." In February, 2006, the contractor notified RES of problems obtaining Electric Power and Research Institute (EPRI) Report NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue," dated April 1989, which the contractor needed to perform its task. From March 2006 through February 2007, RES coordinated with the Office of Administration, Division of Contracts; Office of General Counsel; and EPRI to provide EPRI Report NP-6395-D to the contractor. However, the NRC's attempts to provide this copyrighted document to the contractor were unsuccessful.

During this same time period, two developments led to RES's decision in March 2007 to perform the screening analysis for GI-199 using NRC staff. One development was issuance of SECY-07-0022, "Status Report on Proposed Improvements to the Generic Issues Program," dated January 30, 2007 (ADAMS Accession No. ML063460239). This paper outlines the seven screening criteria for use to determine whether GIs should proceed to the more detailed Safety/Risk Assessment stage under the GIP. The other development was RES hiring additional seismologists with prior experience involving the assessment of seismic hazards on critical facilities. From April 2007 through September 2007, the NRC staff performed the screening analysis of GI-199 using guidance provided in Management Directive MD 6.4 and SECY-07-0022.

In October 2007, for consistency with the performance-based approach for assessing seismic hazards for new reactors, the staff determined that the screening analysis should consider seismic hazard data and models besides those available from the USGS. This determination was based on the staff's ongoing interactions with stakeholders to develop a new performance-based approach for assessing seismic hazards for new reactors as described in a memorandum to the Commission, "A Performance-Based Approach to Define the Safe Shutdown Earthquake Ground Motion," dated July 26, 2006 (ADAMS Accession No. ML052360044). The staff's ongoing work on this performance-based approach resulted in issuance of NRC Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," dated March 2007 that endorses the performance-based approach. The NRC completed the GIP screening in February 2008. The Screening Panel completed its independent review of the initial screening evaluation and concluded that GI-199 should proceed to the Safety/Risk Assessment Stage under the GIP (ADAMS Accession No. ML073400477). The staff is currently assessing the various seismic data and models available and is identifying an approach that is suitable to use in the more detailed Safety/Risk Assessment stage.

The staff has also responded to Freedom of Information Act (FOIA) requests related to GI-199; the USGS data related to the FOIA request is publicly available at ML072880133.

Key Messages

The key messages to be communicated to stakeholders are as follows:

- (1) Recent updates to seismic data and models indicate that estimates of the earthquake hazard at some operating nuclear power plant sites in the CEUS may have increased.
- (2) The updates to seismic data and models could result in estimated seismic hazard levels at some current CEUS operating sites that would be higher than seismic hazard values used in design and previous evaluations.
- (3) The seismic hazard estimates remain small in an absolute sense and current operating nuclear power plants are designed with margin to withstand potential earthquakes.
- (4) The NRC staff has conducted a preliminary review of the recent updates to seismic data and models and has not changed the conclusion that currently operating nuclear plants in the central and eastern U.S. remain safe. The NRC will continue to monitor ongoing research and new information that may alter estimates of seismic hazards with potential impact on nuclear facilities under NRC oversight.
- (5) The NRC staff has also determined that this recent data and models warrant further study and analysis and those activities have been initiated.
- (6) This issue has been screened into the Safety/Risk Assessment stage of the GIP, which analyzes the issue to determine whether or not the issue should proceed to the regulatory assessment stage.

Audience and Stakeholders

Internal

Internal stakeholders include the Commission, NRC management and staff, and the agency's advisory committees (as applicable).

External

External stakeholders include Congress, state regulators, industry (licensees, vendors, owners' group, architect-engineers, and associations involved with existing nuclear power plants), the international nuclear community, interest groups, the media, and the public.

Communication Timeline

The purpose of the activities in this communication plan is to consistently deliver the key messages (identified above) to the agency's internal and external stakeholders. The following table provides the timeline for communicating with stakeholders.

Communication Milestones				
Step	Action	Lead Organization	Support Organization	Date
1	Complete draft communication plan.	RES	NRR & NRO	October 16, 2007 <i>(Completed)</i>
2	Obtain comments on draft communication plan from internal stakeholders and make appropriate changes.	RES	NRR & NRO	<i>(Completed)</i>
3	Identify, contact, and brief internal stakeholders as appropriate.	RES	NRR & NRO	<i>Ongoing</i>
3.a	Brief Deputy Executive Director for Materials, Waste, Research, State, Tribal, and Compliance Programs (DEDMRT).	RES	NRR & NRO	October 24, 2007 <i>(Completed)</i>
3.b	Brief Deputy Executive Director for Reactor and Preparedness Programs (DEDR).	RES	NRR & NRO	November 1, 2007 <i>(Completed)</i>
4	Finalize Rev. 0 of the communication plan, obtain concurrence, and issue the communication plan.	RES	NRR & NRO	November 30, 2007 <i>(Completed – Update as necessary)</i>

Communication Milestones				
Step	Action	Lead Organization	Support Organization	Date
5	Add the communication plan to the GIP Internal Web page.	RES	N/A	December 7, 2007 <i>(Completed)</i>
6	Develop and communicate an agreed upon seismic analysis methodology for screening analysis.	RES	NRR & NRO	December 10, 2007 <i>(Completed)</i>
7	Reconvene the screening panel.	RES	NRR & NRO	January 11, 2008 <i>(Completed)</i>
8	Issue the approved GI-199 screening analysis panel memorandum.	RES	N/A	February 2008 <i>(Completed)</i>
9	Update the communication plan in parallel with the screening memorandum.	RES	NRR & NRO	February 2008 <i>(Completed)</i>
10	Schedule and conduct a public meeting to inform external stakeholders about GI-199.	RES	NRR, NRO, & OPA	February 2008 <i>(Completed)</i>
11	Develop seismic issue fact sheet (general primer on subject of seismic for nuclear power plants).	RES	NRR & NRO	June 2008 <i>(Completed)</i>
12	Add the seismic fact sheet to the GIP Internal and Public Web pages.	RES	OPA	July 2008 <i>(Completed)</i>
13	Sign an addendum to the Memorandum of Understanding between NRC's Office of Research and EPRI	RES	NRR, NRO, & OPA	July 2008 <i>(Completed)</i>
14	Review and respond to inquiries on GI-199 and update the questions and answers (Q&As) as well as the timeline in the communication plan, as appropriate.	RES	NRR & NRO	<i>Ongoing</i>
15	Ongoing communication with industry (EPRI) regarding analysis	RES	NRR & NRO	<i>Ongoing</i>

Communication Milestones				
Step	Action	Lead Organization	Support Organization	Date
16	Brief internal stakeholders (including about collaboration with EPRI and internal seismic analysis work)	RES	NRR & NRO	<i>Ongoing</i>
17	Review and analyze data	RES	NRR & NRO	April 2009
18	Hold discussions under the MOU (with EPRI) on the Safety/Risk Assessment Stage	RES	NRR & NRO	<i>Ongoing</i>
19	Hold Safety/Risk Assessment Panel meeting	RES	NRR & NRO	June 2009
20	Schedule and conduct a public meeting to announce the results of the GIP Safety/Risk Assessment stage.	RES	NRR, NRO, & OPA	August 2009
21	Provide responses to inquiries from the public via established agency channels.	RES	NRR, NRO, OPA, & OCA	<i>Ongoing</i>

Communication Team

RES/DRA/OEGIB has the lead for the Communication Plan and the overall project lead. The Communication Team also includes contacts from the Office of Nuclear Reactor Regulation (NRR), the Office of New Reactors (NRO), the NRC's regional offices, the Office of the Executive Director for Operations (OEDO), Office of Public Affairs (OPA), and Office of Congressional Affairs (OCA) as identified in the following table.

Name	Office	Telephone Number	Email ID
Contacts from RES Operating Experience and Generic Issues Branch			
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Communication Tools

The staff will issue this communication plan and post it to the NRC's Internal Web page at <http://www.internal.nrc.gov/communications/plans/active-plans.html> for agency-wide access. The Communication Team lead will brief key internal and external stakeholders on this issue, as indicated in the Communication Milestones table (above). The NRC staff has published an internal Generic Issues Program (GIP) Web page (<http://www.internal.nrc.gov/RES/GIP/index.html>) and updated the public GIP Web page (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>). These pages include program information and documents, background and historical information, Generic Issue status information, and links to related programs. In addition, the staff has responded to recent Freedom of Information Act (FOIA) requests related to GI-199, the U.S. Geological Survey (USGS) information related to the FOIA request is publicly available at ML072880133. The staff has created a Seismic Issue Fact Sheet as previously indicated (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-seismic-issues.html>). The latest Generic Issue Management Control System (GIMCS) quarterly report, which has GI-199 information, is publicly available at ML081280250.

Questions and Answers

Q1. What is the NRC's Generic Issue Program?

A1. This program evaluates technical issues that apply to two or more facilities and that may not be covered by existing regulatory processes or criteria for their effect on safety, security, and/or the environment. The Generic Issues Program is the program by which these issues can be formally assessed to see if they can be dispositioned by existing regulatory processes or if not, to determine their safety and/or risk significance and how best to treat them within the existing regulatory framework. SECY-07-0022 contains more details and is available from the NRC internal and external Web sites at link: <http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2007/> or in the Agencywide Documents Access and Management System (ADAMS) document number ML063460239.

Q2. What is Generic Issue 199 (GI-199)?

A2. Generic Issue 199 deals with recent data and models that indicate estimates of the potential for earthquake hazards for some nuclear power plants in the Central and Eastern United States may be larger than previous estimates.

Q3. Have all the plants been evaluated as part of Generic Issue 199 (GI-199)?

A3. No, the scope of GI-199 is limited to plants in the central and eastern US because that is where the recent data and models indicate that estimates of earthquake hazards may be larger than previous estimates.

Q4. What do you mean by "increased estimates of earthquake hazards"?

A4. Earthquake or seismic hazard represents the chance (or probability) that a specific level of ground shaking could be observed or exceeded at a given location. Our estimates of seismic hazard at some Central and Eastern United States locations have changed based on results

from recent research indicating that earthquakes occurred more often in some locations than previous estimates. Our estimates of seismic hazard have also changed because the model(s) used to predict the level of ground shaking from a specific magnitude earthquake a certain distance from a site changed. The increased estimates of seismic hazard at some locations in the Central and Eastern United States is discussed in more detail in a memorandum to the Commission, dated July 26, 2006, available in the NRC's Agency-wide Documents Access and Management System (ADAMS), under Accession No. ML052360044.

Q5. *What does this mean for operating nuclear power plants?*

A5. The NRC staff has completed a preliminary review of the recent seismic data and models and has not changed the conclusion that currently operating nuclear plants in the Central and Eastern United States remain safe.

Q6. *Why do you say that nuclear power plants remain safe?*

A6. The plants are designed to withstand anticipated earthquakes with substantial design margins. Based on the NRC staff's reviews associated with Early Site Permits, and the conclusions of the Generic Issue 199 panel, immediate action is not necessary for currently operating plants. This conclusion is based on the facts that 1) existing plants were designed to withstand earthquakes with substantial margins, as confirmed by the results of the Individual Plant Examination of External Events; 2) the probability of exceeding the Safe Shutdown Earthquake Ground Motion may have increased by only a relatively small amount at some sites; 3) the likelihood is that this increased probability is restricted primarily to high structural response frequencies (it is the seismic amplitudes at lower frequencies that are the primary contributors to damage of buildings and equipment); and 4) the preliminary results indicate that the probabilities of seismic core damage are lower than the guidelines for taking immediate action. However, the lack of updated plant specific information warrants further evaluation of this generic issue.

Q7. *What is the seismic design basis for existing nuclear power plants that results in their having substantial safety margins?*

A7. The seismic ground motion used for the design basis is determined from the maximum historic earthquake at the site without explicitly considering the time spans between such earthquakes. In the mid to late 1990s, the staff reviewed the plants' assessments of potential consequences of severe earthquakes (earthquakes well beyond each plant's design basis) that licensees performed as part of the Individual Plant Examination for External Events Program. From this review, the staff determined that seismic designs of operating plants in the Central and Eastern United States have considerable safety margins for earthquakes.

Q8. *If the plants are safe, why are you evaluating the increased earthquake hazards as a generic issue?*

A8. The recent seismic data and models warrant further study and analysis. This further analysis will allow us to better understand the current margins at plants for earthquakes. The agency will take the appropriate action as warranted to ensure public health and safety.

Q9. *What is the timeframe for analyzing the recent seismic data and models?*

A9. The NRC completed the Generic Issues Program screening in February 2008. The NRC expects to complete further evaluations and hold the Safety/Risk Assessment Panel meeting November 2008. The NRC will also continue to monitor ongoing updates of the seismic data and models in the US and evaluate potential impact on nuclear facilities subject to NRC oversight.

Q10. What has been done about this issue since it was identified as a generic issue in the Generic Issues Program?

A10. The issue was logged into the Generic Issues Program (GIP) in June 2005, and based on NRC's determination that the seismic design of plants in the Central and Eastern United States still provided an adequate level of protection, the Agency decided this issue was relatively low priority. In November 2005, the Agency awarded a contract to screen this issue and determine whether it should continue to be evaluated under the GIP. However, in February 2006, the contractor notified the NRC that it was encountering difficulty in acquiring Electric Power and Research Institute Report NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue," dated April 1989, which the contractor needed to perform the screening analysis. From March 2006 through February 2007, the NRC unsuccessfully attempted to provide this copyrighted document to the contractor. Then, in April 2007, the NRC decided to use Agency staff to complete the screening analysis using guidance provided in Management Directive MD 6.4 and SECY-07-0022, "Status Report on Proposed Improvements to the Generic Issues Program," dated January 30, 2007, which outlines the seven screening criteria for use to determine whether Generic Issues should proceed to the more detailed Safety/Risk Assessment stage under the GIP.

Q11. Has the NRC received any requests from government officials regarding seismic issues?

A11. Yes, on November 15, 2007, the NRC received a letter from the Attorneys General of six States (Connecticut, Delaware, Illinois, Kentucky, New York, and Vermont) encouraging the NRC to consider siting and safety requirements, including geographic and seismic issues, in the regulatory process for license renewal. The news release for this request is available at: http://www.oag.state.ny.us/press/2007/nov/nov15a_07.html. The NRC reviewed this letter and has responded.

Q12. Where can I get current information on Generic Issue 199 (GI-199)?

A12. The NRC public Generic Issues Program (GIP) Web page (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>) contains program information and documents, background and historical information, GI status information, and links to related programs. The NRC internal GIP Web page (<http://www.internal.nrc.gov/RES/GIP/Individual%20GIs/GI-0199.html>) contains additional information about GI-199 and is available to NRC staff. The preliminary U.S. Geological Survey data is publicly available at ML072880133. The latest Generic Issue Management Control System (GIMCS) quarterly report, which has GI-199 information, is publicly available at ML081280250.

Q13. What did the Screening Analysis Panel say and what does it mean for Generic Issue 199 (GI-199)?

A13. This screening analysis shows that the estimated increase in spectral acceleration for some existing Central and Eastern United States plant sites might exceed the design basis and values used for the NRC's review of Individual Plant Examination of External Events submittals. This translates to an equivalent increase in seismic demand on plant structures, systems, and components. As a result, this issue has the potential to result in increased seismic core damage frequency estimates for some plants. This screening analysis provides a limited evaluation that does not assess the safety response of the plants. A more detailed analysis will occur in the next stage of the Generic Issues Program – the Safety/Risk Assessment.

Q14. What are the next steps in the NRC's Generic Issues Program for addressing Generic Issue 199 (GI-199)?

A14. The next step is for the staff to complete the Safety/Risk Assessment stage of the Generic Issues Program (GIP) where the staff will assess the risk impact at plants where the seismic hazard exceeds previous levels. The staff plans to complete the Safety/Risk Assessment by November 2008. In this stage the staff will work with stakeholders to assess the various seismic data and models available to determine whether (based on the latest data and models available) any plant sites in the Central and Eastern United States might have seismic hazards that could result in appreciable increased estimates of the plant's risk for response to seismic events. Using this information, the staff will then estimate the potential increase in core damage frequency for any plants identified. The thresholds for this determination can be found in NRC Management Directive 6.4, "Generic Issues Program." If GI-199 is determined to exceed these thresholds, the final stage of the GIP would identify appropriate regulatory actions.

Q15. How does the occurrence of a new earthquake in the Central or Eastern United States effect Generic Issue 199 (GI-199)?

A15. The effect of the occurrence of a single earthquake is believed to be small on the estimated seismic hazard and hence on GI-199, unless a new earthquake occurs in an area previously not recognized as being capable of producing earthquakes, or is larger than previously believed possible in a region. The occurrence of a significant earthquake in the Central or Eastern United States could have some impact on the assessment of GI-199 in three ways. First, the addition of a new earthquake to the database for a particular region could have some influence on our estimate of the rate of earthquake occurrence in that region and hence ultimately the seismic hazard (see A4 for discussion of seismic hazard). However, when performing a seismic hazard study the seismic source zones are specifically delineated to include a sufficient number of earthquakes to provide a stable estimate of the seismicity rate and are thus relatively insensitive to the addition of a single earthquake. Second, if a significant earthquake occurs in an area that was previously not felt to be capable of producing significant earthquakes, that could change experts' perception of the seismic potential of that region and require changes to the seismic hazard model used to develop hazard estimates. Third, if an earthquake occurs in an area and has a magnitude greater than that previously identified as the maximum magnitude possible for that area, then changes to the seismic hazard model would be required.

The magnitude 5.2 earthquake that occurred April 18, 2008 in southeastern Illinois provides a good example of the potential impact of a single earthquake. This earthquake occurred in an area already recognized as being capable of producing significant earthquakes (the Wabash Valley seismic source zone) and was smaller than the maximum magnitude event defined for

the zone based on geologic investigations (maximum magnitude of 7-7.5). The addition of a single event of this magnitude to the earthquake database for this area would likely change the activity rate by less than a few percent and hence have a very small impact on the estimated seismic hazard at any of the nuclear facilities in the area.

Release

COMMUNICATION PLAN FOR POTENTIAL NEW FAULT AT
DIABLO CANYON POWER PLANT

GOALS

This communication plan describes the methods and tools that the Nuclear Regulatory Commission (NRC) staff will use to communicate with internal and external stakeholders regarding the potential new fault, which has informally been called the Shoreline Fault, that was identified in late 2008 about 1 kilometer (km) offshore of the Diablo Canyon Power Plant (DCPP).

BACKGROUND

Pacific Gas and Electric Company (PG&E), the licensee for the DCPP, is collaborating with the U.S. Geological Survey (USGS) to collect and analyze new geological, geophysical, and seismic data to develop improved tectonic models for the central California coastal region through a Collaborative Research and Development Agreement (CRADA). The research is in its second year of a 4-year program. PG&E provided a status of this effort to the NRC staff during a November 21, 2008, conference call.

Preliminary results from ongoing PG&E and USGS studies indicate that there may be a plane of earthquake epicenters approximately 15 km in length, located approximately 1 km offshore from DCPP. This apparent planar zone of seismicity may be found to be associated with a previously unevaluated seismically active fault. Initial evaluations indicate that the ground motion levels resulting from the hypothesized fault are expected to be bounded by those previously determined for the larger Hosgri fault. The Hosgri fault is an offshore fault located 5 km from the power plant.

Although the Hosgri fault is farther from the DCPP than the potential new fault, the Hosgri fault plane is much larger and can, therefore, produce larger magnitude earthquakes ($M=7.5$) than the potential 6.5 magnitude earthquake predicted for this hypothesized new fault. The energy released in a magnitude 7.5 earthquake is approximately 30 times the energy released in a magnitude 6.5 earthquake. Because the ground motions currently calculated for the potential new fault are bounded by those calculated for the Hosgri fault, the design and licensing basis evaluations of the DCPP structures, systems, and components (SSCs) are not expected to be adversely affected.

The information currently available on the potential fault indicates that the faulting mechanism is principally a vertical strike-slip. It is highly unusual for strike-slip faulting to cause the type of significant submarine terrain change necessary to cause a sizable tsunami. Most seismically induced tsunamis result from reverse faulting events, which have the capacity to cause rapid vertical displacement of the sea floor. Therefore, even if the identified zone of seismicity proves to be an active fault, it is highly unlikely to cause an exceedance of the plant's design-basis tsunami characteristics due to its orientation and strike-slip faulting mechanism.

The location of the hypothesized fault is approximately 1 km from DCPP, which is closer than the Hosgri fault. To date, the licensee has not found any indication of surface rupture of the hypothesized fault. Although the fault rupture is unlikely to occur directly under the plant, it may cause deformations in the near field. The potential impact of ground deformation primarily involves the buried components, such as piping and conduits. However, if ground deformations were to occur, they are expected to be minor

and would not have a significant impact on the DCPD SSCs. The action plan provided by PG&E details a path to acquire the data needed to appropriately address the issue.

KEY MESSAGES

The key messages to be communicated through this plan are as follows:

- The USGS and PG&E informed the NRC of preliminary results from its geological studies in the vicinity of DCPD. Based on these results, the licensee made a prompt operability determination that concluded the plant was within its design and licensing basis and that all SSCs remain operable. A more definitive and integrated analysis result is expected to be available in April 2009. USGS plans to present its initial findings at a Seismological Society of America meeting in April 2009.
- The licensee has evaluated the ground motion levels at the DCPD from the hypothesized fault and concluded that these motions would be bounded by the ground motion levels previously determined for the larger Hosgri fault. In addition, the licensee has stated that the tsunami hazard threat is relatively small since it is a strike-slip fault rather than a reverse fault and, therefore, the tsunami hazard is not expected to exceed the plant's design-basis tsunami characteristics.
- Even though the NRC has not been provided with any formal documentation for review, the staff has reviewed the draft information that has been made available and will continue to do so on an ongoing basis. Based on the information made available to the NRC, to date, the staff agrees with the licensee's preliminary conclusions regarding operability of the DCPD SCCs.
- The NRC has performed an evaluation of the tsunami hazard and an independent deterministic seismic hazard analysis of the potential fault based on the preliminary information currently available to confirm the licensee's conclusions regarding the operability of DCPD. Following NRC staff review, the NRC expects to make the study publicly available.
- The licensee provided to the NRC staff an action plan detailing field investigations and analyses to better characterize the potential Shoreline Fault near the DCPD. The NRC staff has reviewed the Action Plan and concluded that the Action Plan and schedule are sufficiently complete and comprehensive in scope for characterizing the Shoreline Fault and its potential effects on DCPD.
- The NRC staff will continue to monitor the progress of the fault investigation study by maintaining an open line of communication with the licensee on this subject.
- PG&E has informed the NRC that it is doing an in-depth probabilistic tsunami hazard assessment at the DCPD. The NRC has requested to review this study upon completion.

- The NRC staff will continue to review interim seismic studies related to the potential Shoreline Fault , as well as the final fault investigation study, to determine if a new fault exists, what the appropriate characterization and impact of the fault may be (if it exists), and if any licensee or regulatory action that may be needed.
- The final study is expected to be completed in December 2010. ~~USGS plans to present its initial findings at a Seismological Society of America meeting in April 2009.~~

AUDIENCE

The intended audience for this communication plan includes the following internal and external stakeholders.

Internal stakeholders:

Allegations Coordinator
 Office of Public Affairs (OPA)
 Office of Congressional Affairs (OCA)
 Office of Federal and State Materials and Environmental Management Programs (FSME)
 Office of Nuclear Regulatory Research (RES)
 Office of Nuclear Security and Incident Response (NSIR)
 Office of Nuclear Material Safety and Safeguards (NMSS)
 Office of General Counsel (OGC)
 Office of the Inspector General (OIG)
 Office of the Executive Director of Operations (EDO)
 Office of the Advisory Committee on Reactor Safeguards (ACRS)
 Office of New Reactors (NRO)
 Office of Nuclear Reactor Regulation (NRR)
 Regions
 Commission

External Stakeholders:

Public
 State energy program offices
 Congress
 Government agencies
 Industry groups (e.g., Nuclear Energy Institute)

COMMUNICATION TOOLS

NRR Web site

Information regarding the application will be made available to internal and external stakeholders through the NRR Web site

Public meetings

Conference calls

Telephone calls

OPA will coordinate all media with external stakeholders, as needed:

COMMUNICATION TEAM

The primary responsibility of the communication team is to ensure that it conveys a consistent, accurate, and timely message to all stakeholders. The team consists of the project management, technical, and communication staff named below.

TEAM MEMBER	POSITION	ORGANIZATION	PHONE
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Alan Wang	DCPP Project Manager	NRR/DORL/LPLIV	301-415-1445
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Tanya Mensah	Communications Assistant	EDO	301-415-0782
Raeann Shane	Sr. Congress Affairs Officer	OCA	301-415-1699

COMMUNICATION CHALLENGE

The issue is complex, clear communication to the public is important.

UPDATES AND REVISIONS

As appropriate.

FINAL CLOSE-OUT

Expected by the end of December 2011.

	ACTIVITIES FOR COMMUNICATING WITH INTERNAL AND EXTERNAL STAKEHOLDERS	OFFICE LEAD	DATE	STATUS
1	Submitted 50.72 notification with an operability assessment to the NRC (Event Number: 44675ML---))	PG&E	November 14, 2008	C
2	FAQ developed (attached)	Region IV	November 26, 2008	C
3	Summary of tsunami hazard (ML090820140 and ML083400496)	RES	December 5, 2008	C
4	Action Plan submitted to the NRC (ML090720505)	PG&E	December 17, 2008	C
5	The NRC concluded the Action Plan and schedule are reasonably complete and comprehensive in scope for this study. (ML090820113)	NRR	January 5, 2009	C
6	Issue summary of results of a deterministic seismic hazard assessment in a Research Information Letter_-(MLM L090330278 Draft-)	RES	TBD	
7	Presentation of more definitive results during a Seismological Society of America meeting. NRC staff members plan to attend.	USGS and PG&E	April 9, 2009	
8	Issue a safety evaluation regarding the operability of DCPD based on a deterministic hazard assessment and a preliminary review of the tsunami hazard by RES.	NRR DE & DORL	April 30, 2009	
9	Complete an operability evaluation of potential ground deformation	PG&E	April 30, 2009.	
10	Support a town-hall meeting, conducted by Region IV, in which the Shoreline Fault is expected to be discussed.	NRR, NRO, & RES	May 28, 2009	
11	Complete seismicity studies	PG&E	September 2009	
12	Complete geophysical studies	PG&E	December 2009	
13	Complete geologic studies	PG&E	December 2009	
14	Complete Shoreline Fault source characterization	PG&E	September 2010	
15	Complete ground motion studies	PG&E	September 2010	
16	Review interim reports as completed	NRR/DE	TBD	
17	Complete final report	PG&E	December 2010	
18	Review final report. to review the final report.	NRR DORL	TBD	
19	The NRC will perform a probabilistic seismic hazard assessment once sufficient information becomes available. DE will develop a users need request to RES/NRO to do assessment.	NRR	TBD	

QUESTIONS AND ANSWERS

1. How was the fault found?

The potential new fault was discovered while reviewing new data gathered as part of a research program being conducted by PG&E and the USGS to better understand the seismology of the central California coastal region. This effort is being conducted through a Collaborative Research and Development Agreement (CRADA) that began in 2007.

2. How long has this research being ongoing?

The CRADA has been ongoing since 2007 and is scheduled to be completed in 2010.

3. Where exactly is the fault?

The zone of seismicity that may indicate a fault is approximately 1 km offshore west of the Diablo Canyon Power Plant (DCPP).

4. When was the NRC notified of the new fault?

The licensee notified onsite inspectors of the fault on November 14, 2008.

5. Has the fault been completely characterized?

No. PG&E and the USGS continue to evaluate the fault through both field investigations and analyses. Interim results from the ongoing work will be provided in spring 2009. A full characterization that incorporates and integrates the full data set and related analysis will be completed in early 2010.

6. What effect does the new fault have on DCPP?

Based on current information, the new fault has a minimal effect on the risk to DCPP. Following identification, the licensee performed evaluations to estimate ground motion and deformation based on the potential new fault. The results of the initial evaluations indicate that the ground motion from this potential new fault would be bounded by the ground motion from the larger Hosgri fault to which the plant has been previously analyzed.

The location of the potential fault is approximately 1 km from DCPP, which is closer than the Hosgri fault. To date, the licensee has not found any indication of surface rupture of the potential fault. Although the fault rupture is unlikely to occur directly under the plant, it may cause deformations in the near field. The potential impact of ground deformation primarily involves the buried components, such as piping and conduits. However, if ground deformations were to occur, they are expected to be minor and would not have a significant impact on the DCPP structures, systems, and components (SSCs). The action plan provided by PG&E details a path to acquire the data needed to appropriately address the issue.

7. What is the Hosgri Fault?

The Hosgri fault is an offshore geological fault located 5 km to the west of the DCP. The Hosgri fault can produce a magnitude 7.5 earthquake and is the maximum earthquake that could be reasonably expected at the plant site. Prior to receiving the operating license for both DCP units, at the request of the NRC, PG&E performed an evaluation that confirmed the seismic adequacy of plant SSCs for the Hosgri design earthquake since it was not included in the plant's original design basis. The seismic qualification basis for the DCP is the original design basis plus the Hosgri evaluation basis.

8. Is it safe for DCP to continue to operate?

Yes. The evaluation of the initial data indicates that the ground motion calculated for the potential new fault would be bounded by the current Hosgri ground motion, to which the plant has been previously qualified.

To ensure public health and safety, DCP has a seismic reactor trip setpoint of 0.35g. If the ground acceleration at the plant site exceeds this setpoint, each reactor will automatically shut down to maintain plant safety and the health and safety of the public.

9. What were the licensee's immediate actions after notification of the new fault?

Once the potential new fault was confirmed, the licensee placed the issue into its corrective action program and notified the shift manager for an immediate operability determination. Since the initial evaluation concluded that the ground motions calculated for the potential new fault were bounded by the ground motions for the Hosgri fault, the shift manager determined that all plant SSCs remained operable. Following the initial operability determination, the licensee notified the onsite NRC inspectors.

The licensee developed and submitted an action plan to the NRC on December 17, 2008, which details its plan and schedule for studying and characterizing the Shoreline Fault and evaluating the potential impacts of the fault on the DCP. The evaluation will consider both ground motion and potential ground deformation.

Following additional data analysis, the licensee also notified external stakeholders. This included state agencies, state political representatives, and local media outlets.

10. What were the NRC's immediate actions after notification of the new fault?

Once notified, NRC inspectors verified that the licensee had placed the issue into their corrective action system. The inspectors also verified the appropriateness of the shift manager's immediate operability determination. The NRC (Region IV and NRR personnel) held a phone call with the licensee's senior management to discuss this issue and their plans for completing all required analysis. NRC staff reviewed the preliminary information available on the potential fault and performed an internal review of the data. This review indicated that the ground

motion level predicted for the potential new fault is bounded by the shaking levels previously calculated for the Hosgri fault.

11. What is the NRC doing in response to this new information?

Currently, the NRC is working with PG&E and the USGS to ensure all new data is thoroughly and properly analyzed.



Transmittal and Public Release of Draft Tsunami Hazards Report

January 3, 2006

Becky Karas (x3711)

Chief, Geoscience and Civil Engineering Branch, NRR

Mike Mayfield (x3298)

Director, Division of Engineering, NRR

Purpose and Overview

Briefing Purpose:

- Inform you of planned release of draft tsunami hazards report and anticipated stakeholder interest
- Receive feedback/concurrence on planned actions

Agenda:

- Background on issue
- Planned actions:
 - Communicating with stakeholders
 - NRC's ongoing tsunami assessment

Background on issue

- Study on Diablo Canyon tsunami hazard funded by NMSS to support Independent Spent Fuel Storage Installation (ISFSI)
- Draft report prepared by consultant (Dr. Sewell) to Center for Nuclear Waste Regulatory Analysis (CNWRA) – 11/03
 - Postulates a number of tsunami scenarios that produce flooding levels exceeding the critical level for the nuclear plant
 - Recommends PG&E perform a state-of-the-art assessment of tsunami hazard
 - Suggests evaluating the potential generic implications to other coastal nuclear facilities
- Draft report not endorsed by CNWRA based on its opinion of the study's technical adequacy, but forwards draft study to NMSS – 3/04

Background on issue

- NMSS finalized licensing of ISFSI based on:
 - Evaluation of Pacific Gas & Electric's (PG&E) more recent assessment of tsunami information
 - Higher ISFSI elevation compared to previously licensed nuclear plant
- Following Indonesian tsunami, NMSS forwarded draft report to NRR and RES – 2/05
- NRR and SFPO requested NRC's Seismic Issues Technical Advisory Group (SITAG) to review draft report – 5/05
- PG&E announced study of tsunami threat – 7/05
- SITAG concluded draft report based on rudimentary modeling and should not be used for licensing actions – 11/05
- NRR plans to provide draft report to PG&E for its information due to its ongoing study and to ensure public openness – potential for significant stakeholder & media interest

Planned actions:

Communicating with stakeholders

- Forwarding letter to PG&E with SITAG evaluation and Sewell's draft report would be placed in ADAMS and publicly available
- Prior to release, plan to:
 - Discuss SITAG's assessment of report with CNWRA and Dr. Sewell
 - Brief Commission TA's on issue
 - Issue communication plan
 - Recommend EDO communicate planned release to the President's Office of Science and Technology Policy (OSTP)
 - On 12/23/05, the AP reported OSTP issued a national tsunami plan including, in part, planned risk assessments for all U.S. coastal regions

Planned actions:

NRC's ongoing tsunami assessment

- Based on historical evidence, staff believes its current licensing basis for coastal nuclear facilities is adequate at this time
- Staff believes scientific developments warrant further study and evaluation
 - Plan to hold public meeting after PG&E completes its study
 - To discuss their results as NRC considers further studies or other actions
 - RES developing plan for tsunami study
 - Evaluate scientific developments and recommend any changes, if appropriate, to current licensing basis, or other actions

Conclusion

- Staff believes draft report should be released soon (next few weeks) before PG&E finalizes its study
- Staff recommends proposed actions for:
 - Stakeholder communications prior to and after release
 - Study of tsunami hazard
- Questions?

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March 24, 2011

**THE TŌHOKU EARTHQUAKE OF MARCH 11, 2011: A PRELIMINARY REPORT
ON IMPLICATIONS FOR COASTAL CALIFORNIA**

To: Commissioners and interested parties
From: Mark Johnson, Staff Geologist

This report is intended to help the Commission place the recent events in Japan in context and to provide perspective for their possible implications to coastal California, based on preliminary information known at this early date. The discussion below includes the following:

- A description of the Tōhoku Earthquake and tsunami effects
- An evaluation of whether the seismic characteristics of the Tōhoku Earthquake are applicable to the California coast
- A brief description of the earthquake and tsunami risks at California's three coastal nuclear facilities

References and links to web resources can be found at the end of this report. Some words or phrases are further explained in an appendix. These words or phrases are marked in *bold italics* where they first occur.

EXECUTIVE SUMMARY

- **The vast majority of faults in California, including the San Andreas fault, could not produce a magnitude 9 earthquake.**
Most of California is not susceptible to an event of the scale of the Tōhoku Earthquake. Nevertheless, it is important not to become complacent; large earthquakes are inevitable throughout coastal California, and could be devastating in their own right. There is a large population and much infrastructure at risk in central and southern coastal California.
- **The Cascadia Subduction Zone could produce a magnitude 9 earthquake similar to the Tōhoku Earthquake.**
The northern part of the coastal California, as well as all of coastal Oregon, Washington, and part of coastal British Columbia—the Cascadia Subduction Zone—is susceptible to an

earthquake and tsunami event similar to that of the Tōhoku Earthquake. Emergency response scenarios and land use planning must take this into account.

- **A nuclear emergency such as is occurring in Japan is extremely unlikely at the state's two operating nuclear power plants.**

The combination of strong ground motion and massive tsunami that occurred in Japan cannot be generated by faults near the San Onofre Nuclear Generating Station and the Diablo Canyon Power Plant. Nevertheless, the geologic conditions near those plants are very likely different than previously believed and ongoing study is warranted. This has been understood for at least the past three years, and some of these studies, and the environmental planning process for other such studies, are underway.

The Tōhoku Earthquake and Tsunami

The magnitude 9.0 Tōhoku Earthquake of March 11, 2011, the fourth most powerful earthquake measured by modern instruments (since about the year 1900), occurred at the interface between the *Pacific* and *North America plates*. Two days prior to the earthquake, a magnitude 7.2 earthquake occurred near what would be the *epicenter* of the Tōhoku Earthquake. It was followed by three aftershocks in the magnitude 6 range later that day. In retrospect, these earthquakes can be viewed as foreshocks to the magnitude 9.0 event that followed. The *hypocenter* of the Tōhoku Earthquake was located 81 miles off the east coast of the Oshika Peninsula, part of the Tōhoku region of the island of Honshu, near the city of Sendai, at a depth of 20 miles below the seafloor.

Over the next several days, hundreds of aftershocks, the largest of magnitude 6.8, outlined the area of the plate boundary that ruptured. Aftershocks extend to depths of about 340 miles, although most are above a depth of 125 miles. As of March 23, some 726 aftershocks have been recorded, 26 of them magnitude 6.0 or greater, and they are expected to continue, at a decreasing frequency, for the next several years.

The Tōhoku Earthquake is what is termed a “*megathrust earthquake*,” a major *subduction zone* earthquake whereby the Pacific plate suddenly lurched beneath the North America plate. The affected portion of the North America plate is a westward and southward extension of the plate from the Alaska region that underlies eastern Siberia and the northern Sea of Japan. Some geologists divide this geologically complex region into a number of microplates (for a representation of the geometry of these plates, see <http://pubs.usgs.gov/gip/dynamic/slabs.html>).

The area of the plate boundary that *ruptured* during this earthquake was about 190 miles long and 90 miles wide, which is larger than the areas of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego counties combined. At the location of the earthquake, *oceanic crust* of the Pacific plate is being thrust under oceanic crust of the North America plate at an angle of about 15 degrees, creating the Japan Trench, a bathymetric trough on the seafloor. The average rate of this movement is approximately 83 mm/yr, one of the higher rates of *plate*

convergence in the world. Much of this movement occurs episodically in earthquakes such as the Tōhoku Earthquake.

The Tōhoku Earthquake was accompanied by violent and long-lasting ground shaking. The highest measured *ground acceleration* was a devastating $2.75 g^1$, measured over 80 miles from the epicenter, although most stations relatively near the epicenter reported ground accelerations more on the order of $1.0 g$. Ground shaking intensity reached a *Modified Mercalli Intensity* of IX (Violent), and resulted in widespread damage. Damaging secondary effects included liquefaction, lateral spread, and landslides.

The most damaging secondary effect of the earthquake was the resulting tsunami. Megathrust earthquakes of this magnitude occurring beneath the sea at relatively shallow depths always produce large tsunamis and the Tōhoku Earthquake was no exception. About 15 minutes after the earthquake, a tsunami with an amplitude of about 30 feet hit the shoreline. The first wave swept up to six miles inland in flat regions, leveling buildings, and sweeping debris, buildings, ships, vehicles, and airplanes far inland.

The tsunami caused the loss of power, and disabled backup generators, at the Fukushima 1 nuclear power plant. The subsequent loss of coolant in several reactors and spent fuel storage pools resulted in explosions, fires, and partial core meltdowns in at least three nuclear reactors, and the release of radiation to the environment.

The full extent of the damage resulting from the Tōhoku earthquake and tsunami is still unknown and will likely be unknown for some time. Given the thousands of lives that have been lost, the billions of dollars worth of property and infrastructure destroyed, and the ongoing nuclear emergency, it is natural to ask how vulnerable California is to a similar event.

Does the Tōhoku quake increase the likelihood of a similar event in California?

Despite some alarmist articles that have appeared in the press, there is no reason to believe that this earthquake has in-and-of-itself raised the likelihood of an earthquake in California. Although there have been three very damaging earthquakes around the Pacific Rim in just the last year, they are not related in a geologic sense.

The magnitude 8.8 southern Chilean earthquake of 27 February 2010 was a major subduction zone earthquake similar in many ways to the Tōhoku Earthquake, but it occurred on a separate plate boundary (the Nazca/South America plate boundary) with no connection to the Pacific or North America plates.

¹ Ground shaking during earthquakes is measured by how fast the earth moves, both horizontally and vertically. It is expressed as a comparison to the force of gravity – that is, the acceleration (which is the rate of change in speed) of the ground relative to the acceleration caused by gravity (or g-force). For instance, ground shaking of $1.0g$ is equal to the acceleration caused by gravity, shaking of $0.5g$ is equal to half the acceleration of gravity, etc. For any location and earthquake, this value varies based on a number of factors, including the area of the fault plane that slipped, depth of the earthquake, distance from the epicenter, and the underlying site geology.

The magnitude 7.1 Canterbury Earthquake of September 4, 2010 near Christchurch, New Zealand, together with its destructive February 22, 2011 magnitude 6.3 aftershock, was not a major plate boundary earthquake, but rather a significant earthquake on shallow crustal faults. The fact that its major aftershock (dubbed the Christchurch Earthquake) was so damaging is more a product of its location and shallow depth than of its significance as a geologic phenomenon.

The relatively recent magnitude 9.1 and 8.6 earthquakes of 2004 and 2005 off the island of Sumatra were far removed from the Pacific plate, and most seismologists do not feel that stress transfer to the Pacific plate occurred as a result of these events.

Although geologists are increasingly realizing that large earthquakes may load stress on adjacent faults, there is no connection between the faults associated with any of these earthquakes and any faults in California. The United States Geological Survey (USGS) writes on their website for the event:

The USGS does not believe that the earthquakes in Japan have significantly raised the probability of future major earthquakes. While the probability of future large earthquakes far from northern Honshu has not increased, neither has it decreased and large earthquakes will continue to occur just as we have observed in the past.

Could an earthquake of this magnitude occur in California?

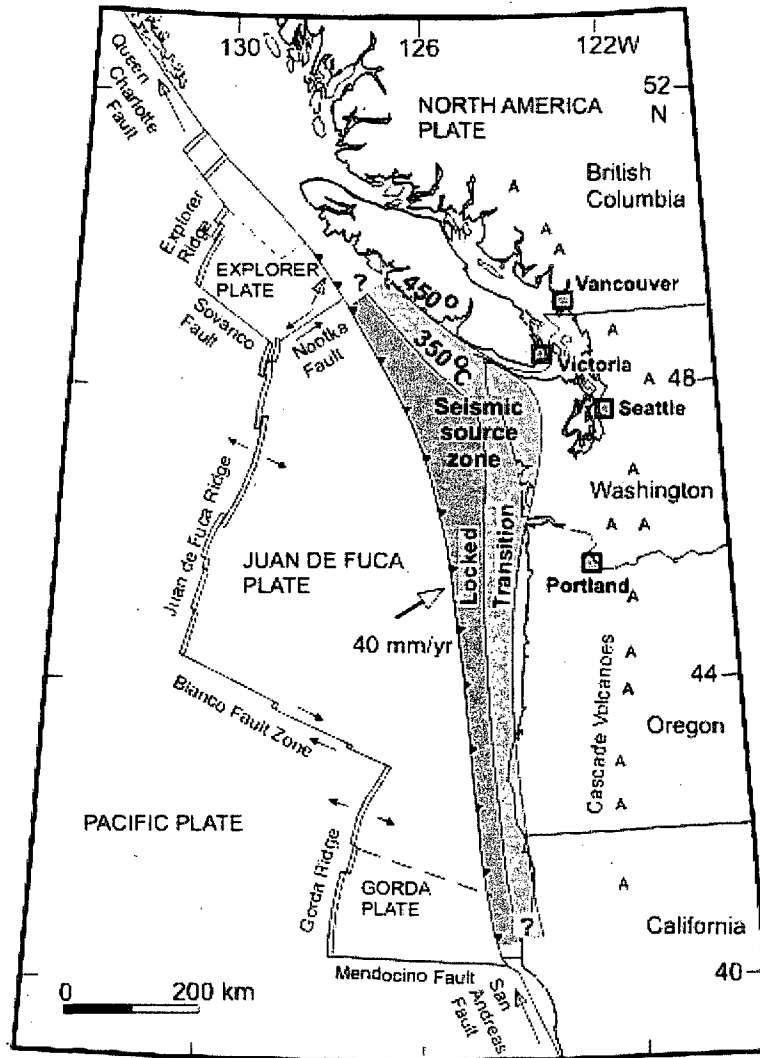
Most faults in California are incapable of an earthquake of the magnitude of the Tōhoku Earthquake. A magnitude 9 earthquake requires rupturing a fault surface thousands of square miles in area. The shallow faults making up most of the state's California's fault systems, including the San Andreas fault, simply do not have sufficient area to generate such an earthquake.

An important exception is the region north of Cape Mendocino, from about 25 miles south of Eureka to north of Vancouver, British Columbia, an area known as the Cascadia Subduction Zone. This region could generate an earthquake comparable to the Tōhoku Earthquake. There are important similarities, and some differences, between the Cascadia Subduction Zone and the part of the subduction zone off the Tōhoku region of Japan that ruptured during the Tōhoku Earthquake.

The Cascadia Subduction Zone

The Cascadia Subduction Zone lies off the Pacific Northwest, and is the zone where the Gorda, Juan de Fuca, and Explorer plates are being thrust beneath the overriding North America plate. Unlike the situation at the Japan Trench, where oceanic crust is thrust beneath other oceanic crust, here oceanic crust is thrust beneath continental crust. The Gorda, Juan de Fuca, and Explorer plates are separated from the Pacific plate by the Juan de Fuca and Gorda Ridges to the west and by the Mendocino Transform Fault to the south. Two prominent sets of fracture zones, healed *transform faults*, are zones of weakness and separate the Explorer plate to the north from

the Juan de Fuca plate to the south, and the Juan de Fuca plate from the Gorda plate further south. All three subplates are moving together, converging on the North America plate at a rate of about 40 mm/yr and diving beneath it at an angle of about 8 degrees, an angle that increases with depth. The upper portion of the subduction zone is locked (not moving), while the lower section is moving, thus creating great stress in the upper part of the subduction zone. Release of this stress will occur during the next megathrust earthquake.



Source: Geological Survey of Canada
http://gsc.nrcan.gc.ca/geodyn/cascadia_e.php

The Cascadia Subduction Zone, about 800 miles long, is thus divided into three segments. The longest segment, about 450 miles long, is the Juan de Fuca plate segment that lies off central and northern Oregon and Washington. The Juan de Fuca plate segment is flanked by the Explorer plate segment, off British Columbia, and the Gorda plate segment, off northern California and southern Oregon, each about 175 miles long. It is unknown if the segments typically rupture together, separately, or in pairs during megathrust earthquakes. This introduces some uncertainty into the estimation of the magnitude of megathrust earthquakes in the Cascadia Subduction Zone.

Nevertheless, most seismologists agree that a megathrust earthquake involving any of these plates would be in the magnitude 9 range, similar to the Tōhoku Earthquake.

Thirteen past megathrust earthquakes associated with the Cascadia Subduction Zone have been identified through submarine sediment deposits triggered by the earthquakes, tsunami deposits preserved on land, and deposits indicative of sudden land subsidence associated with the earthquakes. Of these past earthquakes, the last seven are reasonably well-dated:

Estimated Date	Recurrence Interval (yr)
26 January 1700, ~9:00 PM	780
780-1190 AD	210
690-730 AD	330
350-420 AD	910
660-440 BC	400
980-890 BC	250
1440-1340 BC	unknown

Reference: Atwater et al., 2005

The time of the most recent event is known with such precision because, even though there are no written records from North America, Japanese writings describe an “orphan tsunami” (one not accompanied by an earthquake) arriving in Japan at a time that would correspond to an earthquake on the Cascadia Subduction Zone at about 9:00 PM (local time) on January 26, 1700. This time and date are consistent with the geologic data, and with Yurok legends indicating that the earthquake and tsunami occurred early on a winter night in about that year.

The probability of another megathrust earthquake on the Cascadia Subduction Zone in any given upcoming time interval can be estimated from these recurrence interval data. The mean recurrence interval is 500-600 years. According to a study by Mazzotti and Adams (2004), this yields a probability of between 0 and 12 percent that the next megathrust earthquake will occur in the next 50 years.

However, close examination of the recurrence interval data show that they may be bimodal in distribution: three earthquakes in relatively quick succession, followed by a long pause; then three earthquakes, followed by a long pause, ending in the 1700 event. A sample size of seven events is too small to confirm that this is a real trend, but there are geologic reasons that such a bimodal recurrence interval distribution might make sense. Assuming a bimodal recurrence interval, with the two “modes” being recurrence intervals of 310 and 820 years, the probability of a megathrust earthquake occurring in the next 50 years rises to between 6 and 45 percent.

Finally, it has been recently discovered that, in addition to megathrust earthquakes, a significant amount of the convergence between the Juan de Fuca and North America plates is taken up by what has been termed “slow-slip” events. These are events, lasting one to three weeks and recurring every 13-15 months, when movement between the plates occurs at great depths without causing significant earthquakes. Mazzotti and Adams (2004) calculate that the chance of a

megathrust earthquake occurring during one of these slow-slip events is 30 to 100 times greater than between events.

To summarize, an earthquake and tsunami looking very much like the Tōhoku Earthquake is very likely in northern California. It is, however, very difficult to predict the probability of such an event in any given time interval. The interagency Cascadia Region Earthquake Workgroup (CREW) continues to study and prepare for the next megathrust earthquake. In 2005 they published a very useful and informative planning scenario, which can be found at <http://www.crew.org/papers/CREWCascadiaFinal.pdf>.

Implications for California Nuclear Power Plants and Spent Fuel Storage Facilities

There are two operating nuclear power plants in the California coastal zone and one nuclear plant undergoing decommissioning. The Diablo Canyon Power Plant (DCPP) in San Luis Obispo County and the San Onofre Nuclear Generating Station (SONGS) in northern San Diego County are operating power plants that hold current licenses from the Nuclear Regulatory Commission (NRC). The nuclear unit of the Humboldt Bay Power Plant (HBPP) near Eureka is being decommissioned, although highly radioactive spent fuel and other materials remain on site. A magnitude 9 earthquake near DCPP or SONGS is extremely unlikely. However, the Humboldt Bay plant is in close proximity to the Cascadia Subduction Zone and could be subject to a magnitude 9 earthquake.

All three facilities, including their spent fuel storage facilities, have been subject to numerous seismic investigations. During the permitting process for the Independent Spent Fuel Storage Installation (ISFSI) at each facility, Southern California Edison (SCE) and Pacific Gas and Electric (PG&E) undertook new geologic investigations; particularly extensive for Diablo Canyon and Humboldt Bay. These studies, along with studies undertaken for the original licensing of these plants, ongoing USGS and academic studies, and experience gained from geologically similar regions, were reviewed by the U.S. Nuclear Regulatory Commission (NRC), which ultimately released Final Safety Analysis Reports (FSARs) recommending approval of each facility.

During Coastal Commission review and permitting of each ISFSI, Commission staff reviewed all of this material, conducted independent research of published literature, interviewed knowledgeable parties, and conducted site visits at and around each facility, prior to recommending that the Commission approve each facility. The Commission's adopted findings for each approval can be found at:

DCPP: <http://www.coastal.ca.gov/energy/W5a-1-2005.pdf>

SONGS: <http://www.coastal.ca.gov/energy/e-00-14rf.pdf>

HBPP: <http://www.coastal.ca.gov/energy/Th6a-9-2005.pdf>

The expected earthquake and tsunami risk at each facility is described briefly below.

Diablo Canyon Nuclear Power Plant

Earthquake Concerns: Although a magnitude 9 earthquake is extremely unlikely near the DCP, a magnitude 7.2 earthquake on the Hosgri Fault, lying only 3 miles offshore, is currently considered possible.

The Hosgri Fault was discovered during the construction of the plant. In 1975 the NRC, in conjunction with the USGS, concluded that the Hosgri Fault is capable of a magnitude 7.5 earthquake, and that ground shaking at DCP could be as high as 0.75 g. PG&E retrofitted the plant in 1978 to withstand that level of ground shaking. In 1978 the NRC required the implementation of a Long Term Seismic Program, through which the seismic safety at the plant would be continuously reevaluated. In 1991, NRC approved a report from PG&E that, using improved earthquake models, showed that the maximum credible earthquake on the Hosgri fault was of magnitude 7.2, but that ground shaking at DCP would be as high as 0.83 g. PG&E demonstrated to the satisfaction of the NRC that the plant had been retrofitted in 1978 with adequate safety margins to withstand that level of ground shaking.

The most recent study submitted to the NRC by PG&E examined ground shaking that would result from an earthquake on the newly discovered, "Shoreline Fault" located less than 0.5 miles from the reactor building. Preliminary results of those studies indicate that the potential ground shaking from this fault will be less than those used in the initial plant design. The report of these studies, available at <http://diablocanyonpge.com/home/resources/shoreline-fault-zone-report-with-plates.html> is currently under review by the NRC, as well as by state geologists from a number of agencies, including the Coastal Commission.

As discussed below, AB 1632 required that the State prepare a report making recommendations to facilitate assessing, among other things, the seismic safety of DCP and SONGS. One of the recommendations in that report is for further detailed investigation not only of the Shoreline Fault, but of the total seismic environment of the plant. These studies are currently underway. The proposed high-energy studies meant to identify seismic characteristics deep below the plant and surrounding area will be subject to CEQA review and will require review and permitting by the Coastal Commission.

Tsunami Concerns: DCP is located at an elevation of 85 feet above mean sea level (MSL), atop a high coastal bluff. It is effectively above the range of any conceivable earthquake-induced tsunami, and is mapped as lying outside of the tsunami inundation zone on the Tsunami Inundation Maps recently released by the California Emergency Management Agency, California Geological Survey, and the University of Southern California.

San Onofre Nuclear Generating Station

Unit 1 of the San Onofre Nuclear Generating Station was commissioned in 1968, and was designed to resist ground shaking of 0.67g corresponding to a magnitude 7.0 earthquake on the nearby Newport-Inglewood-Rose Canyon Fault system. Units 2 and 3 were commissioned in

1983 and 1984 to the same design standard. Unit 1 was decommissioned in 1992, but radioactive portions of the reactor still remain at the plant.

Earthquake Concerns: Although a magnitude 9 earthquake is extremely unlikely near SONGS, a few studies indicate that an earthquake larger than the design-basis earthquake may be possible near the reactor site. The Commission considered these studies in its findings for the ISFSI approval in June 2001 and concluded that:

...there appears to be credible evidence that, in addition to the strike-slip faulting recognized at the time of the SONGS licensing review, thrust faults exist in the area offshore of the SONGS site which might interact with the Newport-Inglewood-Rose Canyon fault system in a complex way during an earthquake. If these faults are active or potentially active, the increase in potential fault rupture area has, at a minimum, the potential to increase the magnitude of an earthquake on the integrated fault system. Geologists' understanding of this area is rapidly evolving, and there are few constraints on the parameters needed to assess the increase in earthquake risk (such as slip rate on each of the potentially active faults, segmentation of the faults, and potential for cascading failure between fault segments). One of the few published estimates is that of Shaw and his students (Rivero et al., 2000), who hypothesize that the combined system may be capable of an earthquake ranging from M_w 7.1 to 7.6, depending on which sets of faults are involved in the earthquake...

Shaw's tectonic model for the area is, however, quite controversial (Jones, USGS, pers. comm., 2001). Commission staff consulted with seismologists and geologists at the U.S. Geological Survey, California Division of Mines and Geology, California Seismic Safety Commission, within academia, and at private consulting firms. Although there was near unanimous recognition that there is an increased earthquake risk given our emerging understanding of the complexities of the region relative to a simple strike-slip model used in the SONGS seismic hazard assessments, no one could assess the potential ground shaking that might be expected at the SONGS site.

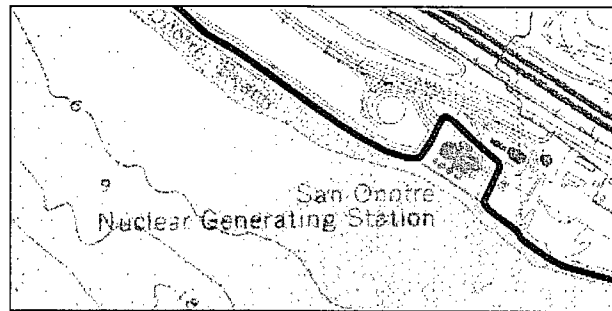
The Commission thus finds that there is credible reason to believe that the design basis earthquake approved by the NRC at the time of the licensing of SONGS 2 and 3—a magnitude 7.0 earthquake on the Newport-Inglewood-Rose Canyon fault system 8 km from the site, resulting in ground shaking with a high frequency component peaking at 0.67 g—may underestimate the seismic risk at the site. This does not mean that the facility is unsafe—although the design basis earthquake may have been undersized, the plant was engineered with very large margins of safety, and would very likely be able to attain a safe shutdown even given the larger ground accelerations that might occur during a much larger earthquake.

Tsunami Concerns: Tsunami run up and inundation were considered by the SCE and NRC for permitting of the SONGS facility. However, more recent examinations indicate that a larger earthquake or a large submarine landslide could generate a tsunami larger than that considered by SCE or the NRC. The potential tsunami risk was included in the Commission's findings for the ISFSI permit which concluded:

These studies suggest that large local-source tsunamis could be generated by mechanisms other than those considered during licensing for SONGS 2 and 3, the basis for the 1995 SCE report. However, there have been no local runup studies based on this mechanism that are widely agreed upon, and certainly none for the SONGS site itself. As Dr. [Mark] Legg indicates, tsunami runup maps are currently being prepared for San Diego County by individuals at the University of Southern California in conjunction with the Office of Emergency Services, but they are not currently available.

Commission staff accordingly concludes that although the proposed project may be threatened by tsunami, the major effect from an earthquake-generated tsunami would be site inundation. Possible inundation has been factored into the [ISFSI] project design; and it would not adversely [a]ffect the stability of the site. There is also a potential for a submarine landslide to generate a tsunami that could threaten this site; however, current mapping and modeling do not provide any information of how the site would be [a]ffected by such an event.

The maps mentioned have since been produced, and they do, in fact, place the SONGS facility in the tsunami inundation zone:



The SONGS site was excavated into the coastal bluff and the nuclear reactors are located at an elevation of less than 20 feet MSL. The tsunami inundation line calculated for this area is at an elevation of approximately 20 feet MSL, and the plant is protected by a 30-foot seawall. Thus, it appears to be protected from the modeled set of tsunamis underlying the state map. How the inundation line on the state map might change if it included the magnitude 7.6 thrust earthquake postulated by Shaw and others is not, however, known. Further study of the tsunami risk at the SONGS facility appears warranted.

Humboldt Bay Power Plant

The Humboldt Bay Power Plant is susceptible to a megathrust earthquake on the Cascadia Subduction Zone. The nuclear unit at HBPP has been shut down since 1976, largely for seismic hazard reasons, and currently is undergoing decommissioning. PG&E expects to complete decommissioning by about 2015. Highly radioactive spent fuel remains on site. Until recently, this fuel was stored in the same type of pool that apparently has been compromised in Japan. In 2005 the Coastal Commission approved a small Independent Spent Fuel Storage Installation (ISFSI) to contain this material. Unlike the ISFSI's at SONGS and DCP, the casks containing the spent fuel and highly radioactive components of the decommissioned reactor are located below ground, in part to make them less vulnerable to tsunamis.

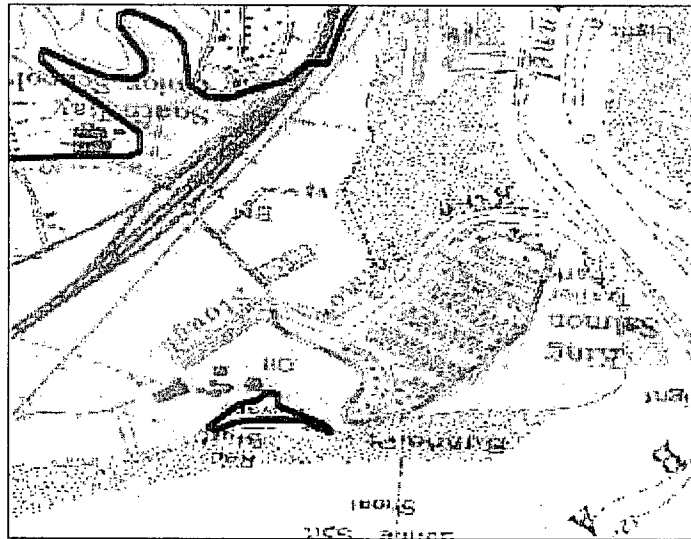
Earthquake Concerns: Regarding ground shaking, the Commission's findings for the Independent Spent Fuel Storage Installation concluded that the facility was designed to withstand the expected level of ground motion:

PG&E designed the ISFSI in part using a probabilistic assessment of the "maximum credible earthquake" likely to occur at the site during a 2000-year return period. This design earthquake is

PG&E assessed how the ISFSI site likely would be affected by tsunamis and tsunami runups. It determined that the maximum tsunami runup resulting from a Cascadian Subduction Zone earthquake during Mean High Water would be from about 23 to 38 feet. Because the ISFSI site is at about 44 feet, and because it is below grade, PG&E concludes that the ISFSI would not be inundated and would not be damaged by debris carried by the tsunami.

However, for several reasons, the Commission cannot conclude that the site will be safe from tsunami hazards either during the relatively short-term or in perpetuity. First, similarities between the expected Cascadian Subduction Zone earthquakes and the December 2004 Sumatran earthquake raise doubts as to the validity of the expected tsunami runup height at the ISFSI site.

The Coastal Commission found in September 2005 that the ISFSI is susceptible to tsunami hazards, including higher runup levels than predicted during the NRC licensing process, and the danger of bluff erosion due to energy from both incoming and retreating waves. As summarized in the Commission staff report:



Tsunami Concerns: The site clearly is at high risk for a tsunami generated during a Cascadia Subduction Zone event. This general region is by far the most studied area on the west coast of North America with respect to tsunami hazards, with many of those studies being funded by PG&E and summarized in the NRC's FSAR for the site. The State's Tsunami Inundation Map shows that the entire site, except for a small area at the top of Buhne Hill, lies in the predicted inundation zone. That small hilltop is the approximate location of the ISFSI.

of magnitude 9.1, roughly equivalent to the recent Sumatra earthquake of December 2004, and has a peak acceleration of almost 2.9 g, which is equivalent to the force near the upper limit of any earthquake anywhere in the world. The Commission's staff geologist has objected to the use of a 200-year return period and instead recommends the use of a 10,000-year return period; however, the Commission concurs with his determination that the overall assessment provided by PG&E results in a conservative design basis for the ISFSI. The Commission therefore recommends that designing the ISFSI to withstand this rate of ground shaking is consistent with Coastal Act section 30253(1) with respect to the ground motion hazard.

The Sumatran quake resulted in tsunami runups of as much as 130 feet, which is about three times higher than the runup predicted at the ISFSI site, but the mechanisms for the earthquakes and the generation of tsunamis in each area are similar. Additionally, the predicted 38-foot runup at the ISFSI site is based only on the height above Mean Higher High Water and does not include the customary additional height provided if the tsunami occurred during a 100-year storm surge. This would put the runup at an even higher level, possibly at or above the 44-foot elevation of the ISFSI structure. Further, the ISFSI site is on a peninsula made up of poorly consolidated soils, and it would be subject during a tsunami to wave energy from both incoming and retreating waves, which could result in substantial erosion and damage to the ISFSI site.

Finally, because the ISFSI is expected to remain in perpetuity, Commission staff requested PG&E evaluate the longer-term potential for tsunami effects. PG&E applied the rate of tectonic uplift at Buhne Point (estimated at about 1.3 feet per 100 years) to several scenarios for anticipated rates of sea level rise. The analyses found that during the next several thousand years, overtopping of the site would be likely, though over the next 10,000 years, the anticipated sea level will likely fall due to increased glaciation and that ISFSI site would become less exposed to risks associated with sea level rise or tsunamis.

Therefore, based on the above, the Commission finds that the siting of the ISFSI is inconsistent with the requirement of Section 30253(1) to minimize risks associated with tsunamis and tsunami runup.

Although the Commission found the project was inconsistent with Coastal Act section 30253 for this and other reasons, as well as other Chapter 3 policies of the Coastal Act, it approved the ISFSI, in large part due to the lack of safer alternative storage sites for the material and the hazards of transporting the material offsite. The Commission's findings state:

Denying the ISFSI on the basis of these inconsistencies would result in the continued presence of the existing storage facility, which would likely result in significant adverse impacts to marine biology, water quality, and environmentally sensitive habitat areas caused by the same geologic hazards that make the blufftop a safer location than the existing storage pool. In such a situation, when a proposed project is inconsistent with a Chapter 3 policy, and denial or modification of the project would be inconsistent with another policy, Section 30007.5 of the Coastal Act provides for resolution of such a policy conflict.

Simply put, although the site is unsafe, keeping the spent fuel in subterranean casks in a hazardous location is less unsafe than keeping the material in the spent fuel pool within the nearby and lower elevation reactor building, where it had been kept for the previous several decades. After Commission approval of the facility, all spent fuel at the site has been moved into the ISFSI. The Commission will soon review an application for an expansion of this facility to accommodate low and mid-level radioactive waste being generated during the HBPP decommissioning process.

Ongoing and Planned Seismic Studies

Both state and federal legislators have in recent days called for renewed study of the seismic safety of nuclear power plants in California and the United States, respectively; however, such studies are in fact already underway in California. AB 1632 (Blakeslee, Statutes of 2006, Chapter 722), directed the California Energy Commission to assess the vulnerability of the state's operating nuclear power plants to a major disruption due to a major seismic event or plant aging,

the potential impacts of such a disruption, potential impacts from the accumulation of nuclear waste at the state's existing nuclear plants, and other key policy and planning issues regarding the future role of California's existing nuclear plants. In 2008, the Energy Commission released the required report "An Assessment of California's Nuclear Power Plants" which can be found at: <http://www.energy.ca.gov/2008publications/CEC-100-2008-009/CEC-100-2008-009-CMF.PDF>

The California Public Utilities Commission has since required PG&E and SCE to undertake the studies recommended in the report, which include, among other things, 3D seismic imaging of the faults around both sites, in order to answer some of the questions about fault geometry and expected ground motions during different earthquake scenarios. The Coastal Commission's staff geologist sits on an Independent Peer Review Panel which reviewed the production of the AB 1632 report and will review the study plan, results, and interpretation of these studies as they proceed. PG&E has begun some of these studies, and has begun the environmental review process for others. SCE, who is not proceeding with relicensing on as aggressive a time schedule as PG&E, has not yet produced plans for the required studies.

Effects of the Tōhoku Earthquake Tsunami in California

The Tōhoku Earthquake produced a tsunami felt throughout the Pacific Ocean. California was moderately impacted, and several harbors around the state suffered damage, collectively totaling tens of millions of dollars. Fortunately, given the state's tsunami preparedness, and the many hours warning time afforded by this distant-source tsunami, early evacuation and preparation were effective and losses were kept to a minimum, although there was one death associated with the tsunami. The Coastal Commission's coastal engineer will prepare an evaluation of preparations, events, responses, and results of this major test of the state's tsunami preparedness and response program in the near future.

Implications for Predictions of Future Sea Level Rise

The way the land responds to a megathrust earthquake such as is expected in the Cascadia Subduction Zone has important implications for planning for future sea level rise. When a subduction zone is locked (not moving through small earthquakes) at the surface, but is moving at depth, as is the case in the Cascadia Subduction Zone, there is a region close to the coast where the land is rising. Further inland is a region of gradual land subsidence. When the locked upper portion of the subduction zone builds up sufficient stress, it suddenly slips (causing a megathrust earthquake), and the region of uplift near the coast suddenly subsides, while the region further inland rises. The Incorporated Research Institutions for Seismology (IRIS) has produced an excellent animation illustrating this process, which can be found at <http://www.youtube.com/watch?v=RVaDXsqLUtI>

In northern coastal California, the land has been rising faster than global average sea level since the 1700 megathrust event, and the long-term average sea level rise *relative to the land* is actually negative (-0.65 mm/yr at Crescent City, for example); *relative* sea level in this region is falling. As global average sea level rise continues to accelerate, the rate of *relative* sea level *fall*

in northern California will decrease, but the uplift of the land will reduce the effects of global sea level rise relative to elsewhere on the coast.

One consequence of the next Cascadia Subduction Zone earthquake is that this effect will be suddenly undone. Past Cascadia Subduction Zone earthquakes have typically resulted in a sudden land subsidence of about six feet. This figure is consistent with what has been observed following other megathrust earthquakes around the world. This sudden subsidence needs to be taken into account when planning for future sea level rise. The National Academy of Science has, at the request of the western states' governors, convened a panel to provide recommendations for predicting sea level trends in California, Oregon, and Washington over the next century. The panel is well aware of this phenomenon, and it will be interesting to see how they incorporate it into their recommendations.

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AB1632 Report: <http://www.energy.ca.gov/ab1632/index.html>

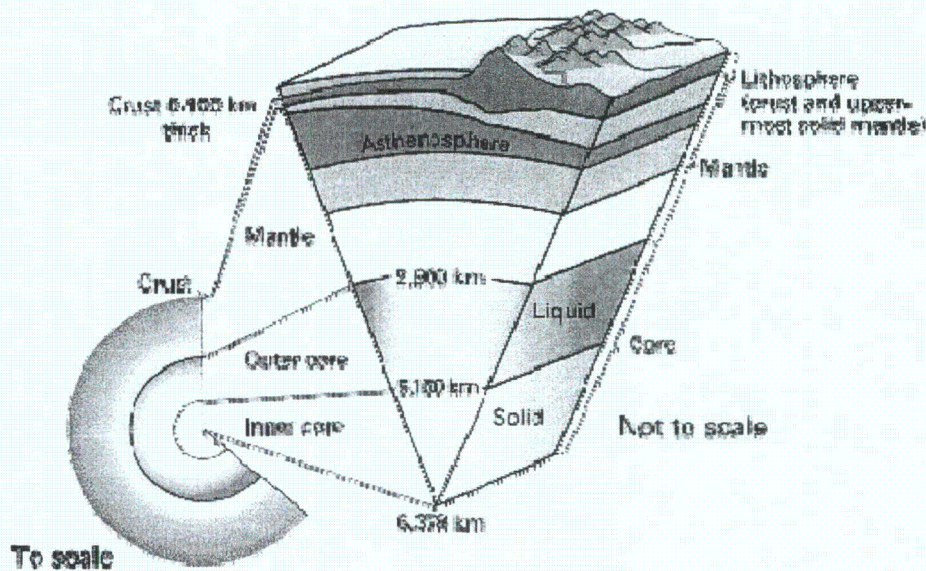
CREW Scenario: <http://www.crew.org/papers/CREWCascadiaFinal.pdf>

APPENDIX: EXPLANATION OF TERMS AND PROCESSES

Plate tectonics

This section is adapted from a USGS publication entitled *This Dynamic Earth*; see <http://pubs.usgs.gov/gip/dynamic/inside.html>

The interior of the Earth can be divided into three sections—the crust, mantle, and core. This layered structure can be compared to that of a boiled egg. The crust, the outermost layer, is rigid and very thin compared with the other two. Beneath the oceans, the crust is made up mostly of dense rocks such as gabbro and basalt and is only about 5 km thick. The thickness of the crust beneath continents is mostly made up of less dense granite and averages 30 km in thickness. The Earth's crust is brittle and can break.

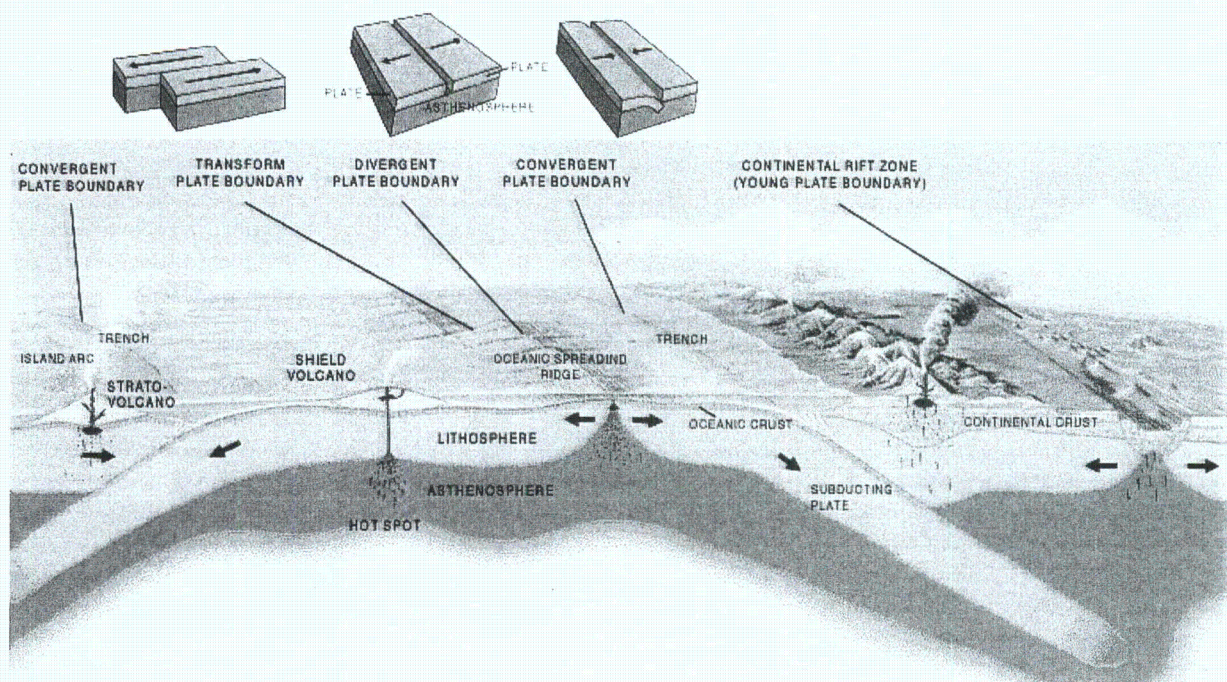


Below the crust is the mantle, a dense, hot layer of semi-solid rock approximately 2,900 km thick. The mantle is hotter and denser because temperature and pressure inside the Earth increase with depth. At the center of the Earth lies the core, which is nearly twice as dense as the mantle because its composition is metallic (iron-nickel alloy) rather than stony. The Earth's core is made up of two parts: a 2,200 km-thick liquid outer core and a 1,250 km-thick solid inner core.

The upper part of the mantle is cooler and more rigid than the deep mantle; in many ways, it behaves like the overlying crust. Together they form a rigid layer of rock called the lithosphere. Averaging 80 km in thickness, the lithosphere has been broken up into the moving plates that contain the world's continents and oceans. Below the lithosphere is a relatively narrow, mobile zone in the mantle called the asthenosphere. The rigid lithosphere is thought to "float" or move about on the slowly flowing asthenosphere. The

movement of the lithospheric plates atop the plastic asthenosphere is the root of plate tectonics. The plates interact at the Earth's surface in a number of ways, with three main types of boundaries between them:

- Divergent boundaries -- where new crust is generated as the plates pull away from each other.
- Convergent boundaries -- where crust is destroyed as one plate dives under another.
- Transform boundaries -- where crust is neither produced nor destroyed as the plates slide horizontally past each other



The earth's two largest plates interacted during the Tōhoku Earthquake of 11 March 2011:

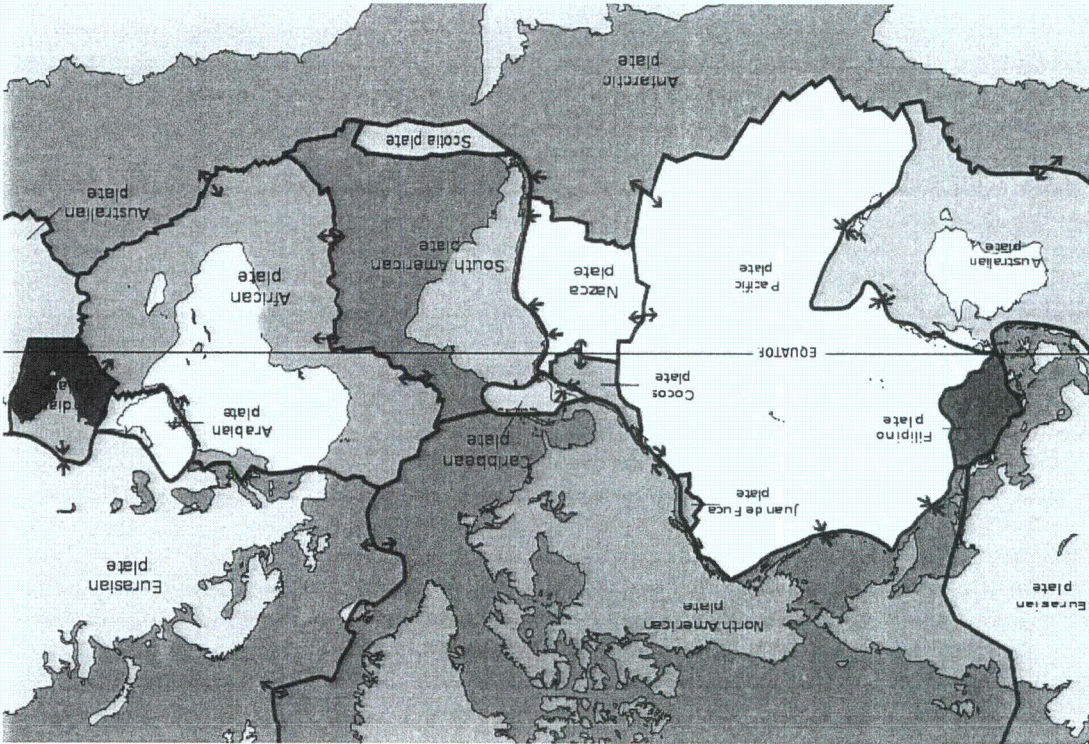
North America plate

The North American plate comprises most of North America, Greenland, Cuba, Bahamas, and parts of Siberia, Japan and Iceland. It extends eastward to the Mid-Atlantic Ridge and westward to the Chersky Range in eastern Siberia. The plate includes both continental and oceanic crust. The interior of the main continental landmass includes an extensive granitic core called a craton. Along most of the edges of this craton are fragments of crustal material called terranes, accreted to the craton by tectonic actions over the long span of geologic time. It

is believed that much of North America west of the Rockies is composed of such terranes.

Pacific plate

The Pacific lies beneath the Pacific Ocean and is made up almost entirely of oceanic crust. The north-eastern side is a divergent boundary with the Explorer, Juan de Fuca and Gorda plates. In the middle of the eastern side is a transform boundary with the North American Plate along the San Andreas Fault, and a boundary with the Cocos Plate. The south-eastern side is a divergent boundary with the Nazca Plate forming the East Pacific Rise. The southern side is a divergent boundary with the Antarctic Plate forming the Pacific-Antarctic Ridge. On its western side, the plate is bounded by the Okhotsk Plate at the Kuril-Kamchatka Trench and the Japan Trench, forming a convergent boundary in which it is subducted under the Philippine Sea Plate creating the Mariana Trench. In the south-west, the Pacific Plate has a complex but generally convergent boundary with the Indo-Australian Plate, subducting under it north of New Zealand forming the Tonga Trench and the Kermadec Trench. The Alpine Fault marks a transform boundary between the two plates, and further south the Indo-Australian Plate subducts under the Pacific Plate forming the Puysegur Trench. The northern side is a convergent boundary subducting under the North American Plate forming the Aleutian Trench and the corresponding Aleutian Islands



Types of faults

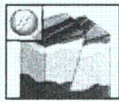
This section is adapted from the USGS *Glossary of Earthquake terms*; see <http://earthquake.usgs.gov/learn/glossary/>

Faults can be divided into two broad categories, depending on the sense of movement on the dipping fault plane

- **Dip-slip faults** are inclined fractures where the blocks have mostly shifted mostly vertically. If the rock mass above an inclined fault moves down, the fault is termed **normal**, whereas if the rock above the fault moves up, the fault is termed **reverse**. A **thrust** fault is a reverse fault with a dip of 45 degrees or less. Oblique-slip faults have significant components of different slip styles. A **megathrust** earthquake refers to a large earthquake on a subduction zone with a thrust type of mechanism.



[Normal Fault Flash Animation](#)



[Thrust Fault Flash Animation](#)

- **Strike-slip faults** are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves to the left, the motion is termed left lateral.



[Strike-slip Fault Flash Animation](#)

- A transform fault is a special variety of strike-slip fault that accommodates relative horizontal slip between oceanic crustal plates. They often extend from divergent plate boundaries at ocean ridges. Where no longer active, they are referred to as **healed transform faults**.

Measuring and locating earthquakes

Some of this section is adapted from the USGS *Glossary of Earthquake terms*; see <http://earthquake.usgs.gov/learn/glossary/>

Earthquake locations

Earthquakes cause slip of an area of the fault plane at depth. The size of this **rupture area** is proportional to the **magnitude** of the earthquake; the larger the

rupture area the larger the earthquake magnitude. The earthquake's **hypocenter** is its position in three dimensions beneath the earth. The earthquake's **epicenter** is the two dimensional projection of the hypocenter on the surface of the Earth.

Earthquake magnitude

The magnitude of an earthquake is a number that characterizes the relative size of an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph. Several scales have been defined, but the most commonly used scale for large earthquakes is the moment magnitude (M_w) scale. Like the other scales, the moment magnitude scale is logarithmic. That is, each numeric increase in the scale (from say to a M_w 8.0 to M_w 9.0) represents a ten-fold increase in ground shaking. The energy released increases by a factor of about 33 times.

Ground shaking intensity

Buildings are not designed to withstand an earthquake of a particular magnitude, but a particular level of ground shaking. Whereas earthquake magnitude is an intrinsic property of the earthquake, the level of ground shaking, or intensity, that is felt at any particular location is a function of a number of factors. These include the distance of the location from the earthquake's epicenter, the depth of the earthquake, and characteristics of the location (such as whether it is underlain by dense bedrock, soft sediments, or artificial fill). The intensity felt usually is measured on the **Modified Mercalli Intensity** scale, and is given as a number (written as a Roman numeral) describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several other scales exist. There are many intensities for an earthquake, depending on where you are, unlike the magnitude, which is one number for each earthquake.

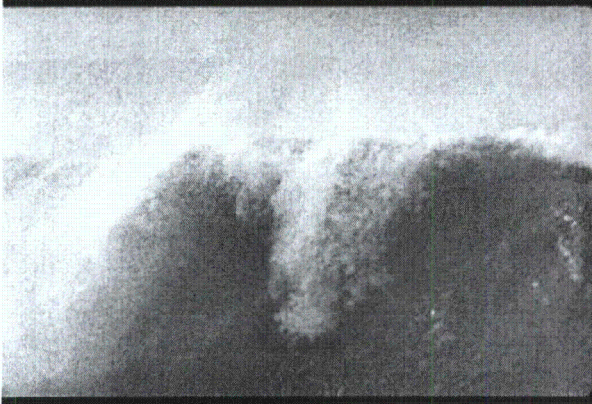
Ground acceleration

A more quantitative way to describe ground shaking intensity is to measure it by a strong motion accelerometer, a special type of seismograph. Ground motion is expressed as a comparison to the force of gravity – that is, the acceleration (the rate of change in speed) of the ground relative to the acceleration caused by gravity. For instance, ground shaking of 1.0 g is equal to the acceleration caused by gravity, shaking of 0.5 g is equal to half the acceleration of gravity, etc. This is also known as **peak ground acceleration**; the maximum amount of ground acceleration regardless of the characteristics of the seismic waves involved.

Spectral acceleration

In reality, ground shaking is caused by seismic waves emanating from the earthquake's hypocenter, and modified during the travel to any particular site. These waves have a variety of wavelengths, periods, and velocities. Buildings and other structures interact with these various waves in different ways. For example, waves with a frequency of 3 to 8.5 hertz (cycles per second) are of particular interest to nuclear power plants since

the critical components of the plants resonate at those frequencies. The level of ground acceleration at any particular seismic frequency is known as its spectral acceleration. A curve describing the acceleration at all frequencies is used to describe the total ground shaking environment at a site.



TSUNAMI RISK REDUCTION FOR THE UNITED STATES: A FRAMEWORK FOR ACTION



National Science and Technology Council

**A Joint Report of the Subcommittee on Disaster Reduction
and the United States Group on Earth Observations**

July 2005

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1. EXECUTIVE SUMMARY

Following the Indian Ocean tsunami on December 26, 2004, the President moved to protect lives and property by launching an initiative to improve domestic tsunami warning capabilities. This plan, developed under the auspices of the National Science and Technology Council, places the President's initiative in the context of a broad national effort of tsunami risk reduction and United States participation in international efforts to reduce tsunami risk worldwide.

Although the frequency of damaging tsunami in the United States is low compared to many other natural hazards, the Indian Ocean event was a reminder that the impacts can be extremely high. Recognizing the potential geographic links to other hazards such as hurricanes, volcanoes, and earthquakes, the framework for tsunami risk reduction incorporates an all-hazards approach and builds upon existing hazard programs.

Successfully developing tsunami-resilient communities depends on enhanced Federal, State and local capabilities in each of the following seven areas:

Determining the Threat. Determining the threat facing coastal communities requires characterization of local and distant tsunami sources and estimation of tsunami frequency.

Hazard identification uses understanding of an area's history of tsunami events to determine the frequency and severity of events that can be expected in the future. Once the hazard has been identified, risk assessment uses advanced scientific modeling to estimate tsunami impacts, loss of life, threat to public health, structural damage, environmental damage, and economic disruption that could result from specific tsunami scenarios.

Actions are required at all levels of government to complete tsunami risk assessments for the Nation's coastal areas.

Preparedness. Preparedness is the advance capacity to respond to the consequences of a tsunami by having plans in place so that people know what to do and where to go if a tsunami warning is issued or a tsunami is observed. This can be achieved through development of additional TsunamiReady communities that have plans, enhanced communications and heightened awareness of their citizens. This will increase resilience to tsunami events, reduce economic losses and shorten recovery periods.

Timely and Effective Warnings. Federal agencies utilize earthquake and volcano monitoring systems, deep ocean buoys and other capabilities to gather as much information as possible about a potential tsunami. This essential data is then provided to analysis centers for the assessment of the immediate tsunami threat. Timely and accurate warnings must then be disseminated in clear and actionable terms to managers and a ready public.

Mitigation. Mitigation involves sustained actions taken to reduce or eliminate the long-term risk to human life and property based on tsunami risk assessments. This includes planning and zoning to manage development in areas particularly at risk for tsunami, embracing tsunami resistant construction, and protecting critical facilities and infrastructure.

Public Outreach and Communication. Communication with the public is critical to help them understand the nature of the tsunami hazard, the risks to personal safety and property and the steps to reduce those risks. Key components include raising public awareness and effecting behavioral change in the areas of mitigation and preparedness; the deployment of stable, reliable, and effective warning systems; and the development of effective messaging for inducing favorable community response to mitigation, preparedness and warning communications.

Research. A continuing broad scientific research effort is needed to improve our understanding of tsunami processes and impacts, and to develop more efficient and effective risk assessment, risk communication, prediction, preparedness, mitigation and warning measures. Research results can improve and make all of the activities within this plan more cost-effective.

International Coordination. Partnerships with international organizations and other countries through bilateral and multilateral agreements are required actions to reduce the threat and impact of tsunamis. The recent events across Southern Asia demonstrate that tsunamis can have global implications, engendering economic, political and social consequences worldwide. The United States will facilitate development of an Indian Ocean tsunami warning system, strive to ensure interoperability between the United States' system and other regional tsunami warning systems, and participate in appropriate international organizations. Through effective international cooperation we can increase national tsunami safety and reduce international losses, thus improving global stability and minimizing future costs of aid and recovery.

The National Tsunami Hazard Mitigation Program, a partnership involving relevant Federal agencies and coastal states, provides the organizational framework needed to execute the President's tsunami initiative in the near-term and shall develop, coordinate and sustain an effective and efficient tsunami risk reduction effort in the United States over the long term. The Subcommittee on Disaster Reduction should be briefed on an annual basis and shall partner with the National Tsunami Hazard Mitigation Program to consider options for a sustained national tsunami risk reduction effort. Specific actions called for in this plan are:

- Develop standardized and coordinated tsunami hazard and risk assessments for all coastal regions of the United States and its territories.
- Improve tsunami and seismic sensor data and infrastructure for better tsunami detection and warning.
- Enhance tsunami forecast and warning capability along our coastlines (Pacific, Atlantic, Caribbean, and Gulf of Mexico) by increasing the number of Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys, tide gauges, and seismic sensors feeding real-time data into on-line forecast models.
- Ensure interoperability between U.S. national system and other regional tsunami warning systems.

- Provide technical expertise and assistance, as appropriate, to facilitate development of international tsunami and all-hazard warning systems, including for the Indian Ocean.
- Encourage data exchange and interoperability among all regional tsunami and all-hazard warning systems, such as The Intergovernmental Oceanographic sub-commission for the Caribbean (IOCARIBE).
- Promote development of model mitigation measures and encourage communities to adopt construction, critical facilities protection and land-use planning practices to reduce the impact of future tsunamis.
- Increase outreach to all communities, including all demographics of the at-risk population, to raise awareness, improve preparedness, and encourage the development of tsunami response plans.
- Conduct an annual review of the status of tsunami research and develop a strategic plan for tsunami research in the United States.

2. INTRODUCTION

2.1 PURPOSE

The Indian Ocean tsunami of December 26, 2004 gave rise to levels of loss and grief unprecedented in the history of natural hazards in the region. Much of the tsunami impact was due to a lack of public awareness, effective warning systems, and implementation of mitigation measures. In addition to providing immediate financial and developmental aid to the affected countries, the President proposed a \$37.5 million initiative to improve domestic tsunami warning systems. The first installment of that initiative was included in the Emergency Supplemental Appropriations Act of 2005, which the President signed into law on May 11, 2005. The Act appropriated approximately \$24 million to expand national tsunami detection and earthquake monitoring capabilities, thus improving tsunami protection for the United States and the world. The President also requested increases in the National Oceanic and Atmospheric Administration and U.S. Geological Survey base budgets in his fiscal year 2006 budget proposal.

Recognizing the complexity and scope of the sustained efforts needed to ensure tsunami risk reduction in the decades to come, additional actions are needed in hazard assessment, warning, response planning, and new or improved actions in public awareness, mitigation, and research. All of these efforts require sustained coordination, attention and support on the Federal, state and local level.

This document was prepared by a joint working group of the Subcommittee on Disaster Reduction and the United States Group on Earth Observations, both under the leadership of the National Science and Technology Council. The principal Federal agencies involved in the implementation of this plan are the National Oceanic and Atmospheric Administration (NOAA), the United States Geological Survey (USGS), and the Department of Homeland Security's Federal Emergency Management Agency (FEMA). Other agencies playing important roles are the Department of State, the United States Agency for International Development (USAID), the National Guard Bureau, and the National Science Foundation (NSF).

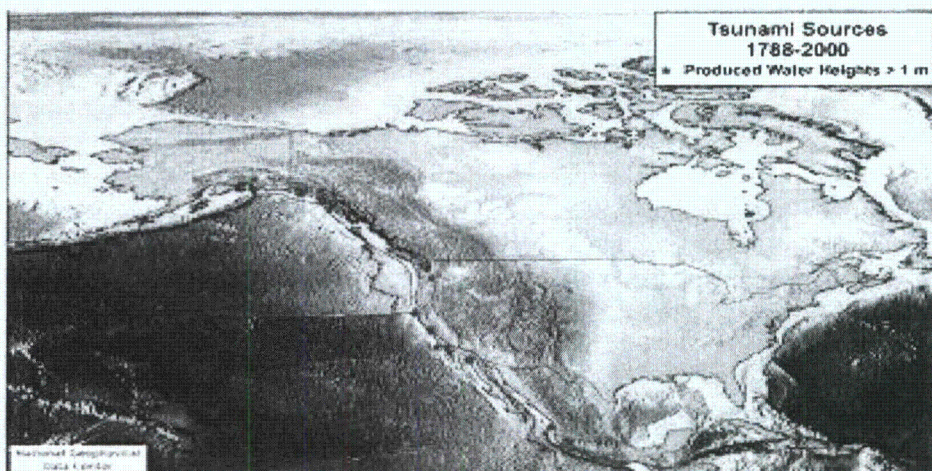


Figure 1. Tsunami hazard for the United States is dominated by the earthquake zones capable of generating tsunamis in the Alaska-Aleutian Seismic Zone, the Cascadia Subduction Zone, near Hawaii, and Puerto Rico.

2.2 THE TSUNAMI THREAT

The Problem. United States coastal communities are threatened by tsunamis generated by both **local** sources and **distant** sources. Local tsunamis give residents only a few minutes to seek safety. Tsunamis of distant origins give residents more time to evacuate the threatened coastal areas, but require timely and accurate tsunami forecasts of the hazard to avoid costly false alarms. For example, United States residents in Alaska can experience a local earthquake—the most common cause of tsunamis—and local tsunami, while residents of Hawaii and the west coast may experience this event as a distant tsunami. Similarly, Pacific Northwest residents can experience a local tsunami that also may have an impact on the distant states of Alaska and Hawaii. A tsunami in the Caribbean could result in a local tsunami for Puerto Rico that also impacts Atlantic coast communities in the Southeast as a distant tsunami. Of the two, local tsunamis pose a greater threat to life because of the short time between generation and impact. The challenge is to design a tsunami hazard mitigation program to protect life and property from two very different types of tsunami events.

The Greatest Threat—Local Tsunamis Generated Near U.S. Coastline.

The Cascadia Subduction Zone threatens California, Oregon, and Washington with devastating local tsunamis (Figure 1) that could strike the coast within minutes¹. Recent estimates indicate a fifteen percent chance of a Cascadia earthquake occurring within the next 50 years². The Alaska and Aleutian Seismic Zone also has been recognized as a region with very high seismic potential³. United States seismologists

Earthquake Spurs First Local Tsunami Hazard Map



This map identifies areas of tsunami flooding, liquefaction, landslides, and intense ground shaking. If the tsunami is generated by a local, major earthquake near Eureka, then Highway 101 probably will be damaged by the liquefied soils to the south. Evacuation then would be feasible only to the north on Highway 101.

In April 1992 a small tsunami was generated at the southern end of the Cascadia Subduction Zone by a large (magnitude 7.1) earthquake near Cape Mendocino, California. This tsunami arrived at Eureka, California only minutes after the earthquake origin time. During a post-earthquake scientific meeting sponsored by FEMA on the Cape Mendocino earthquake/tsunami, participants recommended the immediate production of local tsunami inundation maps for Northern California coastal communities at risk. Tsunami preparedness was deemed to be of such high importance and urgency that the project was funded by FEMA and NOAA to produce tsunami inundation maps for Eureka and Crescent City, California. FEMA also funded an earthquake scenario study of Northern California. The combined study produced the first comprehensive assessment of the nearby earthquake and local tsunami risk to a coastal community. The first-of-a-kind map is illustrated in Figure 2, which clearly shows areas susceptible to tsunami flooding, earthquake shaking intensity, earthquake-induced liquefaction, and earthquake-triggered landslides.

The Eureka tsunami study can be considered the prototype and model for the application of existing technology to local tsunami hazard assessment. These local tsunami hazard maps were incorporated into the emergency plans of Eureka, California and formed the basis of an ongoing education program. The building blocks are partially in place—inundation maps exist for all coastal communities in Washington and Oregon and for selected communities in Alaska, California and Hawaii.

have predicted an eighty-four percent probability between 1988 and 2008 of a major earthquake with magnitude greater than 7.4 in Alaska⁴. Although no estimates of recurrence are available for the Puerto Rico Subduction Zone, local tsunamis have damaged Puerto Rico in the past century⁵. When any of these earthquakes occur, and a destructive tsunami is generated, nearby low-lying coastal areas can expect flooding within minutes.

In addition to earthquake sources, locally significant tsunamis can be generated by submarine landslides (possibly earthquake-triggered) and volcanic eruptions or edifice collapse. This threat can affect all United States coastal areas, including island territories such as the Northern Marianas.

This threat was nearly a reality on June 14, 2005 when a small non-destructive tsunami was generated by a large earthquake off the California coastline. The investments in hazard assessment, warning guidance, and mitigation were all tested in this event and demonstrated their effectiveness under real tsunami threat conditions. Following the earthquake on June 14, NOAA's tsunami warning center issued a warning and the residents of Crescent City, California began to evacuate. Investments in upgrading the real-time seismic network and the educational and mitigation programs implemented by the State of California over the past 7 years, including a tsunami evacuation map and street signs to guide evacuation made this efficient response possible. Within an hour, the warning was cancelled because a network of real-time tsunami detection buoys off the California coastline provided the necessary data to cancel the warning knowing the tsunami posed no threat to the coastal residents in this area. Despite this success at Crescent City, however, the event also demonstrated that other parts of the U.S. Pacific Coast are not as well protected and more work remains to be done.

The Silent Threat—Tsunamis Generated at a Distance. The contiguous United States has suffered damage from tsunamis originating in Chile, Japan, Russia, and Alaska⁶. If an earthquake in Alaska generated a major tsunami, Alaskan shores would be flooded within minutes, while the coasts of Hawaii, Washington, Oregon, and California would be hit within 5 hours of the event⁷. Due to the abundance of remote sources capable of generating a distant tsunami, the probability of damage from a distant tsunami is much greater than a local tsunami in the Pacific Ocean because of the abundance of remote sources capable of generating a distant tsunami. Managing the threat of distant tsunamis requires an accurate, timely forecast to allow coastal populations to evacuate in time to save lives. Issuing unnecessary warnings may result in affected populations ignoring future warnings, while the danger in issuing too few warnings places coastal populations at risk. Recent measurement and modeling technologies produce a more accurate forecast of distant tsunamis, thus reducing false alarms. Tsunami forecasting requires real-time measurement of the tsunami in the deep ocean that can be assimilated into numerical models in time to issue a forecast to coastal populations. Such a system provides accurate forecasts that avoid false alarms while providing warning of destructive tsunamis in time to safely evacuate vulnerable areas.

3. DEVELOPING TSUNAMI-RESILIENT COMMUNITIES

3.1 DETERMINING THE THREAT

Definition. The first step toward developing tsunami-resilient communities is to determine the threat they face. Such a determination begins with assessing the hazard by characterizing potential local and distant tsunami sources (including offshore earthquakes, submarine landslides, and oceanic volcanoes), estimating tsunami frequency through detailed analysis of past events, and developing realistic models of tsunami effects. A risk assessment can then be produced by combining knowledge of the hazard with information on the coastal vulnerability, including the population infrastructure, lifelines, economic activities, and level of local preparedness for such events. These assessments are the fundamental starting point for government officials, private interests, and the general public to begin preparation of community-specific plans to reduce vulnerability.

Complete and effective system. Risk assessments of the tsunami threat for all exposed coastal areas should be performed. These assessments should identify the inventory and value of at-risk structures, infrastructure and population present, the fragility of the structures exposed to the hazard, and categorization and presentation of the resulting damage and casualties. Graphical information products or maps showing the areas exposed to tsunami inundation and maximum tsunami related water depths and velocities in these areas, should be included and available at the appropriate scale for all levels of government to use in preparedness activities.

Current capability. Tsunami hazard exists on the Pacific, Atlantic, Caribbean, and Gulf coasts of the United States. Our understanding of the level of risk associated with this hazard is more advanced for the Pacific and Caribbean coasts, but is minimal or non-existent for the other coasts. Tsunami risk assessments exist for many communities with substantial populations at risk in California, Alaska, Hawaii, Oregon, and Washington. These states are undertaking individual efforts to generate inundation maps that identify areas and depths of tsunami flooding or run up. There are no tsunami risk assessments for the rest of the United States coastal areas.

Needed actions. Actions are required at all levels of government to complete tsunami risk assessments for the national coastal areas. Tsunami risk assessments should take into account existing assessments of storms, flooding, earthquakes, volcanoes, and other potential sources. These assessments should be cast in terms of extreme scenarios or annual probabilities of occurrence or both. To avoid confusion, these assessments should consider and take into account, if possible, the methodologies and terminologies used in the assessments of other natural hazards (e.g., the probabilistic approach used for seismic hazard assessment).

Roles and responsibilities.

NOAA – Provide leadership, technical assistance, and technology transfer to complete tsunami hazard identification and risk assessments for all coastal regions of the United States. Provide mapping and inundation modeling from the Pacific Marine Environmental Laboratory in coordination with USGS.

USGS – Support NOAA by providing earthquake, landslide and volcano source characterizations and frequency estimates and modeling of tsunami effects in support of

tsunami risk assessments. For all United States coasts and island territories, carry out research on tsunami impact models and post-event surveys of coastal flooding, sediment transport, ecological impacts, and other tsunami consequences.

FEMA/NOAA/USGS develop a coordinated risk assessment tool (e.g. Hazards U.S., or HAZUS, a standardized loss estimation software package available from FEMA for earthquakes, high winds and flooding) for effective use in tsunami risk assessments.

States and Territories – Through voluntary and cooperative arrangements with federal agencies, provide requirements for, and reviews of, tsunami hazard identification and risk assessments. Provide data and information in cooperation with NOAA and USGS.

3.2 PREPAREDNESS

Definition. Preparedness is the advance capacity to respond to the consequences of a tsunami. This means having plans in place that tell people what to do and where to go if a tsunami warning is issued or a tsunami is observed. This will increase resilience to tsunami events, reduce economic losses and shorten recovery periods. States, local governments, communities, businesses, schools, public facilities, families and individuals should have preparedness plans.

Complete and effective system. A comprehensive National Response Plan and state and local tsunami response programs will ensure a hierarchy of coordination and communication through all levels of government. In addition, evacuation maps and evacuation routes should be well known by residents and clearly marked for visitors in all coastal areas. Response plans need to account for the demographics of the at-risk population—especially the poor, seniors, and the disabled, and individuals in ill health—ensuring the entire at-risk population has a mechanism (and is aware of the mechanism) to obtain a safe haven.

Current capability. Many communities in states in the Pacific Northwest, Alaska, and Hawaii are TsunamiReady (i.e. they have tsunami response plans and conduct exercises on a regular basis). TsunamiReady communities need to be established in at-risk coastal communities on the Atlantic, Gulf, and Caribbean coasts.

Needed actions. The National Response Plan should comprehensively address tsunami response and recovery. Tsunami response readiness should be established in threatened communities on the Atlantic, Gulf, and Caribbean coasts while maintaining tsunami response readiness in communities on the Pacific coast. End-to-end testing should be in place to ensure that warning and dissemination systems are operating properly; warnings and notices are received and understood; and the entire demographics of the at-risk population—especially the poor, seniors, the disabled, and individuals in poor health—have a mechanism (and is aware of the mechanism) to obtain a safe haven.

Roles and responsibilities.

NOAA – Increase outreach to communities at risk to improve preparedness. Support state and local governments in their efforts to attain TsunamiReady status.

NOAA, with active participation of state and local agencies – implement and conduct routine end-to-end testing of warning dissemination and notification systems.

NOAA/USGS/FEMA – Support the states in their efforts to develop tsunami response plans in all threatened communities to include all United States coastal states, Territories, and Commonwealths. FEMA’s Mitigation and Preparedness Divisions should continue to work with NOAA to improve community preparedness.

FEMA – Provide assistance to states to promote and improve existing relationships for preparedness and planning.

State, Territory, Tribal and local governments – Cooperate with federal agencies to develop response plans, build awareness of and readiness for tsunami hazards in coastal communities and conduct routine exercises that maintain preparedness.

3.3 TIMELY AND EFFECTIVE WARNINGS

Definition. Federal agencies, such as NOAA and USGS, utilize earthquake and volcano monitoring systems, deep ocean buoys and other capabilities to gather as much information as possible about the what, when, and where of a potential tsunami. These essential data are provided to analysis centers for the assessment of the immediate tsunami threat. Timely and accurate warnings are then disseminated in clear and actionable terms to disaster managers and the general public. NOAA’s tsunami warning centers generate warning bulletins using seismic and water depth data from monitoring instruments, real-time communications systems, and data analysis procedures and facilities. These systems determine the occurrence of a tsunami-capable earthquake (or other event), if a tsunami has been generated, predict when the tsunami will reach populated areas, and its likely impacts. This information is quickly disseminated through a variety of means to officials at Federal, state and local emergency management agencies and to the public – in time for life saving actions to be taken. State and local emergency management agencies provide evacuation orders or other response instructions to local communities through multiple channels that may include radio and TV broadcasts, town sirens, and police and fire station loudspeakers.

Complete and effective system. The USGS National Earthquake Information Center, the NOAA Tsunami Warning Centers, and the FEMA Emergency Operations Centers should be staffed on a 24x7 basis by personnel trained to cope with an immediate tsunami threat. The USGS National Earthquake Information Center should transmit international, national and regional seismic data to the Tsunami Warning Centers, where it would be combined with other seismic data and data from coastal and deep-ocean sea level sensors. The Tsunami Warning Centers should analyze the combined data and, if appropriate, transmit timely and accurate tsunami forecasts and warnings to government officials via a robust communications networks. These officials, in turn, must have

The Economic Impact of Tsunami Warnings

Following an earthquake on November 17, 2003, NOAA's tsunami warning center issued a warning within five minutes of the earthquake. Within an hour, the warning was cancelled because real-time tsunami detection buoys off the Alaska coastline provided the necessary data to inform decision makers that a tsunami was not imminent. The early cancellation of this warning avoided an unnecessary evacuation of Hawaii coastlines, saving millions of dollars.

A similar event occurred in 1986, but, without the deep ocean data the warning was not cancelled until after an evacuation had taken place. The Department of Economics estimated the cost to Hawaii in lost productivity in 1986 was \$40M. Adjusted for inflation, a similar evacuation in 2003 would have cost Hawaii \$70M in lost productivity.

access to the reliable and capable communication and broadcast systems necessary to notify emergency managers at all government levels.

The tsunami warning system also will benefit from the work and recommendations of the Task Force for Effective Warnings recently convened by the National Science and Technology Council and Homeland Security Council.

Current capability.

NOAA's National Weather Service operates and administers the tsunami-warning program for the United States. The Pacific Tsunami Warning Center in Ewa Beach, Hawaii has mission responsibility as the operational center for the Tsunami Warning System in the Pacific, as the United States National Tsunami Warning Center for United States national interests throughout the Pacific basin and also as the Hawaii Regional Tsunami Warning Center. The West Coast and Alaska Tsunami Warning Center in Palmer, Alaska, has responsibility as the Alaska and United States West Coast Regional Tsunami Warning Center within the United States and for the Canadian Province of British Columbia. Following the Indian Ocean tsunami in December 2004, the West Coast and Alaska Tsunami Warning Center was directed to also provide tsunami warning to the United States Atlantic, and Gulf of Mexico coasts as well as dissemination of information bulletins for Atlantic Canada. The Pacific Tsunami Warning Center is providing on an interim basis, warning information bulletins to focal points in the Indian Ocean region and to the Caribbean.

The FEMA Operations Center/FEMA Alternate Operations Center use the National Warning System on a 24x7 basis to convey warnings to Federal, state and local governments, as well as the military and civilian populations. The information disseminated by the FEMA Operations Center/FEMA Alternate Operations Center via the National Warning System include information about terrorist actions, aircraft incidents or accidents, earthquakes, floods, hurricanes, nuclear incidents or accidents, severe thunderstorms, tornadoes, tsunamis and winter storms. The National Warning System allows issuance of warnings to all designated stations nationwide or to selected stations as dictated by the situation. The FEMA Alternate Operations Centers/FEMA Alternate Operations Centers conduct tests of the National Warning System twice daily to ensure connectivity to the regional and state warning points. Each state has a Primary State Warning Point and Alternate State Warning Point that exercises operational control of the National Warning System within that State. The Primary State Warning Point is staffed 24x7 and is in contact with its assigned FEMA Operations Center or FEMA Alternate Operations Center, as applicable. The state warning points are responsible for dissemination of warnings to local government officials.

USGS and NSF operate global, national and regional-scale seismic monitoring networks in partnership with other countries, states and territorial agencies and universities. Data from these networks are sent in real time to the USGS National Earthquake Information Center and regional network centers for analysis of earthquake location, magnitude, source characteristics, and potential impacts. Earthquake data and information are also transmitted continuously to the NOAA Tsunami Warning Centers. Earthquake alert information is sent to FEMA, the Department of Defense, other domestic agencies, state emergency centers, the news media, infrastructure managers, and the general public.

Standard procedures and communication links exist between NOAA, FEMA, USGS, and state agencies for the transmission of data and warnings related to potential or actual tsunami situations.

Needed actions. To provide the most accurate predictions and warning guidance, the following specific actions should be taken:

- The Tsunami Warning Centers and USGS National Earthquake Information Center must attain and maintain robust 24x7 operations;
- Increase availability of timely and accurate seismic data through expansion of seismic coverage in the Caribbean, additional telemetry and maintenance for the Global Seismographic Network, and modernization and completion of regional seismic networks in Alaska, California, Hawaii, Oregon and Washington;
- Upgrade existing and deploy new DART buoys in the Pacific, Atlantic and the Caribbean;
- Complete the installation and upgrade of coastal sea level monitoring stations;
- Expand existing information dissemination systems, such as Emergency Managers Weather Information Network and RAdio and InterNET Communications Meteorological and Climate Information, and incorporate their use into an evacuation notification system;
- Complete all modeling efforts for inundation maps;
- Continue to improve the forecast models; and,
- Regularly review the system requirements to ensure adequate sensor coverage.

Roles and responsibilities. Predicting a tsunami and issuing warning guidance is chiefly a responsibility of the federal government:

FEMA – The FEMA Operations Center issues warning messages over the National Warning System.

FEMA/NOAA – Expand and fortify the emergency communications systems used to disseminate, tsunami warnings and information.

NOAA – (1) Establish in-office 24x7 warning center operations; (2) Complete deployment of the DART buoys and coastal sea level sensors; (3) Complete all current inundation and forecast modeling efforts; (4) In coordination with USGS, upgrade local seismic networks in Alaska, California, Hawaii, Oregon and Washington; (5) In coordination with state and local governments, establish requirements for tsunami warning dissemination systems where they do not exist.

USGS – (1) Establish robust 24x7 National Earthquake Information Center operations; (2) Add Global Seismographic Network stations in the Caribbean area, and integrate data from

new and upgraded stations into the National Earthquake Information Center and the Puerto Rico Seismic Network; (3) In coordination with NSF, enhance the real-time seismic information delivery from the Global Seismographic Network by increasing station uptime and telemetry systems; and (4) Upgrade real-time earthquake data analysis systems to improve rapid evaluation of the tsunami threat from local, near-shore earthquakes.

States and Territories – Review and suggest improvements to warning guidance products developed by Federal agencies.

3.4 MITIGATION

Definition. Mitigation involves sustained actions taken to reduce or eliminate the long-term risk to human life and property based on tsunami risk assessments. This includes planning and zoning to manage development in areas particularly at risk for tsunami, developing and enforcing tsunami resistant construction and protecting critical facilities and infrastructure.

Complete and effective system. All sectors of communities with a tsunami risk should understand the nature of the hazard, become aware of long-term measures to reduce risk of tsunami losses, and take appropriate actions. Tsunami resistant elements should be included in building codes, building design and construction practices. Utilities and critical facilities should be protected to reduce exposure to the tsunami threat.

It is critical that efforts to improve tsunami mitigation build on the work done or ongoing in relation to other natural hazards (floods, earthquakes, hurricanes, etc.). An all-hazards approach must be taken.

Current capability. The Disaster Mitigation Act of 2000, commonly known as the 2000 Stafford Act amendments, was signed into law on October 30, 2000 establishing a national program for pre-disaster mitigation. Under this program communities may receive federal funds for mitigation projects or to develop a mitigation plan. Most communities have some local multi-hazard mitigation plans in place, some of which include tsunami mitigation planning.

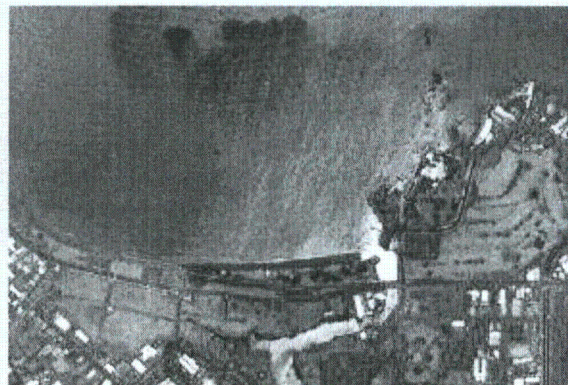
Land Use Decisions to Reduce Loss of Life

There are practical decisions concerning the continued use of land threatened by tsunami that can greatly decrease the potential for life loss. One example comes from the city of Hilo, Hawaii. As described in the book "Tsunami" by Walter C. Dudley and Min Lee:

Following the 1956 tsunami, the strip of land between Kamehameha Avenue and the bay front had been converted into a recreation and parking area that was to serve as a buffer zone against future tsunamis.... Just 8 days after the 1960 tsunami, the Hawai'i Redevelopment Agency was established. The ocean side buffer zone was expanded and a landfill plateau was constructed, raising the inland border of the greenbelt 26 feet above sea level.



Hilo 1954



Hilo 2000

Needed actions. Long-term loss reduction measures should include construction practices that resist tsunami effects. The construction practices that resist earthquake shaking and flooding may apply, in part, to resisting tsunami impacts. Currently, there are generally no provisions in the model building codes, on which many local and state building codes are based, for tsunami-resistant construction. These model code elements should be developed. If possible, critical facilities, utilities, and transportation and other infrastructure elements should be sited, or re-sited, in areas not likely to be affected by tsunamis. Community land use planning can be used to avoid exposure to tsunami dangers. It may be difficult to implement land use planning measures in tourist areas, where beach access and ocean views are valued; nevertheless, efforts must be made to do so.

Roles and responsibilities.

FEMA/NOAA/USGS with active involvement of state and local agencies – Promote the development of model mitigation measures. These materials should be designed in cooperation with state and local government for use and implementation at the community level.

State, Territory and local governments – Oversee the development and implementation of mitigation programs.

Communities – Adopt construction, critical facilities protection, and land use planning practices to reduce impacts of future tsunamis.

3.5 PUBLIC OUTREACH AND COMMUNICATION

Definition. Communication with the public is critical to help them understand the nature of the tsunami hazard, the risks to personal safety and property, and the steps to reduce those risks. Risk communication includes raising public awareness and effecting behavioral change in the areas of mitigation and preparedness; the deployment of stable, reliable, and effective warning systems; and the development of effective messaging for inducing favorable community response to mitigation, preparedness and warning communications.

Complete and effective system. All sectors of communities with a tsunami risk should understand the nature of the hazard, become aware of measures to reduce risk of tsunami losses, and take appropriate actions. Public awareness should include education in schools, signage on highways and beaches, notices in hotel rooms, periodic newspaper inserts and other means of information dissemination. It is critical that efforts to improve tsunami public awareness and mitigation build on the work done or ongoing in relation to other natural hazards (floods, earthquakes, hurricanes, etc.). An all-hazards approach must be taken. In risk communication, many of the countermeasures against one hazard will prove effective against another. Common terminologies, warning levels, and emergency preparedness measures must be used.

A comprehensive National Warning System will ensure a redundant means of communicating warnings and evacuations to residents and visitors in all coastal areas.

Current capability. As part of the National Tsunami Hazard Mitigation Program, Pacific coastal areas, states and local communities have spent several years increasing awareness of the tsunami threat. Focused survey results show that understanding of tsunami risk and warning procedures by

emergency managers in several of these communities has greatly increased because of these efforts. Tsunami signage and evacuation brochures for the public and visitors have been implemented by these states. On the other hand, the tourism industry and interests have not emphasized the tsunami threat and safety measures.

The TsunamiReady Program and National Tsunami Hazards Mitigation Program Mitigation Subcommittee have also improved community awareness and preparedness.

Public awareness programs for communities in Atlantic, Gulf, and Caribbean coastal states and territories are just beginning.

Needed actions. In all coastal areas threatened by tsunamis there should be tsunami education and awareness programs focusing on the immediate and long-term actions that can be taken to save lives and property. Since many coastal areas attract transient vacationers, public education efforts must include non-residents as well as the indigenous population. Increased emphasis and expansion of the TsunamiReady Program will greatly assist in community awareness and preparation.

Roles and responsibilities.

NOAA/FEMA/USGS with active involvement from state and local agencies – Promote the development of model public awareness campaigns. These materials should be designed in cooperation with state and local government for use and implementation at the community level.

NOAA/FEMA/USGS – Develop and deploy enhancements to emergency communications systems/capabilities.

NOAA and FEMA in active partnership – Improve awareness by increasing outreach to communities at risk through the TsunamiReady Program and FEMA's Mitigation Division

State, Territory and local governments – (1) Cooperate with federal agencies to build awareness of tsunami hazards in coastal communities and conduct routine exercises that maintain public awareness; (2) Oversee the development and implementation of public awareness programs.

Communities – Understand the applicable tsunami hazards and take steps to make permanent and transient populations aware of the hazard.

3.6 RESEARCH

Definition. Research refers to those scientific studies and analyses that are needed to improve our understanding of tsunami processes and impacts. Research is also needed to develop more accurate models as well as efficient and effective warning and mitigation measures.

Complete and effective system. Sustained research and development is needed in the following areas on the topics identified:

Determining the Threat. We must improve our understanding of tsunami sources of all types. Deterministic models of how these sources generate tsunamis and probabilistic

models of how often they are likely to occur should be developed. Field surveys are needed to identify past tsunami impacts for specific locations and to characterize potential tsunami sources including offshore faults, submarine landslides and island volcanoes. Geological studies including stratigraphic analyses of prehistoric tsunami deposits to determine past tsunami frequency and size, as well as comprehensive documentation of the coastal impacts of modern tsunamis are needed. Improved models of tsunami run up and flooding are needed to determine tsunami impacts and to develop effective countermeasures.

Preparedness. Scenario exercises should be developed to evaluate response capabilities and deficiencies, establish best practices for tsunami planning in the context of all-hazards and evaluation procedures designed to measure the effectiveness of the planning. Means are also needed to test tsunami awareness levels.

Timely and Effective Warnings. It is crucial to develop new analytical techniques for seismic signals that identify the tsunami potential of a nearby earthquake. New analyses of tsunami records at coastal and deep ocean locations are needed to improve forecasting capabilities. Evaluations of real-time communications technologies and warning dissemination methods are needed, and if warranted, improved technologies and techniques developed. Research is also needed on advanced ocean height and seismic sensors.

Mitigation. Research is needed to establish construction and retrofit practices for threatened areas. Engineering research on tsunami resistant construction and land use practices for resilient communities is lacking and must be addressed.

Public Outreach and Communication. Applied research is needed to develop effective standard materials, message, and communications for tsunami awareness education.

Research efforts are needed on the societal response to tsunami warnings. Social and behavioral science tools are necessary to measure risk communication effectiveness of existing tsunami programs and products to various target groups in the community including decisions makers, citizens, businesses (the tourism industry in particular since their clients make up a large portion of potentially impacted people who will require local resources following an event) and visitors.

Current capability. NOAA supports a national tsunami research program with approximately twelve personnel dedicated to developing tsunami hazard assessment and forecast tools as well as developing and deploying deep ocean tsunami sensors to improve tsunami warning.

Tsunami-related research is supported by the USGS and NSF as components of more broadly focused hazard efforts, such as the National Earthquake Hazards Reduction Program (NEHRP). The USGS component of NEHRP includes targeted research into the record of tsunami-generating earthquakes, and the USGS Coastal and Marine Geology Program carries out research on characterization of tsunami sources, tsunami generation modeling, and post-event surveys of coastal flooding, sediment transport, ecological impacts, and other tsunami consequences. NSF has established a tsunami wave tank facility within the Network for Earthquake Engineering Simulations that provides a facility to study the impacts of tsunami forces on structures.

The National Aeronautics and Space Administration supports tsunami research through ongoing research related to sea level change, oceanography and earthquakes.

FEMA funds two earthquake consortia that also address tsunami issues: The Cascadia Region Earthquake Workgroup (CREW) and the Western States Seismic Policy Council (WSSPC). CREW seeks to develop private/public partnerships that foster a culture of mitigation to improve the region's ability to withstand damaging earthquakes and tsunamis. WSSPC establishes consensus policies on earthquake and tsunami issues.

Needed actions. A strategic plan for tsunami research in the United States should be developed to include a review of ongoing research efforts and identification of research gaps. Areas of research that, given immediate attention, will have the greatest impacts in the near term also should be identified.

Roles and responsibilities.

Agencies working through the National Tsunami Hazard Mitigation Program – conduct a tsunami research review and develop a strategic research plan.

4. INTERNATIONAL COOPERATION

The recent events across Southern Asia demonstrate that tsunamis can have global implications, engendering economic, political and social consequences felt around the world. The United States recognizes that the establishment of a U.S. national warning system has international implications and linkages to processes in the international arena, and that the United States has much to offer and to gain in terms of provision of technical expertise, data, and capacity building for the establishment of detection, forecasting and warning systems for natural hazards in all regions at risk. Through effective international cooperation, the United States can increase national tsunami safety and reduce international losses, thus enhancing global stability and minimizing future costs of aid and recovery.

4.1 CURRENT CAPABILITIES (ONGOING INTERNATIONAL PROCESSES)

Intergovernmental Oceanographic Commission (IOC). Following the tragic events of the Indian Ocean earthquake and tsunami, members of the international community called for prompt establishment of a tsunami early warning system in the region. Following several international meetings, the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Oceanographic Commission (UNESCO IOC) was given the lead role in coordinating UN agency activities for development of a tsunami warning system. UNESCO IOC is holding a series of technical meetings to draft design and work plans and a timetable for development of a tsunami warning system in the Indian Ocean region, acknowledging the importance of an all-hazard approach and recognizing the need for warning systems in other regions.

The existing Tsunami Early Warning System in the Pacific Ocean region is coordinated by UNESCO IOC. Efforts to establish a tsunami early warning system in the Indian Ocean and other regions can benefit from the experience and expertise of the UNESCO IOC, not only in coordinating the Pacific Early Warning System, but also in addressing the full range of ocean and coastal problems through the sharing of knowledge, information and technology among countries.

GEO/GEOSS. In parallel with the international process to create a global tsunami warning system, for which UNESCO IOC has coordinating responsibility, the Group on Earth Observations (GEO) has committed to support the creation of an all-hazard warning system. The processes are linked, as tsunami warning will be part of the all-hazard warning system.

The purpose of GEO, an international effort with over 60 members, is to develop and implement the Global Earth Observation System of Systems (GEOSS). GEOSS seeks to link thousands of technological assets into a comprehensive global observation system, improving our ability to address critical environmental and socio-economic concerns. GEOSS is focused on delivering timely, quality information as a basis for sound decision making in nine societal benefit areas, including reducing loss of life and property from natural and human-induced disasters. GEOSS is also concerned with identifying gaps in observations, such as that for a tsunami warning system in the Indian Ocean, and works with other countries and international agencies to fill those gaps. Key national and intergovernmental operators of Earth observation systems and UN agencies with responsibilities in disaster mitigation/development participate in GEO.

Other related international activities. A number of other intergovernmental organizations and regional bodies are playing an active role in the development of tsunami warning systems and/or all-hazard systems in the Indian Ocean and other regions. The World Meteorological Organization is

hosting activities designed to strengthen global telecommunication system (GTS) capabilities in Indian Ocean developing countries, to meet the requirements for a tsunami warning system. This work is complementary to the IOC meetings. The United States supports these activities and is providing personnel to assist with these preliminary assessments, which are due to be completed by July 2005.

The UN International Strategy for Disaster Reduction (ISDR) and ISDR Secretariat are policy guidance bodies. The ISDR Framework, as a strategy or set of guidelines, is relevant in discussions on disaster risk reduction and how that relates to developing “all-hazard” warning systems. The United States supports the ISDR Framework in its advisory role, under the supervision of the Emergency Relief Coordinator – to identify best practices and lessons learned and ensure dissemination of this information to national and local authorities, throughout the UN system, and to the development community at large (bilateral development agencies, World Bank, regional development banks, etc).

A number of other entities are engaged in discussions relating to warning systems and the United States participates in these discussions, as appropriate, including: the UN World Summit on the Information Society, e.g., discussions of common protocols for communication of warnings and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, which operates seismic sensor systems and is discussing ways it might provide real-time seismic data in support of a tsunami or earthquake warning systems. The Asia-Pacific Economic Cooperation and other Asian regional organizations are hosting a variety of meetings and workshops to facilitate development of a tsunami warning system in the Indian Ocean.

4.2 NEEDED ACTIONS

The Indian Ocean tsunami produced measurable tide-level changes along the east coast of North America as far north as Nova Scotia—further indication that tsunamis are global in nature. Addressing regional efforts to develop tsunami early warning systems are beneficial to our understanding of this phenomenon and our ability to better predict the impact of geologic activity on United States coastlines. Additionally, our efforts to improve foreign governments’ capabilities to interpret data, issue warnings, and take emergency measures to protect their citizens enables our foreign assistance to be used to promote democracy, economic growth and stability, rather than for disaster response and emergency assistance.

The United States strongly supports the international development of a global tsunami detection, forecasting, and warning network that also will contribute to an all-hazards warning system. The United States supports the lead coordinating role of the UNESCO IOC in development of a global tsunami warning network and actively participates in the international process to develop such a system, including for the Indian Ocean region. The United States will work closely with UNESCO/IOC and other interested parties to enhance and expand global tsunami warning systems and to implement recommended tsunami hazard assessment, detection, forecasting, and warning systems in regions at high risk. The United States will contribute technical expertise as well as real-time seismic and sea level data to any national or regional tsunami warning system effort. For tsunami-affected countries, the United States also will provide assistance to improve communication, warning and public education to warn populations threatened by natural disasters. The United States will continue to encourage activities in the Indian Ocean and other regions that enhance the resilience of populations and infrastructure to disasters (e.g., maintaining mangroves

and coral reefs; implementation of disaster-resilient building codes).

The United States will work with the UNESCO IOC to ensure that the United States national system is interoperable with the IOC Sub-commission for the Caribbean and Adjacent Regions (IOCARIBE) plan for developing a tsunami warning system in the Caribbean basin. The United States National Tsunami Warning System will be part of the international tsunami warning system coordinated by UNESCO IOC.

The United States supports GEO as the intergovernmental forum for coordinating activities to expand multi-hazard capabilities for disaster reduction at national, regional and international levels, with particular focus on reducing loss of life and property from disasters. The United States engages in other international fora on tsunami and disasters, as appropriate.

Indian Ocean Tsunami Warning System. The United States has pledged to support the multinational effort to establish an Indian Ocean tsunami warning system. USAID is coordinating a multi-agency, integrated USG program of assistance to strengthen disaster warning and response capabilities through international, regional, national, and sub-national interventions. The Pacific Tsunami Warning Center, operated by NOAA, and the Japan Meteorological Agency are providing interim tsunami advisory information to authorized contacts in the Indian Ocean region, pending the establishment of a full-fledged system.

Data and information sharing. A geographically widespread network of sensors and buoys is key to obtaining the real-time data necessary for analysis of a tsunami threat and for providing lead-time to countries to take measures and actions to reduce fatalities and economic impacts. Some redundancy or overlapping of data can be beneficial. The United States strongly encourages countries participating in an early warning system to engage in full and open exchange of publicly-funded, unclassified data, recognizing relevant international instruments and national policies and legislation. Data sharing remains a hurdle in developing an Indian Ocean tsunami warning system and in broader efforts to develop regional all-hazard warning capabilities. The United States particularly encourages countries in the Indian Ocean region to enhance or develop mechanisms for real-time sharing of seismic and tide gage data.

4.3 ROLES AND RESPONSIBILITIES

International efforts to reduce the risk of tsunamis are inherently more complex than domestic risk reduction. Although scientific and technical issues may be similar, the funding and diplomatic requirements to reduce tsunami risk globally require the participation and resources of the U.S. State Department and the U.S. Agency for International Development for both legal and practical reasons. The primary source of scientific and technical expertise in international efforts should continue to be the National Tsunami Hazard Mitigation Program; the expertise applied within the United States should also be applied globally to assure the same level of technical expertise, and to ensure that a U.S. system is compatible with global systems. As with other international scientific efforts, however, tsunami risk reduction conducted with other nations or international organizations must be conducted within the diplomatic framework provided by the State Department.

The United States has existing agreements and relationships with many nations and organizations that may be profitably used to expedite new work on tsunamis. For example, the United States has long and productive relationships with several UN agencies and programs involved in tsunami risk

reduction. In addition, numerous science and technology agreements exist with other nations that may be useful in facilitating future tsunami research and risk reduction efforts. International tsunami risk reduction work, including such things as production and deployment of buoys, capacity building, establishment of warning systems, and scientific collaboration, should build upon these existing channels of cooperation. In addition, new agreements and new relationships with international partners can be built upon, and coordinated with, existing agreements.

5. ACTIONS FOR SUSTAINED TSUNAMI RISK REDUCTION

A partnership between federal agencies and states concerned with public safety and loss reduction was established in 1997. Known as the National Tsunami Hazard Mitigation Program, this partnership seeks to reduce tsunami risk to United States coastlines through hazard assessment, warning guidance and mitigation. These elements, along with research and international cooperation, will form an effective and comprehensive means to develop tsunami-resilient communities in the United States.

The National Tsunami Hazard Mitigation Program, a partnership involving relevant Federal agencies and coastal states, provides the organizational framework needed to execute the President's tsunami initiative in the near-term and shall develop, coordinate and sustain an effective and efficient tsunami risk reduction effort in the United States over the long term. As the National Tsunami Hazard Mitigation Program develops, coordinates and sustains an effective and efficient tsunami risk reduction effort in the United States, it may be expanded as necessary and should draw upon expertise in other ongoing hazards reduction programs. The Subcommittee on Disaster Reduction should be briefed on an annual basis and shall partner with the National Tsunami Hazard Mitigation Program to consider options for a sustained national tsunami risk reduction effort. Specific actions called for in this plan are:

- Develop standardized and coordinated tsunami hazard and risk assessments for all coastal regions of the United States and its territories.
- Improve tsunami and seismic sensor data and infrastructure for better tsunami detection and warning.
- Enhance tsunami forecast and warning capability along our coastlines (Pacific, Atlantic, Caribbean, and Gulf of Mexico) by increasing the number of Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys, tide gauges, and seismic sensors feeding real-time data into on-line forecast models.
- Ensure interoperability between U.S. national system and other regional tsunami warning systems.
- Provide technical expertise and assistance, as appropriate, to facilitate development of international tsunami and all-hazard warning systems, including for the Indian Ocean.
- Encourage data exchange and interoperability among all regional tsunami and all-hazard warning systems, such as The Intergovernmental Oceanographic sub-commission for the Caribbean (IOCARIBE).
- Promote development of model mitigation measures and encourage communities to adopt construction, critical facilities protection and land-use planning practices to reduce the impact of future tsunamis.
- Increase outreach to all communities, including all demographics of the at-risk population, to

raise awareness, improve preparedness, and encourage the development of tsunami response plans.

- Conduct an annual review of the status of tsunami research and develop a strategic plan for tsunami research in the United States.

APPENDIX A: KEY TERMS

All-hazards approach—an integrated hazard management strategy that incorporates planning for and consideration of all potential natural and technological hazards, including terrorism.

Built environment—the Nation’s constructed facilities, buildings, transportation, and industrial infrastructure systems.

Critical infrastructure—the physical and cyber-based systems that are essential to the minimum operations of the economy and government.

Disaster—a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.

Disaster risk—the chance of a hazard event occurring and resulting in disaster.

Hazard—a natural or human-caused threat that may result in disaster when occurring in a populated, commercial, or industrial area.

Hazard event—a specific occurrence of a hazard.

Hazard mitigation—any action taken to reduce or eliminate the long-term risk to human life and property from natural hazards.

Hazard risk—the chance of a hazard event occurring.

Natural disaster—a disaster that results from a natural hazard event.

Natural hazard—a hazard that originates in natural phenomena (e.g., hurricane, earthquake, tornado).

Resilience/resilient—the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk—the probability of harmful consequences or expected losses (death and injury, losses of property and livelihood, economic disruption, or environmental damage) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

Technological disaster—a disaster that results from a technological hazard event.

Technological hazard—a hazard that originates in accidental or intentional human activity (e.g., oil spill, chemical spill, building fires, terrorism).

APPENDIX B: REFERENCES

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6. IBID
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APPENDIX C: ABOUT THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

ABOUT THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

The National Science and Technology Council (NSTC), a cabinet-level council, is the principal means for the President to coordinate science and technology policies across the Federal Government. NSTC acts as a virtual agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research to improving transportation systems and strengthening fundamental research. This council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, contact the NSTC Executive Secretariat at (202) 456-6101.

ABOUT THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES (CENR)

The purpose of the Committee on Environment and Natural Resources (CENR) is to advise and assist the NSTC to increase the overall effectiveness and productivity of Federal research and development efforts in the area of the environment and natural resources. This includes maintaining and improving the science and technology base for environmental and natural resource issues, developing a balanced and comprehensive research and development program, establishing a structure to improve the way the Federal Government plans and coordinates environmental and natural resource research and development in both a national and international context, and developing *environment and natural resources research and development budget crosscuts and priorities.*

Committee on Environment and Natural Resources Membership

Co-Chairs

Kathie Olsen (OSTP)
 Conrad Lautenbacher (NOAA/DOC)

Members

Ghassem Asrar (NASA)
 Jonathan Perlin (VA)
 Jim Connaughton (CEQ)
 James Decker (DOE)
 William Farland (EPA)
 Robert Foster (DOD)
 Charles "Chip" Groat (USGS)
 Len Hirsch (Smithsonian)
 Kate Jackson (TVA)
 Joseph Jen (USDA)
 Linda Lawson (DOT)
 Margaret Leinen (NSF)
 Jeff Lubell (HUD)
 Michael O'Connor (USACE)
 Ken Olden (HHS)
 Marcus Peacock (OMB)
 Vahid Majidi (DOJ)
 Jacqueline Schafer (USAID)
 Veronica Stidvent (Labor)
 John Turner (State)
 Samuel Williamson (NOAA)
 To Be Named (NEC)

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ABOUT THE SUBCOMMITTEE ON DISASTER REDUCTION

Mitigating natural and technological disasters requires a solid understanding of science and technology, rapid implementation of research information into disaster reduction programs and applications, and efficient access to diverse information available from both public and private entities. The Subcommittee on Disaster Reduction provides a unique Federal forum for information sharing, development of collaborative opportunities, formulation of science- and technology-based guidance for policy makers, and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks.

Chartered in 1988, the Subcommittee on Disaster Reduction is a subcommittee of the Committee on Environment and Natural Resources, an element of the President's National Science and Technology Council. The Chair and Vice Chair are each selected by the White House Office of Science and Technology Policy and serve a three-year term. The heads of relevant agencies and departments annually designate lead representatives to the SDR.

SUBCOMMITTEE ON DISASTER REDUCTION MEMBERSHIP

Subcommittee on Disaster Reduction Leadership

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Helen Wood (NOAA)
Vice Chair
David Applegate (USGS)
NSTC Liaison
Gene Whitney (OSTP)
Secretariat
Dori Akerman

Grand Challenges Task Group

Co-Chairs
John Babb (OSPHS)
Noel Raufaste (NIST)

International Working Group

Co-Chairs
Fernando Echavarria (State)
Larry Roeder (State)
Dennis Wenger (NSF)

Remote Sensing Applications Working Group

Co-Chairs
Steve Ambrose (NASA)
Jay Feuquay (USGS)
Peter Rinkleff (NGA)

Earth Observation Task Group

Chair
Margaret Davidson (NOAA)

Department of Commerce/ National Institute of Standards and Technology

Jim St. Pierre (Member)
Noel Raufaste (Co-Chair, Grand
Challenges Task Group, Alternate)

Department of Commerce/ National Oceanic and Atmospheric Administration

Helen Wood (Chair)
Margaret Davidson (Member)
John Gaynor
Grace Swanson
Nathalie Valette-Silver
Katy Vincent
Pai-Yei Whung

Department of Defense

Earnest Paylor (Member)

Department of Energy

Tom Ryder (Member)

Department of Health and Human Services/ Centers for Disease Control and Prevention

Daniel Sosin (Member)
Josephine Malilay (Alternate)

Department of Health and Human Services/ US Public Health Service Commissioned Corps

John Babb (Member)
Boris Lushniak (Alternate)

Department of Homeland Security

Nancy Suski (Member)
Chris Doyle (Alternate)
Bruce Davis (Alternate)

Department of Homeland Security/Federal Emergency Management Agency

David Maurstad (Member)
Mike Buckley (Alternate)
Priscilla Scruggs

Department of Homeland Security/United States Coast Guard

Russ Doughty (Member)
Ray Perry (Alternate)

Department of Housing and Urban Development

John Kennedy (Member)
Kevin Sheehan (Alternate)

Department of the Interior

Laurence Broun (Member)
Michael Pierce (Alternate)

Department of the Interior/United States Geological Survey

David Applegate (Vice Chair)
John Filson
Rosalind Helz (Chair, Earth Observation
Task Group, Co-Chair, Remote Sensing
Applications Working Group)

Department of State

Fernando Echavarria (Member, Co-Chair,
International Working Group)
Larry Roeder Jr. (Member, Co-Chair,
International Working Group)

Cynthia Brady

Department of Transportation

K. "K.T." Thirumalai (Member)
Sheila Duwadi

Environmental Protection Agency

Peter Jutro (Member)
Regan Murray (Alternate)

National Aeronautics and Space Administration

Steve Ambrose (Member; Co-Chair,
Remote Sensing Applications
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Shahid Habib
Craig Dobson

National Geospatial-Intelligence Agency

Monica Gaughan (Member)
Marty Tierny (Alternate)
Peter Rinkleff

National Guard Bureau

Peter M Aylward (Member)
Frank Hudoba
Stephen Davis

National Science Foundation

Dennis Wenger (Co-Chair, International
Working Group)
Steve McCabe
Bob O'Connor
Larry Weber

United States Agency for International Development

Peter Morris (Member)

United States Army Corps Engineers

Michael O'Connor (Member)
David Mathis (Alternate)
Andrew Bruzewicz

United States Department of Agriculture

Allen Dedrick (Member)
Phil Pasteris

United States Department of Agriculture/Forest Service

Susan Conard (Member)

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ABOUT THE UNITED STATES GROUP ON EARTH OBSERVATIONS

An Interagency Working Group on Earth Observations was chartered by the Committee on Environment and Natural Resources for the purpose of developing the Strategic Plan for the U.S. Integrated Earth Observation System, and to provide U.S. contributions to the Global Earth Observation System of Systems (GEOSS). The Interagency Working Group's charter expired in December, 2004, and the working group has been replaced with a standing subcommittee under the Committee on Environment and Natural Resources, the United States Group on Earth Observations (US GEO).

UNITED STATES GROUP ON EARTH OBSERVATIONS MEMBERSHIP

United States Group on Earth Observations Leadership

Co-Chairs

Ghassem Asrar (NASA)
 Greg Withee (NOAA)
 Teresa Fryberger (OSTP)

Secretariat

Carla Sullivan

Improved Observations for Disaster Warnings Task Group

Co-Chairs

David Applegate (USGS)
 Margaret Davidson (NOAA)
 Craig Dobson (NASA)

Global Land Observation System Task Group

Chair

Jay Feuquay (USGS)

Sea Level Observation System Task Group

Chair

Stan Wilson (NOAA)

National Integrated Drought Information System Task Group

Chair

Tom Karl (NOAA)

Air Quality Assessment and Forecast System Task Group

Co-Chair

Richard Scheffe (EPA)

Co-Chair

Steve Fine (NOAA)

Architecture and Data Management Working Group

Co-Chairs

Kathy Fontaine (NASA)
 Tom Karl (NOAA)

Science and Technology Working Group

Chair

To Be Named

User Interface Working Group

Chair

To Be Named

Capacity Building and Outreach Working Group

Chair

To Be Named

Council on Environmental Quality

Ken Peel

Department of Commerce/

National Oceanic and Atmospheric Administration
 John Jones

Department of Defense

Grant Aufderhaar

Department of Energy

Wanda Ferrell

Department of the Interior/United States Geological Survey

Jay Feuquay (Chair, Global Land Observation System Task Group)
 John Filson

Department of State

Dan Reifsnyder

Department of Transportation

Camille Mittelholtz

Environmental Protection Agency

Gary Foley

National Institutes of Health

Mary Gant

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Tom Spence

Office of Management and Budget

Amy Kaminski
 Andrea Petro

Office of Science and Technology Policy

David Halpern

Smithsonian

Len Hirsch

Tennessee Valley Authority

Frances Weatherford

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United States Department of Agriculture

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 Mark Weltz

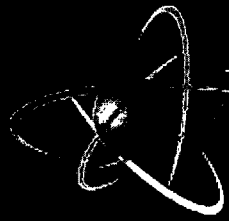
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National Science and Technology Council

**A Joint Report of the Subcommittee on Disaster Reduction
and the United States Group on Earth Observations**

July 2005



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Update to Tsunami Guidance: Future Reactor Siting

Stephen Monarque (Project Manager)

Nilesh Chokshi (Deputy Director)

Leslie Kass (NEI)

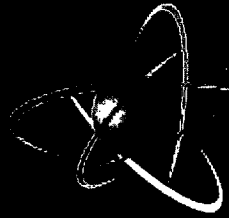
Goutam Bagchi (Senior Advisor)

Yong Li (Geophysicist)

Hosung Ahn (Hydrologist)

Annie Kammerer (Geophysicist)

January 17, 2007



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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Meeting Agenda: Proposed Update of SRP 2.4.6

Introductory Remarks

Tsunami Basics and Reactor Siting

Proposed Update to SRP 2.4.6

- Overview of SRP 2.4.6

- Tsunami Sources

- Tsunami Propagation and Runup

- NRC Research to Characterize Tsunami Hazard for the East and Gulf Coasts

Opportunity for Public Comment and Discussion

Meeting Summary and Adjournment

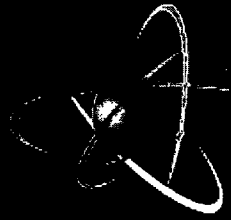


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Protecting People and the Environment

Introductory Remarks



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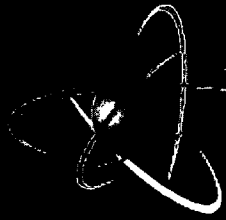
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Protecting People and the Environment

Tsunami Basics and Reactor Siting

Tsunami literally means harbor wave. These waves are generated in a body of water when its bed is rapidly displaced on a massive scale.

- Small Amplitude, but very deep down to the bottom
- Very Long Wavelength
- Unnoticed at Sea
- Shoreline may recede (trough) or rise (crest)
- Rising shoreline / large waves threat to facilities
- Receding shoreline may expose intake structures



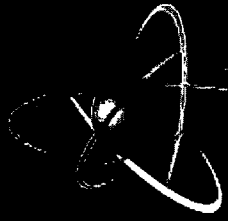
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Protecting People and the Environment

Probable Maximum Tsunami

The PMT is defined as that tsunami for which the impact at the site is derived from the use of best available scientific information to arrive at a set of scenarios reasonably expected to affect the nuclear power plant site taking into account sparsity and uncertainty of historical events..... appropriate phenomena....and combinations of effects.....



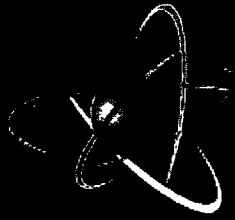
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Protecting People and the Environment

Overview of SRP 2.4.6 (2007 Ed.)

- Title Change from Previous Version
- Review Areas, Procedures and Acceptance Criteria
 - Historical data
 - Probable Maximum Tsunami
 - Tsunami Propagation Models
 - Wave Runup, Inundation, and Drawdown
 - Hydrostatic and Hydrodynamic Forces
 - Debris and Water-Borne Projectiles
 - Effects of Sediment Erosion and Deposition
 - Other Site-Related Evaluation Criteria
 - Additional Information for 10CFR 52 Applications



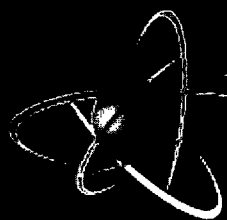
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Protecting People and the Environment

Overview of SRP 2.4.6 (2007 Ed.) (Continued)

- Areas of Review (continued)
 - Review Interfaces
 - SRP 14.3.1 (Site Parameters Tier 1)
 - SRP 2.4.10 (Flood Protection Measures)
 - SRP 9.2.5 (Ultimate Heat Sink)
 - Geophysics/Seismic – Tsunami / Like Waves
 - SRP 2.3.6 (Proposed) DC Parameter Envelope



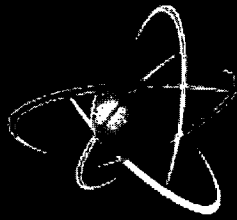
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Protecting People and the Environment

Overview of SRP 2.4.6 (2007 Ed.) (Continued)

- Acceptance Criteria
 - Based on the Following Regulations
 - 10 CFR 100
 - 10 CFR 100.10(c) for Applications Before 1/10/97
 - 10 CFR 100.20(c) Applications after 1/10/97
 - 10 CFR 100.23(d) Applications after 1/10/97
 - 10 CFR 50, GDC 2
 - 10 CFR 52.17(a)(1)(vi) for ESP Applications
 - 10 CFR 52.79(a)(1)(iii) for COL Applications



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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Overview of SRP 2.4.6 (2007 Ed.) (Continued)

- Acceptance Criteria (continued)
 - Guidance Documents
 - RG 1.27 Ultimate Heat Sink
 - RG 1.29 Seismic Design Classification
 - RG 1.59 Design Basis Floods
 - RG 1.102 Flood Protection
 - Data: NOAA, National Geophysical Data Center
 - Regulatory Guides & best current practice



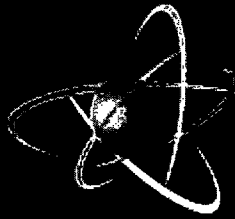
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Protecting People and the Environment

Overview of SRP 2.4.6 (2007 Ed.) (Continued)

- Statements for Evaluation Findings
 - CP, OL, and COL Reviews
 - ESP Reviews
 - Design Certification Reviews
- Implementation
 - 10 CFR 50 & 52 Applications
 - Exceptions for Acceptable Alternative Method



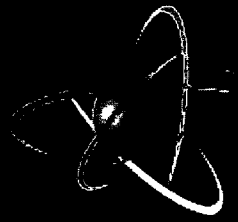
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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

NRC Tsunami Guidelines

- Tsunami hazard at a site:
 - Distance, location & site elevation
 - Historical data
 - Many hazard elements
 - Flooding, drawdown, coastal erosion, hydrodynamic effect on reactor safety



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

NRC Tsunami Guidelines (continued)

- Tsunami hazard at a site (continued):
 - Site vulnerability
 - Choosing hazard elements for site
 - Resources: NOAA, US Corps of Engineers
 - Planning for high quality application



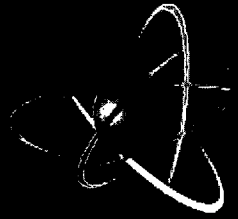
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Probable Maximum Tsunami

- It may be represented by a set of scenarios reasonably expected to affect a nuclear power plant site.
- These scenarios take into consideration
 - appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.
 - safety functions to be performed.



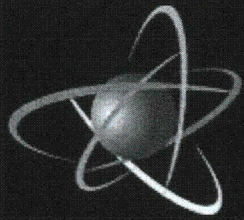
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US Historical Tsunami Records

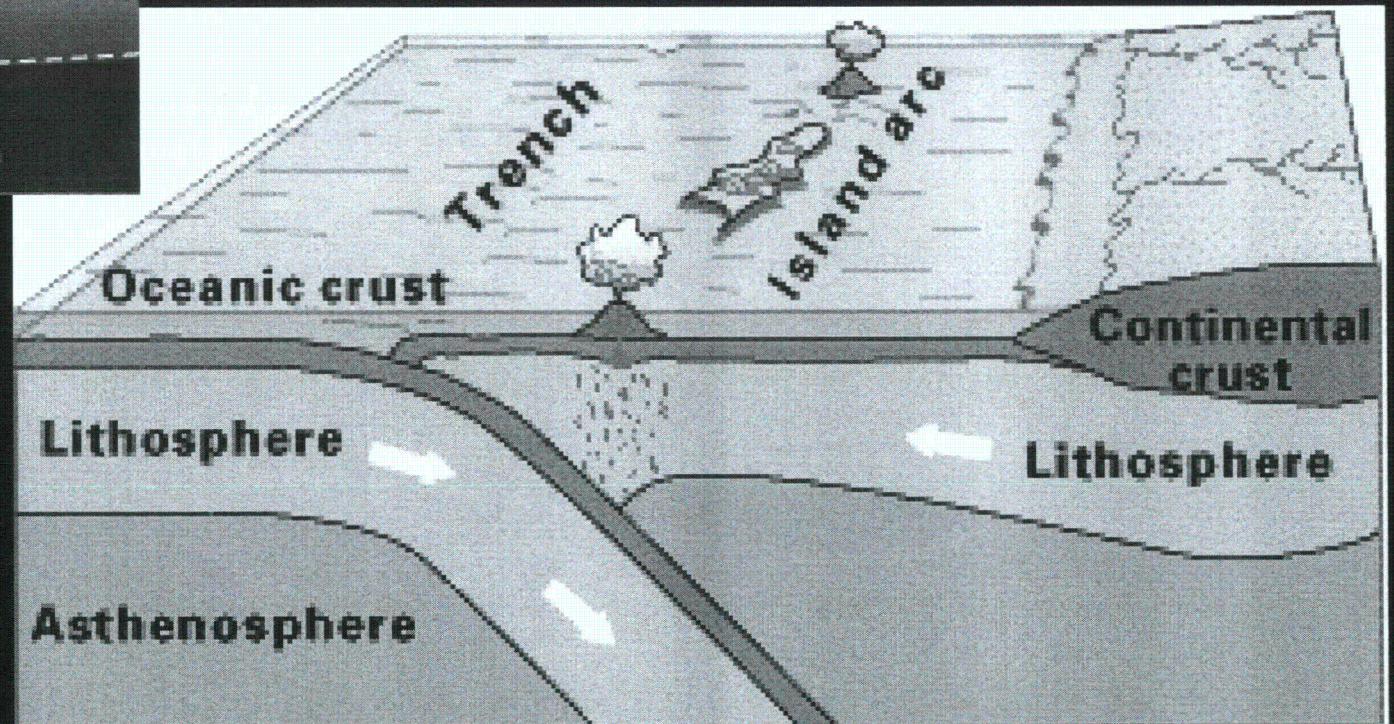
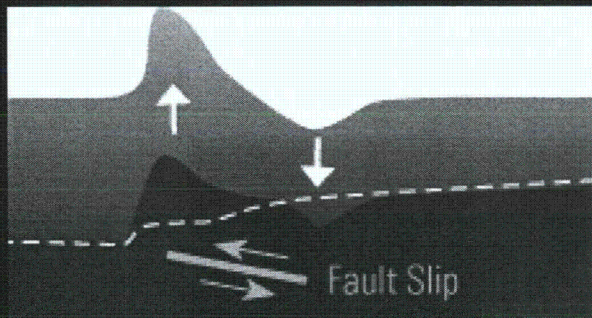
- Tsunamis were induced by
 - Earthquake (71%)
 - Landslides triggered by earthquakes (13%)
 - Landslides (10%)
 - Volcano Eruptions (2%)
 - Others (4%)



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Earthquake Triggered Tsunami



USGS

Oceanic-oceanic convergence



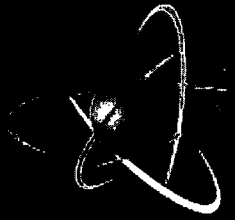
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Earthquake Triggered Tsunami (Continued)

- Local and remote seismic sources
 - Maximum Magnitudes, focal depth, fault dimension, orientation, displacement and the potential sea floor relocating volume
- Tectonic settings
 - Subduction zones (inter-plate thrust)
 - Out-raise normal faults, back-arc thrusts, deep intra-slab events
 - Strike-slip faults



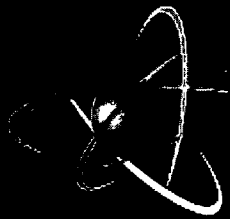
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Earthquake Triggered Tsunami (Continued)

- Return period of the earthquakes associated with a specific tectonic setting
 - Historical data
 - Paleotsunami studies
- Tsunami earthquakes
 - Latest Japan studies indicate tsunami earthquake concept



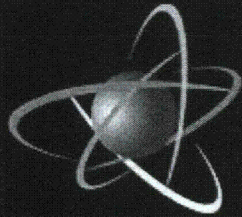
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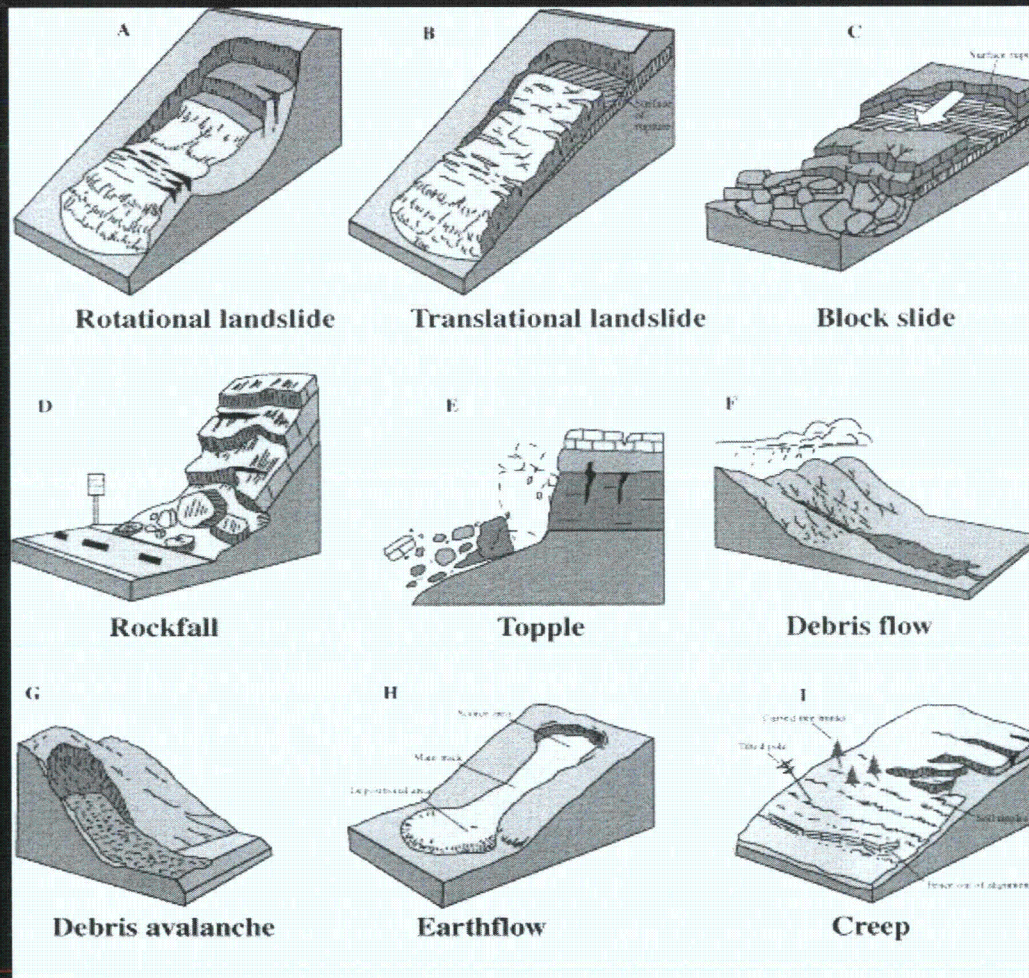
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Landslide Triggered Tsunami

- Submarine Landslides
 - Types: slides, topples, spreads, falls and flows.
 - Important parameters: slide volume distribution and time history (slide acceleration and speed).
- Subaerial Landslides
 - Geographically limited



Landslide Triggered Tsunami (Continued)





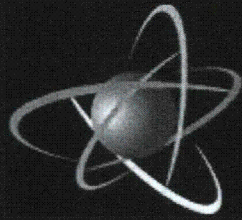
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Volcano Activity Triggered Tsunami

- Submarine Volcano Eruptions
 - Pyroclastic flows
 - Caldera collapses
 - Explosive eruptions
 - Debris avalanche and flank failures



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Some Tsunami Sources In East and Gulf Coasts





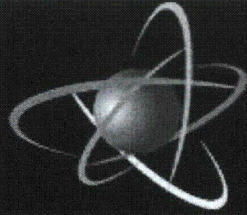
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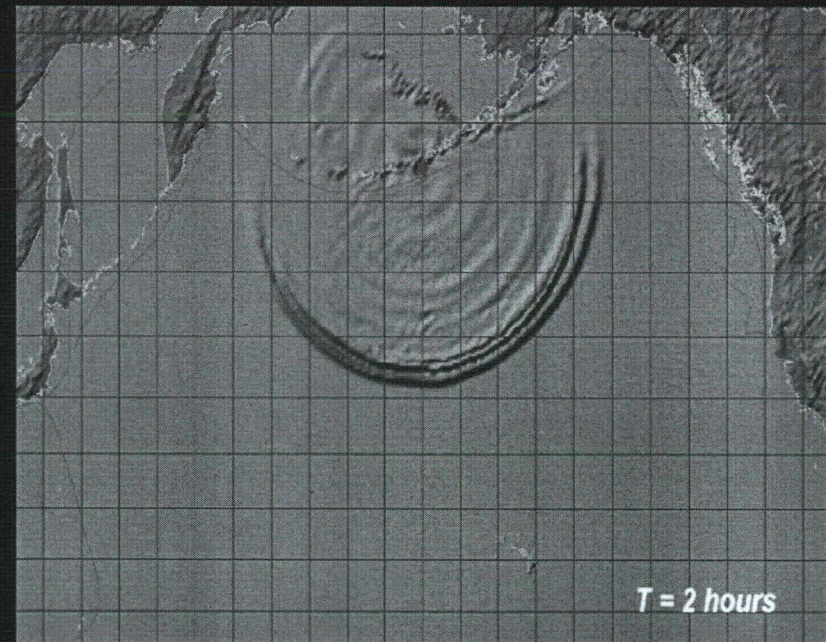
Interacting With Others

- Investigations for tsunami sources should be coordinated with Geology and Seismology related investigations.

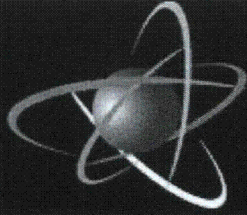


Tsunami Propagation and Run-up

- Concept
- Theories
- Initial & Boundary Conditions
- Parameters & Bathymetry
- Models
- Source of Information

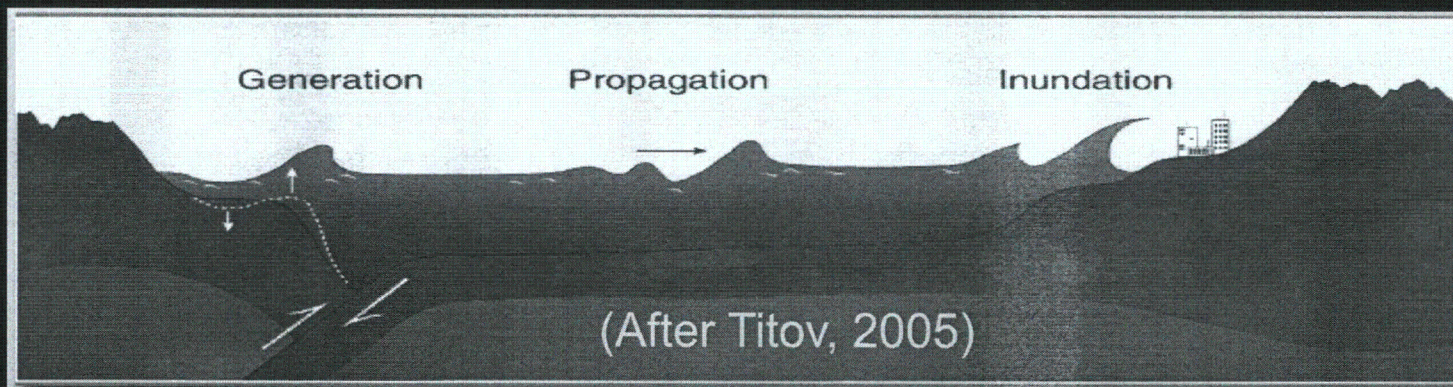


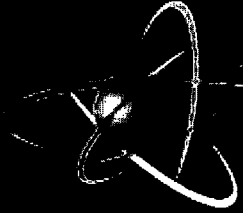
Tsunami Propagation
(from NOAA/PMEL)



Concept

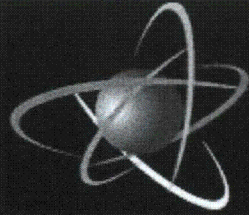
- Wave formation
- Wave propagation: far-field or near-field
- Wave Run-up: inundation and drawdown:
 - Definition: the max. vertical extent of wave up-rush on a beach above the still water level.





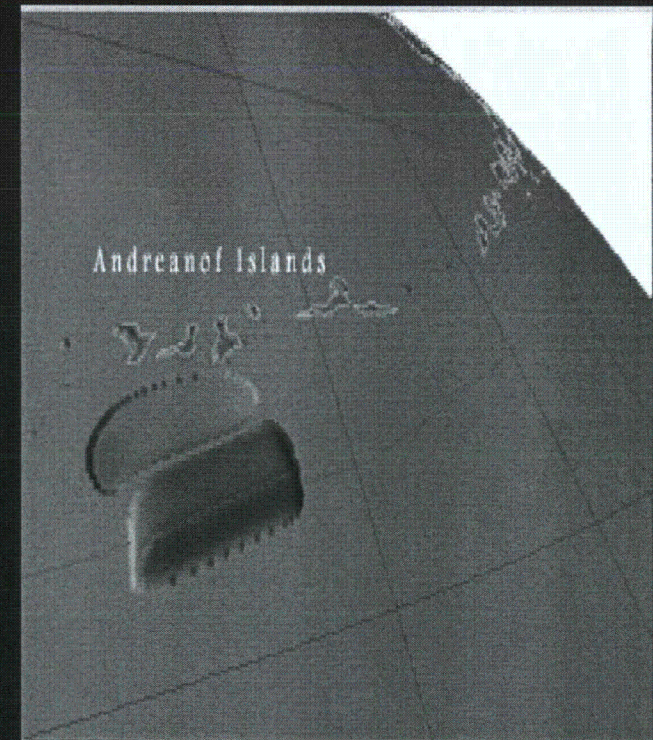
Wave Propagation Theory

- Linear long-wave theory
 - For small h/D ratio, use unsteady +pressure terms
 - Non-linear long-wave (shallow water wave) theory
 - Unsteady +pressure +advection terms, consider steep slope & eddy viscosity
 - Dispersive wave theory
 - Applied when the curvature of tsunami wave increases with propagation
 - Wave dispersion + vertical acceleration
- *** Theory used depends on the specific site
- *** Should include the Coriolis force and adopt a spherical coordinate system for far-field tsunami
- *** Use a 2-D model in general, but 3-D models for (i) a steep slope, or (ii) a small valley acts as a maximum run-up point

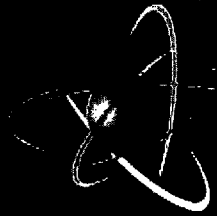


Initial Conditions

- The amount of vertical slip of the sea bottom
- Duration of fault movement
 - Assume an instantaneous displacement as a conservative scenario
- Setting the initial conditions
 - Initial water surface is still, and initial water flux is set to zero
 - Then, apply the vertical slip distribution of the sea bottom



(After Titov, 2005)



Boundary Conditions (BC)

- Offshore BC:
 - Free, open boundaries on offshore and both sides
- Onshore BC:
 - Complete reflection condition
 - Run-up front boundary – allow water flux
- Overflow BC:
 - Breakwater, sea dike, seawall revetment



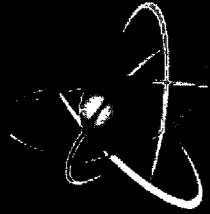
Numerical Modeling

- Model area may be determined based on:
 - The location of tsunami source region
 - Horizontal scale of tsunami
 - Characteristics of submarine and coastal topography
 - Protection structures, etc.
- Spatial mesh grid:
 - The wavelength of a tsunami varies from several hundreds km at offshore to water depth at onshore, thus for the mesh sizes to get accurate computational results
- Key parameters:
 - Fractional coefficients for sea and inundation areas
 - Eddy viscosity coefficient
 - Set a minimum water depth
 - Computing time step



Potential Sources of Data

- Bathymetry data as appropriate:
 - 5-Minute Gridded Earth Topography Data by NOAA/NGDC (1988) for far-field tsunami
 - 2-Minute Gridded Earth Topography Data
 - Use nautical chart, coast guard maps, USACE data for near-field tsunami
- Topographic data in the inundation area:
 - USGS topography maps or DEMs, others
 - Need past topographic data for simulating historical tsunamis



Potential Approaches

- Simple Analytical Equations
 - I-D wave run-up and overtopping
 - USACE's "Tsunami Engineering (1980)"
 - USACE's "Coastal Engineering Manual (2005)"
- Physical Scale Models
 - Example: Diablo Canyon used a 1:45, 80 ft x 120 ft scale model to estimate the harbor and breakwater influences on tsunami to confirm analytical model
- Examples of Numerical Models
 - MOST (Method Of Splitting Tsunami, by Titov and Synolakis):
 - TUNAMI-N2 model by Tohoku Univ.
 - U. of Alaska's model
 - ADCIRC finite element model by Baptista and Myers, and others³⁰



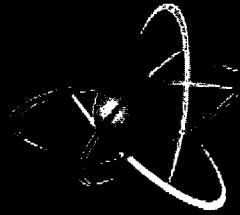
Sources of Information

- Website

- <http://nctr.pmel.noaa.gov/model.html>
- <http://www.ngdc.noaa.gov/mgg/inundation/>
- <http://www.usgs.gov/hazards/tsunamis/>
- <http://www.tsunamiwave.info/>
- <http://chl.ercd.usace.army.mil/chl.aspx?p=s&a=ResearchAreas;20>

- Some Technical Publications

- Camfield, F., "Tsunami Engineering", U.S. Army Corps of Engineers, Coastal Engineering Research Center, Special Report No. 6, Ft. Belvoir, VA, 1980
- USACE, "Coastal Engineering Manual", EM-1110-1100, Coastal and hydraulic laboratory, U.S. Army Corps of Engineers, 2005
- JSCE, "Tsunami Assessment Method for Nuclear Power Plants in Japan", Japan Society of Civil Engineers, 2002.
- Gonzalez et al., "Seaside Oregon Tsunami Pilot Study – Modernization of FEMA Flood Hazard Maps", Tsunami Pilot Study Working Group, Joint NOAA/USGS/FEMA Special Report, 2006
- Gonzalez et al., "Scientific and Technical issues in Tsunami hazard Assessment for Siting of Nuclear Plants", Draft Report, Science Review Working Group, 2006



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NRC Research to Characterize Tsunami Hazard for the East and Gulf Coasts

Purpose of Research Program:

- To develop a source database for review of NPP applications
- To provide characterization of sources for NOAA tsunami modeling
- To investigate potential impact of landslides on tsunami hazard for the east and gulf coasts
- To develop probable maximum tsunami (PMT) using probabilistic tsunami hazard analysis (PTHA) in the long term



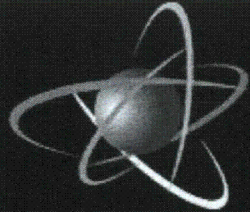
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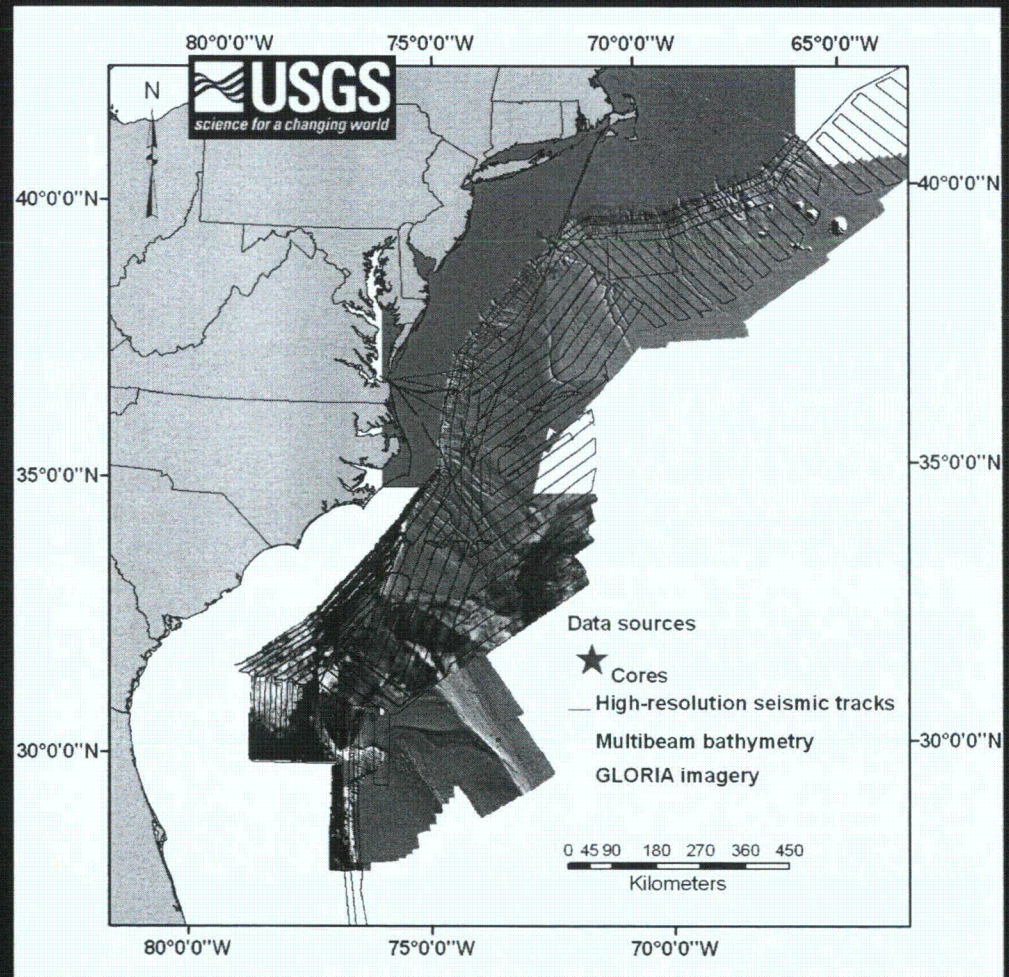
NRC Tsunami Research Program

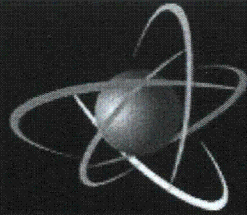
- Research program is composed of two parts:
 - Current work with the USGS focused on developing a tsunami source database (seismic and landslide)
 - Database expected May 2007
 - Future work with NOAA will model the impact of the sources in the database



USGS Study

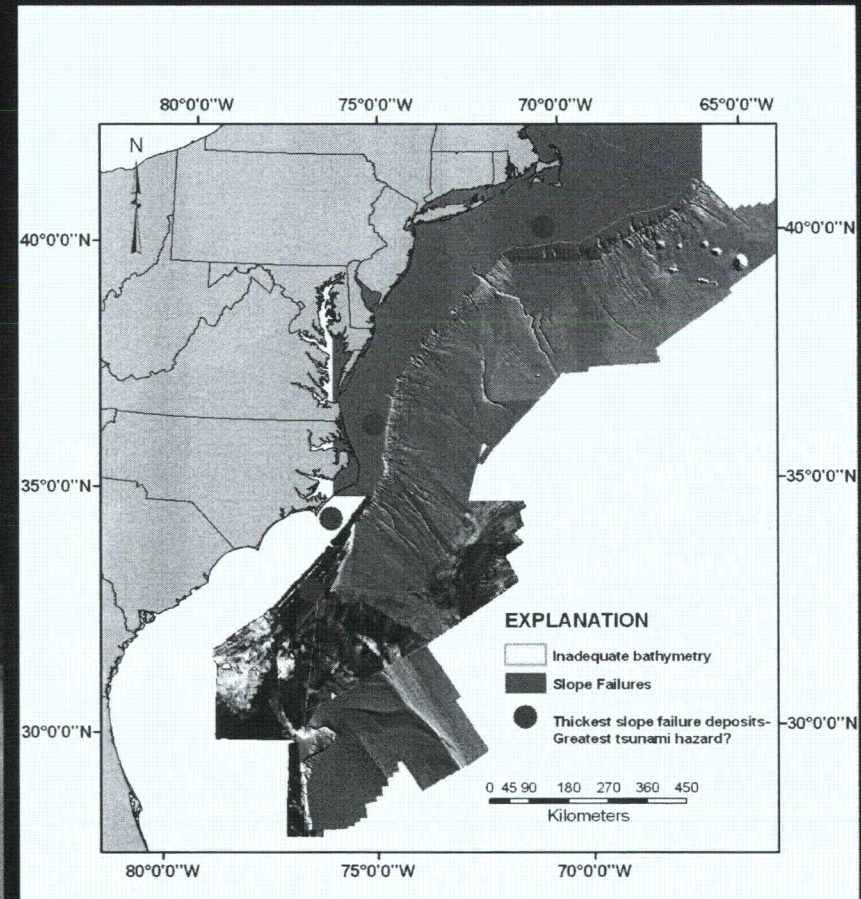
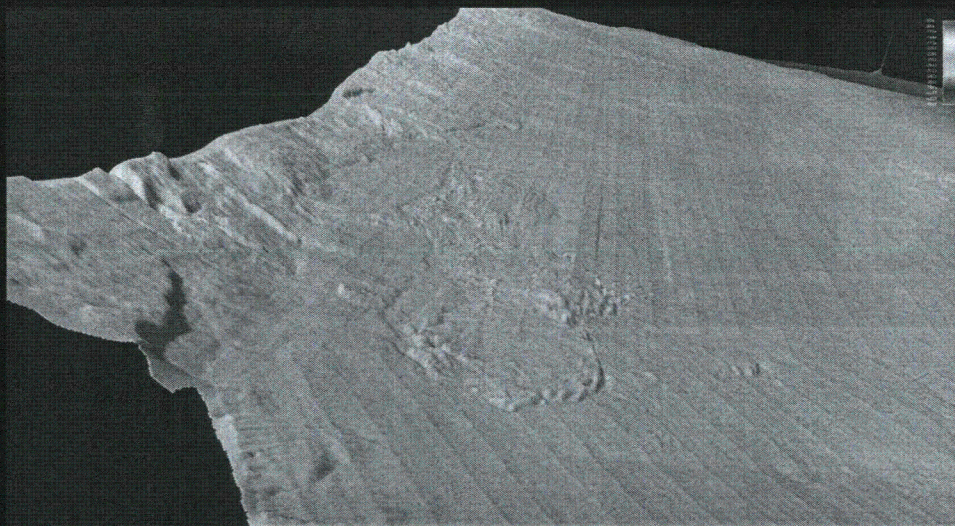
- Historic information of landslide-induced tsunamis
- Analysis of geophysical maps of coasts
- Analysis of available offshore soil/rock cores
 - Separation of events
 - Dating of events
 - Characterization of soil types prone to slides
- Assessment of known seismic sources





Difficulties include:

- Changes in sea level
- Separating multiple events
- Dating events
- Understanding source regions



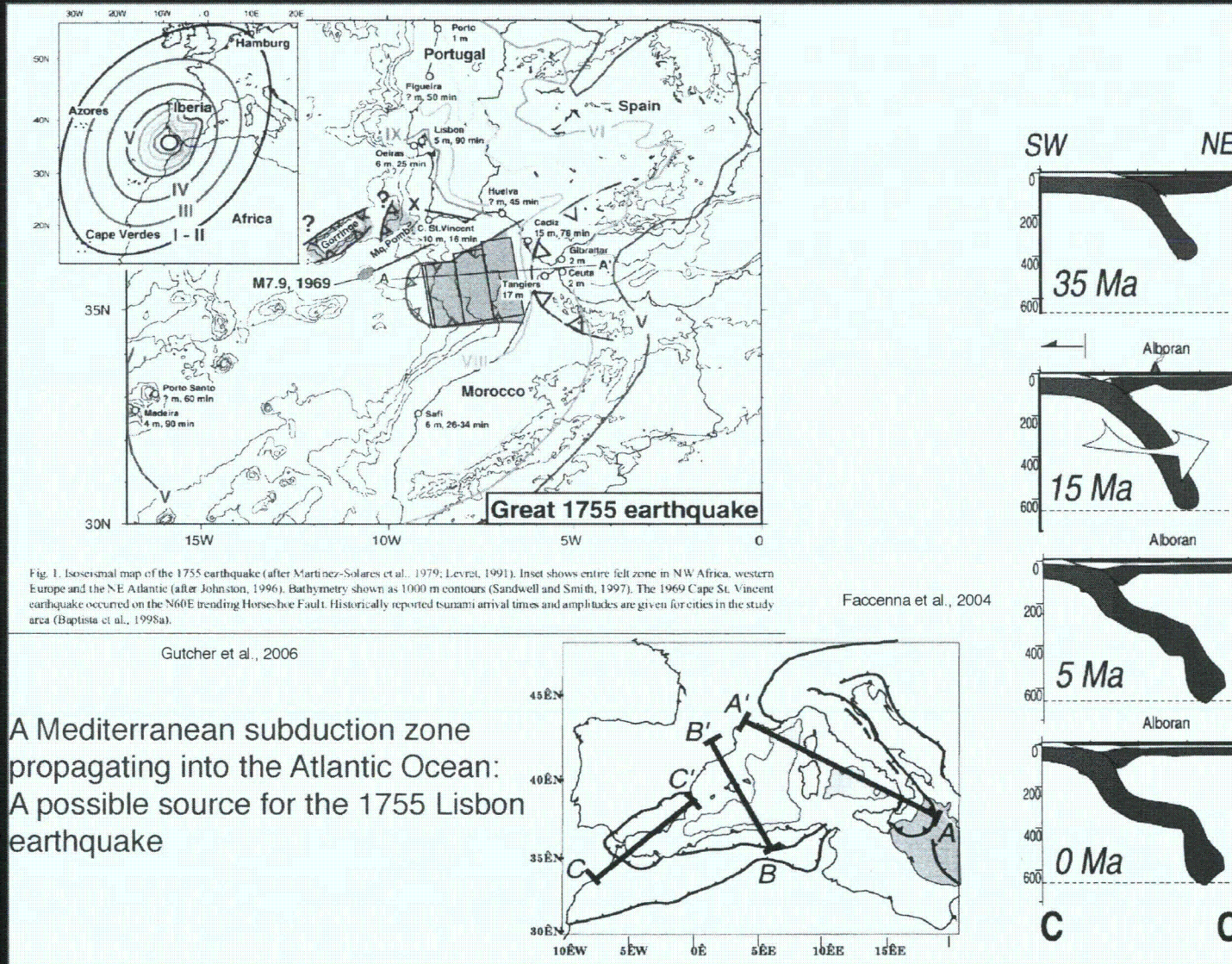
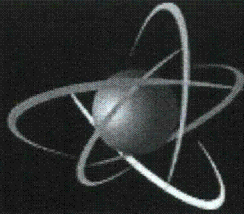
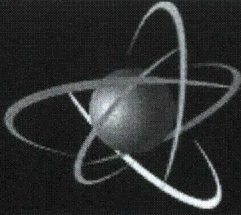


Fig. 1. Isoseismal map of the 1755 earthquake (after Martínez-Solares et al., 1979; Levret, 1991). Inset shows entire felt zone in NW Africa, western Europe and the NE Atlantic (after Johnston, 1996). Bathymetry shown as 1000 m contours (Sandwell and Smith, 1997). The 1969 Cape St. Vincent earthquake occurred on the N60E trending Horseshoe Fault. Historically reported tsunami arrival times and amplitudes are given for cities in the study area (Baptista et al., 1998a).

Facenna et al., 2004

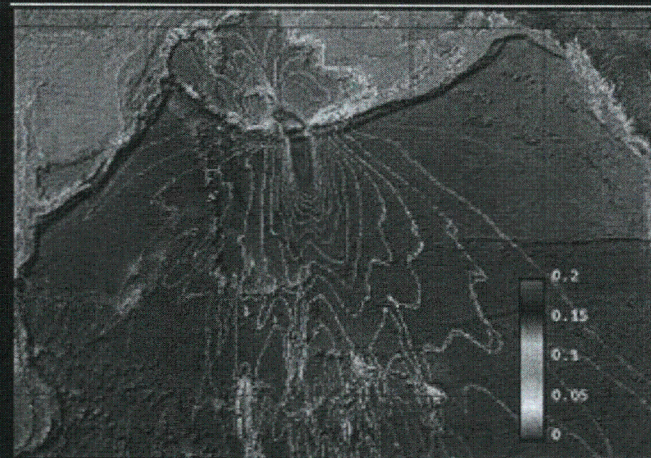
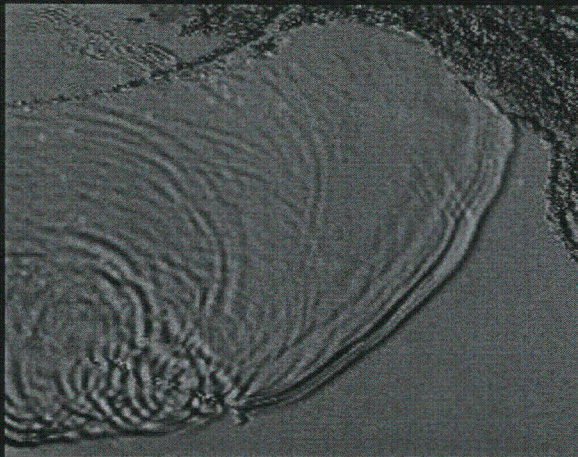
Gutcher et al., 2006

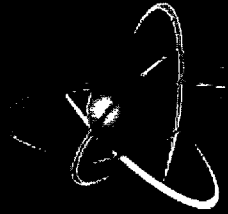
A Mediterranean subduction zone propagating into the Atlantic Ocean: A possible source for the 1755 Lisbon earthquake



Next Step: NOAA Modeling

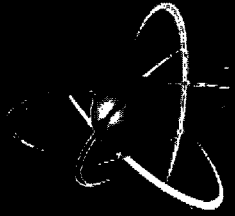
- NOAA to use UGSG source information to add landslide capability to global (MOST) model
- NOAA modeling addresses “linear” part of PMT and PTHA analyses
- Site-specific inundation modeling performed separately





NRC Tsunami Guidance Development Summary

- Tsunami hazard review update is a comprehensive effort
- Includes SRP and application format update
- Includes technical studies
- Coordinated with National Plan
- Includes research plan to develop source database and PTHA



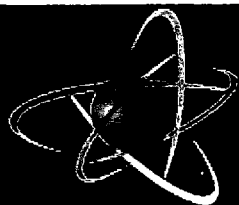
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NRC Tsunami Guidance Development Summary (continued)

- The draft SRP 2.4.6 is on ADAMS 1-17-2007
- SRP update by March 31, 2007
- PNNL NUREG/CR March 31, 2007
- Importance of prior planning
- Consideration of tsunami hazard element affecting reactor safety

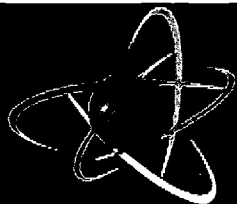


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Update to Tsunami Guidance: Future Reactor Siting

Comments and Discussion



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Update to
Tsunami Guidance: Future Reactor Siting

Meeting Adjourned