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**NUCLEAR REGULATORY COMMISSION**

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                          Metallurgy and Reactor Fuels Subcommittee  
                          Open Session

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON METALLURGY AND REACTOR FUELS

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OPEN SESSION

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TUESDAY, JULY 7, 2020

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The Subcommittee met via Teleconference,  
at 2:00 p.m. EDT, Ronald G. Ballinger, Chairman,  
presiding.

COMMITTEE MEMBERS:

RONALD G. BALLINGER, Chairman

CHARLES H. BROWN, JR. Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DAVID A. PETTI, Member

PETER RICCARDELLA, Member

JOY L. REMPE, Member

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DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

DEREK WIDMAYER

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## P R O C E E D I N G S

2:00 p.m.

CHAIRMAN BALLINGER: Okay. This meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Materials and Reactor Fuels Subcommittee. I'm Ron Ballinger, Chairman of the Metallurgy and Reactor Fuels Subcommittee.

Members in attendance are, I believe, Charles Brown, Walt Kirchner, Jose March-Leuba -- let's see -- Dave Petti, Joy Rempe, Pete Riccardella, Vesna Dimitrijevic.

If I have missed anybody, please say something. I think I got everybody.

Christopher Brown and Derek Widmayer are the designated federal officials for this meeting.

Chris or Derek, I guess we need to be sure that the recorder is on. Are we sure?

PARTICIPANT: Shane (phonetic) has verified that.

CHAIRMAN BALLINGER: Good. Thank you.

The purpose of today's meeting is for the Subcommittee to receive a briefing on staff safety evaluation for the topical report Deformable Spacer Grid Elements. Today we have members of the NRC staff

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1 and industry to brief the Subcommittee.

2 The ACRS was established by statute and is  
3 governed by the Federal Advisory Committee Act, FACA.  
4 The NRC implements FACA in accordance with its  
5 regulations found in Title 10 of the Code of Federal  
6 Regulations, Part 7.

7 The Committee can only speak through its  
8 published letter reports. We hold meetings to gather  
9 information and perform preparatory work that will  
10 support our deliberations at a full Committee meeting.  
11 The rules for participation in all ACRS meetings were  
12 announced in the Federal Register on June the 13th,  
13 2019.

14 The ACRS section of the US NRC public  
15 website provides our charter, bylaws, agendas, letter  
16 reports, and full transcripts of all full and  
17 subcommittee meetings, including slides and  
18 presentations there. The meeting agenda for this  
19 meeting was posted there.

20 Portions of this meeting will be closed to  
21 protect proprietary information pursuant to 5 U.S.C.  
22 552 (b) (c) (4). For the open portion of this meeting,  
23 we have also set aside five minutes for comments from  
24 members of the public attending or listening to this  
25 meeting. We have no requests so far for making a

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1 statement to the Subcommittee has been received by the  
2 public.

3 A transcript of the meeting is being kept  
4 and will be made available on our website for the open  
5 portion of the meeting. Therefore, we request that  
6 participants in this meeting should first identify  
7 themselves and speak with sufficient clarity and  
8 volume so that they can be readily heard. Please  
9 pause from time to time to allow members to --

10 (Simultaneous speaking.)

11 PARTICIPANT: We're wonderful. How are  
12 you?

13 PARTICIPANT: Somebody has got a mic open  
14 somewhere.

15 PARTICIPANT: Remember, please mute your  
16 mic.

17 CHAIRMAN BALLINGER: Well, we are all  
18 wonderful, I guess.

19 Please indicate the slide number that  
20 you're on. We have a bridge line established for the  
21 public to listen to the meeting. To minimize  
22 disturbance, the public line will be kept in a listen-  
23 only mode. The public line will be terminated during  
24 the closed portion.

25 To avoid disturbance, we request that



1 attendees make sure they are muted. And, again, I've  
2 got to check.

3 Thomas, is the public line all set?

4 MR. DASHIELL: Public line is all set.

5 CHAIRMAN BALLINGER: Very good. Thank  
6 you.

7 Okay. Note that we have a scheduled  
8 meeting, on full Committee, on September 10th.

9 We'll now proceed with the meeting, and  
10 I'm going to ask Brian Painter, Framatome, to share  
11 his screen with us. He already has done that. Ms. MJ  
12 Ross-Lee, Deputy Division Director, Division of Safety  
13 Systems NRR, and after, any introductory remarks to  
14 make before we begin with today's presentations.

15 And I see she is here, I think.

16 MS. ROSS-LEE: Yes. Hi. Thank you.

17 Good afternoon. As introduced, my name is  
18 MJ Ross-Lee. I am the Deputy Director for Division of  
19 Safety Systems in NRR. Today we will be discussing a  
20 supplement to the topical report, which describes the  
21 Framatome analysis methodology for capturing the  
22 dynamic behavior of fuel assemblies during oscillatory  
23 loads typical of seismic and/or LOCA events.

24 This methodology is used to demonstrate  
25 compliance with several regulatory requirements which

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1 ensure that, among other things, the fuel geometry  
2 ensures adequate cooling and the guide tubes are not  
3 so severely deformed that control rod insertion is  
4 impeded.

5 The supplement adds a new model element  
6 that can be utilized within the previously approved  
7 analysis framework to represent the unique behavior of  
8 certain spacer grid designs such as the GAIA spacer  
9 grid. The engagement on this review between NRC,  
10 PNNL, and Framatome staff was very efficient,  
11 effective, with the use of a regulatory audit which  
12 was used to identify and address significant issues  
13 via a single round of requests for additional  
14 information despite the novel nature of the proposed  
15 analysis model element.

16 And with that I will turn it over to  
17 Framatome.

18 CHAIRMAN BALLINGER: Brian, are you up?

19 MR. PAINTER: Yes. I'm here.

20 Hello. My name is Brian Painter. I'm an  
21 engineer in the Fuel Mechanical Analysis Group at  
22 Framatome. And I'll start my presentation.

23 So, moving to slide 2, I'll discuss in  
24 this presentation a review of the base methodology, an  
25 overview of the GAIA fuel assembly design, and then a

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1 description of the deformable grid methodology.

2 Moving to slide 3, this is a review of the  
3 base methodology. So Framatome's generic base  
4 methodology, ANP-10337, which is for PWR Seismic and  
5 LOCA mechanical evaluations -- it was approved in  
6 August 2018. And what it accomplishes for us in the  
7 methodology space is it updates the lateral dynamic  
8 models, vertical dynamic modeling, and the on-grid  
9 component stress analysis. It also addresses NRC  
10 information that is 2012-09, which were radiation  
11 effects on spacer grid crush strength.

12 CHAIRMAN BALLINGER: Somebody's got their  
13 microphone not muted. Please.

14 MR. PAINTER: Okay. Thank you.

15 It also defines the spacer grid allowable  
16 impact load and allowable spacer grid permanent  
17 deformations.

18 So, in the base methodology, the impact  
19 response of the spacer grid is assumed to be linear up  
20 to the allowable impact load. With new spacer  
21 designs, as mentioned, the GAIA design in particular,  
22 they exhibit a linear impact response but a limited  
23 one, which is then followed by a nonlinear impact  
24 response.

25 So the deformable spacer grid methodology,

1 its intent is to extend the base methodology to  
2 address spacer grids with these nonlinear impact  
3 responses.

4 On slide 4, I would like to say that most  
5 of the base topical remains applicable to this  
6 supplement, to the deformable grid supplement. So the  
7 fuel assembly beam model architecture is unchanged.  
8 The damping and the hydrodynamic coupling terms that  
9 we apply in the row models and vertical models,  
10 they're unchanged.

11 How we treat irradiation effects on spacer  
12 grade testing is unchanged, and the non-grid component  
13 stress evaluations are unchanged. So the deformable  
14 grid supplement, all it's doing, in essence, is  
15 replacing the linear grid impact element with a  
16 nonlinear impact element.

17 Moving to slide 5, so we'll speak about  
18 the GAIA fuel assembly and the GAIA spacer grid a lot  
19 during the open and close presentation because this  
20 was the spacer grid that kind of launched this effort.  
21 So it's worth giving an overview of the fuel assembly  
22 design.

23 So it's Framatome's latest fuel assembly  
24 design for Westinghouse 17 x 17 reactors. As I've  
25 already mentioned, the GAIA spacer grid introduces a

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1 nonlinear response in seismic and LOCA excitations  
2 from moderate impacts. So, smaller energy impacts,  
3 the grid remains linear. But, as we increase the  
4 impact energies, we can see that -- and we'll show in  
5 the close presentation -- that the nonlinearities  
6 become more important.

7 Now, the spacer grid linear response has  
8 been analyzed using the generic base methodology, the  
9 topical report 10337. It was analyzed as part of the  
10 sample problem for ANP-10342, which is the GAIA  
11 mechanical design topical report.

12 Moving to slide 6. So a little more  
13 detail about the deformable grid methodology. So the  
14 supplement, it implements a nonlinear deformable grid  
15 model, and that will replace the linear viscoelastic  
16 spring that is described in the base methodology.

17 The deformable grid element, or DGE for  
18 short, it can simulate the nonlinear impact response,  
19 and it can predict the residual spacer deformations  
20 that occur during seismic and LOCA events. Including  
21 the DGE or the nonlinear element, it doesn't alter the  
22 modeling of fuel assembly tentative response.

23 As mentioned earlier, the beam model  
24 architecture is unchanged, as are other aspects of the  
25 analysis. One thing that does change is we knew from

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1 an exception to criteria in the base method that's  
2 based on a limiting impact load and we're replacing  
3 this with a limiting residual deformation.

4 I will take any questions you have.

5 CHAIRMAN BALLINGER: Okay. We have a 15-  
6 second rule, I guess. If there are no comments on  
7 this, I think we need to first check the public line  
8 to see if there's any members of the public that would  
9 like to make a statement.

10 Thomas, I'm assuming the public line is  
11 open.

12 MR. DASHIELL: Public line is open.

13 CHAIRMAN BALLINGER: Yeah. So are there  
14 any members of the public that would wish to make a  
15 statement regarding this?

16 (Pause.)

17 CHAIRMAN BALLINGER: Okay. Hearing none,  
18 I guess we can close the public line. And this would  
19 be, also, the end of the public part of this meeting.  
20 And so what we need to do, and Chris can correct me if  
21 I'm wrong, is we need to -- there's a different  
22 invitation, right, Chris?

23 MR. BROWN: Absolutely.

24 CHAIRMAN BALLINGER: So everybody needs to  
25 get out of this meeting, and then we rejoin the

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1 meeting using the invitation for the closed session.

2 So --

3 MEMBER REMPE: Ron, before you do that,  
4 though, don't you need to ask for public comment?

5 CHAIRMAN BALLINGER: I did.

6 MEMBER REMPE: I'm sorry. Then I guess I  
7 missed it. Okay. I apologize.

8 CHAIRMAN BALLINGER: Yeah. Senior moment.

9 (Simultaneous speaking.)

10 CHAIRMAN BALLINGER: Anyway, okay. So I  
11 think what we need to do is say goodbye to this  
12 meeting, and then we'll see you shortly in the closed  
13 session.

14 MR. BROWN: And Derek and I will verify  
15 the people that are coming into the closed session.  
16 Thank you.

17 (Whereupon, the above-entitled matter went  
18 off the record at 2:14 p.m.)

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# ACRS Subcommittee Meeting

## Topical Report Supplement to ANP-10337P-A for Deformable Grids

**Brian Painter**

July 7, 2020



# CONTENT

1. Review of Base Methodology
2. GAIA Fuel Assembly Design
3. Description of Deformable Grid Methodology

# Review of Base Methodology

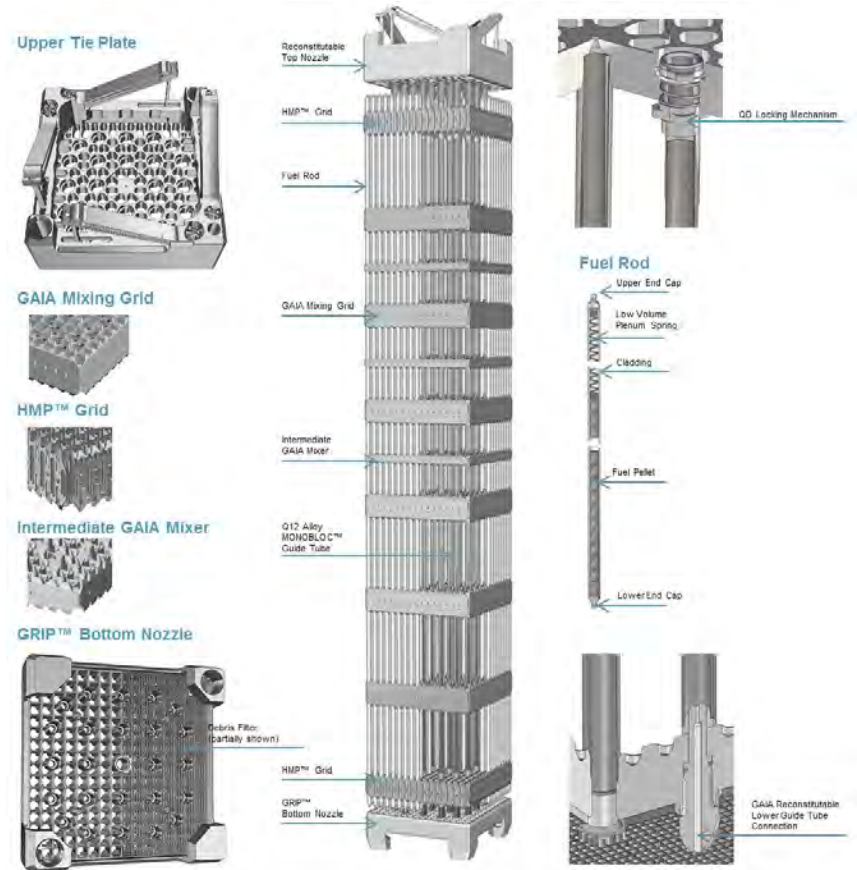
- Framatome's generic base methodology for PWR Seismic / LOCA mechanical evaluations, ANP-10337P-A, was approved in August 2018
- ANP-10337P-A:
  - Updates the lateral dynamic modeling, vertical dynamic modeling, and component stress analysis
  - Addresses NRC Information Notice 2012-09 "Irradiation Effects on Fuel Assembly Spacer Grid Crush Strength"
  - Defines spacer grid allowable impact load and allowable grid permanent deformations
- In the base methodology, the spacer grid impact response is assumed to be linear up to the allowable impact load
- New spacer grid designs, such as the GAIA design, exhibit a limited linear impact response followed by a nonlinear response
- The deformable spacer grid methodology is intended to extend the base methodology to address spacer grids with these nonlinear impact responses.

# Review of Base Methodology

- Most of the base topical remains applicable to the deformable grid supplement
  - Fuel assembly beam model architecture is unchanged
  - The applied damping and hydrodynamic coupling are unchanged
  - The treatment of Irradiation effects on spacer grid testing is unchanged
  - Non-spacer grid component stress evaluation is unchanged
- The deformable grid supplement simply replaces the linear grid impact element with a nonlinear impact element

# GAIA Fuel Assembly

- The GAIA assembly is Framatome's latest 17x17 design for Westinghouse reactors
- The innovative GAIA spacer grid introduces a nonlinear response to external excitation
  - For moderate impacts, the grid remains linear
  - For larger impacts, the nonlinearities become important
- The grid linear elastic response was analyzed in the ANP-10342P-A sample problem using the generic ANP-10337P-A methodology



# Deformable Grid Methodology

- Supplement 1 to ANP-10337P-A implements a nonlinear, deformable spacer grid model to replace the linear visco-elastic spring prescribed in the base methodology
- The deformable grid element (DGE) can simulate the nonlinear impact response and predict residual spacer grid deformations due to seismic and LOCA events
- The inclusion of the DGE does not otherwise alter the modeling of the fuel assembly dynamic response
- The limiting impact load acceptance criteria from the base methodology are replaced with limiting residual deformations

# Acronyms

- ANCOVA – Analysis of Covariance
- BOL – Beginning of Life
- EOL – End of Life
- LOCA – Loss of Coolant Accident
- NRC – U.S. Nuclear Regulatory Commission
- SSE – Safe Shutdown Earthquake
- UCL – Upper Confidence Limit

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Thank you

