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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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METALLURGY AND REACTOR FUELS SUBCOMMITTEE

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MORNING SESSION

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THURSDAY

DECEMBER 15, 2016

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:31 a.m., Peter C. Riccardella, Chairman, presiding.

COMMITTEE MEMBERS:

PETER C. RICCARDELLA, Chairman

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR., Member

WALTER L. KIRCHNER, Member

DANA A. POWERS, Member

GORDON R. SKILLMAN, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANT:

WILLIAM SHACK

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

ALSO PRESENT:

ERICA GRAHAM, Public Participant*

ROBERT HSU, NRR

TIM LUPOLD, NRO

GARY STEVENS, Structural Integrity Associates*

BRIAN THOMAS, RES

ROB TREGONING, RES

ALEXANDER TSIRIGOTIS, NRO

ANDREA D. VEIL, Executive Director, ACRS

*Present via telephone

C-O-N-T-E-N-T-S

PAGE

P R O C E E D I N G S

8:31 a.m.

CHAIRMAN RICCARDELLA: Let's get started. The meeting will come to order. This is a meeting of the Metallurgy and Reactor Fuels Subcommittee. I'm Pete Riccardella, member of the subcommittee and I'll be chairing this meeting. ACRS members in attendance are Charles Brown, Jose March-Leuba, Dennis Bley, Matt Sunseri, Dana Powers, Gordon Skillman and our consultant, William Shack.

Christopher, no Derek Wedmayer will be the designated federal official for this meeting. The purpose of this meeting is to receive a briefing on Reg Guide 1.207 Guidelines for Evaluating the Effects of Light-Water Reactor Environments in Fatigue Analyses of Metal Components. The Reg Guide was issued for public comment as Draft Reg Guide DG-1309. We'll hear presentation from representatives of the Office of Nuclear Regulatory Research, the subcommittee will gather information, analyze relevant issues and facts and form a composed position in action as appropriate for deliberation by the full committee. The rules for participation in today's meeting were announced as part of the notice of the meeting, previously post in the Federal Register on December 13th, 2016. We've

received no written comments or requests for time to make oral statements for members of the public.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice; therefore we request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee. Participants should first identify themselves and speak with sufficient clarity and volume so that they can be really heard. Please silence all phones.

We have one bridgeline established for interested members of the public to listen in. The bridge number of password were published in the agenda posted on the NRC public website. To minimize disturbance the public line will be kept in a listen-in mode only, the public will have the opportunity to make statement or provide comments as designated time toward the end of the meeting. Our last meeting with the staff was on December 14th, 2014 in which Gary Stevens discussed the background information, reason for revising the Reg Guide and revisions to the FEN equations. We understand that you have addressed public comments and are ready to issue the Reg Guide. The full committee is scheduled to hear this matter on

February 9th, 2017.

We will now proceed with the meeting and I call upon Brian Thomas of research to make introductory remarks.

MR. THOMAS: Good morning. I'm Brian Thomas, the Director of the Division of Engineering in the Office of Research. We thank you for having us here; we really appreciate the opportunity of the ACRS for us to brief you on Reg Guide 1.207.

Just a few thoughts about the Reg Guide and the activities involved in it prior to turning it over to your briefer who is Rob Tregoning. Research activities with regard to environmental fatigue on light-water reactors started back in the 90's. Since then a lot of issues have evolved with respect to this Reg Guide. Reg Guide 1.207 first got issued originally back in 2007 and it was based on research that was documented in NUREG CR-6909; that's the effects of light-water reactor coolant environment on the fatigue life of reactor materials, which was also issued in 2007. So the textbook basis was also first issued in 2007.

The Reg Guide, as you know, provides the basis for some of the current guidance documents that has to do with subsequent license renewal. That is the

GALL and the SRP for SLR, subsequent license renewal. So it's the preponderance of the bases for the guidance that's in those documents. The SLR NUREGs, as you know, that provides the basis for GALL and the SRP is NUREGs 2191 and 2192. These NUREGs are currently being finalized, the GALL and the SRP are currently being finalized and targeted for issuance by mid-2017. So the guidance in the Reg Guide is a good proponent of the guidance that's included in those documents.

In 2014 Reg Guide 1.207 was issued for public comments; as you know, we received substantial public comments and those comments contributed to some significant changes in the Reg Guide. So, based on that it's hopeful that the ACRS will consider this guidance and the associated technical basis. Rob will speak to the background, some more of the background as well as what was involved in those comments, the nature and scope of the comments, how the staff resolved those comments.

So with that said, let me turn it over to Rob Tregoning for the briefing.

MR. TREGONING: Okay, thanks. I'm sorry. I'm clearly not qualified to be up here.

(Laughter.)

MEMBER POWERS: He's a metallurgist,

don't expect too much.

MR. TREGONING: If there's going to be some sort of task, I'm clearly --

(Laughter.)

So, yes, I wanted to thank Brian for the introduction and Pete as well for a nice summary of the background of this topic. As he mentioned, it's been a couple of years since, almost two years exactly since we were in front of ACRS talking about this topic. So, I'm going to be covering this proposed Revision 1 to this regulatory guide on addressing environmental effects in fatigue analyses of metal components. I have to acknowledge Gary Stevens and Omesh Chopra; they're the ones clearly that did what I believe is the very good technical work that forms the basis of this regulatory guide. Unfortunately, neither of them could be here in person, but I think Gary at least is on the line and Omesh at least told me he was going to call in, but for those of you who don't know Omesh know he's living now out in San Francisco area, so it's quite early. I don't know if he's going to be up for the beginning part of the meeting, but I expect him to call in at some point.

So, a little bit of background; I think Pete covered most of this, but I just want to make sure

we're all on the same page in terms of what we're here to do and what we're hoping to achieve as a result of this meeting, and then hopefully the February full committee meeting. So, we're here to talk about revising guidance for environmentally assisted fatigue, also called EAF, which we use quite frequently. There is one regulatory guide that went out as a draft for public comment; as Pete mentioned, it's DG-1309. Then there's a supporting technical basis document which is Draft NUREG 6909 Revision 1. We briefed this subcommittee almost exactly two years ago before we went out for public comment, the subcommittee agreed at the time yes, you should send this out for public comment.

So we sent both of the documents, both the NUREG and the Reg Guide out for public comment, not at the same time, slightly different times. We sent the NUREG out first in mid-2014 and then we sent the Reg Guide, really it went out just after this meeting, so it went out in December of 2014. So they were out for public comment during 2014, 2015 we received public comments roughly a month or two after depending on the document. Then since 2015 through this year we've been working on developing responses to the comments, and over that same time period we've been modifying the

documents and we're hoping in the upcoming year, we're hoping in February to go in front of the full ACRS Committee and hopefully get a letter of support from that committee, go forth with the guidance.

As Brian mentioned, the whole idea is that this guidance is really related, or the thing that's driving this revision of the guidance is for subsequent license renewal, so if you look at the GALL document and then the SRP document for subsequent license renewal, the drafts that went out for public comment both referenced Revision 1 of 6909, so the plans are that the guidance will say we want you to use this revision for those applications. So, that's why we're here; we want to make sure that we have the guidance in place before the SLR guidance gets finalized and goes out as well. So the licensees when they come in at the end of 2018 or 2019, they've got plenty of time to factor in this guidance in their applications.

MR. SHACK: It is a little funny, though, that you seem to accept the old versions for everything except subsequent license renewal. I mean, you do it for license renewal, you do it for new reactors as I read the Reg Guide, but SLR's are the --

MR. TREGONING: We're going to talk about that. That's a good question, we got a public comment

on that. We can talk about it now or we can wait till later, because we talked a lot of internal discussion about that as well, what's the best way to do that. Again, you guys know as well as I do, this is just guides, it's not regulations. It's one acceptable way for meeting the regulations. Especially in this area I can say historically the staff has been very flexible, and as long as the licensees have demonstrated an appropriate technical basis, the staff has generally tried to accept that. So, the philosophy that we're trying to have here is that we want to put out what we think is the best guidance, the best most up-to-date guidance. It doesn't mean it closes the door to other analyses, it doesn't mean it closes the door to modifying old analyses, right, but if all we're saying if we use -- again, as with any Reg Guide if you use that, you get a little bit of a past because the staff has already seen that okay, we buy into this Reg Guide. If you want to use a slightly different method, then the staff would need to review and approve it.

MEMBER SKILLMAN: For several licensees that are serious about SLR, has there been discussion with them about the differences between the current regulatory guidance and what will be the Revision 1 to 207?

MR. TREGONING: We have had -- with respect to the GALL and the subsequent license renewal guidance documents in general, there have been a number of public meetings that have outlined the changes that are being proposed or have been proposed by the staff on those guidance documents. In fact, in 2016, and I don't want to speak for the license renewal guys because there's nobody here, but they had public meetings roughly every month on this topic. So, the industry's been well-informed and I think based on the comments that we got back from the industry, the comments that we got back, not just from industry but stakeholders, on both of these documents I thought were particularly well-informed. I think part of that was the fact that we communicated not just through public meetings but through other forms like ASME meetings, we spoke at conferences, symposiums. We let people know what work we're doing and a variety of different methods well before we've gotten to this point.

So when we released these for public comments, we had a lot of people that were sort of armed and ready for unloading on us with everything that they thought about this topic. I'll say up front that as far as technical topics go, and maybe I'm a bit parochial here, but this topic elicits a lot of passion

from people and people feel very strongly about their beliefs. So that's one of the reasons it's taken us quite frankly a good bit of time to go through so many of the public comments, because we wanted to make sure, A, that we understood the public comments and that we understood the basis for the comments. We tried to thoughtfully consider every single comment that we got and respond in what we felt was the most appropriate manner.

Now, you may agree or disagree that we did that, but that was at least the intent that we tried to --

MEMBER SKILLMAN: The reason that I ask that question is kind of building on Bill's question to you; we met last night with DLR on the GALL SLR which is just about complete. It's going through OGC right now, but there are two licensees that are well down the road of getting their ducks in a row for their application for subsequent life renewal, life beyond 60.

MR. TREGONING: Sure.

MEMBER SKILLMAN: So the question that's in my mind is are these licensees going to find that their toil is going to be invalidated because of this revision? That's the real center of my question.

MR. TREGONING: My opinion is no.

MEMBER SKILLMAN: No, okay.

CHAIRMAN RICCARDELLA: As I understand it, I think the changes tend to be in the less conservative, making the FEN less conservative.

MEMBER SKILLMAN: But not all.

CHAIRMAN RICCARDELLA: Not always, but for the most part, they tend to make it less conservative. So if you've done it by the old requirements --

MEMBER SKILLMAN: You ought to be on the mark, you ought to be in good shape?

CHAIRMAN RICCARDELLA: Yes.

MEMBER SKILLMAN: Thank you, Pete.

MR. TREGONING: That's generally the case, but we can't make that blanket statement. So you really need to do the analysis for your specific plant configuration and inputs and everything to be able to make that assessment blanketly. So that's why we're very careful about that.

MEMBER SKILLMAN: Thank you. That's good, thanks.

CHAIRMAN RICCARDELLA: Another aspect of this that I think we need to recognize is we think about this as analyzing for the fatigue lives of the

component. But what we're really talking about here is crack initiation in a very small specimen, and in a real component which is much thicker than those small specimens, you have almost equivalent life from when you initiate the crack until the crack grows to a significant size, so there's another element of conservatism in this as well.

MR. TREGONING: That's one of the things we tried to clarify what we thought failure in a specimen meant to a component in the NUREG, not so much the Reg Guide but in the NUREG, so we have a whole section that talks about what we mean by a CUF exceeding one. It doesn't mean your component's failed as Dr. Riccardella said, it means that in my opinion that if you have a CUF that exceeds one, that you have a like, a possibility of having a crack. It doesn't even mean that you have a crack, but you have a possibility of having a crack.

CHAIRMAN RICCARDELLA: Based on 95.

MR. TREGONING: Well, again, if you do an ASME analysis and then, again, which has conservatism in it, I feel comfortable making the other statement. If you did an ASME analysis with FEN and you were below one, I would say with pretty good certainty that it's not likely that you have a crack in that component.

That statement I can make with much more certainly than the converse statement, the corollary statement.

Anyway, Dr. Shack often says that I speak too long and have too many slides, so I think I need to keep going, if that's okay.

So, here's the agenda and it's basically split the meeting --

MEMBER POWERS: Dr. Shack can offer that comment in his written documents here for the rest of us to enjoy what you have to say, Rob.

(Laughter.)

MR. TREGONING: You obviously didn't read the acknowledgments in the NUREG. I think we stated it quite plainly in those acknowledgments.

MEMBER POWERS: That was a topic I was going to bring up with you on some needed changes in the document.

(Laughter.)

MR. TREGONING: I'm sure you'll have other comments. So, the meeting's basically broken into three parts; the first part is a background and I'll apologize for those that were here at the 2014 meeting. This is really a recapitulation and a condensation of most of the work that Gary presented at a full subcommittee meeting in 2014. I feel it's important

to go back over some of it just for people that might not have been here, but also to try to set the stage for the rest of the talk and make sure you guys have full understanding for the guidance and the basis for the guidance and why we're making changes.

MEMBER BLEY: Rob?

MR. TREGONING: Yes?

MEMBER BLEY: Is it safe to say that if there'd been any changes since that meeting, they're in response to comments you've received?

MR. TREGONING: Yes.

MEMBER BLEY: And you're going to go through those?

MR. TREGONING: Response to comments as well as staff review that might have resulted from a comment. We made some changes that the comment had us go back and look at the NUREG and we said, "Yeah, that's an issue, and oh, by the way, while we're looking at it here's something else that we think might be related that we should go back and either clarify and modify in some sense." Yes, everything was initiated by the public comments.

Then the second part of the meeting I'll go over the technical basis document which is NUREG CR-6909, we'll give an overview of public comments.

We're not going to go through every public comment, but I'll try to pick some of the most interesting ones and good representative ones. Then I'm going to walk you through an overview of the changes to the document that resulted from the public comment. Then we're basically going to follow the same format when talking about the Regulatory Guide; I'll give you an overview, some sample comments and then changes to the documents. Then I'll finish with where we're at with respect to finalizing this guidance and then the next steps.

So, the background. So somebody, I think, somebody mentioned CUF, or as I call it C-U-F. The way you do CUF design using Miner's Rule is you have, I show here that's your design curve that's plotted there and these U's are basically called usage factors, so you look at all the different fatigue transients that your plant goes under and you can characterize those as different cycle regimes or usage factors. You sum up all your regimes and if you're less than one, you're okay. If you're greater than one, you exceed the design curve and you have to do something else. It doesn't mean your component's failed, it means you have to do something else at that point.

So, the way we base this is so this is a plot of site, and I apologize for the, you can't read

the ordinate and abscissa, but this is a plot of alternating stress on the Y axis and the number of cycles to failure on the X axis. So N is the number of cycles of failure that's a function of alternating stress, which is often called SA and these curves are material dependent as you see in the new ray. These curves right now are currently is ASME Code Section 3 and they have codes for different materials. The way those ASME codes were developed, they were based on best fits of test data taken on small laboratory specimens, and then ASME applied what they call design factors to account for things such as data scatter, size effects surface finish, and the term they use is atmosphere. They don't use water, they use the fact that different laboratory environments where these tests are conducted might be slightly different levels of humidity, different even temperatures, things like that, and all those things can add to variability.

When you look at fatigue data, the thing that you're always struck by is the amount of variability you get in the data that you see. Some of it's irreducible and some of it is clearly due to factors that are potentially controllable. All of this keeping of usage factor stuff is just considered, as I mentioned, a laboratory air. So what's

environmentally-assisted fatigue? Okay, so we have the ASME Section 3 fatigue curve there from, again, developed from small specimen, polished specimens in air. The sub-bullets tell us how they got those curves, they did some adjustment of the curves, the best fit mean curves for mean stress effects using the modified Goodman relationship, and then they apply these design factors of two on strain amplitude and 20 on cycle, so you basically have two different margins and then you can construct the design curve as being whichever is the limiting of those margins.

That's how ASME developed their air fatigue curves. But if you do test those same specimens that you tested in air and you just test them in water, either reactor coolant water or water that's high temperature, what you'll find is that, and that's the data that you see up here, is that you get tests in water that fall below the design curve. So, if you looked at the air data plotted on there, the air data would all basically be bounded by the design curves. The water data you would say, at least the data that are plotted there, those air design curves are maybe close to a best fit or maybe not even, maybe like a 60 to 70 percent fit.

So there's clearly an effect of water on

the fatigue life of laboratory specimens and I think that's been clearly well-documented at this point.

CHAIRMAN RICCARDELLA: Rob?

MR. TREGONING: Yeah?

CHAIRMAN RICCARDELLA: Refresh my memory, the factor of 2 and 20, as I recall the factor of 2 tends to apply in the high cycle range and the 20 in the low cycle range, is that true?

MR. TREGONING: That's right. So if you took this mean curve and dropping it by 2 and constructed a curve like that and then shifted by 20, what you would find at the curve site, the curve that you have left the high cycle regime is really governed by the factor of 2 on stress or strain, while the low cycle fatigue is governed more by the factor on life, so that's entirely correct. The break point is maybe around, I don't know, 10 to the 4 to 10 to the 5th, something like that.

CHAIRMAN RICCARDELLA: Thank you.

MR. TREGONING: So, what the environmental correction factor is, the environmental correction factor tries to adjust these curves for the fact that you have degradation of specimen life in water environments, so it's a very simple concept with a simple definition. So FEN, it's

just a shorthand way of calling our environmental fatigue correction factor, is just defined as the number of cycles of failure in an air environment, defined as the number of cycles in a water environment. So if you apply this, it's very simple to apply, you take your same CUF equation where you have the little usage factors for each of the regimes that you're analyzing, and each of those regimes would also have an associated FEN factor. So you multiply the usage factors by the FEN's, sum them up, and at least conceptually if your CU-FEN is less than one, then that gives you a high degree of likelihood that you don't have a fatigue crack in your component.

MEMBER SKILLMAN: Rob, is the data readily available, the N air divided by N water?

MR. TREGONING: All the data, if you look at the NUREG it's all heavily referenced and there's a lot -- yes, so, in fact, all the references in the NUREG are publically available. The challenge, I will say, is with fatigue data. It looks like a scatter plot and a lot of times you can have ten data points that are very close, so it's not the type of data set that you would want to try to dispertise from a plot. So you really need to have the raw data available. In many cases we try to develop and make sure we had actual data

for every data set we had. We weren't always successful, sometimes we had to go back with historical data and it's from digitized sources, but by-and-large, and Gary and Omesh can comment better than me on this, the bulk of the data that we have now is the actual data that we have from the first article source or the original source documentation.

That's one of the thing in this revision that Gary and Omesh spent a lot of time doing that we didn't have any earlier revision going back and actually trying to get that source data.

So the FEN itself, this is an expression from Rev. 0 for stainless steel materials, so it's a function typically of temperature, dissolved oxygen and then also strain rate, and then if I had the expression for carbon and low alloy steel, sulphur content is another variable, it's explicitly modeled in these FEN expressions.

CHAIRMAN RICCARDELLA: I've got a question; I was playing around with this equation a little bit last night. If you go to the range where you wouldn't expect much of an environmental effect which is low temperature and fast strain rates, then that second term of that equation goes to zero and it defaults to 2.

MR. TREGONING: Yes.

CHAIRMAN RICCARDELLA: That's the prior rev, I assume that's been fixed in the new revision that we don't say it's 2 if you have no environmental effect, right?

MR. TREGONING: I think we should be up here, to be honest with you. When Rev. 0 came out we got a lot of comments, that was one of the most common comments that look, your FEN expressions are hosed up, because even if I don't meet your thresholds, I still have a FEN of approximately 2 that I have to apply. That can't be right. Then we realize yes, that's the danger of doing correlative development of factors. Again, the FEN is clearly a correlative approach, it looks at data and tries to make sure that the data is predicted by this correlative approach, so it's not based on mechanistic arguments. If it were based mechanistically or phenomenologically, you wouldn't run into these challenges.

Yes, that was a comment that we got from several stakeholders and it was one of the things that we wanted to fix in this revision so that we didn't have these sort of anomalous behaviors that you wouldn't expect due to the inadequacies of your correlative fit.

Okay, so that's a quick background on just

the technical aspects. Now I want to talk a little bit about related regulations and current NRC guidance on the AF -- Oh, I'm sorry.

MEMBER POWERS: Let me ask you just one question.

MR. TREGONING: Sure.

MEMBER POWERS: You're driven into a parochial approach. Is there any activity not necessarily in the agency to understand fundamentally what is going on with respect to environmental effects and fatigue?

MR. TREGONING: You know, the good Dr. Shacks here can comment probably more eloquently than I can about this, but I would say this topic --

MEMBER POWERS: He doesn't do eloquent well.

MR. TREGONING: This topic as well is crack initiation in general, there's been 50 years of work looking at mechanisms and phenomena. I think the problem that this particular scientific topic has, and this is my opinion, is that there are so many factors that are potentially important that could leak to crack formation, that it's very difficult to have a model that's both I'll say necessary and sufficient, that's comprehensive and yet doesn't --

MEMBER POWERS: There are lots of things in this world that are difficult, that have been overcome. My impression is the challenge we face, so within the crack, the electrostatic fields are exceptionally big, and that as a consequence the chemistry and physics that we know, chemistry especially, thermodynamics especially, just falls all apart in those potential fields. You're operating in a regime where surface forces on adjacent sides of the cracks, the so-called van der Walls forces are just enormous and make anything you do for free field thermodynamics just totally unapplicable. That's my impression. The challenges that you can't reproduce those fields in a macroscopic assembly is big enough to instrument.

MR. TREGONING: Yes, I'm not going to get into a debate with you on thermal-hydraulics of cracked tip chemistry or environments. I would agree with you that when you're dealing with cracks, especially fatigue cracks that are very tight, understanding the exact environment of the cracked tip can be a challenge and understanding how that environment is really from a mechanistic point of view affecting the formation of an accumulation of bandage starting off at the atomistic level and progressing through dislocation

and ultimately leading to what we can see as a crack. Again --

MEMBER POWERS: Just one of those things that the CASL organization salivates over.

MR. TREGONING: I'm sorry, could you repeat that?

MEMBER POWERS: Is this one of those things that the CASL community salivates over or are they ignoring it or?

MR. TREGONING: Again, it's not that they're ignoring it. Again, I've seen many mathematical models to predict crack initiation and fatigue. I'll just say we've had much better success developing models to predict crack growth, because those models are governed more by mechanics, things that we model well. Again, it's the atomistic and the metallurgical factors that lead to the formation of that significant engineering crack. Those are things that are just, they're just a challenge to model. You said yes, there are lots of things that are complex, but there's many inert related factors that lead to the formation of an engineering crack, and I would just say that I don't think that we have the tools to monitor, to model the physics to significant or sufficient enough extent to really develop a phenomenological or

first principles model to address something such as this.

MEMBER POWERS: It's just that many times they may not have the problem solved, but they give you a functional form that's better for things like correction factors on, and you end up with where often-termed semi-empirical kinds of correlations rather than something totally ad hoc.

MR. TREGONING: I would agree with you. In this case I would say that that's not been the case. If I use an analogy with reactor pressure as an embrittlement, that's one where we've used mechanistic understandings to help drive the correlative models that we've had. So, that's an analogy that fits your scenario very well. For this particular phenomena, though, it's not been guided as quantitatively by theoretical or analytical understanding. So I hope that's --

MR. THOMAS: Can I get clarification on your comment, Dr. Powers? Brian Thomas. So you mentioned CASL, were you referring to the modeling efforts?

MEMBER POWERS: Yes.

MR. THOMAS: So I was at a COE meeting last week on Light-Water Reactor Sustainability Program,

which they did a presentation on the whole CASL efforts. It seems like they are really embracing or embarking upon a lot of efforts focused on crack growth, crack initiation, crack growth rate and so forth. So, information that was communicated to me there, we were not previously aware of. Let's say that. With respect to your comment about the community, I think they're ignoring it, they're really striving to really address it more in depth.

MEMBER POWERS: Well, that's good. I mean, nice to have other people looking at the problem every year. It's just that sometimes these semi-empirical things even though you can't quantitatively predict anything a priori, they could do a functional form that's just a little more forgiving. You can't, you can, hopefully more in the future.

MR. TREGONING: Yes, I think that would be a place we would like to get to in the future.

MEMBER POWERS: I mean, maybe just what you said, that you go to the meetings, you make sure they're aware of what your problem is and if they catch fire over it, great, and if they don't, we are really in questioning. I mean, I'm definitely not advocating that NRC immerse itself in this. This is kind of

stuff that you might implore NSF or Department of Energy to pursue, they have the resources and it's not something that's going to resolve itself in a useful timescale for you.

MR. THOMAS: Right, and that's what I'm thinking, to what extent can we leverage the resources, at least as communicated there apparently would be applying to this effort. We want to be cognizant of what they're doing, who's doing what, when, and how does it contribute to our program going forward.

MR. SHACK: Even in the Light-Water Sustainability Program, they focus on stress corrosion cracking, which again, simplifies the problem somewhat. They still have the environmental effect, but they don't have the repeated cycling. Fatigue is really a complicated problem.

CHAIRMAN RICCARDELLA: Well, especially, as I mentioned earlier, this crack initiation phase of it and then the crack propagation phase and what we're talking about here is just the nucleation of very small cracks where you're dealing with things that are smaller than a grain size in the material. So you get outside of the realm of continuum mechanics, really. You can't apply continuum mechanics to that.

MEMBER POWERS: I haven't used continuum

mechanics in a long time.

(Laughter.)

MR. TREGONING: Okay, any other questions or can I move on?

So I just wanted to cover related regulations, why we even need any guidance on EAF and talk a little bit about the history behind EAF guidance just so we have a framework for the revisions. There are basically two general design criteria within Part 50 that apply to these fatigue calculations, and it's DDC 1 and 30 and they're fairly general, broad DDC's about good design practices and fabrication practices for safety significant system structures and components. Then also 30 which is related specifically to components in the reactor pressure boundary. Then elsewhere, 50.55(a) of course EAF endorses the ASME code for design of these safety related systems and components. It's really the ASME Code Section 3 fatigue curves that are endorsed by 50.55(a). As I mentioned, the fatigue design curves, currently ASME do not address the impact of the water environment within the curve.

So the regulatory guidance on EAF exists to provide an acceptable method for addressing the impact of the environment on the fatigue calculation.

MEMBER POWERS: Is there a reason that the ASME code has eschewed the water environment?

MR. TREGONING: That's a great question and there's probably 15 to 20 years of history wound up in it. To be honest, the simply way I answer is people haven't agreed what to do yet. A variety of approaches that have been proposed there just hasn't been the wherewithal to move forward. That's the other reason; we prefer not to be out in front of the code on this, but the code's not going to act, we have to do something, and that's sort of why we're in this place. We've been trying to spur the code in this area for 15, 20 years I think, and we continue to do that.

CHAIRMAN RICCARDELLA: I think it's more like 50 years of when these original fatigue curves were put into the code in 1960's, and at that time I think the committee thought well, we can't predict what type of environments people are going to use these for, so we're going to pretty much leave the select the addressing of environmental effects up to the user.

MR. SHACK: There's language in the code that says that, you're supposed to address it but it doesn't give you any guidance for how to do it.

MEMBER POWERS: Well, I mean, all you do is tell me the code's useless and you're ineffective.

I mean --

(Laughter.)

MR. TREGONING: Look, there's a lot of continued -- I'll say over the last two or three years I've seen some positive motion, so I think the code is going to get there. I think they finally now got organized and gotten the right philosophy and there's a number of code cases that address some of these issues. I think this NUREG and this guidance might actually be used to spur a lot of this, so I think it's a timely NUREG from that perspective.

CHAIRMAN RICCARDELLA: There's a code, a task group in place, isn't there, to address these at this time?

MR. SHACK: There has been one for a long time.

(Laughter.)

MR. TREGONING: There's a couple of different task groups in ASME that address fatigue related issues.

CHAIRMAN RICCARDELLA: I mean, it's been addressed in depth in the Section 11 the crack growth aspect of it.

MR. SHACK: Crack growth always move faster than initiation.

MR. TREGONING: Okay, so --

MEMBER BROWN: I'm not a metallurgist, so you made a comment earlier in the presentation that you were relatively flexible on the CUF and the other in terms of the fatigue analysis. Then I'm harkening back to a couple of the license extension requests that we had before us, and they do all the calculations and I think they've always had a CUF of less than one. You said but yet in your mind a CUF of greater than one is not necessarily -- I'm putting words in your mouth, unsatisfactory to granting an extension. I'm paraphrasing, I'm going forward. Have we ever accepted an extension request that ended up with analyses that showed a CUF of greater than 1?

MR. TREGONING: I don't know that I -- I'm going to --

MEMBER BROWN: I forgot one other point. There was always the evaluation by the applicant that they would take some action, something would be done in order to move them or keep them out of an area where they would exceed the 1, but yet your discussion earlier sounded a bit mushy on it, so that's why -- given the lack of clear either regulation or guidance, I'm just -- and you guys don't want to get ahead of it. I'm just trying to get a feel when I have to deal with this in

the future, how questioning should I be even though I'm not a metallurgist per se?

MR. TREGONING: And Tim Lupold's here, he might want to chime in. I'm not aware that we ever accepted an application that came in and said my CUF is greater than 1 and that's it. If someone's come into us, and usually they wouldn't even come into an application with that, they would come into us before their application and say, "I'm doing these CUF calculations and I'm getting greater than 1." Then we would usually at that point work through with them, "Well, here's what you need to do to address that. You might need to inspect, you might need to put that component in your fatigue monitoring program." So there's other actions that the plan or the licensee would take at that point if they had a CUF that was greater than 1.

So that's been what's commonly happened. I strongly doubt and I'm certainly not aware of a case where a licensee has come in and said, "Here's my CUF calculation. It's greater than 1, but I've got all this other margin. Here's why I have all this other margin, so I'm okay." We've accepted that without them doing something else that's related to defense and depth. These other things are sort of defense and

depth things. CUF is an analytical approach in calculation. If they exceed that, that just says, well you've exceeded sort of a screening criteria to show that your analysis by itself may not be sufficient to provide us reasonable assurance that you don't have a damage component. You need to do something different, be it inspection or monitoring to see what the real plant transients are to provide us assurance that that component is still able to maintain and perform its intended safety function at that point.

MEMBER BROWN: But if you do an inspection or something else of that nature, that still doesn't reduce, it only just says we're looking to see if we actually do have a crack initiation. It doesn't make the CUF less than 1?

MR. TREGONING: That's exactly true.

MEMBER BROWN: I understand that properly?

MR. TREGONING: Yes, so that's true. The calc is just an analysis result.

MEMBER BROWN: I understand that.

CHAIRMAN RICCARDELLA: If you went that approach and did the inspection, then you would do a fatigue crack growth analysis and demonstrate.

MEMBER CORRADINI: You have to find a

crack under those -- if you don't find a crack, what do you do? You can't inspect --

CHAIRMAN RICCARDELLA: No, then you assume a crack equal to the detection limits of your NDE and then you do the crack growth analysis on that.

MEMBER CORRADINI: So you make an assumption then based on the ability to detect the crack?

CHAIRMAN RICCARDELLA: Correct.

MR. TREGONING: So what typically would happen is, like Dr. Riccardella said, you would assume a crack of a certain length, you do a fatigue crack growth and you would set your inspection period based on that. You do an analysis that says well, even if I have a crack, this component's not going to fail for another ten years. Then you would say well, based on that I need to do an inspection at least every whatever, seven or eight. That's when you would negotiate with the NRC on what the actual period would be. Maybe it'd be ten years, maybe it'd be five years depending on what the results show. Maybe it'd be one year, I don't know.

CHAIRMAN RICCARDELLA: Also, if you have a CUF issue say on a component, it's not a general issue that applies to the whole component, it applies to a very specific focused area and you can do the inspection

of that area and do your crack growth of that area, only those areas where you exceed 1. There's a code appendix on that, I forget what it's called, Damage Tolerant Design or something like that. There's a section level appendix that gives guidance to that.

MR. TREGONING: Are you thinking of L or -- Gary's on, he would know better.

CHAIRMAN RICCARDELLA: Yes, he can't speak, unfortunately.

MR. TREGONING: Or Robert, which -- Robert, I think --

CHAIRMAN RICCARDELLA: Yes.

MEMBER BLEY: So Ron can turn it on.

MEMBER SKILLMAN: Yes, or go to the mic and then maybe we can turn it on.

PARTICIPANT: I know you asked a question to Rob, but may I respond?

MR. HSU: Okay, this is Robert Hsu. Okay, that's Section 11 Appendix S, specifically for CUF greater than 1, you can use the evaluation to determine the inspection period. They use the inspection, okay, to address that.

CHAIRMAN RICCARDELLA: I understand that maybe Gary Stevens might want to make a remark. Can we turn on the --?

MEMBER BLEY: As a reminder to all the members, we now have a process where if you just tell Theron, we'd like to hear from the person on the line, the line should open and he should be able to talk.

Is he there?

MR. STEVENS: Hi, this is Gary. Can you hear me?

CHAIRMAN RICCARDELLA: We hear you loud and clear, Gary.

MR. STEVENS: Okay, thanks for letting me speak. Yes, to answer the question, I think you can go look at license renewal applications and see many instances where CUFN is greater than 1, were sent into the commission. But as Rob said, you'll never find a case where the commission approved that without a promise to do something else. There are several ways that this can be addressed; you just heard about Appendix L, there's repair replacement and most of those articulated in a promise to the commission by the licensee of what they'll do to address that issue. So, there's plenty of ways to address it and in fact licensees have done that.

MR. TREGONING: Thanks, Gary.

CHAIRMAN RICCARDELLA: Thanks, Gary. Let me just say, Gary, we're going to put the line back

on mute, but if you feel you need to chime in, just send me an email and we'll turn it back on again.

MEMBER BLEY: Just again, for the members, all he has to do is say he wants to speak and through Ron's monitoring, he'll put him on.

CHAIRMAN RICCARDELLA: Okay.

MR. TREGONING: So, anybody on the phone they just need to say that they would like to speak.

MEMBER BLEY: Not anybody. If we have people on the line, we expect to have speak. It's not an open --

PARTICIPANT: Invitation.

MEMBER BLEY: Everybody out there.

MR. TREGONING: I understand.

MR. STEVENS: Two other questions that came up I wanted to comment on, if I could, or you want me to wait until the end?

CHAIRMAN RICCARDELLA: No, absolutely. Go ahead.

MR. STEVENS: Okay, so there was a question about five minutes to 9:00 that had to do with availability of the data, and I just wanted to clarify on top of what Rob said, 100 percent of the data used in this work, and that was summarized in a lot of detail on the 2014 presentation, all of this is available to

the NRC, they have it all. Just about 25 percent of that data is publicly available that came from tests at Argonne and in the literature. However, about 75 percent of it came from the Japanese and that's proprietary and only the Japanese Nuclear Regulatory Authority and NRC have access to that. So where as it's summarized in the report, it's not available yet to researchers, only the NRC.

Then there was a question about 9:10 a.m. on if anybody's doing research to explain this cracking other than water is worse than air. Chapter 2 of the NUREG 6909 there is a section on mechanism of cracking that gets at that. Right now there's kind of two theories as to what drives cracking, the slip oxidation, dissolution mechanism and the hydrogen induced cracking mechanism; there is some amount of research going on to look into that further. I've seen come out of Argonne recently, but that discussion I refer you to, to help answer that question for you, as Rob said it's difficult research to do, but that gets at your question in more detail, and it starts on at least Page 31 of the draft that went out for public comment.

MR. TREGONING: Yes, just to append what Gary said; there's been a lot of research on

understanding mechanisms of fatigue, but Dr. Powers was specifically asking about quantitative modeling of fatigue, and that's an area that's had much less I'll say success and just leave it at that.

MEMBER BROWN: Well, thank you for -- I'm just trying to make sure I have a better understanding for --

MR. TREGONING: Good question, thank you. Okay, so a little bit of background and history of regulatory guidance; initially as Brian Thomas said, we've been doing work in this area since the 90's, at least explicitly, and with two NUREGs in the late 90's that came out, one on carbon and low alloy steels and one on stainless steels. Those NUREGs were the basis for what went into at the time the 2001 edition of the GALL report, and specifically in Chapter X.N1 on metal fatigue. So, that was the first NRC efforts into research in this area. Then in 27, as Brian Thomas mentioned, we consolidated and updated all the EAF technical guidance we had in the original version of NUREG 6909 and that was issued in February of 2007.

So, this next slide just talks about what's required now, so this is what's required now for either operating or new reactors. This gets a little bit about what Dr. Shack was talking about today. So,

operating reactors and their original licensing period there's no guidance or requirements for considering EAF at all. In many cases for the existing plants it was not considered at all in the original design of this plant. In the license renewal period, again, this spans quite a range so I'm just focusing on recent applicants since those that would be I guess since 2010, but they would be using NUREG 1801 Rev. 2, basically Rev. 2 of the GALL report. Rev. 2 of the GALL Report says for carbon you can either use one of the older 6583 NUREG approach or 6909, the original version or NRC approved alternative, and that's where the flexibility comes in for anybody that wants to come in and provide a technical basis for a particular approach, they can do so.

Stainless is similar, it calls out NUREG 5704, 6909 or a NRC approved alternative. And then nickel-chrome-iron, the first time we really addressed that was 6909, so for license renewal they can use 6909 or a NRC approved alternative.

Now, I bolded what we put in for subsequent license renewal, this is what went out for the draft for comment that went out, and it said that you may use 6909 Rev. 4 or a NRC approved alternative. So, similar language that went into GALL Rev. 2, it just updated

the technical basis from 6909 to 6909 Rev. 1, and the notion here is we'd like people to use the newest and best guidance, so we're not explicitly referencing these older guidance, but if people have used the older guidance and they believe it's still applicable and acceptable, that's something that would fall within this already NRC approved alternative. So that's in there to give licensees and applicants flexibility.

So, as far as new reactors goes, the original version of the Reg Guide for those of you that are paying attention, explicitly in the title said four new reactors. So when we issued that Reg Guide in March of 2007 we limited it for a variety of reasons at that time just for new reactors. The technical basis for the original Reg Guide was that original NUREG 6909 and both Reg Guide 1207 and the proposed revision of Rev. 2, of 7, use the FEN method summarized in Appendix A of the NUREG. So, if you read the Reg Guide there's not a lot in the Reg Guide, it basically just says go use Appendix A summarized in NUREG 6909, so with Rev. 0 it was use Appendix A and NUREG 6909 Rev. 0. For draft Rev. 1 use Appendix A and 6909 Rev. 1.

So why do we go about doing this? I've touched on some of this. Why do we even bother to revise this Reg Guide at this point? I think we've

touched on some of these. One, we want to consolidate all the EAF guidance in one place, have one regulatory guide that applies for EAF. As Dr. Riccardella mentioned, we've gotten stakeholder feedback including such things as when the FEN factor didn't appear to be quite right. Again, we also have got a lot more data, which I'll touch on that we had back in 2007, so we wanted to use all of the data that we had available to update the guidance.

Again, Reg Guide 1207, what is significant revisions? These are significant revisions for the draft went out to public comment, so everything I'll talk about are changes with respect to that draft. What did we do two years ago? Well, first of all, we took four new reactors out of the title and just made it applicable to all WR's, right. The component doesn't care if it's in a new reactor or an existing reactor environment, if it's a water, if it's LWR water and existing plant or new plant, the effects are basically the same. We clarified the guidance, the stated applies to all metal components exposed to LWR environments, and then here's where it gets tricky, they have a CUF calculation required by their plant's licensing basis.

So, you're not going back and telling

people to do fatigue analyses, you're just saying if you've got a CUF calculation that's required, that's part of your licensing basis, you need to at least consider environmental effects as part of that calculation. Then the Reg Guide the background section was revised a little bit. Then the main thing, which I've highlighted, is FEN equations in that draft Reg Guide were revised based on the new data as well as stakeholder feedback.

What did we do? Again, Gary showed this in 2014. I just wanted to highlight it here. This is just a quick chart --

MEMBER SKILLMAN: Please go back on the slide, if you can.

MR. TREGONING: Sure.

MEMBER SKILLMAN: Your Item 2, don't all plants have in some form, for instance, all the plants that I've been associated with for years are all ASME Section 3 Class 1 for the reactor coolant system pressure boundary. And so by that very definition they have a U which I think is the CUF, and so at least as I see it to be complaint under 50.55(a) and in compliance with the code, you have a U, you have a CUF. That goes back to Oconee and for the Babcock plant, it goes back to Ganey and Perry for the old Westinghouse

plants, back to what would have been Maine Yankee for the combustion plants. So while you seem to identify an "if" statement on 2, isn't 2 thoroughly applicable to all plants?

MR. TREGONING: Again, the key phrase there is all metal components. So yes, every plant has some metal components that have CUF's, right, and different plants have a different number of components that they have that they do CUF calculations on.

MEMBER SKILLMAN: So I would agree with that. Now I see that distinction.

MR. TREGONING: So what we're not saying is if you don't have a CUF, we're not requiring you to go back and do a CUF on another component and then consider environmental effects on that component, but where you already have a CUF make sure you're addressing environmental effects as part of that analysis.

MEMBER SKILLMAN: Okay.

CHAIRMAN RICCARDELLA: As I recall, the piping, if it was done to NB3600 doesn't really have a CUF, it had an approximate approach, not a CUF.

MR. TREGONING: That's true.

MEMBER SKILLMAN: Thank you.

MR. TREGONING: Okay, so we're back on the main screen. A couple of charts here that just shows,

and I just want to, Gary made this point, but we significantly expanded the database between Rev. 0 which is in the second column and Rev. 1 showing the number of heats and data points for the main alloys that we talked about, both carbon and low alloy steels as well as austenitic and the nickel-chrome-iron alloys. So we increased at least in many cases almost doubled the amount of data that we considered, and the majority of this, as Gary mentioned, came from the Japanese data set. Gary in particular did really a yeoman's job of getting that data from the Japanese. It's very difficult to share data and the Japanese were just incredibly grateful that they provided their data to us. We of course provided the data that we had to them, but we wouldn't have been able to do this revision without the additional data that they supplied us, so I can't understate their contribution as to this effort at all; it was significant.

The Japanese have done a lot of work over the years in this area. In some cases much more than has been done in the U.S., so we're just very grateful to the Japanese mode of contribution in this regard. Same thing with water, you see in some cases, in fact water it was the number of additional data points have doubled or even more, so we just felt like, especially

as Mr. Powers mentioned, for a correlative approach more data is really needed and welcome because you always want to make sure that your correlative approach addresses the data sets that you have adequately.

So what are the changes to the curve? I'm going to talk about changes between Rev. 0 of NUREG CR6909 and Rev. 1. So the best fit mean data air curves are exactly the same, no changes at all between Rev. 1 and Rev. 0 of the NUREG. The one thing we did in Rev. 1 is we did a Monte Carlo analysis, which again, Gary went into pretty good detail in 2014. Not going to go into a lot of detail now, but to account for these things that they identified in the ASME code, things like surface finish, variability, size effects and loading history. Based on data we took distribution of ranges and assigned them all normal distributions with the balance representing the 5th and 95th percentile, just crank through a Monte Carlo, and develop at least adjustment factors on life. Again, these aren't adjustment factors on strain, but just adjustment factors on life. I've just documented the factors that we got there, for carbon steel we got a factor of about 10, low alloy steel a factor of about 9 and stainless steel a factor of about 9.6.

This is one area that we specifically

requested public feedback on when we went out for public comment, we wanted to see what the public thought about the analysis that we've done. If you read the NUREG, though, it talks about these very, more precise factors, but at the end of the day it says well, we're still going to use adjustment factors of 12 on cycles or life and 2 on strain or stress. We did that for two reasons; one, it's not that much different than the Monte Carlo analysis and at least initially we wanted to retain consistency with Rev. 0 and the ASME code. Again, this is one case where we didn't want to get out ahead of the ASME code.

CHAIRMAN RICCARDELLA: So did the ASME code from 20 to 12 at some point?

MR. TREGONING: For stainless it did that.

CHAIRMAN RICCARDELLA: Oh, okay.

MR. TREGONING: For carbon it's still 20.

CHAIRMAN RICCARDELLA: Gotcha.

MR. TREGONING: I'm hoping that that's a change that they'll adopt relatively soon. That one to me is a low-hanging fruit, so I would think they would be addressing that.

So, at the end of the day the design curves in NUREG Rev. 0 and Rev. 1 are exactly the same, there's no difference whatsoever. Then the other thing that

we do in Rev. 1 and it's similar to both ASME as well as Rev. 0 is it says for nickel-chrome-iron you can use the stainless steel design curves. Even though we recognize that the nickel-chrome-iron has a little bit better feed life than stainless steel, so this is a conservative position, but we adopted it because we had less data for the nickel-chrome-iron alloys, and so we didn't feel comfortable necessarily recommending design curves specifically for those alloys, but we felt very comfortable saying that the stainless steel curves is certainly conservative to use.

So there weren't any changes to the design curves or the air curves at all between Rev. 0 and Rev. 1, so the biggest changes are with FEN. So in Rev. 0, if you read Rev. 0 we had different FEN expressions for carbon and low alloy steels, now we have one expression just for ferritic steels basically. As Pete mentioned, you could have no environmental effects and get FEN factors greater than 1 in Rev. 0, so we fixed that now. If you don't exceed the thresholds required to get environmental effects, your FEN automatically is 1.

We had different constants in expressions for stainless and nickel-chrome-iron alloys if you look at the FEN expressions, now we have the same functional

form for the stainless and the nickel-chrome-iron alloys, so make it easier to use. The only thing that's different are the transform variables are somewhat different. As we talked about already, the expressions are generally less conservative for all materials, can't say categorically that's the case. I just show some plots here for carbon and low alloy steels for different levels of dissolved oxygen, and the curves are a little bit hard to make out, but the solid curves there are the Rev. 1 expressions and then the dash curves there are the Rev. 0 expressions. The other thing we added on there, the Japanese expressions. JNES or now JNRA, they have their own set of expressions that are a little bit different than ours, but I think since we've combined data sets, we're much better in alignment with the Japanese in terms of the curves that they require as well.

CHAIRMAN RICCARDELLA: So the potential non-conservatism of Rev. 0 is just these regions where the solid curve is greater than the dash curve, right?

MR. TREGONING: Again, there's enough competing variables here that it's hard to show in one plot all the possibilities that you can get. For the variables that I've plotted you'll see that there's some regions of the curve that cross over. Again, the

scale of this plot is a little disingenuous, especially the one on the right, because it shows FEN factors going up to 60. To be honest, any real fatigue transient that we've ever seen, I don't think we've ever seen a FEN factor greater than like 6 or 7 or so. So there's sort of exponential behavior that you could potentially get that would lead you to very large FEN factors, that's just not going to show up in any sort of actual evaluation that you do.

CHAIRMAN RICCARDELLA: Very low strain rates, is that what you're saying you need to have?

MR. TREGONING: Well, high temperatures, low strain rates, those are the sorts of things that can give you the high FEN.

MEMBER SKILLMAN: Lots of sulphur.

MR. TREGONING: Lots of sulphur. Again, in this case high dissolved oxygen for the carbon steels. Yes, those are the things that could lead you to a high FEN.

So what else did we do in Rev. 1 that we didn't have in Rev. 0, which again, in these next two areas I think have been big improvements. For one thing we have a whole section to try to validate the method, so we took other data sets both on specimens or component tests that we didn't use to develop our

correlations and then said, all right, let's analyze these other tasks, these independent tasks using the methods and see how well they do. Again, we did this using both EAS code methods and the FEN approach, we just compared the prediction to what was measured in all these cases. When we were looking at the specimen tests, so those particular tests we actually did quite well, and in general, again, you get a lot of variability, but the predicted measures agreed reasonably well, within about a factor of 2, and with respect to fatigue life if you're in a factor of 2 you've nailed it I think. So that's about as good as you would expect. Now that's for the specimen tests, the component tests are much more challenging to predict. Again, you have to remember that the FEN method is built on specimen laboratory data, so you look at more real components with loading gradients, temperature gradients, potentially. Those are much more complicated.

What we've been able to show, at least those far, is that the tests that we've been able to analyze is that generally this approach is conservative, either agrees with or conservative. So we would clearly admit that there's a conservative bias with using this approach, or there appears to be in most

cases for actual component analysis. That's a whole chapter now on Rev. 1 Section 6.

The other thing, and again, we can thank Gary for this as well as some other people, we actually included a sample problem in the appendix to demonstrate how you would apply the methodology and also provide a benchmark if someone wanted to develop their own set of calculations they could at least test to make sure the calculations are done correctly by solving the sample problem.

CHAIRMAN RICCARDELLA: Gary was going to comment on the differences between Rev. 0 and Rev. 1 as to where -- Go ahead, Gary, if you're on.

MR. STEVENS: Okay, can you hear me?

CHAIRMAN RICCARDELLA: Yes.

MR. TREGONING: So back to this.

MR. STEVENS: I was just going to comment on Slide 17. To your comment, Pete, where the new FEN expressions tend to be higher is that higher temperatures, higher oxygen rates and low strain rates, as you pointed out. What you generally see is those are conditions that never factor into a fatigue analysis. Plants really don't experience high oxygen levels much anymore, and more particular when you have a slow strain rate, you don't generate any fatigue

because the stress range is small, so even if your FEN was very, very high you would be multiplying it by zero.

MR. TREGONING: And we got some public comments that sort of touched on this phenomena that we articulated that exact response that generally what we've seen in applications, if you get a FEN your strain range is very small so that the actual effect is not that significant.

MEMBER BLEY: Without interruption I'm going to toss two things in; I've never seen a report like this NUREG that actually integrates the discussion of the comments you received into the NUREG itself and explains how things change. I like it, it helped me, and your Appendix E that shows the equations in the first and the second and how the first morphed into the second was really helpful.

MR. TREGONING: Thank you. Okay, so this sample problem, this was actually based on a sample problem that was done as part of a code activity and it was interesting to get some of the questions. We put the sample problem out through the code to people that do fatigue analyses all the time, we were amazed at the variety of outputs that we got. So, not surprisingly when we put the sample problem out for public comment, we got people that worked the problem

and they found areas that we needed to improve. So, this sample problem, I think it's been helpful for us and we're hoping it's helpful for the user as well. I'll talk a little bit more about that when we get into actual changes to the Rev. 1 document.

That's it for the first third of the presentation, but that's probably the most meaty third where we go through the background of the existing guidance, why we made changes, and this leads us up to the next two parts where we talk about the public comments that we got for both the NUREG and the Reg Guide and then the responses to those comments and changes to the documents.

CHAIRMAN RICCARDELLA: Okay, so by the schedule, we're about ten minutes behind. I think we're doing pretty well considering --

MR. TREGONING: That's the meaty part, I think we're fine.

CHAIRMAN RICCARDELLA: Let's move on.

MR. TREGONING: Okay, so keep plowing ahead. Let me, I'm going to talk now about the NUREG, Revision 1 of the NUREG and provide an overview of the public comments. So for this section of the talk, as I mentioned, I'm going to provide an overview of these comments and a sampling of comments and responses.

Like I said, I tried to pick some of the more both representative and interesting/controversial responses to talk to you guys about today, and then go through a summary and overview of changes that we made to Rev. 1, again, based on either public comments and then further review of this document by both the staff and the report authors.

As I mentioned, we went out, we sent this out for public comment in April of 2014 and we specifically asked for feedback on the following three areas; the first one was the extension of the best fit mean air curve for ferritic steel discussed in Section 3110. So this is the high-cycle fatigue regime beyond like 10 to the 6 cycles. The second thing we asked for feedback on are the adjustment factors that we summarized in 5.5, that's what I talked about before that we developed using Monte Carlo analysis. The third thing, and I admit in hindsight that this was probably a little bit disingenuous enough of us to ask this, but we asked for an accuracy check of the technical content of the NUREG, particularly with respect to all the numerical content of the report. So, we were pretty broad and expansive of asking our reviewers to really do a QA check of the document and to be honest, I don't cover these but we got some pretty

glib comments that said, "You gave me two months. There's no way I can check all the technical content of the report in two months." I would say we fully agree with the public comment or that yes, I think that you wouldn't be able to do all the technical content check in two months.

Yes, in hindsight that could have been worded maybe a little bit more clearly, but again, I think we got a lot of really good comments anyway. Public comment period ended in June of 2014. So we got formal public comments received from ten commenters and what this table does is list the comment's affiliation, who the commenters were and then where you can find those comments and items. We actually got three additional commenters that provided feedback after the public comment period, so while they're not listed here, we've just put their comments into the whole matrix and considered them as well. These other commenters weren't as voluminous, so and I'll show you with the statistics here, but we considered all the comments that we got. Now when you read the response document, and I apologize for this, the NUREG itself is a bit of an unwieldy beast, and the response document is also a bit of an unwieldy best. I think it's about an 80-page document and that's just a reflection of the

number of public comments that we got, number one. Number two, I think we tried to be as thorough as possible in our response to those public comments.

So it's a mouthful and it's very dry reading and I recognize that. So when you look at the responses to public comment, we enumerated and track each, and not only each comment, because if you looked at the comments, many of these comments were expansive and multi-part, so we took every individual comment and broke it down into sub-comments which we thought reflected individual issues. So we really articulated in the NUREG we, so we tracked them with a unique number from the table, so 1 is always the Higuchi comments, plus this abbreviation that you see in the right column. So I admit the number and the abbreviation are redundant, we didn't need to do that, but hey, we're the NRC, we over-design things all the time, I guess. Then a sequential comment number and even a sub-comment number to try to break down each individual issue with respect to a given comment.

So in terms of the unique comments or issues from those ten commenters, we identified about 254 comments or sub-comments; 235 came from the commenters themselves, that additional set of three commenters gave almost five more, so it was a small,

additional set. Then the other things that as we went through, we said hey, here's a change we need to make as well that was spurred by the comment. There were another 14 things that we sort of found that fell into that bin.

So, I think I've talked about this, but with respect to the NUREG, we were really happy with the comments that we got, we though they were well-thought out, very good technical in nature, thoughtful and expansive, so they were very helpful. If I bend and I have a more explicit bend later on, but if I just try to look globally, we got a lot of comments related to the scope, when does FEN method apply, when doesn't it. We got several comments on the adjustment factor analysis and application. Again, that was an area that we asked for comments on and we did get a lot of comments. We got a lot of comments that just said, "What are you trying to say here? Could you clarify this? We don't understand what point you're trying to make there." Those were very helpful and we tried to go back whenever we got a clarification statement and tried to be much more clear about what we were trying to state. We got a lot of comments related, "Hey, this stuff's great for specimens, but it doesn't apply at all to actual plant components and

here's why." So, there's where the philosophical comments came out.

Then we got a lot of kvetching, for lack of a better term, of overall conservatism of current ASME requirements. Especially then they said, "Look, ASME's conservative enough and you're making us apply this FEN factor and you're killing us now." So, we got a lot of comments related to that. I think in general we agree, so if you look through the response document and search for words "disagree" or "not agree," you won't find that in there often. We agreed with almost all the comments. I think when I went back and looked, and this is a bit of a type-o, there were about eight that we didn't agree with in one way, shape or form. Again, I just said when we didn't agree, they weren't significant with respect to the FEN methods, so some cases there was interpretations of ASME code requirements that were within the comments that we didn't necessarily agree with, but that's sort of outside the scope of what we're doing here anyway.

We had some comments related to load sequence effects that said that they weren't important. Well, we think in certain cases that they are so; we disagreed with those comments. There's been a big debate about whether you need to include strain

thresholds or not in your FEN analysis, many people think you don't need them. We included them here and said if you don't include them, that's fine, it's actually more conservative not to include them. So we're giving them to you to relax some of the conservatism. Then we had some comments we asked about the high-cycle fatigue cut-off of the design curve, we had some comments related to that that we didn't agree to, and then the other area, some of the component testing that was done was AREVA, interpreting that testing is not an easy thing to do, and so we had disagreements in comments about the best way to interpret those test results, and we document how we interpret them, but I'll just say there's not universal acceptance at the way NRC chose to interpret those tests and this NUREG is the way that other people would choose to interpret those tests.

So then, here's some more data --

CHAIRMAN RICCARDELLA: Were any of those comments from AREVA who actually ran the tests?

MR. TREGONING: Oh, yeah. No, we got a lot of that. In fact, one of the things, and this put us in a weird point because one of the tables that we have in the NUREG, AREVA came back and said, "There's some errors in the table." We said, "What do you mean?

We took your source documents." They said, "No, we had errors in our source doc." That puts us in a weird point because we're like, "Well, then you need to go back and give us a referenceable thing to fix." They were relatively minor things. I mean, nothing major, but just that some of the actual numbers had changed. That was one case where they actually gave us in their responses, they said here's what that new Table 21 should look like. We didn't take all of their changes because we said, "Well, you fix the source documents. Give us something to reference and then we'll publish an ERATA for the NUREG. Yes, we got a lot of comments from AREVA on their own text.

Okay, so what you see on this slide I just further discretized the comments. Again, I've highlighted the ones, the ones I've highlighted are related to the questions that I asked. We asked three questions on adjustment factors, high-cycle fatigue design curve and then miscellaneous was, hey, check everything that we did in this report. So if I look at this, again, we got a lot of questions on adjustment factors, a lot of questions about the database, what data are you using, is this material property really the right one. We went back and did QA of the data records to make sure all of that was right.

I mentioned the example problem, we got a lot of good feedback on the example problem, people actually going down and starting to work the problem, and finding issues with it. If you look at Appendix C we made some fairly substantial modifications to Appendix C to help correct some of the deficiencies we found from other people running the problem, as well as to make it easier for other users. There was information, we didn't have enough material information for someone to really run the case that they need to run.

Then I mentioned relevance to components, we got a large number of comments with respect to that. Then we got a sub-set of comments that were editorial, strictly editorial in nature, and I think by-and-large we tried to address those editorial comments, all of them, if not largely all of them.

So now I'm going to give you some sample public comments and responses themselves. Here's one; this is comment FAIDY, so for those of you that know, this came from Claude Faidy who was reviewer a comment or two, and this was Comment 3A. Again, it's a very good comment; he said, "All the reduction factors," and he's talking about adjustment factors, "They're considered to be independent of each other. It's not

accepted in all international approaches in particular that a constant FEN independently of number of cycles is not justified clearly." So here's actually a sub-comment which really has two points that he's making; one, that these reduction factors for light material variability, size, surface finish, his point is will you consider them in your analysis to be independent. In reality that's necessarily the case, that there could be relationships between those parameters that if the surface finish is this, it might have an effect on the size adjustment factor. We agreed; we said the report does consider the reduction factors are independent. We actually went back and clarified the NUREG from that perspective, and then we just said, "Look, we recognize that there may be correlations between these things," but to really do that in any sort of analysis requires really rigorous and a pretty good data set to do that in any sort of quantitative way.

So we just said, "Look, we recognize your point. This is the assumption that we made and we just don't have sufficient data to really evaluate if this correlations, how strong they might be in some of these areas."

CHAIRMAN RICCARDELLA: But do your

adjustment factors bound the worst that might be seen?

MR. TREGONING: Again, during a measure they will comment -- how we basically develop those is we looked at experimental data and tried to isolate it as much as possible and said, okay, for surface roughness we've seen effects of water that vary between factors of 1 and 3, for instance. So what we did based on that range is we said that's the 5th and 95th of our distribution, right, so those are my 5th and 95th, and then I'm going to fit it all normal through those points, run the Monte Carlo. What the Monte Carlo didn't do, if it took a point from that distribution, it didn't rank/correlate it with another distribution in the data set, so we did a fully independent Monte Carlo on all those adjustment factors.

Is that clear?

CHAIRMAN RICCARDELLA: Yes, but if you correlated them, would it make them less conservative or more?

MR. TREGONING: It depends on how they're correlated. If you correlated the first percentile, it could make them very conservative. We didn't do that, we did not do that. In fact, some people accused us of doing that. We said, if you just multiplied the ranges together and the bounds, you would get margins

that were bigger than 9 or 10, you would get margins of like 20 or greater. We did not correlate them.

MR. SHACK: The ASME code does, the multiplication straightforward?

MR. TREGONING: Basically. For the carbon curves they do, yes. We did not multiply them, but we did not consider -- we considered that they didn't affect each other. The other point that Claude makes in this is that FEN or the amount of adjustment you give could be a function of strain. We assume here that it's a constant regardless of the strain range that you have, because if you notice the strain rate is explicitly modeled, but it doesn't matter what the strain is if it's low cycle or high cycle, we assume that it's the same FEN.

MR. SHACK: For the threshold?

CHAIRMAN RICCARDELLA: If you have cut-offs, say if you're below that?

MR. TREGONING: Of course. If your above the thresholds that FEN is not an explicit function of strain. Again, we said that that's assumption and you could develop a method that would be a function of strain, it's just a much more complicated approach at that point. So we just clarified that within the NUREG that yes, this is an assumption that we made.

Here's a sample of comments that we got from adjustment factors and I think we touched on some of this, this was an AMEC comment. I've paraphrased it somewhat and tried to get to the meat of it, but it basically talks about discussion about adjustment factors for first of a factor of 10 on life being supported, but the NUREG recommends a factor of 12 for use pending further validation. The comment is, "It's unclear what validation data is required because the existing database is already large." Then another comment was, "There was no clear justification for a factor of 2 on stress provided in the NUREG." So here was a summary of how we responded to that, that basically the analysis supports a factor of 10 without the need for additional data. I think we have enough laboratory data to say a factor of 10 is a sufficient margin. However, the report's maintained a factor of 12 to be consistent with the factor used in the ASME design curve. So right now, again, we're retaining that for consistency. But again, the fatigue world the difference between 10 and 12 is not great.

CHAIRMAN RICCARDELLA: Like you said, if you hit it with a factor of 2, you're doing great, and here you're talking a factor of 1.2

MR. TREGONING: We're honest, we didn't

evaluate the factor of 2 on strain at all. So we clarified in NUREG we didn't do any analysis to look at this and we just retained that for consistency with the code. We haven't looked at trying to reduce that margin at all. So these were good points and we just tried to make sure that the NUREG clearly stated that in several places.

Here's a good one related to the ASME method and requirements in general and I think this is a good representative comment. We got several that are similar to this. The comment was basically first there just hasn't been a reconciliation between specimen fatigue test data and the complete, and I'll stress the word "complete," ASME code fatigue methodology, so how you do the analysis, all the assumptions that you have to make. Then it goes on to state the ASME methodology already contains a lot of multiplication of effects that have not been considered by both the developers of the in air design fatigue curves and the FEN factors. So the notion here is that ASME code in and of itself is so conservative and you haven't factored that into your approach here. We agree with that, we haven't, and not explicitly. So we developed, and I'll get into this a little bit later, one of the biggest things we developed in Rev. 1 with this whole new Section 1.5

where we try, and it's a long section, it's about ten pages, but we tried to go through the bases and assumptions for everything that we're going to lay out in the NUREG and we tried to be very clear.

One of the things we talked about here is we talked about some of the ASME code conservatism, and again, the purpose of this report was not to indict or evaluate the ASME code fatigue requirements. The purpose for this report was to make sure that we're addressing environmental effects. Again, we've tried to state that in many places the data shows, at least that we've accumulated in the NUREG, that we believe the FEN approach in concert with the ASME design curve will give you either accurate or conservative predictions of environmental effects. So accurate or conservative. Eliminate conservatism in the ASME code is outside of the scope of this particular report; however, we're trying to encourage people go forth and make changes to the code. If you want to revise the code procedure, let's do it through the proper channels.

I think we're hopeful that we'll be able to make some progress in this area, but we weren't going to solve the code problems within this particular report.

CHAIRMAN RICCARDELLA: Doesn't your evaluation of your methodology against the component tests do some form of reconciliation? Were those constant amplitude tests or did they have varying spectrum?

MR. TREGONING: It depends on the test. I mean, again, even the component tests are representations of reality. In an actual true application of plants, way more complicated than any of the component tests we've done.

CHAIRMAN RICCARDELLA: Just finding the actual magnitude of the cycling is --

MR. TREGONING: So I think the notion that look, you're required to use design stresses, design cycles, you're required to pair them in a certain way in the ASME analysis, there's lots of things about the analysis. Gary's on, he can speak way better to this than I can. If you look at them in total you'd say there's a lot of conservatism here. But what we've struggled with is try to identify okay, which particular thing do we want to pick at without upsetting the apple cart, because sometimes if you remove one conservatism you need to make sure it still holds together at the end of the day. I think that's part of the challenge as well.

Okay, as I move on, so we also asked for comments about the high cycle fatigue regime and one of the comments we got back from MHI just said, "Look, the extension that you guys are doing it's too conservative." That was the comment, too conservative. In our response we do agree that the extension is too conservative. The extension that we have in Rev. 1 is also identical to the extension that's been proposed in the ASME code, so it's fully consistent. Again, that's based on data that has a prominent mean stress effect, and the mean stress effect can really affect significantly what your high-cycle fatigue cut-off is. Again, basing it on data is meant to be both conservative and allow application of components, which have high mean stress component. We tried to be very clear that if you have data or components without a significant mean stress effect, then yes, the proposed curve could be significantly conservative. So, I think while we don't argue with the approach, you can always interpret if something is too conservative or conservative enough.

Then, okay, I mentioned that there were few comments that we disagreed on. I wanted to pull out, this is probably the most interesting one that we disagreed on in some sense, so I wanted to make sure

we covered this. This one came from AREVA and they postulated in their comment that, "Look, the only concerns we should have that should consider environmental effects are those transients that have low strain rates." So what they were proposing or postulating is that look, for those low strain rates you shouldn't even have to consider environmental effects, and they go on to make that point here. The other transients that you have, for example, insurgence and outsurgence, need to be evaluated for fatigue, but the current methodology without any FEN penalty is very appropriate for those transients. That was the gist of the comment.

Our response was, "Look, most transients that you look at have a wide range of strain rates, and it's not really important how environmental effects are going to be until you look at the entire transient as an entire beast." You can't just cherry pick one portion of your transient and say I'm going to look at the environmental effects here but not consider them through the whole transient. Only through this way can you say if the FEN for that transients is really significant or not. That was really the point here that we think this approach we don't want to cherry pick and say you need to consider environmental effects

here, you don't need to consider them here. The whole idea for the cut-offs and thresholds is that if you are below all of those thresholds, by default then environmental effects are one and there's no penalty whatsoever.

CHAIRMAN RICCARDELLA: But if you evaluated an insurge/outsurge change in the strain rates for high, wouldn't you end up with a FEN that's pretty close to 1?

MR. TREGONING: Exactly. Okay, so what changes did we make to Rev. 1 compared to what went out for public comment? That's what I'm going to cover next. Again, I think we tried to address virtually all the public comments and what we were trying to do by addressing the comments in general, we wanted to explain as clearly as possible the bases and assumptions that support not only the NUREG but the Reg Guide. We're using the NUREG as well to summarize the current state of knowledge in this area. We wanted to make sure we did that, and look, with any technical work it's not the final question, it's sort of wherever you are in that point in time. We want this NUREG to provide a starting point or foundation for continued work in this area. I think if there's a need for such work, especially by licensees, we're hoping that we

would encourage them to pursue that.

As a result of these desires that I list up front, the downside is the NUREGs turn into quite a beast. Rev. 0 was 120 pages, Rev. 1 draft that went out for public comment was 320, the final, it's not final yet, but where we're at is almost 500 pages and it's about a 90 meg file so it's becoming a little unwieldy. As far as the main body goes we haven't added a lot, there's maybe ten more pages, but what's really adding the girth is we added this new Appendix D and new Appendix E. Dr. Bley talked a little bit about new Appendix E, I'm going to talk about those appendices and why we added them here in a minute. The main body's grown not as much as the appendices.

Here's what at least the table of contents looks like after the public comments, and the only things I've highlighted here, we actually changed the title of Section 5 and we tried to be clear that we're calling these adjustment factors and not, we don't want to call them design factors or design margins or things like that. These are factors to adjust for things that weren't considered in the best fit mean air curves, things like size effects, material variability, surface roughness and loading sequences, so it's all the same things that the ASME code calls reduction

factors. We're just calling it here to be clear, adjustment factors.

So, it's a relatively minor change, but we're just trying to be clear and distinguish what we did in that chapter from what's done in the code. Then the other main thing as I mentioned is we added an Appendix D which is a compendium of figures. One of the comments that we got back, first of all, the figures that you got in the main body they're too small and they're hard to read, so one of the things we did is we went back and we're using high res files in the NUREG now for all of the little individual files, so they're better scalable. If you put them on your PC and you try to scale the figure out, you don't run into resolution issues. Now, that's caused a big increase in the size of the document, but so be it. The other thing we did is we took every figure in there and blew it up and put it on either its own page or no more than two figures per page and that's all Appendix D is, it's every figure that's in the NUREG from 1 to N, bigger so that if somebody really wants to look at it and really wants to pick out fatigue data, they can at least have that opportunity.

Then the other thing we did, if you look at the draft that went out for public comment, because

we started with Rev. 0 and then built on it, there was a lot of well, here's the Rev. 0 equation and here's the Rev. 1 equation. A lot of commenters said, maybe not a lot, but some said that's confusing. " We don't know what equations we should use. What are you telling us, which ones should we use?" So we made the decision of look, Rev. 1 is only going to include the latest equations and we struck all the old equations, but we wanted people to understand here are the changes to the equations. So we added Appendix E, all Appendix E does it lists every equation that we had in Rev. 0, that's one section of it, and then the next section lists every equation that we had in Rev. 1, that's the second section. Then the third section is a mapping that says this equation number in Rev. 0 between this equation or equation number in Rev. 1. So if somebody really wants to map, they're able to do it in an easier way. And I can just know from my own perspective, I found that appendix to be pretty helpful. So those are some of the major structural changes.

I just want to summarize, I do it in two ways. I'm summarizing here the major comments and then I'll walk you through by section by section and just let you know what some of the changes were. But at least this first slide summarizes the major changes

that we made to the NUREG due to comments. I mentioned this earlier, we added this new section up front, the Section 1 on bases/assumptions associated with the FEN method, and again, this was in response for a lot of the public comments that we just thought were good comments, but a lot of them were outside of the scope or intent of the reg itself, so we wanted to try to lay that bases much more clearly and explicitly.

The other thing that we did, and this was an artifact from Rev. 0, we had a Section 41-14 on the modified rate approach, and that's an approach you use regardless of what material you're looking at, but we had it within a section where we were dealing with carbon and low alloy steel. Somebody pointed out well, that's stupid, that's not just applicable to carbon and low alloy steel, that's applicable to any material. We agreed with that, so we moved that whole thing to its own section. It's a new Section 4.4 and then we got a number of questions related to lack of clarity in that write-off, so we tried to significantly clarify the write-off associated with the modified rate of approach.

I mentioned this previously, Gary did a lot of work to rework and revise the example problem in Appendix C. I mentioned this one, we eliminated all

the Rev. 0 equations from the main body and I talked about Appendix E and I talked about these other things with respect to the figures in Appendix D. The other thing that we did which was I think an important change, it was a change that we did with some care, is we recognized we were sort of sloppy in our terminology and we used a lot of different terms/adjectives for environment. Sometimes we said reactor environment, sometimes we said coolant environment, sometimes we said water environment, so we went back and tried to be more consistent and just talk about a water environment, because again, a water environment that trips the thresholds, we believe, leads to environmental effects. We didn't make a categorical change, but where we thought it was appropriate we made those changes throughout the report.

So for instance, if somebody did a set of tests and said we did testing in simulated reactor coolant environment, we didn't go back and change that, we left that source reference the same. But when we're talking about applicability and guidance, we took out the terms reactor coolant and said water environment, and to try and make it more consistent with the Reg Guide, and we got some comments with respect to the Reg Guide, with respect to lack of clarity from that, that

we wanted to make sure that we were consistent in our guidance and our interpretation.

The other thing we did, and we had done this before but we're gluttons for punishment, we did it again, we went through technical editing, so if I show you guys a red line strike-out version of the document, it'd probably look pretty messy, but a lot of these changes aren't significant, so that's why we didn't give you a red line strike-out version of the document per se.

So, those were the major changes, now I'm going to walk you through section by section and just touch quickly on some of what was done on each section. In the executive summary there wasn't anything significant, but what we did is we added some new language as well as clarified existing language related to the applicability of the FEN method, margins and adjustment factors. So, again, if you did a red line strike-out you'd see a couple new sentences added in the executive summary. As I mentioned in the introduction, the big thing was this new Section 1.5 and we felt like this new Section 1.5 really addressed a lot of the public comments we got, or at least that was the intent of adding that section, and we specifically addressed 26 topics in the sections, or

we called them items, and we got a paragraph or so discussion on each topic within Section 1.5. Other than that which was significant, there's no other really significant changes in Section 1.

Gary mentioned before Section 2, which this talks about some of Dana's question about our understanding of the mechanisms of fatigue, what leads to the formation of these cracks. No significant changes to that section, but we did clarify what we meant between, and Pete touched on this, what are sort of micro-structural cracks, things that are on the order of the grain size or the metallurgical features of the material and things which are small which are starting to become almost governed by mechanics, which we're calling mechanically small, correct. So we tried to be very clear about that terminology in Section 2. Section 3, this is where we look at all the strain-like behavior in air, no significant changes, but we did get a lot of questions about when we looked at materials we looked at the common materials that we use in U.S. applications. There's other applications particularly in Germany where they use titanium and niobium, stabilized stainless steels, that are actually designed to have better fatigue performance.

So if you look at those materials and

compare them to the design curves, those have much better fatigue life. So we tried to be very clear that yes, we didn't look at or evaluate those particular grades of stainless steel in this particular analysis. Again, we made those statements in Section 3. Section 4 they were at --

MR. SHACK: On that topic, when those curves are originally drawn people use the high carbon steels by-and-large and the low carbon steels are sort of a toss-in. Now I suspect it's the other way around, that almost nobody is going to use a high carbon steel, it's all going to be L or LN or nuclear grade.

MR. TREGONING: For new applications.

MR. SHACK: Certainly for new applications. And they do have different behaviors, but you're following the code there. Again, the question is probably whether they should be broken out at this point.

MR. TREGONING: We agree. In fact, we gave a talk, we've given a couple of talks, one of the talks where we identified changes that we thought would be technically defensible. One of the things we did is for certain alloys for stainless and nickel, we said if enough data develops we think there's a basis for less conservative design curves here, certainly. We

also indicated with ferritic materials that there's a good correlation between strength and fatigue life and using that correlation and developing design curves for specific classes of ferritic steel components, we think that's also a modification that could be defended. We don't do that per se, but we're trying to identify areas that we think are right for making some modifications. Those are a couple of them.

Okay, so back to this Section 4; this is the section that we talk about with all the environmental effects. I mentioned these changes already, at least the significant ones that are in bold I mentioned. We eliminated all the Rev. 0 equations and we moved that modified rate approach. The other thing that we did, this gets to Dr. Shack's point, is 718 was the one alloy that we know, it's used in some U.S. applications and we had really good air date on nickel 718. If you look at the air design data, nickel 718 is very much more resistant to fatigue or less susceptible than the other nickel-chrome-iron alloys. So we said, "Look, if you use a stainless steel design curves for air, that's going to be very conservative for 718." But we are clear to say that we don't have data for 718 or enough data for 718 in water environments to know if the FEN approach holds

together, so we do make it clear that at least this time that we're not recommending use of the method with nickel 718 until, again, sufficient data is developed so we can either see if the FEN approach applies or if different factors are actually appropriate for that particular alloy.

Another thing we did, we had different nomenclature for the transformed variables between carbon and low alloy steels. We just unified the nomenclature we were using so it's not different depending on the material that you're looking at. It's a minor thing but it can be pesky and annoying, so we just did that.

MR. SHACK: That's confusing, though. Your epsilon.star is a log of a strain rate, so it's a negative number, but nobody thinks of epsilon.star as a negative number. You look at the equations and things are going the wrong way until you realize it's really the log of a small number that you're looking at.

MR. TREGONING: That's a valid point, I'm not going to disagree with you. In fact, we went five times around because if you looked at the NUREG we had times because whether you have the negative sign or not in front of the transformed variables, and we had

sometimes when it was negative and sometimes when it was positive.

MR. SHACK: Just to find epsilon.star as the strain rate with your factors, then written log of that thing in that expression, it would have been much clearer the way the signs went.

MR. TREGONING: I promised I wouldn't do this, but I'm going to have to, and I'm just going to blame Omesh for that.

(Laughter.)

I don't know if he's on and wants to defend himself, but I'm not going to disagree.

CHAIRMAN RICCARDELLA: Yes, but then in the FEN, it's exponential over negative.

MR. SHACK: It's exponential of log epsilon.star and you would know that log epsilon.star is negative, so negative times a negative is a positive and in fact FEN is increasing. You keep thinking that epsilon.star is a positive number and it isn't because you've taken the log.

MR. TREGONING: Look, believe me, I struggle, I have to check myself all the time, so I'm not, like I said, I'm not going to disagree with you on that comment. That's a valid point. If you feel that strongly, maybe you can put that in your letter

and it might compel us to gauge, I don't know. Again, some of this is historical based as well, that was how it was defined historically.

MR. SHACK: I was the co-author of the first report, so I can't hide.

MR. TREGONING: Okay, the other thing we did we tweaked thresholds based on comments and some people said "Well, we think the threshold should be this and we think the data really shows that it should be this." In all cases we went back and looked at the data and sometimes we agreed with them and sometimes we didn't, but in cases where we agreed with them, we adjusted the thresholds accordingly, so that's indicated in there.

Section 5, I've talked about this. There's no real significant changes to that section, but we did try to clarify why we ended up recommending margins of 12 and 2 even though the analysis would argue that you could maybe reduce at least a factor of 12 by some additional percentage. Section 6, based on comments, again, we actually went back and re-analyzed a couple of the tests that we used in those sections. The re-analysis we changed some of the quantitative numbers, but overall in terms of significance, there weren't really any significant changes associated with

the re-analysis. Just wanted to make sure everything was accurate. Again, we tried to indicate at least in some ways when FEN tends to be in conservative. I think we would all agree with this, if you have gradient effects in your tests and what gradient effects are in either loading or temperature and sometimes it's temperature that induces the gradient and loading, that FEN tends to be conservative. I think we would all agree on that.

MR. SHACK: But the whole ASME code is conservative in those cases.

MR. TREGONING: Right. Yes, definitely. No other significant changes to Section 6.

In summary, basically all the summary we made changes that are consistent with any changes that we made in the rest of the report, including the executive summary. Then we also added a couple of paragraphs on the evaluation of the procedure, and then the applicability of the method and future work, because again, we want to make sure that the door is open doing future work and we want to try to at least encourage that.

Other than that, no other significant changes to the summary. As far as the appendices go, Appendix A was really just a mimic of everything else,

so if we needed to make consistent changes based on the equations, we made some changes. Again, that's changing of thresholds and things like that. We clarified what temperature you should use when picking your Young's modulus. It's a relatively minor point, but it's somewhat important, nonetheless. Some people said what do you do if you have a maximum temperature limit that's greater than your bound of 325, so we added some clarification on what you would potentially do on that. It's pretty vague, it's just says, "Look, 325 we think covers most applications." If you really need to have an application that goes beyond 325, you just need to justify what you're doing in that regard.

So we tried to be very clear because once you get up closer to 400, the temperature effects on FEN start to change dramatically, so we want to stay outside of that regime. That's why we're pretty careful about limiting things to 325. Again, if you're really substantially higher than that, again, you have different phenomena that are starting to come into play.

Appendix B, this is where we summarized all the material information that makes up the data sets that we analyzed in the report, no real significant changes to that information. I've mentioned, I've

already talked about the sample problem. Again, I thank Gary as well as the public reviewers for scrubbing this hopefully better. I'm sure we have three or four more people that would do it, who will find more problems with it, and we would encourage that. We're hoping that as more people use this, if we need to modify it further, will do so. The biggest thing, we added a new Table C1 that had material properties that you would use in the sample problem. So that was a glaring admission, we needed to provide better guidance that people could hopefully get the same result.

Then we added Appendices D and E which I've already discussed. That's it for the NUREG. The next piece is the same sort of talk but just talking about the Reg Guide, and I don't know if you want to take a break or?

CHAIRMAN RICCARDELLA: The schedule shows a break within five minutes of that time, so let's take about a 15 minute break and come back at 20 of.

MR. TREGONING: Just for planning purposes, we're two-thirds of the report as far as topic, but as far as content goes we're probably 80 to 85 percent of the way through, so there's not a whole lot left.

CHAIRMAN RICCARDELLA: Yes, so we should

be done early is what you're saying.

Thank you.

MR. TREGONING: Did you say a quarter of?

CHAIRMAN RICCARDELLA: 20 of.

MR. TREGONING: 20 of, okay.

So we talked about the basis of the -- the technical approach in the first part, and then we covered the NUREG, its public comments and changes, in the second part. Now we are going to cover the comments to the Reg Guide itself. And again, as I mentioned, the Reg Guide itself is pretty spartan. It just basically says go forth and apply Appendix A of NUREG/CR-6909 Rev 1.

So same thing here. I am going to provide you an overview and sampling of the public comments and responses, and then summarized changes that we have made now to Rev 1 of Reg Guide 1.207. And again, these are -- these changes are in direct response to public comments and also further review by the staff.

So as I mentioned, we sent this out. Actually, it was sent -- sent out at the end of November 2014. The public comment period ended in early 2015, and for the Reg Guide itself, we got public comments from seven different commenters, and you will see a very

similar table and similar way that we have categorized and abbreviated the comments.

And I will mention that four organizations, Rolls Royce, Westinghouse, AREVA, and EPRI, they commented on both the NUREG and the draft guide. And if you looked at their comments on the draft guide, they were -- a lot of them were similar comments and very technical in nature, where the other three commenters were more not necessarily technical in nature comments, but more applicability, procedural, things like that.

So some of the comments that you see in the Reg Guide are also -- they have been mimicked from comments that we got in the NUREG, and as you read the public responses, we have tried to reflect that whenever we can.

We have the same way of enumerating them where we track them both by abbreviation letter number and then sequential comment number. Here we did not have to break them into sub-comments, however, so we got -- from those seven commenters, we got 49 actual unique comments that we addressed in the responses to public comment.

So I have characterized, just like I did

with the NUREG, the following -- the areas associated with the comments. Actually, the -- almost half of the comments were editorial or clarification in nature, so they -- they did not have a -- again, any technical or any applicability issues that they were trying to address. They had just found some editorial things that they wanted to suggest changes, or areas where the guidance was not clear in their perspective.

Another big percentage was, like I said, related to the technical basis, so these were the comments that were similar to comments that we got on the NUREG itself, and that was about 22 percent of all the public comments on the Reg Guide.

This third topic, which we have touched on, we got a good number of comments about applicability of earlier either reports or guidance for those applications. Do they remain applicable? And then we got a -- a subset that related to Reg Guide scope, use, and applicability. And there were three comments that I could not really fit neatly into any of these other comments, so I just said they covered new topics.

Now I mentioned with the NUREG, we agreed with virtually all the comments we got. Here it was not quite as unanimous. I think we fully agreed with

about two-thirds of the comments. The remaining third, about half of those we at least partially agreed, and the other half of those, so the other six of those comments, we probably -- we just disagreed with.

And the areas of disagreement -- and we sort of -- you know, I wouldn't call them significant areas of disagreement, but the one area was applicability of earlier technical reports and guidance, and I will talk about that in a little bit.

So in fact, maybe I will summarize it now. They wanted us in the Reg Guide to cover this issue, you know, what's the applicability of earlier guidance, earlier reports within the Reg Guide? And we have debated internally whether we thought we should include that in the Reg Guide or not. Right now at least the position is that we're not going to include it in the Reg Guide, but where it is going to be included will be in other documents like the SLR guidance documents, things like that.

So the idea is that the Reg Guide wants to focus on here's the method that we think is the best applicable method, and if you have questions about old analyses or things like that, that should be addressed sort of offline, and we didn't want to try to be

expansive within the Reg Guide itself because you can't cover every situation that might use this Reg Guide anyway. So -- so --

MR. SHACK: But the first paragraph of your discussion section says it's an alternative to -- for new reactors and for license renewal, which I read that as you can use the old stuff for those things.

MR. TREGONING: Yeah, I think that is -- I think that is a fair interpretation. And with reg guide language, you know, the language is meant to be very precise and specific, so yes, and it is interpreted literally, as it should be, so yes, I think that's an accurate interpretation.

And then the other areas where reg guides go --

MR. SHACK: But you said you weren't going to address it, but it really is addressed.

MR. TREGONING: Not explicitly.

(Laughter.)

MR. TREGONING: People want to know --

PARTICIPANT: You're going to be a lawyer, not an engineer.

PARTICIPANT: Evidently, some commenters --

MR. TREGONING: Oh no no --

PARTICIPANT: -- wanted more.

MR. TREGONING: -- no, those were the comments. The comments said we want you to explicitly address me using -- and I will show you --

PARTICIPANT: Okay.

MR. TREGONING: -- NUREG -- I want -- what if I use Rev 0, 6909? What do I do? Those sorts of comments, so they wanted specifically to us address the use of these prior existing NUREGs.

So I will have a comment that gets into that, so we'll talk about that a little bit. In fact, we will talk about it sooner rather than later.

Sample public comments and responses: so this was one, you know, and I am only putting ones here that I think are interesting or that we slash disagreed on, so -- and I tried to find at least one from all of these four topic areas. And I will be honest with you: I struggled to find anything that was really that good for the editorial or clarification comments.

So this is one that, you know, just shows that we disagreed with it, but here is why. And, you know, if you look at the Reg Guide, it is broken into different sections, and Part D of the Reg Guide is the

implementation section, and it states there that the guidance may be used to demonstrate compliance with the -- with underlying NRC regulations. And the comment said it would be useful to define the underlying regulations, and then it goes on to say that the background of the Reg Guide mentions 54.21, which is license renewal regulation, but that would only apply to renewed license applicants.

And then it goes on to say 54.21 addresses and cites internal aging management reviews and TLAA evaluations rather than the basis for environmentally adjusted CUF analysis, and then we just clarified in the response that the phrase "with underlying NRC regulations" pertains to the applicable regulations, which are defined earlier in the document, Part A and Part C, and the purpose of Part C is not to restate that information.

So Part D if you read it is mainly a lot of boilerplate stuff. There is really not anything new there, but again, so all that's in Part D is applicant and licensee use of the Reg Guide and then NRC's planned use of the Reg Guide. And like I said, it is pretty much generic, not necessarily specific to this particular guidance as well.

So again, I didn't think this is a great example, but I tried to give you one example, really the only one within this category where we didn't agree with the comment. Otherwise, the editorial or clarification questions that we've got we have tried to address in some way.

Again, so here's the next group. These were comments related to the Rev 1 technical basis, and I pulled out an AREVA comment. And I didn't cover a similar comment in the NUREG, but I can tell you that we got some more comments of this in the NUREG, and I will just summarize it.

Many do not agree with the direct multiplication of the in-air design usage factors, which, to be honest, we didn't do that anyway, that are based on membrane types of loadings of small specimens. And then it goes on to state, you know, this conservatism is in addition to (a), quick in-surge/out-surge types of loadings not being considered; (b), favorable hold time effects not being considered; (c), load sequence penalties being incorporated into the factor of 12 although not justified for nuclear plant applications, and it goes on.

And at the end, it states why hasn't a square root sum of squares of these factors be considered? So instead of a Monte Carlo analysis, why wouldn't you use something that you would do like an uncertainty analysis, by doing a square room sum of squares?

So, you know, in this case, we took the comment, and we didn't -- if you read the responses to the Reg Guide, they don't really respond to the comment per se. It just basically says hey, we got a similar comment to this in our public comments on NUREG/CR-6909, and we tried to identify specifically those comments that we got that are associated with those same issues, and particularly for this comment, we had NUREGs -- NUREG comments related to hold time effects, surge loadings, and the basis of the factor of 12, so we have tried to point that Reg Guide commenter to the similar comments within the NUREGs so we're just not replicating responses in both sets of documents.

So if you read those responses to the Reg Guide comments that fall within the second category that apply to the technical basis, in every case, we have referred them to this other public comment response document.

Okay. So this gets it -- we said we'd talk about this, so this is a comment that we got on applicability of prior guidance. And -- and we got one of these for every NUREG, so every NUREG that we have ever had guidance, we said what about this NUREG, what about that NUREG? So I am just pulling this one out.

This said the draft guide does not clarify if the use of NUREG/CR-6909 Rev 0 formulas remain acceptable, and it goes on to state several license renewal applicants have used Rev 0 methods and formulas for computing FEN values and would not wish to revise them just in order to meet Rev 1 criteria. And this comment actually came from NEI.

And so we have disagreed that we need to have explicit guidance for prior methods within the Reg Guide, and we have tried to clarify in the response that prior methods previously approved by the staff remain valid for the period of their intended use. We don't go back and revisit any decisions that we have made in licensing space based on this Reg Guide at all.

We mention that for SLR, that we are -- as part of that guidance, that we are going to try to clarify at least for SLR use of prior methods that we use for license renewal and how those were going to be

addressed within SLR, but we're going to include that within the SLR-specific guidance documents themselves and not this Reg Guide.

But we did -- what we have tried to do is -- is clarify the intended use of this Reg Guide, and we -- we have tried to put some statements in Part C to modify that intended use statement accordingly. Now, whether we -- we have achieved that or not still remains to be seen, but that was the intent of some of that new language in Part C.

The next set of comments, this is one related to scope, use, and applicability, and this is actually a good comment that covers a couple of different issues, so I think I -- this is a Westinghouse comment, and it goes on to say, you know, page -- Paragraph 2 states that quote "These methods apply to those components exposed to reactor coolant that are required by regulation to have a fatigue CUF evaluation or have an existing current licensing basis, that is CLB, fatigue CUF evaluation."

And then it goes on to state these components that quote "have an existing CLB fatigue CUF evaluation that are not exposed to reactor coolant but are in secondary systems exposed to secondary fluid,"

it says they are not required by regulation to have a fatigue CUF. And then it goes on to ask, "The applicability of FEN factors to such components should be clearly stated."

So what we have tried to do is at least clarify what we think are applicable environments and applicable analyses, so there's two things here. One is this notion of reactor coolant versus water, so we've said, look, we believe -- staff believes that the methods described in the Reg Guide are applicable to both primary and secondary systems. Again, if you're above the thresholds for environmental effect, if you're in reactor coolant water or secondary water, you're still potentially going to see environmental effects.

However, we do agree that the Reg Guide does not clearly define the terms "reactor coolant" and "coolant," so we went back through in the Reg Guide and stripped out everywhere that we said "reactor coolant" or "coolant" and just said "water," to make that abundantly clear that we just mean water.

So that is what we did to address the first part of that response, right? Now the second part of the response, and all I have done here is to comment,

that's the same comment that we got before, so you see that on the slide just for your own convenience. But the summary is what is different, so this is the second part of the requirement about the applicability of the Reg Guide specifically in an existing licensing application.

So there's two things that we would say are required to consider environmental effects. One, the component is required by regulation to have a CUF evaluation, so you touched on that already a little bit. And in one, a component has a CUF evaluation that may not be required by regulation, but it's in their current licensing basis, so they have it anyway even though it is not required specifically by the regulation.

So we have tried to say if either -- if either one or two above are true, then that needs to be evaluated for subsequent -- depending on the period of applicability for license renewal using GALL Rev 2 or GALL SLR for the subsequent license renewal period, if both of those things are false, you don't have an existing CUF calculation. You don't have to address environment effects. And we have tried to -- we have added clarifying language to the Reg Guide to make this point -- or in an attempt to make this point even

clearer.

PARTICIPANT: What --

MEMBER SKILLMAN: Rob, let me --

PARTICIPANT: Oh, go ahead.

MEMBER SKILLMAN: The first bullet under summary, staff believes the methods described in Reg Guide are applicable to both primary and secondary systems. Some of the secondary heat exchangers are as large as the steam generator, some of the plants. Until I read that sentence and listened to what you said, I had pretty much said to myself this is applicable to reactor coolant system pressure boundary, and the steam boundary limited probably to the first valve out.

I wasn't thinking feedwater pumps, main feedwater heaters, reheaters. How is that boundary established in the Reg Guide so that we -- we don't have people deep in the secondary systems digging out CUF even though CUF might be needed from an ASME perspective?

MR. TREGONING: Right, so that boundary is not delineated in the Reg Guide. The Reg Guide just says if you have a CUF, you need to at least consider if environmental effects are important. Now for many

of these secondary systems, you probably can do a pretty simple analysis to show that yes, we're not going to -- we're not expecting environmental effects because, again, either the strain rates are too high or the temperatures are too low or the -- or the water, you know, or the dissolved oxygen content of the water, whatever it might be, don't meet those thresholds.

So it does not -- it does not say you have to do a hardcore FEN analysis, it just means that you have to think that environmental effects could be important there, and you at least have to consider them or determine if they're going to have an effect or not. But again, that is only if you have a CUF calculation.

CHAIRMAN RICCARDELLA: Yes. I think a lot of the components you're referring to were probably ASME Class 2 --

MR. TREGONING: Yes.

CHAIRMAN RICCARDELLA: -- Section 8, which really didn't have a CUF.

MR. TREGONING: So I think I don't want to preclude that there wouldn't be some secondary component out there that you would have a CUF calculation for. I think it's a very small, maybe null subset.

MEMBER SKILLMAN: No, I think Dr. Riccardella is right. I think it is a very, very small group. I would just kind of --

MR. TREGONING: So that's why we didn't make an effort --

MEMBER SKILLMAN: I was putting --

MR. TREGONING: -- to have --

MEMBER SKILLMAN: -- in Westinghouse's place writing that comment, trying to understand why I would have written that comment. What might I be trying to not --

CHAIRMAN RICCARDELLA: Right. I think --

MEMBER SKILLMAN: -- apply this to?

CHAIRMAN RICCARDELLA: I think you took care of that by replacing reactor coolant with water.

MR. TREGONING: I think that -- and that was one of the reasons --

CHAIRMAN RICCARDELLA: But let me go in the other direction: what about reactor internals?

MR. TREGONING: What about reactor internals?

CHAIRMAN RICCARDELLA: I mean, if you've got some internals that are -- that do have CUFs calculated -- I think some of them might -- then you

would be required to apply this --

MR. TREGONING: We would --

CHAIRMAN RICCARDELLA: -- under SLR.

MR. TREGONING: -- we would want them to consider environmental effects. Now whether they would do that through the application of this Reg Guide or not, that would be another issue. But yes, we would want them to consider environmental effects, if they have a CUF calculation on those internal components.

MR. STEVENS: This is Gary. I have a comment.

CHAIRMAN RICCARDELLA: Yes, go ahead, Gary.

MR. STEVENS: So yes, I was going to make two comments, but Pete, you addressed the first one as far as out in the secondary system, I think those are Class 2 and therefore, you know, that the rules don't apply because you don't have CUF. An example of a place in Class 2 where you probably do have a CUF that is driven by regulation would be feedwater nozzles and PWR steam generators.

CHAIRMAN RICCARDELLA: Right, right.

MR. STEVENS: Now regards to internals, so let's talk about that for a minute. Keep in mind that

the guidance does not say that you must calculate CUFen if you have a CUF, so in the case of internals for example, a licensee may choose to manage EAF through inspection.

MR. TREGONING: That is always the case. Anything else, Gary?

CHAIRMAN RICCARDELLA: Wait. I don't think I understand. I mean, if you have a CUF of your internals, and that is part of your current licensing basis, does -- doesn't this require you to -- you to address environmental fatigue? Or -- or wouldn't it be included? I guess it is not required. You can do another technically acceptable alternative. But --

MR. STEVENS: Yes, okay. I will let -- the staff can maybe comment, but my position would be that you need to -- your aging management program needs to address environmental effects.

CHAIRMAN RICCARDELLA: Yes.

MR. STEVENS: And how you choose to do that, there could be several ways, one of which is a CUFen calculation and showing that to be acceptable. There are other ways, including inspection.

CHAIRMAN RICCARDELLA: Yes.

MR. TREGONING: But that's -- that's just

not internals, Garry. That would be the only thing I would comment on. That is really any component, right? Any -- any component, right?

MR. SHACK: But for --

MR. TREGONING: Any -- any component, you have that option.

MR. SHACK: -- internals, you might question the applicability of the NUREG since there is very little on irradiated materials there, and whether that would change --

CHAIRMAN RICCARDELLA: Well, the NUREG --

MR. SHACK: -- behavior.

CHAIRMAN RICCARDELLA: -- the NUREG does have a section on irradiation --

MR. SHACK: Yes, but there is --

CHAIRMAN RICCARDELLA: I think it says there is no effect.

MR. TREGONING: It says based on the data we've seen, we haven't seen a significant effect.

CHAIRMAN RICCARDELLA: Yes.

MR. TREGONING: But you're right, there is a paucity of data, to say the least, on irradiation effects, and that is an area to be quite honest with you we have been talking to DOE and others about trying

to address in some way, because again, it is just not much knowledge out there. There's some data sets, and you know -- and I think quite frankly, I think if there's a detrimental effect, it would be within the low cycle fatigue regime. I think within the high cycle fatigue, it might actually be a beneficial effect because you are --

MR. SHACK: Strengthening.

MR. TREGONING: -- you are strengthening the material. So to me, if we were going to actually do something in this area, I would want to focus on sort of the more higher plasticity low cycle fatigue regime.

But that remains to be seen, whether we are able to actually do some work. Like I said, we are trying to partner with -- or we are trying to spur DOE on for some activities here. Dr. Powers mentioned that sometimes, they are better equipped to deal with these more fundamental issues, and -- and might have better resource availability to address some of these things that also can be very pricey, so I think this is a great PhD topic for instance, so -- .

CHAIRMAN RICCARDELLA: You know, let me just address something. Gary, you said you could address internals by inspection, but I assume it is not

just inspection, it is not just inspection, it is inspections plus some sort of a flaw tolerance analysis out into the future, right?

MR. STEVENS: Yeah, right. There would have to be justification that whatever you are inspecting occurs at the right frequency and you are adequately managing the degradation mechanism.

CHAIRMAN RICCARDELLA: Understood. Thank you.

MR. TREGONING: And thanks, Gary. Any other discussion on that point?

(No audible response.)

MR. TREGONING: Okay. The last topic -- I mentioned there were three comments that could not really group into any of the other comments, so I threw that in miscellaneous, and I took again probably the most interesting/controversial one that I want to highlight here in Slide 52.

And the first comment was, you know, introduction of Part C, it says Appendix A to that report includes detailed descriptions and additional guidance concerning the overall method and all the required calculations. And the comment was kind of wryly stated: look, Appendix A does not -- it is not

insufficient to develop practical engineering procedures, and it goes on to say this is especially true for analyses according to ASME sub-article NB-3600, and just the further point that look, insufficient guidance leads to the development of individual methods with a greater risk of higher operation and regulatory cost in the future.

So the gist of the comment was that we're not overly prescriptive, and we don't say do Step A then Step B then Step C following this rigorous set of procedures. We provide an approach and a method, but we recognize that there's a lot of different fatigue analyses and assumptions that go into these analyses, so this method is really designed to be general, and it is designed to be used by someone that's an expert in this area that understands the effect of other assumptions within the analysis.

And for us to develop something prescriptive that would try to account for all the variability that's out there in fatigue analyses would have just been an almost intractable problem. So again, we have tried to develop a general method. So we are not disagreeing with the comment. Yes, we agree, it is not fully prescriptive, and that there is

some degree of application and assumptions that need to still go into the application of -- of this method.

But again, the approach is tried -- we have tried to design it to give the analyst, the person that's using it, flexibility, right? And again, that is another reason that we added this example problem, was to try to at least show people the intent and the general approach for using this method.

But we did agree that the quote that we had that said that we have, you know, sufficiently detailed descriptions was probably misleading, and that we went and changed that and just said, look, we are providing a general method, right, for you to account for environmental effects.

So that was it as far as a snapshot of the comments, and let me talk about changes to the Reg Guide itself. And before I talk about changes, I at least wanted to -- since I didn't do it anywhere else, I wanted to at least cover what the Reg Guide looks at.

Part A is the introduction, and it covers the purpose, applicable rules and regulation, and related guidance. And again, I have sort of only brought out here sort of the unique sections of the Reg Guide and subsections that are unique to this

particular Reg Guide. There are other sections in here, but they are pretty much boilerplate, so I am not really covering those here.

And then there is a discussion part which includes the reason why we're making this revision as well as background. And then of course the true guts of the Reg Guide is the regulatory positions section, Section C, and there's three subsections, one on carbon and low alloy steels and welds, one on wrought and cast austenitic stainless steels and welds, and one on nickel-chrome-iron alloys and welds.

And each of those subsections have sub-subsections on each of the following areas: they talk about -- they provide guidance for CUF in air calculations, environmental factor or correction factor, FEN, calculations, and then ultimately the environmental CUF calculations. And then, as I mentioned, there is an implementation section, and followed by references, which is not a -- an alphabetical section.

So I have talked about -- I think I have covered most of these in general so far. There were only a few of what I consider major changes to the Reg Guide -- or, I am sorry, the -- yes, the Reg Guide, as

a result of public comment. One is that we -- everywhere it said "reactor coolant" or "coolant," we have just changed it to "water," including the title. And we actually did that -- as I mentioned earlier, we made companion changes to the NUREG itself, so even the NUREG title, we're, you know, planning to change the NUREG title to "water" in the revision instead of "reactor coolant."

We have tried to characterize the applicability of the Reg Guide, and again, that would be new applications, new licensing applications that require CUF calculation or existing calculations that are required by regulation as part of the current licensing basis that -- that they want to, again, extend -- extend in some way, so not -- the application itself for the period of its intended use, there's no changes that are required. It's only if they want to take that existing application and extend it to another period, like for subsequent license renewal.

MEMBER SKILLMAN: Rob, let me ask this --

MR. TREGONING: Yes.

MEMBER SKILLMAN: -- just to get me calibrated. You're on Slide 55 --

MR. TREGONING: Yes.

MEMBER SKILLMAN: -- and the title is "Summary of Revised NUREG: Summary of Major Changes." If you go back to 54, it is "Summary of Reg Guide 1.207." Are you on 1.207, or are you on the NUREG?

MR. TREGONING: I am on the Reg Guide. I am --

MEMBER SKILLMAN: You're on the Reg Guide?

MR. TREGONING: -- sorry, when -- if I said NUREG, I --

CHAIRMAN RICCARDELLA: No, the title, the title --

MR. TREGONING: The title is wrong. I apologize. I apologize.

MEMBER SKILLMAN: Good, okay --

MR. TREGONING: Yes.

MEMBER SKILLMAN: -- I was just trying to make sure I --

MR. TREGONING: You caught something that no one else caught, so I appreciate you -- even me, I have looked at these slides a lot, so yes, I apologize for that title.

MEMBER SKILLMAN: You're on the Reg Guide?

MR. TREGONING: I'm on the Reg Guide. I apologize for the incorrect title, so that should read

"Summary of Revised" --

MEMBER SKILLMAN: You passed the test.

MR. TREGONING: And I hope I didn't say it any -- anything else in this section is pertaining to the Reg Guide.

MEMBER SKILLMAN: All right.

MR. TREGONING: I just want to see if I --

MEMBER SKILLMAN: Thank you.

MR. TREGONING: So I butchered it on that slide. I probably butchered it the rest --

CHAIRMAN RICCARDELLA: The title --

MR. TREGONING: -- butchered it the rest of the way through here, so these next three slides --

CHAIRMAN RICCARDELLA: Should be Reg Guide.

MR. TREGONING: -- you know, should all be Reg Guide, so thank you for -- thank you for catching that.

Now the ACRS staff has found other -- other problems with this, so --

PARTICIPANT: No, I --

MR. TREGONING: I am going to say it's management's fault. They didn't review these things adequately enough before they --

(Laughter.)

MR. TREGONING: No, it is clearly my fault, so I apologize for that.

So we did try to be clear that at least as of now, that the guidance isn't applicable for 718, so we actually state that in the Reg Guide, again, due to lack of data; and that we clarified that at least that the nickel-chrome-iron alloys should use the stainless steel design curves, either in NUREG 6909 Rev 1 or ASME Code Section III. They are the same, so pick them from whatever source you want, just clarify that point.

And so then just like I did for the NUREG, for the Reg Guide, these are the changes by section. Again, the introduction, the only significant thing, we're changing "coolant" to "water." In the discussion, we actually define what we mean by an LWR water environment, so we add a sentence there. We clarified the use of the method for the nickel-chrome-iron alloys in the discussion section. We provided some rationale for that adjustment factor of 12 on life, and again applicability of 718.

Under the regulatory position section, again, changed "coolant" to "water." This is where we had the discussion on applicability of the Reg Guide

to either new or existing licensing applications, and -- and clarified also, because we called out specific curves in the NUREG reference, so we wanted to make sure that we were using exactly the same language that's in the NUREG. We didn't have exactly the same language before, so we make sure we have that language.

And implementation, again, we just said that with any regulatory guidance, you can either use it in whole or in part. You don't have to use an entire regulatory guide method. You can pick out parts of it as are applicable and as you are able to justify.

So that is it with respect to the Reg Guide, and then I've got a slide on at least the current status and next steps. So before I go to that, are there any other questions or comments? I know we went through the Reg Guide pretty quickly, but again, most of the meat was really on the NUREG, so there is not a lot really with respect to the Reg Guide. If you did a red line strike out of the Reg Guide, it's not that different, the version now between the version that went out as a draft for public comment.

(No audible response.)

MR. TREGONING: Okay. So no other questions. I will move on to current status and next

steps.

And as far as status, and I apologize for this, we are a little bit out of sync in that this document is undergoing inter-agency concurrence now, so I've had meetings with NRR and NRO and tried to at least within the version that we have now reflect the intent of the staff, but what --

MEMBER POWERS: Why do you call it inter-agency and not intra-agency?

MR. TREGONING: Okay. I think intra-agency would have been correct, so yes, I made a grammatical error. So duly noted by --

MEMBER POWERS: Unless you're sending it out to DOE --

MR. TREGONING: No --

MEMBER POWERS: -- or --

MR. TREGONING: -- I am not sending it out to DOE --

MEMBER POWERS: -- DOJ or DoD? You may be interested in DoD, or NRR, anyway.

MR. TREGONING: We at least have two errors in the slide. If those are the only two, I am happy, so --

(Laughter.)

MR. TREGONING: -- so yes, it's intra-agency concurrence, so sorry.

And I recognize we're a little bit out of process. Ideally, we would have gone through all the office concurrence before we came to you guys to present this. Now the reason that we did not is it is just really schedule-related.

Based on your schedule, it was now, or it was mid-2017. There really was not other opportunities. So if I had -- in a perfect world, I would have waited a month or two, gotten all my ducks in a row, and then come here and said yea, verily, here is the guidance, it has been concurred by staff, and we --

MEMBER POWERS: The only difficulty that arises from this, and the reason we usually don't review these things, if there is any major change as a result of the concurrence process.

MR. TREGONING: And I -- look, I do not want to -- I do not want to try to predict --

MEMBER POWERS: You can't.

MR. TREGONING: -- what the concurrence process --

MEMBER POWERS: You can't --

MR. TREGONING: -- is going to uncover --

MEMBER POWERS: -- but --

MR. TREGONING: -- I think -- in fact, I expect there will be some changes. I don't expect there will be significant technical changes. What I expect is there will be -- there could be changes related to these scope and applicability statements, right? I could clearly see that, because again, we are trying to make sure that -- we are trying to consider existing reactor applications as well as new reactor applications, and we just have to make sure that we sort of serve both of those constituencies within the agency because they both might have occasion to use this document.

Sometimes each party reads it with their own perspective in mind, so we just -- the final language needs to be consistent from that perspective.

MEMBER POWERS: And that is fine, but when you come to the Full Committee, that has to be resolved.

MR. TREGONING: So again, and why now versus waiting till mid-2017? Well, as I mentioned before, we -- this needs to get out in advance of the GALL guidance because the GALL guidance says now, hey, use this Reg Guide. So that was always the staff's

plan, to get this guidance issued first.

So again, I apologize. I think, you know, there will likely be -- because I have been through enough of these concurrence processes -- there will likely be some changes resulting from concurrence in the Reg Guide.

And again, as part of that concurrence package, the NUREG as well as the public comments and all the responses to comments are being concurred upon now. And like I said, I am sure we will -- the other thing that is going to be needed potentially is some of the responses to public comments, even as we have gone through technical editing and things like that, we have made some minor modifications that we'll need to go back through the public comments and make some tweaks. Just sometimes we have quoted changes in the NUREG, and we made actually changes, actual quotes, so we are going to have to make some minor conforming changes to those public comment responses, but again, nothing significant will be made -- there will not be anything significant in my opinion made to the responses to the public comments at this point.

With respect to NUREG/CR-6909, we have completed the technical editing review. We are still

incorporating some of the final changes from that, and again, as a result of that, we might need to make some conforming changes.

So ultimately, we are going to request ACRS recommendation to finalize Reg Guide 1.207, and we are hoping that we get this finalized before the issuance of the SLR guidance. I think right now, we are tentatively on the schedule to go in front of the main committee in February.

CHAIRMAN RICCARDELLA: Yes.

MR. TREGONING: Certainly by February, the expectation is everything -- we should have completed the concurrence process by that point, and we should have the final guidance as well as everything finalized by the time we need to go in front of the main committee. So there will be some changes, and I am -- I am -- I apologize for that, but I am hopeful that there will not be anything that will be significant. And I don't expect there will be anything significant from a technical nature. And so that was all I've got.

CHAIRMAN RICCARDELLA: So I think, you know, we're intending -- or my recommendation is going to be for the main committee to write a letter on this in February. I think that that letter won't just be

one on the Reg Guide, but it will have to refer to the NUREG as well --

MR. TREGONING: Sure.

CHAIRMAN RICCARDELLA: -- since all the technical need is in the NUREG.

MR. TREGONING: Yes, yes, I think that is reasonable.

CHAIRMAN RICCARDELLA: Okay. Okay. So if you are done, Theron, if we could open the -- the outside line for comments? We have had comments from Gary. Is there anybody else on the outside line? If so, would you please speak up?

(Pause.)

CHAIRMAN RICCARDELLA: Okay. I --

MS. GRAHAM: Hello, this -- hello, can you hear me?

CHAIRMAN RICCARDELLA: Yes we can.

MS. GRAHAM: Hi, this is Erica Graham calling from Richmond, Virginia.

Well, I first want to mention that I -- I did ask Christopher Brown for the slides, and he said he would send them to me, but of course I did not receive them. He mentioned that there were some virus issues and whatnot. They were having problems I guess at the

NRC, so of course I am kind of disappointed that I could not follow along the slides because I was never given the presentation.

So that's the first thing. I guess the second thing would be I heard -- and excuse me for not being able to kind of follow on, take notes so well on such a long meeting -- but it was mentioned that the NRC has never granted an extension for I guess it was a greater than a 1, I guess when we are talking about cracking, and then it was kind of I guess not -- I am not totally sure exactly what exactly you were saying because I know with the -- I live in Virginia, Dominion is one of the licensees that is applying for an extended license to take the plant to 80 years, the Surry plant.

And so if no extension has ever been given for a size 1, how do we -- how do we know -- how do we know if they have a size 1 or not at Surry?

PARTICIPANT: So I think I --

MS. GRAHAM: What tests are they doing to be able to -- to qualify for that license extension?

MEMBER BLEY: This is Dennis Bley on the committee. As a FACA committee, we only speak through our letters so that we don't engage with comments at this time. We'll receive your comments and consider

them, and our full transcript and all the slides will be published on the website within about a week or two, probably two weeks until we get the transcript back, so you can see all the details at that time.

MS. GRAHAM: Okay. Well, I guess it will be interesting to see how that plays out because if no license has ever been granted for more than a 1, surely by this point we probably got cracks and whatnot in some of the facilities. So I guess you can't really answer that.

And then also, I am not really sure about when you all say that if it's greater than a 1 on the crack analysis, then I guess the licensee can't negotiate with the NRC about inspecting every 10 years or so. This doesn't sound like that is much of a true kind of formal way of knowing what you will do, if you have more than a grade of 1, so I am a little concerned about that.

CHAIRMAN RICCARDELLA: The word "negotiate" wasn't used. It was do additional analysis in accordance with the ASME codes.

MS. GRAHAM: Well actually, someone did use the word negotiate. That's why I wrote down the note, so hopefully there will be some real meaningful

ways to know about that inspecting every ten years or so, because I was on a call at one point where they were telling Dominion that they could be able to write it up so that somehow, that they could go beyond that ten years, so I am not really sure how you all will write that up.

But needless to say -- and I am not sure about when you were talking about what's required now, it said no guidance or requirements at all for operating reactors. I am hoping that we are being very careful as these aging plants -- as these facilities are aging and we can probably expect more problems to occur, so I am hoping the NRC really addresses those issues.

And I guess finally, you know, I am not really sure how -- how this committee, the subcommittee is addressing the issue, but I did see that the Wall Street Journal the other day on December 13th came up with a story about the cover-up of French nuclear supplier sparks global review. Inspector says AREVA unit files suggest manufacturing flaws in critical parts were covered up for decades.

Dominion is mentioned for their millstone plant having one of those components, and I am assuming -- it seems like this industry relies heavily on AREVA,

in particular on guidance, and obviously because of their parts and manufacturing. I think we need to be extremely careful in going over the data and whatnot from AREVA because there seems to be an issue, and I am not sure what components are -- because it mentions nine other U.S. facilities were mentioned, but it's only Dominion's name was put out for millstone, so I don't know if some of those components are also in the -- evidently the two -- I know Dominion is one -- for their subsequent license renewal for Surry. I am not sure what components might be also from that same manufacturer, so I have concerns there.

But like usual, for most of the guidance and regulations and whatnot I have noticed over the years for the NRC, it is always typically these generic guidances. I am sure hoping that safeguards are put in and making them more conservative because I am very disturbed to hear any time it is mentioned that things, especially from NEI or whoever, that they are too conservative. Well I think the issues at Fukushima and the ongoing huge disaster there, I don't believe there is a tie-in to the words of "too conservative" when it comes to nuclear energy, so I would hope that we go way beyond conservative when it comes to nuclear energy and

how we are using it.

And I guess that is all I have. Thank you.

CHAIRMAN RICCARDELLA: Okay. Thank you for your comments. I don't see anybody else in the room, members of the public in the room, so at this point we will go around the room for member comments. Charlie, do you have any comments?

MEMBER BROWN: No additional comments.

CHAIRMAN RICCARDELLA: Walt?

MEMBER KIRCHNER: No additional, thank you.

CHAIRMAN RICCARDELLA: Dennis?

MEMBER BLEY: Yes, a few. I am thinking forward to our Full Committee meeting, and I know you will have to negotiate with staff some. My own thoughts are, you know, you will get an hour-and-a-half to two hours. I would do most of the tech, but maybe simplify it a little bit, and really summarize your responses to the comments, pretty short, and especially for us highlight any changes that occur between now and then with the technical side or the applicability.

I don't know if we will cover it in our letter, but this idea that conservatism elsewhere, like in the ASME Code, is a reason not to consider the

environmental effects when we know there are environmental effects just doesn't work. One can consider those other conservatisms and deal with them, but we don't have any way to know the true extent of the conservatisms over there under all situations, so that does not work.

I would like to compliment the staff. I think you guys did the most thorough job of responding to comments that I have seen and incorporating them in a way everybody can see how it was dealt with. Thanks a lot.

CHAIRMAN RICCARDELLA: Matt?

MEMBER SUNSERI: I appreciate the review. It was a very thorough review of the changes to the Reg Guide, and being a new member, it really helped me come up to speed, so thank you very much.

CHAIRMAN RICCARDELLA: And Dick, do you?

MEMBER SKILLMAN: I agree with Matt and Dennis. Thank you. Very thorough job, very comprehensive presentation. Thank you.

CHAIRMAN RICCARDELLA: And finally, our consultant, Bill Shack?

MR. SHACK: No, I -- you know, I think the staff has done an excellent -- has done an excellent

job in responding to the public comments. I mean, this is the sort of topic that is never finished. You know, it is a very complex thing.

And I would echo Dennis's thing. It is very difficult to deal with conservatisms. You know, when you don't really understand the uncertainties, removing one piece of conservatism sort of leaves you with an unanswered question, and it's, I mean, you're either going to do a full-blown uncertainty analysis or you're going to do conservative analyses, and it is very difficult to get something in between. And I think the staff has tried to eliminate conservatisms to I think the sort of feasible or technical extent, and -- and you're really going to have to take a much more unified approach to go much further.

CHAIRMAN RICCARDELLA: Okay. Thank you. I too agree that it was an excellent presentation, and the staff has done a meticulous job of organizing and addressing the comments received, and I look forward to an abbreviated presentation in February, Full Committee, and as I said, we will plan to make our recommendations in a letter at that time.

If there is nothing else --

MR. THOMAS: Just again, thank you for the

opportunity. Yes, thank you for the opportunity again for the staff to come before you and make this presentation. I too want to compliment Rob and the rest of the staff. I thought it was a pretty comprehensive job, a job well done.

Thanks for the comments, the concerns. I am -- one takeaway for me is your comment, Dr. Bley, that has to do with the -- the quality of the report, the way we approached the integration of the resolution of the comments into the report. I will take that back. We have a group that focuses on quality reviews of our products, so I will take that back to them to see. Well, we will have to talk more about that and your appreciation of that and how we can continue that sort of method, but thank you very much.

CHAIRMAN RICCARDELLA: Okay. So with that, the meeting is adjourned.

(Whereupon, the above-entitled matter went off the record at 11:33 a.m.)

Regulatory Guidance for Evaluating the Effects of Light Water Reactor Water Environments in Fatigue Analyses of Metal Components

(Proposed Revision 1 to Regulatory Guide 1.207)

Rob Tregoning
Nuclear Regulatory Commission

Gary Stevens
Structural Integrity Associates

Omesh Chopra
Argonne National Laboratory (retired)

Meeting of Advisory Committee on Reactor Safeguards
Metallurgy and Reactor Fuels Subcommittee
Thursday, December 15, 2016
NRC Headquarters
Rockville, MD

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Issue Summary

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- Revising guidance for environmentally assisted fatigue (EAF)
  - Regulatory Guide (RG)
    - Draft Regulatory Guide DG-1309, "Guidelines for Evaluating the Effects of Light Water Reactor Coolant Environments in Fatigue Analyses of Metal Components"
  - Supporting technical basis
    - Draft NUREG/CR-6909, Revision 1, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials"
- Briefed ACRS - Metallurgy and Reactor Fuels (December 2014)
- Released both draft documents for public comment (2014 – 2015)
- Received public comments on both documents (2014 – 2015).
- Developed responses to comments (2015 – 2016)
- Modified documents as a result of public comments (2015 – 2016)
- Soliciting ACRS support for final regulatory guidance (2017)
- Planning to finalize regulatory guidance for EAF in support of subsequent license renewal (2017)

Meeting Agenda

U.S.NRC
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- Background
  - Environmentally Assisted Fatigue (EAF)
  - Related regulations and NRC guidance on EAF
  - Proposed revision of NRC guidance
- NUREG/CR-6909, Revision 1
  - Overview of public comments
  - Sample public comments and responses
  - Changes to document
- Revision 1 of Reg. Guide 1.207
  - Overview of public comments
  - Sample public comments and responses
  - Changes to document
- Current status and next steps

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Background:
Environmentally Assisted Fatigue (EAF)

Cumulative Usage Factor (CUF)

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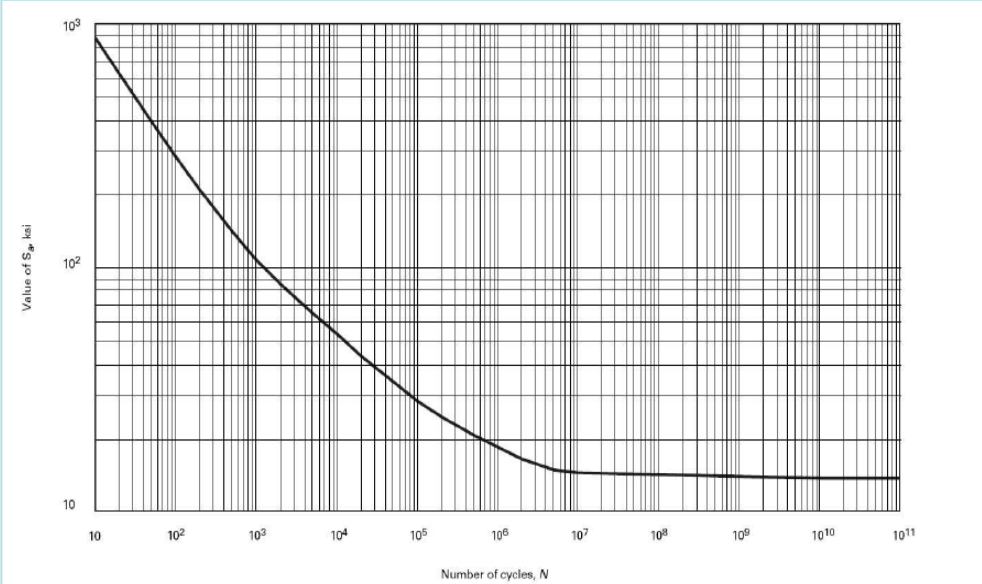
- For nuclear plant design, cumulative fatigue damage due to applied cyclic loading is estimated using cumulative usage factor (CUF)

$$\mathbf{CUF} = \sum_{i}^{Z} \frac{n}{N} = U_1 + U_2 + U_3 + \ldots + U_Z < 1.0$$

where: n *is the applied number of cycles for load* i
N *is the allowable number of cycles for the stress associated with load* i
Z *is the number of applied loads*

- N is a function of the alternating stress, S_a, applied to a component, and is material dependent
- S-N design curves ("fatigue curves") are provided in ASME Code, Section III, Mandatory Appendix I for different materials
- ASME fatigue curves are based on best fits of air test data with design factors applied to account for aspects such as data scatter, size effect, surface finish, atmosphere



Example Fatigue Curve

Environmentally Assisted Fatigue

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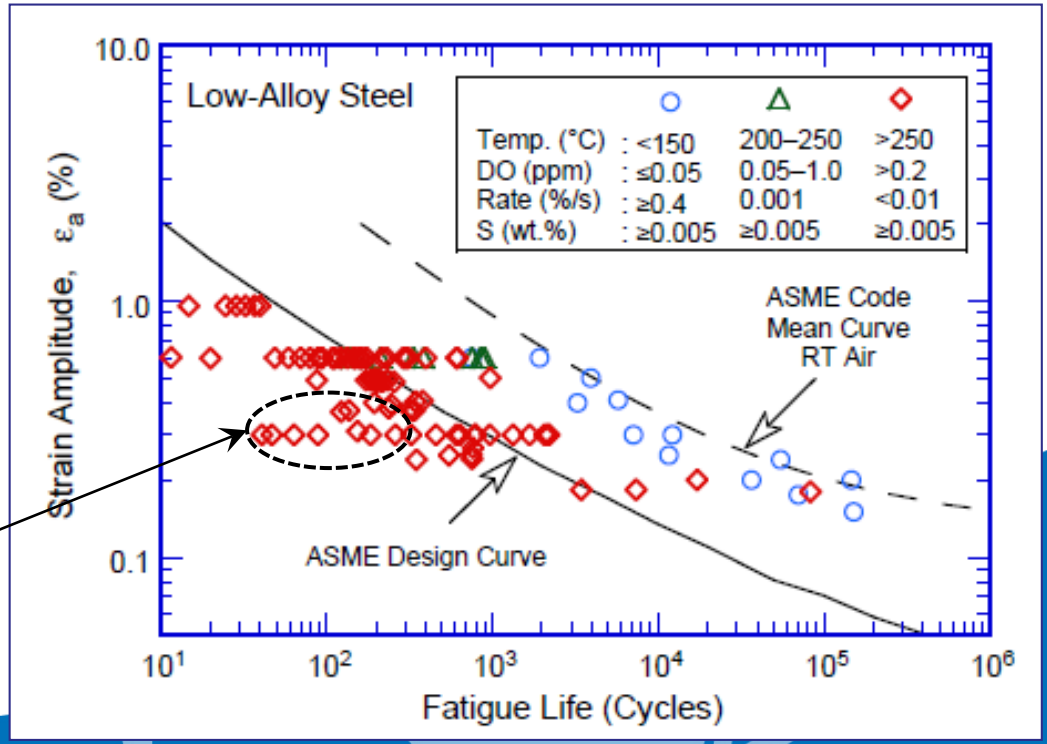
- ASME Code Section III fatigue curves developed from small-scale, polished specimens tested in **air**
  - Develop best-fit log-log curves for each material type
  - Adjust best-fit curves for worst-case mean-stress effects using modified Goodman relationship
  - Apply factors* of 2 on strain amplitude (e_a) or 20 on cycles (N), whichever is more conservative, to develop **air** design curves for each material

- Laboratory testing of specimens tested in water show that the air design curves may not adequately define fatigue life for materials exposed to water



*Some of the tests in **water** fall below the **air** design curve.*

Environmental Fatigue Correction Factor

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- Environmental fatigue correction factor ($\mathbf{F_{en}}$) is defined as the ratio of fatigue life in air at room temperature to the fatigue life in water:

$$F_{en} = N_{air}/N_{water}$$

- F_{en} is multiplicative to the calculated CUF in air:

$$CUF_{en} = U_1 F_{en,1} + U_2 F_{en,2} ..... U_Z F_{en,Z}$$

- From Revision 0 of NUREG/CR-6909 for stainless steel materials

$$F_{en} = \exp [0.734 – T' O' R']$$

where:

T' = transformed temperature:
T' = 0 for temperature, T ≤ 150°C
T' = (T – 150)/175 for 150 < T < 325°C
T' = 1 for T ≥ 325°C

O' = transformed oxygen:
O' = 0.281 for all fluid dissolved oxygen levels

R' = transformed strain rate:
R' = 0 for strain rate, R ≥ 0.4%/s
R' = ln(R/0.4) for 0.001 ≤ R < 0.4%/s
R' = ln(0.001) for R < 0.001%/s

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Background:
Related Regulations and NRC Guidance on EAF

Related Regulatory Requirements

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Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities, Appendix A, "General Design Criteria for Nuclear Power Plants"

- General Design Criterion 1

  Safety related SSCs must be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function performed
- General Design Criterion 30

  Components included in the reactor pressure boundary must be designed, fabricated, erected, and tested to the highest practical quality standards
- 10 CFR 50.55a (c), endorses ASME Code for design of safety-related systems and components (Class 1)
  - ASME Code, Section III fatigue design curves
  - Fatigue design curves do not address the impact of the water environment
- **Regulatory Guidance on EAF exists to provide an acceptable method for addressing the impact of water environment on fatigue calculations**

Regulatory Guidance on EAF

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- Initial NRC research efforts related to EAF
  - Chopra, O. K., and W. J. Shack, "Effects of LWR Coolant Environments on Fatigue Design Curves of Carbon and Low–Alloy Steels," NUREG/CR–6583, 1998.
  - Chopra, O. K., "Effects of LWR Coolant Environments on Fatigue Design Curves of Austenitic Stainless Steels," NUREG/CR–5704, 1999.
- These NUREGs provided basis for guidance for license renewal applicants in the initial release of NUREG-1801, "Generic Aging Lessons Learned (GALL) Report" (2001)
  - Chapter X.M1, "Metal Fatigue of Reactor Coolant Pressure Boundary"
- Updated and consolidated EAF technical basis
  - Chopra, O. K., and W. J. Shack, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials – Final Report," NUREG/CR–6909, Feb. 2007.

Regulatory Guidance on EAF, cont.

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- Operating reactors
  - Original licensing period: No guidance or requirements for considering EAF
  - License renewal period: Recent applicants use NUREG-1801, Rev. 2
    - Carbon steel: May use either NUREG/CR-6583, NUREG/CR-6909, or NRC-approved alternative
    - Stainless steel: May use either NUREG/CR-5704, NUREG/CR-6909, or NRC-approved alternative
    - Ni-Cr-Fe alloys: May use NUREG/CR-6909 or NRC-approved alternative
  - **Subsequent license renewal period: Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report (NUREG-2191) – draft for comment**
    - **All materials: May use NUREG/CR-6909, Revision1 or NRC-approved alternative**
- New reactors
  - RG 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light Water Reactor Environment for New Reactors" March 2007.
  - Technical basis for RG 1.207 is NUREG/CR-6909
  - Both RG 1.207 and proposed Revision 1 of RG 1.207 use the F_{en} method summarized in Appendix A of the NUREG.

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Background:
Proposed Revision of NRC Guidance

Revision of Reg. Guide 1.207:
Draft for Public Comment

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- Rationale for revision
  1. Consolidate all EAF guidance
  2. Update the guidance based on stakeholder feedback
  3. Update the guidance based on all available research data
- RG 1.207 significant revisions
  1. The RG was made applicable to all LWRs
  2. The guidance was clarified to apply to all metal components exposed to LWR environments that have a CUF calculation required by a plant's current licensing basis (CLB)
  3. The background section was revised to incorporate the relevant content for operating reactors, license renewal, etc.
  4. The F_{en} equations were revised based on stakeholder feedback and the updated research as documented in NUREG/CR-6909, Rev. 1

Updated Air Fatigue Data

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Material	Data in NUREG/CR-6909, Rev. 0	Data in NUREG/CR-6909, Rev. 1	Increase*
Carbon Steels	153 points (8 heats) [Figure 7(a) of Rev. 0]	254 points (19 heats) [Figure 32(b) of Rev. 1]	66 %
Low-Alloy Steels	358 points (19 heats) [Figure 7(b) of Rev. 0]	430 points (22 heats) [Figure 32(d) of Rev. 1]	20 %
Austenitic Stainless Steels	357 points (38 heats) [Figure 35 of Rev. 0]	622 points (40 heats) [Figure 45(b) of Rev. 1]	74 %
Ni-Cr-Fe Alloys	Not quantified [Figures 56 & 57 of Rev. 0]	559 points (45 heats) [Figures 50 – 52 of Rev. 1]	N/A

* The majority of additional data from Report No. JNES-SS-1005.
* NRC gratefully acknowledges the release of the Japanese EAF research data. The NUREG revisions would not have been as comprehensive without this information.

Updated Water Fatigue Data

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Material	Data in NUREG/CR-6909, Rev. 0	Data in NUREG/CR-6909, Rev. 1	Increase*
Carbon Steels	318 points (12 heats) [Figure 27 of Rev. 0]	638 points (21 heats) [Figure 79 of Rev. 1]	100 %
Low-Alloy Steels	327 points (13 heats) [Figure 27 of Rev. 0]	536 points (20 heats) [Figure 79 of Rev. 1]	64 %
Austenitic Stainless Steels	276 points (14 heats) [Figure 52 of Rev. 0]	683 points (32 heats) [Figure 108 of Rev. 1]	147 %
Ni-Cr-Fe Alloys	Not quantified [Figures 58 & 59 of Rev. 0]	162 points (13 heats) [Figures 109 – 110 of Rev. 1]	N/A

* The majority of additional data from Report No. JNES-SS-1005.
* NRC gratefully acknowledges the release of the Japanese EAF research data. The NUREG revisions would not have been as comprehensive without this information.

Changes to Air Fatigue Curves

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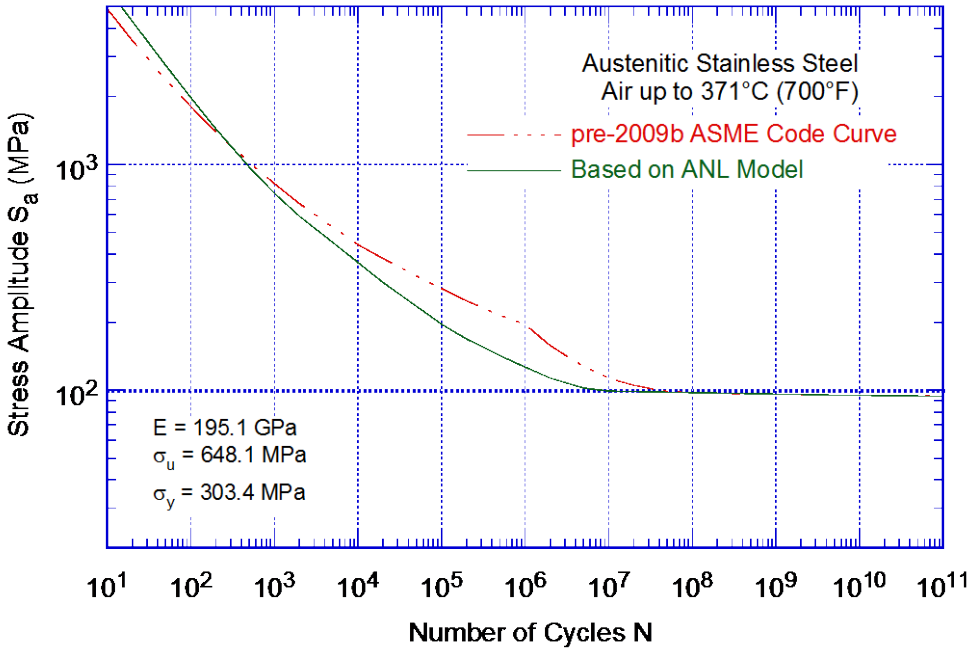
- Best-fit mean-data air curves are the same between NUREG/CR-6909, Rev. 0 and Rev. 1 for all materials
- Adjustment factors developed using Monte-Carlo analysis
  - Account for surface finish, material variability, size effects, and loading history
  - Chosen as the 95th percentile of the MC results
  - Carbon steel – 10; low-alloy steel – 9; stainless steel – 9.6
  - **Requested public feedback on adjustment factors in FRN**
- Adjustment factors of 12 on cycles retained for consistency with Rev. 0 and ASME
- Design curves are same in Rev. 0 and Rev. 1 for carbon, low-alloy, and stainless steels
- Recommend use of stainless steel design curve for Ni-Cr-Fe alloys (conservative)



Significant Changes to F_{en}

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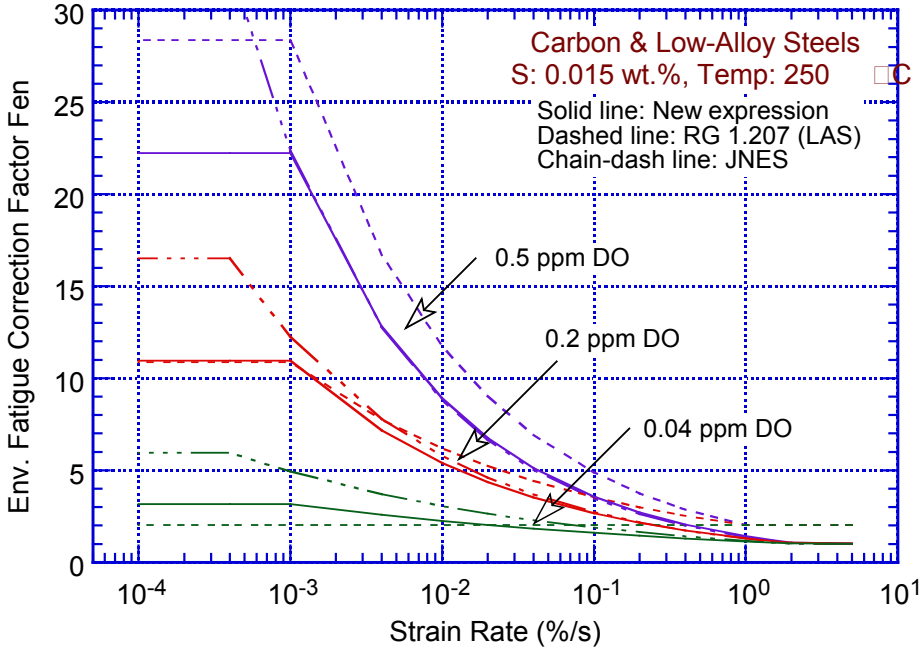
NUREG/CR-6909, Rev 0

- Different expressions for carbon and low-alloy steels
- $F_{en} > 1.0$ with no environmental effects
- Different constants in expressions for stainless steels and Ni-Cr-Fe alloys

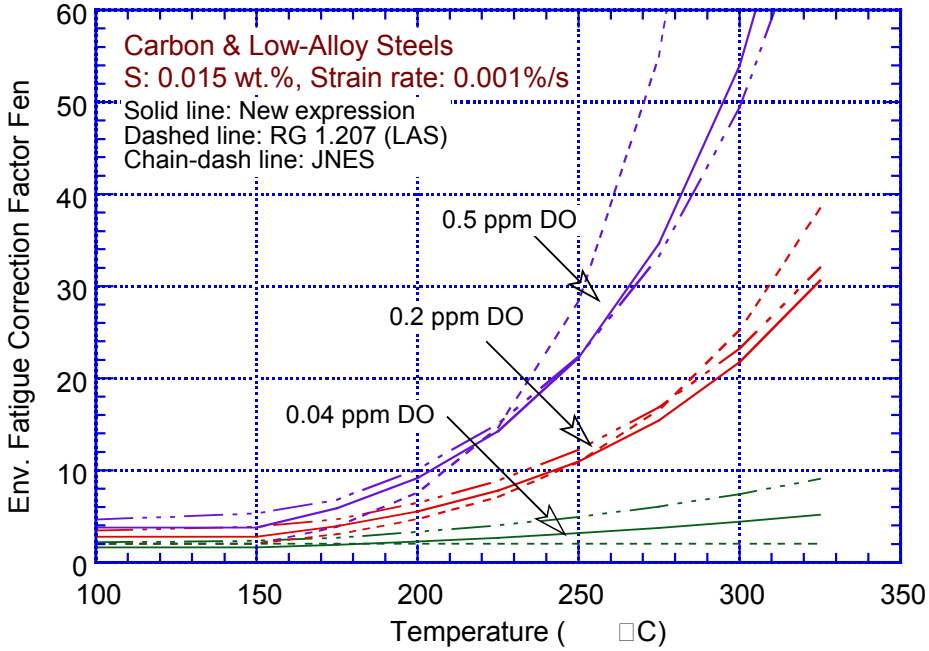
NUREG/CR-6909, Rev 1

- Same expression for carbon and low-alloy steels
- $F_{en} = 1.0$ with no environmental effects
- Same functional form for stainless steels and Ni-Cr-Fe alloys
- Expressions generally less conservative for all materials

F_{en} vs. Strain Rate, R



F_{en} vs. T



Other Significant Additions to NUREG/CR-6909, Rev. 1

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- Validation calculations
  - Performed on both specimen and component tests (6 total test series)
  - Estimated life using ASME Code methods with F_{en} and compared prediction to experimental fatigue life
  - The predicted and measured lives for specimen tests agreed within the data scatter (i.e., factor of 2)
  - The predicted lives for component tests either agreed with or conservatively predicted the experimental results
- Sample problem (Appendix C)
  - Demonstrate one example application of the F_{en} methodology
  - Promote consistency in the application of EAF methods
  - Received positive feedback from stakeholders

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NUREG/CR-6909, Revision 1:
Overview of Public Comments

Section Objectives

U.S.NRC
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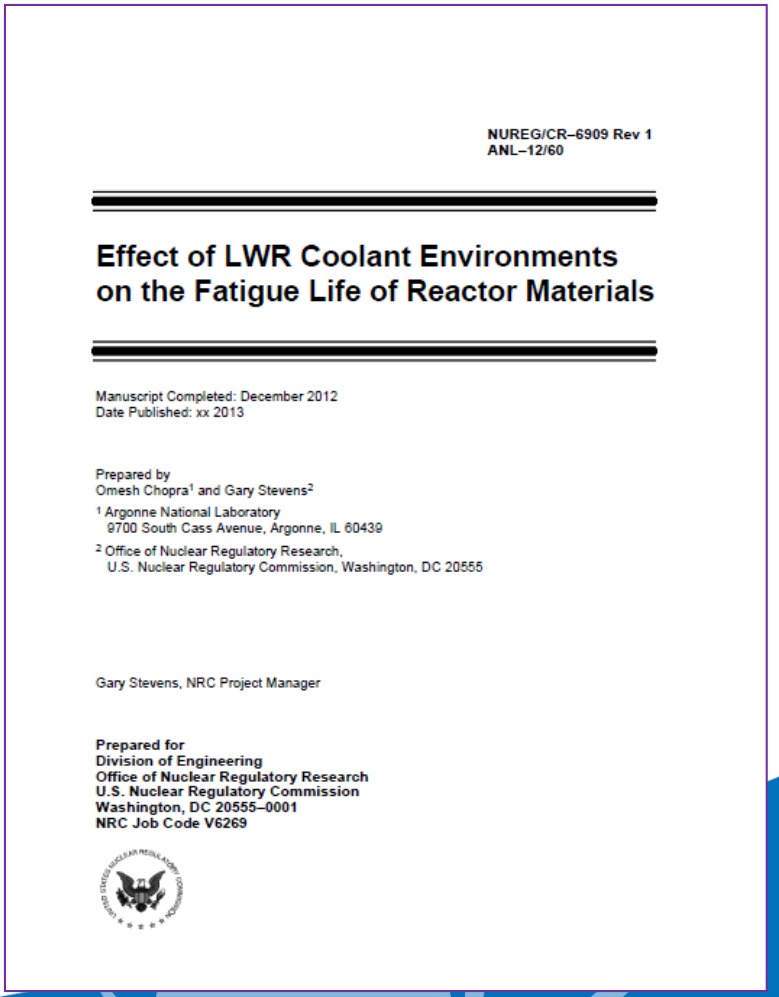
- Provide an overview of public comments on draft NUREG/CR-6909, Revision 1
- Provide a sampling of public comments and responses
- Summarize changes to NUREG/CR-6909, Revision 1 resulting from both public comments and further review by the staff and report authors



NUREG/CR–6909 Rev 1
ANL–12/60

Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials

Manuscript Completed: December 2012
Date Published: xx 2013

Prepared by
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Gary Stevens, NRC Project Manager

Prepared for
Division of Engineering
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555–0001
NRC Job Code V6269

Overview of Public Comments

U.S.NRC
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- Draft NUREG/CR-6909, Rev. 1 sent for comment under Federal Register Notice for docket ID NRC-2014-0023 dated April 17, 2014 (Vol. 79, No. 74) (FR Doc # 2014-08792)
  - Specifically asked for feedback on the following three areas:
    I. The extension of the best-fit mean air curve for ferritic steels discussed in Section 3.1.10.
    II. The air fatigue design curve adjustment factors summarized in Section 5.5.
    III. Accuracy check of the technical content of the NUREG, particularly with respect to all of the numerical content of the report.
  - Public comment period ended on 6/2/2014.

Overview of Public Comments

U.S.NRC
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- Formal public comments were received from 10 commenters.

Letter No.	ADAMS Accession No.	Commenter Affiliation	Commenter Name	Abbreviation
1	ML14157A322	Consultant, Japan	Makoto Higuchi	HIGUCHI
2	ML14157A323	Consultant – CF Int. Engineering, France	Claude Faidy	FAIDY
3	ML14157A324	AMEC, United Kingdom	David Tice	AMEC
4	ML14157A325	Westinghouse Electric Company, USA	James Gresham	WEST
5	ML14157A326	Mitsubishi Heavy Industries, Japan	Seiji Asada	MHI
6	ML14157A327	Rolls Royce PLC, United Kingdom	Keith Wright	RR
7	ML14157A328	Electricite de France, France	Thomas Metais	EDF
8	ML14157A330	Hitachi, Japan	Akihiko Hirano	HITACHI
9	ML14157A331	AREVA, Inc., USA	Devin Kelley	AREVA
10	ML14157A332	Kansai Electric Power Company, Republic of Korea	June-soo Park	KEPCO

- Three additional commenters provided feedback after the public comment period officially ended.

Overview of Public Comments

U.S.NRC
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- Comments enumerated (if they weren't already) and then partitioned into single issues (sub-comments) wherever possible
- Each issue was uniquely identified and tracked as [XXX]-[YYY]-[ZZZ][a]
  - [XXX] = Abbreviation from table
  - [YYY] = Letter No. from table
  - [ZZZ] = Sequential comment number
  - [a] = sub-comment
- Total sub-comments/Issues: 254
  - Formal commenters 235
  - Additional commenters 5
  - Authors and staff comments 14

Overview of Public Comments

U.S.NRC
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- Comments were generally technical in nature, thoughtful, and often expansive
- Most technical comments associated with the following areas
  - Scope of the F_{en} method
  - Adjustment factor analysis and application
  - Clarification of statements
  - Relevance to nuclear plant applications
  - Overall conservatism of ASME requirements in conjunction with F_{en}
- Staff and authors agree with over 95% (approximately 8) of the individual sub-comments
- Areas of disagreement are generally not significant with respect to F_{en} method.
  - Interpretations of ASME Code requirements
  - Application of load sequence effects
  - Basis for and application of strain threshold
  - Interpretation of AREVA test results
  - High-cycle cut-off of design curve

Overview of Public Comments

United States Nuclear Regulatory Commission
Protecting People and the Environment

- Technical comments can be broadly categorized
  - **Adjustment factors** **36**
  - Applicability of F_{en} method 16
  - ASME method and requirements 14
  - Best-fit of mean curves in air 13
  - Data base and material properties 22
  - Definition of fatigue life/crack initiation 5
  - Effects not considered in F_{en} method 12
  - Example problem 26
  - Fatigue crack growth/damage tolerant approach 6
  - **High cycle fatigue** **9**
  - **Miscellaneous** **7**
  - Modified rate approach 12
  - Relevance to components 27
  - Thresholds and limits of applicability 11
- All other comments (38) were editorial

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NUREG/CR-6909, Revision 1:
Sample Public Comments and Responses

Sample Comments and Responses:
Adjustment Factors

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- Comment
  - *All the reduction factors are considered independent, it's not accepted in all international approaches in particular a constant F_{en} independently of number of cycles is not justified [stet] clearly* (FAIDY-2-3a)
- Summary of response
  - The report does consider the adjustment factors to be independent
    - There is insufficient data to develop correlation factors for a more rigorous analysis.
    - This point has been clarified in the NUREG..
  - The method presented does assume that F_{en} is not a function of applied strain.
    - The point has been clarified several places within the NUREG.

Sample Comments and Responses:
Adjustment Factors

U.S.NRC
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- Comment
  - *"…discussion about fatigue adjustment factors refers to a factor of 10 on life being supported… but a factor of 12 is recommended for use pending further validation…. It is unclear what validation data are required because the existing database is already large.*
  - *No clear justification of the factor of 2 on stress is provided.* (AMEC-3-12)
- Summary of response
  - Current analysis supports a factor of 10 without the need for additional data,
  - Report has maintained a factor of 12 on life to remain consistent with the factor used in the ASME design curve.
  - The factor of 2 on strain was similarly chosen simply for consistency with the factor in the ASME Code.
  - These points have been clarified in several places within the NUREG.

Sample Comments and Responses:
ASME Method and Requirements

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- Comment
  - *Hasn't been a "…reconciliation between the specimen fatigue test data… and the complete ASME-Code Fatigue Methodology ….."*
  - *"…ASME-Code Fatigue Methodology already contains a lot of multiplication of effects that have not been considered by the developers of both the in-air design fatigue curves and the F_{en} factors."* (AREVA-9-17f)
- Summary of response
  - New Section 1.5 identifies and discusses some ASME Code conservatisms.
  - The F_{en} approach, in concert with ASME design curve, will lead to either accurate or conservative predictions of environmental effects.
  - Eliminating conservatism in the ASME Code is outside the report scope.
  - A technical basis for revising ASME Code procedures could be developed by working through the appropriate Code committees

Sample Comments and Responses:
High Cycle Fatigue

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- Comment
  - *"…Extension of the Best-Fit Mean Curve from 10^6 to 10^{11} cycles …is too conservative."* (MHI-5-1a)
- Summary of response
  - Extension of the fatigue curve is conservative.
  - NUREG/CR-6909 Rev. 1, extension is identical to that proposed by the ASME Code committees.
  - Extension is based on data that has a prominent mean stress component.
  - Basing the curve on such data is meant to be both conservative and also allow application to engineering components, which often have high mean stress loading.
  - NUREG states that, for data without a significant mean stress effect, this proposed curve could be significantly conservative.

Sample Comments and Responses:
Miscellaneous

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- Comment
  - *"…the only concerns we should have are for those transients with low strain rates (slow transients)."*
  - *The other transients (for example, in-surges and out-surges) need to be evaluated for fatigue, but the current ASME-Code Class 1 Component classic Fatigue Methodology (without any F_{en} penalty factors) is very appropriate for those transients…"* (AREVA-9-17k)
- Summary of response
  - Comment postulates that environmental effects should only be considered for slow transients.
  - Most transients have a wide range of strain rates and importance of environmental effects is not always obvious without evaluating their effects in totality.
  - Entire transient has to be evaluated to determine both the F_{en} and the accumulated strain associated with each strain rate range.
  - The average F_{en} for the transient can then be determined.

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NUREG/CR-6909, Revision 1:
Changes to Document

NUREG/CR-6909, Revision 1:
Modifications After Public Comment

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- Authors and staff made significant modifications to the NUREG in an attempt to address virtually all of the public comments
  - Explain more clearly and completely all the technical bases and assumptions supporting the work.
  - Summarize the current state of knowledge
  - Provide a foundation for continued research
- NUREG has expanded significantly over time
  - Rev 0: 120 pages
  - Rev 1, draft: 320 pages
  - Rev 1, final: almost 500 pages
    - Revised Main Body – +10 pages
    - New Appendix D – 135 pages
    - New Appendix E – 12 pages

NUREG/CR-6909, Revision 1:
Major Sections - After Public Comments

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NUREG/CR-6909, Revision 1:
Major Changes due to Comments

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- Added new Section 1.5 on bases and assumptions of F_{en} method
- Moved original Section 4.1.14 (Modified Rate Approach) to new Section 4.4 and clarified write-up.
- Reworked and revised example problem (Appendix C)
- Eliminated all Revision 0 equations from main body
- Added App. E: "Equations in NUREG/CR-6909 Rev. 0 and Rev. 1"
  - Equations and Equation Numbers from NUREG/CR-6909 Rev. 0.
  - Equations and Equation Numbers in NUREG/CR-6909 Rev. 1
  - Changes in the Equations or their Number in NUREG/CR-6909 Rev. 0 and Rev. 1
- Replaced all figures in main body with higher resolution images
- Added App. D: "Compendium of Figures"
  - Enlarged and high resolution images of all figures in main body
- Defined LWR water environment and changed "reactor coolant" to "water" throughout report, as appropriate
- Subjected NUREG to technical editing

NUREG/CR-6909, Revision 1:
Summary of Changes by Section

U.S.NRC
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- Executive Summary
  - No significant changes
  - Added new statements and clarified existing statements related to applicability of method, margins, and adjustment factors
- Section 1 - Introduction
  - **Added Section 1.5 – Bases and Assumptions**
    - Address the nature of many public comments.
    - 26 topics addressed
    - Generally, a paragraph discussion on each topic
  - No other significant changes
- Section 2 – Mechanism of Fatigue
  - No significant changes
  - Clarified discussion on effects of environment on microstructurally small cracks (< 200 μm) and mechanically small cracks (> 200 μm)

NUREG/CR-6909, Revision 1:
Summary of Changes by Section

U.S.NRC
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- Section 3 - Fatigue Strain vs. Life (ε–N) Behavior in Air
  - No significant changes
  - Clarified applicability of stainless steel grades
- Section 4 - Fatigue ε–N Behavior in LWR Environments
  - **Moved modified rate approach and clarified aspects of method**
  - **Eliminated Rev. 0 equations**
  - Clarified that In 718 cannot be used with method (insufficient data)
  - Unified the nomenclature for transformed variables
  - Decreased stainless steel temperature threshold from 150°C to 100°C
  - Decreased stainless steel strain rate threshold from 10%/s to 7%/s
- Section 5 – Adjustment Factors in ASME Fatigue Design Curves
  - No significant changes
  - Clarified that use of 12 for life factor is for consistency with ASME Code although 10 is justified by analysis
  - Clarified basis of the factor of 2 on stress/strain

Summary of Revised NUREG:
Summary of Changes by Section

U.S.NRC
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- Section 6 - Validation of F_{en} Expressions
  - Reanalyzed the tests in Sections 6.2 and 6.3 and made some relatively minor changes to associated text.
  - Indicated that F_{en} tends to be conservative, in part, due to gradient effects in these tests.
  - No other significant changes
- Section 7 – Summary
  - Made changes consistent with Executive Summary
  - Added a paragraph on the evaluation procedure
  - Added a paragraph on the applicability of the F_{en} method and future work
  - No other significant changes

Summary of Revised NUREG:
Summary of Changes by Section

U.S.NRC
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- Appendix A - Incorporating Environmental Effects into Fatigue Evaluations
  - Made changes consistent with those in main body for equations
  - Clarified the temperature to use for selecting Young's modulus, E
  - Clarified the use of the maximum temperature limit of 325°C
  - No other significant changes
- Appendix B – Material Information
  - No significant changes
- **Appendix C – Sample Problem**
  - Modified Problem Description (C2), Evaluation (C3), and Results (C4)
  - Added new Table C1 with material properties for use in sample problem
- **Appendix D – Compendium of Figures**
- **Appendix E – Equations in NUREG/CR-6909 Rev 0 and Rev 1**

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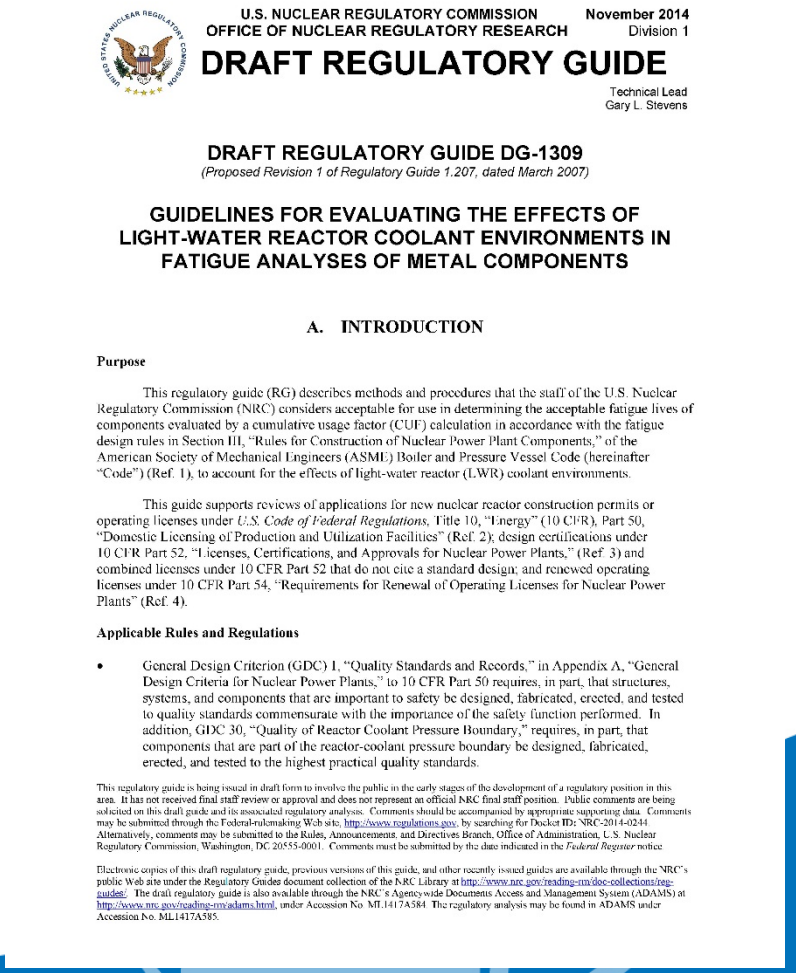
Revision 1 of Reg. Guide 1.207:
Overview of Public Comments

Section Objectives

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

- Provide an overview of public comments on Revision 1 of RG 1.207 (DG-1309)
- Provide a sampling of public comments and responses
- Summarize changes to Revision 1 of RG 1.207 from both public comments and further review by staff



U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH
November 2014
Division 1

DRAFT REGULATORY GUIDE

Technical Lead
Gary L. Stevens

DRAFT REGULATORY GUIDE DG-1309
(Proposed Revision 1 of Regulatory Guide 1.207, dated March 2007)

GUIDELINES FOR EVALUATING THE EFFECTS OF LIGHT-WATER REACTOR COOLANT ENVIRONMENTS IN FATIGUE ANALYSES OF METAL COMPONENTS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes methods and procedures that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in determining the acceptable fatigue lives of components evaluated by a cumulative usage factor (CUF) calculation in accordance with the fatigue design rules in Section III, "Rules for Construction of Nuclear Power Plant Components," of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (hereinafter "Code") (Ref. 1), to account for the effects of light-water reactor (LWR) coolant environments.

This guide supports reviews of applications for new nuclear reactor construction permits or operating licenses under *U.S. Code of Federal Regulations*, Title 10, "Energy" (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2); design certifications under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," (Ref. 3) and combined licenses under 10 CFR Part 52 that do not cite a standard design; and renewed operating licenses under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants" (Ref. 4).

Applicable Rules and Regulations

- General Design Criterion (GDC) 1, "Quality Standards and Records," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires, in part, that structures, systems, and components that are important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function performed. In addition, GDC 30, "Quality of Reactor Coolant Pressure Boundary," requires, in part, that components that are part of the reactor-coolant pressure boundary be designed, fabricated, erected, and tested to the highest practical quality standards.

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position. Public comments are being solicited on this draft guide and its associated regulatory analysis. Comments should be accompanied by appropriate supporting data. Comments may be submitted through the Federal rulemaking Web site, http://www.regulations.gov, by searching for Docket ID: NRC-2014-0244. Alternatively, comments may be submitted to the Rules, Announcement, and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments must be submitted by the date indicated in the *Federal Register* notice.

Electronic copies of this draft regulatory guide, previous versions of this guide, and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. The draft regulatory guide is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML14174A584. The regulatory analysis may be found in ADAMS under Accession No. ML14174A585.

Overview of Public Comments

U.S.NRC
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- Revision 1 of RG 1.207 (DG-1309) sent for comment under Federal Register Notice for docket ID NRC-2014-0244 dated November 24, 2014 (Vol. 79, No. 226) (FR Doc # 2014-27712)
- Public comment period ended on 1/23/2015.

Overview of Public Comments

U.S.NRC
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- Formal public comments were received from 7 commenters.

Letter No.	ADAMS Accession No.	Commenter Affiliation	Commenter Name	Abbreviation
1	ML15023A569	Rolls Royce PLC, United Kingdom	Keith Wright	RR
2	ML15023A570	Westinghouse Electric Company, USA	Camille Zozula	WEST
3	ML15023A571	Nuclear Energy Institute, USA	Jason Remer	NEI
4	ML15027A334	Union of Concerned Scientists, USA	David Lochbaum	UCS
5	ML15033A382	Southern Nuclear Operating Company, Inc., USA	Charles Pierce	SNOC
6	ML15033A383	AREVA, USA	Morris Byram	AREVA
7	ML15033A384	Electric Power Research Institute, USA	Nathan Palm	EPRI

- Four organizations (Rolls Royce, Westinghouse, AREVA, and EPRI) commented on both NUREG/CR-6909, Revision 1 and DG-1309.

Overview of Public Comments

U.S.NRC
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- As before, each comment was uniquely identified and tracked as [XXX]-[YYY]-[ZZZ]
  - [XXX] = Abbreviation from table
  - [YYY] = Letter No. from table
  - [ZZZ] = Sequential comment number
- Total Comments/Issues: 49

Overview of Public Comments

U.S.NRC
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- Almost all comments associated with the following areas
  - Editorial or clarification (≈ 45%)
  - NUREG/CR-6909, Rev. 1 technical basis (≈ 22%)
  - Applicability of earlier technical reports and guidance (≈ 14%)
  - RG scope, use, and applicability (≈ 12%)
- Remaining 3 comments covered unique topics
- Staff fully agree with about 2/3 of the comments
- Staff partially agree with about 1/2 of the remaining comments
- Most common areas of disagreement
  - Applicability of earlier technical reports and guidance
  - RG scope, use, and applicability

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Revision 1 of Reg. Guide 1.207:
Sample Public Comments and Responses

Sample Comments and Responses:
Editorial or Clarification

U.S.NRC
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- Implementation section states that guidance may be used to demonstrate compliance with underlying NRC regulations.
- Comment
  - *"…It would be useful to define the "underlying regulations."*
  - *"…background mentions 54.21, but that would only apply to renewed license applicants.*
  - *"…54.21 addresses license renewal aging management reviews and TLAA evaluations… rather than…the basis for environmentally adjusted CUF analysis." (NEI-3-26)*
- Summary of response
  - Phrase, "*…with underlying NRC regulations…*" pertains to the applicable regulations.
  - Applicable regulations are identified in Part A., *Introduction,* and Part C., *Regulatory Position*.
  - Purpose of Part D., *Implementation*, is to provide information on
    - Applicants and licensees use of the RG.
    - NRC's planned use of the RG.
  - Not intent of Part D. to repeat information provided earlier.

Sample Comments and Responses:
NUREG/CR-6909, Revision 1 Technical Basis

U.S.NRC
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- Comment
  - *Many do not agree with…direct multiplication of the in-air design usage factors…that are based on membrane types of loadings of small specimens.*
  - *This conservatism…is in addition to a.) "quick in-surge/out-surge" types of loadings not being considered…, b.) favorable hold-time effects not being considered…, c.) load sequence penalty being incorporated into the factor of 12.0, although not justified for nuclear plant applications…"*
  - *"…Why has an SRSS combination of these factors not been considered? (AREVA-6-7)*
- Summary of response
  - Generally pointed the commenter to the responses to public comments associated with NUREG/CR-6909, Revision. 1.
  - Identified NUREG comments associated with the issues raised in the RG comment for response.
  - For this comment, identified NUREG comments in following areas
    - Surge loadings
    - Hold time effects
    - Basis for factor of 12

Sample Comments and Responses:
Applicability of Prior Guidance

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- Comment
  - *"…the DG does not clarify if the use of NUREG/CR-6909, Revision 0 formulas remains acceptable.*
  - *Several LR applicants have used NUREG/CR-6909, Revision 0 methods and formulas for computing F_{en} values and would not wish to revise them just in order to meet NUREG/CR-6909, Revision 1 criteria. (NEI-3-1)*
- Summary of response
  - Staff disagrees that guidance for prior methods is needed in RG
  - Prior methods previously approved by the staff remain valid for the period of their intended use.
  - Staff is developing SLR-specific guidance to clarify the use of prior methods for SLR.
  - Staff does agree that the intended use of this regulatory guide by staff should be clearly stated and Part C has been modified accordingly.

Sample Comments and Responses:
Scope, Use, and Applicability of RG

U.S.NRC
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- Comment
  - *Page 6, paragraph 2, states: "These methods apply to those components exposed to reactor coolant that are required by regulation to have a fatigue CUF evaluation or have an existing CLB fatigue CUF evaluation."*
  - *"…there are components that 'have an existing CLB fatigue CUF evaluation' that are not exposed to reactor coolant, but are in secondary systems…exposed to secondary fluid."*
  - *"…They are not required by regulation to have a fatigue CUF…."*
  - *"…the applicability of the F_{en} factors to such components should be clearly stated…." (WEST-2-3)*
- Summary of response
  - Applicable environments
    - Staff believes that the methods described in RG are applicable to both primary and secondary systems
    - Staff agrees that the draft RG does not clearly define the terms "reactor coolant" and "coolant"
    - Replaced "(reactor) coolant" with "water" and added definition for LWR water environment

Sample Comments and Responses:
Scope, Use, and Applicability of RG

U.S.NRC
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- Comment
  - *Page 6, paragraph 2, states: "These methods apply to those components exposed to reactor coolant that are required by regulation to have a fatigue CUF evaluation or have an existing CLB fatigue CUF evaluation."*
  - *"…there are components that 'have an existing CLB fatigue CUF evaluation' that are not exposed to reactor coolant, but are in secondary systems…exposed to secondary fluid."*
  - *"…They are not required by regulation to have a fatigue CUF…."*
  - *"…the applicability of the F_{en} factors to such components should be clearly stated…." (WEST-2-3)*
- Summary of response, cont.
  - RG applicability in existing licensing application
    1. Component is required by regulation to have a CUF calculation
    2. Component has an existing CUF calculation
  - If either 1 or 2 are true, evaluate using GALL, Rev. 2 (LR) or GALL-SLR (SLR)
  - If both 1 and 2 are false, not necessary to address environmental effects
  - Added clarifying language to the RG

Sample Comments and Responses:
Miscellaneous Comments

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- Comment
  - *Page 6 introduction of Part C: 'Appendix A to that report includes details descriptions and additional guidance concerning the overall method and all the required calculations':*
  - *"The staff's developed guidance in Appendix A is insufficient to develop practical engineering procedures…."*
  - *"…This is especially true for analyses according to ASME Sub-article NB-3600."*
  - *"Insufficient guidance leads to the development of individual methods with a greater risk of higher operational and regulatory cost in the future." (AREVA-6-2)*
- Summary of response
  - Guidance is general for adaptation within the range of methods used in existing fatigue CUF evaluations
  - Approach provides the analyst with flexibility
  - Guidance is not intended to provide prescriptive, step-by-step methods
  - Example problem was added to NUREG/CR-6909, Rev. 1 to provide additional guidance on using the F_{en} method.
  - Staff agree that the quoted phrase is misleading and have changed it accordingly.

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Protecting People and the Environment

Revision 1 of Reg. Guide 1.207:
Changes to Document

Summary of RG 1.207:
Outline of Unique Sections

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A. Introduction
   - Purpose
   - Applicable Rules and Regulations
   - Related Guidance

B. Discussion
   - Reason for Revision
   - Background

C. Regulatory Position

   1. Carbon and Low-Alloy Steels and Welds
      1.1 CUF in Air
      1.2 Environmental Factor (F_{en})
      1.3 Environmental CUF

   2. Wrought and Cast Austenitic Stainless Steels and Welds

   3. Ni-Cr-Fe Alloys and Welds

D. Implementation

- References

Summary of Revised NUREG:
Summary of Major Changes

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- Defined LWR water environment and changed “reactor coolant” and “coolant” to “water” throughout RG, including title
- Clarified applicability of RG
  - New licensing applications that require a CUF calculation
  - Existing licensing applications that are either required by regulation to have a CUF or have an existing CUF as part of current licensing basis
- Clarified that guidance is not applicable for Inconel 718
- Clarified that Ni-Cr-Fe alloys should use the stainless steel design curves in air provided in NUREG/CR-6909, Rev. 1 (or associated ASME Code Section III curves)

Summary of Revised NUREG:
Summary of Changes by Section

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A. Introduction
   - Changed “coolant” to “water”
   - No other significant changes

B. Discussion
   - Defined LWR water environment
   - Changed “coolant” to “water”
   - Clarified use of F_{en} method for Ni-Cr-Fe alloys
   - Discussed additional margins that may be present in components
   - Provided rationale for adjustment factor of 12 on life
   - Clarified that guidance is not applicable for Inconel 718

Summary of Revised NUREG:
Summary of Changes by Section

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C. Regulatory Position
  - Changed “coolant” to “water”
  - Clarified applicability of RG to new licensing applications that require a CUF calculation
  - Clarified applicability of RG to existing licensing applications that are either required by regulation to have a CUF or have an existing CUF as part of current licensing basis
  - Clarified which design curves in NUREG/CR-6909, Rev. 1 are applicable for a given material.
  - Identified that method is not applicable to Inconel 718

D. Implementation
  - Clarified that guidance can be used in whole or part, as applicable
  - No other significant changes

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Current Status and Next Steps

Guidance Finalization:
Current Status and Next Steps

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- Revision 1 of RG 1.207
  - Undergoing interagency concurrence (December 2016)
  - Requested technical staff concurrence from NRR/NRO
  - Submitted NUREG/CR-6909, Revision 1, public comments, and responses to comments for information as part of package
  - Some additional changes may result from concurrence process.
  - Some conforming changes to responses to public comments will be needed.
- NUREG/CR-6909, Revision 1
  - Completed technical editing review
  - Incorporating technical editing changes
  - Some conforming changes to responses to public comments will be needed.
- Requesting ACRS recommendation to finalize RG 1.207
- RG 1.207 should be finalized before issuance of SLR guidance (i.e., NUREG-2191, NUREG-2192) in mid-2017.