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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

April 7, 2006

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on April 7, 2006, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

1 UNITED STATES OF AMERICA

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3 NUCLEAR REGULATORY COMMISSION

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7 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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9 531ST MEETING

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13 FRIDAY,

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15 APRIL 7, 2006

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20 The meeting was convened in Room O-1G16

21 of One White Flint North, 11545 Rockville Pike,

22 Rockville, Maryland, at 8:30 a.m., Dr. Graham B.

23 Wallis, Chairman, presiding.

24

25

1 MEMBERS PRESENT:

2 GRAHAM B. WALLIS	Chairman
3 WILLIAM J. SHACK	Vice-Chairman
4 J. SAM ARMIJO	ACRS Member
5 RICHARD S. DENNING	ACRS Member
6 THOMAS S. KRESS	ACRS Member
7 DANA A. POWERS	ACRS Member
8 OTTO L. MAYNARD	ACRS Member
9 JOHN D. SIEBER	ACRS Member-at-Large

10

11 ACRS STAFF PRESENT:

12 SAM DURAISWAMY	ACRS Staff, Designated
13	Federal Official
14 JOHN T. LARKINS	Executive Director,
15	ACRS/ACNW
16 CAYETANO G. SANTOS, JR.	ACRS Staff

17

18 NRC STAFF PRESENT:

19 JOHN FAIR	NRR
20 GENE IMBRO	NRR

21

22 ASME STAFF PRESENT:

23 KEN BALKEY

24 RICHARD BARNES

25 KEVIN ENNIS

1 I-N-D-E-X

2

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7 Review of the 1994 Addenda for Class 1, 2 and 3
8 Piping systems to the ASME Code Section III
9 and the Resolutions of the Differences Between
10 the Staff and ASME

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1 M-O-R-N-I-N-G S-E-S-S-I-O-N

2 8:33 a.m.

3 CHAIR WALLIS: On the record. The meeting
4 will now come to order. This is the third day of the
5 531st meeting of the Advisory Committee on Reactor
6 Safeguards. During today's meeting, the Committee
7 will consider the following: Review of the 1994
8 Addenda for Class 1, 2 and 3 Piping systems to the
9 ASME Code Section III and the Resolutions of the
10 Differences Between the Staff and ASME. We will then
11 take a break and we will move to Room T2B1 which is
12 the Subcommittee Room of the ACRS up on the second
13 floor in the other building.

14 Then we will discuss subcommittee reports,
15 future ACRS Activities/Report of the Planning and
16 Procedures Subcommittee, reconciliation of ACRS
17 comments and recommendations, selection of and
18 assignments for the quality assessment of NRC research
19 projects and the preparation of ACRS Reports. This
20 meeting is being conducted in accordance with the
21 provisions of the Federal Advisory Committee Act. Mr.
22 Sam Duraiswamy is the Designated Federal Official for
23 the initial portion of the meeting.

24 We have received no written comments or
25 requests for time to make oral statements from members

1 of the public regarding today's session. A transcript
2 of the portion of the meeting is being kept and it is
3 requested that that speakers use one of the
4 microphones, identify themselves and speak with
5 sufficient clarity and volume so that they can be
6 readily heard.
7 I now turn to Sam Armijo to lead us
8 through the first items the ASME Code for Class 1, 2
9 and 3 piping.
10 MEMBER ARMIJO: Thank you, Mr. Chairman.
11 During this session, we will hear presentations from
12 representatives of the staff and ASME to discuss the
13 resolution of differences between the NRC and SME
14 regarding the 1994 Addenda to Section III of the ASME
15 Boiler and Pressure Vessel Code for Class 1, 2 and 3
16 piping systems. The seismic design criteria described
17 in 1994 Addenda to the Code permitted higher allowable
18 stresses than in previous versions and the staff did
19 not endorse these revisions because of concerns with
20 the technical bases used to establish these criteria.
21 The Materials and Metallurgy Subcommittee reviewed the
22 status of the resolution of these issues in June of
23 1998 and March of 1999.
24 Today's presentations will describe the
25 1994 Addenda to the Code, the staff's concerns with

1 these revisions and efforts and I should say also
2 progress by the staff and ASME to resolve their
3 differences. I would like to turn it over to Mr. Gene
4 Imbro of NRR to begin.
5 MR. IMBRO: My name is Gene Imbro. I'm
6 the Deputy Director of the Division of Engineering and
7 I also participate in ASME Code activities as does
8 John. I just wanted to give a quick overview of our
9 Agency's participation in ASME and a description of
10 ASME and I know some of you have been members of ASME
11 for years. So this may be information that you
12 already know. Please bear with me.
13 Just to start, the ASME Board on Pressure
14 Vessel Code is compromised of, I think, it's 12
15 sections, it might be 13. and it covers things like
16 how power boilers, unfired pressure vessels, NDE, a
17 whole host of things. It's a consensus code and it's
18 based on the expert opinions of the participants.
19 But today we're going to focus on Section
20 III, "Rules for Construction of Nuclear Facility
21 Components." Section III of the ASME Boiler and
22 Pressure Vessel Code focuses on the design of pressure
23 vessels and piping for nuclear applications. The ASME
24 Code is written by volunteers and the volunteers
25 represent utility organizations, design organizations,

1 consultants and the NRC, the regulator. The NRC
2 participates in many code committees with ASME and we
3 have approximately 20 staffers that participate on
4 ASME Code Committees. ASME Boiler and Pressure Vessel
5 Code plays an important part of NRC's regulations of
6 NPPs. It has been incorporated by reference in the
7 Code of Federal Regulations.
8 (Tape recording issues.)
9 CHAIR WALLIS: Can we just come off the
10 record?
11 (Whereupon, the foregoing matter went off
12 the record at 8:37 a.m. and went back on the record at
13 8:38 a.m.)
14 CHAIR WALLIS: We're back on the record.
15 MR. IMBRO: Thank you. The ASME Boiler
16 and Pressure Vessel Code is compromised of 12 sections
17 covering power boilers, unfired pressure vessels, NDE,
18 in-service testing and a host of other things. It's
19 a consensus code that's based on the expert opinions
20 of the participants.
21 Today we want to focus on Section III,
22 "Rules for Construction of Nuclear Facility
23 Components." Section III of the ASME Code on Pressure
24 Vessel Code focuses on the design of pressure vessels
25 and piping for nuclear applications. The ASME Code is

1 written by volunteers representing utilities, design
2 organizations, consulting organizations and NRC, the
3 regulator. We have approximately 20 staffers that
4 participate on various ASME Code committees. So we
5 have quite a large presence on ASME.
6 The ASME Board on Pressure Vessel Code
7 plays an important part in NRC's regulation of nuclear
8 power plants. It has been incorporated by reference
9 in the Federal Code of Regulations since, I believe,
10 1971. What that means "incorporation by reference" is
11 verbatim compliance with the ASME Boiler and Pressure
12 Vessel Code as required by NRC regulations. So it
13 basically takes on the status of law. The Boiler and
14 Pressure Vessel Code and only a few other codes have
15 really incorporated in CFR. So the status of the ASME
16 Section 3 is somewhat unique. The other --
17 incorporated in 10 CFR 5055(a) and ASME Section --
18 which is the in-service -- in-service inspection,
19 Operation of Maintenance Code IEEE 279 and IEEE 603.
20 (Tape recording issues.)
21 CHAIR WALLIS: Off the record.
22 (Whereupon, the foregoing matter went off
23 the record at 8:40 a.m. and went back on the record at
24 8:43 a.m.)
25 CHAIR WALLIS: Okay. We're off again.

1 MR. IMBRO: As I said before, verbatim
2 compliance with the ASME Boiler and Pressure Vessel
3 Code is required by NRC regulation. Section 3 has a
4 special status in that it and only a few other codes
5 are incorporated into the 10 CFR. Management
6 Directive 6.5 has NRC participation in the development
7 and use of consensus standards specializes staff
8 responsibilities for participation in the development
9 of consensus standards and part of what that says is
10 the NRC staff are directed to represent the Agency
11 opinion and not necessarily their own personal views.
12 Most of the time, they coincide.
13 Occasionally, the Staff's technical
14 position does not agree with the requirements of the
15 Code and this results in limitations and modifications
16 which the Agency places in CFR when we endorse a later
17 addition and addenda of the Code and the Regulation.
18 Overall, the NRC and ASME have a professional and
19 constructive working relationship and however as I
20 said, the NRC and ASME don't always agree on technical
21 things which I will discuss today is one area where
22 the staff has taken exception to ASME Section 3
23 Seismic Design Rules and the resolution of most of
24 these issues.
25 MR. FAIR: Yes, I'm John Fair with NRR and

1 I'll discuss the issue with the piping seismic rules.
2 The concern was in 1994. ASME Code Section 3 adopted
3 revised criteria for the Piping Seismic Design and
4 these criteria allowed for significantly higher
5 allowable stresses than were specified in the previous
6 ASME Code.
7 The staff did not endorse the revised
8 criteria because of concerns with the technical basis
9 used to establish the criteria and the staff still has
10 not endorsed these criteria up to this state.
11 CHAIR WALLIS: It's been around for 12
12 years.
13 MR. FAIR: It's been around for even
14 longer than 12 years. What I'll do is go over --
15 CHAIR WALLIS: We're supposed to snap our
16 fingers and solve it.
17 MR. FAIR: Yes. I thought that's what was
18 going to happen. We were waiting for ACRS. This
19 issue has been around for quite a while. Back in the
20 mid '80s, there was a concern that the piping design
21 criteria had become overly conservative and that too
22 much supports were being used and so a number of
23 initiatives were taken at that time to try to revise
24 the criteria and make the criteria more realistic.
25 One of the initiatives happened to be dynamic tests of

1 piping components and these tests were used as the
2 bases for establishing the new allowable criteria.
3 In 1991, ASME established a special task
4 group to assess the margins in the piping design rules
5 and the staff participated as members in this group.
6 As a result of the effort of this group, the ASME
7 published the revised rules in the 1994 Addenda and
8 the revised rules established these higher allowable
9 stress values. The NRC representatives on the
10 committee voted negative on the proposed change to the
11 rules because of the technical concerns we had the
12 time. The NRC actually informed ASME via letter that
13 we would not endorse the new rules and in a second
14 letter we sent to them, we specified the reasons why
15 we wouldn't endorse these rules.
16 In the response to the NRC letter, the
17 ASME established a special working group on seismic
18 rules to evaluate the technical concerns raised by the
19 NRC and there had been some technical concerns raised
20 by other people, too. In parallel with this effort,
21 the NRC established the contract under research with
22 the Engineering Technology Research Center to review
23 the technical basis for the '94 rules and the NRC
24 staff and the research contractors participated in the
25 ASME group meetings as observers and not

1 representatives. The research effort was culminated
2 in a NUREG 5361 which contained the assessment of the
3 1994 Piping Seismic Rules. The staff had twice
4 briefed the ASME subcommittee in June Of '98 and March
5 of '99.
6 In order to understanding some of the
7 technical issues, I'm just going to have a very brief
8 overview of the piping design criteria. This is at a
9 very high level. There's a lot of detail to the
10 criteria that I really won't go into. But the ASME
11 contains criteria for Class 1, 2 and 3 piping. The
12 Class 1 piping was the reactor coolant pressure
13 boundary. The difference between Class 1 and Class 2
14 and Class 3 is that Class 1 requires a detailed
15 fatigue analysis, whereas Class 2 and Class 3 don't
16 and Class 2 and Class 3 are essentially the same
17 design criteria.
18 Piping is typically evaluated using design
19 rules in ASME Code Sections NB,/NC,/ND-3600 and these
20 are really simplified formulas for evaluating the
21 stresses. Occasionally, the rules in NB-3200 are used
22 for Class 1 piping and the rules in 3200 are basically
23 allowable stress limits and generally what is done in
24 3200 analysis is a finite element analysis of the
25 component and the stresses are compared to the

1 allowable stresses.

2 Now the Code contains allowable stress
3 limits for four levels of load combinations, A, B, C
4 and D. Level A is generally your operating loads like
5 dead weight and pressure. Level B are plant
6 transients and generally include an operating basis
7 earthquake load combination. Level C is designed pipe
8 rates other than LOCA and main steam and feed water.
9 Usually this criteria is not used at often. You don't
10 see too many load combinations under Level C. And
11 Level D contains LOCA loads and SSE loads.

12 I'll just go over the more significant
13 changes in the 1994 Code revisions. Strain limits
14 were added to NB-3200 which are the detailed design
15 rules and these strain limits were specifically for
16 piping. The rest of the bullets on this slide pertain
17 to the 3600 Rules. The Level D allowable strain limit
18 was raised by 50 percent.

19 CHAIR WALLIS: Do you remember the
20 numbers? What was the stress limit before and what
21 was it afterwards?

22 MR. FAIR: I'm going to show you on the
23 next one.

24 CHAIR WALLIS: You're going to show us.

25 MR. FAIR: Yes. A frequency limitation

1 was established and the reason this occurred is when
2 they did the testing at ANCO on these components, the
3 way they tested is they drove them at their natural
4 frequencies and the reason you drive at the natural
5 frequency is it's easy to drive the response to high
6 level. When we were discussing the evaluation of this
7 criteria, it turns out that you get your maximum
8 margin if you compare it to the Code analysis criteria
9 at the resonance of the component because the elastic
10 analysis shows a very high amplification and if you
11 get any inelastic response of the piping you won't get
12 that much of an amplification.
13 So part of the evaluation, the complexity
14 of the evaluation, was to have to look at off-
15 resonance conditions and if you look at, say, a very
16 slowly applied force to a component you find it acts
17 more like a static load. That's why this frequency
18 limitation was put into the '94 Code rules.
19 Another thing that was added in 1994 was
20 a Level D limit for seismic anchor motions. Now the
21 ASME Code divides stresses into two categories,
22 primary and secondary. Primary loads are for loads
23 like dead weight that can cause a failure of the
24 component by collapse. Secondary loads are generally
25 used for femoral type stresses where you're worried

1 about progressive distortions and fatigue and not
2 collapse. So in coding evaluation space for Level B
3 limits which are one time loads, you generally don't
4 evaluate secondary type stresses, but because there
5 was a concern that the seismic anchor motions had
6 caused failures at the fossil plants during plant
7 surveys, they added a Level D limit in the rules for
8 seismic.
9 They also based on the testing that was
10 done --
11 VICE CHAIR SHACK: How was that limit put
12 in, John?
13 MR. FAIR: It's just an equation. What it
14 is --
15 VICE CHAIR SHACK: So it's a stress limit.
16 MR. FAIR: It's a stress limit and
17 actually at the time they put it in, I didn't consider
18 it very meaningful because usually you evaluate
19 secondary loads to what's known as $3S_m$ stress limit.
20 What they did when they put this in, secondary loads
21 include OBE loads in Level B under a $3S_m$ limit. What
22 they did when they put this Level D in is they put a
23 $6S_m$ limit for seismic anchor motions which if you
24 would have met the $3S_m$ limit with OBE you're obviously
25 going to meet the $6S_m$ limit with SSE. It is now

1 irrelevant since the rules changed for seismic where
2 the new rules for seismic say you don't have to
3 evaluate OBE if you meet certain criteria. So it is
4 now a relevant limit and it's one of the issues that
5 came up later in the review process.
6 The last major thing that was done was new
7 Level B and Level C limits were established in
8 parallel with the Level D limit. The one I talk about
9 is the '94 Level D stress limit which is the one that
10 was of most concern and most of the evaluation effort
11 was geared towards reviewing.
12 What I've shown here is the basic code
13 designed by rule formula for Level D and it's a fairly
14 simple formula. What it is is the first term is
15 simply longitudinal pressure stress. The second term
16 is your bending stress and it has to be less than
17 equal to the allowable limit.
18 CHAIR WALLIS: Four times 4.5 times --
19 MR. FAIR: S_m and I'll go over that in a
20 minute what that means. First, the B indices are a
21 function of the type of components you're evaluating
22 and they're simple adjustments to go from a straight
23 pipe to a component like a elbow or a T.
24 CHAIR WALLIS: This is all thin-walled
25 pipe theory.

1 MR. FAIR: It's -- Yeah, it is thin-walled
2 pipe theory, but if you look at the B indices for
3 straight pipe, the B-1 index would be a one-half. So
4 this would just be the longitudinal pressure stress in
5 the first term and again for straight pipes, the B-2
6 index would be one. So you just have MC/I type of
7 stress.
8 Now the S_m is a function of the material
9 that you're evaluating and the basic allowable S_m is
10 established by a couple of criteria, either two-thirds
11 of the minimum yield stress at temperature or one-
12 third of the ultimate stress. So if you look at this
13 equation, it's quite obvious that the $4.5S_m$ would
14 allow you to go over the ultimate strength of the
15 material.
16 CHAIR WALLIS: Seems like a good criterion
17 to me.
18 MR. FAIR: So that's why we were very
19 concerned with it.
20 CHAIR WALLIS: -- to break it.
21 MR. FAIR: The next slide I'll go over the
22 basis.
23 VICE CHAIR SHACK: That's the last that we
24 calculated.
25 MR. FAIR: Exactly.

1 CHAIR WALLIS: Right.

2 MR. FAIR: The justification for this new
3 limit was that the component test data demonstrated
4 that piping collapse cannot occur during a seismic
5 event so that the possible failure modes during a
6 seismic event are fatigue, fatigue ratchet and
7 progressive ratchet. What I mean by these are fatigue
8 is a fairly simply concept. If you keep cycling --

9 CHAIR WALLIS: It's a fairly funny
10 statement. Piping collapse cannot occur. I mean
11 obviously if a seismic event is big enough you can
12 collapse a pipe. It's just that it --

13 (Several speaking at once.)

14 CHAIR WALLIS: It's a very strange thing.

15 MR. FAIR: I'll go into that in the next
16 slide, but I just want to explain these three terms.
17 Fatigue is regular fatigue/slightly fatigue. Fatigue
18 ratchet really means that if you're cycling the
19 piping, a pressurized pipe under high strains, the
20 pipe tends to budge and this budging can affect the
21 fatigue endurance of the pipe. And the third concern
22 was progressive ratchet which is essentially a
23 progressive displacement of the system under the
24 cyclic loads.

25 MEMBER SIEBER: That is plastic

1 deformation.

2 MR. FAIR: Plastic deformation. So the

3 bottom line was that the ASME considered their

4 evaluation that the component test data demonstrated

5 that the new rule did provide adequate margin against

6 the possible failure of modes discussed above and they

7 also believe that their evaluation of the piping

8 system, their tests, confirm the new seismic rules.

9 CHAIR WALLIS: Now what do they mean by

10 adequate margin? Does that mean that they're within

11 50 percent of failure or one percent or what?

12 MR. FAIR: Yes. At the time that these

13 rules were established, the adequate margin was

14 defined as a factor of safety of two on the lowest

15 bound value from the tests and we did have some

16 concerns with that and I'll get into that in the next

17 slide.

18 The first bullet is there were

19 insufficient test data to demonstrate, to support, the

20 conclusion that a piping system collapse will not

21 occur. As a matter of fact, in our opinion, one of

22 the tests was exhibiting collapse before they stopped

23 and they stopped prior to the end of the seismic input

24 before it did fall down and collapse.

25 MEMBER SIEBER: Test 38.

1 MR. FAIR: Test 37.

2 MEMBER SIEBER: Test 37.

3 MR. FAIR: Yes. Our second concern was
4 that there were inadequate evaluation of the existing
5 test data and what I mean by that is when these
6 components were tested some of them took more than one
7 seismic input before they failed. So in order to
8 normalize the data, the failure load was adjusted by
9 the number of cycles of fatigue type loading because
10 the issue was that it was more of a fatigue loading
11 than anything else.

12 The way they adjusted it was to adjust it
13 by the same criteria that's in the fatigue curve. For
14 instances, at very low cycle fatigue if you were to
15 double the amount of cycles, you would have about a 40
16 percent change in the fatigue life of the component.
17 So this adjustment was done on the data and then the
18 adjusted data was used to establish the margin.

19 The problem we had with that was when you
20 look at the adjusted data, the scatter was greater
21 than the unadjusted data which told us there's
22 something wrong with your adjustment and the reason
23 there's something wrong with the adjustment in this
24 situation was there was some funny ways they did the
25 adjustment on some of the data. But when you look at

1 trying to use the fatigue curve, the fatigue curve is
2 for strain based on an elastic basis. When you're
3 testing these components, you have a combination of
4 fatigue and ratchet occurring simultaneously. So you
5 wouldn't expect the adjustment to be the same as you
6 would with a specimen under a fixed displacement
7 condition.
8 The third issue was there was really
9 insufficient basis for establishing the minimum design
10 margin. The margin of two sounds good, but again
11 given the adjusted data had a greater data scatter, we
12 felt there needed to be some consideration of the data
13 scatter in the development of margin.
14 And finally, they had a couple of system
15 tests to confirm the conservatism of the criteria, but
16 there was no way to adjust the system test data in
17 similar fashion to the component test data. So we
18 didn't think that they had enough basis to extrapolate
19 the margins from the component test to the system
20 test.
21 Now I'll go over the results of the NRC
22 Research Program. It was established with ETEC in
23 1993. It includes an independent evaluation of the
24 test data, independent from the ASME evaluation and
25 the independent analytical studies of test margins

1 extrapolations were performed. These extrapolations
2 were done by CalTech researchers and also the program
3 included peer review group of experts and the results
4 were published in the NUREG 5361. The review
5 concluded that the basis published for the '94 rules
6 were incomplete and this data was provided to the ASME
7 working group.
8 I'll go over it really briefly. There
9 was a lot of effort on this special working group on
10 seismic rules, but I'll just briefly go over the key
11 elements. The special working group relied heavily on
12 the ETEC evaluation of the data because they didn't
13 have resources to contract out additional evaluations.
14 They did vote to accept the margin definition that was
15 proposed by Bob Kennedy which he was one of the peer
16 reviewers and he had proposed a margin that was based
17 on the existing seismic margin studies, derived from
18 that. That was essentially a factor of two on the one
19 percent capacity failure probability and when you
20 translated this into the actual component test data,
21 some credit was given for system redundancy in the
22 piping system going from a component to a piping
23 system. So the actual evaluation of the component
24 test data was looking at the one percent capacity
25 factor of 1.5 giving some credit for system

1 redundancy.

2 And the reason that we don't have a

3 problem with that is when they finally did the

4 evaluations of the capacities they went away from the

5 margin extrapolations analytically to an actual

6 evaluation of measured margins during the test and

7 these were called "ultimate dynamic moments" that were

8 measured actually during the test. So we have the

9 real capacity of the component and not a calculated

10 value. On the basis of this evaluation, this special

11 working group proposed modifications of the rules and

12 revisions were incorporated in the 2001 and 2002

13 Addenda of the Code.

14 After this effort was performed, the staff

15 decided it was time to try to endorse the current code

16 rules since they had made some changes to address our

17 concerns. Let me go over briefly what the changes in

18 2002 Addenda were. The Level D stress limit was

19 revised back to what it was previously, $3S_m$. New

20 seismic stress indices were added for elbows, Ts and

21 thickness transitions.

22 Now the reason that happened was the

23 original proposal raised the allowable stress limits

24 across the board for all components. However, the

25 component test data only had certain components tested

1 and the evaluation of the data also showed that some
2 cases that the Code criteria really wasn't that
3 conservative. I'll get into that later on the revised
4 criteria.
5 CHAIR WALLIS: Did they make adjustments
6 for welds in all of this?
7 MR. FAIR: Yes, and I'll get into that.
8 Yes sir. So anyway, they made these revisions. What
9 happened when they --
10 VICE CHAIR SHACK: Just a question,
11 Chairman. This $3S_m$ limit, how is that related to the
12 Kennedy margin? You go through, you get the ultimate
13 bending moment, you make some estimate of the
14 nonlinear dynamic effect, some less than the
15 redundancy effect, and then you end up with these
16 stresses as roughly equivalent to that.
17 MR. FAIR: The way it works is you take
18 from the test data you measure the ultimate dynamic
19 moment. This is a measured moment. It's actually not
20 measured at the point. You're measuring the
21 translated moment down to the point of the component
22 failure. You have that measured moment and you have
23 the moment computed by the Code equation with $3S_m$ in
24 it and you take that measured moment divided by the
25 $3S_m$ limit, calculating moment with $3S_m$ and make sure

1 that that margin in there has a factor of safety of
2 1.5 really. That's the way that thing was evaluated.
3 VICE CHAIR SHACK: But Kennedy's thing has
4 a nonlinear dynamic adjustment. So the 1.5 is the
5 redundancy adjustment.
6 MR. FAIR: No, let me start -- I probably
7 should have brought a slide on that. Their proposal
8 was a capacity factor of 2.0. What he proposed was
9 the fact that there are some nonlinear factors and a
10 redundancy factor which could give you additional
11 margin. He took a fixed number of 1.33 as being a
12 lower bound conservative number and divided two by
13 1.33 to come up with a fixed value of 1.5 as the
14 criteria using to evaluate to the one percent level.
15 So you took all the test data, calculated the margin
16 based on the Code $3S_m$ limit, did a statistical
17 evaluation of the data to determine that the one
18 percent limit met that 1.5 factor.
19 MEMBER SIEBER: What constitutes a test
20 failure? We've established that collapse is not one
21 of those. I take it that plastic deformation is a
22 failure.
23 MR. FAIR: In many of the cases and in the
24 majority of the cases, it was through-wall crack
25 through the system which then leaked. In a couple of

1 the cases, there was excessive deformation. As I said
2 one of the cases, Test 37, was about to collapse and
3 they stopped the run. So most of the cases it was
4 through-wall fatigue failures. In a couple of the
5 cases, it was excessive deformation failures.
6 MEMBER SIEBER: Right.
7 CHAIR WALLIS: It is an interesting
8 culmination of things. You're doing a lot reasonably
9 sophisticated statistics to get one percent.
10 MR. FAIR: Yes.
11 CHAIR WALLIS: And presumably you need
12 some competence attached to that and then you slapped
13 on these numbers which are very crude like 1.52 of
14 three. There's an incompatibility here in the levels
15 of sophistication applied.
16 MR. FAIR: There are, but if you go back
17 to the bases for deriving the capacity factors, the
18 one percent capacity factors, there are some
19 judgmental numbers that go into that evaluation. So
20 if you try to take it out to two or three decimal
21 points, it's meaningless.
22 Again, when they translated this into the
23 Code revisions, actually what happened was that the
24 stress indices for ASME Class 1 and Class 2 components
25 came out different than the ones for the Class 3

1 components. Now the reason this occurred and again
2 this comes at the end as one of the remaining issues
3 was there was a staff proposal on what these indices
4 should be made at the special working group level and
5 that staff proposal was working its way up through the
6 Code and when it got to the main committee, there were
7 some objections at the main committee and so they
8 revised the criteria to another criteria.
9 When they translated it into the Code,
10 apparently they left some of it the way it was
11 proposed by the staff and other areas, it was what the
12 ASME wanted. That's why the dual criteria. I'll
13 discuss that. And they corrected that via a RATA
14 later on.
15 The other thing that was done was a D/t
16 limitation was put in and this was to address the one
17 case where you had the collapse, the Test 37, which
18 was a thin-walled piping system that had a very low
19 margin and it's probably due to a local buckling of
20 unpressurized --
21 CHAIR WALLIS: What's going through my
22 mind is you hold the theory you present is
23 extraordinarily crude. Doesn't it count for certain
24 modes of theory like buckling?
25 MR. FAIR: Yes.

1 CHAIR WALLIS: Which is what happens. You
2 take a beer can and twist it. It buckles.
3 MR. FAIR: Yes, and that's why they put
4 D/t on that.
5 MEMBER SIEBER: Yes, the original
6 assumption was though that that was impossible.
7 Right?
8 MR. FAIR: Yes.
9 CHAIR WALLIS: Buckling your paper.
10 MEMBER SIEBER: Yes.
11 MR. FAIR: Just a comment on that now,
12 it's not as bad as it sounds because the original
13 criteria for the use of a B indices has a D/t criteria
14 of 50 which is not that thin a wall but it is thin and
15 again, that wasn't good enough if you're going to go
16 to these higher limits. So we cut it back to a D/t of
17 40 and since we had gotten rid of all this
18 extrapolation evaluation of trying to calculate and
19 extrapolate in margin and went with the actual measure
20 margins from the test, we were able to eliminate, the
21 frequency limitation was eliminated and this frequency
22 limitation would have been very hard to implement in
23 a practical sense when you're doing piping analyses.
24 The next slide shows the revised 2002
25 primary stress limit. You can see the criteria went

1 back to $3S_m$. You have instead of the B2s you have B2
2 primes for specific components. Now if you look at
3 the second B2 prime which is the one that the ASME
4 wanted and you put that into the equation above and
5 flip it around, you essentially get close to the $4.5S_m$
6 that they originally wanted. But this is just for
7 elbows and Ts. It's not for all the components,
8 straight pipes, etc.
9 If you go down to the next bullet, it was
10 actually going more conservative for places where you
11 have thickness transitions. What happened in the
12 evaluation of the data is these tests were canti-
13 levers driven by sleds at the base and the component
14 was done near the bottom of the canti-level with a
15 small transition piece to attach to the sled base. In
16 order that the prosticity (PH) occurred in the
17 component, the little transition piece to the sled had
18 to be much thicker.
19 So when we went back and looked at the
20 actual failure, a lot of times the failures were
21 occurring not in the component themselves, but on the
22 other side of wall that the transition feeds and when
23 you evaluated the margins which would have a B of 1 at
24 that location, you found that maybe you didn't have
25 adequate margins. So since the proposal was to make

1 all the margins more or less compatible with each
2 other, you really needed to put a B prime of 1.33 at
3 these thickness transitions. So it's actually more
4 conservative than the original Code criteria at these
5 particular locations.
6 Now the staff concerns with --
7 CHAIR WALLIS: This is very strange to me.
8 Shouldn't all this be related somehow to your
9 probability of failure in a nuclear context and what
10 you're aiming for in terms of that probability of
11 failure in a nuclear context rather than just
12 arbitrarily having these threes and 4.5s?
13 MR. FAIR: It's not that arbitrary because
14 the basis for the --
15 CHAIR WALLIS: If you want your pipe not
16 to break in a seismic event with a probability of 10^{-6}
17 or something, then this may tell you something about
18 what you need to do. You don't seem to put it in any
19 kind of a nuclear context.
20 MR. FAIR: Well, let me try again.
21 CHAIR WALLIS: Risk context.
22 MR. FAIR: I thought I did. The basis for
23 establishing the required margin was started out with
24 the margins that are in existing seismic margin
25 studies in PRAs and the concept was we didn't want

1 piping to become a dominant factor in there. So the
2 starting point of the evaluation was the margin in
3 existing seismic margin studies and derived from that
4 was the capacity factor needed for the piping.
5 CHAIR WALLIS: But if you get 10^{-6} or that
6 sort of order, you're way out on the tail of some
7 distribution. You have to be very careful about how
8 you make predictions, don't you?
9 MR. FAIR: I agree with you. It's --
10 VICE CHAIR SHACK: But it's not 10^{-6} given
11 the occurrence of the earthquake.
12 MR. FAIR: Right.
13 CHAIR WALLIS: What is the -- occurrence?
14 MR. FAIR: Zero.
15 CHAIR WALLIS: What's the conditional? Is
16 it one percent? That's the Kennedy thing?
17 MR. FAIR: That's the Kennedy thing.
18 That's exactly right. Yes.
19 CHAIR WALLIS: Okay. That's where it came
20 from.
21 MR. FAIR: Yes.
22 MEMBER SIEBER: Now all these seismic
23 loads are added to the stress that's caused by dead
24 weight and pressure.
25 MR. FAIR: The equation for the seismic

1 load contains dead weight and pressure.

2 MEMBER SIEBER: Okay.

3 MR. FAIR: And the terminology used in the

4 Code is reversing bionic load. So what you have is

5 dead weight and pressure with whatever the reversing

6 dynamic loads are associated with that. If you have,

7 say, a large, what they call, nonreversing load in

8 concert with these, you can't use that criteria.

9 MEMBER SIEBER: Like if you were standing

10 on the --

11 MR. FAIR: Yes.

12 CHAIR WALLIS: Do you have some kind of

13 residual stress for welds or something in all this as

14 well?

15 MR. FAIR: Those are usually not evaluated

16 in ASME Code criteria.

17 CHAIR WALLIS: It's a separate criterion

18 of some sort.

19 MEMBER SIEBER: Yes, it's like they don't

20 exist because they're supposed to be stronger than the

21 base material.

22 MR. FAIR: Yes, the way residual stress

23 works into the Code evaluation is really when you do

24 fatigue analysis in the fatigue curve which is

25 adjusted for residuals.

1 So we have a change in the piping rules in
2 2002 and the staff went to endorse it in 5055(a) and
3 went back and reviewed the rules carefully. Now
4 again, we had spend a lot of time on this Level D
5 allowable limit of 4.5. When we went back for the
6 endorsement, we looked at the whole set of rules that
7 had been changed way back in 1994 and said, "Well
8 we've probably overlooked a few things in the Code
9 deliberations."
10 One of the issues the way the Code rules
11 were written is that these rules would apply to
12 anything called a reversing dynamic load and these
13 reversing dynamic loads would have included flow
14 transient type loads that you have a water hammer or
15 a valve opening. The problem was all the data
16 reduction was done on components that were loaded by
17 the base sled motions and not by internal pressure
18 loads. So there was no basis to use this criteria for
19 flow transient loads.
20 A second concern --
21 CHAIR WALLIS: This is where you do have
22 real incidents in plants where -- dead breakers are a
23 result of water harm.
24 MEMBER SIEBER: You certainly do.
25 MR. FAIR: Yes.

1 CHAIR WALLIS: So presumably they weren't
2 designed to take that kind of load or the load was
3 underestimated or something.
4 MEMBER SIEBER: They're pretty severe.
5 MR. FAIR: Yes.
6 CHAIR WALLIS: Yes, they were severe, but
7 it might still --
8 MR. FAIR: What happens on some of those
9 is you've supposedly designed the system so that you
10 don't have those.
11 CHAIR WALLIS: That's right.
12 MEMBER SIEBER: Right. Then you don't
13 have to figure out how big they are.
14 MR. FAIR: Yes, very difficult to design
15 something to take the worst case water hammer type
16 load.
17 So the second concern we had was back in
18 the original slides that they had added some strain
19 criteria to NB-3200. This was complex criteria which
20 was looked at ratchet strains and peak strains and we
21 didn't think the technical basis had been established
22 for those rules.
23 The third item we had was when they went
24 back and modified the Level D limit they didn't go
25 back and look at the impact on the Level B limits and

1 thought that they needed to be brought into
2 consistency with the change in the Level D limits.
3 Another item was in the definition of the
4 moment load and this goes back, way back, to the
5 original development of the margins. The moments
6 specified the method of analysis to obtain the moment
7 which was damping and inspector input. That's really
8 licensing basis criteria. So we couldn't have the
9 Code superseding licensing basis criteria and that was
10 the reason we had a concern with that.
11 And the next item was the inconsistency in
12 the B indices. The three quarters we liked. The two-
13 thirds we didn't like.
14 The other one was with the new allowables
15 for seismic anchor motions. We had a concern that at
16 $6S_m$ there's a concern that if you have a strain
17 concentration that you could cause a problem even
18 though they were a secondary type load. So we felt
19 the need to have some restriction in on that.
20 To go over the recent activities in that,
21 the staff proposed an amendment to 5055(a) to
22 incorporate the new rules with limitations. The ASME
23 submitted comments on the rules and essentially asked
24 us to keep our non-endorsement of the rules until we
25 worked out our differences. Then the ASME formed a

1 special project team to resolve the remaining issues
2 and the project team resolved five of the six issues.
3 CHAIR WALLIS: So you're very close to
4 closure.
5 MR. FAIR: Very close.
6 CHAIR WALLIS: I was hoping you would be
7 because the last thing we need is to have ACRS doing
8 all these calculations and things for you.
9 MR. FAIR: I'll take whatever help we can
10 get.
11 MEMBER SIEBER: It's more like the
12 revolver though. You keep pulling the trigger until
13 you find the cylinder that's not empty.
14 MR. FAIR: Yes.
15 VICE CHAIR SHACK: You don't want that.
16 MR. FAIR: I'll go quickly over the
17 resolved issues. ASME initiated Code changes to
18 eliminate the operability of the seismic rules to flow
19 transient loads. ASME initiated changes to eliminate
20 3200 strain criteria. They had initiated this prior
21 to our comments because of the practicality of
22 applying it.
23 ASME initiated Code changes to modify the
24 Class 2 and Class 3 level B limits to be consistent
25 with the Level D using the B prime criteria, initiated

1 Code changes to eliminate the discussion of the method
2 to generate the loads from the definition of the
3 moment and they initiated changes to add provisions to
4 the criteria to address strain concentration and these
5 are just precautionary limits put in there. It says
6 look out for cases where you could have possible
7 strain concentrations such as smaller pipes in series
8 with larger pipes and things like that. We think
9 that's good enough to at least give a precaution to
10 the designer that he doesn't do anything bad in the
11 design.
12 The remaining open item was that there's
13 testing at Battelle showing that certain carbon steel
14 materials are subject to dynamic strain aging at
15 temperatures greater than 300 degrees F. The concern
16 here was all the pipe testing was done at room
17 temperature. So you have to either assume that these
18 same margins will apply at temperature or you needed
19 some data to show that they were good at the higher
20 temperatures.
21 The actual testing that was done, the
22 specimen testing, showed a fairly significant
23 reduction in ultimate tensile capacity at higher
24 strain rates. There was also some testing of loops
25 with large flaws that showed a reduction at

1 temperature versus at room temperature at higher
2 strain rates and we concluded that the seismic strain
3 rates can be in a range of concern of dynamic strain
4 aging.
5 The next slide is just to show some of the
6 data from Battelle. This is just one set of specimen
7 data. If you look at the bottom it's elongation. At
8 the top is showing ultimate tensile strength and
9 yield. On the left side, the data points are
10 equivalent to what you get on a quasi-static type of
11 strain, a fairly slow strain rate, and these would be
12 the basis that you would establish the ASME Code
13 allowable limits. If you go over to where they test
14 it at, at one inch per inch per second and ten inches
15 per inch per second you get a fairly significant drop.
16 The other thing between us and the ASME on
17 that is how high the seismic strain rates can possibly
18 get. Their evaluations, we estimated they could be at
19 the one inch per inch per second level and they
20 estimate that they're somewhat less than that and
21 their feeling is it was not enough difference to
22 revise the Code rules for the little bit of difference
23 in capacities at their estimated strain rates.
24 Now I will say I don't want to drag on too
25 long. But I will say that a lot of the arguments that

1 we had was we believe that you had to evaluate these
2 capacities at the failure point and we have to look at
3 the strains that you would get if the component were
4 failing. Some of the ASME evaluations were looking at
5 it at pseudo-Code limits and things like that where
6 you didn't go up to the failure point. So you would
7 calculate a much lower strain and consequently a much
8 lower strain rate.
9 And we don't agree with that methodology.
10 We think that if you're trying to evaluate these
11 capacities for margins studies where the loads could
12 be above what you're designing to then you have to
13 look at the failure capacity of the component at its
14 limit, not at the Code allowable limit.
15 So our proposed resolution of the final
16 issue is to take exception in 5055(a) endorsement that
17 the B2 prime, B3 quarters, B2 for carbon steel elbows
18 and Ts at temperatures greater than 300 degrees F and
19 again the ASME has it at two-thirds. So the
20 difference is not that great. We're taking about a 12
21 percent reduction for this concern with dynamic
22 straining aging.
23 MEMBER SIEBER: Other than that, you agree
24 that the rest of the Code's requirements are adequate.
25 MR. FAIR: With the changes that they've

1 proposed, yes.

2 MEMBER SIEBER: Okay.

3 VICE CHAIR SHACK: Now that only affects

4 the Class 3 components.

5 MR. FAIR: No, did I say that? Oh, gosh,

6 I hope I didn't.

7 MEMBER SIEBER: You didn't say that.

8 VICE CHAIR SHACK: No, I'm just going back

9 looking at the Level D limits. They're already three-

10 quarters for 1 and 2.

11 MR. FAIR: Yes, but they fixed that via a

12 RADA to make it two-thirds. They didn't intend to do

13 that. That was a mistake.

14 MEMBER SIEBER: Less than Code. So what's

15 the plan now? Revise 5055(a)?

16 MR. FAIR: Yes, when the new Code changes,

17 get it into the Code. Then the plan is the next

18 endorsement in 5055(a) after those changes get in, we

19 will endorse with this one exception.

20 MEMBER SIEBER: What do you want from us?

21 MR. FAIR: I really wasn't --

22 (Several speaking at once.)

23 MEMBER SIEBER: Just information.

24 MEMBER ARMIJO: John, when do you think

25 that's going to get resolved, the final issue in the

1 new Addenda?

2 MR. FAIR: I think the ASME representative

3 is probably better posed to give you the schedule.

4 MEMBER ARMIJO: Okay.

5 MR. FAIR: But once the Code gets changed,

6 then in our cycle of updates we'll pick it up.

7 MEMBER ARMIJO: Okay. Mr. Chairman, I

8 think the next speaker will be ASME and Mr. Balkey.

9 We're running a little bit late. So we'll try not to

10 interrupt if you'll just move right along.

11 MR. BALKEY: Good morning. I'm Ken

12 Balkey. I'm Vice President of ASME, Nuclear Codes and

13 Standards. I'm joined here today with my colleagues,

14 Richard Barnes who is the Chairman of ASME Section 3

15 and also with Kevin Ennis who's the Director of ASME's

16 Nuclear Codes and Standards from the ASME's staff.

17 Thank you for the opportunity to meet with you here on

18 a subject that has gotten an enormous amount of work

19 over the many years addressing these seismic concerns.

20 Could we go to the next slide please?

21 What we'd like to do is Kevin and I would

22 like to give a little bit of an overview of our Codes

23 and Standards process and some of the questions you

24 just raised about using more of a risk-informed

25 approach to dealing with these issues. I'm going to

1 discuss about that in terms of addressing the issues
2 we have here, of today's topic, but where we're trying
3 to go in the future. I'll just take a few minutes to
4 do that and then we'll turn it over to Richard Barnes
5 to do the technology discussion that will compliment
6 the remarks the staff has just provided to you and
7 then Richard will provide a summary. Next slide
8 please.
9 Today's a special day for our society. It
10 was founded exactly 126 years ago today at the first
11 meeting of the society and our Boiler and Pressure
12 Vessel Code was founded in 1911. So the main
13 committee of the Boiler and Pressure Vessel Code is in
14 its 95th year of operation.
15 MEMBER SIEBER: You don't look that old.
16 MR. BALKEY: None of us were there. Our
17 colleagues from Westinghouse in the early days were
18 there back, not 1915, but back of that very long
19 period and the Boiler and Pressure Vessel Code of
20 course addresses a very serious issue that was
21 occurring 100 years ago with we had a boiler explosion
22 every day that was killing people and the strength of
23 the process is actually bringing representatives from
24 the people who built the equipment, the people who
25 owned the equipment, those who insure it, those who

1 manufacture it and come in as engineers, as
2 individuals engineers, to come to agreement on what
3 are the appropriate standards we all need to work to
4 in order to assure safety in our operation.
5 So in our codes and standards while we are
6 representing the nuclear codes and standards, we also
7 have three other boards that deal with standards
8 dealing with standardization and testing, dealing for
9 instance like screw threads and safety codes and
10 standards such as like for elevators and escalators.
11 In our Board on Pressure Technology is where the
12 Boiler and Pressure Vessel Committee resides and as
13 Gene Imbro indicated in his remarks, there are 12
14 sections reporting to the Boiler and Pressure Vessel
15 Committee, two of them being nuclear, Section 3 and
16 Section 11, Section 3 with the design rules and
17 Section 11 with the in-service inspection.
18 But the way that we are organized, our
19 Board on Nuclear Code and Standards, we have technical
20 oversight of Sections 3 and 11. But any technical
21 procedures that come forward out of those groups come
22 before the main committee that has very broad
23 representation from a number of industries who are of
24 course addressing the same issues and I think you
25 heard John Fair indicate that even though the nuclear

1 representatives can bring an action forward John
2 mentioned a case where other representatives from
3 other industries say that they may disagree before
4 they were allowed to move forward.
5 The other connection we're trying to make,
6 I won't go through our entire organizations, but our
7 newest group is on the left side there with this
8 Committee on Nuclear Risk Management. So we have been
9 working for the last at least ten years, maybe even 12
10 years bringing experts on to our standards committees
11 who have background in risk analysis and in
12 probabilistic methods. The issue is how we organize
13 it and I'll discuss it in terms of some of our
14 strategic initiatives that build off the discussion on
15 the issue of concern. Next slide.
16 The next slide just gives verbally the
17 listing of the committees in order to go along with
18 the abbreviations. So we have the committees
19 reporting to the Boiler and Pressure Vessel Committee
20 including our subcommittee on Nuclear Accreditation
21 and on the direct nuclear ones dealing with the in-
22 service testing, quality assurance, risk management
23 and we even have a committee on cranes. Next slide
24 please.
25 I'd like to ask Kevin Ennis to take a few

1 minutes to walk through how we put our roles together
2 and I know the question came up, this has been going
3 on for 12 years and one thing that ASME has done is we
4 have greatly expanded the international organization.
5 We have Mr. Barnes who will discuss we
6 have enormous contributions coming from Japan in
7 particular dealing on this issue in addition to our
8 colleagues here in the United States with the Electric
9 Power Research Institute along with many others. In
10 fact, Mr. Barnes is from Canada and chairs our group.
11 So we are trying and as all of you are well aware, our
12 nuclear industry is becoming more global as each day
13 moves forward, just not that the plants operate
14 globally, but in terms of how other countries look to
15 us for standards and seek our standard or another
16 standards and we're always trying to seek the input,
17 the worldwide input, on what we do.
18 At this point, I would like to turn it to
19 my colleague, Kevin Ennis, here to just go through the
20 process we go through to get this input.
21 MR. ENNIS: Thank you, Ken. As noted
22 earlier, I'm Kevin Ennis. I'm Director of Nuclear
23 Codes and Standards. I'm the person, I guess,
24 responsible for finally getting all these documents
25 actually in print and out the door which means I get

1 blamed for most everything. But that's the nature of
2 what I do.
3 We sum up our process saying that we try
4 to bring together two things to equal a product. We
5 try to get the best people we can. We have a good
6 process that we understand and we actually follow.
7 And we try to deliver a product that everyone can use.
8 Our people are good technically, some of the best in
9 the world and as Ken noted, internationally we have
10 people from all over the world that do participate in
11 our process.
12 Just in nuclear, there is approximately
13 800 engineers that do participate in the process. Now
14 most of them are in Sections 3 and 11. Those are the
15 two really big groups that we have and these
16 participants are supported by their employers.
17 They're not paid by ASME. The NRC, thank you,
18 strongly supports our process and sends their people.
19 Our process is formal. We do have
20 requirements and we do maintain it for balance of
21 interest so no one can predominant. We have the
22 regulatory authorities. We have the suppliers, the
23 vendors. We have the utilities. We have inspection
24 agencies and we actually have state authorities
25 represented at both 3 and 11, so that there is a broad

1 group that goes on. While it was mentioned a number
2 of times especially in the Boiler Code, something
3 unusual happens in that after we get through
4 discussing all the issues and we come to consensus on
5 the solution, we have to bring it to the Boiler and
6 Pressure Vessel main committee. We really have an
7 extremely broad view of all the items because now you
8 bring in petrochemical, you bring in fossil fired
9 utilities and others, even pharmaceutical companies
10 that use our equipment. So there is a broad range of
11 knowledge and experience, a lot of it very
12 sophisticated, but has a different point of view.
13 CHAIR WALLIS: So while this was going on
14 with these numbers changing from three to 4.5 or
15 whatever they were doing, was this consistent with
16 what's done in the chemical industry or was it much
17 more conservative or what was it?
18 MR. ENNIS: A personal opinion if I could
19 put it there is this is more conservative than what's
20 done in the petrochemical industry.
21 MEMBER POWERS: A lot of the chemical
22 industry differences are associated with the
23 anticipated link to lifetime of equipment.
24 MR. ENNIS: Right, and they also use risk
25 technology in the petrochemical industry also and

1 their use of risk technology is also quite
2 sophisticated, but it is different from ours.
3 MEMBER POWERS: Yes.
4 MR. ENNIS: So they do bring something to
5 the table. All our meetings are open to all and, of
6 course, we do provide for procedural due process.
7 Anybody who is adversely affected by a rule change can
8 appeal to a higher authority at the ASME. It happens,
9 fortunately, rarely, but it does happen.
10 And here's where we talk specific about
11 now. We want a technologically-superior product at
12 the end of the day and we are willing, as you note, 12
13 years to sacrifice our schedule to achieve it.
14 Sometimes in good humor and sometimes not, we refer to
15 some time frames as ASME years and I think if we
16 usually use the one to seven ratio we're only two
17 years into this process. Hopefully, we can speed it
18 up. Next slide.
19 Our participation as I said earlier is
20 voluntary participation. For those in my position,
21 the term of art is herding cats. We know we want
22 certain things to happen, but the priorities are
23 really set by the volunteers themselves. We rely on
24 industry experts and so the expertise that comes to
25 the table is what develops the code. My staff, we

1 provide the structure and administrative support and
2 we do check to make sure all the procedural processes
3 are followed before any item will ever get to my board
4 for final approval.
5 CHAIR WALLIS: You don't say anything
6 about academia. There are many members of ASME in
7 academia.
8 MR. ENNIS: Yes, there are.
9 CHAIR WALLIS: There is not just industry
10 that you're referring. Industry includes academia.
11 MR. ENNIS: Industry in my term includes
12 everybody.
13 CHAIR WALLIS: Okay.
14 MR. ENNIS: We include at ASME the NRC as
15 part of our industry that we support. The regulatory
16 authority isn't separate from that industry and
17 actually we had a joint meeting yesterday where one of
18 the individuals who's the Chairman of ANS committee,
19 we have a joint committee going, who is a professor.
20 So, yes, we do have academia in our structure.
21 Actually, on that particular group yesterday, we had
22 two professors. One is from the University of Mexico.
23 MEMBER POWERS: That's way too much.
24 MR. ENNIS: So we have Texas and Mexico
25 represented on our committees. With that, I'll turn

1 it over back to Ken.

2 MR. BALKEY: Next slide please. In

3 looking at the issues that were discussed here with

4 the seismic design rules, our board has been looking

5 out to the future, where we need to go, and we have

6 gone through a very intense strategic planning effort

7 and we have four areas that we're trying to address

8 and it gets right at the heart of the technical issue

9 which is the subject here today.

10 We have, as you well know, been in front

11 of the ACRS on risk-informed in-service inspection and

12 testing, our policy risk informed standard. But now

13 under Mr. Barnes' leadership, we have set up a working

14 group on probabilistic methods and design. And the

15 reason for that is that in the piping design you're

16 always competing against, if you add too much

17 conservatism in the seismic, it then can cause actual

18 challenges and making systems stiffer that can cause

19 higher stresses during normal operations, just heating

20 up and cooling down the plant.

21 And you're trading off how do you deal

22 with this event. It occurs with the likelihood

23 hopefully much less than one with events that do occur

24 at one and trying to balance that and it depends on

25 the system. If I have a system with many different

1 operating states where I get a lot of changes, I need
2 to have more flexibility to deal with the thermal
3 expansion and if I make that system stiff, it will
4 work against me in my normal operation.
5 The Code in its present form, the
6 deterministic rules, don't allow for that. You have
7 to use the same stress indices and allowables for each
8 system and what we're trying to move to is a
9 reliability-based method using this load resistance
10 factor design method that would allow the designer to
11 move those margins as appropriate depending on the
12 case and you would be working to a probability of
13 failure and acceptance criteria rather than saying I
14 have a factor of two.
15 I think as most would know I could say I
16 have a factor of two and in one system it may
17 translate to a very low probability. But in another
18 system because of all the scatter, the probability may
19 not be as low as you may think it would be. So we are
20 trying to get to that, but to get to that point we're
21 bringing the expertise into standards groups and in
22 fact, we have an effort underway how we organize in
23 developing rules. Do we bring the experts all into
24 Section 3 or do we let our committee on Nuclear Risk
25 Management build on their expertise and have a

1 relationship? So we are right now evaluating how to
2 organize to be able to move forward with that
3 initiative and we actually have a research project
4 underway with support from an NRC grant and a Japanese
5 grant looking at this approach.
6 The other need as you're all very well
7 aware is the filing here for early site permits and
8 combined construction and operating licenses and, of
9 course, developments in China and over in Europe and
10 Eastern Europe and we are very interested in getting
11 this issue today done, endorsed and Mr. Barnes will
12 talk to it because of the developments around the
13 world. We can't take that long in the future if we're
14 going to support new construction.
15 So we're trying to make our codes and
16 standards easier to use not just in the United States,
17 but in the international community and we have
18 actually set a team up under our board and so has the
19 Nuclear Regulatory Commission. As we get our
20 standards done, they get endorsed in a more timely
21 manner, both together. As Kevin indicated, we need to
22 get things through our process and likewise if we keep
23 the staff informed of what our priorities are that
24 will help things move along as well. We have that in
25 place as well.

1 But we just thought you may interested
2 instead of just talking this issue about what we're
3 trying to do in a broader context as well. With that,
4 I'm going to turn it over to Mr. Barnes and let him
5 now get into the technical discussion.
6 MR. BARNES: Thanks, Kevin. Kevin was the
7 Chairman, gentlemen. I think I've met a couple of you
8 previously. The face is familiar but I think you were
9 in one of the presentations we made.
10 I would just like to turn to the slide
11 where the background review is and I'm not going to
12 take long on this. Obviously, it's been hit a couple
13 of times. There are effectively three studies the way
14 I viewed it and the first one was the one where we
15 looked at the results of the experiments. An actual
16 fact: Industry provided $1 million to set up a
17 separate group of people to try and develop rules from
18 that and they picked out the experts that they felt
19 could do that.
20 These rules were provided back to the Code
21 committees and this occurred just at the time I took
22 on the chair of Subgroup Design. So I've been around
23 as long. I also must admit to you that I still didn't
24 have hair when I started on. I didn't lose the hair
25 because of this work, however. What happened there

1 was we had extensive discussions and we came up with
2 a set of rules.
3 The second study occurred. We got the
4 letter from -- We set up a committee immediately
5 afterwards because that was my role and I realized
6 that when the new rules came out, we had unresolved
7 issues. We got the letter from NRC and that was the
8 basis of some of the discussion, but we also got
9 letters from Japan and we got letters from individual
10 members. We had whole slew of issues that a couple of
11 meetings were spent just breaking them out into lots
12 to know how to handle it. This resulted in some small
13 changes in the Code that were set out in 1994. It's
14 small in our opinion, but obviously significant from
15 the U.S. NRC.
16 The Study No. 3, 2003-2005, I refer to the
17 recent cooperative effort between U.S. NRC staff and
18 ASME people, experts, and I'll address those. I think
19 I've handled this next slide.
20 CHAIR WALLIS: Can I ask you something?
21 MR. BARNES: Sure. Go ahead.
22 CHAIR WALLIS: We saw very crude numbers
23 formulated this morning.
24 MR. BARNES: Yes.
25 CHAIR WALLIS: Threes and fours and so on.

1 MR. BARNES: Right.

2 CHAIR WALLIS: This must depend on the
3 materials. I mean the stainless piping isn't the same
4 as carbon steel piping and it isn't the same at
5 different temperatures and so on. You can't just have
6 a magic number it seems to me that covers all
7 materials.

8 MR. BARNES: Let me explain my
9 understanding of this. One of the problems, I'd just
10 like to preface this by saying unfortunately we're an
11 organization as you see we meet four times a year and
12 our ability to get ready for something like this that
13 came up after the last meeting and before the next
14 one, it's impossible to get people organized. I'm
15 going to ask that we have a chance to make a
16 presentation at a later date to at least get our
17 position on there.

18 I don't usually talk about frivolity but
19 I believe we've spent so many millions and millions of
20 dollars and man hours on this job. It's extensive
21 that's going on and I believe it deserves at least to
22 have our side also put into it even though we have
23 reached agreement on things.

24 It's just Study No. Two I would like to
25 just address the issues, Mr. Chairman. The two, the

1 factor of two, as I understood it, was based on the
2 fact that if we maintain the factor of two, the
3 capacity factor of two I think it is, for one percent
4 probability that the piping would then no longer be
5 considered as part of the meltdown of the reactor. So
6 if we kept two, that factor, then we are kept out of
7 that hornet's nest. Now I may be wrong, but that was
8 my understanding.
9 We then put a factor of 1.5, they were
10 three factors that Robert Kennedy, and just to preface
11 this, the three factors, the 1.5 was on the stresses.
12 Then there was the factor for redundancy and the
13 factor for -- What was the other one?
14 VICE CHAIR SHACK: Dynamic effect.
15 MR. BARNES: Dynamic effects, yes.
16 VICE CHAIR SHACK: Nonlinear dynamic
17 effects.
18 MR. BARNES: And Kennedy came up with the
19 point, the 1.33, was there. Then the rest was in the
20 redundancy. So the term of it is all we have a set of
21 experiments which we tried to get some understanding.
22 What we did discover was that the experiment showed
23 which everybody I think sort of knew that the failure
24 mechanism was not collapse but fatigue when you got --
25 Now that's pretty obvious, but however we had tried to

1 handle it with plastic collapse. It resulted in very
2 conservative results and you have to excuse me. I am
3 not an expert in this field, but I've been around long
4 enough that I have some of the language together. It
5 resulted in this excessive conservatism at the time.
6 Furthermore, the thing that worried me as
7 chairman of Subgroup Design, it did not address the
8 failure mechanism and I don't care how strong you make
9 things if you don't understand why things fail. So
10 what happened was they took all the results and there
11 was a lot of discussion. John was part of the first
12 area of it very much so.
13 They developed these equations. They had
14 a problem. They had these equations in programs,
15 hundreds, probably thousands of programs around the
16 world and they said if we change the equation which it
17 should have been a fatigue-based equation, they're
18 going to impact all these programs. So what they
19 decided to do was effectively change the factors in
20 the equations and make it an empirical equation. And
21 what always astounds me is people go into this
22 empirical equation and start to adjust the numbers as
23 if it were a true descriptor of the --
24 CHAIR WALLIS: But it's supposed to
25 describe it. It says it describes a brand new pipe

1 and a 60 years old pipe as the same.

2 MR. BARNES: What it does is basically the

3 way you use, the way I interpret this, is if you put

4 the numbers into this equation what it effectively

5 gives you is a system that's supple enough to

6 withstand the earthquake. See, the concept is is to

7 keep away from the forcing function of the frequency,

8 the forcing function that is the same as the natural

9 frequency of the system. That's where the worse

10 situation is.

11 What this does if you meet these

12 equations, you effectively get a system that's more

13 flexible. Now the difference is how you take all

14 these experiments and translate it into this empirical

15 equation and that's one of the difficulties we did

16 have in ASME because our people are interestingly type

17 people, not on the experimental side and we brought in

18 Robert Kennedy and Bill Iwan from CalTech to assist us

19 and they had been part of the U.S. NRC effort in this

20 area as well.

21 Effectively the rules we have, the

22 concept, we had this 4.5 which wasn't a true

23 descriptor of the stresses, but the trouble of it is

24 is it looks like it and it created a lot of problems.

25 And Kennedy said let's adjust it. Let's go to three

1 and adjust the figures on the front end and the optics
2 are correct. But basically, if you would, you get
3 into the detail of it, Kennedy shows you that
4 effectively the components remain elastic although
5 some local plastic activity in it. But effectively,
6 the overall system is elastic.
7 Now I'm starting to get into really deep
8 water here.
9 CHAIR WALLIS: Good swimming.
10 MR. BARNES: There's a good chance that I
11 could quite easily become very tired if somebody
12 questions all these details. But the point is that
13 was the sort of concept and we have a very lot of
14 intelligent people as U.S. NRC has too and they aren't
15 just playing numbers for the sake of it.
16 What we ended up coming down to because
17 the practicality of life also rules, what you end up
18 doing is you make decisions and say "What the heck?
19 That doesn't mean anything. We can argue about this.
20 We can disagree, but if we change it to that, nothing
21 has changed. We still have to save systems." So
22 that's the way standards are developed. Nothing is
23 perfect, but we know that we have at least a safe
24 area.
25 MEMBER KRESS: Sounds like to me ACRS

1 knew.

2 MR. BARNES: Yes. Well, I'm sure you tell

3 an operator the same given all the background that you

4 have.

5 CHAIR WALLIS: Well, you're really scaring

6 me because you're making me feel like I'd better find

7 out more about what you're doing.

8 MR. BARNES: And we'd be happy.

9 CHAIR WALLIS: I don't really want to get

10 involved.

11 MR. BARNES: We have the same feeling.

12 Believe me. We would love the opportunity to go into

13 it in more depth if you would like to.

14 VICE CHAIR SHACK: Just out of curiosity,

15 do you think that the piping systems for new plants,

16 will they still be designed by rule or will they be

17 designed by analysis now? We can do so much more.

18 MR. BARNES: Piping, I think it's too

19 complex to decide.

20 VICE CHAIR SHACK: Still --

21 MR. BARNES: Yes. Furthermore, piping is

22 so forgiving. It's hard to believe. You look at the

23 effort that's going in and you wonder about it. You

24 look at the unknowns that are in the seismic event and

25 all of that and you come up with these rules. The way

1 I look at it is as long as if you address the failure
2 mechanism and you've given as much bounding as you
3 can, then you've done about what you can do I think.
4 I think we need much more complex analytical
5 techniques eventually to actually truly analyze.
6 VICE CHAIR SHACK: Of course, the
7 conservatism has turned out to be quite useful that
8 you can live with cracking. It's amazing how flaw
9 tolerant these systems have turned out to be.
10 MR. BARNES: Yes.
11 VICE CHAIR SHACK: And no one designed
12 them to be that way.
13 MR. BARNES: No, except in actual fact,
14 it's the materials.
15 VICE CHAIR SHACK: Yes.
16 MR. BARNES: They went to a great effort
17 and ASME goes to extreme effort to make materials good
18 and in the Class 1 particularly, it's limited to very,
19 very forgiving material. Do you know what I mean? So
20 in the end, that's probably the clue to the whole
21 thing.
22 MR. ENNIS: Yes, and if you look at the
23 other sections of the Code, sometimes in Nuclear, we
24 forget that the rest of the world exists. There is
25 ASME stamped equipment that has been operating for 80

1 years and when I worked at my previous employer at the
2 National Board, we would answer questions on riveted
3 vehicles. So the limitations while many times they
4 seem to be 1.5, 3, three-quarters, the basis of the
5 Code is not only to design it new but to assure that
6 there is a good useful life so that equipment, yes,
7 has imperfections and it over time cracks, leaks, what
8 have you, but it prevents it from catastrophic failure
9 and that comes back into when these things come up to
10 the main committee, there is experience with this.
11 Some of these people are running utilities that are
12 much older than the nuclear plants on the fossil side.
13 So they do have lots of experience with this type of
14 problem.
15 MR. BARNES: Okay. I just want to make a
16 couple more points on this second study. One thing
17 that John forgot to mention was that there was a very
18 extensive Japanese effort that went into this as well
19 and Kennedy was able to take the Japanese experimental
20 results and use those to validate what had happened
21 previously and to validate the approach that he had
22 given ASME in that direction.
23 The Japanese did some fantastic work.
24 They took that Test 37 that went over. They were able
25 to actually reproduce that analytically and explain

1 it. So we had a much better understanding of all
2 this. In fact, we had some pretty interesting tools
3 that could come out of it. We didn't have to end up
4 doing this very complex analysis. They were able to
5 take the work that they did and the work that Iwan
6 did, although this is not in the Code as such, but
7 predict this with much simpler analytical techniques.
8 Generally speaking, those two people
9 agreed with what we had come up with, although NRC had
10 disagreed with it, some aspects of it. But
11 effectively, Study 2, the rules we came up with then,
12 we had really good analytical and really good expert
13 background from all areas as a basis for the concepts
14 we came up with. And we believe we had more than
15 enough adequate conservatism in them.
16 Moving on, I'd just like to go to Study 3.
17 Gene Imbro and I got together and I really appreciate
18 it. To be honest, I must compliment to Gene. He's a
19 very accessible person who is looking for solutions
20 and as the Chairman of 3, I found that very useful and
21 ended in a very collaborative effort, of which we came
22 up with and we finally came down, we got a group of
23 experts together again, and we came up with and
24 resolved five of the issues.
25 So I would like quickly to just go through

1 to the sixth issue which is on page 16. And our 12
2 percent, I look at that 12 percent and I think what's
3 12 percent. With all the uncertainties around this,
4 it's a joke. Well, I don't want to be recorded as
5 saying that, but the point about it is --
6 CHAIR WALLIS: But you have been here.
7 MR. BARNES: But I didn't finish if you
8 notice. I just said joke. Anyhow the point I'm
9 trying to make is that why we have a difficulty with
10 it I guess is because when the Code committees looked
11 at it they thought that it is just not that
12 significant. We believe that the strain rates
13 achieved during the seismic event is insignificant in
14 its impact on dynamic strain aging. We agree it's
15 there, but for the reactors, we just don't believe
16 it's significant.
17 Although there are no experimental tests
18 to demonstrate this, an analytical evaluation was done
19 to show that the safety margin did not reduce below
20 1.5 at the higher temperatures.
21 VICE CHAIR SHACK: Haven't we done enough
22 dynamic analyses of these systems to have a pretty
23 good feel for what the strain rates are?
24 MR. BARNES: Well, we think so, but there
25 are disagreements. There are opinions. The Code

1 committee decided that the margins available are more
2 than enough to cover the seismic loadings and so no
3 change was made to the Code requirements from that.
4 CHAIR WALLIS: So what you're saying is
5 the seismic event is nothing like getting hit with a
6 hammer. It's something that builds up.
7 MR. BARNES: Yes, and it's a fatigue.
8 That's why we address that part of it as fatigue.
9 MEMBER POWERS: When you think about a
10 seismic event and you think about failure by fatigue,
11 do you think about a seismic event or do you recognize
12 that all significant seismic events will be
13 accompanied by certainly aftershocks and often
14 preshocks? Do you think of them as the set of seismic
15 events or do you just think of a single event?
16 MR. BARNES: You're hitting me in deep
17 water here at this particular point, but we
18 effectively have, the way the Code evaluates it, it
19 takes 20 cycles of this criteria. It was based on 20
20 of the cycles. I don't know whether John can answer
21 that question.
22 CHAIR WALLIS: So it's only 20 cycles or
23 some seismic events last longer than that or come back
24 instead.
25 MR. BARNES: Yes. I think what happens is

1 when we get past the 20 cycles, then we --

2 MEMBER SIEBER: It appears longer.

3 MR. BARNES: Yes, I don't know whether --

4 MR. FAIR: I have to get up near the mike.

5 If I go there, it's the wrong place. The current

6 criteria you evaluate fatigue under OBE and you assume

7 five OBEs. In the new criteria that's eliminating

8 OBE, the previous design certifications have thrown in

9 two SSEs for the fatigue evaluation. We haven't

10 really developed an official staff position right now

11 for going forward, but, say, for the older plants, the

12 staff position was 5 OBEs which were intended to

13 account for the build-up of cycles to aftershocks and

14 things like that.

15 CHAIR WALLIS: What's an OBE?

16 VICE CHAIR SHACK: Operating basis

17 equation. Your plant keeps on ticking after that.

18 MR. BARNES: That's right.

19 CHAIR WALLIS: I thought an OBE was an

20 Order of the British Empire.

21 MR. BARNES: That's my time to exit. I'm

22 starting to get in deep water here.

23 MR. ENNIS: Yes. When we said he was

24 Canadian, we didn't tell you the whole truth. He's

25 really Australian, then Canadian.

1 MR. BARNES: I'm really very confused.

2 MEMBER POWERS: That's all very

3 interesting because we think about sites and spend a

4 lot of time worrying about the intense earthquake, but

5 we don't characterize sites by if you had an

6 earthquake how many preshocks do you have, how many

7 postshocks do you have.

8 MR. BARNES: Yes.

9 MEMBER POWERS: And clearly the challenge

10 that we face is is it hard enough to find the

11 paleoseismic data for having an earthquake. We have

12 no paleo-data from preshocks and aftershocks and if

13 you don't have good models of seismic events on the

14 east coast, how do you have a database that

15 substantiates whether 5 OBEs or 2 SSEs are inadequate

16 for failure that you assume is occurring by fatigue?

17 VICE CHAIR SHACK: Of course, it is the

18 big ones that kill you. You can take a lot of elastic

19 cycles, the number of plastic cycles that you can take

20 goes down real fast.

21 MEMBER POWERS: Understand that an

22 aftershock can be pretty indistinguishable from the

23 main shock. Seismologists have an understanding on

24 what constitutes an aftershock, but the magnitude of

25 the earthquake can come very close to what the main

1 shock is. Now five is a pretty good number for large,
2 I mean it's a conservative estimate of large
3 aftershocks, but it's not completely wild by any
4 means. There's nothing. It's not completely
5 unimaginable for California earthquakes that I have
6 absolutely no experience nor does anybody here though
7 maybe your founders in 1880 did with large east coast
8 earthquakes and how many aftershocks and preshocks.
9 But I would suspect they have more.
10 MR. BARNES: The summary, the industry
11 cooperation with ASME and U.S. NRC have spent
12 millions. NRC has funded very extensively and we
13 appreciate that input. We have reached major
14 agreement and there really is only one issue
15 separating us and the Code committee believes that the
16 impact of dynamic strain aging for the reactors is
17 insignificant. As you have seen in our presentation,
18 the Code process is consensual. We really require
19 meetings to discuss and approve the Code position.
20 We didn't have an opportunity to develop
21 a consensus presentation for the Code position in time
22 for this meeting. The next set of meetings is in May
23 and a presentation will be developed at that time and
24 we respectfully request the opportunity to --
25 CHAIR WALLIS: By that time, you will have

1 resolved your differences.

2 MR. ENNIS: Maybe.

3 CHAIR WALLIS: I think that would be a

4 good time to tell us when you've resolved your

5 differences which I hope will be soon.

6 MR. BARNES: Okay. Yes, that's mine.

7 Thank you very much.

8 CHAIR WALLIS: Mr. Barnes, gentlemen,

9 thank you for the opportunity.

10 MEMBER ARMIJO: We're right on schedule.

11 A little bit over. I think we can wrap this up.

12 Although we don't have a date for closure which would

13 be nice to have, maybe May or so, and I think the

14 issue of dynamic strain aging has to take some

15 negotiation. It seems like a small issue but

16 apparently not so small to the NRC staff. So we'll

17 have to just wait and see how they can resolve that.

18 Does anyone else have any comments? I'll

19 just tell you from myself this is an issues that's

20 surprisingly long term and it is pretty much resolved

21 and I frankly don't understand why we're reviewing it.

22 CHAIR WALLIS: I think the question is do

23 we write anything about this or do we just wait until

24 we hear resolutions?

25 MEMBER ARMIJO: Right. I think other than

1 a short note to whomever you care to write that we've
2 reviewed it and it's well on its --
3 CHAIR WALLIS: We don't necessarily have
4 to write anything. We don't necessarily need to.
5 MEMBER ARMIJO: We don't have to. That's
6 fine. I don't know if anybody else on the Committee.
7 MR. SANTOS: The way it was explained to
8 me, Cayetano Santos, NRC staff, by Sandra Osami is
9 that the Commission ordinarily asks the ACRS to review
10 and once the Addenda came out and the staff raised all
11 the concerns with it, that's why it's before the
12 Committee in this format as opposed to when the staff
13 typically updates this 10 CFR 55(a). That's the way
14 it was explained to me and why the Committee was asked
15 to review it and maybe write a letter to the
16 Commission.
17 CHAIR WALLIS: They want us to make a
18 technical review of the issues. That's quite an
19 undertaking.
20 MEMBER ARMIJO: I can't imagine that. I
21 think if it's a status report, I don't know whether
22 that's our function. We reviewed it. It seems on its
23 way to resolution.
24 MEMBER MAYNARD: I don't think we
25 necessarily need to send a letter. I do think we

1 should encourage both the staff and the ASME to come
2 to agreement on this. I don't see that there's that
3 big a difference and I'm wondering if we're kind of
4 getting into egos here or whatever when really you
5 just need to decide on one of the two numbers. I
6 don't see that it's that big a difference.
7 VICE CHAIR SHACK: Yes, without reviewing
8 a number of dynamic analyses of plants, I have no real
9 good feel for what these strain rates are. But it
10 seems to me a technically resolvable thing. I just
11 believe there are enough calculations that have been
12 done that they can be reviewed and the decision made.
13 But I certainly can't do it.
14 MEMBER ARMIJO: Even if there is no
15 resolution, there's resolution on five of six items
16 and the other one can just be NRC staff takes
17 exception to that and continues on.
18 CHAIR WALLIS: So if we get involved in
19 this, we might decide the number should be 2.95
20 instead of something else and then we'll really get in
21 trouble.
22 MEMBER ARMIJO: I don't think --
23 MEMBER MAYNARD: I would like to encourage
24 the staff though and the ASME to try to come to
25 resolution even on this one so that it doesn't have to

1 be endorsed with an exception. Again, I'm struggling
2 with whether there's a big enough difference to
3 constitute an exception or not.
4 MEMBER ARMIJO: Okay. Thank you, Mr.
5 Chairman.
6 MEMBER POWERS: It seems to me that
7 there's a couple of issues that one needs to think
8 about a little bit not in connection specifically with
9 this but in the future. I think Dr. Shack raised the
10 question of design by rule design by analysis and what
11 will happen there and that seems like an interesting
12 issue for the Committee to pursue a little bit. In
13 the thinking about what we're going to face in 2008,
14 this question of fatigue and earthquakes seems to be
15 one that we need to chase down a little bit farther.
16 CHAIR WALLIS: So we have some take-aways
17 from this too. Anyone else? Are you ready for me to
18 declare a break? We will take a break until 10:30
19 a.m. We will reassemble in the Subcommittee Room up
20 on the second floor in the other building. We won't
21 need the transcript anymore. Thank you very much and
22 thank you for your patience with the mike problem.
23 Off the record.
24 (Whereupon, at 10:11 a.m., the above-
25 entitled matter was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards 531ST Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Lindsey Barnes

LINDSEY BARNES
Official Reporter
Neal R. Gross & Co., Inc.

PIPING SEISMIC DESIGN CRITERIA

Presented to
Advisory Committee on Reactor Safeguards

April 7, 2006

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Statement of Issue

1994 Addenda to the ASME Code, Section III adopted revised criteria for piping seismic design. These criteria specify significantly higher allowable stresses than those specified in the previous ASME Code version. The NRC staff did not endorse the revised criteria because of concerns with the technical basis used to establish these criteria.

Background

- Dynamic tests of piping components (EPRI, ANCO) performed during mid to late eighties.
- ASME Code Special Task Group established 1991 to assess margins in current piping rules. NRC staff participated as members.
- ASME revised the Code piping rules in the 1994 Addenda. The revised rules established higher allowable stress limits for seismic loads.
- NRC representatives on ASME committees voted negative on the proposed change to the rules.
- NRC informed ASME that it would not endorse the new piping criteria in a December 14, 1994 letter.
- NRC staff documented its technical concerns with the new rules in a May 24, 1995, letter to ASME.

Background (Continued)

- ASME established the Special Working Group - Seismic Rules (SWG-SR) in September 1995 to evaluate technical concerns raised by NRC and others.
- Energy Technology Research Center (ETEC) reviewed the technical basis 1994 for the piping seismic criteria under contract with RES.
- NRC staff and RES contractors participated in SWG-SR meetings as observers.
- NUREG/CR-5361 published June 1998 documented ETEC assessment of the 1994 piping seismic criteria.
- NRC Staff Briefed ACRS Subcommittee on Materials and Metallurgy June 1, 1998 and March 25, 1999.

Piping Design Criteria

- The ASME Code contains design criteria for Class 1, 2 and 3 piping.
- ASME Class 1 piping includes the reactor coolant pressure boundary.
- The design requirements for ASME Class 1 piping include a detailed fatigue evaluation whereas the design requirements for Class 2 and 3 piping do not.
- Piping is typically evaluated using the design rules in ASME Code Sections NB/NC/ND-3600.
- Class 1 piping is sometimes evaluated using the design by analysis criteria in Section NB-3200.
- The Code contains allowable stress limits for Level A, B, C and D load combinations.

Significant 1994 Code Revisions

- Strain limits were added to NB-3200.
- The Level D allowable stress limit was raised by 50%.
- A frequency limitation was established.
- Level D allowable limits for seismic anchor motions were established.
- A Level D allowable weight limit was established.
- New Level B and C allowable limits were established.

1994 ASME Code Level D Primary Stress Limit

$$B_1 \frac{P_D D_O}{2t} + B_2 \frac{D_O}{2I} M_E \leq 4.5 S_m$$

$B_1, B_2 = stress\ indices$

$P_D = pressure$

$D_O = pipe\ diameter$

$t = pipe\ wall\ thickness$

$I = pipe\ moment\ of\ inertia$

$M_E = moment\ amplitude$

$S_m = material\ allowable\ stress$

ASME Basis For Piping Criteria Changes

- Piping component test data demonstrates that piping collapse cannot occur during a seismic event.
- Piping component test data demonstrates that the possible failure modes during a seismic event are fatigue, fatigue/ratchet and progressive ratchet.
- Evaluation of the piping component test data demonstrates that the new seismic rules provide adequate margin against the possible failure modes.
- Evaluation of piping system tests confirms that the new seismic rules provide adequate margin against the possible failure modes.

Major NRC Staff Technical Concerns (May 24, 1995 letter)

- Insufficient test data to support the conclusion that piping system collapse will not occur.
- Inadequate evaluation of the existing test data.
- Insufficient technical basis for establishing minimum design margin.
- Inadequate technical justification for extrapolating margins obtained from component test results to actual piping systems.

NRC Research Program

- NRC established a program with ETEC in 1993.
- The program included an independent evaluation of EPRI/ANCO test data.
- Independent analytical studies of test margin extrapolations were performed.
- The program included a peer review group of experts.
- The program was completed and the results of this effort were published in NUREG/CR-5361.
- The review concluded that the technical basis for the rules published in the 1994 Addenda was incomplete.
- ETEC provided the technical information to the SWG-SR.

SWG-SR Effort

- The SWG-SR relied on the ETEC evaluation of the EPRI test data.
- The SWG-SR voted to adopt the margin definition proposed by R. Kennedy (i.e., 1% probability of failure capacity of 2).
- The SWG-SR proposed modifications to the rules based on evaluation of the test data using the Kennedy margin definition.
- Revisions to the piping rules were incorporated to address NRC technical concerns in the 2001 and 2002 Addenda to the Code.

Piping Seismic Design Criteria in 2002 Code Addenda

- The Level D allowable stress limit was revised back to 3Sm.
- New seismic stress indices were added for elbows, tees and thickness transitions.
- The stress indices for elbows and tees are different for ASME Class 1/2 components from those for Class 3 components.
- A D/t limitation was added to the criteria.
- The frequency limitation was deleted.

2002 ASME Code Level D Primary Stress Limit

$$B_1 \frac{P_D D_O}{2t} + B_2' \frac{D_O}{2I} M_E \leq 3S_m$$

$B_2' = 3/4 B_2$ *for Class 1/2 elbows and tees, but not less than* 1.0

$B_2' = 2/3 B_2$ *for Class 3 elbows and tees, but not less than* 1.0

$B_2' = 1.33$ *for thickness transitions*

$D_O / t \leq 40$

Staff Concerns With 2002 Piping Rules

- The new criteria should not be used with flow transient loads.
- The technical basis for the detailed rules in NB-3200 has not been established.
- The Class 2 and 3 Level B rules should be consistent with the Level D criteria.
- The rules should not supercede licensing basis criteria for generating seismic loads.
- The stress indices published in the 2002 Addenda for Class 3 tees and elbows were not acceptable.
- The use of the allowable stress for anchor motions should be restricted.

Recent Activities

- The staff issued a proposed rule amending 10 CFR 50.55a to incorporate by reference the 2001 Edition up to and including the 2003 Addenda.
- The proposed rule contained limitations to address the remaining staff concerns with the piping seismic design criteria.
- The ASME submitted comments on the rule limitations and requested that NRC continue its prohibition on using the seismic rules until the remaining issues were resolved (March 22, 2004 letter).
- The ASME formed a Seismic Project Team to resolve the remaining issues.
- The Seismic Project Team resolved 5 of the 6 issues.

Resolved Issues

- ASME initiated Code changes to eliminate applicability of the seismic rules to flow transient loads.
- ASME initiated Code changes to eliminate the NB-3200 strain criteria. This change was initiated by ASME prior to NRC comments.
- ASME initiated Code changes to modify the Class 2 and 3 Level B limits to be consistent with the Level D criteria.
- ASME initiated Code changes to eliminate specifying the methods to generate the seismic loads in the definition of M_E.
- ASME initiated Code changes to add provisions to the piping seismic criteria to address potential strain concentrations.

Remaining Open Issue

- Testing at Battelle has shown that certain carbon steel materials are subject to dynamic strain aging at temperatures greater than 300 °F.
- The dynamic strain aging results in a significant reduction in ultimate tensile capacity of the material (NUREG/CR-6226).
- Battelle testing of actual piping loops with large flaws under simulated seismic loads have shown a significant reduction in dynamic capacity at high temperature for certain materials (NUREG/CR-6233).
- Seismic strain rates can be in the range of concern (NUREG/CR-6226).

High Temperature Strain Rate Test Data (NUREG/CR-6226)

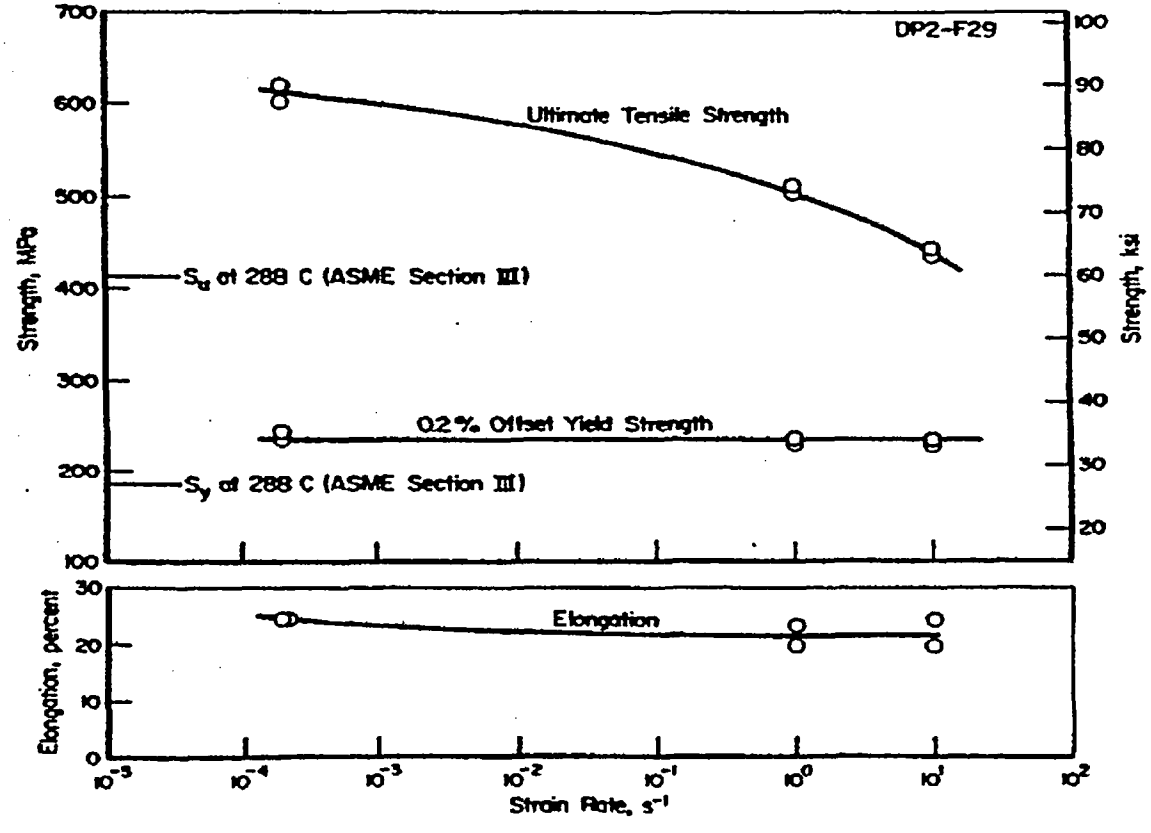

Figure 2.15 Tensile properties at 288 C (550 F) versus strain rate for Pipe DP2-F29 (A106 Grade B carbon steel pipe)

Proposed Resolution of the Issue

- Place restriction in the 10 CFR 50.55a endorsement of the ASME Code piping rules that $B_2' = 3/4 B_2$ for carbon steel elbows and tees at temperatures greater than 300 °F.

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ASME Nuclear Codes and Standards
ASME Code Section III – 1994 Addenda for Class 1, 2, and 3 Piping Systems

Advisory Committee on Reactor Safeguards
April 7, 2006
Rockville, Maryland

Ken Balkey, Vice President, ASME Nuclear Codes & Standards
Richard Barnes, Chair, ASME B&PV Subcommittee III
Kevin Ennis, ASME Director, Nuclear Codes & Standards

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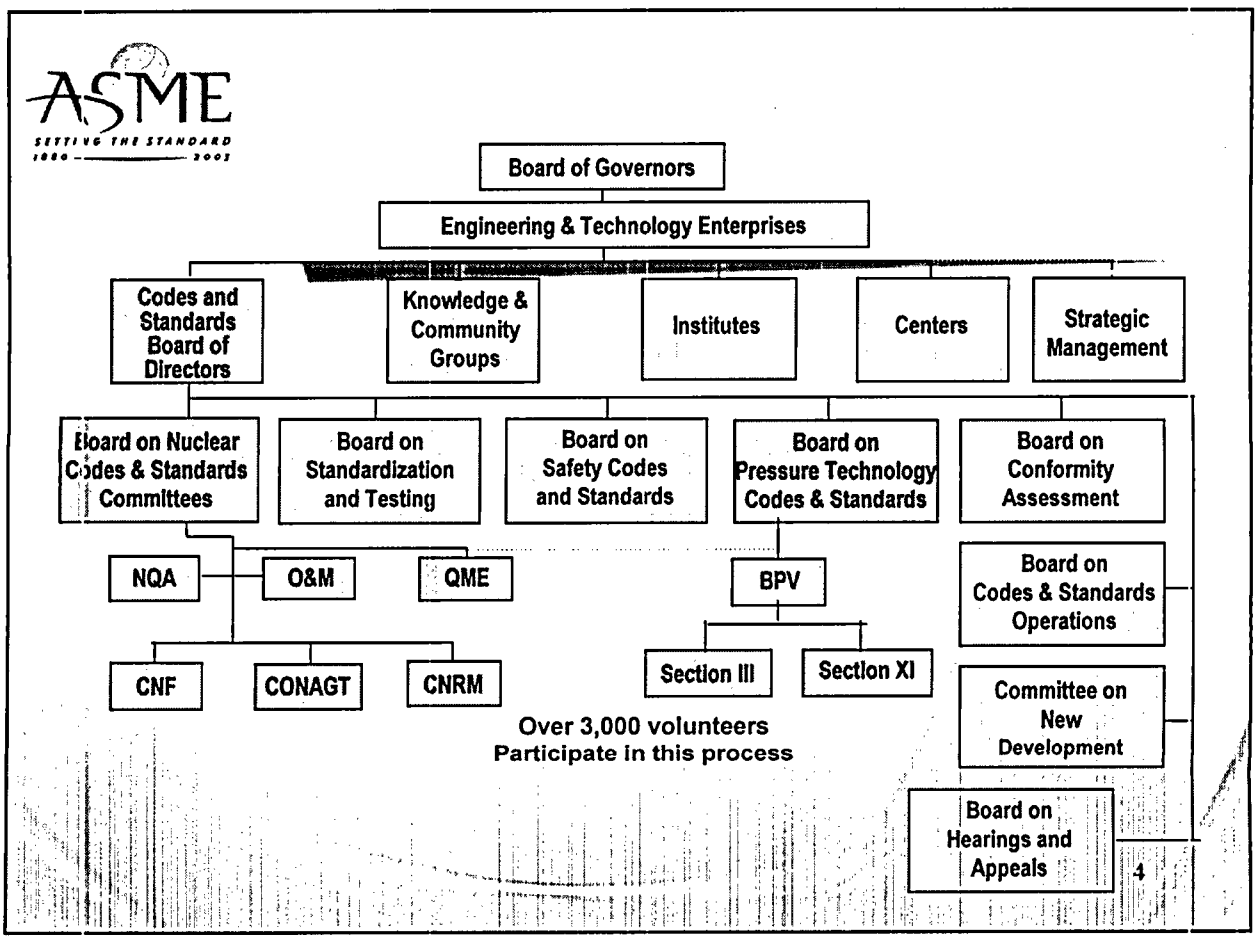
Topics

- ASME Nuclear Codes and Standards Overview and Initiatives
- Technical Discussion on Section III 1994 Addenda for Class 1, 2, and 3 Piping Systems
- Summary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Institutes
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Strategic Management
Board on Nuclear Codes & Standards Committees
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Board on Safety Codes and Standards
Board on Pressure Technology Codes & Standards
Board on Conformity Assessment
NQA
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BPV
Board on Codes & Standards Operations
CNF
CONAGT
CNRM
Section III
Section XI
Committee on New Development
Over 3,000 volunteers
Participate in this process
Board on Hearings and Appeals
4

Board on Nuclear Codes & Standards

- Standards Committees
  - Operation & Maintenance
  - Qualification of Mechanical Equipment
  - Nuclear Air & Gas Treatment
  - Nuclear Quality Assurance
  - Nuclear Risk Management
  - Nuclear Cranes
- 3 Subcommittees of BPV Committee
  - III – Nuclear Power
  - XI Inservice Inspection
  - Nuclear Accreditation

Nuclear Codes and Standards Consensus Process

- People
  - good technical people
  - approximately 800 engineers participate
  - participants are supported by their employers
- Process
  - formal procedures
  - balance of interest
  - open to all
  - Procedural due process
- Product
  - technically superior product
  - willing to sacrifice schedule to achieve it

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Nuclear Codes and Standards Consensus Process

Participation

- Voluntary participation.
- ASME Codes and Standards relies on industry supporting participation by knowledgeable experts.
- ASME provides the structure and and administrative support.

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Board on Nuclear Codes and Standards Initiatives

- Apply risk technology to Nuclear Codes and Standards
- Evaluate technical needs for new reactor technology
- Make Nuclear Codes and Standards easier to use for the international community
- Facilitate regulatory endorsement of Nuclear Codes and Standards

Seismic Rules for Piping

Status Report

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Background Review

- Three separate studies were done under the guidance of Section III
  - Study No: 1 1990-1994
    - Resulted in the publishing of new requirements in the BPV Code
  - Study No: 2 1995-2003
    - Resulted in some relatively small changes to the Code requirements set out in 1994
  - Study No: 3 2003-2005
    - Resulted in the further changes to the Section III Code

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Study No: 1 1990-1994

- The rules developed were based on a set of experiments that were funded by industry and government.
- Industry funded the development of a set of requirements that were presented to SWG that included USNRC membership, which reviewed and modified the proposed requirements.
- The USNRC had concerns and wrote to the Chair of BNCS.
  - These concerns were addressed in Study No: 2.

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Study No: 2 1995-2003

- This Special Working Group (SWP) of the code attempted to address all the concerns expressed by various stakeholders of the Code, including the USNRC
- It consisted of various experts
  - Code members, external consultants, international representation particularly from Japan
  - Various external experts were also invited to make presentations on appropriate aspects of the work
  - Results of new experiments run in Japan were introduced to SWG, and
  - Results of a USNRC funded review of the original experiments were also provided
  - The USNRC did not participate as members in this activity but maintained a watching brief on the committee activity