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8	ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
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2	NUCLEAR REGULATORY COMMISSION
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4	668TH MEETING
5	ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
6	(ACRS)
7	+ + + + +
8	OPEN SESSION
9	+ + + + +
10	THURSDAY
11	NOVEMBER 7, 2019
12	+ + + + +
13	ROCKVILLE, MARYLAND
14	+ + + + +
15	The Advisory Committee met at the Nuclear
16	Regulatory Commission, Two White Flint North, Room
17	T2B10, 11545 Rockville Pike, at 1:00 p.m., Peter
18	Riccardella, Chairman, presiding.
19	COMMITTEE MEMBERS:
20	PETER RICCARDELLA, Chairman
21	MATTHEW W. SUNSERI, Vice Chairman
22	JOY L. REMPE, Member-at-Large
23	RONALD G. BALLINGER, Member
24	DENNIS BLEY, Member
25	CHARLES H. BROWN, JR. Member

		2
1	VESNA B. DIMITRIJEVIC, Member	
2	WALTER L. KIRCHNER, Member	
3	JOSE MARCH-LEUBA, Member	
4	DAVID PETTI, Member	
5		
6	DESIGNATED FEDERAL OFFICIAL:	
7	CHRISTOPHER BROWN	
8		
9	ALSO PRESENT:	
10	REED ANZALONE, NRR	
11	BRIAN GREEN, NRR	
12	JOSHUA KAIZER, NRR	
13	NADIM KHAN, NRR	
14	ATSUSHI KUMAKI, MHI*	
15	ROBERT LUKES, NRR	
16	SCOTT MOORE, Executive Director, ACRS	
17	SHEILA RAY, NRR	
18	JOSEPH TAPIA, MHI	
19	GEORGE WUNDER, NRR	
20		
21		
22		
23		
24	*Present via telephone	
25		
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PROCEEDINGS
1:05 p.m.
CHAIRMAN RICCARDELLA: (presiding)
The meeting is in session.
MEMBER SUNSERI: All right. Thank
you, Mr. Chairman.
So, today's presentation involves our
review of the Design Certification Application
and staff's Safety Evaluation Report for the MHI
USAPWR. Our review today is the continuation of
the DCA review that involves Chapter 8,
"Electrical Power"; Chapter 18, "Human Factors
Engineering Program", and a Topical Report on Advanced
Accumulator.
We held an in-depth Subcommittee meeting
review on September 19th with representatives from MHI
and staff. And we are holding this meeting today to
engage the full ACRS for the preparation of an Interim
Letter Report of our review of the DCA and the staff's
SER.
So, I understand that the staff, George,
you have no opening remarks at this time?
MR. WUNDER: That's correct.
MEMBER SUNSERI: So, we'll turn to Joe
Tapia of MHI.

	5
1	MR. TAPIA: Thank you very much.
2	We'll start with the Accumulator, and the
3	Accumulator
4	MEMBER SUNSERI: Just one thing here to
5	note. So, Joe is representing MHI, but we have a
6	staff of people on the phone line listening in. Is
7	that correct?
8	MR. TAPIA: Yes, there is a colleague on
9	the phone line.
10	MEMBER SUNSERI: Oh, okay, a colleague.
11	MR. TAPIA: Yes, we've confirmed that.
12	MEMBER SUNSERI: Okay. Good. Go ahead.
13	MR. TAPIA: So, the green light is on.
14	MEMBER SUNSERI: The green light is on,
15	yes.
16	MR. TAPIA: Okay. Great.
17	The advanced accumulator is an accumulator
18	tank with a flow damper inside the tank that provides
19	two stages of flow injection. It uses a passive
20	fluidic device and is part of the Emergency Core
21	Cooling System that is utilized during loss-of-coolant
22	accident. The use of this accumulator into our LOCA
23	mitigation strategy simplifies the ECCS configuration
24	by elimination of a low head safety injection system,
25	which is normal in a conventional PWR.
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Our Topical Report that we're describing 1 today includes all of the design characteristics, 2 3 operational principles, design features, and testing 4 programs that we conducted. And it also confirms the 5 safety analysis model that is used in other chapters. The accumulator itself is a vertical, 6 7 cylindrical tank with a volume listed here of 3180 8 cubic feet. Its height is 30 feet. It's quite large. 9 I have a picture of it later. The inner diameter is 10 12 feet. The design pressure is 700 pounds, and it's qot two volumes, basically, inside for flow, large 11 flow and small flow. And I'll go into that in more 12 detail in just a moment. 13 14 This schematic shows the simplified structure of the accumulator, what we call the flow 15 16 damper inside the tank. At the top, you see the 17 yellow. That is nitrogen overpressure gas, and on the left you will see the standpipe. The basic concept is 18 19 that the initial injection is, the portion of the blue below the nitrogen down to the top of the standpipe, 20 that's the volume that's calculated for large flow. 21 And after that, the standpipe no longer has any flow 22 going through it. So, we switch over to small flow. 23 24 This schematic shows basically what happens inside of the damper itself. As I described, 25

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on the left side we have large flow injection, which comes from the combination of the standpipe and the small flow pipe at the bottom connected to what we call the vortex chamber. Once that top volume is exhausted, we switch over to small flow injection, depicted on the righthand side.

7 For the large flow injection phase, the 8 design requirement or performance requirement is that 9 the lower plenum and downcomer of the reactor vessel 10 be filled with water as rapidly as possible, and the required volume is 1307 cubic feet. For the small 11 12 injection phase, the downcomer needs to be kept filled with water until the SI pumps take over injection. 13 14 And the required volume there is a bit less, 724 cubic 15 feet.

This schematic shows the simplified ECCS 16 17 configuration. It shows the location of the accumulators which inject into the cold leg. 18 There 19 are four high head safety injection subsystems that follow after the accumulator injection. As you can 20 see, there is no low head safety injection as the 21 result of the use of this accumulator. And the size 22 of this accumulator allows for water injection a lot 23 24 longer than the conventional accumulator, and that allows for more time for the safety injection pumps to 25

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1	start, which also allows us to utilize the gas turbine
2	generators in lieu of the conventional diesel
3	generators for power, emergency power. So, there are
4	a couple of benefits from the use of our
5	simplification design from the use of this
6	accumulator.
7	MEMBER SUNSERI: Joe, I thought I heard
8	you say the accumulators inject into the cold leg, but
9	it's really direct-vessel injection, is that right?
10	MR. TAPIA: No, sir.
11	MEMBER SUNSERI: No?
12	MR. TAPIA: It's to the cold leg.
13	MEMBER SUNSERI: The cold leg? Oh, okay.
14	MR. TAPIA: If you could see the
15	drawing
16	MEMBER SUNSERI: Okay. I'm thinking about
17	something else. Sorry. Yes, yes.
18	MR. TAPIA: High head is a different
19	okay.
20	This explains the flow requirements and
21	compares the normal conventional accumulator in the
22	PWR, on the top, with our advanced accumulator on the
23	bottom. And as you can see, the blue line on the top
24	drawing shows the injection of a conventional
25	accumulator. Once it empties, it rapidly declines;

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the blue line goes straight down. And at that point in time, the red line indicates the required flow to maintain the design requirements for keeping the core sufficiently covered. What happens is that you need to have the low head injection during that phase before the high head injections come on.

7 So, with the use of the advanced 8 accumulator, and as you can see, without the low head flow 9 pump, injection injection the from the 10 accumulator is in two stages, indicated by the blue line on the bottom right. We first have the large 11 flow, and it switches over to a small flow portion, 12 which still maintains the requirement or supersedes 13 14 the requirement for maintaining the reactor core And that allows removal of the low head 15 covered. 16 injection.

And as you can see on the bottom on the timescale, that time allows for the use of gas turbine generators which need to be up and running less than 100 seconds, as opposed to a conventional diesel which is, I think, about 12 seconds or so for starting and running. We have a lot more margin, which allows the use of gas turbine generators.

24 So, we designed this accumulator in 25 several steps. The first one was a development phase

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where confirmatory tests were utilized, scale models
that confirmed several aspects of it. One was the
anti-vortex function to make sure that there was no
vortexing, and that was a 1-to-3.5 scale. We also
used a 1-to-8.4 scale to confirm the principles of
flow. It basically has a plastic or glass underneath
to confirm the flows. The 1/5th scale was done to
better inform the actual conditions during the flow
switching. And the design verification phase entailed
complete, full-scale qualification tests.
This is a picture of the full-scale test.
And just for illustration, if you see the two white
signs in the front of the tank, those are about the
height of a person. So, the tank is 30-feet tall.
So, it's quite a large tank.
The design was verified with qualification
testing, as I just illustrated, full-scale. As a
result of that testing, the flow damper performance
with both the small and large flows were verified as
well as the flow switching. From that testing data,
we were able to generate empirical characteristic
equations for the flow coefficients to describe the
flow characteristics, and that was utilized in our
LOCA analysis, design analysis, to confirm compliance
with all requirements.

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1	So, as a conclusion, the accumulator has
2	been fully tested and satisfies the design
3	requirements.
4	MEMBER KIRCHNER: Joe, I suspect this
5	thing really made a racket. I bet it vibrated pretty
6	strongly. Did you also look at the structural
7	supports, and such, needed to hold this thing in place
8	when this happens?
9	MR. TAPIA: No, sir, that wasn't part of
10	the qualification test.
11	MEMBER KIRCHNER: Yes, just hydraulic
12	testing, yes.
13	MR. TAPIA: Yes, that was the performance
14	testing. But you're right. I was there for the full-
15	scale testing. It does make a noise, but the
16	restraints in that test stand were adequate. We
17	didn't see any problems. And I'm sure that the
18	loading is included in the calculations for the
19	support in the plant itself.
20	MEMBER KIRCHNER: Thank you.
21	MEMBER BALLINGER: There's another plant
22	that has a similar configuration, if you want to call
23	it that. And when they did the tests, Walt's
24	prediction came true. They had huge vibrations, and
25	it actually impacted design of the plant because it

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	12
1	was Walt's predictions were correct. They had huge
2	vibrations and it affected the fatigue design of the
3	plant.
4	MR. TAPIA: I understand. Again, we
5	didn't experience large vibrations during the testing.
6	MEMBER BALLINGER: Okay. They did.
7	MR. TAPIA: Yes. Okay.
8	MEMBER BALLINGER: They did.
9	MR. TAPIA: Okay.
10	MEMBER BALLINGER: It's not exactly the
11	same. The principle is the same, but it's the
12	vortex thing was the same.
13	MR. TAPIA: Yes, of course, there are some
14	large forces, but those will be incorporated into the
15	support designs.
16	CHAIRMAN RICCARDELLA: I would think the
17	real concern is support of those internal pipes
18	MEMBER BALLINGER: Yes.
19	CHAIRMAN RICCARDELLA: as opposed to
20	the overall vessel, but I'm sure it can be designed
21	for.
22	MEMBER REMPE: So, during our Subcommittee
23	meeting it's been a while since I've looked at this
24	but it seemed like even your last sentence, it's
25	applicable to the actual plant. And I believe your
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1 Topical Report made reference to some of the parameters that were extracted for your design of the 2 3 advanced accumulator based on the LOCA analysis that's 4 documented in your submittal. And so, it is something 5 that is dependent and very specific to your plant, or at least another plant who would come in would have to 6 7 show, because we always think about these Topical 8 Reports could be adopted by somebody with Joe's 9 reactor. And so, there is a connection to the actual plant. 10

And the reason I'm bringing this up is I 11 asked the staff why their SER didn't acknowledge that, 12 somewhere in there, there should be -- I would have 13 14 thought they would have some sort of limitation saying 15 that the plant needs to follow up or the applicant 16 needs to justify that it meets those specifications or 17 characteristics that you find in this Chapter 15 analysis. 18

And I never heard finally back from the staff. Actually, I think what the staff did was they actually said, yes, you may be right. But when they get up, we're going to follow up with the question of, well, why didn't you do that? Because I don't think they did when I saw the updated SE.

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MEMBER MARCH-LEUBA: I mean, the Chapter

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	14
1	15, we have to follow the local file of what they
2	really install.
3	MEMBER REMPE: But sometimes we see in the
4	Topical Reports that, when the staff does an SE, they
5	have to say, hey, it's not just this is a wonderful
6	advanced accumulator design. They actually need to
7	have some sort of limitation that references it back
8	to the design.
9	MEMBER KIRCHNER: Well, I think, Joy, my
10	own opinion, not to answer your question on behalf of
11	the staff or the Applicant, my own opinion is they can
12	run these tests, and then, for the XYZ plant, you can
13	look at what the demand curve is, which Joe showed in
14	some of his figures. And then, you can say this
15	particular accumulator at this size, and such, will
16	supply the demand curve with margin, or whatever. And
17	you can see it in the charts here. And then, it's
18	fine. You know, it doesn't matter. It's the
19	accumulator doesn't care what plant it's injecting
20	into, so to speak.
21	MEMBER REMPE: But it has to have
22	something that will meet that demand for a
23	probability
24	MEMBER KIRCHNER: Yes, but the demand
25	curve is set by the Chapter 15 analysis. And then,

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	15
1	you would have to demonstrate, bringing this
2	accumulator to the table, that it's going to supply
3	the requisite flow stay below the demand curve.
4	MEMBER REMPE: So, we'll have to hear from
5	the staff how they did that connection in their SE.
6	MEMBER KIRCHNER: Yes. So, where I was
7	going with this, though, is I think that you could
8	probably plug such a design into multiple PWR plants
9	as long as you can demonstrate you're going to supply
10	enough capacity.
11	MEMBER REMPE: So, there are no
12	limitations and the staff can correct me, because
13	maybe I'm wrong but when I looked through this
14	information, which has been over a month ago and I may
15	have made a mistake, but there was no limitation
16	saying that this Topical Report is approved along as
17	of course, the applicant would need to show they've
18	met that, that they can do the probability
19	MEMBER KIRCHNER: Yes, that I can't
20	answer.
21	MEMBER REMPE: Yes.
22	MEMBER KIRCHNER: But I was just trying to
23	suggest that this thing can stand on its own. It's a
24	little bit different than I'll make up an example
25	methods that are attuned to a specific fuel element
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1	design with specific spacer grids, and so on. Because
2	here all you want to do is demonstrate that you can
3	satisfy the demand curve of flow.
4	MEMBER REMPE: So, maybe the SE does do
5	that, but I expected there would be some sort of
6	limitation that would reflect that.
7	CHAIRMAN RICCARDELLA: Your table
8	indicated that the design pressure is 700 psig. What
9	is the actual delivery pressure?
10	MR. TAPIA: Injection occurs at about 650.
11	CHAIRMAN RICCARDELLA: Six fifty? Okay.
12	MR. TAPIA: Yes, sir. And, of course,
13	tech specs require pressure to be within a certain
14	range.
15	MEMBER BLEY: Pressure that's in the
16	nitrogen space?
17	MR. TAPIA: Yes, sir. And it's part of an
18	ongoing surveillance required by tech specs.
19	MEMBER BLEY: Okay. Which is standard.
20	CHAIRMAN RICCARDELLA: And that's the
21	same, regardless of whether it's the high flow or the
22	low flow?
23	MR. TAPIA: That is correct.
24	CHAIRMAN RICCARDELLA: It's just the gas
25	pressure.

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	17
1	MEMBER DIMITRIJEVIC: What's the high
2	pressure, head pressure for high pressure injection in
3	pounds?
4	MR. TAPIA: I'll have to get back to you
5	on that, the high pressure injection value?
6	MEMBER DIMITRIJEVIC: No, what's the
7	pressure
8	MR. TAPIA: I don't know the exact number,
9	but I can get back to you.
10	MEMBER DIMITRIJEVIC: That's all right.
11	Okay. It's not so important.
12	MEMBER KIRCHNER: You can infer it from
13	the curve. Oh, we don't have pressure. We don't have
14	the pressure coastdown. If you had the pressure
15	coastdown curves, then you can infer what the head is
16	at the pumps.
17	MR. TAPIA: I'm sorry, this is flow. It's
18	not pressure.
19	CHAIRMAN RICCARDELLA: But the yellow
20	portion in that says, "high head pumps". I'm
21	surprised that you need high head pumps that late in
22	the transient. I would think you would need high flow
23	pumps than high head.
24	MEMBER KIRCHNER: That's the conventional
25	accumulator.
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1	MEMBER DIMITRIJEVIC: They're both yellow.
2	CHAIRMAN RICCARDELLA: Well, they both
3	have the yellow. The bottom one says, "high head
4	pumps," too. Oh, it just says, "safety injection
5	pump". Okay. All right.
6	MEMBER DIMITRIJEVIC: This says that the
7	injection pump is a high pressure safety injection,
8	right?
9	MEMBER KIRCHNER: Well, it's kind of
10	medium.
11	MEMBER DIMITRIJEVIC: Oh, it's kind of
12	medium?
13	MR. TAPIA: It's not the conventional.
14	CHAIRMAN RICCARDELLA: Six fifty.
15	MEMBER DIMITRIJEVIC: Oh, okay. All
16	right.
17	MEMBER KIRCHNER: Yes, if you were to plot
18	these curves on pressure, they're not quite the same.
19	The high head injection pump is not the same as the
20	safety injection pump.
21	CHAIRMAN RICCARDELLA: Yes. Okay. Thank
22	you.
23	MEMBER DIMITRIJEVIC: No, no, it's sort of
24	medium, the Reg Guide. That's what I was curious. I
25	mean, you have a tragedy, which is your pressure.
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	19
1	MR. TAPIA: Yes.
2	MEMBER DIMITRIJEVIC: Then, you have this
3	sensitivity sort of medium.
4	MEMBER SUNSERI: Okay. All right. If
5	there's no further questions, we can move on to the
6	next chapter.
7	MR. TAPIA: The next chapter is Chapter 8,
8	"Electrical". Let's see. Oh, here it is. Okay.
9	Chapter 8 of "Electrical". Of course, we
10	comply with Reg Guide 1.206 and the Standard Review
11	Plan format, which is an offsite power description,
12	and then, the onsite power, which is broken down into
13	AC and DC, and then, station blackout. So, this is
14	what I'll cover in this presentation.
15	The offsite power is conventional. It's
16	two offsite sources with a normal preferred power from
17	the reserve auxiliary transformers, and then, the
18	alternate preferred power comes from the UATs through
19	the main transformer. They're independent and
20	physically separated, and both have a supply circuit
21	which has the capacity for normal ops and for design
22	basis events, to comply with all of the GDCs. So,
23	that's pretty standard.
24	The onsite power is a little different.
25	We have four trains of Class 1E AC electrical power,

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and each train has a gas turbine generator as part of 1 emergency power source. 2 its These qas turbine 3 generators are highly reliable and they're air-cooled 4 as well.

The online maintenance, including with the single failure criterion, 6 concurrent is satisfied. And permanent buses are also supplied by 8 an alternate AC power source, which are also gas 9 turbine generators.

10 And non-safety-related loads are electrically separated from the Class 1E buses. 11 Required non-safety-related loads are supplied from 12 these alternate AC power sources during a loss of 13 14 offsite power. And the AACs also provide power to all station blackout required loads to bring and maintain 15 the unit in safe shutdowns. 16

This is one line of the electrical system. 17 And as you can see on the bottom, we have the four 50 18 19 percent capacity each gas turbine generators, safetyrelated, and then, the red ones are the non-Class 1E 20 And they are diverse from the safety in that 21 also. they are different design, 22 separate desiqn and So, those are diverse. 23 manufacturers.

24 And the rest of it is pretty standard 25 design.

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	21
1	Yes, sir?
2	MEMBER KIRCHNER: Do you fire these gas
3	turbines with diesel or
4	MR. TAPIA: Yes.
5	MEMBER KIRCHNER: a jet fuel or
6	MR. TAPIA: Diesel, sir.
7	These gas turbines have a continuous
8	rating of 4500 kW, in a short time 4950. That's two
9	hours within 24 hours, in accordance with IEEE. And
10	the rating for the generator is listed here, a power
11	factor of .8 and 6900 volts. The starting time has to
12	be less than 100 seconds.
13	And these gas turbine generators were
14	tested in a testing program that complied with Reg
15	Guide 1.9, IEEE Standard 387, and the Draft ISG-21.
16	And that testing program was submitted in two parts.
17	They're listed on the bottom, qualification and test
18	plan. And the initial type test results were
19	submitted in these two reports which the staff
20	reviewed.
21	The initial type test included load
22	capability testing; start and load acceptance testing,
23	which was comprised of 150 start tests, and then, the
24	margin test to demonstrate capability to carry most of
25	your load step, which is plus 10 percent.

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	22
1	With regard to the station blackout, which
2	is another section in this chapter, the basic concept
3	for coping with the station blackout is the use of the
4	alternate AC gas turbine generators. And the design
5	basis utilizes the diverse AACs to minimize the
6	potential for common-cause failures between the
7	regular gas turbines. That's a distinction. The non-
8	Class 1E AACs packaged with the gas turbine generator
9	are connected to the 6.9 kV permanent bus. And they
10	can be aligned to any of the four Class 1E buses in
11	response to the station blackout. And they supply
12	safe shutdown loads during the SBO coping period,
13	which is eight hours. It is in accordance with the
14	Reg Guide 1.55.
15	With regard to open phase, the MHI
16	response to this bulletin, which was the famous Byron
17	bulletin, is to provide detection and protection, and
18	this chapter describes the single failure criteria,
19	and then, lists COL and some ITAACs.
20	With regard to detection and protection
21	for open phase, the detection systems are provided on
22	the high side of the main transformer and the reserve
23	auxiliary transformer, and they have redundancy, as

seen here in the drawings. So, they're redundantprotection systems.

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23 1 The COL item details the design and surveillance requirements that need to be defined in 2 3 the COL. And for the DCD, Tier 1, we have one ITAAC, 4 which is to ensure that the design is adequate to 5 protect an open phase conditioning with monitoring, detecting, and alarming in the main control room. And 6 7 that's listed here on the bottom as well. The supporting documentation that 8 was 9 submitted to the staff on Chapter 8 is listed here. 10 We had an AC power system calculation standard, and the COL, as I listed before, the Qualification Test 11 Plan for the gas turbine generator and the type test 12 results for the generator itself. 13 During the Subcommittee meeting, 14 the 15 question was asked about reliability, and that number 16 -- I looked it up -- it's 3.5 times 10 to the minus 4 17 for the gas turbine. MEMBER DIMITRIJEVIC: For an hour? That's 18 19 a liquid hour? 20 Well, it's --MR. TAPIA: Yes. MEMBER DIMITRIJEVIC: It's not for it to 21 start? 22 MR. TAPIA: It's for start. 23 It's to 24 start, yes. 25 MEMBER DIMITRIJEVIC: It's to try to

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1	start?
2	MR. TAPIA: To start. Per request.
3	MEMBER DIMITRIJEVIC: Okay. And what's
4	the hourly favorite?
5	MR. TAPIA: I'd have to get back to you on
6	that. I don't know.
7	MEMBER DIMITRIJEVIC: All right.
8	MR. TAPIA: I don't know. Once it's
9	running, it would be, you know
10	MEMBER DIMITRIJEVIC: No, it's, I mean, a
11	little better; I would say not. But most important is
12	how it runs.
13	MR. TAPIA: Yes.
14	MEMBER DIMITRIJEVIC: All right.
15	MR. TAPIA: Okay?
16	MEMBER SUNSERI: Any more questions?
17	CHAIRMAN RICCARDELLA: Yes, let me
18	understand. I'm sorry, I'm not an electrical guy.
19	So, going back to the slide where you talk about
20	onsite power system. It's slide 4. So, you have
21	these 1E electrical gas turbine generators are
22	different than the AAC?
23	MR. TAPIA: Yes, sir.
24	CHAIRMAN RICCARDELLA: Okay.
25	MR. TAPIA: If you look at this drawing
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1	here
2	CHAIRMAN RICCARDELLA: All right.
3	MR. TAPIA: on the bottom you can see
4	the blue GTGs. Those are the safety-related that are
5	taken into account in our analyses.
6	CHAIRMAN RICCARDELLA: Okay.
7	MR. TAPIA: The red ones are the non-
8	Class, which are diverse in that they're a different
9	manufacturer and are accounted for in the SBO, station
10	blackout.
11	CHAIRMAN RICCARDELLA: Okay.
12	MR. TAPIA: And they're all 50 percent
13	capacity. So, what you're looking here is 300 percent
14	capacity for all those six gas turbine generators.
15	CHAIRMAN RICCARDELLA: And there's no
16	diesels whatsoever?
17	MR. TAPIA: No, sir.
18	CHAIRMAN RICCARDELLA: I've always
19	wondered why plants haven't been doing it this way for
20	years.
21	MEMBER KIRCHNER: It ties into the
22	accumulator, among other things.
23	CHAIRMAN RICCARDELLA: Ah, I see.
24	MEMBER KIRCHNER: And in the old days, too
25	the technology for gas turbines is vastly improving
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1	the reliability wasn't there and they could be
2	cranky starting them up with diesel. That's why I was
3	asking the fuel source.
4	CHAIRMAN RICCARDELLA: Yes.
5	MEMBER KIRCHNER: I mean, they're nice
6	when you go with natural gas, but
7	CHAIRMAN RICCARDELLA: Thank you.
8	MEMBER BALLINGER: You can't make a direct
9	comparison between pounds of thrust in a gas engine
10	and horsepower, but, generally speaking, these things
11	are about four times the size of a 100,000-pound
12	thrust gas turbine engine for an airplane. So,
13	they're big. They're framed turbines that you would
14	have in a
15	MEMBER KIRCHNER: Like in a combined cycle
16	plant.
17	MEMBER BALLINGER: Yes.
18	MEMBER SUNSERI: All right. If there's no
19	more questions, we can move on to Chapter 18.
20	MR. TAPIA: Chapter 18. Okay, Chapter 18.
21	I'll cover it in this manner: I'll talk about the
22	supporting documentation that was submitted, describe
23	our design-specific HFE program management plan, and
24	then, I'll talk about the US-Basic HSI, and then,
25	summarize.
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1 These are all the supporting documents 2 that were submitted. Well, this is the first page. On the top, you have the Human Factors Engineering 3 4 Program Management Plan. That's Item 1. And below 5 that, you have nine Technical Reports which -- I'm sorry -- eight Technical Reports, which are basically 6 7 the implementation plans that provide the detailed methodologies that address the NRC's review criteria 8 9 and ensure compliance with NUREG-0711. 10 We also submitted one Topical Report, listed there, Item 10. That Topical Report describes 11 a Human System Interface System and incorporates the 12 resolution of issues that were identifying using U.S.-13 14 licensed operators who were utilizing the US-Basic HSI 15 The other two documents are supporting simulator. 16 documents that were audited by the NRC staff as part 17 of the review of this chapter. So, USAPWR-specific HFE 18 the program 19 management plan was developed in accordance with the NUREG, of course. And its scope is listed here. 20 It's that the design team organization enrolls, processes, 21 22 procedures the human engineering discrepancy and process technical programs in the COL information. 23 24 So, HFE activities completed within the scope of the 25 APWR design, the program element methodologies

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1	described in each of those implementation plans which
2	are separate Technical Reports that I highlighted
3	earlier. And those elements are going to be
4	documented in the Results Summary Report as part of
5	the program after implementation.
6	The USAPWR HSIS sorry for the confusion
7	here is based on the application of the US-Basic
8	HSIS, which is the generic monitoring, alarm, control,
9	and computerized procedure technologies that are
10	employed in the main control room. That US-Basic HSIS
11	is what is described in that Topical Report, and I'll
12	go into that in more detail a little bit later.
13	The generic HSI technologies of the US-
14	Basic HSIS combined with the specific HSI inventory
15	needed for the specific USAPWR design, that is what
16	was used to create the USAPWR HSIS. So, the
17	development process for that site-specific HSIS
18	confirms or changes the HSI inventory to reflect those
19	site-specific items for that design.
20	As part of all this, one of the
21	fundamental design assumptions and constraints for
22	that is that the plant can be operated with a minimum
23	operation staff of one RO and one SRO in the main
24	control room during all postulated modes. However,
25	that's not what occurs in real practice. The staffing

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is augmented in real practice with another RO and another SRO.

3 With regard to the generic US-Basic HSI 4 which was utilized to develop the USAPWR specific 5 human factors approach, that document was submitted as 6 a Topical Report, and its foundational elements use the Japanese Basic HSIS as a starting point to create 7 this U.S.-based HSIS which is described in the Topical 8 9 Report. And it applies combinations of design review, 10 redesign, and design validation through a phased implementation that occurred. Appendix A of that 11 document contains all the information about the 12 Japanese Basic HSIS and its development history. 13

14 Okay. As I described earlier, the normal 15 main control staffing consists of one RO and one SRO, 16 but they're supplemented in real life. And the space 17 and the layout of the main control room can accommodate that augmentation of the additional SRO 18 19 and RO during normal operations, as can be seen by There are four chairs there that are 20 this drawing. the normal complement, two SROs and two ROs. However, 21 the HFE analysis is based on just one SRO and one RO. 22 And the next slide shows a picture of the 23 24 control room. It has several VDUs, large ones in the back and several at the operators' station. 25 These are

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four different kinds of VDUs, operational that execute all the normal plant control and monitoring functions, including the safety systems. We have separate safety VDUs for controlling the safety-related and monitoring functions, and, also, serve as a backup for the operational VDUs.

7 We have alarm VDUs to acknowledge and 8 display individual alarms using prioritization color 9 codes that were defined during this HFE analysis. And 10 they also provide confirmation and non-confirmation 11 information to the operators.

And finally, as a tool, operator tool, we have the operating procedure VDU, which is computerbased procedure displays near the alarm stations and operational stations to facilitate and simplify the performance of the operators.

So, in summary, the US-Basic HSIS -- I have to slow down to say this stuff; there's too many letters (laughter) -- well, it used the U.S. -- the development of the USAPWR HFE program utilized the US-Basic HSIS, which was developed, as I described earlier, in utilizing operator inputs.

The DCD has one COL item that requires the COL applicant to develop a Human Performance Monitoring Program, and then, there are two ITAAC

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1	items in the DCD. After the HFE programs described in
2	the Technical Reports are implemented, Results Summary
3	Reports will be generated and will be submitted to the
4	NRC for review. This is the standard process.
5	These are the two ITAAC items. The first
6	one is verification of the HFE program by use of
7	validation testing. And the second one is
8	confirmation of the as-built condition of the control
9	room. Pretty standard.
10	I like this drawing because it basically
11	condenses everything I've tried to describe and
12	mumbled through a little bit in one simple drawing.
13	You take the Topical Report, which is the US-Basic
14	HSI, and from that, you develop the plant-specific
15	design application which is described in our Technical
16	Reports that I listed. And then, after
17	implementation, we submit the Results Summary Reports,
18	and the staff will review those.
19	And that's how we addressed the HFE. Any
20	questions?
21	MEMBER SUNSERI: One of the things I
22	believe I heard and saw in the Subcommittee meeting on
23	this topic was that the way Mitsubishi has approached
24	this is, you know, in the application, it's really
25	gone beyond what we normally see in a lot of the
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1	applications, where we just see the plans, because
2	you've had time to actually put the operators and get
3	some implementation of those plans. And so, it's a
4	more complete, I guess, program than maybe what we've
5	seen before. Is that accurate to say that?
6	MR. TAPIA: I would say so. We've been
7	working on this for a long time, about 10 years. And
8	actually, we had a lot of help back and forth with the
9	staff and were able to generate, as you say, more than
10	the standard approach for defining the HFE.
11	MEMBER SUNSERI: It was also my
12	understanding that the feedback from the U.S.
13	operators that performed was substantial and provided
14	good advancement to the design.
15	MR. TAPIA: That is true.
16	MEMBER BLEY: At one point, you folks told
17	us this is a long time ago that you actually had
18	emergency operator procedures in place, but you hadn't
19	submitted them. Is that still the case?
20	MR. TAPIA: For the USAPWR?
21	MEMBER BLEY: Yes. You don't think so?
22	MR. TAPIA: I don't think so, no.
23	MEMBER BLEY: It's an old note. Somebody
24	had said that at
25	MR. TAPIA: No, sir.
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1	MEMBER BLEY: Okay.
2	MEMBER SUNSERI: Well, then, if there's no
3	more questions for Joe or MHI, last call, then we'll
4	swap out with staff.
5	MR. TAPIA: Thank you very much.
6	MEMBER SUNSERI: Thank you.
7	And my colleague next to me has noted it's
8	three o'clock a.m. in Japan. So, we appreciate the
9	commitment there.
10	MR. WUNDER: Good afternoon, Mr. Chairman,
11	ladies and gentlemen of the Committee. I'm George
12	Wunder and I'm the Lead Project Manager for the USAPWR
13	Design Certification Review. I'm joined here by
14	members of the staff, Nadim Khan and Sheila Ray of
15	Electrical Engineering, and Dr. Brian Green of Human
16	Factors.
17	We'll be presenting the staff's finding on
18	the Phase 4 review of the Applicant's Advanced
19	Accumulator Topical Report and on Chapter 8, "Electric
20	Power," and 18, "Human Factors".
21	Getachew Tesfaye did the staff review of
22	the Topical Report, but since he's out of the office
23	today, I'll be making his presentation. I'll do my
24	best to answer any questions you might have, but if I
25	don't know the answer, I'm going to have to punt and

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defer the response.

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A couple of years 2 Okay. ago, MHI submitted Revision 5 of their Advanced Accumulator 3 4 Topical Report. The staff prepared a Safety 5 Evaluation. Rev 5 of the report is based on three small-scale tests and a full-height half-scale test. 6 7 Computational fluid dynamics analyses were used to adjust for scaling effects. The staff's SER imposed 8 9 increased uncertainties on the inputs for the LOCA 10 analysis, for the high flow and low flow injection regimes. 11

The Committee approved Revision 5 with the increased uncertainties. The increased uncertainties account for use of the CFD analyses models to extend the half-scale test results to predict the full-scale accumulator performance.

17 Revision 6 of the report is based on the three previous small-scale tests and a new full-scale 18 19 The full-scale test replaced a half-scale test test. and a CFD analysis was not needed to account for the 20 scaling effects. Revision 6 also introduced a 21 modified flow damper with a pressure equalizing pipe. 22 The flow damper was introduced to remediate flow 23 24 instabilities identified during the full-scale test. The primary focus of the staff's review 25

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35 1 was to make sure applicable regulations are still met. To do this, the staff confirmed the adequacy of the 2 3 conclusions of the small-scale test in light of the 4 full-scale test and evaluated the addition of the flow 5 damper to the design. 6 Oops. Sorry. There they are. Already 7 talked about them. Okay. concluded 8 The staff that the characteristic equations developed from the full-scale 9 test which do not contain the additional uncertainties 10 imposed by the Rev 5 SER are comparable to the Rev 5 11 tests with the computational fluid dynamic analysis. 12 Staff also concluded that the characteristic equations 13 14 developed from the full-scale tests are applicable to the full-scale accumulator. 15 16 And that's what I have to say. And now, 17 I assume --Do you want my question? 18 MEMBER REMPE: 19 MR. WUNDER: Absolutely. 20 MEMBER REMPE: Okay. So, you heard me discuss it earlier. 21 Right. 22 MR. WUNDER: I've just been wondering 23 MEMBER REMPE: 24 how you have confidence, then, when an applicant comes in, not necessarily this design center --25

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1	MR. WUNDER: Right.
2	MEMBER REMPE: but someone else, that
3	their widget will match up with this approved
4	accumulator report. And I did bring up the document
5	where you refer to the fact that uncertainties were
6	based on analyses
7	MR. WUNDER: Yes.
8	MEMBER REMPE: from Chapter 15 of the
9	DCA.
10	MR. WUNDER: Again, from a project
11	manager's standpoint, what we're doing is we're saying
12	this component, this can deliver this demand. And
13	when you're trying to say, is this going to work on my
14	plant, then you have to do your Chapter 15 analysis.
15	And to put a regulatory hook or something in a Safety
16	Evaluation for the Topical Report doesn't seem to me
17	to make any real sense.
18	MEMBER REMPE: Okay. So, when I asked the
19	question at the Subcommittee meeting, I got a
20	different answer. It was like, "Yeah, we probably
21	should," is what I recall. And I can pull up the
22	transcript and verify that. So, I was expecting
23	something to happen after the Subcommittee meeting on
24	this topic.
25	MR. WUNDER: No, in my discussions with

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1	the and your memory may well be better than mine
2	but in my discussions with the staff, they were pretty
3	much confident that this was the right way to go.
4	MEMBER REMPE: Okay. Well, again, I just
5	was a little puzzled because of the response I got.
6	And perhaps you're right that it's just known that
7	you're going to do that comparison, but what prompted
8	the question was the fact that they refer to the
9	Chapter 15 analyses as a way to characterize what
10	uncertainties needed to be considered. So, there is
11	a sentence in your SE, at least the version I have,
12	which may have changed, that refers back to Chapter
13	15.
14	MR. WUNDER: It won't have changed.
15	MEMBER REMPE: Yes. But, anyway, if
16	everyone else is happy I just remember asking a
17	question.
18	MR. WUNDER: Okay. Any other questions?
19	(No response.)
20	In that case, I will move on to Chapter 8
21	and turn it over to Nadim Khan.
22	MEMBER BROWN: Excuse me. I don't
23	remember asking this before years ago when we did
24	this. It just now occurred to me on the accumulator.
25	This is a giant tank, 30-feet high. The water is just
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1	sitting in there forever while you're operating. The
2	lower plenum area is that whatever you call the vortex
3	generator with all the stuff going on
4	MR. WUNDER: Yes.
5	MEMBER BROWN: and you're sitting there
6	for years. Was there any consideration to any water
7	purification or contamination or sediment buildup,
8	such that it would constrain the flow and the buildup
9	of the actual movement of the flow through that lower
10	flat, pancake-like device?
11	MR. WUNDER: I don't know the answer to
12	your question. I don't know.
13	MEMBER BROWN: I'm not even sure it's
14	relevant. It's just I'm sitting here thinking you
15	operate for a long time. Is there any V&V and of the
16	type things? I guess my thought was, does it get
17	flushed periodically or is it just Grade A reactor
18	water the whole time, and it just sits there for 40 or
19	50 years and nobody cares? That's the wrong word. I
20	didn't mean to say it that way.
21	MR. TAPIA: Joe Tapia.
22	MEMBER BROWN: Yes?
23	MR. TAPIA: This tank is an ASME tank.
24	MEMBER BROWN: I have no idea I mean,
25	I understand what ASME is, but that doesn't mean it's

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1	clean necessarily.
2	MR. TAPIA: Well, it requires, I think,
3	every 10 years a complete inspection.
4	MEMBER BROWN: That's an internal
5	inspection, is what you're talking about?
6	MR. TAPIA: Basically, it involves
7	inspecting the tank visually and ultrasonic testing of
8	welds. So, it's a Class 1 component. So, it falls
9	under the ASME testing surveillance requirements. And
10	the water is reactor grade and it's stainless.
11	MEMBER BROWN: Oh, it's a stainless steel
12	tank?
13	MR. TAPIA: Yes, sir.
14	MEMBER BROWN: Oh, okay.
15	MR. TAPIA: So, I hope that answers your
16	question.
17	With regard to inspecting and making sure
18	that something like that doesn't
19	MEMBER BROWN: Okay. When you said
20	"inspected," I mean, I'm trying to wrap my hand around
21	that. I mean, I'm thinking internal down at the
22	bottom. You say every 10 years they're required to do
23	I'm sorry for a minute. The computer people just
24	told me I've got to put my pin in. It's not working.
25	MEMBER SUNSERI: We don't need to know

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1	that, though.
2	MEMBER BROWN: I know, but I'm taking time
3	away from their time. All right. Now I'm there.
4	So, that's where I was going with it. You
5	say 10-year inspection.
6	MR. TAPIA: That's what I'm sure of.
7	There may be other tech spec surveillance.
8	MEMBER SUNSERI: There's typically a flow
9	test required at some periodicity of the plant. I
10	don't know if it's five years or two, or something.
11	MEMBER BLEY: It might even be every
12	refueling, but that's what I
13	MEMBER SUNSERI: Yes, I don't remember
14	doing them every refueling, but they're periodically.
15	MEMBER BROWN: You're going to have to
16	lower the nitrogen pressure.
17	MEMBER KIRCHNER: And flush.
18	MEMBER BROWN: And flush.
19	MEMBER KIRCHNER: Refueling provides a way
20	also of kind of cleaning out any potential debris that
21	may accumulate, because you've got to depressurize the
22	system, and then, depressurize the nitrogen
23	overcharge, and cetera.
24	MEMBER BROWN: Well, it wasn't obvious how
25	we flush it, that's all, because you've got the

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1	initial surge down with the big standpipe, and then,
2	you're coming up and out. So, it's not like you've
3	got a drain at the bottom. It doesn't look like it.
4	MEMBER KIRCHNER: I don't know firsthand
5	what their inspection procedures are, but it is, as
6	Joe points out, covered on the ASME under the Boiler
7	and Pressure Vessel Code. It's got to be at least a
8	10-year inspection interval, and that would include
9	visual
10	MEMBER BROWN: Internal visual
11	inspections.
12	MEMBER KIRCHNER: Internal visual
13	inspections.
14	MEMBER BROWN: Okay. I'm sorry. It was
15	just something that occurred to me.
16	MR. TAPIA: That 10-year is a minimum I'm
17	sure of. There may be other surveillances that are
18	required by the tech specs. I'm not sure of that, but
19	I think there are.
20	MEMBER BROWN: Okay. Thank you.
21	CHAIRMAN RICCARDELLA: I mean, I would
22	say, other than this somewhat complicated flow device,
23	it's no different than accumulators that are used in
24	current plants.
25	MEMBER BROWN: It's that lower, the
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1	generator, the little amplifier, if you want to call
2	it, the vortex thing with the pipe coming in for the
3	rest of the second level of flow that you're going to
4	get. That's just a different layout than just a giant
5	tank with a pipe at the bottom.
6	That's all. So, thank you. I'm done.
7	MR. WUNDER: Okay. We'll now move on to
8	Chapter 8, and I present Nadim Khan and Sheila Ray.
9	MR. KHAN: Thank you, George.
10	As George mentioned, my name is Nadim
11	Khan.
12	The USAPWR electric power system consists
13	of the offsite power system and the AC and DC power
14	system. During the staff's review, there were two
15	open items. Both issues were closed in Phase 4. And
16	today, we will discuss the open items and the
17	resolution of these items. The open items are open
18	phase condition and gas turbine generator reliability.
19	Next slide.
20	The first open item is regarding the open
21	phase condition and the staff's position as outlined
22	in BTP 8-9. BTP 8-9 discusses the electric power
23	system design vulnerability due to an open phase
24	condition in the offsite electric power system.
25	The staff requested that the Applicant
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explain how its electrical system design would detect, alarm, and respond to an open phase condition. The Applicant provided a COL item in which the COL applicant is to determine the type of open phase detection and protection system and address the guidance in BTP 8-9.

7 The staff determined that the COL item 8 will ensure that the COL applicant will determine an 9 open phase detection and protection system that meets 10 the guidance in BTP 8-9, including detection, alarm in 11 the main control room, and protection feature, in that 12 the Class 1E medium voltage bus will transfer to a 13 power source without an open phase condition.

14 Therefore, the staff finds this issue 15 closed.

Now I will turn it over to Sheila.

MS. RAY: Thank you.

And again, my name is Sheila Ray and I'll be presenting on the second open item, on GTG reliability.

proposed the use of 21 MHI qas turbine generators and the Class 1E emergency power source for 22 the onsite power systems. GTGs have not been used in 23 operating fleet 24 the as Class 1E power sources. Therefore, there is no operating experience and no 25

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1	reliability data in nuclear applications.
2	In the absence of operating experience and
3	reliability data, the staff requested the Applicant to
4	perform type tests to ensure the GTGs will perform
5	their intended function and achieve their target
6	reliability level.
7	Next slide.
8	MHI discussed the qualification
9	methodology in initial type tests for the GTGs in
10	Technical Report MUAP-107024. Specifically, the type
11	test includes load capability testing, start and load
12	testing, and margin tests for IEEE 3871985, as
13	endorsed by Regulatory Guide 1.9.
14	The Applicant documented the successful
15	qualification of the Class 1E GTGs in Technical Report
16	MUAP-10023. MHI successfully performed 150 start and
17	load acceptance tests of the GTGs. The report
18	demonstrated that the GTGs were able to start and be
19	ready to accept load within 100 seconds, which is the
20	GTG start time used in accident analyses. The
21	successful start satisfied the reliability criterion
22	of 0.975 with 95 percent confidence.
23	In conclusion, the staff finds that the
24	Applicant's approach to demonstrating Class 1E GTG
25	reliability is adequate, considering compliance of

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1	GDC 17, conformance to Regulatory Guide 1.155, as well
2	as successful qualification via type testing.
3	This concludes the staff presentation.
4	Any questions?
5	MEMBER KIRCHNER: Sheila, just a minor
6	point. On slide 4, I think what you're implying in
7	that second bullet is that there's no operating
8	experience with 1E, Class 1E, equipment.
9	MS. RAY: In nuclear power plants.
10	MEMBER KIRCHNER: Yes, yes. But there's
11	a lot of gas turbine experience.
12	MS. RAY: Correct. Absolutely. There is
13	a lot of gas turbine
14	MEMBER KIRCHNER: Yes. So, it's just
15	implied. Thank you.
16	MS. RAY: Uh-hum.
17	CHAIRMAN RICCARDELLA: Could I get a
18	comment from our PRA folks as to, you know, there's
19	150 tests; gets you .975 reliability with 95 percent
20	confidence?
21	MEMBER DIMITRIJEVIC: Do you want me to
22	calculate this in this moment now?
23	CHAIRMAN RICCARDELLA: No. I mean, is
24	that in the right ballpark?
25	MEMBER DIMITRIJEVIC: Well, I just want to
	1

1 this is а system that the deterministic say requirement, in my opinion, from this GDC 1.17. 2 So, they have their principles. I am not even familiar 3 4 with this requirement. I mean, you know, I was 5 wondering how does this experience with gas turbines in the industry. And they said, the staff, the data 6 they gave me backed up this. So, I wasn't really 7 8 requiring to check the validity of this, you know. 9 CHAIRMAN RICCARDELLA: Okay. 10 MEMBER MARCH-LEUBA: Although 56 tests with no failures gives you 95/95. 11 CHAIRMAN RICCARDELLA: Oh, really? Okay. 12 MEMBER MARCH-LEUBA: Yes, and this is the 13 14 So, 150, the fact that you're wrong here, I'm .975. sure it's not 150. It's either 147 or 152. 15 16 CHAIRMAN RICCARDELLA: Yes, okay. Ι 17 understand. That's all I wanted, was, is it in the ballpark? 18 19 MEMBER MARCH-LEUBA: Oh, it is. CHAIRMAN RICCARDELLA: Yes. 20 Okay. MEMBER MARCH-LEUBA: 21 And you can more tests without one failure. Like what we did yesterday 22 with the --23 24 CHAIRMAN RICCARDELLA: I see. This is 150 tests with no failure. 25

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1	MEMBER DIMITRIJEVIC: I think no failure,
2	right, right.
3	CHAIRMAN RICCARDELLA: This is like
4	binomial distribution or something like that?
5	MEMBER MARCH-LEUBA: This is called no
6	parametric statistical testing or something.
7	CHAIRMAN RICCARDELLA: Okay. Thank you.
8	MEMBER BROWN: Can I provide an
9	observation? The Navy must have about 500,000 of
10	these installed in the DDG-type ships. All of their
11	electric power in all recent there's no steam
12	turbine. There's no steam systems for the last 30
13	years just about. And they operate all the time.
14	The biggest issue on the GTGs was the
15	startup time and being able to load them. They can't
16	do it in 10 or 12 seconds the way you can diesels, but
17	you, with the design of the plant and the systems that
18	you've got, the 100 what did you say, 100 seconds?
19	And that's more than enough time for those to come and
20	be ready to be loaded.
21	That's based on they're not in the
22	nuclear plants. This is in the non-nuclear plants,
23	but we were aware of everything they were doing, and
24	I also worked on some of that post-retirement with the
25	non-nuclear Navy. So, they work very well with
	1 I I I I I I I I I I I I I I I I I I I

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1	reasonable information.
2	MEMBER SUNSERI: Well, thank you.
3	And, George, I guess we're ready to move
4	on.
5	MEMBER BLEY: Yes, well, before you do
6	MEMBER SUNSERI: Okay.
7	MEMBER BLEY: I looked up the NUREG on
8	surveillance testing. If you have valves do they
9	have valves in their accumulators? On other PWRs,
10	they do have valves. And there, you would normally
11	have a quarterly test, except they're exempt. These
12	valves are exempt and you have to test the valves
13	every time you go into cold shutdown. And my memory
14	is, when you do it, you have somebody watching the
15	accumulator level, and that's how you know those
16	valves are really open.
17	MR. WUNDER: Thank you.
18	And for our final presentation, we move to
19	Dr. Brian Green.
20	Brian?
21	MR. GREEN: Good afternoon.
22	You can go to the next slide, and you can
23	even skip that one and we'll go right to some
24	conclusions here. We wanted to make sure we weren't
25	going to kill you with PowerPoint slides today.

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1	Mr. Tapia gave a real nice presentation
2	about how the application was set up. So, I'll just
3	focus on the staff conclusions.
4	Staff reviewed the Topical Report
5	MUAP-07007. Staff found that it describes an
6	acceptable generic platform, referred to as the US-
7	Basic HSI, or HSIS, as the Applicant calls it. If we
8	couldn't make this any more complicated, we have one
9	set of acronyms to describe the same thing and they
10	have another one. So, I apologize if I forget the
11	second "S" there.
12	After that, the implementation plans have
13	been provided, produced in iteration on the US-Basic
14	HSI. Staff has found that this will be consistent
15	with the state-of-the-art human factors principles and
16	applicable regulations that would apply.
17	Staff also found that the ITAAC are an
18	acceptable means to confirm that the HFE practices are
19	incorporated into the final design. And there are no
20	open items at this time or confirmatory items.
21	MEMBER SUNSERI: Anybody have any
22	questions for staff?
23	MEMBER BROWN: Yes, I wanted to go
24	backwards. On the open phase detection system, I'm
25	trying to remember what we talked about in the
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2 It's literally been put off based on the BTP and into the operating COL period. 3 And I can't 4 remember whether I asked this question or not. Who 5 gets involved in that review of the completion or satisfactory compliance with the BTP requirements when 6 7 it's actually developed by a COL five, six, seven, 8 eight, nine years from now? Is it just a site 9 inspector involvement with the applicant or the 10 licensee or does staff get involved in assessing whether that's satisfactory, whether they ended up 11 with a satisfactory system? 12 I mean, I recognize we How's it going to be don't know what it looks like. 13 14 reviewed by the top level at that time?

15 MS. RAY: I understand. So, when the COL 16 application comes in, the electrical staff at NRC will review the will 17 compliance with BTP 8-9, which show compliance with GDC essentially 18 17. So, 19 electrical staff will review it.

20 MEMBER BROWN: Okay, but will there be 21 some -- as part of that review, does that include not 22 just the fact that they're going to do it, say they're 23 going to do it? Does that include some actual looking 24 at what the design looks like and the testing that's 25 being required, or something like that? I've just

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1	forgotten what's in the BTP.
2	MS. RAY: It would depend on the design.
3	MEMBER BROWN: Okay. So, there's some
4	involvement
5	MS. RAY: Typically, what we have done
6	and I can give you some experience what we have done
7	for South Texas Project 3 and 4.
8	MEMBER BROWN: Okay.
9	MS. RAY: We did look at their analyses.
10	They did load flow studies to show that the detection
11	would pick up an open phase. And we looked at their
12	protection as well to see how that would pick up an
13	open phase. So, we did look at calculations and
14	studies to verify
15	MEMBER BROWN: Were there any actual tests
16	as opposed to just calculations done at South Texas?
17	MS. RAY: Not at
18	MEMBER BROWN: They never got there?
19	MS. RAY: Because it wasn't built yet.
20	MEMBER BROWN: Yes.
21	MS. RAY: So, it's just the design phase.
22	MEMBER BLEY: And it will never be built.
23	MEMBER BROWN: No, I understand. Yes, I
24	understand that, based on what's going on.
25	MS. RAY: However, there was an ITAAC.
	1

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1	MEMBER BROWN: That would have operation
2	and actual tests?
3	MS. RAY: Correct.
4	MEMBER BROWN: Okay. Oh, all right. I
5	forgot that. Thank you.
6	MS. RAY: Right. And the protection side,
7	if it was a Class 1E protection, there would be tech
8	specs.
9	MEMBER BROWN: Okay. Thank you.
10	MS. RAY: Uh-hum.
11	MEMBER SUNSERI: Any others?
12	(No response.)
13	All right. While I ask for the control
14	booth to open the phone line, I'm going to turn to the
15	audience and see if there's any members of the
16	audience that want to make a public statement. Come
17	to the mic; state your name; make your statement.
18	(No response.)
19	None?
20	All right. Now I'm turning to the open
21	phone line. If there's any members of the public on
22	the open phone line that would like to make a
23	statement or a comment, please do so now. State your
24	name and provide your comment or statement.
25	(No response.)
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All right. No comments or statements
coming in on the public line.
So, that concludes our presentation, Mr.
Chairman, on the USAPWR application. We are prepared
to discuss a proposed Letter Report at your leisure on
the agenda, according to the agenda.
CHAIRMAN RICCARDELLA: Well, we have
another topic coming up at 2:30, NUREG knowledge
management on credibility assessment for critical
boiling transition models.
Do we have time to do a read-through of
the letter before that? Do you agree? Would you like
to do that?
MEMBER SUNSERI: If that's allowed, I
think.
I guess I did miss asking if there were
any statements. Nobody wants to make anything? Yes,
right. Yes.
Yes. Chris, are we ready for we can do
a read-through.
MEMBER REMPE: If you can't switch out the
computers, just hand out the hard copies, right?
CHAIRMAN RICCARDELLA: Yes.
MEMBER REMPE: Okay. Let's just do it
that way.

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54 1 CHAIRMAN RICCARDELLA: Yes, that would be fine. 2 3 MEMBER SUNSERI: And I want to thank the 4 staff and Mitsubishi for their great presentations today and good interaction during the Subcommittee as 5 well. 6 7 MEMBER REMPE: Do you have them separated, 8 so they can do it? 9 CHAIRMAN RICCARDELLA: Yes. 10 MEMBER REMPE: Oh, that's wonderful. MEMBER BALLINGER: Is he off the record 11 right now or not? 12 13 CHAIRMAN RICCARDELLA: Yes, I think, yes, 14 he's off the record. MEMBER BALLINGER: Off the record, but we 15 will be back, for 20 minutes or so. 16 CHAIRMAN RICCARDELLA: Until 2:30. 17 (Whereupon, the foregoing matter went off 18 19 the record at 2:12 p.m. and went back on the record at 2:34 p.m.) 20 21 CHAIRMAN RICCARDELLA: Okav. MR. KAIZER: Good. Good afternoon. 22 My name is Joshua Kaizer. I work in the -- sorry, we 23 24 just changed our title -- so, it's Nuclear Methods Fuel Analysis Branch in NRR, and this is Reed 25

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1	Anzalone.
2	MR. ANZALONE: Reed Anzalone. I'm in the
3	Nuclear Systems Performance Branch.
4	MR. KAIZER: And we are here to talk about
5	this credibility assessment framework for critical
6	heat flux and critical power models.
7	So, when we were going through the slides,
8	one of the first things Reed said was we wanted to
9	give you some type of background, some motivation.
10	So, that's what these textbooks are for.
11	I started with the NRC in 2006. And when
12	I got here, this was pretty much the textbooks I had.
13	Most of them were forced on me by Larry Hochreiter at
14	Penn State: Collier and Thome, Todreas and Kazimi.
15	A couple of them I picked up this year. It's actually
16	an autographed copy of Graham Wallis' One-Dimensional
17	Two-Phase Flow, the BWR textbook, and then, the Hewitt
18	and Hall Taylor for film boiling. And then, Tong and
19	Tang for CHF.
20	And I had all of these textbooks and I had
21	all of this knowledge about thermal hydraulics in
22	general, but what I didn't have was knowledge of,
23	okay, that's great, but how do you do code review,
24	because my Branch forever was called Nuclear
25	Performance Code Review. How do you review a code?
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1	And I wanted a textbook in that area. I never really
2	found one.
3	The closest I got, because I frequent old
4	bookstores too much, was this Philosophy of Auditing
5	by the American Accounting Association. And I read
6	part of it and it's not really that great. It was
7	kind of there but not really.
8	(Laughter.)
9	So, when I got to go back to do my
10	dissertation, I actually got to write what I
11	considered. So, my dissertation became a NUREG. I
12	call it "The Fundamental Theory of Scientific Computer
13	Simulation Review". And the idea was this was more of
14	a textbook on how do you do code review.
15	And in that process, I discovered that a
16	lot of people have obviously thought of it before, but
17	I now had the words to actually go back and look at
18	it. And so, a big motivation for this framework came
19	out of applying what the NRC sent me back to learn
20	into this one particular area of critical heat flux
21	and critical power.
22	Why that area? We had a really smart guy
23	named Tony Attard who had been in this area for a long
24	time and he was retiring. And we were trying to
25	capture that knowledge. We had a number of reviewers

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57 1 that started doing these reviews and, shock of shocks, they were learning the same things that Tony Attard 2 3 had taken years to learn and they had to relearn them 4 and said, okay, is there a way to make this faster? 5 I will admit that, when we started this effort, the main object was to increase objectivity. 6 7 I wanted the same review for every CHF correlation 8 qoing out there. That is nice, but it also helped 9 that increasing efficiency was, let's say, a natural byproduct, but that was also, I think, the big seller: 10 hey, if you go through this type process, it will make 11 your life a lot easier. 12 And the cool thing is we 13 have real 14 objective evidence to show that we've had pretty much the same review done with and without the NUREG. 15 And with the NUREG, it takes less than 50 percent of the 16 time. It's even smaller than that of how much in time 17 savings this is. 18 19 Basically, my motivation here, we wanted to create a textbook on how perform a specific type of 20 So, this basically is just going to walk 21 review. through our NUREG. It's forming chapters. 22 The first chapter introduces the idea of 23 24 credibility and credibility assessment frameworks.

literature review.

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1	framework, the summary.
2	The interesting thing to me about this
3	outline is, when creating this NUREG, we wanted to
4	create one that could be easily replicated. We're
5	coming up with one for CHF. That's great, but there's
6	other problems with CHF. So, we tried to create it,
7	when we made the framework, okay, you should be able
8	to take this and apply it to any area, LOCA, fuel
9	thermal-mechanical. You name it; it should go in
10	here.
11	And we also tried to base it similarly to
12	a dissertation because we wanted a little bit more of
13	that "researchy feel". So, like the literature review
14	and technical background is Chapter 2, having a
15	detailed explanation by the staff; trying to put all
16	the references in there, which is really helpful.
17	We'll talk about that later, too.
18	So, first, again, please feel free to stop
19	me or ask any questions.
20	MR. ANZALONE: Oh, yes, and I guess one
21	thing I would point out, when we were developing this
22	presentation, we were trying to figure out, well,
23	what's the best way to structure how we're going to
24	talk about this. And because the NUREG itself
25	provides such a structured approach to performing a

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1	review, we thought it made the most sense to just walk
2	through that.
3	MR. KAIZER: Yes.
4	MR. ANZALONE: So, that's how we're going
5	to approach this. We're just going to walk you
6	through the NUREG and how it works.
7	MR. KAIZER: So, first is "Introduction to
8	Credibility and Credibility Assessment Frameworks".
9	This is a fun name. A lot of these slides come from
10	ASME verification and validation presentations I've
11	given over the years. Credibility is this new term.
12	I think the first people that actually coined it that
13	I've seen were NASA in the wake of the Columbia
14	disaster. They had a big presidential board that
15	looked and said, hey, how can we go back and better
16	determine that we can trust simulations? And they
17	came up with that term "credibility".
18	Credibility is basically, in a general
19	definition, it's a determination that an object can be
20	trusted for its intended purpose. That's what it is
21	high level. Generally, that object for us is a model
22	or simulation, and the intended purpose is whatever
23	we're using it for in safety analysis.
24	It's interesting because most of
25	verification and validation, and certainly

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1	quantification, is focused on credibility, but no one
2	really talks about it. So, all of these are
3	standards. In textbooks that talk about it, it's
4	actually the main focus, but they don't ever bring it
5	up. In this case, we're saying, okay, now we are
6	talking about credibility. Validation feeds into it.
7	Uncertainty quantification feeds into it. Because,
8	ultimately, what we really care about is, can we trust
9	the simulation for whatever its intended purpose is?
10	And this is where I think the history of
11	the ACRS comes in. These frameworks, it was really by
12	so, the second one was produced at Sandia. And it
13	was a guy named Marty Pilch. Marty was actually
14	heavily influenced in the nuclear sector, heavily
15	influenced by CSAU, got to work with Novac Zuber. And
16	then, he left the commercial world and started working
17	in Sandia for like atomic weapons research. And he
18	became head of Sandia's V&V program.
19	And so, he took everything he had from
20	CSAU and that highly-structured approach, and he
21	pretty much applied that there and came up with

22 another structured approach that was, I'd say, a 23 little broader than CSAU. Like CSAU was really good, 24 but they like restrict it to this is for a LOCA 25 analysis. Well, it could be for any analysis. They

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1	worked out a really nice framework for it.
2	And so, Marty took that and made that, and
3	that was later derived by a guy named Bill Oberkampf
4	into Predictive Capability Maturity Model. NASA came
5	up with a similar type of framework. And the most
6	recent one is ASME V&V 40 that FDA came up with a very
7	similar framework to determine the credibility of
8	for them, it's a small medical device. That is what
9	they really wanted to focus it as. But they're trying
10	to have simulations that support those small medical
11	devices.
12	So, these are just examples of common
13	frameworks to say this is not really a new thing.
14	CHAIRMAN RICCARDELLA: What does CSAU
15	stand for?
16	MR. KAIZER: CSAU, Code Scaling,
17	Applicability, and Uncertainty.
18	CHAIRMAN RICCARDELLA: Thank you.
19	MR. KAIZER: I don't know if you know
20	Kumar at Brookhaven. He was one of the main authors
21	of that as well. He's got a lot of cool stories, too.
22	MEMBER MARCH-LEUBA: Kumar has been a
23	consultant for this Committee, Kumar Roharkie
24	(phonetic). Don't ask me spell it.
25	MR. KAIZER: So, what is a framework?
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1	Well, it's pretty much you have some list of the
2	traits of these are they each have these criteria.
3	It's generally a small number of criteria. These are
4	the things you have to look at. And then, you have
5	different evidence levels. How good are you in each
6	of those criteria? That's what the framework is.
7	So, these are some high levels of the NASA
8	framework which I give because I don't think they're
9	really useful, but it was out there. Verification,
10	this is the questions they asked: were the models
11	implemented correctly? What was the numerical error
12	of uncertainty? And you rank that between 1 and 4.
13	Validation, how did you compare against data? You
14	rank that between zero and 4.
15	This is, to me, kind of the Holy Grail of
16	decisionmaking. The atomic weapons people really
17	wanted something like this because you had the experts
18	who were your PhDs, and they needed to communicate to
19	the decisionmakers, and the decisionmakers just wanted
20	that single number, but the experts would do anything
21	but give you the single number. So, they tried to
22	come up with a system like this.
23	To the best of my knowledge, it did not
24	work very well. To the best of my knowledge, almost
25	all the methods I talked about earlier CSAU, it
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1	does work. It's intensive, but it works, and it's how
2	I think we do a lot of our regulation today, how we
3	structure it. So, that's good.
4	PCMN, when it was initially applied, it
5	didn't work. DOE has modified it and they have some
6	ideas of making it work, but not for decisionmaking.
7	The NASA standard I haven't heard anything about, and
8	ASME V&V 40 hasn't been tried yet.
9	MEMBER BLEY: Pete, when we hear people,
10	the thermal hydraulics guys especially, talking about
11	best estimate with uncertainty, they are usually
12	talking CSAU.
13	MR. KAIZER: Yes, sorry about that.
14	CHAIRMAN RICCARDELLA: When you say that
15	V&V 40, is that part of NQA-1?
16	MR. KAIZER: No. NQA-1 is not an ASME
17	standard. I think it's an ANS standard.
18	CHAIRMAN RICCARDELLA: ASME you say
19	ANS?
20	MR. KAIZER: Yes, it's a different area.
21	ASME, the American Society of Mechanical Engineers
22	came up with a you know what ASME is. They came up
23	with a whole verification-validation committee.
24	There's 10, 20, 30. Thirty is the thermal hydraulics
25	one. So, you've seen Hassan is on that one. He's
	1 I I I I I I I I I I I I I I I I I I I

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1	their current chairman. The NRC has a couple of reps.
2	The 40
3	CHAIRMAN RICCARDELLA: I'm familiar with
4	the ASME
5	MR. KAIZER: Okay.
6	CHAIRMAN RICCARDELLA: Code Committee,
7	Section 3/Section 11, and they have some V&V
8	standards.
9	MR. KAIZER: Yes, this was pushed off into
10	its own committee group of people.
11	CHAIRMAN RICCARDELLA: Okay.
12	MR. KAIZER: And it's actually a lot of
13	the same people from the National Labs.
14	MEMBER PETTI: Because it's not thermal
15	mechanical. It's not thermal mechanical-based. It's
16	more thermal hydraulic.
17	CHAIRMAN RICCARDELLA: Yes.
18	MR. KAIZER: It was what you just talked
19	about, but it was really thermal mechanical.
20	CHAIRMAN RICCARDELLA: V 30, V&V 40.
21	MEMBER PETTI: There are different ones
22	for different subject areas.
23	MR. KAIZER: Yes, they try to span all of
24	verification-validation, which maybe I'll talk about
25	that later. That's fine.

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1	So, anyway, this is what the current
2	levels look like. This is how we've changed it a
3	little bit. So, there was this thing that was
4	developed in the early 2000s in England I think it
5	was literally like 2000 called Goal Structuring
6	Notation. All it is is a beautiful way to understand
7	an argument. And the idea is they standardized it.
8	It was used in the Department of well, I think it's
9	the Ministry of Defense over there. It was used in
10	their I did talk with their their naval reactors
11	is Rolls Royce because Rolls Royce controls all the
12	subs. And their Rolls Royce program used it a little
13	bit. They use is very high level; we use it much
14	lower level. But, I mean, it works; it's pretty
15	basic.
16	You have some high-level goal. You have
17	some two low-level goals. The idea is that satisfying
18	this is equivalent to satisfying these two. So, these
19	are both necessary, and together they're sufficient
20	for that to be true. It's that simple.
21	And we had come up with a similar notation
22	we were using, and we were like, well, these people
23	developed this beautiful notation; we're just going to
24	adopt it. And that's Goal Structuring Notation, and
25	that's how the NUREG is pretty much laid out.
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66 1 MEMBER MARCH-LEUBA: What I like about this notation is -- it's probably not complete. 2 It's 3 very difficult to make it accurate, but it's all 4 detailed. 5 MR. KAIZER: Yes. MARCH-LEUBA: You 6 MEMBER make your 7 decisions ahead of time before doing the review. 8 MR. KAIZER: Yes. 9 MEMBER MARCH-LEUBA: And you document it. 10 And somebody who has a problem with it can go and review what it is. 11 One of the things --MR. KAIZER: Yes. 12 I'll show you the big chart later. I have it behind 13 14 The reason I love this notation is, when I have me. 15 to give a presentation to -- let's say I have a 16 problem with something and actually show it to the 17 Office Director. It's going to be extremely hard for me to get my Office Director to learn all parts of 18 19 thermal hydraulics to the point where they can now confidently say, hey, I understand what Josh is 20 saying. 21 But when I break it down in this notation, 22 I've just got to, hey, do you agree that, if that's 23 24 true, those two are true? "Yeah, yeah, yeah." And And that's what we'll do a 25 you go down the tree.

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1	little later. We'll show you how to go down one of
2	those trees. So, we can go over that.
3	This is the simple example I give of a
4	complete credibility assessment framework. Is it safe
5	to drive over a bridge? I'll try to stay over here.
6	I'm going to say, okay, I'm going to say it's safe if
7	the bridge can withstand the weight of my car and,
8	also, if there won't be a natural disaster while I'm
9	driving over the bridge. And I'm presenting to you
10	that, if those two things are true, then it's safe to
11	drive over the bridge.
12	Now, at this point, you can say, well,
13	hey, you're missing something. Okay, great, I can add
14	it. But, now at least when I say it's safe to drive
15	over the bridge, you know exactly what I mean. I'm
16	saying the bridge can withstand the weight of my car;
17	there won't be a natural disaster while I'm driving
18	over the bridge.
19	The second thing is, okay, the bridge can
20	withstand the weight of your car. What levels of
21	evidence can you provide? Here, the evidences are
22	ranked zero through 6. I've talked with people at
23	Sandia, and one of the hardest things that managers
24	don't understand in this area is that these are not
25	numbers with magnitudes. It's called an ordinal set,
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1	where level 1 is less mature than level 2, but we
2	don't know by how much.
3	MR. ANZALONE: But it's not half as
4	mature.
5	MR. KAIZER: Yes, it's not
6	MR. ANZALONE: It's just they're ranked.
7	MR. KAIZER: It's just less.
8	MR. ANZALONE: There's no magnitude
9	associated with it.
10	MR. KAIZER: Yes. So, you know it's less;
11	you know it's more; you don't know how much.
12	So, basically, what can I do; the bridge
13	can withstand the weight of my car? Well, I don't
14	think about it. Or maybe a little more evidence, I
15	say, hey, somebody's probably checked it. Or I say,
16	well, now I drove over it yesterday. As you increase
17	the levels, you become more and more confident that
18	your statement is true.
19	And it's the same thing with G2. Now what
20	we purposely did in G2 was we added No. 4, which is
21	it's an impossible level to reach. A time traveler
22	came from the future and confirmed no natural
23	disasters occurred on the bridge for at least 100
24	years. If that actually happened, that would
25	certainly prove that there won't be a natural
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1	disaster.
2	And having those artificial evidence
3	levels is really helpful because it's kind of like
4	when you put zero or infinity in your equation; you
5	see where you're going. It gives you that asymptote.
6	What are we actually aiming for? Initially, I was
7	going to say a guy in a blue box, but I just didn't
8	know how many people were Doctor Who fans. So, I said
9	time traveler.
10	But that is a quick idea of what a
11	credibility assessment framework is. And it's simple.
12	I'm sure there's other names for it. I'm sure people
13	have used it potentially elsewhere. I haven't seen
14	it. But it's really basic.
15	So, with that, the rules for the
16	framework. You start with some main goal you want to
17	figure out. You logically decompose that main goal
18	into other subgoals, where those set of subgoals are
19	necessary and sufficient. And then, you just repeat
20	that decomposition until you can't figure out any more
21	subgoals. Then, you provide evidence.
22	So, for example, here
23	MR. ANZALONE: Or maybe you can figure out
24	ones that are below that, but
25	MR. KAIZER: Yes.

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1	MR. ANZALONE: you decide that you've
2	gone far enough.
3	MR. KAIZER: Yes. So, here we could have
4	decomposed G1 into other subgoals, and then, provided
5	evidence for each of those.
6	MR. ANZALONE: Right. The bridge can
7	withstand the weight of my car could go down to the
8	level of like these bolts are designed to meet the
9	standard. The beams that are composing the bridge
10	were manufactured to blah, blah, blah.
11	MR. KAIZER: We probably shouldn't have
12	picked a bridge.
13	(Laughter.)
14	MEMBER DIMITRIJEVIC: Do you have anything
15	that probabilistically analyzes this?
16	MR. KAIZER: Yes.
17	MEMBER DIMITRIJEVIC: It's exactly the
18	same thing. Here you will have end gate instead of
19	all gate because it will be that big. So, you have
20	end gate and you break it down until you have data
21	for
22	MR. KAIZER: Yes, this is
23	MEMBER BROWN: And you have qualitative
24	measures at the bottom.
25	MR. KAIZER: Exactly.

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1	CHAIRMAN RICCARDELLA: What were you
2	talking about, exactly compared to
3	MEMBER DIMITRIJEVIC: Approaches in the
4	PRA.
5	CHAIRMAN RICCARDELLA: In the fault tree.
6	MR. KAIZER: Yes, the difference between
7	because, I mean, I've read at least some of the
8	stuff by Apostolakis. Where they will combine levels
9	in PRA because they can add stuff, we say, no, it's
10	independent. It's like those are pressures; these are
11	temperatures. You just can't add pressure to
12	temperature to get 150 pressure kelvin pascal or
13	something. So, I mean, again, yes, it shows up
14	everywhere, and a lot of people use it. And it's just
15	trying to write up, okay, how do you do this. I mean,
16	it's logic.
17	MEMBER DIMITRIJEVIC: But what is missing
18	in this approach is, look what you said, and they both
19	have to be satisfied.
20	MR. KAIZER: Uh-hum.
21	MEMBER DIMITRIJEVIC: But you have a
22	situation where BAN (phonetic) or Advec (phonetic) has
23	to be satisfied, as you were saying. You don't have
24	a way to express this with a simple
25	MR. ANZALONE: Yes, and I've thought a
1	I contraction of the second seco

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72 1 bunch about this, and I think that's one of the shortcomings of this approach, is that it can make it 2 difficult 3 in situations where you have like 4 conservatisms in one place that are offset in another 5 place. You can't leverage that. This can drive you to say this needs to be complete and this also needs 6 7 to be complete. But, really, you should be weighing them together holistically. I feel like that could be 8 9 a shortcoming of this. 10 I think it's addressed by recognizing that, you know, you can leverage two different things 11 together and consider them in like an integrated 12 But you have to be thinking about it that 13 fashion. 14 way to do it. Well, you have to be 15 MEMBER KIRCHNER: careful here, too, because -- I'm going to pick on 16 17 this a little bit. on the lefthand side, you have On the righthand side, you have deterministic. 18 19 probabilistic. Think about it. So, you're saying you can't add P and T together, but you've got really two 20 different things here. But it's okay. It works. 21 Ιt works. 22 CHAIRMAN RICCARDELLA: There's a low 23 likelihood of a --24 25 MEMBER DIMITRIJEVIC: Yes, and also,

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1	connectible has a different meaning in risk
2	assessment. A credible accident is not high
3	probability, not so awful big that it's incredible.
4	Incredible is upper size, which is completely
5	different.
6	MR. KAIZER: Yes, that's totally not the
7	same kind of meaning that we're using here.
8	MEMBER DIMITRIJEVIC: And also, in this
9	structure you wouldn't see your No. 4 on the right
10	side. Actually, it could be the only thing satisfying
11	everything. Because if you have a time traveler which
12	can confirm that that bridge never collapsed, you
13	don't have to worry about anything else.
14	MR. KAIZER: Yes. Yes. I guess I'll have
15	to change what the time traveler says.
16	(Laughter.)
17	MR. ANZALONE: You don't want to know how
18	many times we iterated on the examples.
19	(Laughter.)
20	MR. KAIZER: Yes, initially, I had the
21	bachelor example that an unmarried male was a
22	bachelor, but that was kiboshed by someone.
23	The other important thing that I forgot to
24	mention here was, with these frameworks, you need to
25	come up with a situation that satisfies all possible
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1	inputs. So, in other words, if you're driving over
2	like it is safe to drive over a bridge. This is
3	probably a determination you make almost every day if
4	you drive. Now if you drive over a bridge, you might
5	ignore it. But, all of a sudden, you're driving in
6	northern Michigan and you hit the Mackinac Bridge
7	which is three miles, you might start thinking, gee,
8	is it safe to drive over this?
9	So, you're going to use some version of
10	this framework, and you might ignore some of these.
11	And so, it has to be able to be used for that bridge,
12	but, then, it also has to be able to be used for like,
13	if the U.S. military is transporting a nuclear weapon,
14	they're probably going to be looking at these lower
15	levels. They're going to look for a recent inspection
16	of the bridge. And so, it's all that you have to be
17	able to address every time someone drives over it.
18	MR. ANZALONE: And there are clearly
19	things that aren't addressed sorry, I'll let you
20	talk in a minute but there are clearly things that
21	aren't addressed in this framework or in this
22	particular example, like it doesn't say anything about
23	the safety of the car that's driving over the bridge.
24	MR. KAIZER: Yes, the other passengers,
25	yes.
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1	MR. ANZALONE: That is something that you
2	would need to add. And you start thinking, well, when
3	did I last have my tires replaced, stuff like that.
4	MEMBER PETTI: But, also, it seems like
5	you need to in trying to figure out what's the
6	right level, it seems to be a function of how close or
7	how far away you are from something bad happening,
8	right?
9	MR. KAIZER: Yes. Yes.
10	MEMBER PETTI: So, if you have margin, you
11	might be willing to accept level 3 and don't have to
12	go to level 6.
13	MR. KAIZER: Absolutely, yes. And your
14	level question is actually a really good one. So, we
15	talked about that.
16	MR. ANZALONE: I think we'll get to that.
17	MR. KAIZER: Yes, we'll definitely get to
18	that.
19	The literature review background, the only
20	thing I wanted to say about the literature review was,
21	earlier when I said this NUREG was useful, if, for no
22	other reason, than we actually provide a list of every
23	CHF and critical power Topical Report that the NRC has
24	ever reviewed. It took a very long time to compile
25	the list. And a lot of those Topical Reports we put
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1	in ADAMS our self because we had to request it from
2	Records, and it was like 1980-something, and put it
3	in. So, that was really awesome.
4	And I think that having that list for like
5	all of the LOCA methods and all of the fuel thermal-
6	mechanical methods would be an amazing resource.
7	MEMBER REMPE: Are you going to update it?
8	I mean, we still review CHF.
9	MR. KAIZER: Yes. The idea is that, I
10	mean, because it's a NUREG/KM, we can update it. The
11	other reason of making it a KM was getting it out
12	there, so people can look and say: hey, do you agree?
13	Did we miss anything? Do we have anything that
14	doesn't need to be there? The idea is that you would
15	update this at some basis. And also, it is a lot
16	easier to find the more recent documents in ADAMS than
17	it is to find the ones from like 1973.
18	MEMBER REMPE: But it would be nice to
19	have it updated, though. Ten years from now, we'll
20	say, "Ah"
21	MR. KAIZER: Pretty much, I agree.
22	So, the technical background, we give a
23	discussion of the relevant phenomena, a discussion of
24	how the phenomena is modeled. I like writing these
25	areas because it's not extremely explained well in
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1 these books because these books focus on the phenomena 2 explicitly, and you're trying to talk about how it's 3 happening in the actual reactor in the fuel bundle. 4 And so, we can listen to the experts in the industry 5 or we can write up how we think it's going to work, 6 and then, ask the industry, hey, you guys should 7 comment on this. And if we didn't tell it right, 8 because this is our understanding, you should let us 9 know.

So, that I think, for us, was a good verification that, yes, we understand how this is happening. We understand how all the modeling is working. We understand at least the current ideas of how CHF and critical power occur. So, that was really fun; and also, how the model was applied.

Chapter 3, the framework itself. So, I'm 16 going to give you a high level and we're just going to 17 walk down one path of this framework. So, the high 18 19 level was the Critical Boiling Transition Model can be trusted in reactor safety analysis. We say that this 20 is if these subgoals 21 true three are true: experimental data supporting the model is appropriate; 22 the model was generated in an acceptable manner, and 23 the model has sufficient validation. 24

So, did we miss anything? Can you think

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1	of, no, you missed this one thing where you also need
2	this other category? So far, we haven't come up with
3	anything.
4	So, we go from G; now we're going to go
5	down to G1, the experimental data supporting the model
6	is appropriate.
7	MEMBER MARCH-LEUBA: Will this help you
8	define or recommend the range for applicability?
9	MR. KAIZER: The range of applicability of
10	the model?
11	MEMBER MARCH-LEUBA: Yes.
12	MR. KAIZER: This has it in there. I
13	mean, like we
14	MEMBER MARCH-LEUBA: I mean, it's good
15	between pressures of 100 and
16	MR. KAIZER: Yes, it's one of the
17	criteria. Because we use the range of applicability
18	to say, first, I think in G1 no, in G3, we say you
19	have to define the range of applicability. And then,
20	we say, okay, prove to me that you've validated your
21	model over the entire range of applicability and the
22	uncertainty you've established
23	MEMBER MARCH-LEUBA: Are those going to
24	show up in lower levels?
25	MR. ANZALONE: Yes.
	1 I I I I I I I I I I I I I I I I I I I

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1	MR. KAIZER: Yes, that does show up lower
2	levels. I don't know if it's in this example.
3	MEMBER MARCH-LEUBA: I was thinking that
4	I meant the top level, but
5	MR. KAIZER: Oh, okay.
6	MEMBER MARCH-LEUBA: That's what he was
7	telling you, that this focuses your thinking and you
8	can discuss and agree or disagree or improve it.
9	MR. KAIZER: Uh-hum. So, the experimental
10	data supporting the model are appropriate. So now,
11	what does that mean? Well, that means the
12	experimental data have been collected at a credible
13	test facility. They've been accurately measured, and
14	the test bundle reproduces the local conditions in the
15	reactor.
16	Okay. Now we break it down again. Well,
17	what does it mean the experimental data have been
18	correctly measured? And now, we break it down one
19	more time.
20	Before I talk about these individual ones,
21	it's generally a good idea, when you break these goals
22	down, to not have too many levels, not have too many
23	subgoals, and not have too few. There is a 1950s
24	psychology paper, and I think it's "The Magic Number
25	of 7 Plus or Minus 2". And they talk about how you

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1	generally want it's like less than 5 and you don't
2	have enough; more than 9 and it's too many. So,
3	that's kind of what you shoot for for each breakdown.
4	So, here we just happen to have six; sometimes we have
5	three. It is what it is.
6	Anyway, the experimental data has been
7	accurately measured.
8	MEMBER KIRCHNER: Less than 10.
9	MR. KAIZER: Yes.
10	MEMBER KIRCHNER: Definitely less than 10.
11	MR. KAIZER: So, what does it mean the
12	experimental data have been accurately measured?
13	Well, it means the test facility has an appropriate
14	quality assurance program. The example we're going to
15	look at is the experiment has been appropriately
16	statistically designed, statistical design of
17	experiments.
18	We're saying, also, the method used to
19	obtain the critical boiling is accurate. The
20	uncertainties of the instruments have been addressed.
21	The uncertainty in actually calculating CHF, because
22	they do it a very specific way, has been addressed.
23	And then, you've also established your heat losses.
24	So, again, this is one of those. If all
25	six of those are true, then I'm going to call that

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experimental data has been accurately measured; that's true.

3 And finally, this is just a discussion of 4 the statistical design of experiment. When you're 5 looking at a statistical design of experiment, you need to ensure that the experimental methods don't 6 7 introduce any statistical bias. So, Box, Hunter, and 8 Hunter, which is the classic book on this, which I 9 didn't realize that. Like John Stuart Hunter, there's 10 all these cool YouTube videos of him teaching about actually gave class 11 it, and he the first to Westinghouse. And there's like a seven series of 12 13 Westinghouse books all on statistical design of 14 experiment.

Anyway, you do the random sampling. Make sure that you randomize your input parameters. Almost all the methods in statistics assume a randomization of your initial conditions of experiments.

In CHF testing, the one thing you don't have is a randomization of your initial conditions because you have this big metal structure and it takes a lot of energy to move it from certain pressures and mass flow rates and temperatures.

24 MR. ANZALONE: And it takes a long time to 25 heat up and cool down.

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1	MR. KAIZER: Yes.
2	MR. ANZALONE: You can cause the seals at
3	the top and bottom of the assembly to leak, which will
4	cause you to have to shut down the whole experiment.
5	MR. KAIZER: Yes.
6	MR. ANZALONE: There are a lot of issues
7	with having a truly random set of data.
8	MR. KAIZER: So, here we have to actually
9	account for that. And we do account for it in other
10	areas, but that's the thing we're worried about.
11	And this kind of goes back to the question
12	earlier about what level do you use and what level is
13	necessary. That's a really tricky question. And I
14	think the way we actually addressed it in the NUREG is
15	really good. We came up with the NUREG. We came up
16	with the levels. And then, we said, what level is
17	necessary or what level do we currently use? And if
18	you go out and you figure out how you've made this
19	decision already, that's probably the best guess for
20	that's probably the best level going forward.
21	And so, here we just came up with four
22	levels. And I think that we have a discussion in each
23	NUREG about all the historic evidence levels that you
24	would see looking back, thanks to our Office of OGC,
25	which provided, I will have to admit, OGC provided
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1	amazingly good comments on this, and not just like
2	legal comments, technical comments. They had two
3	lawyers, Robert Weisman and Julie Ezell, phenomenal
4	comments. Now they know a lot about CHF, too, which
5	is interesting.
6	So, anyway, these are the levels.
7	Obviously, ideal. All system parameters were
8	completely randomized. You don't really have that
9	so, we basically identified, okay, well, which level?
10	Is it 1? Is it 2? Is it 3? Is it 4?
11	I'd say in the NUREG, we identify the
12	level. When you actually write this in an SE, you
13	don't just say, oh, it's level 3. You generally just
14	provide a justifications of how you know this goal has
15	been met. So, it is usually like level 2, level 3,
16	but we say, hey, that's acceptable because we've done
17	it this way before.
18	MR. ANZALONE: And I think one of the
19	things that you might be concerned about, if you were
20	looking at this and you said, okay, well, our NUREG
21	says level 3 is the most common, well, does that mean
22	that that's what we expect? Not necessarily. It
23	means that, if you have less than level 3, well, you
24	might need to beef up the justification or the
25	documentation compared to what we've seen before.

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1	MR. KAIZER: Yes.
2	MR. ANZALONE: If you have more than level
3	3, maybe you don't need to do as much. So, it's a
4	little bit fuzzier and subjective.
5	MEMBER PETTI: It's also a function of
6	margin.
7	MR. KAIZER: Yes.
8	MEMBER PETTI: The closer you are
9	MR. KAIZER: Yes.
10	MEMBER PETTI: the more you need.
11	MR. KAIZER: Yes.
12	MEMBER PETTI: Right?
13	MR. KAIZER: So, here we just say, yes, we
14	just talk about level 3 is the most common.
15	This is what the entire it's an eye
16	chart, but I just want to throw it up there this is
17	what the entire framework looks like. To me, it's
18	interesting because each of these areas, if you're
19	going to learn about all these areas in total, it
20	takes a long time to actually just grasp them all.
21	But if I have to have an office director understand a
22	specific issue, I can get down to my little one area
23	and have them become not an expert on it, but
24	understand it enough that they're not just relying on
25	me. They understand why it's an issue fairly quickly.

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1	We just did that here. And that, to me, is an extreme
2	benefit, to have your senior management not just
3	fighting for you because they think you're smart, but
4	fighting because they understand why it's an issue.
5	So, here is this beautiful framework in
6	all its glory. We printed it out. If anybody really
7	wants to see, it's the largest printout I've ever had.
8	It's like 4 feet. It's really cool.
9	And our future work. So, future work,
10	this is what I'm working on right now for ASME
11	standards. There's nothing special about critical
12	heat flux and critical power models. They're data-
13	driven models. This whole framework, it took us a
14	long time to develop it, but what we really came up
15	with was a credibility assessment framework for all
16	data-driven models. You have to go in and you have to
17	adjust the levels a little bit, but, ultimately, CHF
18	models live and die by the empirical data. Data-
19	driven models live and die by the empirical data.
20	We even stole language from machine
21	learning, training data, validation data, k-folds
22	testing, all that great stuff, because it just works
23	so well. And so, right now, there's two ASME
24	subcommittees that are getting together, and we're
25	basically trying to turn this into one for data-driven
I	1 I I I I I I I I I I I I I I I I I I I

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1	models.
2	One of the participants in the ASME
3	standard group is actually using this for their data-
4	driven model. It's not CHF. It's got nothing to do
5	with nuclear safety. But they're using it, and it's
6	like in a manufacturing areas, because it just works
7	for data-driven models. So, that's what we're trying
8	to do.
9	I would really like to, if I picked one
10	for the future to develop, it would be the one for
11	fuel thermal-mechanical models, because I see that as
12	an area where we're seeing
13	MEMBER MARCH-LEUBA: This is the computer
14	model or the results?
15	MR. KAIZER: For the data-driven model?
16	MEMBER MARCH-LEUBA: No. This is
17	MR. KAIZER: Sorry.
18	MEMBER MARCH-LEUBA: Oh, you're talking
19	about a fuel thermal-mechanical correlation?
20	MR. KAIZER: Yes, a fuel thermal-
21	mechanical correlation or code. It would be
22	interesting. I'd like to take on that challenge.
23	MEMBER MARCH-LEUBA: Or taking TRACE?
24	MR. KAIZER: Yes.
25	MEMBER MARCH-LEUBA: You would, then,
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87 1 apply this to TRACE? You would apply it to the correlation --2 3 MR. KAIZER: I would love -- so, that's 4 why that last one is grayed out, large break LOCA 5 models -- I would love, and it's actually one of the goals I'd like to have before I retire. I would love 6 7 to have a framework for just modeling and simulation 8 in general. You have a code; use this framework. 9 MEMBER MARCH-LEUBA: To validate it? 10 MR. KAIZER: Yes, to demonstrate that you can trust it. And I think that you can get there. 11 Because this framework, it pictures like, I think, how 12 people think -- I mean, I think people naturally think 13 14 in this. It's necessary and sufficient, and they 15 break it down, because it's based on set theory, and 16 most people use sets when they're considering stuff. 17 CHAIRMAN RICCARDELLA: When you say "datadriven," do you mean models for which there really 18 19 isn't a strong theoretical basis? MR. KAIZER: Yes. Yes, data-driven models 20 are models where you only believe them because you 21 have some empirical data. 22 CHAIRMAN RICCARDELLA: I think in terms of 23 24 like a finite element analysis, a stress analysis model, there's theory behind it. 25

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1	MR. KAIZER: Yes. Yes. So, this would
2	not be
3	MR. ANZALONE: Directly like empirical
4	correlations.
5	MR. KAIZER: Yes.
6	CHAIRMAN RICCARDELLA: Yes, yes. Thank
7	you.
8	MR. KAIZER: Yes, so they used to call
9	them empirical correlations, but, then, the empirical
10	correlations people hired an advertising company, and
11	they're like empirical correlations was so 1800s; call
12	them data-driven models now.
13	MEMBER MARCH-LEUBA: Because it's the same
14	thing, right?
15	MR. KAIZER: Yes. So, yes, I would really
16	love to see one of these for just all of modeling and
17	simulation. I mean, I think we've proven with CSAU
18	that you can do it. I think it needs to be refined.
19	And there are a number of other people Nam Dinh at
20	NC State does a lot of work like this. There's a lot
21	of engineers that see this and they're like, wow, this
22	makes so much sense. You're going to have to do this
23	going forward. How else can you process all of this
24	information? And so, there is this natural push to do
25	a lot of this stuff.

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1	MEMBER PETTI: Yes, I would probably
2	argue, though, that the application into the different
3	fields, there's a different cost driver, right?
4	MR. KAIZER: Yes.
5	MEMBER PETTI: I mean, to do this for CHF
6	is one thing. To do it for another part of nuclear
7	safety could be cost-prohibitive.
8	MEMBER REMPE: Well, on the other hand,
9	though, when we were talking about what to do about
10	this expanded power-to-flow thing that we wrote or we
11	just approved a letter for, I think a lot of the
12	agency processes could benefit from such a framework.
13	You're going to have to rethink up through the levels,
14	but I was going to wait until your last slide. But
15	I think they've got to do things that are sort of
16	repetitive, but it takes a lot of you know, they
17	know the tricks and what to check. And the people who
18	do it are going to retire. I think it's a good thing
19	to encourage.
20	MEMBER MARCH-LEUBA: Yes. I love the fact
21	that it's a knowledge management, a knowledge
22	transfer.
23	But what got me to thinking about this
24	was, just as you were showing the D5 correlation, we
25	were reviewing Reg Guide 1.99, which we saw today.
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1	And how does this model work, this assessment, if you
2	happen to have 188 points to develop a correlation,
3	and 20 years later you have 2,000 points, and the
4	correlation doesn't work anymore?
5	CHAIRMAN RICCARDELLA: Well, it has some
6	inaccuracies.
7	MEMBER MARCH-LEUBA: No, let's see what
8	MEMBER REMPE: You weren't so good at
9	extrapolating that data, is what I would say.
10	(Laughter.)
11	MR. ANZALONE: I was thinking about this
12	last night because I was trying to think about the
13	benefits and the shortcomings. And I've already
14	talked a little bit about what I think one of the
15	shortcomings is of this framework. But one of the big
16	benefits is that you are going into explicit detail
17	about why you found something to be acceptable. And
18	if you collect more data that invalidates that reason
19	that you found something acceptable, you have it there
20	in black and white, the basis for your decision. And
21	you can go back and say, I can refute this point now.
22	We need to like call this into question and take a
23	look at whether we really believe that anymore. So,
24	that, to me, is one of the strongest components of
25	this, is that it allows for that kind of

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retrospection.

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2 I'm just thinking of MEMBER KIRCHNER: 3 other nuclear applications first. Probably the 4 biggest data-intensive-driven set is ENDF. Have you 5 thought through how this notionally would work there? And have you compared how they -- because that's 6 7 international. And so, I'm not sure of all the rules 8 for entering new cross-sections and how you prove that 9 it's statistically valid, and all the things that you would use to come up with a credibility assessment. 10 But, anyway, have you thought of some of the things 11 that are in the mission space of the agency? It might 12 be a good place to look first. 13

14 MR. KAIZER: We haven't applied this to 15 ENDF. Where we have roughly applied it is to just 16 other code reviews in general. I mean, again, CSAU, 17 I would argue that this is very much in the vein of So, almost all of our code reviews do this 18 CSAU. 19 I think this is just a refinement of it. somehow.

20 MR. ANZALONE: I would say for nuclear 21 data specifically, like we think the high-level goals 22 are still probably where we would want them to be, but 23 the lower-level ones maybe you would need to take a 24 look at. I don't think that we've explicitly thought 25 about it, but --

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1 MR. KAIZER: Yes. Right. We've been explicitly trying to get -- because, right now, we 2 3 just had comments, and I'm still addressing the 4 comments. Nothing major. It's just I had a bunch of 5 them, and then, I had other work assigned. So now, I'm trying to get back to it. 6 7 So, I do want to go to the last slide. We

8 wanted to talk about the surprises. The surprise that 9 came, I'd say, most shocking was that it works and how 10 well it works. I have written things like my dissertation, which was great for me, but not really 11 useful for many other people. But this really worked. 12 I mean, it was very awesome to know that all these 13 14 people have come up with these frameworks before, but 15 we came up with a framework, and then, within a period of like two or three years, we've applied it four or 16 17 five times.

And in one case where we could actually have a close measure, because, I mean, usually it was Reed and I applying it. But there was a lot of authors. We were the main authors.

But we had one case where we had someone who had a very strong background in thermal hydraulics do a review of CHF, and we know how long that took that person. And we had someone else who also had a

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1	very strong background in thermal hydraulics do
2	another review of CHF correlations, but they had this
3	NUREG. And it took that person under 50 percent of
4	the time, and it was significantly under 50 percent of
5	the time.
6	And it makes sense because the first
7	person had to learn everything from scratch because a
8	lot of the CHF stuff, it's not captured in these
9	textbooks. And they had to learn it. The second
10	person had the benefit of this, and it's like, oh,
11	okay, yes, check, check, check, check, and it went
12	quick, really quick.
13	I've used this framework, I mean, now to
14	write Safety Evaluations in, I'd say, under a week,
15	because I can get it down to, wait a minute, I
16	understand now; I just need to prove G3 is true. So,
17	I just grab that whole set and say, okay, demonstrate
18	how I've satisfied all these subgoals. Done.
19	MEMBER REMPE: So, for advertising
20	purposes, it's great to say you saved resources, but
21	I would emphasize it reduces regulatory uncertainties.
22	MR. KAIZER: Yes.
23	MEMBER REMPE: The applicant knows what
24	you're going to be looking
25	MR. KAIZER: Yes.
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1	MEMBER REMPE: You're establishing the
2	groundrules.
3	MR. KAIZER: Yes.
4	MEMBER REMPE: And that was why we really
5	liked it when we first saw it, is that it wasn't a
6	proprietary document that's couldn't be shared.
7	MR. KAIZER: Yes.
8	MR. ANZALONE: Now that it's out there,
9	we're able to have those conversations with the fuel
10	vendors about what the expectation is for them to
11	submit stuff.
12	MEMBER MARCH-LEUBA: And then, they have
13	an expectation. Their submittal takes half the
14	effort.
15	MR. KAIZER: Yes.
16	MEMBER REMPE: It saves their resources,
17	too. But that's not supposed to be something you're
18	advertising.
19	(Laughter.)
20	MEMBER MARCH-LEUBA: Twenty-five of the
21	RAIS.
22	MR. KAIZER: Yes.
23	MEMBER MARCH-LEUBA: Because you probably
24	don't have to even issue RAIs anymore because they're
25	going to answer your questions. They know what you're
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1	going to ask.
2	MR. KAIZER: The one I'm really waiting
3	for, there's apparently a new CHF correlation coming
4	in, and I would be interested to see how closely they
5	follow this. Because if you do follow this framework
6	really closely, it should not take long at all.
7	And there's this weird tendency as a
8	reviewer, when you have something, to want to hold
9	onto it for months. Even if you look at it and don't
10	think about it again, you feel like, if you look at it
11	and say, oh, yeah, that was good, and then, sign it
12	out right away, you haven't done your due diligence
13	because you haven't thought about it. But, at least
14	with this framework
15	MEMBER MARCH-LEUBA: If they give you work
16	and you do it in a week after they give you the TR,
17	they'll say, "Aw, he didn't do the work."
18	MR. KAIZER: Yes. But, with this
19	framework, you feel like, well, I've actually thought
20	about it ahead of time. And one of the things I'm a
21	proponent of is you should be able to write your
22	Safety Evaluation before the report ever comes in.
23	Because if you can't tell me what you need for a
24	specific Topical Report to be considered safe before
25	you see it, then, after you see it, you're just
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1	reacting to subjective things. There should be some
2	objective standard, and that's what we really like.
3	MEMBER BLEY: So, your ordinal scale, I'm
4	not concerned about those. I think those work pretty
5	well.
6	MR. KAIZER: Uh-hum.
7	MEMBER BLEY: Your completeness issue is
8	one that, of course, you can add it when you find it
9	later, but when you find it later, it may be because
10	something went really wrong.
11	MR. KAIZER: Uh-hum.
12	MEMBER BLEY: So, you know, I've got to
13	fix it. The same thing you bring up in PRA all the
14	time. Your initial simple model of the bridge, now
15	the bridge has collapsed because of vibrational modes,
16	and, you know, that wasn't in there.
17	MR. KAIZER: Yes.
18	MEMBER BLEY: And so, somehow
19	reinvestigating that you are complete across the range
20	of things you need to check for is important. I don't
21	know how you structure to that.
22	MR. ANZALONE: I guess to that, I would
23	say, for this particular framework, we have enough
24	history and experience that I think we can say we're
25	comfortable that this is probably about as close to
1	1

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1	complete as it's going to get.
2	MEMBER BLEY: You base that on reviews
3	that have been done before without it and that you've
4	covered everything that is in those reviews.
5	MR. ANZALONE: Exactly. But the
6	challenge, then and I think you're exactly right
7	comes in addressing, if we expand this kind of
8	framework to other areas that maybe the agency has
9	less experience dealing with.
10	MEMBER BLEY: I guess one more. The thing
11	on the ordinal scale that could eventually be
12	troubling somewhere is that, as you say, it's not a
13	quantitative scale. One, two, and three might all be
14	about the same effect and something else might be much
15	bigger, and there's no sense of that, which might lead
16	you to focus more effort on less important things.
17	And I don't know what you're doing with that.
18	MR. KAIZER: Basically, the framework,
19	even though you give the one, two, three four, it ends
20	up being very binary. Either you've demonstrated that
21	you've satisfied that goal or you haven't. And so,
22	you have to come up with, okay, is level 3 enough; is
23	level 2 enough? And people are always worried, oh,
24	you're taking the engineering out of it. Not really.
25	MEMBER BLEY: No, you're organizing it.
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1	MR. KAIZER: We're just trying to focus
2	it. Yes, the engineering comes in with, is level 2
3	enough, is level 3 enough, and why?
4	MR. ANZALONE: Yes, that's exactly where
5	engineering judgment comes into play.
6	MR. KAIZER: Yes.
7	MEMBER BLEY: And is your set complete?
8	And when the individual sits down to do it, his or her
9	sets may or may not be complete, depending on how good
10	they are at thinking, at searching for those kinds of
11	problems.
12	MR. ANZALONE: And while the shorthand for
13	the framework is that big picture that he showed,
14	there's a narrative along with it that says, like when
15	we've seen this level of evidence historically in the
16	past, this is why we've felt it was acceptable. When
17	we go through the phenomenal logical review in the
18	beginning, that's sort of laying out why we think that
19	this set of goals is complete.
20	MR. KAIZER: Well, the only modification
21	I would say is I'm convinced that this set of goals is
22	not complete because I would love to prove from first
23	principles that this is perfect, but outside of some
24	mathematical things, as soon as you enter the
25	engineering world you can't.
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99 But what I actually have now is anyone 1 that wants to can look, and it's like, okay, if it's 2 3 not complete, tell me where. So, it might not be 4 complete, but at least I get it out there in front of 5 all the experts and they can provide feedback and say, wait a minute, you forgot about this: in 1957, this 6 7 Russian thing happened, and blah, blah, blah. 8 MEMBER BLEY: The reviewer using this 9 won't forget the ones you have here. One quick question. 10 MR. KAIZER: Uh-hum. 11 that MEMBER BLEY: I'd like to have 12 The KM has all the pieces of the picture. 13 picture. 14 MR. KAIZER: Okay. 15 MEMBER BLEY: Given that it's electronic, you could put the whole picture in there. 16 17 MR. KAIZER: At a page? Yes. It would look like this, some slightly --18 19 MEMBER BLEY: Now my copy of the KM looks like the thing you said is your thesis. 20 Yes. MR. KAIZER: This one? 21 No, mine has the same 22 MEMBER BLEY: picture --23 24 MR. KAIZER: So, then, you probably printed out my thesis. 25

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1	MEMBER BLEY: Okay. It says, "KM-006" on
2	it.
3	MR. KAIZER: Yes, 006 is the thesis.
4	MEMBER BLEY: Oh, what's this one? What's
5	this one?
6	MR. KAIZER: Thirteen, yes.
7	MEMBER BLEY: Thirteen?
8	MR. KAIZER: Yes.
9	MEMBER BLEY: Oh, okay. And it's a KM?
10	MR. KAIZER: Yes.
11	MEMBER BLEY: Okay. I didn't grab that
12	one. Okay.
13	MEMBER REMPE: So, to follow up on your
14	thing about completeness and your comment about this
15	is a general framework, and then, just life
16	experiences we've had lots of confidences in the
17	past in nuclear power, and then, learned, oh, we
18	didn't think about that. Maybe it's worthwhile having
19	another box that says any new information that could
20	be push the person who's using this to force them
21	to say, "I looked and I didn't see anything else." I
22	mean, you said it's in your narrative, but maybe is it
23	in there strong enough, is where I'm kind of going.
24	MR. KAIZER: I think because of the way
25	the framework was, I would put that in like an

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1	introduction section. Because, I mean, I don't know
2	if you would want that like next to each and every
3	goal.
4	MEMBER REMPE: Maybe not in every goal,
5	but maybe somewhere at the top just about new things.
6	Somehow, make sure that they've checked that box.
7	Because if they go to apply this
8	MR. KAIZER: Yes.
9	MEMBER REMPE: and I'd like them to try
10	and apply it other places, but we've had a history
11	where we didn't think severe accidents are always
12	something we didn't think about.
13	MR. KAIZER: One of the areas I would like
14	to get to, which I think will be awesome, is if there
15	is a way to quantify an uncertainty measure with how
16	comfortable are we with this breakdown like do we
17	have a lot of experience saying G1.1, 1.2, and 1.3 are
18	equal to G1? Are we like, yes, we know this or, you
19	know, this is an area where we have high uncertainty,
20	but this is the best we have? And how to even
21	incorporate uncertainties correctly in this? I mean,
22	I think that's also that part of it. It's like, okay,
23	this was based off of old information.
24	MR. ANZALONE: Almost going back to like
25	a PERT.
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1	MR. KAIZER: Yes.
2	MR. ANZALONE: Like what's the state of
3	knowledge on this particular aspect?
4	MR. KAIZER: Yes.
5	MEMBER REMPE: Something. I'm wondering.
6	It's been a long time. We didn't meet for a month,
7	and I think I looked this over when you guys did it
8	earlier. So, I didn't spend time re-reading it.
9	MEMBER PETTI: I think what you're arguing
10	is the unknown unknowns.
11	MEMBER REMPE: Yes, and just to make
12	people check the box that I really am thinking outside
13	the box here. If you've got a process, it would be
14	real easy to have that ground engineer to say, oh, I
15	don't have to do anything else; I did this process.
16	And I make him think.
17	MEMBER BLEY: But you've got to always be
18	pushing to think of new things. But the good thing
19	here is you've thought about it pretty well against
20	what's been done in the past. And whoever uses this
21	is likely to be more complete than they would have
22	been on their own.
23	MR. KAIZER: Yes.
24	MEMBER BLEY: And if they come up with
25	something new, it would be real good if you have some

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1	mechanism to really coax them to talk to you.
2	MR. KAIZER: Yes.
3	MEMBER BLEY: I mean, theirs would be
4	better, but the overall system wouldn't have gained
5	from that.
6	MEMBER MARCH-LEUBA: It's a small enough
7	community that they would be talking about it.
8	(Laughter.)
9	MEMBER BLEY: We say that, but we don't
10	always do that.
11	(Laughter.)
12	MEMBER REMPE: Some of the observations
13	about the fuel failures and trying to understand what
14	occurred, it's just there's always new information out
15	there. And if this sits on the shelf and again,
16	also trying to give the applicant realistic
17	expectations. This is the process we're going to use.
18	You had better address this stuff. But we'll both be
19	looking to see if there's anything new we ought to
20	consider.
21	MEMBER DIMITRIJEVIC: I want to say
22	something. Everything that you said, in short, PRA
23	has, Probabilistic Risk Assessment has 40 years of
24	experience. Everything is totally identical to what
25	I heard in the beginning of development of the PRA.

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1 However, PRA has 40 years of experience. So, a million questions. And even if it's identical that 2 3 you carry, because I used to carry the model for 4 failure of status of the water system developing, 5 exactly which means that it goes around the walls. And everything that you want to accomplish and 6 7 everything what you think can be accomplished, that's called the story of the PRA beginning. It's totally 8 9 identical. It's actually spooky.

10 I was listening to you. And now, you're starting some completely new application which has to 11 be, you know -- this is not quantitative, PRA is 12 totally quantitative. So, there is a way to put 13 14 uncertainties in. You know, there are questions which also brings it so that the PRA will be completely 15 The questions then is all applicable. 16 applicable.

Even we have standards now which have four 17 categories, which is completely similar to your 18 19 numbers 1, 2, 3, 4, you know. The limits of this is show quality of results or 20 that you cannot uncertainty, and how close are the results to the 21 reality, and what is the uncertainty base either of 22 your level of detection or based on the grades you put 23 24 for every input.

You know, if you have whatever, how many

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1	grades you have, four or five, four like you want
2	three.
3	MR. KAIZER: It varies for each one, yes.
4	MEMBER DIMITRIJEVIC: Let's say that all
5	four of your uncertainty grades will be these sort of
6	you know, if you have a different mix, the
7	importance of the different things.
8	But, basically, like in the PRA, with the
9	PRA we often say, even we start using numbers now all
10	the time. The numbers are not so important, and
11	actually, where you can see where your contribution
12	comes from, the difference, you know.
13	MR. KAIZER: I didn't get back to it, but
14	in the Predictive Capability Maturity Model, which
15	they started at Sandia, and it kind of failed
16	initially, when they started using it later, that
17	conclusion was this is helpful if we ignore the
18	numbers, but we see which ones are the major
19	contributors.
20	MEMBER DIMITRIJEVIC: Yes.
21	MR. KAIZER: In this one, I don't think
22	it's refined enough because it tries to give you the
23	quantitative answer that PRA does, but, to me, this is
24	just it's a logical map like PRA is. It's a mental
25	map. You can think about it. You put it down. It

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1	makes more sense
2	MEMBER DIMITRIJEVIC: Your process of
3	development is equally important as that. We forget
4	now because we are 40 years in development and
5	everybody forgets where the actual module came from.
6	MR. KAIZER: Yes.
7	MEMBER MARCH-LEUBA: Essentially, we're so
8	used to thinking about uncertainties, but you have to
9	remember that this process gives you the quality of
10	your decision. You want the uncertainty and the
11	quality because the correlation at the end, you
12	have data and you have your correlation. You fit it,
13	and you know what the error in the uncertainty and the
14	correlation is.
15	What this more allows you to define is the
16	quality of that.
17	MR. KAIZER: Yes.
18	MEMBER MARCH-LEUBA: And looking for
19	uncertainty in her quality, I don't know. I mean, I
20	think we're overdoing it then.
21	MR. KAIZER: It would be fun to do it.
22	How would you do an uncertainty?
23	MEMBER DIMITRIJEVIC: Well, how would you
24	define, I mean, how would you define quality of the
25	software?

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1	MEMBER MARCH-LEUBA: But, at the end of
2	the process, he says this is credible or this is not
3	credible.
4	MR. KAIZER: Yes.
5	MEMBER MARCH-LEUBA: So, what you say is
6	it's credible plus or minus
7	MEMBER DIMITRIJEVIC: But the problem, his
8	design is obviously Because his purpose is to
9	calculate your what, critical heat flux? Gives you a
10	number which can be blah, blah, blah or it can be
11	blah, blah, blah two. Which one is the better? See,
12	that's not credible. That doesn't like to do quality.
13	It just gives you chances to say it's good enough.
14	MEMBER BLEY: Well, and that's what the
15	ordinal scales do.
16	MEMBER DIMITRIJEVIC: Yes.
17	MEMBER BLEY: Once you've exercised them,
18	you get to a point and you say this is acceptable.
19	But it's really a good enough kind of thing.
20	MR. KAIZER: Yes, it's binary. I mean, to
21	me, every decision by every decisionmaker is
22	ultimately binary. Yes, we're going forward; no,
23	we're not. And so, you just try to come up with this
24	framework. Yes, that's how I defined credibility or
25	I tried to, which is, yes, it's credible, we're going
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1	to go forward; no, it's not credible; stop, we're not
2	going to go forward. And I think you need a way to
3	reach that from the decisionmaker's
4	MEMBER MARCH-LEUBA: You can tell the
5	vendor it's not credible because it failed G12.
6	MR. KAIZER: Yes, yes.
7	MEMBER BLEY: Well, going back to your
8	analogy to the PRA, which there is some, but I don't
9	know how many times you've done this, but it hasn't
10	been all that many. Ten years from now when you've
11	had a lot of experience, there may be apparent ways to
12	make this more quantitative and clear. But, right
13	now, it seems to me it is better than anything I've
14	seen to get a good review.
15	MEMBER DIMITRIJEVIC: Well, was it the
16	case when Jose jumped because there was two totally
17	different critical heat flux results in something we
18	reviewed?
19	MEMBER BLEY: Yes, yes.
20	MEMBER DIMITRIJEVIC: Remember when you
21	got upset? Okay, so
22	MEMBER MARCH-LEUBA: I didn't get upset.
23	I told them something was wrong.
24	(Laughter.)
25	MEMBER DIMITRIJEVIC: Yes, but
	I

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1	MEMBER BLEY: They'll figure it out.
2	(Laughter.)
3	MEMBER DIMITRIJEVIC: Would those both
4	pass this?
5	MEMBER BLEY: They might have.
6	MEMBER MARCH-LEUBA: No, they were using
7	two different correlations for two different
8	calculations.
9	MEMBER BLEY: Yes.
10	MEMBER MARCH-LEUBA: And now, we're
11	reviewing two Topical Reports. Well, you haven't met
12	the V&V yet.
13	MEMBER BLEY: Either of those correlations
14	might have passed this process.
15	MEMBER DIMITRIJEVIC: Yes.
16	MEMBER BLEY: But they're different for
17	particular reasons. But, then, you learn some more
18	and you
19	MEMBER MARCH-LEUBA: It's not proprietary.
20	There were two different correlations. One was a
21	critical heat flux and the other was a critical power
22	issue. And they were giving you the numbers.
23	CHAIRMAN RICCARDELLA: I've seen processes
24	where people are going to run a lot of tests. And say
25	you're going to run 500 tests, and they take 400 of
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1	those tests and they train their correlation on those
2	400. And then, they test them on another group. Is
3	some of that built into this?
4	MR. KAIZER: Yes. So, the training
5	validation split and the way we've actually I don't
6	give the thing back here, let's see, in mathematical.
7	It's one of the validations. We tell you, okay, how
8	much data are you using for training, and we give it
9	a percentage. The highest credibility is that you're
10	using zero percent of your data for training. The
11	lowest credibility is you're using 100 percent of your
12	data for training.
13	CHAIRMAN RICCARDELLA: Okay.
14	MR. KAIZER: And then, validation, we ask
15	the same question and we reverse it. And there's even
16	another, I won't say it's a pseudo-requirement, but
17	because, as a regulator, I don't care how well your
18	correlation predicts data that it already saw; I care
19	how well your correlation predicts data that it hasn't
20	seen yet. We pretty much say you should not be
21	developing your uncertainty on the data that was used
22	to train your correlation. You should only be
23	developing your uncertainty on the data that was used
24	to validate.
25	MEMBER MARCH-LEUBA: But it also forces
	I contract of the second se

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1	you to question the quality of the experimental data.
2	CHAIRMAN RICCARDELLA: Yes.
3	MEMBER MARCH-LEUBA: For example, in the
4	red dot fuel, the rollout is going to go like this
5	letter.
6	CHAIRMAN RICCARDELLA: Yes.
7	MEMBER MARCH-LEUBA: We can develop a
8	polynomial that fits it perfectly.
9	CHAIRMAN RICCARDELLA: Sure.
10	MEMBER MARCH-LEUBA: But maybe the guys
11	that took this, they didn't know how much copper was
12	in
13	CHAIRMAN RICCARDELLA: That data was
14	valid, but there was an ASTM committee that scrubbed
15	that data.
16	MEMBER MARCH-LEUBA: Yes, I know, but
17	CHAIRMAN RICCARDELLA: I don't know if
18	they used all of your processes, but, I mean, it
19	wasn't just
20	MEMBER MARCH-LEUBA: Just the fact they
21	used 400 points for the data doesn't mean the 400
22	points were good.
23	CHAIRMAN RICCARDELLA: Yes.
24	MEMBER MARCH-LEUBA: If you didn't know
25	what the chemistry of your sample was, the data is

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1	useless. And this process forces you to check the
2	experimental evidence; does it cover the intended use?
3	CHAIRMAN RICCARDELLA: Yes.
4	MEMBER DIMITRIJEVIC: You don't think that
5	the time traveling guide developed the correlationship
6	of that data because he had too many variables. It's
7	not like two-dimensional. It doesn't really fit all
8	the time.
9	MEMBER MARCH-LEUBA: I think it's a novel
10	approach. As we told them, once you see a wheel, you
11	say, "Yes!" But the first man that came up with the
12	wheels, they said, "Oh, look at this! That was good."
13	(Laughter.)
14	CHAIRMAN RICCARDELLA: So, could we
15	develop this process to help us pick stocks? Then,
16	maybe we wouldn't have to work that much.
17	(Laughter.)
18	MEMBER REMPE: We're still on the record.
19	I think we ought to thank Jose for bringing it to our
20	attention instead of worrying about your finances.
21	(Laughter.)
22	MR. KAIZER: Actually, the person who's
23	got the most developed one of these frameworks that
24	I've seen is actually the diamond industry because
25	they have the four Cs: caret, cut, clarity, and
	1 I I I I I I I I I I I I I I I I I I I

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1	color. And you can grab their diamond chart and it's
2	set up like a framework, and they actually have
3	extremely defined levels of what's in each level. And
4	there is even and I was talking to Tomasz Kozlowski
5	from the University of Illinois. He said that there
6	is a machine-learning database that gives you the
7	value of like something like 150,000 diamonds and it
8	tells you the value in their charts and it tells you
9	the price of the diamond. So, the idea is, can you
10	come up with a machine-learning technique to determine
11	prices of diamonds better than anyone else?
12	So, people have used something like this
13	to come up with something monetary. Although if I
14	could come up with something with stocks, I'm not sure
15	I would I'll say I probably still would be here.
16	I like this job.
17	(Laughter.)
18	MEMBER DIMITRIJEVIC: You know, why cannot
19	the review this morning as a part of our QA instead of
20	these NUREGs we selected?
21	MEMBER REMPE: Because the Office of
22	Research selects, provides us a list, and we must pick
23	something from it. And again, that's another topic.
24	But, as you know, that may not be continuing in
25	outyears anyhow, but that's why it was not on

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1	MEMBER DIMITRIJEVIC: Yes, but we didn't
2	finish reviewing the
3	MEMBER REMPE: But we have to pick
4	something from the list that Ray Furstenau provided.
5	MEMBER MARCH-LEUBA: It will be issued
6	next year. We can hint that we would like to see it
7	again.
8	MEMBER BLEY: If we want to write a
9	report on this, we could do it.
10	MEMBER REMPE: We are doing a Letter
11	Report on this. Jose has a draft Letter on it.
12	That's another reason, too. So, we're writing a
13	letter on it.
14	MEMBER BLEY: So, thank you, guys. It was
15	a little more fun than what we usually do.
16	MEMBER REMPE: That's why we should thank
17	Jose for bringing it.
18	MEMBER MARCH-LEUBA: As another topic, I
19	would like to poll the members if we would like to
20	write a letter on this NUREG to the Commission,
21	because I do have one ready
22	MEMBER REMPE: Oh, I thought we were doing
23	it.
24	MEMBER MARCH-LEUBA: if we want to do
25	it.

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115 1 MEMBER REMPE: We'll see how the letter is. 2 did 3 MEMBER KIRCHNER: But we give 4 favorable mention to this framework in the letter. 5 What was it? Was it NuScale or was it --MEMBER MARCH-LEUBA: 6 1.99 7 MEMBER KIRCHNER: -- or APR1400? Who sees that correlation --8 MEMBER MARCH-LEUBA: We made some decision 9 10 in 1.99 orally. Nothing that I --MEMBER KIRCHNER: Anyway, we have a letter 11 that references this, but at that point it was part 12 of --13 14 MEMBER MARCH-LEUBA: Oh, that's D5. 15 MEMBER REMPE: Yes. MEMBER PETTI: But I think --16 MEMBER BLEY: That wouldn't shine the same 17 kind of light on it. 18 19 MEMBER PETTI: Yes, I think a separate particularly talk 20 letter where we about the applications beyond the limited application here. 21 We've got a draft. 22 MEMBER REMPE: MEMBER PETTI: Right. So, I don't have a 23 24 problem with that. Okay, I'll take a 25 MEMBER MARCH-LEUBA:

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1	unanimous consent.
2	MR. LUKES: Bob Lukes. Is this one
3	(referring to microphone)?
4	CHAIRMAN RICCARDELLA: Yes.
5	MR. LUKES: Great. Bob Lukes. I'm the
6	Chief of the Nuclear Methods and Fuels Branch. I'm
7	Chief of Josh and was Reed until he abandoned me.
8	(Laughter.)
9	So, three years ago I took this job, and
10	I think the Nuclear Methods is probably the most
11	technical branch in the NRC, aside from our research
12	sisters. And Josh, three years ago, dropped the CHF
13	on my desk, when I first got the job. And I'm like,
14	okay, I've got to learn this. So, I pulled down this
15	thing called NUREG-0800, the Standard Review Plan, to
16	look at it, and it says nothing.
17	(Laughter.)
18	So, I called Josh and I'm like, "How did
19	you do this?" Right? "There's no way you did it from
20	this." And he drops a verification and validation
21	textbook on my desk.
22	(Laughter.)
23	And I'm like, "What is this?" He tells
24	me, "Don't worry. I've got it covered."
25	MR. KAIZER: It's this one, if anybody
	I contract of the second se

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1	wants it.
2	(Laughter.)
3	MR. LUKES: Yes, that's the one. And he
4	gave it to me, actually. He gave me the copy.
5	Three years later, here we are. He
6	independently without direction saw a need, saw a
7	hole, wrote this new NUREG/KM. And I've done my best
8	at throwing his praise above me, and I don't know if
9	I've done a good job. So, I just want to praise the
10	ACRS for recognizing the importance of this and taking
11	the time to let him come present.
12	Because, you know, as I entered the back
13	third of my career, I realized that this is the legacy
14	that we're going to have left here when everybody
15	goes. And we're losing people more than we're getting
16	new people. And we're losing knowledge. And
17	everything he's done has been just knowledge
18	management or what do we call it? tribal
19	knowledge. Someone told him how to do it and nothing
20	was ever written down. So now, we finally have
21	something written down, and I just really want to give
22	praise to the ACRS for recognizing that and seeing the
23	importance of this.
24	MR. KAIZER: Thank you.
25	CHAIRMAN RICCARDELLA: Great. Thank you.
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1	MEMBER DIMITRIJEVIC: That is for this co-
2	creating, you know, for creating solutions.
3	MEMBER MARCH-LEUBA: Innovation.
4	MEMBER DIMITRIJEVIC: Innovation, exactly.
5	MEMBER MARCH-LEUBA: Maybe we just start
6	in the letter.
7	MR. KAIZER: Okay. Thank you.
8	CHAIRMAN RICCARDELLA: Thank you.
9	MEMBER BLEY: We go to comments first.
10	MEMBER MARCH-LEUBA: Yes, yes.
11	MEMBER REMPE: Are there comments? Is
12	there a phone line?
13	MEMBER MARCH-LEUBA: We already had some
14	comments from the public. Any other comments from the
15	public?
16	(No response.)
17	MEMBER REMPE: And the phone line?
18	MEMBER MARCH-LEUBA: We are going to open
19	the phone line.
20	Anybody on the phone line?
21	(No response.)
22	MR. ANZALONE: We did go out for public
23	comment and we did receive not an insignificant number
24	of public comments from industry and academia. Most
25	of them were

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1	MEMBER MARCH-LEUBA: Anybody on the phone
2	line, can you identify yourself and provide us
3	comments, if you have one?
4	(No response.)
5	Okay. Hearing none, we can close the
6	line.
7	And please continue.
8	MR. ANZALONE: Oh, yes, I was just going
9	to say most of them were primarily editorial in
10	nature. I think we got a lot of comments agreeing
11	with the overall approach, favorable comments.
12	MEMBER MARCH-LEUBA: It's good for the
13	reviewers. It's good for the submittal. It's good
14	for the public because we guarantee a certain level of
15	predictiveness. The review, someone is told to have
16	this much level.
17	CHAIRMAN RICCARDELLA: Okay. So, I think
18	we'll go off the record now.
19	(Whereupon, the foregoing matter went off
20	the record at 3:39 p.m.)
21	
22	
23	
24	
25	

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Presentation to the ACRS US-APWR Chapter 8 Electric Power

November 7, 2019

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Overview of Chapter 8: Electric Power



In accordance with RG 1.206 and the SRP, Chapter 8 consists of following subsections:

8.1 Introduction

8.2 Offsite Power System

8.3 Onsite Power Systems8.3.1 AC Power Systems8.3.2 DC Power System

8.4 Station Blackout



Offsite Power System (8.2)

> Design Features

- \checkmark Two (2) sources of offsite power provide;
 - 1) Normal Preferred Power from Reserve Auxiliary Transformers (RAT)
 - 2) Alternate Preferred Power from Unit Auxiliary Transformers (UAT) through Main Transformer
- ✓ The two (2) offsite power supply circuits are independent and physically separated.
- ✓ Either offsite power supply circuit has the capacity for normal operations and Design Basis Events (DBE) to comply with the applicable GDC's.



Onsite Power Systems (8.3)

Design Features

- ✓ Four train Class 1E AC electrical power systems
- ✓ Each train includes an independent Class 1E GTG as its emergency power source
- On-Line Maintenance with Single-Failure Criterion remains satisfied
- ✓ "Permanent" buses supplied from Alternate AC Power Source (AAC-GTG)
- Non-safety related loads are electrically separated from class 1E buses
- Required non-safety related loads are supplied from AAC during LOOP
- AACs provide power to all SBO required loads to bring and maintain the unit in safe-shutdown

Electrical Power System



Transmission System1



Main One-Line Diagram

Emergency Power



Class 1E Gas Turbine Generator (GTG) Specification/Rating

Gas Turbine Rating

- ✓ Continuous Rating: 4500 kW
- ✓ Short time Rating: 4950 kW

Generator Rating

- ✓ Continuous Rating: 4500 kW / 5625 kVA
- ✓ Power Factor: 0.8
- ✓ 6900 Volt, 3 Phase, 60 hertz

Starting Time

✓ < 100 seconds</p>



Class 1E GTG Testing Program

Regulatory Guide 1.9

 Application and Testing of Safety-related Diesel Generators in Nuclear Power Plants

➢ IEEE 387

 ✓ IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.

ISG-21 (Draft)

✓ Interim Staff Guidance On the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System

MHI Technical Report (Qualification Test Plan and Initial Type Test Result)

- ✓ Qualification and Test Plan for Class 1E Gas Turbine Generator System: MUAP-07024
- ✓ Initial Type Test Result of Class 1E Gas Turbine Generator System: MUAP-10023



Class 1E GTG Initial Type Tests

- Load Capability Test
 - ✓ IEEE 387 6.2.1
 - ✓ To demonstrate the capability to carry rated load
- Start and Load Acceptance Test
 - ✓ IEEE 387 6.2.2
 - ✓ To establish the capability to start and accept load within the required time period
 - ✓ 150 Start Tests

> Margin Test

- ✓ IEEE 387 6.2.3
- ✓ To demonstrate the capability to carry the most severe load step + 10%



Station Blackout (8.4)

- Basic Concept for Coping with SBO
 - The AACs are available in the event of SBO, when all offsite power sources and EPSs are not available to bring the unit to a safe shutdown condition and maintain that status

Design Basis

- ✓ Diversified AACs to minimize the potential for common cause failures between AAC and EPS system
- ✓ The non-class 1E AAC is a packaged gas turbinegenerator connected to a 6.9kV AC "Permanent" bus
- ✓ AAC can be aligned to any of the 4 class 1E buses in response to an SBO
- ✓ AAC supplies safe shutdown loads during the SBO coping period (8 hours)



NRC Bulletin 2012-01, "Design Vulnerability in Electric Power system," addressed the loss of one of the three phases of offsite power (single-phase open circuit condition) at Byron Station

MHI Response to Provide Protection against OPC (Open Phase Condition)

- (1) Detection and Protection Method
- (2) Single Failure Criteria
- (3) COL and ITAAC

Open Phase Condition



> MHI Response

(1) Detection and Protection Method

OPC detection systems are provided on the high voltage side MT and RAT.

(2) Single Failure Criteria

OPC detection system has redundancy.



Open Phase Condition



(3) COL Item and ITAAC

✓ COL items on detail designs and surveillance requirement were added in

DCD section 8.2.

1		
	COL 8.2(12)	Deleted The COL applicant is to determine the specific type of the OPC detection devices which properly address and meet the requirements of B.1. & B.2. of BTP 8-9. taking into account the site-specific design configuration. installation condition. (field) performance testing and gualification status. and operation experiences of the OPC Detection and Protection system. The COL applicant is also to provide the detailed design of the OPC Detection and Protection system for the COL applicant site The COL applicant is to perform a field simulation on the site-specific. design of the offsite power system to ensure that the settings of the OPC Detection and Protection system and appropriate for the COL applicant site.
	COL 8.2(13)	The COL Applicant is to provide surveillance requirements for the device(s) used to detect open phase condition on the high voltage side of the RATs and MT, with or without grounding.

✓ One ITTAC was added in Tier 1 of DCD.

Table 2.6.1-3 AC Electric Power Systems Inspections, Tests, Analyses, and Accentance Criteria (Sheet 8 of 8)

Acceptance Ontena (Oneer 0 01 0)						
Design Commitment	Inspection, Test, Analyses	Acceptance Criteria				
28 The Class 1E equipment is protected from open phase conditions with monitoring, detecting and alarming in the main control room.	28.i Analysis will be performed verify the Class 1E equipment is protected from open phase condition.	28.i A report exists and concludes that the Class 1 E equipment is protected from open phase condition by open phase protection system.				
	28.ii Inspection and test will be performed to verify the as-built protection system bounds the result of analysis for Class 1E equipment protection from open phase condition and to verify that open phase condition will be monitored, detected and alarmed in the main control room.	28.ii The as-build protection system bounds the result of analysis for Class 1E equipment protection from open phase condition. The as-built detection system design monitors, detects and alarms in the main control room.				



Technical Reports

#	No.	Rev.	Document Title	lssue Date	Submittal Date	MHI Ref.
1	MUAP-09023	1	Onsite AC Power System Calculation	Aug. 2013	Sep. 3, 2013	UAP-HF-13221
2	MUAP-07024	3	Qualification and Test Plan of Class 1E Gas Turbine Generator System	Sep. 2012	Sep. 28, 2012	UAP-HF-12270
3	MUAP-10023	7	Initial Type Test Result of Class 1E Gas Turbine Generator System	Dec. 2013	Dec. 18, 2013	UAP-HF-13311



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Presentation to ACRS

Chapter 18

November 7, 2019

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- **1. Supporting Documentation**
- 2. US-APWR HFE Program Management Plan
- 3. US-Basic HSI
- 4. Summary





Technical Reports

#	No.	Rev.	Document Title	lssue Date	Submittal Date	MHI Letter #
1	MUAP-09019	5	Human Factors Engineering Program Management Plan	Aug. 2014	Aug. 22, 2014	UAP-HF-14047
2	MUAP-13005	1	Operating Experience Review Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
3	MUAP-13007	1	Functional Requirements Analysis and Function Allocation Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
4	MUAP-13009	1	Task Analysis Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
5	MUAP-10008	4	Staffing and Qualifications Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
6	MUAP-13014	1	Human Reliability Analysis Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
7	MUAP-10009	4	Human-System Interface Design Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
8	MUAP-10012	4	Human Factors Verification and Validation Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042
9	MUAP-10013	4	Design Implementation Implementation Plan	May 2014	Jun. 4, 2014	UAP-HF-14042





Topical Report

#	No.	Rev.	Document Title	lssue Date	Submittal Date	MHI Letter #
10	MUAP-07007	6	Human-System Interface System Description	May 2014	Jun. 4, 2014	UAP-HF-14042

Audited Documents

#	No.	Rev.	Document Title	Issue Date	Audit Date
11	JEJC-1763-1001	2	HSI Design Style Guide	May 2008	May 26 th and July 12 th , 2010
12	7DS-UAP- 20140012	0	Operating Experience Review Results	Aug 2014	August 22th, 2014



2. US-APWR HFE Program Management Plan



- The US-APWR HFE program implementation plan was developed in accordance with NUREG-0711, Revision 2, "Human Factors Engineering Program Review Model," issued February 2004.
- \checkmark The scope of the HFE PMP includes:
 - HFE design team and organization, roles and responsibilities
 - HFE process and procedures
 - HFE issues tracking (HED process)
 - HFE technical program
 - Combined license (COL) information
- ✓ For HFE activities completed within the scope of the US-APWR design, the program element methodology is described within an implementation plan (IP) and the element is documented in a results summary report (ReSR) as per the IP.

2. US-APWR HFE PMP



- The US-APWR HSIS is based on application of the US-Basic HSIS, which establishes the generic monitoring, alarm, control, and computerized procedure technologies to be employed in the Main Control Room (MCR) for all plant systems.
- The generic HSI technologies of the US-Basic HSIS are combined with the specific HSI inventory needed for the US-APWR plant design to create the US-APWR HSIS.
- ✓ The development process for a US-APWR site-specific HSIS confirms or changes the HSI inventory to reflect a site-specific plant.
- A fundamental design assumption and constraint of the US-Basic HSIS that also applies to the US-APWR HSIS is that the plant can be operated with minimum operation staff, one RO and one SRO in the MCR during postulated plant operating modes.



3. US-Basic HSI



US-Basic HSI features and functions

- Submitted as a topical report, MUAP-07007
- MHI used the foundational elements of the Japanese-Basic HSIS as a starting point to create the US-Basic HSIS, applying combinations of design review, redesign, and design validation through a phased implementation
- Appendix A contains information about the Japanese-Basic HSIS & development history
 - Developed Japanese-Basic HSIS with Japanese utilities from 1987 to 2003 with guidance from NUREG-0711 and NUREG-0700
 - Japanese operators were involved in conducting V&V
 - Introduced Japanese HSIS to Japanese latest plant design and MCR modernization
 - No performance issues identified


Operating crew composition

- The normal MCR staffing consists of one RO and one SRO
- The normal MCR staff is supplemented by one additional SRO and one additional RO that will be at the plant to accommodate unexpected conditions

- While the HSIS is designed to support the minimum MCR staffing described above, the space and layout of the MCR are designed to accommodate the foreseen maximum number of operating and temporary staff



MCR personnel allocation





US-Basic HSIS simulator





VDU application	Main purpose
operational VDU	To execute all of the plant control and monitoring functions, including control of the safety systems.
safety VDU	To execute the safety-related control and monitoring functions as a backup for the Operational VDU. It can control operation signals from the Operational VDU.
alarm VDU	To acknowledge and display individual alarms using prioritization color codes. Alarm VDU also provides the alarm confirmation/non-confirmation information to the operator.
operating procedure VDU	To provide computer-based operation procedure displays near the operational VDU and the alarm VDU in order to facilitate and simplify the performance of operation procedure.



4. Summary





- MHI has developed its US-Basic HSIS and used the US-Basic HSIS for the US-APWR HFE program application.
- US-APWR DCD has one COL item (in HPM) and two ITAAC items.
- When HFE programs have been implemented, Results Summary Reports will be submitted by MHI to NRC for NRC review.



These ITAAC items will confirm the proper implementation of the program

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The Control Room design incorporates human factors engineering principles that minimize the potential for operator error.	1. An Integrated System Validation (ISV) test will be performed in accordance with the Human Factors Verification and Validation implementation Plan.	1. All pass/fail criteria associated with each test scenario are passed either on initial performance of the scenarios or following remediation of failures.
2. The as-built Control Room Human-System Interface is consistent with the final validated design specifications.	 An inspection of the as-built Control Room Human-System Interfaces will be performed. 	2. The as-built Control Room Human- System Interface conforms to the validated design with no configuration deviations.

(DCD Tier 1 Section 2.9 Table 2.9-1, DCD Rev.4 Markups, UAP-HF-14042)



US-Basic HSI Plant Specific Design Application







Presentation to the ACRS

Topical Report MUAP-07001 Advanced Accumulator (ACC), Rev. 7

November 7, 2019

Mitsubishi Heavy Industries, LTD

US-APWR

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Introduction



- The advanced accumulator (ACC) is an accumulator tank with a flow damper inside the tank that provides dual reactor injection flows with a highly reliable passive fluidic device as a part of the emergency core cooling system (ECCS) during a Loss-of-Coolant Accident (LOCA).
- Incorporation of the ACC into the LOCA mitigation strategy enables simplification of the ECCS configuration by eliminating the Low Head Safety Injection System (LHSIS) of a conventional Pressurized Water Reactor (PWR).
- The ACC topical report describes characteristics, operational principles, important design features, and testing programs that were conducted to verify the performance of the ACC and confirm the safety analysis model.



Specification of the ACC

Туре	Vertical cylindrical		
Volume per tank	3,180 ft ³ (90 m ³)		
Height	Approx. 30 ft (9.2 m)		
Inner diameter	Approx. 12 ft (3.7 m)		
Design pressure	700 psig (4.83 MPa[gage])		
Design temperature	300 °F (149 °C)		
Large flow injection volume per tank	1,342 ft ³ (38 m ³)		
Small flow injection volume per tank	784 ft ³ (22.2 m ³)		

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Operational Principle (1/2)

Structure of the ACC

- ✓ Flow Damper is installed inside the tank
 - Vortex Chamber at bottom of Accumulator Tank
 - Standpipe connected to vortex chamber
 - Inlet port of standpipe at the middle of Accumulator Tank

Flow Damper

• Outlet pipe of vortex chamber connected to injection pipe







> Passive Flow Switching without need of Any Moving Parts





For Large Flow Injection Phase

- ✓ Required Performance
 - The lower plenum and the downcomer of the reactor vessel shall be filled with water as rapidly as possible during the refilling period.
- ✓ Required Water Volume: \ge 1307 ft³ (37 m³)

For Small Flow Injection Phase

- ✓ Required Performance
 - The downcomer shall be kept filled with water during the core reflooding period until SI pumps take over the injection
- ✓ Required Water Volume: \ge 724 ft³ (20.5 m³)



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Simplified ECCS configuration

- ✓ Four ACCs connected to each Reactor Coolant System (RCS) cold leg.
- Four High Head Safety Injection Subsystems following accumulator injection.
- Low Head Safety Injection Subsystems are not installed.
- The ACC injects water longer than a conventional accumulator
 - Allowing more time for the Safety Injection Pumps (SIP) to start.
 - Allowing the use of gas turbine generators (GT/G) for the emergency power source, if needed.



RCP: Reactor Coolant Pump R/V: Reactor Vessel S/G: Steam Generator PRZ: Pressurizer RWSP: Refueling Water Storage Pit ACC: Advanced Accumulator SIP: Safety Injection Pump GT/G : Gas Turbine Generator S: Safety Injection Signal

MHI document US-APWR

Comparison between Conventional Accumulator and the ACC

- FCCS with a Conventional Accumulator ECCS function during a LOCA is assigned to three subsystems:
 - ✓ Accumulator System,
 - ✓ Low Head Safety Injection System (LHSIS),
 - ✓ High Head Safety Injection System (HHSIS).
- ECCS with the Advanced Accumulator (ACC)

The ACC automatically shifts its flow rate from large to small, allowing;

- Elimination of the LHSIS and simplification of the ECCS.
- \checkmark More time before the safety injection pump and supporting emergency power are required.



Core Reflooding

(Step 2)

Accumulator Flow

Blow Down

& RV Refill

(Step 1)

Injection Flow

ECCS with Conventional Accumulator







Long-Term Cooling

(Step 3)

Low Head

Injection Pump



Development Phase

✓ Confirmatory tests were performed using several scale models (1/8.4 scale, 1/3.5 scale, 1/5 scale).

Design Verification Phase

✓ A qualification test was conducted using a full-scale test facility.



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US-APWR





MHI document US-APWR

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- The ACC design was verified by qualification testing using a fullscale test facility. The performance of the flow damper during large flow and small flow phases, and flow switching without any moving parts were verified.
- Empirical characteristic equations of flow rate coefficients have been developed from the qualification test results covering the range of the expected applicability under design basis LOCA conditions and are used in the ECCS analysis to confirm compliance with all US safety standards.
- As a conclusion, the ACC is applicable to the actual plant as a part of ECCS.



MHI document US-APWR



United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS Full Committee

Mitsubishi Heavy Industries, Ltd. US-APWR Design Certification Application Review

Safety Evaluation with No Open Items: Chapter 8

ELECTRIC POWER

November 7, 2019



Technical Topics

- US-APWR electric power system comprises of the following systems:
 - Offsite power system
 - Onsite AC power system, including 4 Class 1E trains each with a Class 1E Gas Turbine Generator (GTG), and Alternate AC source
 - Onsite DC Power System, including 4 trains of Class 1E 125Vdc
- Staff's review:
 - In the Phase 4 review the staff concluded that the DCD application, Chapter 8 met all applicable regulatory criteria.
 - In particular, the staff will discuss the closure of the following open items:
 - Open Phase Conditions (OPC)
 - GTG Reliability



Open Item #1: OPC

- Design criteria to address OPC includes:
 - Detection
 - Alarm
 - Response to a open phase conditions
- OPC protection features per BTP 8-9
 - COL Item 8.2(12) requires the COL applicant to identify the type of open phase detection and protection (OPDP) system.

Resolution of Open Item #1

 COL Item 8.2(12) will ensure that the COL applicant will determine an OPDP system that meets the guidance in BTP 8-9 including detection, alarm in the main control room (MCR), and protection features in that the Class 1E medium voltage buses will transfer to a power source without an open phase condition.



Open Item #2: GTG Reliability

- MHI proposed the use of GTG as the Class 1E emergency power source.
- The challenges of this proposal included:
 - First of a kind application in the nuclear fleet, therefore there was no operating experience
 - No reliability data available
- In absence of operating experience and reliability data, the staff requested the applicant to perform type tests to ensure GTGs will perform their intended function and achieve their target reliability level.



Resolution of Open Item #2

- The GTGs have been qualified for Class 1E application using methodology and assumptions in Technical Reports MUAP 07024-P, "Qualification and Test Plan of Class 1E Gas Turbine Generator System."
- The applicant documented the successful qualification of the Class 1E GTGs in Technical Reports MUAP-10023-P, "Initial Type Test Result of the Class 1E Gas Turbine Generator."
- The result presented in Technical Report MUAP-10023-P states that to satisfy the starting reliability of 0.975 with 95 percent confidence, 150 start tests should be performed with no failures.
 - MHI performed 150 start and load acceptance tests of the GTGs.
 - The staff finds that these tests prove that the GTGs satisfy the reliability criterion of 0.975 with 95 percent confidence.
- In conclusion, the staff finds that the applicant's approach to demonstrating Class 1E GTG reliability is adequate, considering compliance with GDC 17, conformance to RG 1.155, as well as successful qualification via type testing.



United States Nuclear Regulatory Commission

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Mitsubishi APWR Design Certification Review

SER Chapter 18 Human Factors Engineering Program Presentation to the ACRS November 7, 2019



Chapter 18 Review Team

Technical Staff

- Brian Green, Ph.D. NRR/DIRS/IOLB
- **Project Manager**
 - -George Wunder, NRR/DONR/LB3

Conclusions



- The topical report describes an acceptable generic platform referred to as the US-Basic HSI.
- Implementation Plans provide confidence that iteration on the US-Basic HSI will be consistent with "state-of-the-art human factors principles" and applicable regulations.
- ITAAC will confirm that acceptable HFE practices are incorporated into the final design.
- There are no open or confirmatory items.



United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the Full ACRS Committee

US-APWR Topical Report MUAP-07001, Advanced Accumulator (ACC), Rev.7

Safety Evaluation

November 7, 2019

Staff Review Team

United States Nuclear Regulatory Commission Protecting People and the Environment

- Technical Staff
 - Getachew Tesfaye
- Project Manager
 - George Wunder Lead PM

Background



- Topical Report MUAP-07001, Revision 5, "The Advanced Accumulator"
 - Based on three small scale tests and full height 1/2 scale test with computational fluid dynamics (CFD) analyses for comparison with the fifth-scale and half-scale test results.
 - The ACRS concurred with the staff's recommendation to approve the Rev 5 with an increased uncertainties that are used in loss of coolant accident (LOCA) analyses for the high-flow and low-flow injection regimes. The increased uncertainties account for the use of CFD analysis models to extend the half-scale test results to predict full-scale accumulator performance.
- Topical Report MUAP-07001, Revision 6
 - Based on three small scale tests and full scale test without CFD
 - Modified flow damper with a pressure equalizing pipe across the vortex chamber



Review Objectives



- Review compliance with GDC 35, "Emergency core cooling," and 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"
- Review the modified flow damper design and the reason behind the modification
- Review the adequacy of confirmatory scaled tests
- Review the adequacy the ACC full-scale qualification testing and the verification of the flow characteristics equations

Conclusion:



- The staff reviewed US-APWR Topical Report MUAP-07001, Revision 7, "The Advanced Accumulator" (ML18178A267), along with the responses to the staff's requests for additional information. As a result of its review, the staff concludes:
 - that the characteristic equations developed from the full-scale test facility are comparable to the full height 1/2 scale test with CFD analyses to extend the half-scale test results to predict fullscale.
 - that the characteristic equations developed from the full-scale test facility are applicable to the full-scale accumulator with additional uncertainties and bias, which are described in the report.



MHI Generic List of Acronyms

ACC	Advanced Accumulator	PCT	Peak Clad Temperature
APWR	Advanced Pressurized Water Reactor		Pressurizer
ECCS	Emergency Core Cooling System		Pressurized Water Reactor
GT/G	Gas Turbine Generator	RCS	Reactor Coolant System
GUM	Guide to the Expression of Uncertainty in Measurement	RCP	Reactor Coolant Pump
IEC	International Electro-technical Commission	R/V(RV)	Reactor Vessel
ISO	International Organization for Standardization	RWSP	Refueling Water Storage Pit
LOCA	Loss-of-Coolant Accident	S/G	Steam Generator
МНІ	Mitsubishi Heavy Industries, Ltd	SI	Safety Injection
		SIP	Safety Injection Pump



Questions/Comments


Credibility Assessment Framework for Critical Heat Flux and Critical Power Models

Joshua Kaizer Reed Anzalone

Nuclear Reactor Regulation Division of Safety Systems

November 7, 2019



Motivation

- Knowledge Management (retirement of Tony Attard)
- Increase objectivity
- Increase efficiency



A textbook on how to perform a review.



NUREG/KM-0013 Outline

Chapter	Торіс
1	Introduction to Credibility and Credibility Assessment Frameworks
2	Literature Review & Technical Background
3	Credibility Assessment Framework
4	Summary



Chapter 1

Introduction to Credibility and Credibility Assessment Frameworks







Credibility - the determination that an object can be trusted for its intended purpose.

- Seems to appear just "off the main stage" of the VVUQ community
 - ASME V&V, VVUQ, V&V-10, V&V-20
 - Verification and Validation in Scientific Computing
 - Verification and Validation in Computational Science and Engineering
 - Fundamentals of Verification and Validation
 - Model Validation Perspectives in Hydrological Sciences
 - NASA-STD-7009 Standard for Models and Simulations
 - Assessing the Reliability of Complex Models
- Determining credibility of is the "goal" of VVUQ



Common Frameworks

Common Frameworks

- 1. EMDAP (CSAU)
- 2. Predictive Capability Maturity Model (PCMM)
- 3. NASA-STD-7009 (Credibility Assessment Scale)
- 4. ASME V&V 40

<u>Traits</u>

• List of criteria



- Small number of criteria (6-12)
- Few levels of evidence for each criterion (4-6)



"Credibility Assessment Levels" (NASA)

Verification: Were the models implemented correctly, and what was the numerical error/uncertainty?

0	1	2	3	4
Insufficient Evidence	Conceptual and mathematical models verified.	Unit and regression testing of key features.	Formal numerical error estimation.	Numerical errors small for all important features.

Validation: Does the M&S results compare favorably to the referent data, and how close is the referent to the real-world system?

0	1	2	3	4
Insufficient Evidence	Conceptual and mathematical models agree with simple referents.	Results agree with experimental data or other M&S on unit problems.	Results agree with experimental data for problems of interest.	Results agree with real world data.



Goal-Structure-Notation

"GSN is a graphical argumentation notation..."

(GSN Standard, 2011)



Combine GSN with current frameworks 8



Driving over a bridge





Rules for Frameworks

- 1. Start with a Main Goal
- 2. Logically decompose the goal into sub-goals
 - Each sub-goal indivudally must be necessary
 - All sub-goals in a level must be sufficient
- 3a. Repeat Step 2 for each sub-goal.

- OR -

3b. Provide spectrum of evidence used to demonstrate the *base goal* has been met.



Chapter 2

Literature Review and Technical Background







Literature Review

- 1. Selected Textbooks and Journal Articles.
- 2. Every CHF or CP topical report.
- 3. All associated regulations or guidance.

Technical Background

- Discussion of the relevant phenomena
- Discussion of how the phenomena is modeled
- Discussion of how the model is applied



Chapter 3

Credibility Assessment Framework





Main Goal (G)





Sub-Goal G.1





Sub-Goal G1.2





Discussion of G1.2.2

- Ensure that experimental methods do not introduce any statistical bias.
- Most methods assume independent and random uncertainties.
- Not strictly true, as you can't randomize input conditions due to large stresses on the test loop.



Possible Evidence for G1.2.2

G1.2.2	The experiment has been appropriately statistically designed (i.e., the value of a system parameter from any test was completely independent from its value in the test before and after the test).
Level	Evidence
1	One or more system parameters were randomized, but no consideration was given to other system parameters.
2	One or more system parameters were randomized, and some consideration was given to all other system parameters.
3	One or more system parameters were randomized, and those parameters that were not randomized between tests were randomized in larger test blocks.
4	All system parameters were completely randomized.



- Level 3 (is most common).
- Randomization has been generally limited.
- This is why it is important that there is another means to demonstrate no bias in the testing.





Chapter 4+ Future Work







- Credibility Assessment Framework for Critical Heat Flux and Critical Power Data Driven Models (ASME standard)
- Credibility Assessment Framework for Fuel Thermal Mechanical Models
- Credibility Assessment Framework for Large Break
 LOCA Models





- It works!!!
- It saves significant resources!
- We haven't found any holes yet, but we can fix them if we do.
- Resulting SE's can be written very fast and are very similar to each other.
- It should work for anything...









































