UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

November 8, 2010

MEMORANDUM TO: ACRS Members

FROM: Zena Abdullahi, Senior Staff Engineer ***/RA/***
Reactor Safety Branch A, ACRS

SUBJECT: CERTIFICATION OF THE POWER UPRATE SUBCOMMITTEE MEETING MINUTES ON APRIL 23, 2010

The minutes for the subject meeting were certified on November 4, 2010. Along with the transcripts and presentation materials, this is the official record of the proceedings of that meeting. A copy of the certified minutes is attached. The subcommittee meeting was open to the public, since no proprietary material was presented or discussed.

Enclosure: As stated

cc w/Enclosure: E. Hackett
C. Santos
A. Dias
J. Delgado

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MEMORANDUM TO: Zena Abdullahi, Senior Staff Engineer
Reactor Safety Branch A - ACRS

FROM: William J. Shack, Chairman
Power Uprates Subcommittee

SUBJECT: THE MINUTES OF THE POWER UPRATE SUBCOMMITTEE MEETING ON APRIL 23, 2010 IN ROCKVILLE, MD

I hereby certify, to the best of my knowledge and belief, that the minutes of the subject meeting are an accurate record of the proceedings for that meeting.

/RA/ ***11/4/2010***

William J. Shack, Chairman Date
Power Uprates Subcommittee

April 23, 2010 Subcommittee Meeting Minutes

Table of Contents

MEETING AGENDA

1. **BOILING WATER REACTOR OWNERS' GROUP TOPICAL REPORT, NEDC-33347P, REVISION 0, "CONTAINMENT OVERPRESSURE FOR NET POSITIVE SUCTION HEAD (NPSH)."**

2. **NRC DRAFT GUIDANCE FOR THE USE OF CONTAINMENT ACCIDENT PRESSURE IN DETERMINING THE MARGIN OF ECCS AND CONTAINMENT HEAT REMOVAL PUMPS.**

ACRS Contact: Zena Abdullahi (301) 415-8716; E-mail: zxa@nrc.gov

- PROPOSED SCHEDULE -

Friday, April 23, 2010

Topics	Presenters	Time
1. Opening Remarks	Chairman Shack	8:30 AM – 8:35 AM
2. BWROG - NEDC-33347P	(Xcel Energy)- Wojchouski	8:35 AM– 10:12 AM
3. Break		10:12 AM – 10:25 AM
4. NRC - NEDC33347P Safety Evaluation Report	Sallman, NRR	10:25 AM -- 10:45 AM –
5. NRC- Introduction	Ruland, NRR	10:45 AM-10:50 AM
6. NRC - Risk Aspects of Containment CAP Credit	Stutzke/Goldfeiz/Gilbertson RES	10:50 AM – 12:23 PM
Break	Lunch	12:23 PM– 1:00 PM
7. NRC – Staff CAP Credit Guidance	Lobel/Sallman, RES	1:00 PM – 2:46 PM
Break	Commissioner Inauguration	2:46PM – 3:39 PM
8. NRC – Staff CAP Credit Guidance	Lobel/Sallman, RES	3:39 PM –4:50PM
9. Subcommittee Caucus	ACRS Members	4:50 PM – 4:57 PM
10. Meeting Adjourns		4:57 PM

The ACRS Subcommittee on Power Uprate, with Chairman William Shack presiding met on April 23, 2010 at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, Rockville, Maryland. The meeting started at 8:30 AM and adjourned at 4:57 PM. The Subcommittee met with NRC staff members in order to discuss the staff draft guidance, "*Use of Containment Accident Pressure in Determining the Available Net Positive Suction Head (NPSH) of Emergency Core Cooling Systems and Containment Heat Removal Pumps*," and the Boiling Water Reactor Owners' Group (BWROG) licensing topical report NEDC-33347P, Revision 0, "*Containment Overpressure for Net Positive Suction Head (NPSH)*." The purpose of this meeting was for the Subcommittee to hear the specifics of the staff's proposed methods and acceptance criteria for justifying the use of predicted containment accident pressure (CAP) in calculating the available NPSH, during the postulated events. The BWROG topical report, NEDC-33347P proposed a statistical 95/95 method to calculate the available NPSH and establish the margin in the calculations relative to the licensing basis deterministic calculation.

ATTENDIES of POWER UPRATE SUBCOMMITTEE MEETING

April 23, 2010

ACRS Members/Staff	**NRC Staff**	BWROG/Licensees
William shack (Chairman)	Robert Dennig	Michael Crowthers
Said Abdel-Khalik (Member)	Richard Lobel	Alan Wojchouski (Xcel Energy/BWROG)
J. Sam Armijo (Member)	Ahsan Sallman	Guangan Li (GE)
SANJOY BANERJEE (Member)	William Ruland (DSS Director)	
Dennis C. Bley (Member)	Marty Stutzke	
Mario V. Bonaca (Member)	Allen Budris (Consultant)	
Charles H. Brown, Jr. (Member)		
Harold B. Ray (Member)		
Michael T. Ryan (Member)		
John D. Sieber (Member)		
John w. Stetkar (Member)		
Graham Wallis (Consultant)		
Edwin Hackett (ACRS Director)		
Zena Abdullahi (DFO)		

The presentation slides used during the meeting are attached to the associated transcript at the following website:
http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/

The presentation and discussions to the ACRS Power Uprate Subcommittee are provided below. There were no requests by members of the public to make written or oral statements. Listening only telephone connection were made available for members of the licensees, the NRC regional staff and the public.

Certified On: November 4, 2010

Certified By: William Shack

AGENDA ITEM 1: OPENING REMARKS

Chairman Shack introduced the attending ACRS members and consultant. He briefly summarized the ACRS involvement in the issue of using containment accident pressure in determining the available NPSH by stating:

- ACRS expressed its views in crediting CAP in series of letters dating back to the development of RG 1.1 *(also known as Safety Guide 1.10)*

- Recently ACRS issued a March 18, 2009 letter which delineated the Committee's Concerns and proposed some approaches

The Chairman expressed Committee's interest in: (1) the BWROG's technique for quantifying the conservatisms in the containment analyses that factor into the available NPSH calculations; and (2) the Staff's guidance for crediting CAP needed for operations of the ECCS and Heat removal systems. He then proceeded, inviting Alan Wojchouski, representing the BWROG to begin the presentations.

AGENDA ITEM 2: BWROG PRESENTATION of NEDC-33347P:

(Alan Wojchouski : Xcel Energy/BWROG)

Mr. Wojchouski started the presentation with background information on the design and configurations BWR Mark I containment and high level overview of the deterministic and the proposed statistical methodology for demonstrating margin in calculations of the available NPSH.

2.1 BACKGROUND ON MARK I CONTAINMENT DESIGN

In the discussion of Mark I design, Mr. Wojchouski pointed out that for BWRs, the plants with Mark I containment need CAP credit. For some plants, the pumps are very conveniently, located down in a hole so they have a lot of head. Other Mark I BWRs, such as Monticello, the ECCS pumps are located in corner rooms (in secondary containment building) that are adjacent and level with the torus. The main function of the primary containment is to be a barrier for the release of fission products from the reactor to secondary containment. The other function of it is to reduce the pressure inside inside the drywell during LOCA. It will force the noncondensibles and the steam down the vent lines through the vent header and down the downcomers. The downcomers are submerged underneath water. So as the condensable are forced through the water, they'll condense, reducing the overall pressure of the whole containment.

2.1.1 DISCUSSION

Mr. Wojchouski affirmed Consultant Wallis question on whether plants need CAP credit depends on the location of the pumps. Member Banerjee asked if there were some plants which need CAP credit without uprate. Mr. Wojchouski responded that Monticello was one of the plants that needed CAP credit before uprating. Member Banerjee pursued further, inquiring if this was for a short duration. Mr. Wojchouski responded that it was shorter. Expanding further, he stated that Monticello was originally licensed for 1,675 MWth and it was currently licensed for 1,775 MWth. In the original licensed, the plant was permitted to credit CAP for small duration but it was not quantified. In 1997, when suction strainers *(new design)* were installed at Monticello, we (licensee) formally request approval for CAP credit. In response to further questions, Mr. Wojchouski explained that Monticello ECCS pumps are single-stage. They are not in a pit and they are not multiple-stage pumps. He added that Vermont Yankee, and Duane Arnold have similar design.

In regards to containment as barrier, Consultant Wallis commented that the fuel is also barrier and with CAP credit, one barrier would be dependent on another barrier. This raises the question of defense-in-depth and how you evaluate this independent barrier idea. Mr. Wojchouski deferred the question to when he would present the specific slides that address containment failure as the single (failure) and additional questions would be addressed at that time.

2.2 OVERVIEW OF METHODOLOGY

Mr. Wojchouski gave an overview of the methodology discussed in the topical report. The deterministic calculation of available NPSH without containment accident pressure credit uses conservative assumptions for DBA LOCA and nominal assumptions for special events. The (*calculation*) determines the wetwell pressure and the available NPSH is compared against the required NPSH. The statistical evaluations calculate the available NPSH, without containment accident pressure credit. If the NPSHa is lower than the NPSHR, then this provides a realistic evaluation of the event in support of the deterministic CAP *(credit)* calculations.

Mr. Wojchouski continued stating that if NPSHa is lower than NPSHR, you go ahead and statistically do some calculations to find out more realistically what the needed pressure would be. If even with CAP credit, you do not have enough NPSHa to equal to NPSHR, then you evaluate alternative means, which basically means start working with the pumps and vendors. You see what other things you can actually do to accommodate the operation of the pumps.

For NPSH calculations for the Special Events, Mr. Wojchouski stated that the topical report provides brief description of each of the special events and compares it with the DBA-LOCA NPSH calculational methodology. The LTR also identifies the conservatisms in the Special Events NPSH evaluations. The deterministic approach utilizes nominal input values in the NPSHa calculation. Should the approach does not satisfactorily show that NPSHa minus NPSHR is greater than zero, the statistical approach is performed, using the mean output vales to show the expected realistic response to the event.

2.2.1 DISCUSSION

a. Alternative Engineering Fix If NPSHa Remains Less than NPSHR (DBA LOCA)

In reference to when the BWROG recommends seeking alternative means (engineering fix), Member Abdel-Khalik rephrased the approach, stating that you enter the last scenario if and only if the entire totality of available accident pressure credited is insufficient to provide what you need in terms of available NPSH? Mr. Wojchouski affirmed the statement and expanded further, stating that if you use realistic calculations and your NPSHa is less than NPSHR, you would have to do another method. Discussion ensued in which member Abdel-Khalik questioned if the approach was prudent. Member Armijo commented that it bothers him that licensees are not looking for alternative engineering fix that ensure the pumps can deliver the needed flow. He remarked that in the BWROG (proposal) the alternative engineering fix is the last resort rather than the initial step. Member Armijo continued stating that the Subcommittee had not heard any kind of discussion of the extent to high the licensee would go to upgrade the plant so that it can deliver the power you need without compromising the safety systems.

Mr. Wojchouski explained that at Monticello as an example, you would have dig 12 feet of structural concrete with lots of rebar beneath in order to place the two RHR and one core spray pumps in deep well. You would also have to analyze the structural impact on the building itself.

Member Armijo acknowledged that there would be a cost and it could be a great cost. He added that there is also a big benefit. Member Armijo pointed out that if it was a generator you (licensee) had to replace to get more power out of the plant, you wouldn't hesitate. But for these pumps, the sequences of considerations are wrong. Member Banerjee interjected that to carry Member Armijo's thoughts maybe you can add another heat exchanger. Why not look into adding the new heat exchanger at an earlier point. Chairman Shack commented that it is the last resort and not the first resort. In the ensuing discussion, the Chairman asked that as an example, why the licensees can't replace the pumps with pumps that can handle two phase fluid. Mr. Crowthers of BWROG stated that the BWROG could not prescribe *(the specific plant modifications to the licensees.) The BWROG is trying to provide generic methodology to go through.*

Mr. Wojchouski reiterated that plants were designed and needed containment accident pressure before the power uprate and there's no reason why they shouldn't be allowed to have containment accident pressure after uprates. Member Ray inquired if their position was that it was not the BWROG business *(in terms of decision to make plant modifications)* but it is rather the licensees business.
Mr. Wojchouski affirmed that it was their position.

b. Special Events Methods and Types of Analyses

Consultant Wallis quoted the following statement in the topical report, "special consideration is given to potentially nonconservative modeling assumptions." He asked for explanation as to what is meant by this statement. He asked that if COP credit is needed, what is meant by "special consideration." Member Abdel-Khalik remarked that you are already in the hole. He inquired if you are going back to look at non-conservative assumptions to put you deeper in the hole. Mr Crowthers intervened stated that they (BWROG) would review the context of the statement and get back to the members.

Consultant Wallis asked for clarification on whether the mean value of the statistical method is greater than the nominal. Mr. Wojchouski reported that the statistical approach yields minimum, maximum and mean values. Mr. Lobel interjected, stating that his presentation will contain comparison of statistical analyses, realistic analyses and conservative analysis. Consultant Wallis inquired how it relates to nominal. Mr. Lobel responded that what he refers to as realistic is what the BWROG refers to as nominal. He elaborated further explaining that they used Gothic for the three types of analyses. For the realistic case, they tried to make everything as realistic as they could, except for service water temperature.

Chairman Shack asked if the "realistic value," for a parameter is the mean, - an estimated mean value. Mr. Lobel agreed. He stated that it was almost exactly that. Chairman Shack disagreed, noting that there is a statistical mean for the distribution. There is also the mean for each individual parameter. He proposed that perhaps what is meant is that when you calculate, using the mean values of the *(input parameters)* distribution, you get something that sort of looks like the mean of the statistical? Mr. Lobel disagreed. He expanded further by saying that what they did was run 59 cases and took the mean of the 59 cases. Mr. Wojchouski interjected explaining that what they did for the special events is use either bounding numbers same as the deterministically and occasionally used few other numbers. Instead of using an absolute bounding number, they applied about the 95 percent confidence level on that particular parameter.

After further explanation, Chairman Shack stated that maybe they (the BWROG) ought to explain how they get the distributions of these parameters. At which event, Mr. Wojchouski discussed specific calculation. He stated that for Monticello statistical analysis, they took five years worth of our plant data. From these data, you can come up with a mean, a standard deviation, or a 95 percent confidence level of that particular input variable. In response to further questioning on what the nominal value was, Mr. Wojchouski stated that the nominal value is a value that isn't bounding that you select to put as an input. He explained that it is typically more realistic than the bounding deterministic. In relation to the mean, he stated that typically nominal is not compared against the mean. You would instead elect the 95% confidence, so it is upper bound.

2.3 DETERMINISTIC AND STATISTICAL CALCULATION

Mr. Wojchouski described how the available NPSH is calculated using the inputs from the containment analyses and the plant-specific system losses. For the deterministic approach**,** the traditional conservative analysis is performed, using inputs at bounding containment initial conditions. The resulting pool temperature response is maximized and available head response is minimized. This approach provides conservative available NPSH assessment. The statistical approach is new:

- The statistical method takes credit for the variability in the analysis inputs. The order of statistical method is applied. Random draws are made from corresponding probability distributions in order to determine the input values. With calculations of containment responses with one set of those random draws, the input values represent one trial of statistical process.

- The input parameters can be statistically defined and will not necessarily be at their extremes, your maximum, your minimum values at the same time. The remaining inputs are identical to those used in a deterministic approach. Random draws are made from corresponding probability distributions in order to determine the input values. Calculations of containment responses with one set of those random draws input values represent one trial of statistical process. So you do that 59 times. So you have 59 independent calculations of containment response in order to come up with a 95 percent probability, 95 percent confidence level. The fifty nine cases are the minimum number of cases that you need to come up with a 95 percent confidence level. If you did a lot more cases, you could come up with a 96 or 98 confidence level.

- The different input parameters that can be statistically defined are initial reactor power, decay heat, initial suppression pool temperature, service water temperature, which basically is the river water temperature (or the) the heat sink, the initial suppression pool volume, the initial drywell temperature, the RHR heat exchanger, heat removal capability, initial drywell pressure, wetwell pressure, and the containment leakage rates.

- The outputs that are needed for NPSHa are the pool temperature, the wetwell airspace pressure, and the pool volume. Those are calculated with SHEX. They are also used on a time history basis to determine what your NPSHa requirements are. Based on these outputs, calculation of the term Hww as a function of time (minimal values of Hww as a function of time) for each one of the 59 different calculations are obtained

Mr Wojchouski described the three different scenarios analyzed in establishing the proposed approach. One of the analyses covered the short-term response, which is less than 600 seconds, assuming a single limiting failure. The long-term containment analysis is greater than 600 seconds and assumed a different limiting single failure. In the last scenario, the containment integrity was not credited. It was intended to determine what happens if you lose containment integrity? Each of the different scenarios was done in two ways: the deterministic approach, which is a typical licensing basis; and the statistical approach, which is the Monte Carlo approach.

Mr Wojchouski presented figures comparing the results from the different analyses. He discussed Figure A-2, which shows the long-term suppression pool temperature for design basis accident LOCA (DBA LOCA), with a diesel generator failure. The reason loss of diesel generator is considered worst failure is that one division of the low-pressure ECCS is also not available, resulting in only one division remaining (*powering one train of low pressure ECCS system*).

Another *(single failure)* assumption for DBA LOCA is loss off-site power. One diesel (*generator*) would be operating, *(powering)* two RHR pumps and one core spray pump to address the scenario. Mr Wojchouski stated that as can be seen from the different curves, the deterministic calculation (plot 4) shows the peak suppression pool temperatures as a function of time. For the statistical analysis, (plots 1, 2, and 3) represent the maximum, the mean, and the minimum. The comparisons in the figures show the expected suppression pool temperatures for the different methodologies.

Mr. Wojchouski discussed the long-term DBA LOCA case that assumed loss of containment *(or did not credit containment integrity)* shown in Figure B-2. He emphasized that this scenario is different than the other DBA LOCA case, because you are not assuming loss of the diesel (generator). Both trains of low pressure ECCS systems are available, including the two RHR heat exhangers. Comparing against the earlier deterministic analysis shown as line 4, Mr Wojchouski noted that instead of (suppression pool temperature) being above 200 degrees, for this case it is around 170 degrees, which is much lower. He credited the lower suppression pool temperature availability of the extra heat exchangers.

Slides 19 through 23 showed plots of wetwell pressure for the long-term DBA LOCA scenario, with the different single failures (diesel generator failure and loss of containment integrity). The figures presented the statistical and deterministic results (wetwell pressures) for the different low pressures pumps (RHR and CS) for the different single failure scenarios. In his discussion, Mr. Wojchouski explained that the wetwell pressures represent the wetwell pressure needed to have NPSHa equal to NPSH required. You can look at the peak and the margin is between the required and the calculated.

In his assessment, Mr. Wojchouski stated that the comparisons of the deterministic and statistic wetwell pressures show that the statistical approach is a lot less *(in terms of accident pressure needed).* This is a comparison of what *(you need)* deterministically and what you would need statistically *(relative to atmospheric pressure)*.

He also discussed the case containment integrity is not assumed because single failure leads to unavailability of containment accident pressure above atmospheric (Slides 22 and 23). Two trains of low pressure CS and RHR are available and in operation. Mr. Wojchouski observed that if you do the deterministic analyses, you are using bounding inputs for river temperature and initial suppression pool temperature. However, despite the complement of RHR pumps, the deterministic analyses would still need to credit some containment accident pressure in order for NPSHa equal NPSHR. He drew attention to the fact that for the statistical method, the wetwell pressure is below the atmospheric pressure. He concluded that you do not need crediting containment pressure if you lose your containment *(for the specific plant-specific application)*, which is your major single failure.

2.3.1 DISCUSSION

With the presentation of the plant-specific (Monticello) deterministic and statistical NPSH calculations, Mr. Wojchouski closed his presentation. This section covers the significant issues discussed during this segment of the BWROG topical report presentation.

a. Strainer Debris Head Losses

Consultant Wallis commented that NEDO-32686 PA is used to calculate the suction strainer head loss. Significant information is now known about suction strainer losses than in 1998. He questioned whether it was appropriate to use this old document for what could be an important element in the determination of the head losses. Mr. Wojchouski responded that for Monticello that (NEDO-32686 PA) was the licensing basis method for calculating the strainer head loss. Member Wallis inquired if the licensing method was realistic or conservative? Mr. Wojchouski described the licensing method used at Monticello to determine the head losses. New suction strainers where installed at Monticello. Moreover, plastic was taped outside the strainers as additional conservatism in the determination of the strainer head losses through testing. In the prototype testing, debris, paint chips, iron oxide and NUKON insulation were added into the slurry. The licensing document requires that if you cannot measure iron oxide from your piping, you assume 300 lbm/year of accumulation. Mr. Wojchouski explained that if the actual measurement is available, the utilities could use 150 lbm/year accumulations. For Monticello, the measured debris (iron oxide?) was 75 lbm. Mr. Wojchouski stated that there was a lot of conservatism in how much debris is being generated and used in the determining the suction strainer losses. New strainer design was installed at Monticello in 1997. Subsequently, the licensee performed testing according to the methodology specified in the licensing documents.

Mr. Crowthers reminded the Committee of the separate BWR strainer head loss effort that is currently in progress. Mr. Wojchouski commented that this is another reasons that utilities that did not uprate their plants may request additional CAP credit. So this methodology *(BWROG CAP Credit topical report)* maybe needed as an outcome of suction strainers. Consultant Wallis inquired if the strainer head loss is varied in the statistical NPSH analysis. He paraphrased, asking if the Hloss due to strainer clogging is changed in any way statistically. Mr. Wojchouski confirmed that the head loss is not varied. What is being changed in the equation is the containment analysis (*input parameters in the containment analysis).*

b. Best Estimate Codes and Uncertainties

Member Banerjee asked if for the containment analyses best estimate code is being used.
Mr. Wojchouski stated that SHEX code was not a best estimated code. Mr. Li of GEH commented that one of the staff RAIs related to this issue. GEH compared their CSAU methodology to their SHEX methods. He referred to *(containment analysis)* PIRT process that they utilized. He explained that SHEX is a simple code that maximizes suppression pool temperature and there is no code (model) uncertainty. Mr. Li added that if you are going to use best estimate code such as TRACG, than the uncertainties need to be quantified.

Mr. Li commented that in Step 11 *(of the RAI response)* inputs the parameters within the PIRT in the CSAU methodology. He stated that the statistical method is being used to demonstrate margin and if the code results with some conservatism, than it is reasonable. Member Banerjee responded that the problem was what is meant "conservatism," is not known *(quantified?).* Mr. Lobel of NRC interjected, stating that in his presentation he would show a comparison of the SHEX code against GOTHIC code, using basically the same inputs. He promised to show (containment) pressure and temperature (response) comparisons against a more realistic code and SHEX. Member Abdel-Khalik requested that for the record to state whether SHEX has ever been formally evaluated by the staff. Mr. Lobel replied that SHEX has been used for years in licensing calculations, but the staff never wrote a formal SER approving it.

In reference to the SHEX code maximizing the suppression pool temperatures, The Subcommittee Chairman Shack commented that it all comes back to the question raised by Member Banerjee about the code. He observed that the approach does not deal with model uncertainties. Instead, the method deals with input parameters *(in the statistical treatment)*. Chairman Shack pointed out that it is the wetwell head (Hww) instead of the temperature (that is of interest). It is the pressure minus the vapor pressure or the head. He continued stating that he would find it acceptable if the modeling errors in the code are on the conservative side. He asked if it can be demonstrated that SHEX is calculating the quantity conservatively.

Mr. Li explained that in the statistical calculation, where you assume a drywell/wetwell relative humidity of 100 percent minimizes the drywell and wetwell pressure. He referred to a wetwell comparison that was not in the current version of the topical report. Member Banerjee remarked that at some point SHEX must be reviewed seriously. He recommended that the issue be pursed when the codes are discussed and table it for now.

c. Use of 95/95 criteria

In reference to the statistical approach of determining the containment response for 95 percent probability at 95% confidence level, Consultant Wallis commented that there is nothing magical about 95/95. He stated that there are some things which you might want to be surer of then the 95 percent. He explained that a five percent probability that something is going get wrong is tolerable in some aspects of LOCAs and not in other aspects of LOCAs. He proposed that the staff in their presentation explain why 95/95 isn't a magic formula that you can apply to everything because sometimes you want to be more certain. He clarified further stating that sometimes you want to be less certain depending on how severe the consequences are.

d. Ultimate Heat Sink Distribution Used in the Statistical Approach

Consultant Wallis remarked that the river temperature *(ultimate heat sink)* is the most important (*input variable).* The *(temperature)* may vary in to extreme conditions and that makes a big difference. Mr. Wojchouski explained that at Monticello, the ultimate heat sink (used in the deterministic calculation?) is 90 degrees. He reported that the ultimate heat sink at Monticello reached as high as 87 1/2 degrees Fahrenheit twice over the 40 years life of the plant. He added that since Monticello is up in the north, for half of the year, the river is very cold, with ice forming. The average temperature is in the mid 50s. Mr. Wojchouski elaborated further how the ultimate heat sink is established in the statistical methodology, using Monticello as an example. The Monticello five year river temperature data is categorized in different temperature bins and the exceedance probability is determined.

Consultant Wallis requested that Mr. Wojchouski give a sense of order of magnitude of which one is important (in terms of the key input parameters that are varied.) Mr. Li responded, stating that the service water temperature was one of the top key parameter of importance in addition to the decay heat. He cited sensitivity studies results shown in table 3-1. Mr. Li reported that a 20 degree change in service water temperature results in a 10 degree change in the suppression pool temperature. Consultant Wallis commented that without plant modification wouldn't decrease in the power level when the service temperature is high be considered as an alternative (approach to crediting CAP). Mr. Wojchouski answered that the problem lies with the decay heat, which depends on the power history. Mr. Armijo remarked that they (licensees) could be pick the range of power levels.

Consultant Wallis asked what action is taken for years when an unusually high river temperature occurs. He observed that a five year data may not be very reliable environmental barometer because El Niño cycles are longer than 5 years. Mr. Wojchouski responded that river temperature above the TS value will require the plant to shutdown.

e. Plant-Specific Deterministic and Statistical Analyses

During Mr. Wojchouski presentation of the Monticello (Pilot plant) deterministic and statistical results, Member Bley inquired if the statistical results shown *(wetwell pressure)* in figures were the minimum, maximum or the mean. Mr. Wojchouski stated that the wetwell head, Hww is the minimum for the statistical analysis.

Member Abdel-Khalik observed that the statistical methods does not account for the uncertainties in the required NPSH. Mr. Wojchouski confirmed that the currently shown margins do not include uncertainties in the required NPSH. They used the NPSH required provided by the vendors. Mr. Wojchouski acknowledged that the methodology would use NPSH required and incorporate the uncertainties and apply the NPSHeffective in determining the required.

Under further questioning on whether the minimum HWW corresponds to the maximum or minimum suppression pool temperature relative to Slide 19 designations, Mr. LI confirmed that the pressures (S*lides 19, 20, 21 & 22)* corresponds to the maximum containment overpressure needed. In response to the difference between slides 19 and 20, Mr. Wojchouski explained that the red line (Slide 19) represents the accident pressure at the wetwell and the black lines represent the RHR pumps deterministic required pressure *(NPSHa = NPSHR)*. Slide 20 shows the NPSHR for both the deterministic and statistic calculations.

The members discussed the distributions and the selections of input parameters in the statistical approach and its representation of the plant conditions. In reference to the suppression pool temperature in Figures A-2 and B-2, Subcommittee Chairman Shack observed that the statistical calculations represent range of scenarios. For the deterministic (plot 4) the accident occurs at the worst conditions in the summertime with the hottest suppression pool. He commented that 3 (minimum Monte Carlo) is actually a realistic calculation if the break happens to occur in January. He purposed that the best estimate in this sense is kind of a proportion of scenarios more than in a classic best estimate plus uncertainties approach. The approach deals with range of scenarios.

f. Throttling Core Flow

During the discussion on operation of the pumps under cavitating conditions, Mr. Lobel commented that the operators have instructions in their procedures to keep the core cooled. If the pumps are cavitating, the operator would try to continue to use these pumps and he would not turn off the pump. It also does not mean that the pumps would not keep pumping flow. He continued, emphasizing that the pump may not deliver the flow that was considered in the safety analyses but it does not mean that there is no cooling. Mr. Wojchouski added that the when the operator throttles the flow, the NPSHR required also goes down and you would need less CAP credit. The EOPs would also direct the operators to mitigate the cavitating pumps and may direct the operators to add water into the torus or other actions to mitigate the cavitation of the pumps.

Member Brown asked if the throttle valves are controlled manually or remotely. Mr. Wojchouski confirmed for Monticello, the RHR system throttle valve could be operated from the control room Member Abdel-Khalik observed that the graph is obviously demonstrating that if you were to use the statistical calculation, you can demonstrate that the amount of containment accident pressure that you would need would be smaller and would be for shorter duration. He added that in words, what the statistical calculation is telling you is that we are 95 percent confident that we will not require more than about 2 psi of containment overpressure for more than about 10 hours. Member Abdel-Khalik asked that given the potentially severe consequences of this, do they think a 95 percent confidence level associated with this calculation is appropriate. Mr. Wojchouski responded that he thought it was appropriate. Member Abdel-Khalik remarked that it is a judgment call. He asked how much the graph would shift upwards level (relative to the deterministic) if they used 99% confidence. Mr. Wojchouski stated that they had not done the calculations.

2.4 OVERALL MEMBER COMMENTS: BWROG METHODOLOGY

Member Sieber commented that Paragraph 5.4, "Defense in Depth," relies on NUREG-0800 or its basis is really a little bit different than the way defense-in-depth was originally defined. He stated that the idea was no dependence of one barrier upon another. Member Sieber observed that the ACRS through the years had initially stated that, "We are not going to allow any dependence of one barrier on another." The Committee had subsequently allowed a small amount for a short period of time. As the Committee moved on and looked into some of the applications, “the small and short” became a little bigger (amount of credit) and for a little longer. Member Sieber warned that the Committee to be careful of *(how to handle)* those instances, beyond which a pump would actually need containment pressure and not ignore those situations where a pump was cavitating but not destroying itself. He stated that a probabilistic argument that says all of the barriers remain intact goes beyond the philosophy of the way the regulations in the Atomic Energy Act were originally written. Member Sieber explained that he intends to use caution in what it is that is proposed in the case of some BWRs. If the allowances that are requested are modest, perhaps, it is justified on these bases, but in other cases, it may not be. He urged caution that the steps that the industry takes is (consistent with) the foundation and the founding principles of the agency rules and that the Committee just doesn't allow going over the edge. Consultant Wallis commented that the BWROG had stated they would address this issue. Mr. Crowthers promised to get back to the Committee in regards to the dependency of the barriers in crediting CAP.

Subcommittee Chair Shack acknowledged that crediting containment overpressure does introduce dependency between the first barrier, the fuel clad, and the third barrier, the containment. He added that previous examples indicate a very small delta CDF. So there is an insignificant increase in the likelihood of failure as compared to existing conditions.

AGENDA ITEM 3: STAFF PRESENTATION - BWROG LTR NEDC-33347P (Ahsan Sallman)

3.1 NEDC-33347P DRAFT SAFETY EVALUATION

Mr. Sallman proposed to present the highlights of the staff's safety evaluation. He stated that the staff used GDC-35, -38, the Standard Review Plan 6.2.2, Reg Guide 1.82, and 1.157 in performing their review. In their review the staff found that the topical report had conservative assumptions and bounding values of inputs. Typical analysis that was done by the Owner's Group had been accepted by the staff in the previous containment overpressure reviews. The topical report used a conservative computer code, SHEX, which has been accepted by NRC for previous licensing calculations. Both the inputs and the SHEX code itself are a conservative.

Mr. Lobel stated that in past presentations, the staff listed some of the conservative assumptions in SHEX. He explained that the staff presented independent calculations for some of the Duane Arnold power uprate submittal that contained comparison with MELCOR. Two staff codes, MELCOR and CONTAIN, and the industry code that staff is using, GOTHIC all show that SHEX itself is conservative. Mr. Lobel pointed out that using the same input that SHEX used, with conservative input assumptions, SHEX is still more conservative than the other codes.

Mr. Salman described the key input parameters and assumptions they used in their independent calculations. He discussed the limitation and conditions associated with the staff's approval of the topical report. Some portion of the topical report would be plant-specific basis. An example, of this is determining the head losses due to strainer/sump debris blockage, during LOCA. The new staff CAP credit Guidance would method would be used to determine the NPSH required. Containment response codes, such as SHEX can be used on plant-specific basis. However, best-estimate codes would include model uncertainties in the statistical methodology specified in the BWROG topical report.

He also identified topics in the BWROG topical report, NEDC-33347P that were not part of staff review or approval. The sections included Section 5.3 of the topical report, which relating to the risk assessment. Mr. Salman states that risk assessment approach would follow Standard Review Plan (SRP) 19.2 Appendix D. Appendices C and D of the topical report are also not reviewed or approved by the staff. Appendix C pertains to accident management to preserve containment accident pressure. Appendix D covers the plant modifications that would reduce or eliminate the need for CAP credit. The staff states these areas would be addressed on plant-specific basis.

Mr. Salman presented some of the responses to the staff's request for additional information (RAIs) out of the 36 staff RAIs issued. RAI-1 (slide 5) asked how the statistical approach was consistent with and different from NUREG/CF-5249, which is Quantifying Reactor Safety Margins. He stated that the response to this RAI was discussed in the previous BWROG presentation. RAI-4 asked if only the SHEX computer code would be used in the LTR. The BWROG response was the methodology was not limited to SHEX. The licensees will provide evaluations and disposition those aspects of the topical report related to SHEX. For some BWRs in which MSIV leakage is considered separately from containment leakage, the RAI asked how is this considered in the analysis? The BWR RAI response stated that as a conservative leakage assumption, the maximum allowed MSIV leakage would be combined with the maximum containment leakage rate. RAI-10 related to the type of statistical distribution will be used for the input variables and whether the distribution would be determined on a plant-specific basis. The response stated that either normal distribution or a distribution that represents plant/parameter-specific data will be used. As an example, normal distribution would be used for power and decay heat, while for parameters that can be measured the plant-specific distribution would be used. In RAI-16, the staff asked why is it conservative to assume that spray droplets are in thermal equilibrium with airspace before falling to the bottom of the drywell or suppression pool. The response stated that the temperature of the spray water would be less than the drywell or wetwell temperature. The containment pressure would be minimized because the energy transfer from the airspace to the liquid spray drops is not accounted for. RAI 19 inquired how operator actions such as throttling of the flow were included in the analysis of the Special Events, The BWROG response stated that the timing for the special events would be dictated by the analysis results and it would be consistent with operator actions as directed by procedures.

The staff's presentation concluded that the deterministic analysis would be the licensing basis. The statistical analysis will be used to quantify the uncertainty and demonstrate margins.

3.1.1 DISCUSSION

a. Conservatism of SHEX code

Consultant Wallis asked how can the code *(in terms code models)* be conservative in the maximizing containment pressure *(for containment integrity calculations)* and minimize containment pressure (for CAP credit). He wanted to know how the same *code (model)* can be conservative in both directions. He commented that he understand that inputs can be conservative because you can bias them one way or the other. However, the code itself and the way it models with nodes is going to be biased up or down, but it can't be biased both up and down. Mr. Lobel stated the assumptions do have a big effect and SHEX overestimates the temperature. The higher *(suppression pool)* temperature is the most important parameter. Consultant Wallis asked *(if the code does not bias)* the containment atmosphere because that would change the pressure.

Mr. Lobel responded that the containment atmosphere could be made higher. The containment atmosphere for the purposes of design basis calculations, you obtain the highest temperature with a small steam line break analysis. He stated that for peak pressure analysis, you bias the assumptions to give you the peak pressure. When you do the suppression pool temperature analysis, you bias the assumptions for that. But the code is also biased. Mr Li of GE agreed, stating that actually they perform two kinds of calculations. One is called containment integrity, in which you maximize the pressure through the inputs. For NPSH calculation, you minimize the pressure and maximize temperature. For both cases, you maximize the pool temperature, since that is a design limit.

Consultant Wallis inquired how for things like heat transfers to structures, you assume in one case the maximum and in another case the minimum. Mr. Li answered that for the NPSH calculation, they credit (heat transfers to structures) since the heat transfer to the heat sink reduces the pressure for the integrity calculation. For some plants, they credit (heat transfers to structures), for some (applications) they do not (heat transfers to structures) in order to maximize pressure. It is based on the (plant-specific) licensing basis.

Consultant Wallis asked how nodalization of the containment is handled. Mr. Li of GE explained that they don't nodalize because SHEX is a very simple code. The reactor pressure vessel (RPV) is one node. The drywall is one node. The separation pool is one and the wetwell is one node. SHEX is not an estimating code but rather a simplified code. Mr. Lobel added that the peak pressure occurs in a very, very short time. Therefore, the heat transfer usually doesn't have much of an effect on the calculation. Instead, it is more the flow resistance through the vent system to the suppression pool that you make conservative *(assumptions)*. That keeps the (drywell) pressure higher for the peak *(containment)* pressure calculation.

ACRS Chairman Abdel-Khalik paraphrase the concern, stating that the members are trying to determine whether the bias up or down is determined by varying the input parameters only or there are specific model approximations or assumptions that is changed, depending on whether you want the code to bias the results high or low. Member Banerjee elaborated, asking how the things like the condensation coefficients are handled. Chairman Abdel-Khalik agreed. He paraphrased asking the BWROG to clarify what were the parameters that they bias within the model rather than the inputs that would cause the results to be either biased high or biased low. Mr. Li explained that (it is achieved) mainly through the inputs. He added that they do have another parameter, called the mixtures coefficient. The break flow depends on the condition in the containment. (There could be some) liquid flashing. It depends on the condition. If it (containment?) is cold, there is no flashing. Through sensitivity analysis, it is set it in the conservative direction. Consultant Wallis responded that he understood the changes in the inputs but he did not understand how one can make the statement that the code is conservative.

Member Banerjee requested that SHEX be outlined during the closed session, with *(discussion on)* the model parameters which contribute to model uncertainties. He proposed that this be done briefly so that they could understand where the model uncertainties arise.

b. Potentially New Regulatory Process

Member Ray inquired what the purpose of the topical report was and what role it plays. He asked how it (the topical report) is used in the regulatory process. Member Ray questioned the implication of having deterministic licensing-basis and using statistical to show margin. He commented that they ought to understand the implication. Presumably, if the deterministic calculation shows there is not enough margins in theory, then the statistical analysis is used to show there is sufficient margin. He commented that the deterministic rule is satisfied by taking credit for containment overpressure. But you can only do that to the extent that the statistical analysis says you have enough margins. He noted that it (the topical report approach) seems like a new “regulatory device” that needs to be understood better. He asked why the topical report’s approach wouldn’t apply to other things that don't satisfy the deterministically (licensing-basis requirements). He posed the question of why (couldn't licensees) not just come back and do a statistical report and state that yes, they didn't satisfy the deterministic rule. But they got a lot of margin.

Subcommittee Chairman Shack concurred that it (the topical report approach) is probably new. Consultant Wallis gave a parallel example to show the concern, stating that for the LOCA analysis, they can use realistic analysis with uncertainty and the statistical method is the way of satisfying the regulation. Mr. Lobel of the staff agreed and stated that it is different. Member Brown commented that one of the other points that falls from (the topical report approach) is if an applicant has problems in some area other than this (CAP credit), the licensee can state that you (ACRS) agreed to this approach and they got a compensating factor in another area. He observed that may lead to a slippery slope routine.

AGENDA ITEM 4: RISK ASPECTS OF CONTAINMENT CAP CREDIT (NRC- MARTY STUTSKE)

Mr. Stutske started his presentation with an overview on risk-informed regulations and guidance as it relates to the Commission and ACRS views and positions and the associated regulatory guide 1.174. He subsequently presented the risk studies the staff performed.

4.1 OVERVIEW ON DEFENSE-IN-DEPTH AND RISK EVALUATION

Mr. Stutske outline his assessment of the role of DID, stating that the adequacy of DID should reflect risk insights. There are circumstances where it is reasonable to accept some reduction in defense-in-depth if the corresponding risk increase is acceptably small. Mr. Stutske pointed out that in the past NRC accepted designs where there is a balance between the defense-in-depth and acceptable risk. He cited interfacing LOCA and steam generator tube rupture as an example where there is a tradeoff. Mr. Stutske commented that NRC accepted plants that have possibilities of suffering interfacing system LOCAs and steam generator tube ruptures. He added that these (cases), in fact, directly bypass the containment.

He also cited TS allowance of operation with equipment out-of-service as situations where redundancy and diversity could be lost but the risk could be acceptable low. During outage times, the risk is small and can be represented as series of spikes. However, when equipment is taken out of service the risk increases for a very short duration. Whenever equipment is taken out of service for maintenance, there is some reduction in the defense in depth posture of the plant. And that is managed or limited by the allowed outage times that are provided in technical specifications. He reported that the technical specification change for allowed outage time in risk space is a series of pulses. Initially, the risk is very small and when the equipment is taken out, the risk increases for the duration of that maintenance. You see spikes in the risk. The risk goes way down when equipment are put back in proper order. He explained that the industry has a speed limit on how big a spike can be. However, the staff has not formally endorsed it. The staff hasn't accepted it or rejected it. Rather, the staff bases their judgment on the area under that risk pulse.

Mr. Stutske cited Regulatory Guide 1.177 as providing the guidance on how much increase in risk can be tolerated and the increase in allowed outage time that can tolerate. He stated that his message was that, in fact, the staff routinely strikes balances between defense-in-depth and risk. So containment accident pressure should be treated in the same way. Mr. Stutske recapped his first segment of the risk presentation, acknowledging that the very use of CAP credit affects the independence of barriers but it doesn't, by itself, make changes to programmatic elements. He remarked that the heart of the risk assessment is to show the influence of containment integrity testing on the increase in core damage frequency.

4.1.1 DISCUSSION

Relating back to the topic at hand, Mr. Stutske stated for CAP credit, the risk is uniform and not a spike. In terms of the impact of service water temperature on the available NPSH margin, Consultant Wallis pointed out that risk of CAP credit is not uniform. It is worse in the summer on the hottest days. Mr. Stutzke agreed it is worst in the summer, but reiterated his position that there are risk-informed changes that the staff actually relaxed programmatic elements of defense-in-depth.

Referring to the example of defense-in-depth changes the staff presented, Member Bonaca commented that CAP credit increases the likelihood of relying on pumps cavitating in any one of these events. He stated that the tradeoff in this case is the convenience for the licensee to use this approach. Mr. Stutzke replied that there are other tradeoffs in the new staff CAP credit guidance.

Member Ray observed that for the TS, the duration of the outage is strictly limited not to what is acceptable from a risk standpoint but what is necessary to maximize the long-term assurance of performance, given whatever the component or device or system is. He expanded further, stating that there is a dimension implied by what Mario. Even for changes that have a tiny, tiny contribution to risk, you have to keep the outage really short just because you don't want to allow any increase in risk more than is necessary for the maintenance of the item involved.

Member Bonaca added that CAP credit is a design change in which you are running those pumps in a configuration that the pumps were not designed to operate in that mode. He asked how does the design change fits in the DID and what does it *(risk-wise)* produce. Mr. Stutzke explained that in his risk evaluations, he assumed that the pump failed if the available NPSH is smaller than the required NPSH. There is no CAP credit used in the PRA evaluations. The operator throttling of the flow was also not credited.

Member Abdel-Khalik requests that the staff define the La, the design basis leakage rate. Mr. Lobel stated that La is the containment leakage rate when the containment is pressurized to the maximum LOCA pressure. It is the mass leakage rate over 24 hour period. Mr. Stutske explained that is one hundred percent of the design basis or the ratio of the actual to the design basis.

Member Abdel-Khalik inquired if the distribution of the leak rate makes a difference *(in terms of the Risk evaluation)*. He clarified further asking if for example a high leak rate early that cause the pumps to fail early versus a uniform leak rate in 24 hours would make differences *(in the risk evaluation)*. Mr. Stutzke responded that the La is not a major contributor to the accident. He added that if the leak rate is high enough in the beginning, you could lose the containment pressure. If you stop the leakage, you get average *(leak rate).* Member Bley observed that is assuming the leak rate that could cause loss of NPSH is equivalent to average leak rate in 24 hours. He asked the staff to confirm that the leak rate that could cause loss of NPSH is equivalent to that average leak rate over 24 hours. Mr. Lobel affirmed Member Bley's observation. Mr. Stutzke stated that you would need a smaller hole to lose containment pressure than you need to create LERF. It is more likely that you will get a small hole than a big hole. Even if the accident sequence progresses to severe accident (scenario), you would not necessarily suffer from LERF.

AGENDA ITEM 5: RISK EVALUATION OF USING CONTAINMENT PRESSURE TO PREVENT ECCS PUMP CAVITATION (Stutzke/Goldfeiz/Gilbertson)

5.1 RISK STUDIES

In this segment of his presentation, Mr. Stutzke discussed the risk evaluation performed by the staff to determine the increase in risk if CAP is credited. The purpose of the staff's risk evaluation was to estimate the increase in core damage frequency (CDF) that results from relying upon containment accident pressure (CAP) to prevent ECCS pump cavitation.

The discussions on the model, key assumptions and the methodology used in the staff's PRA presentation are described below.

- <u>SPAR Model</u>
    - Used Browns Ferry and Monticello SPAR models
    - SPAR models benchmarked against licensee' PRA
    - Current SPAR models limited to internal events

    - Full spectrum of transient and LOCA models
    - No seismic and fires
    -
  - 2 peer review of the SPAR model and they compare well

- Key Assumptions

  - Mark I containment needs CAP when the core spray or the RHR pumps take suction from suppression pool
  - No winter or summer consideration for the service water temperature
  - No assumption about number of pumps running or reactor power
  - Risk evaluation limited to internal events (no fire or seismic)
  - Full spectrum of transient and LOCA
  - No fragility information on the seismic event
    - Even with fragility no seismic PRA available
  - Loss of containment means big hole that prevent adequate NPSH
  - To determine the hole size that will prevent NPSH, thermal-hydraulic models such as MELCOR, GOTHIC or SHEX are needed.
  - SPAR model for internal events assumed containment rate of 20 La. No specific basis aside from being lower edge *(lower bound?)*

    - Vermont Yankee EPU application used (27 La) hole for App K and 60 La for realistic (LOCA)
    - Browns Ferry LOCA (PRA) used 35 LA
    - Trade off in leakage rate assumed. No potential for early release for small La. For large La, potential for release close to LERF.
    - Used 20 La

5.1.1 INTERNAL EVENT METHDOLOGY

Mr. Stutzke described the main features of the staff's PRA methodology. The staff PRA models three different time frames of when the containment could leak:

- Pre-Initiator: *(Containment may be leaking before an initiating event occurs)*
- Upon-Initiator: *(Containment may fail to isolate when an initiating event occurs)*
- Post Initiator: *(Containment may start to leak after the initiating event occurs)*

The staff explained that previously, the licensees' risk evaluations used EPRI document that was developed to support extending integrated leak rate test intervals. They select the leak size for their unit. From the EPRI data, the licensees pick the pre-initiator leak probabilities which go into their in their PRA model. Therefore, their risk evaluations used pre-initiator (pre-existing leak) probability that depended only on the size of containment leakage. Mr. Stutzke characterized this approach as using kind of a monolithic failure probability of preexisting leaks. He states that the *(use?)* probability that a leak exists when the initiating event occurs ignores the other ways that one could detect containment leakage. Mr. Stutzke gave examples of ways leakage can be detected *(in some BWR plant designs)* such as: (1) detection of increase in the inerting of the containment with nitrogen to balance the leak; (2) detection of increase in oxygen concentration; and (3) wetwell and drywell pressure differential alarms. The model considers that the containment leakage testing may not detect the leakage or determine the right leak size. The staff developed Semi-Markov model to represent the impact of containment integrity testing on the risk evaluation.

The staff presented typical primary containment leakage testing limiting condition for operation (LCO) (Slide 7) in order to show how the TS surveillance leak testing and related action items factor into their risk study. Mr. Stutzke explained that for the primary containment O_2 concentration, if the leakage rate is at or above the magic number such as 20 L_a, as an example, *(the licensee needs to)* reduce it to the TS limit, within the TS time, $T_{ST.}$ As a base case, the TS time is 24 hours. If the leakage is not reduced below the *(magic)* value within the required TS timeframe, the plant will shutdown. Mr. Stutzke expanded further, explaining that once a leak is detected, there is 32-hour window. And you've got another eight hours in order to shut down the plant. He capped the objective of the TS requirements, stating that once a leak is detected, there is at least a 32-hour window while the plant could be operating with a known leak that would defeat the containment accident pressure credit. He stated that the additional TS requirement is surveillance testing that requires verification of the containment leakage. He cited an example of seven days surveillance test interval. Mr. Stutzke wrapped up the TS discussion, stating that he would show a full sensitivity study, using these numbers.

5.1.2 RESULTS OF STAFF's RISK EVALUATION

In performing the analyses, Mr. Stutzke summarized important parameters as: (1) leakage failure rate itself, lambda; (2) the mean time to repair the leak; (3) the surveillance test interval, which is how much time you are going to allow the licensee to try to fix the leak while the reactor is still operating; (4) how much time you allow before shutdown; and (5) finally what is known as test sensitivity or the probability that the test doesn't find the leak. The test probability is the probability for false positive or false negative.

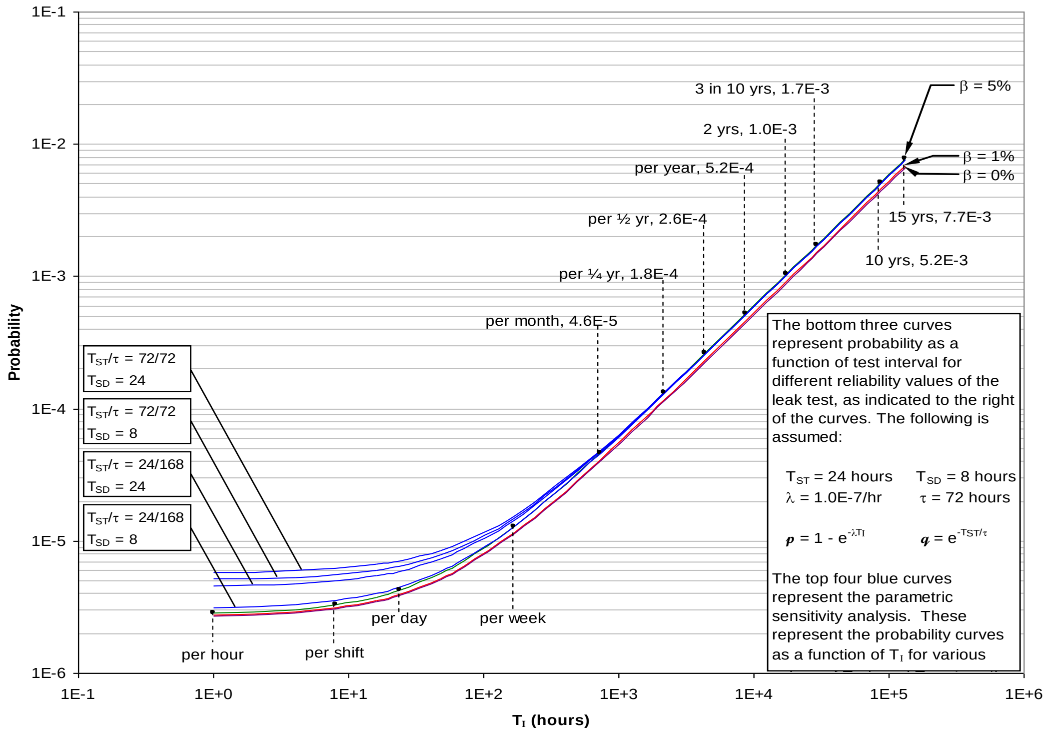
He described the semi-Markov model the staff developed to represent the impact of containment integrity testing on the pre-initiator leak probabilities. He discussed the conclusions of the sensitivities analysis of the pre-existing leak cases they performed.

- *Pre-Initiator Leak Probability::* Data of how often plants fail integrated leak rate testing for a leak rate of 20 La was determined to be on the order of ten minus seven per hour (λ (20 La) = $1x10^{-7/h}$). Mr. Stutzke presented the pre-initiatory leak probabilities for different leak rate test surveillance intervals. The test intervals were varied from once per hour to once in 15 years, which is the integrated leak rate testing (ILRT). In discussing Slide 13, Mr. Stutzke states that once the SR test interval is beyond once a week, the pre- pre-initiatory leak probabilities is only sensitive to the SR test interval. It is insensitive to the other parameters.

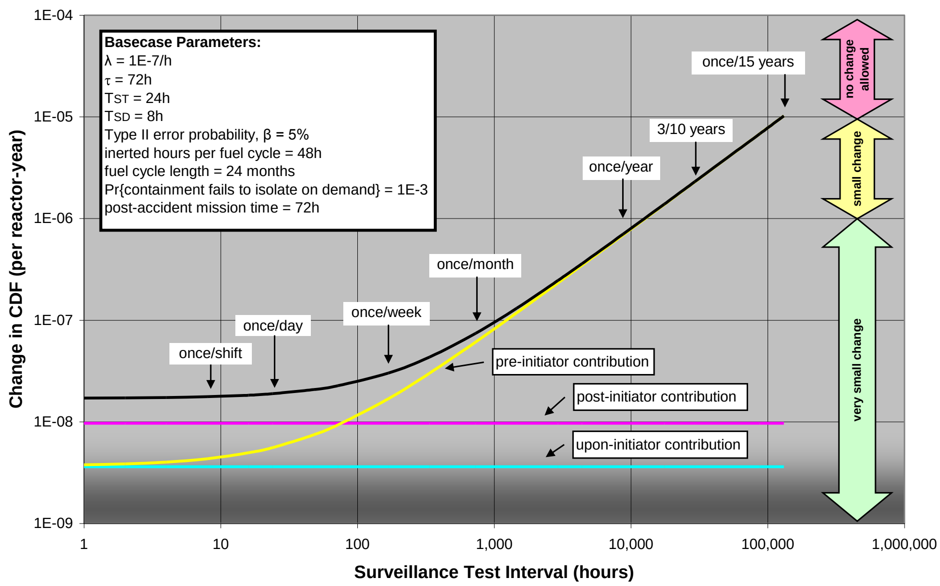
- *Leak upon Initiation Probabilities- Failure of Containment Isolation-*: For the leak upon initiation case, the staff considered pathways that could bypass containment isolation. For Mark I containment, Mr. Stutzke stated that there are no pathways open between the containment and the atmosphere. The pathways exist right after startup and while the plant is being inerted *(with Nitorgen)*. Mr. Stutzke pointed out that the weighted probability of a containment isolation system failure during the time when it really mattered, which could be two, three or maybe four days into the fuel cycle. He added that it was clear that containment isolation system doesn't always have to work as previous risk evaluations assumed. One scenario considered by the staff is an issue raised during the VY EPU applications. If during LOCA, the mainsteam isolation valves fail (MSIVs), the containment could be depressurized through the mainsteam lines pathway and out into the plant. The staff included into their LOCA model, the probability that MSIVs fail and accounted for all the different common cause combinations. Mr. Stuzke explained the probability that all fail to close on demand was small (about 10^{-4}), because the MSIVs are reliable. The staff found that the containment isolation pathways contribution to the change in the core-damage frequency was very small because the LOCA frequencies are relatively small.

- *Post-Initiator Leak Probabilities*: Mr. Stutzke pointed post-initiator leak probability addresses, in part, the CAP credit concern behind the short amount for small duration criteria. In PRA, the parameter is referred to as the mission time, which is the time CAP is credited. Mr. Stutzke stated that of interest is the leaks that occur within 72 hours of the initiating event. He added that the pre-initiator and upon-initiator leak probabilities were insensitive to duration.

Pre-Initiator Leak Probability v .s. Surveillance Test Interval, T_I -- Slide 13



Browns Ferry CAP Credit



Slide 18

Discussing Slide 18, Mr. Stutzke stated that there are some insights that can be ferreted out risk evaluation.

- Surveillance testing more than one week doesn't really effect the delta CDF because it goes up asymptotically horizontally flat. However, if you have longer surveillance test intervals around the integrated leak rate testing time of three in ten year or once in 15 years and that is the only way containment integrity can be confirmed, the change in risk is unacceptably high.

- One accident sequence that contributes directly to core damage frequency is large break LOCA sequence. All the other scenarios would require multiple failures.

Mr. Stutzke explained that the increase in CDF is very small (RG 1.174 definition of significant > 10^{-6}/y) when SR testing is performed at least once/year, assuming a leak failure rate of 10^{-7}/h. He concluded his presentation, stating that with adequate testing, the delta (CDF) can be controlled at least for internal events.

5.2 DISCUSSION

a. Semi-Markov Model

Mr. Stutzke described Markov model. He stated that what makes the staff model semi-Markov is the idea that it remains in a given state for a random period of time with an arbitrary distribution. In response to Member Bley inquired about the arbitrary distribution. Mr. Stutzke responded that the reason the staff used semi-Markov process is the time at a given state is not exponentially distributed as is typical in risk assessment. The technical specification is not exponentially distributed or fixed and constant. He noted that the TS have all kinds of things going on so the *(time intervals?)* and the differences don't really matter that much when you look at the average.

b. Leak Pathways

In reference to the containment leakage, Consultant Wallis commented that some of these are real leaks and some of them are valves left open, which would be different. Mr. Stutzke responded that the valves as leakage pathways are covered in another part of the model. Consultant Wallis remarked that if you have a hole in the containment, then fixing it is not trivial. Mr. Stutzke agreed. Member Ryan proposed that there are couple pathways out of which the leak could occur, adding complications. Member Bley commented that it could also be a condensation effect *(instead of leak?)*. Mr. Stutzke agreed it could also be condensation and that the lambda for a 20 L_a leak is on the order of ten to the minus seven per hour. The value came from some data that was collected on how often plants fail integrated leak rate testing.

Member Bley asked further discussion on the two cases where the licensees had used the old EPRI report that had probability that differed by a factor of two to three. *(This is in reference to data in Slide 6 and the staff's risk pre-initiator leak failure rates in Slide 14. Slide 6 shows that Vermont Yankee EPU used 2.47 x*

10^{-4}, which is from EPRI TR 1009325. Browns Ferry EPU used 9.86 x 10^{-4} from EPRI TR 1009325. The pre-initiator (pre-existing leak) probability depended only on the size of containment leakage.) Mr. Stutzke showed pre-existing leak probabilities in Slide 13, which increases for higher surveillance intervals. He stated that the family of curves relate to the sensitivity studies performed because the staff did not know *(the impact of?)* some of the parameters. He introduced into the model all the LOCAs, not just the double-ended large break LOCA. He pointed out that the contribution was very small, mainly because MSIVs are pretty reliable. This is the probability that they (MSIVs) all fail, including all the independent and all the different common cause combinations there. That's ten to the minus four.

c. Containment Isolation Failure:

In the discussion on the MSIV failure probability ten to the minus four, Consultant Wallis asked if the operator actions were modeled in bypass of the containment assessment. Mr. Stutzke stated that the analysis is all based on automatic. Member Abdel-Khalik inquired if you do not need all MSIVs to fail *(to lose containment pressure that affects CAP credit)*. Mr. Stutzke affirmed, stating that you need just one steamline or two MSIVs to open.

d. Post-Initiator Leak Rate:

In regards to the 20La leak rate, Subcommittee Chair Shack commented that the staff's evaluation assumed the leak rate during the accident is the same as it has been all the time. Mr. Stutzke agreed but added that they are excluding external events. Member Ray reiterated the point, stating that the most likely breach of the containment is going to be during seismic event.

e. Model and Distribution Uncertainty

Member Banerjee inquired if there is a sort of uncertainty applied to the change in CDF? Mr. Stutzke agreed there is uncertainty associated with it but stated that he has not computed it. He elaborated further, explaining that the reason is he did not decide on the appropriate uncertainty distributions for everything in the model. For the failure rate and the mean repair time, it is easy. He explained that the real problem is what sort of uncertainty to apply to the other parameters of the model. He added that it is not clear what an appropriate uncertainty distribution would look like for testing efficacy. He stated that the staff instead treat it (the uncertainty) with sensitivity studies to see if it (parameter) really matters a great deal. Member Banerjee responded that the staff at least needs some sort of distribution rate. Mr. Stutzke agreed and said it would be completed.

f. Importance of SR Test Interval Insight:

In reference to the pre-existing leak of once a week SR interval findings, Member Abdel-Khalik asked if a once-per-week inspection frequency is a reasonably realistic. Mr. Stutzke responded that it is how often the licensees test for oxygen in the containment. He explained that for the Mark I containments that are inerted and for plants that have sub-atmospheric; they are probably already doing enough to be helpful to us *(in terms of the pre-existing leak probabilities)*.

Member Abdel-Khalik asked if the conclusions of the risk insight would be incorporated into a new technical specification (LCO) that may require that if you detect a leak of a given size, as long as you do the testing once a week, then you would shutdown. Mr. Stutzke agreed and stated that licensees may make case, using existing TS. He continued, adding that what bothered him was that the current requirement is based other reasons such as oxygen concentration and preventing hydrogen explosion.

Mr. Wojchouski intervened stating that for Monticello and many BWRs, the TS require that if the La is greater than the limit, it should be restored in one hour or in 12 hours or to shut down the plant. He explained that they monitor containment pressure and there is a low pressure alarm in the control room, although it is not a TS requirement. If the drywell pressure is less than 0.01, an alarm will annunciate. For a leak of 20 or 30 La, this is a very large leak that is beyond the normal make-up system capabilities and the control room (operators) would be aware of really fast. Member Bley asked if the nitrogen is supplied continuously or do you apply if you lose pressure then cut it off? Mr. Wojchouski replied that most Mark I BWRs have a make-up system in which it can be put in service to maintain the pressure. He stated that Monticello has a nitrogen system (of a liquid tank outside containment) that goes through a vaporizer. That is what is supplied to normal instrumentation inside the drywell. Mr. Wojchouski offered additional clarification, stating that they found that MSIVs, solenoid valves, actuators, and diaphragms experience small leakage through some of those fittings, because they are at 100 pounds, which is enough to maintain the containment atmosphere positive. He also added that they actually control the pressures through continuous air monitor, which pulls sample off the containment. The sample is runs over filter paper to determine the radionuclides on it and estimate any leakage within the sample. The sample is either pumped right back into the containment to maintain the pressure or it goes off to the reactor building plenum, which will reduce the pressure. Typically if you're losing containment pressure, you will put it (sample air) right back in the reactor vessel containment. If pressure is high pressure, you will direct it off to the plenum. Member Bley commented that he was thinking you might never hit one of the alarms because you might be gradually, over period of some months, ramp up the rate of nitrogen feed. Mr. Wojchouski responded that would be something each licensee would have to look at. He offered an example of the frequency of needing makeup, stating that the last time they actually did the make-up at Monticello was in 2005.

g. External Events:

Member Ray observed that the staff's risk insight would not be applicable to a design basis event, like an earthquake. He remarked that if you're talking about the probability of a containment leak affecting your ability to get CAP credit, how can you set aside the major reason. Mr. Stutzke replied that personally, fire worries him worse than the earthquake.

h. Risk Evaluation of Sump Strainer Blockage

Member Banerjee commented that sump strainer blockage is a specific scenario. He observed that the concern for sump strainer blockage, as an example is to account for uncertainties and margins. The scenario could lead to core damage, although perhaps containment integrity would still be preserved. If I want to limit core damage, then knowing the sort of margin I have is useful for all the things that I don't know well. He then inquired how does that *(these sump blockage concerns and unknowns)* get factored into this risk assessment? Mr. Stustzke answered that for the PRA, the strainer blockage would be a separate basic event in the model of the loss of containment integrity. Both *(containment isolation failure and sump blockage?)* would have the same functional effect on the system *(model)*, though their likelihoods of occurrence could be different.

AGENDA ITEM 6: NRC – STAFF CAP CREDIT GUIDANCE (Lobel/Sallman)

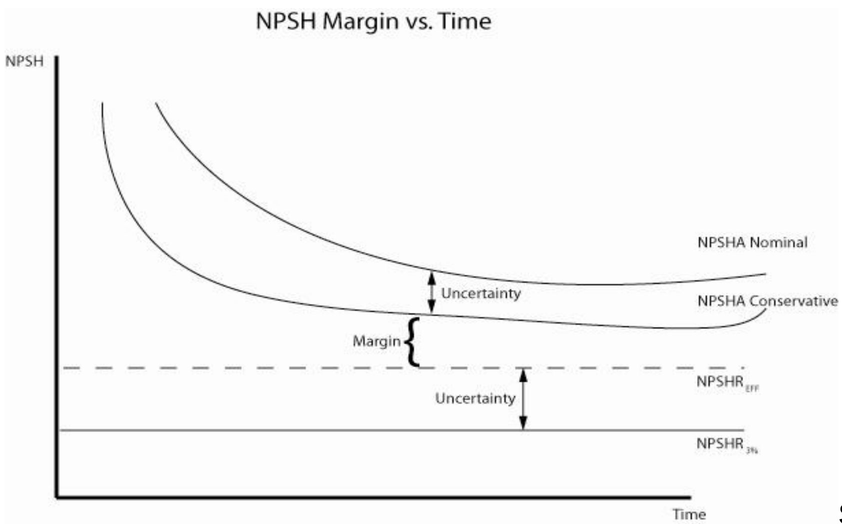
6.1 STAFF DRAFT GUIDANCE PRESENTATION

Mr. Lobel introduced himself and Mr. Sallman. He started the presentation in defining often used nomenclature, including containment overpressure credit. He emphasized that there is no system, component or structure that is being overpressurized. The use overpressure has several definitions, depending on which licensee was using it. It can be referred to as overpressure, if the pressure was greater than atmospheric pressure; the pressure was greater than saturation pressure; the pressure was greater than the containment pressure before the accident. The BWR Owners' Group topical report used the first definition, which is pressure greater than atmospheric pressure. He stated that the staff proposed using the phrase of containment accident pressure (CAP) in determining available NPSH..

Mr. Lobel presented the main components of the draft guidance developed for crediting CAP. The guidance is intended for the licensees to use in determining the available and required NPSH. He also gave the status of the plants crediting CAP. There are 27 operating reactors that credit containment accident pressure for the NPSH *(available calculations). (Of these plants, there are),* 19 BWRs and eight PWRs. There are two EPUs on hold, pending the revised guidance on the use of containment accident pressure. All of the BWRs have Mark I containments.

6.1.1 OVERVIEW OF CRITERIA FROM CAP CREDIT

Staff slides 4, 5 and 6 outline the main features of the staff's criteria for crediting CAP and the measures needed to demonstrate that the emergency core cooling and heat removal system would perform their safety functions, in mitigating accidents and special events. The staff described the specific features of the draft CAP credit guideline given in Slides 3-6.



Slide 3

- In Slide 3, the staff presented a diagram, depicting the estimates of the uncertainties and margins in the NPSH available and required calculations for the ECCS pumps for a BWR/4 with Mark I containment. The estimate of the uncertainty in the required NPSH includes both the uncertainty associated with the determination of the required NPSH at the pump vendor's facility and the expected uncertainties for an installed pump, which is called the installed or field uncertainties. The NPSHR required is defined by (1.0 +uncertainties) * NPSH3%. The uncertainty in the available NPSH includes the uncertainty in the calculation of the containment conditions that are input in determining the available NPSH. For both the required and available NPSH, a realistic value is determined. For the available NPSH, conservative and statistical values are also determined. The difference between the conservative available NPSH and the effective required NPSH is the conservative NPSH margin, which would be used for postulated design basis accidents. Mr. Lobel added that there is also a margin between the realistic required NPSH and the realistic available NPSH, which would be used for non-design basis accidents.

- The second guideline calls for the maximum flow rate chosen for the NPSH analyses should be greater than the flow rate used for the core and containment cooling analyses. Mr. Lobel states that this at least makes sure that the NPSH analysis is conservative and are consistent with the pumps (flow) requirements (assumed) in the containment and core cooling analyses.

- Likewise, either a conservative or a 95/95 lower tolerance limit from a Monte Carlo calculation should be used in determining the available NPSH for the design basis events.

- Another guideline for the review of applications requesting CAP credit is that the containment isolation shouldn't be in Appendix R Fire event, associated with circuits problem *(spurious circuit actuations)*, or due to containment venting required by procedures. There shouldn't be a situation where an operator following procedures is told to vent the containment at a time when they are taking credit for containment accident pressure *(in the NPSH available calculations for operation of the ECCS and heat removal pumps)*.

- Operator action to control containment pressure *(such as turning off the drywell coolers?)* is acceptable if justified by human factors considerations and are included in the appropriate procedures.

- Operation for a limited time with the available NPSHA less than the required NPSH *(when all of the calculated containment accident pressure is credited)* is acceptable if justified by testing. Mr. Lobel stated that this is already a position in Regulatory Guide 1.82. He added that in the draft guidelines, the staff tightening up requirement considerably by defining the conditions better as to what would be acceptable in this case.

- The licensees should justify *(why)* that the use of containment accident pressure is necessary because the design cannot be practicably altered.

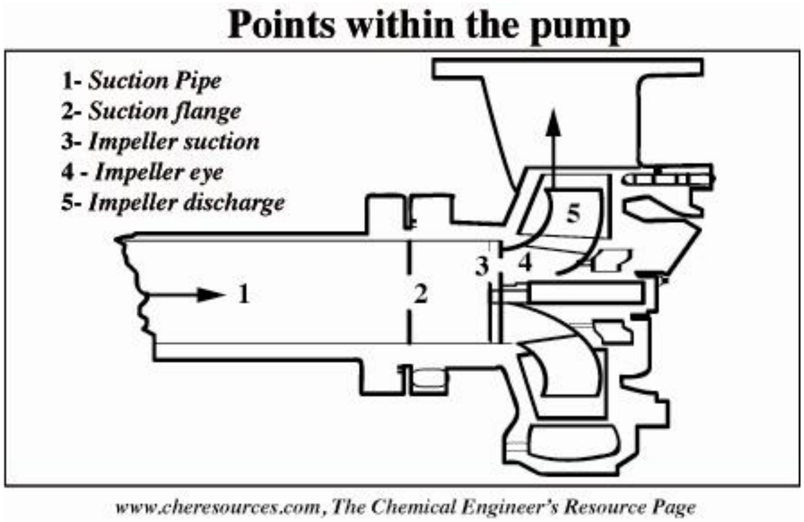
- A realistic calculation of available NPSH would also be done and compared against the available NPSH determined from the conservative or the 95/95 Monte Carlo *(containment calculations)*. Mr. Lobel stated from staff calculations it turned out that the realistic and the mean are practically on the same line.

6.1.2 SUPPORTING TECHNICAL BACKGROUND

In order to explain the bases for the staff's guidelines in their acceptance criteria for establishing the duration for crediting CAP and need for protecting the pump mechanical seals from excess entrained air, Mr. Lobel described the mechanisms involved in the adverse effects of cavitation.

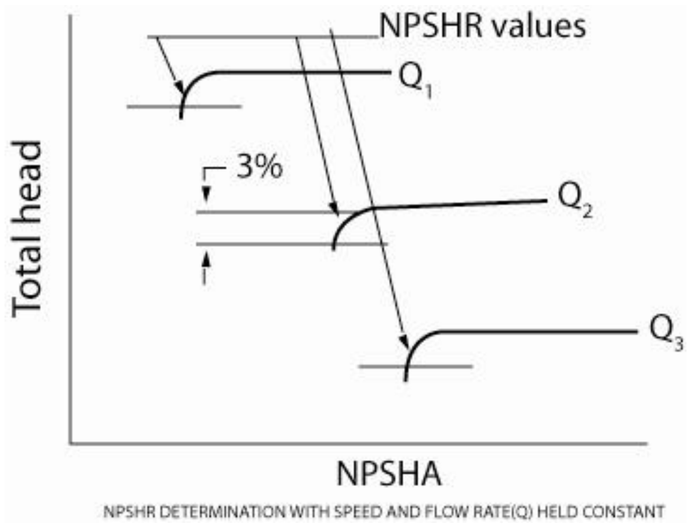
Suction energy is a concept that provides a classification of the degree to which centrifugal pumps are prone to the adverse effects of cavitation and also another pump effect, suction recirculation. Suction recirculation is a low flow phenomenon that isn't directly connected to containment accident pressure. It is a condition where the flow is low enough that the flow doesn't completely fill the impeller blades and cavitation, as well as surging occurs. It is similar in some ways although the mechanisms are to the effects to a water hammer. Large pressure surges occur in the system that can damage the system but it is not directly connected to containment accident pressure. The *(use of)* suction energy has some benefits over some of the previously used criteria *(in defining the limitations)* on pump operation. It is *(Pumps are)* classified as low suction energy, high suction energy, and very high suction energy. For the BWRs, the RHR and the core spray pumps are either high energy or very high suction energy pumps. As the suction energy increases, the pumps become more susceptible to adverse effects. So it *(suction energy)* is a fairly accurate description of the susceptibility of the pumps to problems.

From the suction flange to the impeller, there is a decrease in the pressure and an increase in flow. So the low-pressure point or the point at which you would expect cavitation to occur is at or near the entrance to the blade. Where you would exactly get the cavitation, depends on the flow rate, the angle of incidence to the blade but it *(cavitation)* is usually close to the blade leading edge and may continue for some distance up the blade.



The required NPSH is just the NPSH that is needed *(to overcome the pressure loss as the flow accelerates)*. (*NPSH required is)* the stagnation energy or the total energy that the liquid has to have in order that the pressure at the beginning of the blade would be low enough to give you a certain amount of cavitation. And that *(the degree of cavtation)* is specified in the number (e.g., NPSH1% or3%) for the required NPSH (in terms of) how much cavitation is going to be allowed. Mr. Lobel explained that the required NPSH gives you a certain *(degree of)* cavitation for a drop in pressure from point two to four. Using the diagram in Slide 12, Mr Lobel stated that starting from the suction source, you figure all the lines losses, valves, fittings, piping, until you get to *(point)* two *(in the diagram*). The loss term and the elevation term and the pressure term above the water would all be the values that would be calculated up to location two.

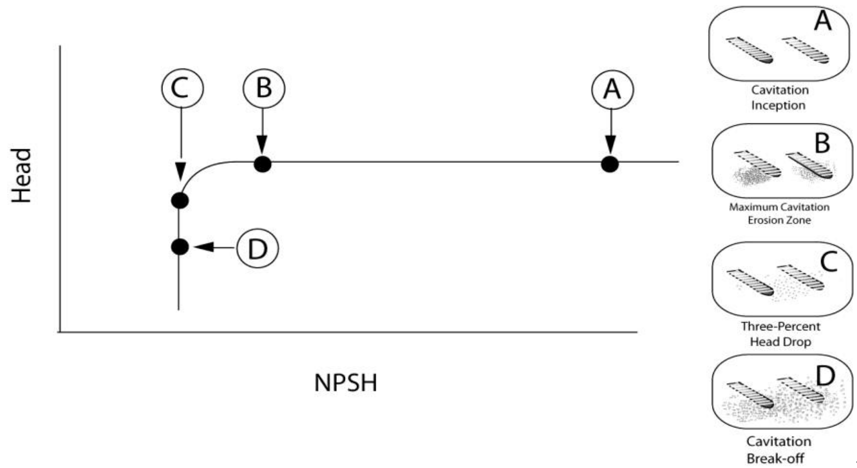
The *(vendor)* test that is done to determine the required NPSH consists simply of a tank of water as a suction source. The pump takes suction from that tank at a given flow rate at a given pump speed and returns the water back to the tank. The tank may have a constant level or you may change the level (in order) to change the available NPSH. You start out the test at a given flow rate and pump speed. The pump will put out a certain discharge head or a total dynamic head as it is called that would be horizontal (See Slide 13). The (discharge head) would be constant until you get to a point where the cavitation *(due changes in pump inlet conditions, simulating changes in the available NPSH)* in the pump is such that the pump just can't put out that (constant) head anymore and the pressure head starts to drop. The three percent head-drop, which the hydraulic institute recommends) is simply where this curve has dropped three percent from (*the constant discharge head)*.



Slide 13

Mr. Lobel reported that the uncertainty in the pump vendor's test is really on the low side because the test is carefully controlled. *(During the vendor test),* you are controlling the height of the water. You are controlling the temperature of the water. You are controlling maybe the air in the water and the pump speed. The suction piping is usually a straight run of pipe (relative to the onsite piping configurations), so you are minimizing the (vendor's required NPSH) uncertainties determined during the test. If the pump is installed it in the field or at the power plant, you may not have the same kind of controls over all those conditions. So the (NPSH required) uncertainties are going to be greater for the installed pump. Mr. Lobel explained that the staff looked at the possibility that the pump speed could change and that the water temperature could be different than the temperature that is used. Usually in a required NPSH test, the temperature is at ambient 60 or around 60 degrees. The suction piping layout could be much different. The air content of the water could be different. The pump that is tested at the pump vendor facility will be basically a new pump and it won't have any wear. So the wear rings will have whatever the (initial or design) starting clearances which have not increased with time.

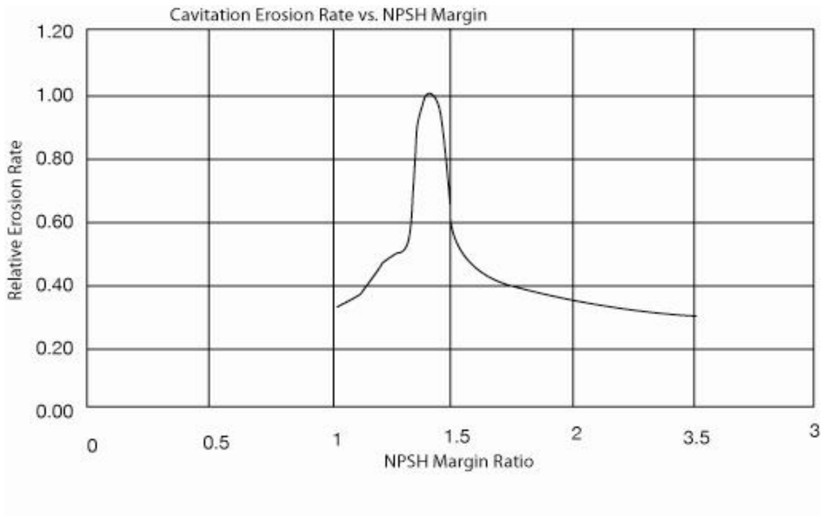
Giving credit to the pump consultant (Mr. Budris), Mr. Lobel reported that the staff considers these effects *(and recommends)* to increase the NPSHR required uncertainty over the vendor's uncertainty. He stated that the staff was proposing to define a new required NPSH: an effective required NPSH that would include these uncertainties. The staff proposed to use the effective required NPSH for determinations of the NPSH margin for LOCA. However, for the non-design basis events *(Station Blackout, Appendix R fire and ATWS),* Mr. Lobel stated that, consistent with current staff practice, the staff proposes to use the three percent head-drop, recommended by the hydraulic institute for definition of NPSH be used.



Slide 17

Referring to Slide 17, Mr. Lobel discussed the different levels of pump cavitation, stating that the effects of cavitation depend on the amount of voiding you get, the amount of vapor you are forming and the distribution of the vapor in the front. He reported that it turns out that the maximum erosion occurs between the point of incipient cavitation and the three percent head-drop. There are two natural limits to cavitation. The first one is (point) A, the incipient cavitation, where it first starts and you get just a few bubbles. There is no effect on the pump but there is a physical thing that is happening. The break-off is also, where a physical thing that is happening (point D of the diagram in Slide 17). The pump is just not pumping anymore. He explained that neither of these (conditions or states) is very useful as limits because you don't know where the incipient (cavitation) is and you don't want to know where the break-off is because you are in trouble if you are there. Mr. Lobel pointed out that the limit that was chosen by the hydraulic institute is the three percent value because it is something that is relatively easy to measure and gives you a change that you can measure. Also, one percent head-drop or a zero percent head-drop right before you started to get the head-drop can be used. The three percent is more of an arbitrary number.

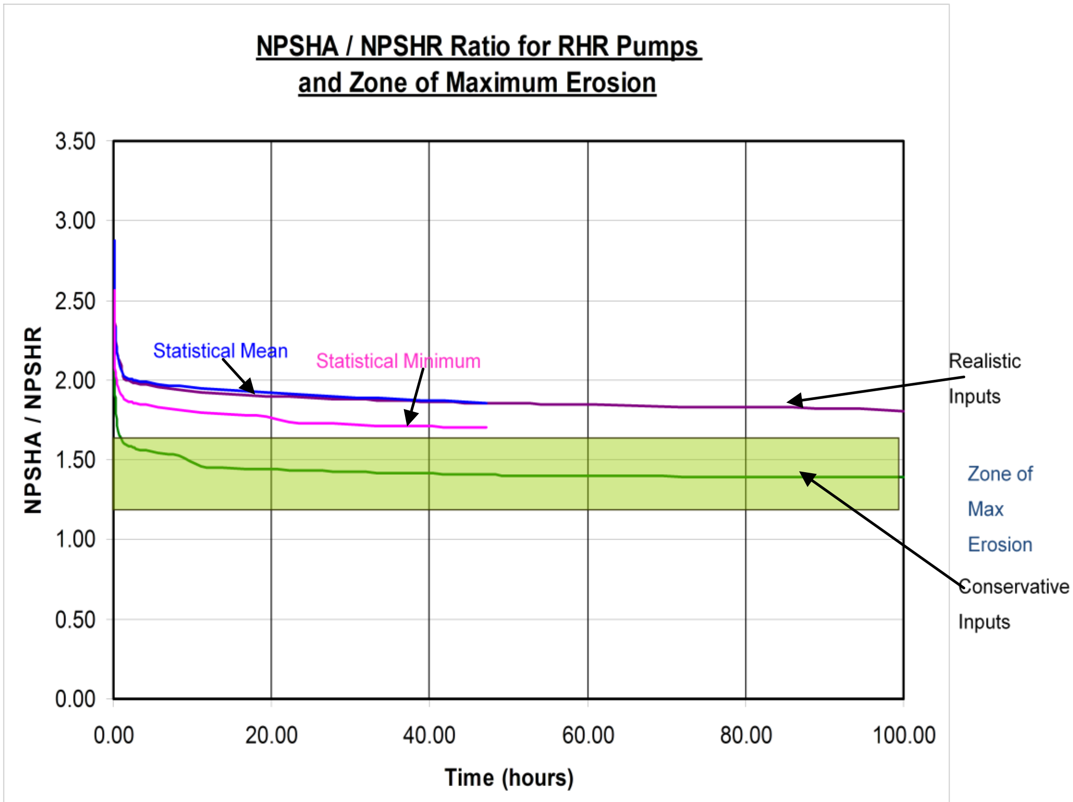
Mr. Lobel elaborated on the pump operation at the different statepoints, marked in Slide 17, stating that at Point D, the impeller is running in a vapor cloud. The cavitation erosion is very limited, since the impeller is surrounded predominantly by vapor and not much in the way of vapor bubbles. Even though the pump isn't pumping anymore, the good news is the impeller is in great shape. For Point C, which is the three percent head-drop value, you still have a lot of vapor, huge volumes of vapor exist, but you have more vapor bubbles and the collapsing of these vapor bubbles is causing some pitting and erosion of the impeller and the flow is also slightly unstable or maybe more than slightly unstable. Point B is a state reached, where there is a lot of vapor bubbles, a lot of vapor cavities and entrained bubbles in the liquid. When the bubbles collapse after moving to a higher pressure zone at the pump, you don't have the cushioning effect of the vapor clouds as much and you get a lot more erosion and this is the maximum erosion *(state)*. He explained that even though there is no indication on the pump curve *(in terms of head drop or change in flow rate)* and the pump from outward appearances seems to be working just fine, but it is having the highest level of cavitation. Finally, at the incipient cavitation of point A, there are only a few bubbles and it is not doing any damage and the pump is working fine.



Typical Relative Erosion Rate vs. NPSH Margin near BEP Flow Rate

Slide 18 (Cavitation Acoustic Signal)

One way to measure the amount of cavitation is with acoustic measurements. Pressure transducers or other acoustic transducers on the pump suction measure the cavitation noise that comes from the imploding bubbles. He noted that this is the relative noise that is stated in terms of cavitation, erosion rate, but it is really a measurement of cavitation noise as a function of the NPSH margin ratio which is the available to the required. When the value is high, the noise is relatively low. As margin is lowered, as the available NPSH goes down, the noise increases until you reach a peak, then the peak starts to decrease again. That *(reasons for the decrease in noise)* is due to the vapor bubbles and due to the air that is coming out of solution in the water. Mr. Lobel described how they came up with the erosion range, stating that the staff took this curve (See Slide 18) to a typical curve and picked a high and a low boundary to this curve that captured the peak and said that was the result of maximum erosion. Under member questioning on how to establish points B or C, in terms of 3% NPSH required, Mr. Lobel referred to Slide19 (shown below).



Slide 19

Mr. Lobel described the results of large-break loss of coolant accident calculation the staff performed. It *(Slide 19 plot)* is a plot of the available over the required NPSH or plot of the NPSH margin ratio as a function of time. The staff plotted the zone of maximum erosion, which is shaded in green. The staff also performed statistical, conservative and the realistic cases for (determining) the ratio as a function of time for large break LOCA. The staff is proposing that the time that pumps operate in this green zone shouldn't be more than a hundred hours. He added that it is how the staff would use this maximum erosion zone limit. The staff draft guidance includes the criterion for crediting NPSH, which limits operation with NPSH margins corresponding to the maximum erosion zone to one hundred hours. All the calculations performed were for one type of plant.

Another criterion in draft guidance addresses when the available NPSH is less than the required NPSH. Mr. Lobel reported that this was an existing criterion in which the staff allowed in some previous reviews that the available NPSH could be below the required NPSH, if: (1) the licensee performed a test and showed that pump could go for that length of time; and (2) when the pump was inspected after the test, there wasn't any sign of damage or wear to the pump. Mr. Lobel noted the staff added some extra requirements in the draft guidelines. Of important was the requirement to make sure that when the pump was tested, it was tested at the available NPSH value that was expected. Considering that the pump experiences the most cavitation in the maximum erosion area of 1.2 to 1.6 margin, Mr. Lobel pointed out that if the pump is tested farther and farther to the left (see slide 18), then the pump testing would be getting farther and farther away from the area of maximum erosion. The staff concluded that maybe the tests that have been done up until now haven't been the right tests. The staff contemplated that the pumps should be tested at whatever times it is predicted to operate in the area of maximum erosion or at least in an area where it is predicted the pump is going to operate. The pumps should not be tested at some values, where there is so much vapor that there are no bubbles anymore and cavitation damage would not occur. The staff acknowledged that this was an area of the CAP credit criterion that probably still needed some more development.

In covering the staff's mechanical seal criterion, Mr. Lobel described the manner CAP credit needed is determined. The initial calculation does not assume the accident pressure and the available NPSH is determined. If there is sufficient margin, no CAP credit is needed. If there isn't sufficient margin (NPSHavailable <NPSHrequired), then you add pressure to get up to the point where the available is equal to the required. That is the containment accident pressure credited.

He explained that by doing this approach, you are making the available NPSH equal to the required NPSH. According to these calculations, the pumps are going to be operating at that point. Mr. Lobel iterated that at that point, the fluid could be releasing air that is dissolved in the water. He stated that the dissolved air at 190 degrees of water is not much, but the air would still be released. Air tends to go towards the mechanical seals and towards the shaft because of the centrifugal force throwing the liquid out. The concern is that the seal faces may run dry and if they do, the seals are not going to do that for very long before they experience damage. So this criterion protects the seals by having an external source of cooling so that they won't run dry. Mr. Lobel acknowledged implementation of the criteria has its drawbacks, which makes things complicated. A system is added to the pump that the pump is going to need to operate properly. The staff is requesting feedback from the pump vendors and the Owners' Groups and they are also holding discussion with the NRC pump consultant.

6.1.3 STAFF SENSITIVITY ANALYSIS

Mr. Lobel remarked that the Committee had asked several times how important were the different parameters (that factor into the NPSH calculations). The staff performed sensitivity analysis for one typical BWR/4, with the Mark I containment. Slide 36 lists all the variables that the staff thought contributed to the NPSHA calculation significantly. For the sixteen input parameters, the staff changed each single input parameter from the base case by 5%. The table (below) provides the corresponding percentage change in the suppression pool temperature, wetwell pressure, and NPSHA. The staff also performed three additional calculations that: (1) changed the decay heat sigma value from 2-sigma to 0-sigma;
(2) increased the containment leakage increased from La to 5.0La; (3) performed calculations with and without heat sinks was performed; and (4) changed the heat transfer coefficient options in the GOTHIC code from empirical correlations to the heat and mass transfer analogy (DLM). Mr. Lobel discussed their assessment of the results of the sensitivity analyses, stating that they found the presence or absence of passive heat sinks to be significant. He added that the area of the passive heat sinks is less significant but important. The staff also found that the sensitivity to the condensation heat transfer coefficient is significant. The staff found the containment leakage rate not to be significant. He explained that the strainer and piping losses are not as significant as many other input variables. Mr. Lobel concluded that as

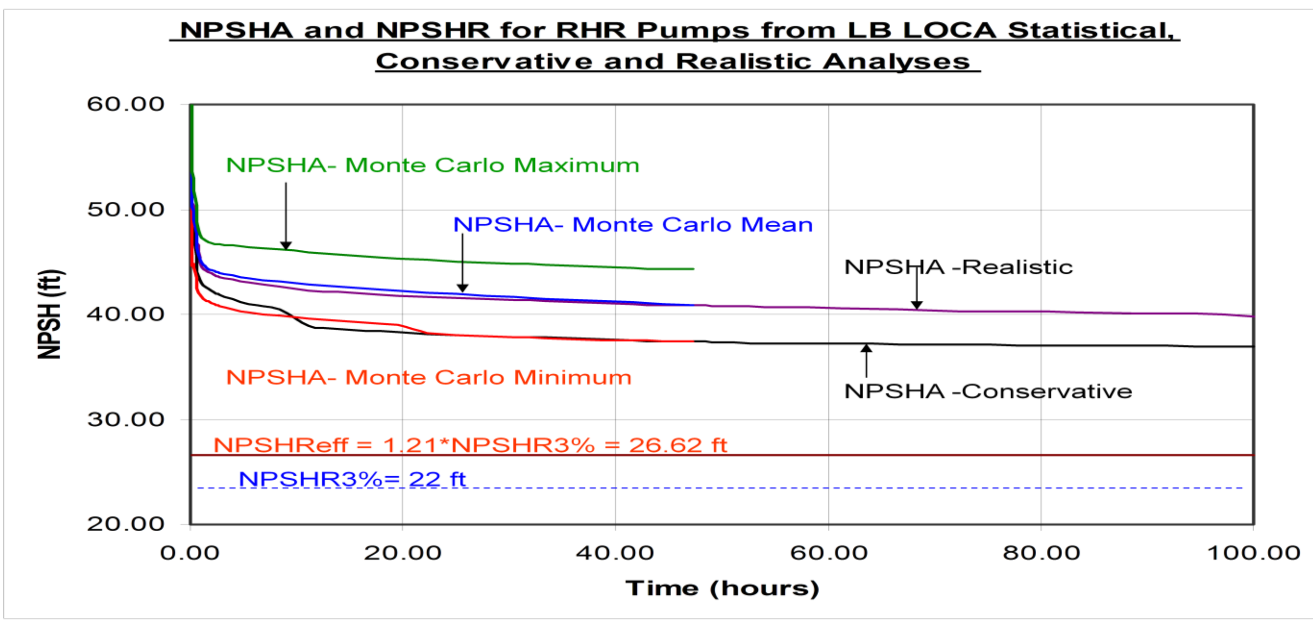
shown in the table (Slide 36), a relative large number of input variables have significant effect on the available NPSH.

Slide 36

No	Parameter	Base Value	Compared Value	Change in Parameter Value (%) (Note 1)	Maximum Change in Supp Pool Temp (%)	Maximum Change in Wetwell Pressure (%)	Maximum Change in Available NPSH (%)
1	Power (percent)	100	95	-5	-2.34	-5.47	-4.24
2	Core Spray Flow (gpm)	3027	2876	-5	-0.17	1.12	2.67
3	Initial Drywell Pressure (psia)	14.26	14.97	5	-0.1	2.02	2.53
4	Initial Wetwell Pressure (psia)	14.26	14.97	5	-0.2	2.16	2.32
5	Initial Supp Pool Temp (deg F)	90	85.5	-5	-2.93	-3.89	-2.27
6	Service Water Temperature (deg F)	90	85.5	-5	-2.63	-3.83	-2.26
7	RHR HX K-Value (Btu/sec deg F)	147	139.65	-5	2.76	4.89	2.14
8	Initial Drywell Temperature (deg F)	135	128.25	-5	-0.12	1.58	2.02
9	Initial Torus Liquid/Volume Ratio	0.3858	0.4051	5	-1.82	-3.67	1.29, -0.96
10	Reactor thermal conductors area reduced by 5%	100%	95%	-5	-0.38	-1.11	-0.98
11	Drywell Spray Flow	3800	3610	-5	-0.08	0.77	0.88, -0.22
12	Strainer & Piping Loss (ft)	5.79	5.5	-5	0	0	0.78
13	Initial Drywell Relative Humidity (%)	100	95	-5	-0.09	0.44, -0.72	0.67, -0.76
14	Wetwell Spray Flow	200	190	-5	-0.01	0.34, -0.08	0.54, -0.09
15	Decay Heat (sigma)	2	1.9	-5	-0.12	-0.22	0.21, -0.45
16	Containment Leakage (Weight%/day)	1.2	1.26	5	0.01, -0.03	0.12, -0.14	0.16, -0.17
17	Decay Heat (sigma)	2	0		-4.36	-8.14	-5.04
18	Containment Leakage (Weight%/day)	1.2	6.0	500	-0.02	-2.31	-2.86
19	Passive Heat Sinks	Present	Absent	-	1.31	2.12, -0.15	1.52, -0.03
20	Heat Transfer Coefficient for Containment Heat Sinks	Empirical	Heat & Mass Transfer Analogy	-	0.31, -0.01	0.08, -3.34	0.13, -3.65

Mr. Lobel also presented realistic, conservative and Monte Carlo (statistical) available NPSH comparisons that the staff performed. The calculations NPSH available (shown in Slide 37) were for RHR pumps for large-break LOCA. The Monte Carlo (statistical minimum) curve corresponded to the value of available NPSH which is below 95% of the NPSHA values determined with a 95% confidence. The Monte Carlo statistical mean curve was the mean of the 59 Monte Carlo calculation results obtained at each time step. He explained that the three percent required NPSH is the horizontal line. The staff used an uncertainty of 21% for the effective required NPSH, which is shown in the horizontal line. The estimate is based on Mr. Budris' (Pump Specialist) Task 2 Report. The staff used the maximum number *(in the required NPSHeffective)* but didn't include the temperature correction, which was a negative number. Mr. Lobel emphasized that this was a fairly high estimate of the effective required NPSH or the uncertainty in the three percent NPSH. The wear ring uncertainty value was not included in the calculation because it was obtained later.

Mr. Lobel reported that the Monte Carlo minimum, which is the 95/95 is very close or overlaps with the conservative available NPSH. This provides an approximate quantitative measure of the conservative calculation. The statistical mean and the realistic calculations also agree very closely. This provides an approximate quantitative measure of the realistic calculation. These curves *(See figure below)* show the margin between the conservative NPSHA and the realistic NPSHA. The curves also show the margin of most interest which is that between the NPSHA and the NPSHR values. The guidelines require that the licensees calculate a conservative or Monte Carlo 95/95 NPSHA curve and an NPSHR eff ective value for LOCA and a realistic NPSHA curve and a percent head drop NPSHR value for the be drawn from only one calculation. He added that for other BWR Mark I's, it might be pretty close but one cannot be sure, unless more calculations are done.



Slide 37

The staff showed comparison of the drywell conditions, using GOTHIC and SHEX codes (*See Slide 41*). Mr. Lobel commented that SHEX gives a higher peak drywell pressure, drywell gas temperature, and long-term LOCA suppression pool temperature. The calculations were performed for different accidents *(large break LOCA and mainsteam line break)*.

Comparison of Staff (GOTHIC) and GE (SHEX) calculations
Typical BWR/4 Mark I

Parameter	GOTHIC	SHEX
Short Term Containment Pressure & Temperature Response Analysis		
Peak DW Pressure (psig) (LB LOCA analysis)	40.7	44.1
Peak DW Gas Temp (^{o}F) (SSLB analysis)	334	338
Long Term Suppression Pool Temperature Response Analysis		
Peak SP Bulk Temp (^{o}F) (LB LOCA Analysis)	199.5	203
Long Term NPSH Analysis		
Peak SP Bulk Temp (90^{o}F) (LB LOCA Analysis)	202.5	207.1

The staff presentation portion of the meeting ended, with Slide 41 summarizing the key features supporting the conclusions of the staff draft guidance for crediting CAP.

6.2 DISCUSSION

The Subcommittee members made numerous comments and raised important issues. The following section captures the issues discussed that clarify some significant components of the staff draft CAP credit guidelines.

a. Impracticality of Design Change

Criterion 8 (Slide 5) of the staff guidelines recommends that the licensees justify that the use of CAP credit as necessary, because the design cannot be altered. Member Armijo inquired if Mr. Lobel could expand on this criterion. He asked if "practicably altered" means that it cannot be accomplished in terms of cost or it poses a real engineering challenge. Mr. Lobel replied that the staff did not talk about this in any details. He stated that as generic judgment, things that are necessary such as new pumps, bigger heat exchangers and some kind of additional cooling capability to the water before it got into the (pump) suction would have qualified as not being practical. Member Armijo asked if the reasoning is that it is expensive. Mr. Lobel responded that the staff had not asked this *(justifying that it is impractical to alter the design?)* question before but instead made the judgment themselves. He explained that bullet *(in Slide 5)* states that the staff would ask the question and the staff will develop criteria and guidance.

Member Ray asked for confirmation that if the staff would come up with specific criteria. He indicated that the members would want to review it to see if it (specific criteria) makes sense. Mr. Lobel affirmed that if the Committee does not see it as guidance, the members would see it in extended power uprate reviews. Member Ray replied that it would surprise people if the Committee finds the guidance (criteria) is not good in an individual extended uprate. After some discussion, Subcommittee Chairman Shack reaffirmed that it

(Criteria 8) is consistent with the Committee's previous letter. He emphasized that the letter asked that Criteria 8 be the first priority rather than the last. Member Ray agreed that Criteria 8 in the guidance was out of order. Mr. Lobel affirmed that the staff is going to ask the licensees if there is anything else they can do. The staff would develop criteria to evaluate the licensees' response.

Member Brown observed the staff already have in mind what these criteria are. He explained his statement further, stating that the staff has already stated that replacing a pump is too hard. Replacing a heat exchanger is also too hard. Mr. Lobel replied that is what the staff has been doing up to now. Member Brown responded that it becomes a money issue.

b. New Reactors and Crediting CAP

Consultant Wallis asked if Criteria 8 applies to a new reactor. He inquired if they (vendors) are going to keep changing the design until they don't need to credit CAP? Mr. Lobel stated that he had advised the new reactor staff that they would be much better off not approving the use of containment accident pressure. He commented that he had contacts with the new reactor staff and they are aware of the issues involved.

c. Operator Actions

Member Armijo asked if turning off containment spray to maintain sufficient head is an acceptable operator action in the guidance in the event a LOCA. Mr. Lobel answered that the first thing that came to his mind was it might be okay to turn it off but how long it is turned off before you need it again if you do (factors into the decision). He explained that is the kind of question that would go into the review of operator action like that. Member Armijo stated that the philosophy really bothers him the most. Mr. Lobel clarified that the BWR procedures now have a caution. If a plant is (not) taking credit for CAP, the procedure cautions the operator. The normal action is that the containment pressure can go down to zero psig. But if CAP is being credited, there is a caution in the procedure that states the *(operator needs to*) make sure that the containment pressure is at the pressure needed *(credited)*.

Member Brown inquired what if the system can't be turn it back on or something breaks or there is now air in the line. Mr. Lobel acknowledged the point, noting or the motor needs some time before you can turn back on. Member Brown warned that once you are in these accident conditions, you can all of a sudden get air in the line, whereby it will block the flow. Whereas, it (the system) already vented and it was operating, if turned it off, you can't turn it back on. Mr. Lobel replied that is the kind of question that would be asked in the review. The staff would not automatically say *(accept)* any operator action.
Member Abdel-Khalik asked if the staff is doing away with General Design Criteria 38. He explained that GDC 38 essentially states that the operator should rapidly reduce the containment pressure and temperature. Mr. Lobel said GDC-38 squares with GDC 35 which requires abundant cooling. He emphasized that the first priority is the flow to the core. Member Armijo observe that the only alternative is not to either ignore GDC 35 or ignore GDC 38 but there is another alternative that is to fix the pump and meet both criteria. Member Sieber added or don't uprate the power. Member Armijo remarked or uprate to

the power (level) that you don't need CAP credit. Member Armijo elaborated his concern more, stating that he may be hardware-oriented and deterministic in his approach because there are ways to fix things (engineering fix) but it is not getting enough attention.

Mr. Lobel noted that (engineering fix) gets into another issue, which is backfit. And the staff have to follow that 51.09. Member Armijo asked if power uprate would be a backfit. Mr. Lobel responded no and stated that there are other situations beside power uprates. Mr. Ruland interjected that (backfit) essentially implies cost benefit analysis. The current Commission policy does not require licensees to do cost benefit analyses for modifications that they are proposing. The staff is required to determine if their proposal is acceptable and assures reasonable assurance of adequate protection. There is no requirement for the staff to do a cost benefit analysis. Number eight is going to require the licensees to answer this *(practicality)* question. The staff is going to make a case-by-case judgment about whether or not this is practicably altered. In the Vermont Yankee uprate, the licensee claimed it was not practicable to dig a hole under their ECCS pumps and lower them and the staff accepted that.

d. Maximum Erosion Zone

In reference to Criterion 9, Member Abdel-Khalik observed that the maximum erosion zone corresponds to a ratio of (NPSHa/NPSHR) greater than one for both the lower bound *(1.2 for 3% NPSHR)* and the upper bound *(1.6 for 3% NPSHR).* He asked if the guidelines would allow margin outside this maximum erosion zone if *(the pumps are)* operated at a ratio less than one. Mr. Lobel confirmed. He explained that there is another criterion they (the licensee) need to meet that states the available must be greater than the required so they (the licensee) can't operate *(the pumps with NPSH ratio)* less than one. Member Abdel-Khalik requested confirmation that they (the pumps) are going to always operate above the erosion zone. Mr. Lobel confirmed that they are always going to be above.

In explaining cavitation behavior on the pump impeller voiding in Slide 17, Mr. Lobel explained that air also cushions the cavitation. He explained that the point of maximum cavitation is between the incipient cavitation where you have the first numbers (upper bound of 1.6) way out to the right on the test curve of the three percent head-drop. Member Abdel-Khalik asked if at point C, it is assumed that the pump characteristics remain unchanged. After some explanation on the duration the pumps operate at point C in the other industry relative to the nuclear, Member Abdel-Khalik interjected that he was concerned about how would the corresponding volumetric flow rate would be determined, given the fact that you have a two-phase mixture. Mr. Lobel responded that you don't. He elaborated that he had not seen anything in the pump literature where people have even tried to define things similar to quality avoid fraction. Consultant Wallis commented that you have a three percent loss of head and you draw your load line and you can match it with this three percent loss of head. Member Abdel-Khalik replied that is why he was asking whether the characteristic curve remains unchanged because it wouldn't change. Mr. Lobel agreed that the pump curve would change at that point, depending on what the available NPSH is, instead of being on the curve, it will start to drop vertically down.

e. Nominal, Conservative and Statistical NPSH Available and Erosion Zone

The staff presented Slide 37 which showed the Monte Carlo maximum, mean, minimum and the realistic and the conservative. Discussions ensued as to the: (1) definition of realistic and nominal; (2) quantification of the uncertainties associated with conservative calculations; and (3) consistency between the BWROG's statistical 95/95 calculations and the conclusions of the staff's calculation. After questions on the reasoning behind Criterion 10, Mr. Lobel stated that their purpose was just to give another indication of margin between the available and the required for the conservative or the realistic. The staff also wanted to have a comparison between the conservative and the realistic just to show the margin that there (exists) in the realistic.

Member Shack commented that criterion nine and ten were coupled because nine states that maximum erosion zone is at (NPSH) ratio of 1.1 to 1.6. He remarked that the realistic calculation is used to find out whether pumps really were in the zone of maximum erosion. Mr. Lobel agreed. Member Shack noted that the whole treatment is not just margin. It really is a question of determining where the pumps would really operate at in relation to that maximum erosion zone. He observed that, therefore, one needs a realistic calculation that is more like the 95/95. That is most of the time (it will show) where you (the pumps) are really likely to be operating. He concluded that the conservative answer may not be conservative from that point of view. Mr. Lobel agreed and cited the Vermont Yankee application as an example. He said that in the VY case, you (NPSH available calculations) were so conservative that you really didn't know where you were anymore (the pumps were operating). He stated that is why the staff is suggesting the use of the realistic value.

Member Abdel-Khalik asked if the hundred hour limit only applies to the realistic input result. Mr. Lobel agreed. Consultant Wallis asked why the staff would apply the 100 erosion time calculation to the realistic. Mr. Lobel stated the reason is because the staff wants to know what is actually happening. Consultant Wallis responded that you never know what is really happening. There is uncertainty in the statistics. You never know what is actually happening in the realistic. After further discussion, Member Wallis stated that safety isn't based on the mean. It is based on being reasonably sure that probably nothing will go wrong. He asked why the staff would not go for the 95/95 calculations? Mr. Lobel commented that if you go for 95/95, you could even end up below the erosion zone, but it is a judgment.

Member Shack proposed that logically, the calculation to pick would be the statistical minimum. He elaborated, explaining that there is no worry about uncertainties in the calculation. A whole batch of scenarios is look at. The statistical minimum is the one that in fact looks at all the scenarios. He suggested that if one can keep the statistical minimum above 1.6, then that is the only guarantee. For any other calculation, you don't know what scenario you are going to be in. He observed that in this case there is no need to worry about whether the hundred hours is conservative. Mr. Lobel responded that the staff was trying to leave the choices to the realistic or the conservative because the staff does not want to ask the licensees to do Monte Carlo calculations. Member Shack pointed out that as described before, the realistic input really only covers one scenario, the summer day. If the line break occurs in January, the pumps could be down in the zone of maximum erosion, unless you know where the statistical minimum is at least 95 percent of the time. Member Shack stated that unless you can convince yourself that the hundred hours criteria is extremely conservative, you are in the zone of maximum erosion. You can avoid the erosion by either making the time very short or staying above it but somehow allowing yourself to float around. Mr. Lobel emphasized that the hundred hours (criteria) is conservative and there is not any possibility that the impeller will have enough erosion that it is going to affect the pump safety function in a hundred hours.

Member Armijo recommended that the pump consultant address the expected life in that green band. Mr. Budris introduced himself and gave a brief description of his experience. He commented that many variables affect the hundred hours. He cited air as an example in which a little bit of air can reduce the damage and other variables can also have substantially effect. He reported some Sulzer (test) reports, where they actually did tests on these types of pumps in their field. The pumps ran for a day and experienced absolutely no damage, running around a three percent or less than a three percent value (head loss). He also cited cases (pump tests) that he had personally seen, where there was substantial damage even with stainless steel impellers, which is a fairly cavitation corrosion-resistant material. He report that the damage occurred after two thousand hours or so.

Member Shack commented that his *(Budris)* report focused on the very high suction pumps, which are the ones of interest and seem susceptible (to erosion). Mr. Budris replied that the one (test) he was referring to actually wasn't for nuclear power industry. It was a cooling pump but some of the worst cavitation damage happens with water around 100 degrees.

Member Shack asked if the hundred hours was an estimate at the three percent NPSH or at the maximum erosion rate. Mr.Budris said that it was at the maximum erosion rate. He remarked that the Sulzer tests were probably done around 1.0 *(NPSH margin?),* around the three percent intra point. Member Armijo asked for confirmation that this (damage) experience was for stainless steel impellers. Mr. Budris affirmed it. He stated that cavitation damage is time-related, in which you can get a few pock marks in an impeller, without any real reduction in the pump performance. He remarked you almost have to have the erosion go all the way through and break off pieces of vane, before you really substantially impact the performance of a pump.

Member Abdel-Khalik asks if the hundred hours limit would apply to both the conservative analysis and the realistic analysis. Mr. Lobel responded it would only apply to the realistic. At later discussions, Member Abdel-Khalik inquired if the denominator in the ordinate, the NPSHR, is the same for all graphs. Mr. Lobel said no. Member Abdel-Khalik asked if it was the NPSHReffective. Mr. Lobel clarified, stating that for the conservative, it is the NPSHeffective- required. For the other cases, it is the three percent head drop. Member Abdel-Khalik followed up on the question, noting that for the various methods or the various results that are present take into account uncertainties in the calculation of NPSH available. Mr. Lobel agreed. Member Abde-Khalik pointed out that his question was why the staff does not have the same denominator in the plot, which is the NPSH required effective for all the (different) calculations, since the uncertainties in the required NPSH would be the same, regardless of how the available NPSH is calculated. Mr. Lobel conceded that the staff could have done it that way but chose that the realistic use the three percent value. Member Abdel-Khalik commented that the staff is doing a realistic calculation to account for uncertainties. Mr. Lobel affirmed. Member Abdel-Khalik observed that the staff decided to essentially forego any concern about uncertainties in the required NPSH value. Mr. Lobel acknowledged, stating that it would be the same containment calculation and just a different number in a spread sheet. Member Abdel-Khalik explained that these realistic graphs would fall lower than where they are on this plot, depending on how much difference is there between *(NPSH3% and NPSHR)*. Mr. Lobel agreed.

Member Armijo asked if then the statistical minimum would go into the green erosion zone. After some discussion, Member Abdel-Khalik stated that if the staff calculated and re-plot them, except for the green curve *(erosion zone),* all the other curves will go down because you are dividing by a larger number. Mr. Budris (pump specialist) agreed.

Considering the higher NPSHR effective value, Consultant Wallis suggested that the statistical minimum can go into the green zone for a while and come out again (see Slides 10 and 37). He asked if that was acceptable. Mr. Lobel replied that it is the total time of maximum erosion that matters. Member Shack commented that the question was whether the staff should be using the realistic value. He added that it would seem that the statistical minimum should not be in the green zone for more than a hundred hours. Consultant Wallis remarked that they can make a more conservative assumption and make the plot look better because it (NPSH ratio) goes down below the green and then it comes back again. He expressed the concern over this potential.

f. Simpler Regulations and Backfit

Following up on comment made by Consultant Wallis for a need of a simpler way to define an acceptable boundary, Member Abdel-Khalik asked wouldn't it be a lot simpler if the staff required that that the NPSH ratio always be above the zone of maximum erosion. In agreement, Member Armijo suggested a NPSH ratio of 1.6. Mr. Lobel agreed that it would be simpler.

Consultant Wallis cautioned that this criterion might bring some of the plants which don't need CAP into a situation where they do need CAP. He observed that if plants that have not requested CAP and are now using atmospheric containment conditions apply (this criteria, NPSH ratio of 1.6?), presumably they may need CAP. Mr. Lobel stated that from the curves (plots) based on the staff's calculation it may be almost be the same thing (result). He offered that the curves seem to decrease a certain ways and then flatten out. So at a hundred hours, the curve may still end up in the maximum erosion zone. He proposed that it wouldn't make any difference if you had a limit on the amount of time or you didn't because you are going to exceed the limit anyway. Consultant Wallis inquired what plants that don't need CAP now that if they apply factors like 1.21 (estimated NPSH effective =1.21 * NPSHR 3%) and 1.6 (NPSH ratio upper bound) may need CAP. He speculated that if they don't do that now, the plants may end up operating in the green (maximum erosion) zone. He acknowledged that the staff has been discussing informally but have not reached any conclusions. Mr. Lobel said that it would be a backfit to impose the (guidelines) requirements and the staff would have to justify that the requirement. It would depend on what kind of backfit it is determined to be, in terms of whether it was going to be a compliance backfit or an increase in safety backfit. Mr. Lobel proposed that another option would be to find data that shows these pumps can operate in the maximum erosion range for some long length of time that is longer than the duration CAP is necessary.

Member Abdel-Khalik remarked that it would be plant-specific. Mr. Lobel replied that it would depend on how it is done. If these curves would be used, it would be plant specific. If you show that operationally, the maximum erosion zone even for a thousand hours isn't going to affect a pump, with a certain impeller material then maybe that would solve the problem.

Mr. Budris warned that the pumps maybe in a better shape, because of the impact of the entrained air on the cavitation. He stated that air which can hurt the mechanical seal and can actually increase slightly NPSH requirement by cushioning any damage you are going to get from the cavitation bubbles. At one percent or higher air, you can substantially reduce the erosion damage, making the pumps be in better shape. He also noted that the fact that the flow is at a higher temperatures helps. The vapor bubbles aren't as big at higher temperatures as they are when at lower temperatures. The implosion does not have as much energy and the cavitation damage would be less. Mr. Budris advised that actually in the field, even though the pumps may be at the maximum erosion zone, there are some other factors mitigating the damage.

g. Mechanical Seals

In the mechanical seals (Criteria 17) discussion, Member Shack inquired how close you (NPSHavailable) have to be to the 3% NPSHR before the seals become a concern. Mr. Budris explained it depends on how much entrained air there is. Mr. Budris stated that he measured the entrained air in the water as it went through the NPSH test, which meant dropping the NPSH available. At NPSH ratio of about 1.3 to1.4 air comes out of solution. What happens, in part, is that when cavitation bubbles form, any dissolved air is liberated and it becomes entrained air. Therefore, it is like adding entrained air. The more (vapor) bubbles form, the more is the entrained air, which cushions it (bubbles collapse and cavitaion). He elaborated, explaining that the more and more air that is generated end up at the mechanical seal faces, causing failure. Mr. Budris cited a case for a different pump (vertical turbine pump), where the pump was in severe cavitation. The air that was liberated ended up causing some internal bearings to run dry and the pump to fail. The bearings were about the same place where a mechanical seal would be pumps.

Member Shack joked that it appears there is a need for a pink zone. Considering his recommendation that the staff's apply the 100 hours erosion limit using the statistical minimum, he stated that if the statistical minimum is in the pink zone, then you have to install (new design of) seals. If the NPSH ratio is above the pink zone, you don't have to change the seals. Mr. Budris mentioned that double seal with external cooling may not be absolutely needed as long as there is a flush line off the discharge and maybe a throttle bushing. These designs may preclude the air from getting to the seal. A flush line off the discharge causes the flow to go in towards the pump, which should keep the air out. He concluded that there are (viable) ways (or designs) that other than a dual-seal arrangement. Mr. Wojchouski noted that we (Monticello) have such arrangement for their mechanical seal design.

h. Staff Sensitivity Analysis

In the staff's presentation of their conclusions of the NPSH available sensitivity analyses, Subcommittee Chair Shack commented that he found it strange that the sensitivity to the strainer and piping losses were insignificant. He said that he expected a five percent change to make a five percent change in the available head. Mr. Lobel explained that the strainer losses weren't very large and it is combined with the piping friction losses. Member Abdel-Khalik remarked that this (result) is all an artifact of the five percent variability that that was imposed because five percent change in power is a huge change. He added that whereas a five percent in the heat sink temperature in degrees F, because that is units dependent, is relatively small compared to the range that you expect to operate within. Mr. Lobel accepted the comment and stated the staff was open to suggestions of what the Subcommittee would like to see, because it is not hard to do.

In the presentation of the available NPSH calculations, Mr. Lobel stated that the conservative and the statistical minimum were fairly close. He also said that the realistic calculation and the mean were also close. These conclusions lead to discussion on the consistency of the staff's conclusions with the basis of the BWROG topical report methodology and the supporting results. Since the staff presented available NPSH calculations, the staff and the Subcommittee attempted to reconcile the differences by comparing the BWROG and staff suppression pool temperature and wetwell pressure calculations

Consultant Wallis pointed out that the difference between the Monte Carlo and the conservative, whether it is NPSH or psi, should be consistent because you are just adding the same constants to both. He observed that it does not explain that the BWROG's presentation showed four to six psi difference between the conservative and the 95/95 statistics. Member Abdel-Khalik agreed that the morning session message was that the statistical method bought them several psi. Consultant Wallis noted that the staff is saying that the 95/95 statistics does not buy you anything over the conservative and he did not think that is correct. He suggested that the conservative usually is so conservative that it is way above or different from the statistical approach. Consultant Wallis expounded on it, pointing if you look at the river water temperature, the conservative value would take 90 degrees. For the statistical this occurs so infrequently that it wouldn't really show up in the statistical analysis and you would cut off the tail. Member Ray agreed, stating that five percent exclusion is substantial and you would expect if you included what is in the tail, it would make a difference. Member Wallis reiterated that it would make a difference because the tail is so spread out.

Member Abdel-Khalik added that this (BWROG's) graph shows that if you do the conservative calculation, you need a lot more containment over pressure to meet the criterion than you would if you were to use this 95/95 method, which means that there is a big difference between the two analyses.

Mr. Wojchouski (BWROG) intervened stating that in their presentation, for their deterministic calculations all of the values were put at bounding peak values and low values. The statistical was the 95/95 confidence level. He suggested that what the NRC was doing is their conservative value was realistic and then they added in some uncertainty to it. He proposed that the staff's conservative isn't really the same basis as the BWROG deterministic.

Mr. Sallman disagreed, explaining that the BWROG deterministic is the same as the staff conservative. Consultant Wallis inquired if they were using extreme values for everything. Mr. Sallman stated that the staff used conservative input values. After examining the BWROG Slides 20 and 21, Mr. Sallman interpreted the relative slides and commented that the containment accident pressure required is being calculated by back calculation starting from the NPSH required and how much wetwell pressure is required. He determined that the calculations were not the same and proposed that for comparisons to use the wetwell pressure required which is Slide 69 of the staff's presentation. Member Abdel-Khalik remarked that the graphs were not the same scale.

Mr. Sallman described Slide 69. Member Armijo asked if the staff calculations used the Gothic code. Mr. Sallman said yes. Member Armijo commented that the BWROG calculations were done with SHEX. He observed that by eye-balling, if you plot both with same semi-log pressure scales and take into account the different assumptions in the analysis, they don't look that different. He stated that the magnitudes and the peaks are about the same. Referring to the staff Slide 70 (See below), Member Shack asked why their realistic comes close to the conservative. He also commented that he was surprised that the Monte Carlo maximum is so different, is above the conservative.

Mr. Sallman theorized that the reason could be because they are trying to maximize the suppression pool temperature but it doesn't have the effect of minimizing the wetwell pressure simultaneously. Mr. Lobel elaborated stating that when you do the calculation, you try to minimize the pressure and maximize the temperature. When you maximize the temperature, that increases the vapor pressure above the water and you are also providing more heat to the non-condensable gas to the nitrogen. So at the point of maximum temperature, you don't have a minimum pressure. He stated that he was trying to explain why first of all the conservative pressure is above the realistic pressure because the conservative is maximizing the temperature. That is increasing the pressure, the realistic pressure. Member Abdel-Khalik stated that all along the have been trying to tell the committee that conservative means that you are biasing the calculation to give you high temperature and low pressure. You can't do both things.

Mt. Lobel offered that the staff is trying to do those two things but can't do them both at once. So the thing the staff is doing based on sensitivity studies is they maximum temperature for the limiting NPSH. The staff use assumptions that limit the pressure but it is not going to be the minimum pressure because of because the vapor pressure is going to be higher. Also, the nitrogen in the wetwell is heated to a higher temperature. You can't have minimum and maximum temperature at the same time

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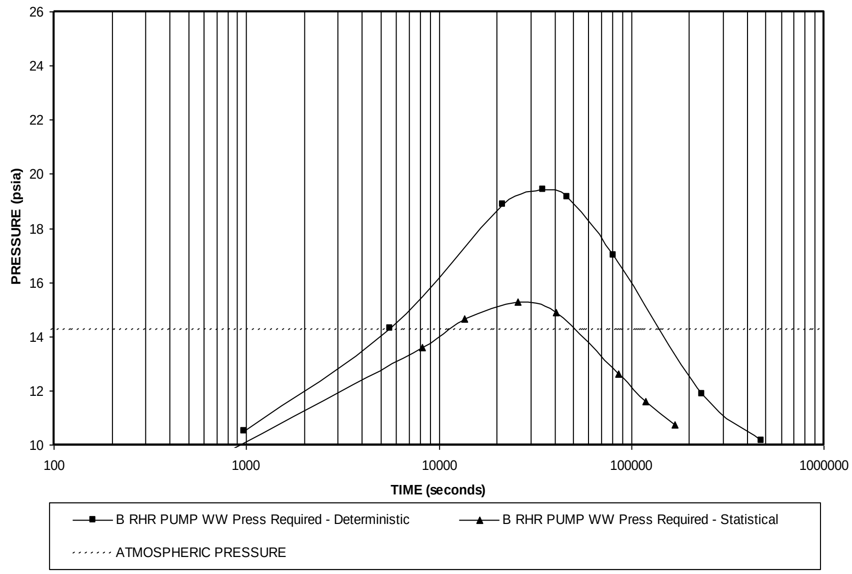
Mr. Lobel stated that this is another reason why the staff is trying to emphasize using an NPSH rather than looking at temperature and pressure, because you have to think through all of this when you look at one (temperature) or the other (pressure).

After more discussion, Subcommittee Chairman Shack stated that the staff needs to provide some comparisons of the same quantities. If BWROG is doing required, the staff also provides a plot of required. If staff is doing NPSH, the BWROG needs to provide a plot of NPSH. With this guidance for the upcoming full committee, the issue was closed.

CAP Required for RHR Pumps During DBA LOCA



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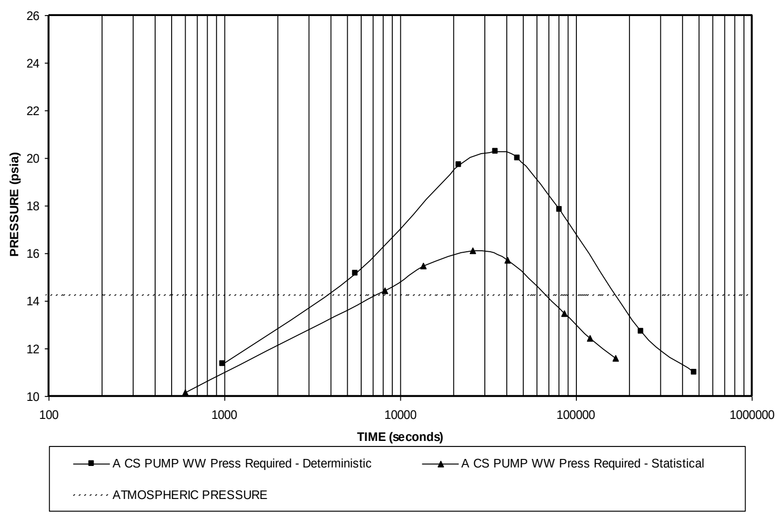
April 2010

CAP Required for Core Spray Pumps During DBA LOCA



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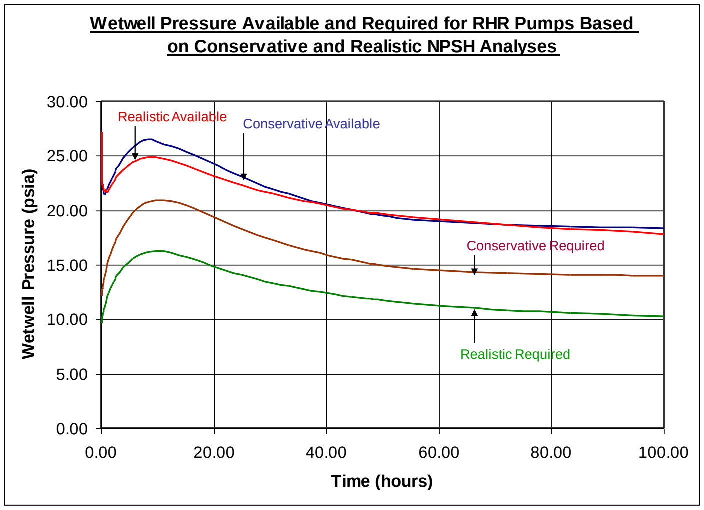

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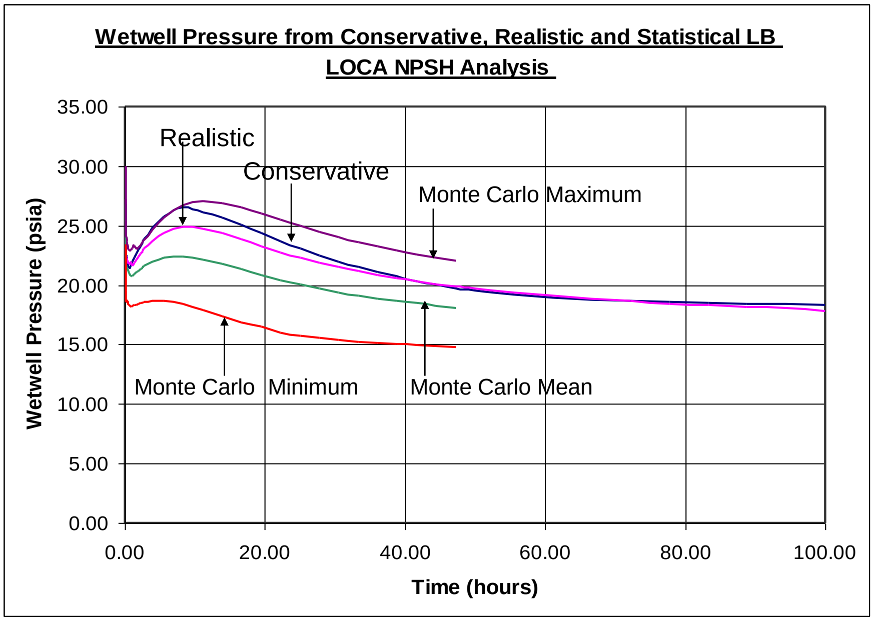
Staff Sensitivity Analysis



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6.3 OVERALL SUBCOMMITTEE CONCLUDING COMMENTS

In this portion of the meeting, the Committee members summarized their overall comments on the information presented by the staff. Subcommittee Chairman Shack began the discussion with the remark that looking at the Staff's summary, there is containment integrity. He stated that the staff presentation on internal events was excellent. The question is how applicable the conclusion is or if the conclusion can be extended to external events like fire and seismic. He noted that independence of the barriers is fundamentally a question of just how strongly one can believe that all possible losses of containment integrity were accounted for. If one considers internal events, one gets one answer. If one considers a broader range of initiators, one might get another answer. Member Shack offered that it is a critical topic in the overall concept that needs to be discussed.

Member Shack agreed that one way to make the argument that there is enough margins, even if one can't quantify it very well. He suggested that the fundamental difference up to date is that Committee is not ready to assume that containment integrity is a given. Therefore, the Committee has been unhappy with the use of containment accident pressure. He commented that the uncertainties in the NPSH require to be quantified, which is one of areas the Committee had problems with. He stated that it would be helpful to have both the realistic and the conservative NPSH, although there needs to be a better definition of what realistic is. Member Shack proposed that that the margin cannot be quantified, without doing something like the statistical analysis. He acknowledged that it was very interesting concept to look into the integrity of the seal and the maximum erosion rate. He added that whether that it is unclear if is ready for primetime. Member Shack recommended that the Staff may need to addressed the issue either as part of the regulations or find more data to resolve it.

The Subcommittee discussed the material to be covered at the Full Committee. After considering the; (1) the role and the need for the BWROG topical report; (2) its priority relative to the staff draft guidance; and (3) potential differences between the BWROG topical and the staff guidance, the Subcommittee agreed that the BWROG topical report be shelved for now and not be addressed in the associated Full Committee meeting.

Member Bonaca agreed stated that there was great progress working out some solution since last meeting. He noted that there was a lot of material information that can be used to achieve some kind of agreement.

Member Brown stated that he agreed, in part, with the guidance. He commented that there were lot of discussion on conservative, realistic, minimum and maximum calculation methodology and which parameters are (significant). He suggested that it would be useful to generate a table with the results of the different methods. For each method, the corresponding key input parameters should be listed and whether each parameter is conservative or not specified. Member Brown also proposed that the staff clarify the terms used for the different methods so that the designations and its meaning do not change on case by case basis. In terms of the BWROG statistical methods, Member Brown stated that he had some concern over which key parameters ought to be kept constant across the board and which other ones can be treated randomly.

Member Brown also touched on the problems that could arise if operator action is relied upon to maximize the containment accident pressure by turning equipments and systems off. He warned that sometimes if you turn it off *(the system and/or equipment)*, you may not get it going again *(operable)*. He stated that whether the system can re-engage or not and the consequences of operator actions should be evaluated. This issue was previous also brought up by Member Harold.

In his overall guidance, Consultant Wallis observed that the Staff's conclusion that the conservative and the statistical yield the same results differs from the conclusions in the BWROG topical report.
He pointed out that the BWROG topical report showed that they could gain eight feet in available head by using the statistical method rather than the conservative. Consultant Wallis cautioned that it would be very embarrassing if the approved guidance states that the conservative and statistical result in the same answers (results). However, a plant-specific application could show considerable difference in the results between the two methods. After some discussion, the members acknowledged that they need more information in order to understand if there is significant differences or not between the conservative and the statistical methods.

ACRS Chairman Abdel-Khalik started his remarks by acknowledging Marty Stutzke's risk presentation, referring to it as enlightening. He stated that despite concerns over fire and seismic events and containment integrity, the risk evaluations at least addressed an important aspect of the questions raised. He commented that the staff needs to evaluate the justification for allowing containment accident pressure credit against the practicability of the design changes. He reminded the staff to be aware of the potential conflict between GDC-35 and GDC-38 requirement and not to elect to keep one and disregard the second GDC requirement. Member Abdel-Khalik also suggested that the staff consider the potential for requiring the ratio of NPSH available divided by NPSH required effective be set above the zone of maximum erosion. The staff needs to consider and evaluate what would be the implication of requiring that NPSH ratio be set above the erosion zone? He observed that his colleagues may not all agree, however he would like to have the thought process and the potential implications to be determined.

Member Armijo observed that there is no urgency in the approval of the BWROG topical report and it seems to be out of sequence. There is also lot of material to cover. He, therefore, proposed that the Staff focus on the draft CAP credit guidance during the Full Committee meeting. Member Armijo noted that Stutzke's risk presentation was helpful to him. It all hinges on the risk in that if the risk change is trivial, then it is hard to oppose the change. He expressed his continued concern over *(crediting CAP without further assessment of)* fire, seismic and counterintuitive operator actions that *(inhibit)* systems intended to protect the containment. Member Armijo also stated that the Staff's and the BWROG statistical work appeared to be consistent. He recommended that the two results be plotted in the same scale.

Member Ray stated that he agreed with all of the member comments so far. He observed that it appears that the focus is on things that can be measured and calculated, while settings aside the things can't t be.

Member Ray advised that the real issues such as external events not be ignored. He also pointed out that the potentially broader implications from a process standpoint be considered (in reference to the BWROG approach).

Member Banerjee also agreed with the members' concluding comments. He stated that Mr. Stutzke's risk presentation was interesting but he would like to see uncertainties, in terms of how large they are. Member Banerjee stated that knowing the magnitude of the uncertainties would make him more comfortable *(or provide more confidence in the conclusions of the risk evaluations.)* For the deterministic analysis, Member Banerjee urged the staff try to move forward and sort out the gray areas. He cited the quantification of model uncertainties as an example. He stated that even though the results are within a few degrees when using different codes, he was not comfortable blessing the results, when there has not been very detailed justification for the *(accuracy of the)* best estimate code.

Member Sieber stated that the presentations were very good and congratulated the staff for their work and the effort. He acknowledged that the staff performed a lot of work and has gone the extra mile to make things understandable to the members. Member Sieber also agreed with the members' concluding comments. He expressed his continued reservation to crediting CAP, stating that in the back of his mind he still is concerned about the (*impact on the)* independence of barriers. He note that there are number of PWRs also involved, which maybe sub-atmospheric plants. Mr. Lobel clarified, stating that there are some large drys and the rest are sub-atmospheric. Member Sieber continued pointing out that defense-in-depth was the basic tenants of the design and safety philosophy for these plants. He cautioned that it bothered him enough that he would veto the legitimate need *(for CAP credit)* for consideration as being proposed now.

With these member concluding remarks, the CAP credit Subcommittee meeting adjourned.