RG 1.157 REVISION WORKING GROUP

TO: MEETING PARTICIPANTS

FROM: ROBERT MARTIN, MEETING SECRETARY

SUBJECT: MAY 27-28 2008 MEETING MINUTES

DATE: 7/1/2009

Attendees: Ralph Landry (NRC), Tim Collins (NRC), Steve Bajorek (NRC), Shanlai Lu (NRC), Jaclyn Dorn (NRC), Anthony Mendiola (NRC), William Ruland (NRC), Bert Dunn (AREVA), Bob Martin (AREVA), Don Todd (AREVA), Philippe Dias (AREVA), Meghan Leslie (W), Michael Shockling (W), Jeff Kobelak (W), Charley Heck (GE)

On May 27-28, 2009, representatives from the U.S. NRC, AREVA, GE, and Westinghouse met at the U.S. NRC's White Flint office building for the 3rd meeting addressing several "unresolved issues related to best-estimate plus uncertainty methodologies" used in safety analyses. Committee chairman Tim Collins called the meeting to order around 1:10 am.

Tim presented the scheduled agenda (Attachment A), addressed meeting formalities and then introduced the first agenda item, reporting on his participation the ANS/ASME Joint Committee on Risk Standards Committee held March 12th. This meeting was prompted by comments made by the ANS Standards Committee at the Winter ANS meeting (attended by Kurshad Muftoglu) suggesting that our objectives may best fit with the Risk Standards Committee. Tim was given the opportunity to described to the Risk Standards Committee the nature of our objectives, our short history and solicited their feedback with regard to our participation within this committee. Tim described their response as polite, but cold. His impression was that they appeared utility-driven and that NEI was notably disinterested.

The working group discussed Tim's report for a short time, questioning whether our mission is too ill-defined at the moment or whether the Risk Standards Committee is simply the wrong group for our purpose. Eventually, Bert Dunn reiterated a suggestion from previous meetings that NRC sponsorship may be our solution. Ralph Landry reminded the group that it would not be in our best interest to appear "NRC-driven"; however, in recent internal discussions at the NRC there is a recognition of the need to capture a permanent record of decision-making related to nuclear safety analysis, i.e., "knowledge management," and that some form of NRC-sponsorship may be better received by NRC management with this additional objective. Ralph mentioned that the forthcoming Advanced Notice of Proposed Rulemaking on 10 CFR 50.46 will reflect this new knowledge management objective.

Action Item: Tim agreed to approach NRC management with this proposal as soon as this working group can draft a Charter.

ENCLOSURE

Ralph then addressed his action item from the previous meeting – providing everyone with a copy of the draft IAEA guideline on the application of deterministic and best-estimate safety analysis. He noted that the IAEA will be hosting a meeting on this subject in September and he plans to attend to discuss our activities.

The remainder of the meeting on the 27th and 28th focused on discussing the industry responses (see Attachment B) to the suite of questions prepared during the March 4-5 meeting to help the working group draft our Charter. The discussion of each question drew a considerable amount of comments. The principle outcome from the discussions was simply whether the question itself should be included in the scope of this working groups activities.

Defining the objectives of this forum

1. Should discussion be expanded to consider other thermal-hydraulic analysis domains, such as severe accidents (Chapter 19) and containment analysis (Chapter 6)? Should discussion be expanded beyond thermal-hydraulic analysis domains?

[RETAINED] Initial industry response revealed no consensus. Both Tim and Ralph expressed the merits focusing on a real problem while retaining the possibility of expansion to other applications through pointers in the final prepared text. Ralph reminded the group that only LOCA analysis is described in the regulations. Other analyses are described only in NUREG-0800. As such, group decided to accept the suggestion to pursue the LOCA problem and provide generic comment as appropriate.

2. Should we strictly focus on issues related to the application of statistical methods? Alternatively, should we consider a broader focus on other unresolved or ill-defined aspects appearing in Regulatory Guide 1.203 (e.g., scaling, validation and verification, meaning of frozen code, 50.46 reporting methods, etc.)?

[RETAINED] Industry response revealed no consensus. AREVA stated that it is difficult to separate a single piece of a methodology without affecting the whole while Westinghouse disagreed and GE affirmed that the statistic question should be our first priority. After much debate, this question was simplified into a two part question: Should it be the mission of this working group to revise RG 1.157? RG 1.203? In response, the working group agreed that there is merit to revise RG 1.157; however, RG 1.203 is sufficiently general that revision is unnecessary.

Action Item: Vendors are tasked with developing a section-by-section list of criticisms of RG 1.157 (including the reference section); i.e., make a case for revision. This is due by June 19th

3. RG 1.157 states that RELAP5 and TRAC-based codes "reasonably predict the major phenomena observed over a broad range of thermal-hydraulic and fuel tests". Should we explore the question of what makes a computer code sufficient for performing BE analysis?

[DROPPED] There was general consensus that this is adequately addressed in RG 1.203 and should not be reopened by the working group.

4. Are there certain plant-specific differences (e.g., BWR vs. PWR, upper plenum vs. cold leg injection plants, etc.) that need to be explicitly considered or acknowledge?

[COMBINE with #5].

5. What consideration should be made for non-LWR technology, including gas and sodium-cooled plant designs?

[RETAINED] The working group expressed consensus that LWR-technology should be the focus of our attention. Specificity should be avoided to retain a technology neutral position when possible.

6. What elements of existing regulatory precedence fundamental to all evaluation methodologies should be captured in our discussions?

[RETAINED] The discussion of this question raised the earlier comment by Ralph about the importance of "knowledge management." There was agreement that a revision of RG 1.157 could meet this objective.

Defining "Best-Estimate"

7. What should be the definition of "best estimate analyses" in licensing applications? Does the term relate to evaluation methodologies? To codes? To both? Where and how do you incorporate conservatisms?

[RETAINED] This question raised the general issue of ambiguity with the meaning of various terms appearing in regulatory documents on transient and accident analysis.

Action Item: Everyone was asked to build a list of terms to be included in a glossary. Draft definitions are encouraged.

8. 10 CFR 50.46(a) states that the "calculated ECCS cooling performance [is such that] there is a high level of probability that the criteria [is] not exceeded." What does "high probability" mean in this context? Should the likelihood of the event and its consequences be considered in its definition? What is the correct mathematical statement of the regulatory requirement?

[RETAINED part (a)] While there were comments about overlap between this question and #7, discussion on this question migrated to the concern of "retained margin." Specifically, that retained margin is a probability statement applied to the output of an analysis. Important to defining this term are any regulatory imposed exceptions, such as those coming from General Design Criteria. It was acknowledged that for Appendix K LOCA, the 1.2 decay heat multiplier was conservatively adopted to address epistemic uncertainties. A description of how these uncertainties are addressed in best-estimate plus uncertainty (BEPU) methods needs to be documented.

[DROPPED part (b)] Questions of the event likelihood will not be a formal part of the working group's Charter.

[RETAINED part (c)] There was consensus that a mathematical statement regarding the application of statistical methods to BEPU analyses needs to be explicitly expressed.

9. How should upcoming rulemakings be factored in? Change in equivalent clad reacted (ECR) limits and risk-informed break size…

[RETAINED] The working group needs to stay aware of progress in ongoing rulemaking activities and its impact on our end products.

10. How should change management, i.e., new data, operating parameters, code/model, etc. be implemented in a BE methodology?

[RETAINED] There is general consensus that there are unique challenges associated with BEPU methods. In addition, the current practice has never been formalized and this may be complicated by upcoming revisions to 10 CFR 50.46.

Application of Engineering Judgment

11. Under what conditions can a parameter be sampled in a safety analysis?

[RETAINED – combine with #12] There was general consensus among vendors that anything parameter should be open to statistical treatment (i.e., not just those considered phenomenologically important).

12. What parameters should not be ranged (or defined with a restricted range):
    - (a) Time in life
    - (b) Break area
    - (c) Some plant parameters
        - (i) core power
        - (ii) peak linear heat rate
        - (iii) decay heat
        - (iv) SI temperature
    - (d) LOOP, or should there be separate 95/95 values for LOOP and non-LOOP?

[RETAINED] This question was considered an extension of #11. The industry reaffirmed that all parameters should be available for statistical treatments. Restrictions need to be formalized by the regulator.

13. How should parameters that are addressed in plant technical specification be treated in an uncertainty analysis?

[RETAINED] There was consensus that the incorporation of technical specifications into BEPU methods need to be clarified in regulatory documents.

14. How should "expected" operator actions be treated in uncertainty analyses? Emergency operating procedures?

[RETAINED] There are examples in RG 1.157 regarding operator actions. This subject has greater relevance to small break LOCA and non-LOCA transients. As such, the question of how operator action uncertainty should be included in the working group's charter.

15. For each output parameter, what set of input parameters should be sampled and ranged for each scenario? Does the input parameter set for a single output parameter (e.g., PCT) sufficiently cover other output parameters (e.g., MLO and CWO)?

[DROPPED] There was consensus that this question reinforces other questions (e.g., #2) and, therefore, redundant.

16. Can recommendations be established for BE analyses using coupled codes? Examples: TRACE/CONTAIN for containment pressure feedback and TRACE/PARCS for cases where 3D kinetics may be needed.

[DROPPED] There was consensus that there was materially no differences between integral and coupled codes with regard to safety analysis methodologies.

Convolution of Uncertainties

17. Are regulations written addressing outcomes (i.e., safe vs. not safe) or a convolution of processes? If the latter, under what conditions should analysis supporting a plant license be treated as a multivariate problem? Is the LBLOCA a unique problem? SBLOCA? AOO's?

[DROPPED] There was consensus that this question reinforces other questions (e.g., #8) and, therefore, redundant.

18. What is the minimum number of calculations on which a 95/95 uncertainty should be based if the output parameter(s) of interest are:
    (a) PCT, MLO, CWO
    (b) Min. water level, peak pressure, or other (single) output parameter
    (c) Applications with several output parameters of interest (5 or more, e.g., certain AOOs, severe accidents, others?)

[RETAINED] There was consensus that this question overlaps with question #8; however, the discussion eventually focused on the subject of *dealing with failure when applying non-parametric approaches* and whether BEPU methodology documentation include a description of how to deal with such failure?

19. What constraints apply to the development of a probability distribution function for an uncertainty analysis?

[RETAINED] The key discussion focus was on the meaning of "having a probability distribution function that is *justified*." The objective of "being physical" was reinforced while accepting certain conservative treatments. Otherwise, it was acknowledged that there is overlap with other questions.

20. How should uncertainties due to nodalization, time step size, and other convergence parameters be included a BE methodology?

[RETAINED] These subjects are already in RG 1.157. The working group will review, reaffirm or alter.

21. How do we qualify the statistical approach?

[DROPPED] This topic was considered to be outside the scope of this working group and dependent on NRC audit capabilities which are rapidly evolving with the development of the TRACE code.

Data for Quantifying Uncertainties

22. How should distributions be developed when there is a lack of knowledge about the distribution?

[DROPPED] There was consensus that this question reinforces other questions (e.g., #8).

23. BE methodologies range parameters based on various code models and correlations, such as heat transfer coefficient. These are often regime dependent and are based on experimental data from numerous sources:
    (a) To what extent should regime dependence be accounted for in the ranging? (For example, when is it acceptable to range single phase convection the same as film boiling?)
    (b) When ranging a specific model, should its effect be ranged locally (as in ranging heat transfer in the core only or interfacial drag in the chimney region only) or globally throughout a given model?
    (c) How sufficient must the assessment database be to determine a code bias and the type of distribution and limits over which to range a certain model/correlation?

[RETAINED] These subjects are already in RG 1.157. The working group will review, reaffirm or alter.

24. If a plant initial condition is ranged as part of an uncertainty methodology, when is it appropriate to use plant technical specification limiting values, and when can or should plant performance data be used to establish the range and distribution?

[DROPPED] There was consensus that this question reinforces other questions (e.g., #13).

The working group elected not to address the follow-on "Purpose and Scope Questions" since it was concluded that these questions addressed issues already discussed. The group wrapped up with a decision to change our name to the "Regulatory Guide 1.157 Revision Working Group. Our upcoming schedule will be to

- Address the action item pertaining to itemizing RG 1.157 criticisms by June 19th.
- Tim will draft a Charter statement and deliver to the vendors by July 1st.
- Vendors will provide comment by July 7th
- Time will meet with management mid-July
- Working group will reconvene in August.

Attachment A
Meeting Agenda

AGENDA FOR THE MAY 27-28, 2009, PUBLIC MEETING

BETWEEN THE U.S. NUCLEAR REGULATORY COMMISSION (NRC)

AND INDUSTRY REPRESENTATIVES

REGARDING AN ACCIDENT UNCERTAINTY METHODOLOGY FORUM

TOPIC	DURATION (minutes)
Wednesday 1:00 PM Review of Agenda	5 minutes
Report on meeting with ASME/ANS Joint Committee on Risk Standards Review of Comments on Discussion Questions from March meeting	5 min 90 min
Break	15 min
Continue Review of Comments on Discussion Questions from March meeting Time Designated for comments/questions from the public ----------Adjourn Wednesday 5:00 PM---------- ----------Resume Thursday 8:30 AM---------- Finalize Charter	60 min 30 minutes 90 minutes
Break	15 minutes
Planning for next meeting	30 min
Time designated for comments/questions from the public	30 min

Attachment B
Defining the objectives of this forum

The debate over best-estimate (BE) methods has emphasized design-basis safety analysis, in general, (i.e., Chapter 15) and large-break LOCA, in particular.

1. Should discussion be expanded to consider other thermal-hydraulic analysis domains, such as severe accidents (Chapter 19) and containment analysis (Chapter 6)? Should discussion be expanded beyond thermal-hydraulic analysis domains?

   AREVA: As a first go the forum should stay with an acceptable approach to design basis accidents and expand to the other accidents for insights into developing generic statements. The forum can expand to more fully treat other FSAR-related analyses following success with design basis accidents.

   WESTINGHOUSE: suggests Chapter 15 only at this time

   GEH: The regulations as interpreted in the RGs establish the framework for what processes may be used. This forum should provide clarification where it is needed.

   The discussion should consider the process of applying statistical methods. This process should be generic except as required by specific regulation. The same process should apply for transients, infrequent events and accidents. For severe accident the analyses do not have to generate bounding values for critical safety parameters, but the process should assure that the analysis is not non-conservative.

   Final Recommendation: Focus on DBA LOCA, but be mindful other events.

2. Should we strictly focus on issues related to the application of statistical methods? Alternatively, should we consider a broader focus on other unresolved or ill-defined aspects appearing in Regulatory Guide 1.203 (e.g., scaling, validation and verification, meaning of frozen code, 50.46 reporting methods, etc.)?

   AREVA : These general evaluation methodology concepts should be included in the forum's charter. This is AREVA's #2 PRIORITY. Our focus should be on all modeling aspects that are required to perform a statistical evaluation, including:

   (a) Identification of the most sensitive regions of the event and evaluation methodology

   (b) Verification and validation, including the qualification of the transient prediction technique and issues on scaling

   (c) The proper or reasonable statistical evaluation of the results of the transient prediction technique

   (d) Requirements for specifying uncertainty distributions for:
      (i) Phenomena

(ii) Design
(iii) Operating conditions

WESTINGHOUSE:
(a) "application of statistical methods" needs to be clarified
(b) Westinghouse feels that the rest of the question is outside the scope of a standard

GEH:
Many of the aspects are already covered by the existing guidelines in RG 1.157, RG 1.203 and the regulatory reviews and approvals for the existing applications. Primary outcome of the forum is to be "from licensing application and regulatory point of views, acceptable use of statistical methods in uncertainty analysis of best-estimate methods". This is, after all, why we have started the forum. Secondary outputs are to be 'recommendations' on ancillary issues such as scaling, V&V, frozen code, error/change evaluations, etc. Such recommendations can be proactively adapted by vendors. We can work, after we successfully complete Phase 1, on creating standards on other aspects.

Final Recommendation: Use RG 1.157 indexing and consider broader areas. Each vendor will produce of list of issues based upon a review of RG 1.157 and also identify vacancies in the RG 1.157.

3. RG 1.157 states that RELAP5 and TRAC-based codes "reasonably predict the major phenomena observed over a broad range of thermal-hydraulic and fuel tests". Should we explore the question of what makes a computer code sufficient for performing BE analysis?

AREVA:
Consistent with AREVA's response to question 3, code applicability should be explored as part of this forum's charter. It is an acknowledged element of CSAU (Step 6) and EMDAP (Step 12). Standard practice is to cross-reference code models and correlations with important phenomena identified through the PIRT process.

As a follow-on effort to this question, the meaning of "importance" should also be explored qualitatively, as done in PIRT, and quantitatively.

WESTINGHOUSE:
This is outside the scope of the forum and is adequately addressed in RG 1.203

GEH:
No, these other aspects are already covered by the existing guidelines in RG 1.157, RG 1.203 and the regulatory reviews and approvals for the existing applications. The adequacy of a code is established, the PIRT tables, the evaluation of the code applicability and the assessment matrix.

Final Recommendation: Drop this question.

4. Are there certain plant-specific differences (e.g., BWR vs. PWR, upper plenum vs. cold leg injection plants, etc.) that need to be explicitly considered or acknowledge?

AREVA:
No, other than maybe light water reactors, this forum should be inclusive in its first go. However, it should not try to reach the level of detail that would require these considerations.

WESTINGHOUSE:

(a) Westinghouse feels this is adequately addressed in RG 1.203

GEH:
There are many differences between plant types and the different generations for each type. The important characteristics for each plant type are identifies in the scenario definition, PIRT tables, evaluation of code applicability and assessment. These differences are already covered in the existing approved applications and in planned applications.

Final Recommendation: Drop this question.

5. What consideration should be made for non-LWR technology, including gas and sodium-cooled plant designs?

AREVA: Technology neutrality should be an objective of this forum.

WESTINGHOUSE: This is outside the scope of the forum and is adequately addressed in RG 1.203

GEH:
None. This should focus on existing plants and planned new LWR reactors.

Final Recommendation: Limit the scope to LWRs.

6. What elements of existing regulatory precedence fundamental to all evaluation methodologies should be captured in our discussions?

AREVA:
Conclusions drawn from this forum should retain consistency with previous regulatory conclusions on BE methodologies appearing applicable Regulatory Guides, NUREGs, and SECY reports.

WESTINGHOUSE: This question requires clarification

GEH: The regulatory requirements and the approved applications.

Final Recommendation: Work through this as part of 1.157 review.

7. What should be the definition of "best estimate analyses" in licensing applications? Does the term relate to evaluation methodologies? To codes? To both? Where and how do you incorporate conservatisms?

AREVA:
The #1 PRIORITY of this forum is to come to a consensus and endorse a clear definition of "best estimate analyses" in licensing applications. The range of the definition should apply to the methodology used which incorporates any codes employed by the methodology. The regulatory statement, "high probability...," is imprecise; the forum should develop a correct prose and mathematical statement of the regulatory requirement. The forum should also address

conservatism and model simplification which can be incorporated into a BE method (e. g., RG 1.157, Sec C.1).

WESTINGHOUSE:
This is outside the scope of the forum and is adequately addressed in RG 1.157

GEH: The definition should be 'Realistic evaluation with quantified uncertainties and biases'. It applies both to codes and their applications.. CSAU methodology addresses how uncertainties and biases are quantified for specific code and its specific application. The lesson learned from TMI and the intent of RG 1.157 is not pile conservatism into the models as it leads to unrealistic and potential erroneous evaluations. The conservatism is included through the evaluation for the upper bounds for the critical safety parameters through the statistical analysis at the end of the evaluation.

Final Recommendation: A glossary should be developed as part of the effort to cover questions such as these.

8.(a) 10 CFR 50.46(a) states that the "calculated ECCS cooling performance [is such that] there is a high level of probability that the criteria [is] not exceeded." What does "high probability" mean in this context?

AREVA:
The #1 PRIORITY of this forum is to come to a consensus and endorse a clear definition of "best estimate analyses" in licensing applications. The range of the definition should apply to the methodology used which incorporates any codes employed by the methodology. The regulatory statement, "high probability...," is imprecise; the forum should develop a correct prose and mathematical statement of the regulatory requirement. The forum should also address conservatism and model simplification which can be incorporated into a BE method (e. g., RG 1.157, Sec C.1).

WESTINGHOUSE: Mathematical statement is of high priority for this forum

GEH:
For accidents RG 1.157 states that 2 standard deviations is an adequate amount of conservatism. This is consistent with a 95% probability and 95% confidence for a single critical safety parameter in many existing approved applications. Consideration of the likelihood of the event and its consequences makes sense and is the basis for risk informed regulation. This is why severe accidents have generally been evaluated based on nominal calculations with minimal conservatism in the process sufficient to assure that the results are not non-conservative. The requirements of the analysis flow down from the regulations.

Final Recommendation: Question 8a is a priority for the group (i.e. a mathematical statement of the problem)

8. (b) Should the likelihood of the event and its consequences be considered in its definition?

AREVA: The approach to regulation already considers the likelihood of the event and its consequences allowed in accepted evaluation methodologies and criteria imposed.

WESTINGHOUSE: Event likelihood question depends on the scope of the forum

GEH: See answer to first part of this question.

Final Recommendation: Question 8b should be dropped.

8. (c) What is the correct mathematical statement of the regulatory requirement?

AREVA: This should be a focal point of discussion by this forum.

WESTINGHOUSE: Mathematical statement is of high priority for this forum

GEH: See answer to first part of this question.

Final Recommendation: Question 8c is a priority for the group.

9. How should upcoming rulemakings be factored in? Change in equivalent clad reacted (ECR) limits and risk-informed break size…

AREVA: These rulemakings are irrelevant. If BE is used it will remain but with different specific criteria for acceptance. If a plant opts out of LBLOCA they can apply these results to small breaks that will remain in the spectrum.

WESTINGHOUSE: No comment

GEH: The applications have to meet the current limits. If the regulations change, the applications will have to meet the new limits, except for grandfathering. Adding new parameters does not change the probability and confidence of the parameters that are previously considered.

Final Recommendation: This is only an awareness issue.

10. How should change management, i.e., new data, operating parameters, code/model, etc. be implemented in a BE methodology?

AREVA: These should be included in the discussion.

The #3 PRIORITY of this forum should be a determination of the maintenance requirements for a statistical approach. Consideration should be given to:

(a) the concept and meaning of frozen code and provision for incorporating new phenomena
(b) how to determine and measure reporting requirements

WESTINGHOUSE: No Comment

GEH:
When new data become available, they need to be considered either in the limits or in the definition of the uncertainties included in the statistical process. If a code changes are needed, so be it. The existing requirements stipulate what is necessary for process changes, code changes, and input changes (10CFR50.59, 50.46, 10CFR21, 10CFR50 App. B, etc.). Changes to biases and uncertainties for particular applications should be managed by the applicant and allowed provided that the process for evaluation does not deviate from the approved methodology.

Final Recommendation: All of these aspects should be addressed.

11. Under what conditions can a parameter be sampled in a safety analysis?

AREVA:
The conditions of sampling and the parameters of sampling should be part of the forum discussions. RG 1.157 and NUREG-5249 already address the issue and should be reviewed, reaffirmed, or altered.

AREVA note: In general, regulatory statements in RG 1.157 and NUREG-5249 state that best-estimate methodologies should address the "important parameters associated with a particular phenomenon". Specifically,

RG 1.157 says, "A best-estimate model should provide a realistic calculation of the important parameters associated with a particular phenomenon to the degree practical with the currently available data and knowledge of the phenomenon. The model should be compared with applicable experimental data and should predict the mean of the data, rather than providing a bound to the data. The effects of all important variables should be considered."

RG 1.157, Sec 4.4, says, "The influence of the individual parameters on code uncertainty should be examined by making comparisons to relevant experimental data. Justification should be provided for the assumed distribution of the parameter and the range considered."

NUREG-5249, Step 11, says, "Realistic variations in the input and process parameters are determined with experimental data and/or analytical studies. The uncertainties are best quantified as biases and distributions, but can be treated as separate (bounding) biases if necessary."

It is AREVA's view that any parameter (important or not) is eligible for sampling. This view is further supported by the RG 1.157 statement (Sec B) that, "[t]he current revision of §50.46 permits ECCS evaluation models to be fully "best-estimate" and removes the arbitrary conservatisms contained in the required features of Appendix K for those licensees wishing to use these improved methods. Safety is best served when decisions concerning the limits within which nuclear reactors are permitted to operate are based upon realistic calculations."

The only condition that is implied by these regulatory guidance documents is that the uncertainty of individual contributors be "realistic" and "justification should be provided for the assumed distribution of the parameter and the range considered."

WESTINGHOUSE: recommends the question be revised to "Under what conditions can a parameter not be sampled

GEH:
Uncertainties in model and plant parameters should be sampled. Initial conditions, event type or initiating event should not be sampled. The methodology should define how ranges in the initial conditions are addressed.

Final Recommendation: Reword the question as follows: "Under what conditions can a parameter NOT be sampled."

12. What parameters should not be ranged (or defined with a restricted range):
    (a) Time in life

(b) Break area
(c) Some plant parameters
  (iv) core power
  (v) peak linear heat rate
  (vi) decay heat
  (vii) SI temperature
(d) LOOP, or should there be separate 95/95 values for LOOP and non-LOOP?

AREVA:
The concept of parameters not available for sampling should be addressed by this forum. As stated in response #11, AREVA's position is that any parameter is eligible for sampling and we would drop the specifics items indicated above as many of these are within current sampling approaches for BE LOCA methodologies. However, the general discussion of preserving some fixed or biased parameters is legitimate. RGs already address the issue and should be reviewed, reaffirmed, or altered.

AREVA note: As stated in response 11, it is AREVA's position that all parameters are eligible for sampling, including those highlighted in this question:

Related to (a), RG 1.157, Sec 3.2.1, says, "The steady-state temperature distribution and stored energy in the fuel before the postulated accident should be calculated in a best-estimate manner for the assumed initial conditions, fuel conditions, and operating history." AREVA views this statement as an endorsement of sampling of time-in-life for the purposes of obtaining best-estimate fuel conditions.

Related to (b), RG 1.157, Sec 3.1, says, "The calculations performed should be representative of the spectrum of possible break sizes from the full double-ended break of the largest pipe to a size small enough that it can be shown that smaller breaks are of less consequence than those already considered. The analyses should also include the effects of longitudinal splits in the largest pipes, with the split area equal to twice the cross-sectional area of the pipe. The range of break sizes considered should be sufficiently broad that the system response as a function of break size is well enough defined so that interpolations between calculations, without considering unexpected behavior between the break sizes, may be made confidently." AREVA view this statement as an endorsement of sampling break area. Further, the sampling of break area was explicitly endorsed by the ACRS in their letter to the NRC Commission recommending that AREVA's RLBLOCA methodology be accepted.

Related to (c) and (d), the RG 1.157 Sec B quote given in AREVA's response to question 11 is viewed by AREVA as exempting best-estimate methodologies from Appendix K limitations related to initial conditions. AREVA agrees that this relaxation from Appendix K requires that statistical distributions be justified.

WESTINGHOUSE:
This is ultimately a regulatory decision if a restriction is beyond guidance provided in any other "Inputs" or "Process" standard

GEH: Realistic initial conditions must be first established for the analysis. Then the methodology should address how the ranges in the initial conditions (TS ranges, plant parameters, setpoints, etc.) will be considered. This does not preclude sampling the uncertainties associated with the

specified initial conditions, i.e., thermal limits established at prescribed initial condition have uncertainty about that point.

Final Recommendation: This question is covered by question 11.

13. How should parameters that are addressed in plant technical specification be treated in an uncertainty analysis?

AREVA:
It is AREVA's opinion that implementation of technical specifications into safety analyses is a general evaluation methodology topic and could be grouped with question #2.

AREVA note: AREVA's position on this subject was presented in a technical paper entitled, "Application and Licensing Requirements of the Framatome ANP RLBLOCA Methodology," by Robert P. Martin and Bert M. Dunn, that appears in the proceedings of the BE2004 Topical Meeting (an ANS Winter Meeting embedded Topical).

A particular safety analysis (i.e., LOCA or NonLOCA) does not necessarily serve as the technical basis supporting every licensing element that happens to be considered in preparing an analysis. For example, for an LBLOCA parameters such as the Refueling Water Storage Tank (RWST) temperature, the Reactor Coolant System (RCS) pressure and temperature, accumulator pressure, various setpoints, and secondary feedwater flow rate, pressure and liquid level have either negligible or inconclusive influence on LBLOCA acceptance criteria; however, they are characterized with limits supporting plant licensing. The basis for such parameter limits may be derived from methods unrelated to LOCA; hence, treatment in LOCA is not necessarily required. As such, the treatment of a plant's technical specification can be subjective. In AREVA's RLBLOCA methodology important plant parameters are identified based on an assessment of their impact on important phenomena. Technical specifications on those important parameters are incorporated as long as they are considered realistic. AREVA works with utility customers to identify those limits of operation that are clearly required to support their plant with an LBLOCA calculation.

The sampling of an important plant parameter defined with a technical specification considers the uncertainty contributors used to derive the documented technical specification value. As such, a mean technical specification value can be identified and a distribution can be derived. Plant parameters not considered important may be sampled, if desired by the customer, using available plant data, measurement uncertainties, or using appropriate analytical studies.

WESTINGHOUSE: feels that the phrasing should be "that are included …."

GEH: Full range within the technical specifications need to be considered to define the range of the initial conditions. Many values such as set points are treated as analytical limits. Other values are better treated in BE space with uncertainties such a relief valve capacities. The treatment depends on the application and should be addressed as part of the methodology.

Final Recommendation: This question should be addressed.

14. How should "expected" operator actions be treated in uncertainty analyses? Emergency operating procedures?

AREVA:

The role of operator actions in safety analysis is best reserved for long-term events in which an operator response is required by an EOP. AREVA recommends that corresponding actions should be considered in analyses especially any that may have a negative effect of the event being studied. If a particular action has a significant impact on analysis measure, it is difficult to justify a particular action other than one that reflecting a conservative response. If a time window is provided for the action, then sampling of the timing of the action may be justifiable.

WESTINGHOUSE: No comment

GEH: Operator action should be defined as part of the scenario. No credit should be taken for short-term operator actions that improve the scenario. The RG should provide guidance for what constitutes short-term and long-term operator actions. If longer-term operator action is credited then operator response time should be considered. The operator actions are not credited for transients and accidents. Operator actions are credited through the EPG for severe accidents, but nominal calculations are used for these events.

Final Recommendation: This question should be addressed.

15. For each output parameter, what set of input parameters should be sampled and ranged for each scenario? Does the input parameter set for a single output parameter (e.g., PCT) sufficiently cover other output parameters (e.g., MLO and CWO)?

AREVA:
It is AREVA's opinion that this is a general evaluation methodology topic and could be grouped with question #2. The treatment will come from a logical discussion of the parameters.

AREVA note: AREVA's position is that the determination of important input parameters used in a best-estimate safety analysis must consider all output parameters used in assessing the stabilization of plant structures, systems, and components following events leading to an abnormal plant condition or accident. This process begins with an appropriately developed PIRT.

As mentioned in question/response #3, a follow-on effort to this question should be discussion on the meaning of "importance", explored qualitatively, as done in PIRT, and quantitatively.

WESTINGHOUSE:
This question is too narrow and is therefore outside the scope of the forum; also, this question is addressed during the PIRT process.

GEH:
The sum of all parameters important for all critical safety parameters should be sampled.
Final Recommendation: This question should be dropped.

16. Can recommendations be established for BE analyses using coupled codes? Examples: TRACE/CONTAIN for containment pressure feedback and TRACE/PARCS for cases where 3D kinetics may be needed.

AREVA:
AREVA believes this is a low priority for the forum other than to recognize that coupled codes used in safety analysis should be considered as a single safety analysis tool. Best-estimate evaluation methodology using coupled codes allow for expanded treatment of uncertainty contributors.

WESTINGHOUSE:
This is outside the scope of the forum and is adequately addressed in RG 1.203

GEH:
No, the generic methodology is sufficient to address this.

Final Recommendation: This question should be dropped.

17. Are regulations written addressing outcomes (i.e., safe vs. not safe) or a convolution of processes? If the latter, under what conditions should analysis supporting a plant license be treated as a multivariate problem? Is the LBLOCA a unique problem? SBLOCA? AOO's?

AREVA:
The characterization of regulations as addressing outcomes vs. a convolution of processes should be part of the forum discussions. It is closely linked to question #7, "what is the definition of best estimate?" - which is AREVA's #1 priority for resolution in this forum.

AREVA note: AREVA's position is that as public documents, regulations have to be written to address outcomes rather than the convolutions of processes. As such, the performance of analyses should be independent of the number of analysis outputs used to determine whether plant response to an event has been successful. The application of a set of criteria, as is done for LBLOCA analysis where all of which must be satisfied to demonstrate plant/design compliance, to a set of code outputs is a one-outcome test. Though there are separate criteria, the only outcome of interest from applying them is a single question related to whether the plant response remains within the regulatory limits and, thus, safely
mitigates the consequence of the initiating event. RG 1.157, Sec 4.1, says, "[t]he purpose of the uncertainty evaluation is to provide assurance that for postulated loss-of-coolant accidents a given plant will not, with a probability of 95% or more, exceed the applicable limits specified in paragraph 50.46(b)." AREVA views this statement as an endorsement of their point-of-view.

The question regarding the perception of a univariate vs. a multivariate problem is really the question of what is the meaning of "a high level of probability that the criteria are not exceeded." Resolution of this question should be independent of events being analyzed.

WESTINGHOUSE:
If a mathematical statement of the regulatory requirement is developed, this question is addressed by having a qualified statistical method to meet the regulatory requirement

GEH: Each safety parameter should be treated as a univariate problem that combines the uncertainties important for that problem.

Final Recommendation: This question should be addressed as part of question 8.

18. What is the minimum number of calculations on which a 95/95 uncertainty should be based if the output parameter(s) of interest are:
    (a) PCT, MLO, CWO
    (b) Min. water level, peak pressure, or other (single) output parameter
    (c) Applications with several output parameters of interest (5 or more, e.g., certain AOOs, severe accidents, others?)

AREVA:
This item should be included in the discussions as a sub-issue under item 17.

AREVA note: Based on AREVA's response given in question 17, the 95/95 condition should be given on the question of whether the analysis demonstrates that the plant response remains with the regulatory limits. As such, the 59 calculations derived from the Wilks univariate model applies.

WESTINGHOUSE:
If a mathematical statement of the regulatory requirement is developed, this question is addressed by having a qualified statistical method to meet the regulatory requirement.

GEH: 59, because each output parameter is assumed to be a univariate problem.

Final Recommendation: This question should be addressed as part of question 8. It would be desirable to develop a listing of approved techniques. The discussion should include procedures for handling of "failures" i.e., situations where criteria are exceeded.

19. What constraints apply to the development of a probability distribution function for an uncertainty analysis?

AREVA:
It is AREVA's opinion that this is a general evaluation methodology topic and could be grouped with question #2.

Simply stated, the development of a probability distribution is constrained by available data. It should be noted that data can come from experimental programs, analytical studies, experience or a combination thereof, as is acknowledged in 10 CFR 50.43. Conservative distributions can be constructed to accommodate limited data.

WESTINGHOUSE: No comment

GEH: The distribution should bound the data, but not be able to produce unrealistic results.

Final Recommendation: This question should be addressed.

20. How should uncertainties due to nodalization, time step size, and other convergence parameters be included a BE methodology?

AREVA:
It is AREVA's opinion that this is an important topic for any evaluation methodology and should be specifically added as a sub-heading under question #2.

AREVA note: NUREG 5249, Sec 2.2.2, NPP Nodalization Definition, says "In principle, nodalization can be treated as an individual contributor to uncertainty; however, experience indicates that the quantification of nodalization uncertainty can be very costly and is highly user-dependent. Thus, the preferred path is to establish a standard NPP nodalization for the subsequent analysis. This minimizes or removes nodalization, and the freedom to manipulate noding, as a contributor to uncertainty." AREVA's position is that the consistent use of a standard nodalization, time step sequence, and other unique modeling elements during methodology

development, V&V, and applications is the preferred approach to addressing these types of uncertainties.

WESTINGHOUSE: No comment

GEH:
This is covered in the CSAU process. Nodalization and time step sensitivity studies are performed in order to demonstrate adequate and converged results. In addition there must be consistency in the nodalization used in the assessment and quantification of model uncertainties and the nodalization used for plant calculations. Scaling needs to be addressed for events such as LOCA where full-scale plant data do not exist.

Final Recommendation: This question should be addressed, but at a lower priority.

21. How do we qualify the statistical approach?

AREVA:
It is AREVA's opinion that evaluation methodology qualification is a general topic and should be specifically added as a sub-heading under question #2.

AREVA note: Qualification of the evaluation methodology begins with standardization of the methodology development process. With NUREG-5249 and issuance of RG 1.203, the NRC has provided the industry with the guidance necessary to document a BE evaluation methodology. Like the development of BE methodology, further qualification of these methodologies requires a top-down/bottom-up approach examining the processes applied to identify important analysis parameters (i. e., PIRT) and the subsequent derivation of uncertainties in the form of code biases and probability distributions. Audit calculations are appropriate.

The chosen statistical approach can be tested in typical spreadsheet program.

WESTINGHOUSE:
If a mathematical statement of the regulatory requirement is developed, then statistical methods may be shown to comply with the requirement

GEH:
By applying the statistical approach to integral tests and plant data to demonstrate that the process bounds the data. Effects of scale needs to be addressed when full-scale data is not available. Another option is to use alternative statistical processes such propagation of errors for the dominant phenomena.

Final Recommendation: This question should be dropped.

22. How should distributions be developed when there is a lack of knowledge about the distribution?

AREVA:
The characterization and application of uncertainty when there is a lack of knowledge should be addressed by this forum. It is AREVA's opinion that this is a general evaluation methodology topic and could be specifically added as a sub-heading under question #2.

AREVA note: As stated in AREVA's response to Question 19, data to support the development of distributions can come from experimental programs, analytical studies, or experience.

Conservative distributions can be constructed to accommodate limited data. Analytical studies are justified because they are in many respects a repository of phenomenological understanding gained through NRC and international research into the LBLOCA event. Often bounding values can be identified through analysis or through constraints characterized by setpoints, technical specifications, or physical limitations. The form of the distribution can also be justified as being conservative. For example, a uniform distribution is often considered conservative because limiting parameter values typically appear as a maximum or minimum of a particular uncertainty domain. A uniform distribution raises the likelihood of sampling conservative conditions that are associated with the tails of a normal distribution.

WESTINGHOUSE: No comment

GEH:
This would have to be determined on a case-by-case basis. In some cases a bounding distribution such as a uniform distribution could be used, and in other cases it may be appropriate to apply a high confidence level for the distribution. However in no cases should the distribution be able to produce unphysical results.

Final Recommendation: This question should be addressed as part of questions 8 and 19.

23. BE methodologies range parameters based on various code models and correlations, such as heat transfer coefficient. These are often regime dependent and are based on experimental data from numerous sources:
    (a) To what extent should regime dependence be accounted for in the ranging? (For example, when is it acceptable to range single phase convection the same as film boiling?)
    (b) When ranging a specific model, should its effect be ranged locally (as in ranging heat transfer in the core only or interfacial drag in the chimney region only) or globally throughout a given model?
    (c) How sufficient must the assessment database be to determine a code bias and the type of distribution and limits over which to range a certain model/correlation?

AREVA:
The characterization and application of uncertainty using data based on global vs. local or integral vs. separate effects conditions should be addressed by this forum. RG 1.157 does address the issue and should be reviewed, reaffirmed, or altered.

AREVA note: With regard to the separation or combination of data for describing phenomenological uncertainties, RG 1.157, Sec 4, says "In evaluating the code uncertainty, it will be necessary to evaluate the code's predictive ability over several time intervals, since different processes and phenomena occur at different intervals. For example, in large-break loss-of-coolant accident evaluations, separate code uncertainties may be required for the peak cladding temperature during the blowdown and post-blowdown phases. Justification for treating these uncertainties individually or methods for combining them should be provided."

Statistical integrity is provided by maintaining consistency with how code model uncertainty is evaluated using experimental data or analytical studies and then applied in production safety analysis. Combined or integral treatments of uncertainties will have larger uncertainties than

separated or local treatments. Convolved with other uncertainty contributors, the output measures of interest will reflect the conservatism inherent in the statistical description.

WESTINGHOUSE:
Westinghouse feels that parts (a) and (b) are overly specific and therefore are outside the scope of the standard. Recommend part (c) be reorganized with questions related to input

GEH: This is covered by the PIRT process. See the above responses for further details.

Final Recommendation: These issued will be addressed as part of the review of RG 1.157 discussed under question 2.

24. If a plant initial condition is ranged as part of an uncertainty methodology, when is it appropriate to use plant technical specification limiting values, and when can or should plant performance data be used to establish the range and distribution?

AREVA:
This question is similar to #13. It is a general evaluation methodology topic and could be grouped with question #2. The forum should create guidance for describing uncertainty for phenomena or initial conditions (i.e., technical specification ranges, etc.) when a lack of detail information exists. For example, even though a plant may operate at 1800 psia, it is very unlikely to do so and that unlikeliness should be reflected in the initial pressure probability distribution function so that a reasonable reality condition is analyzed.

WESTINGHOUSE:
This question appears to be a subset of question 13 and may be removed as a specific question

GEH: See previous responses.

Final Recommendation: This question should be addressed as part of Questions 12 and 13.