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General Comment

See attached file(s) for comments

Regards

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Attachments

Review of Draft RG-1422 Rev 4

Review of U.S NRC Draft Regulatory Guide (DG)-1422 Revision 1

Section 1.2

Figure C-1 lists the steps for a PFM. While model input uncertainty is listed, there is nothing for model uncertainty. PFM Benchmarks (see AEN projects supported by Xinjian Duan) have shown that model uncertainty can be a big factor in the results. We would like to recommend the consideration of model uncertainty and how to address it in this Reg. Guide.

Section 2.1 Regulatory Context.

The *first paragraph* applies to changes in existing and well-known fracture mechanic problems. The impact is assessed as a relative or absolute change compared to a previously approved submission. Everything is described as "proposed change". This limits the area of application of PFM to Cases that have been assessed with DFM. We believe that this paragraph should be expanded to include new analyses and assessments of direct results.

The *third paragraph* states that the probabilistic approach must be compliant with the regulatory criteria. There is nothing mentioned on how the regulatory criteria may be affected by the use of probabilistic methods instead of deterministic ones.

Section 2.3 Quantity of Interest and Acceptance Criteria

Second paragraph last sentence. It is stated that if there is no precedent for an acceptance criterion, this is the responsibility of the applicant to derive one.
RG 1.200 and RG. 1174 are cited as references, but they seem to focus on the Core Damage Frequency (CDF) and Larger Early Release Frequency (LERF) more than giving guidance on how to develop a new acceptance criterion. As a result, it is hard to understand how the applicant could select an acceptance criterion considered valid for the NRC.

<u>Section 2.6 Inputs</u>

Table C-5

- For 1-2D, 1-2R, I-4D and I-4R, there is a justification of expert judgment when there is a lack of data. We wonder of the necessity of expert judgement for I-2D and I-2R (since they are listed as low importance). Second, other methods exist, such as using larger uncertainty (such as using student-t instead of normal), to address this issue. Should they also be listed here?
- For 1-3D, 1-3R, 1-4D, 1-4R there is a request to explain correlations between inputs. We wonder what the rationale is to consider correlations when the values are deterministic (1-3D and 1-4D): if Correlation is important between an uncertain input A and a deterministic input B, shouldn't the deterministic input B be sampled to avoid limiting the distribution of the uncertain input A? We would recommend also considering correlations when the values are of low importance (I-2R, and I-1R). Importance should not affect whether we create a physically valid input set.
- I-xR (x=1 to 4). The definition of the term *sampling frequency* in the first bullet is not entirely clear. It is not defined in the nomenclature. Additional information would be helpful.

<u>Section 2.7 Uncertainty Propagation</u>

Table C-6:

- The Monte Carlo sampling techniques are limited to pseudo Monte Carlo. The quasi-Monte Carlo (Halton sequences, Sobol Lp-tau) which are not random and optimize the coverage of the multidimensional input set do not seem to be considered. Was this an oversight, or a preference from NRC to use specific MC techniques?
- Similarly, the use of adaptive sampling is not listed. Would it be considered in the importance sampling category? The same question can be applied to optimization techniques (such as the numerous methods included in Dakota). Are they included in the importance sampling category? If so, should the importance sampling category definition be updated to reflect what is considered?
- It is not clear what would be considered a surrogate model. For instance, compared to finite element (FE), we could argue that FAVOR and xLPR use surrogate models (models fitted to more accurate FE calculations so they can be run at a larger scale). But we believe the term in this document (and the term surrogate model) is intended for purely algebraic fitted model (such as neural networks) that would run extremely

fast. Though it is not clearly defined in the table or in the nomenclature text for surrogate. We believe it would be beneficial to clarify what exactly is considered a surrogate model.

Section 2.8 Convergence

Figure C2 . While the graph makes sense, there are two potential caveats here: (1) for a new problem application, the acceptance criteria must be defined by the applicant. (2) if the events/QoI tested by the criteria are extremely rare, this is possible to have a zero value. What would be the rule for one order of magnitude difference? Does it mean that a high quantile upper confidence bound has to be used instead of the QoI? Additional information would be welcome.

Table C7:

- Row SC-2B seems to imply that the uncertain QoIs would always be summarized with means and standard deviations. Can other statistics be considered? If so, should it be included in the description?
- The sampling uncertainty characterization is not clear. Based on the nomenclature this is basically the accuracy of the Monte Carlo technique (equivalent to what is called "sampling uncertainty" in the report). But what does it mean to use one or two methods? And what is "sufficient" in this context? Should one order of magnitude be considered regardless of the potential impact from a failure? Should the degree of confidence be the same all the time? Maybe the answer is yes, but it would be beneficial to have confirmation.

Section 2.9 Sensitivity Analyses

Table C8: footnote (a) states that "as the cost of performing a global sensitivity analysis (SA) increases with the number of inputs". We believe that it is local SAs that tend to be more costly when the number of inputs increase, because they are based on derivatives according to each uncertain input, and thus increase linearly with the number of inputs for single parameter variation (and a lot more when the conjoint derivative of multiple uncertain inputs is considered). Comparatively, the cost of some global SAs (such as correlation coefficients or regression coefficients) is not as large. And global SAs such as the Morris Method can be used to screen out the number of parameters.

In addition, several Global SAs can be performed using the Monte Carlo sampled inputs and resulting outputs, which does not require rerunning the code, while local SAs would often require some rerunning of the code. It is true that other global SAs techniques (such as the Sobol decomposition or the Fourier Analysis Sensitivity Test) require extensive rerun of the code and may be prohibitively expensive and a reduction in the number of important variables as well as the use of fast response surfaces may be needed for those.