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Regulatory Publications Branch DFIPS
Office of Administration
US NRC
Washington, DC 20555

Subject: Draft Regulatory Guide DG-1025 "Calculational And Dosimetry Methods For Determining Pressure Vessel Neutron Fluence"

Attachment: BWNT Comments on Draft Regulatory Guide DG-1025

Gentlemen:

Attached for your use and information are the B&W Nuclear Technology comments to the subject draft regulatory guide.

Should you have comments or questions with regard to these comments, or require any further assistance, please call Mr. J. F. Walters at (804)385-2208.

Very truly yours,

J. H. Taylor
J. H. Taylor
Manager
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JHT/DLH/mcl

Attachment

cc: Mr. A. Taboada

BWNT Comments On
Draft Regulatory Guide DG-1025

"Calculational And Dosimetry Methods For Determining
Pressure Vessel Neutron Fluence"

Overview -

B&W Nuclear Technologies' (BWNT) overall impression of the guide is positive. As noted below, we understand the objective of the guide is to provide guidance for performing calculations to predict the fluence and performing dosimetry measurements to determine the uncertainty in the calculations. We believe this objective not only improves the degree of safety associated with vessel fluence predictions, but it also upgrades the technology that the neutron physics community has previously used for fluence analyses.

BWNT would like to encourage the NRC to make further improvements by (1) upgrading the uncertainty methodology, (2) having a comprehensive integration of fluence uncertainty and the irradiation embrittlement reference temperature shift uncertainty, (3) requiring a more rigorous source analysis for each cycle with qualified uncertainties, and (4) requiring more frequent updates of the fluence analyses for vessels that will come close to limiting guidelines, such as the RT_{PTS} values.

BWNT is concerned that the following comments will produce the impression that our overall impression of the guide is negative. As noted above, this is not the case. We have provided comments with the intent of improving our understanding of various parts of the guide. We have not provided comments on the parts of the guide that are already very clear. Thus, the comments generally have a negative connotation. While the comments may have a negative connotation, be assured that our overall impression is positive.

General Comments -

1) The "Regulatory Position" (Section C) is very detailed and prescriptive. Within the extensive details, there are various statements that appear to be contradictory with other statements providing specific prescriptions. This is very confusing. In addition, some of the technical terminology has been abbreviated. The abbreviations result in imprecise terminology that is difficult to understand. Before BWNT could follow this guide, changes in the wording are necessary to ensure that our understanding is correct.

Rather than repeating the comments that "a particular page and line are confusing, contradictory or difficult to understand"; we have simply reworded the various parts of the guide to reflect our understanding. While the comments provide suggestions for rewording, we have made a particular effort not to simply edit or to change the specific terminology.

2) Although the "Regulatory Position" of the guide is not very clear and is somewhat confusing, the "Introduction" (Section A) and "Discussion" (Section B) provide statements that BWNT believes are the keys to the intent of the guide. These key statements are as follows:

Key Statements

A. Introduction

I) Page 1, Lines 12 and 13
To satisfy the requirements of both Appendix G of 10 CFR Part 50, and 10 CFR 50.61, methods for determining the fast neutron fluence (E > 1 MeV) are necessary.

B. Discussion

II) Page 2, Lines 25 and 26

The methods and assumptions described in the guide are for vessel fluence calculations and dosimetry measurements.

III) Page 2, Lines 30 to 33

The methodology is for a best-estimate, rather than bounding or conservative fluence determination. When required, an uncertainty margin should be included separately.

IV) Page 3, Lines 5 through 7

The determination of the pressure vessel fluence is based on both calculations and measurements: The fluence prediction is made with a calculation: The dosimetry measurements are used to qualify the calculational methodology.

V) Page 3, Lines 11 and 12

Calculation-to-measurement comparisons identify biases in the calculations and provide an estimate of the calculated fluence uncertainties.

VI) Page 3, Lines 17 to 20

Sensitivity analyses provide a method of qualifying the calculated fluence uncertainties at the vessel.

VII) Page 3, Lines 20 to 22

The predictions of the vessel fluence must be made by an absolute fluence calculation. Using calculations to extrapolate fluence measurements from dosimetry locations to the vessel is not acceptable.

Assuming that the above 7 statements are the keys to the intent of the guide, BWNT intends to change its methodology and comply with the guide.

3a) The guide addresses (1) the prescription for a calculational methodology, and (2) the qualification prescription for an uncertainty methodology. To comply with the guide, BWNT is assuming that the methodologies need to be presented to the NRC only one time, such as in a topical report. Thereafter, fluence and uncertainty values may be updated with notification to the NRC "for information only", such as a 50.59 submittal.

3b) Assuming one topical report is satisfactory for compliance with the guide, the purpose of subsequent measurements is not addressed. BWNT believes the guide needs to address the purpose of measurements once the calculations have been verified.

Specific Comments up to Section C,1

4) Page iii, "2. Neutron Fluence Measurement Methods"
It will be clarified later that this title should be changed.

Suggested rewording:
2. Dosimetry Measurement Methods

5) Page 1, Line 20
This abbreviation of the terminology is confusing.

Suggested rewording:
parameter called the "reference temperature for nil-ductility transition" in the material's properties, or

6) Page 2, Lines 25 and 26

The Regulatory Position in Sections C,1 and C,2 seems to be contradictory, it would be much clearer if this wording is precise.

Suggested rewording:

The methods and assumptions described in this guide are for vessel fluence calculations and dosimetry measurements for core and vessel geometrical and

7) Page 3, Lines 2 and 3

There are dpa cross sections from the thermal (eV) energy range to 20 MeV. Thus the word "entire" should be deleted from the phrase on line 2, "entire damage fluence" or the parenthesis removed on line 3, "(from 0.1 to 15 MeV)".

8) Page 3, Line 21

On page 2, line 30, it is stated that the methodology is a best-estimate. This concept is also noted later in the discussions on the Regulatory Position. Therefore, it would be better if line 21 began with the words "best-estimate".

Specific Comments on Section C,1

9) Page 4, Lines 7 to 9

This statement is misleading and leads to confusion.

Suggested rewording:

The calculational methodology should be qualified to predict the vessel fluence to within an uncertainty that is equal to, or less than an absolute value of 20% for the determination of RT_{PTS} as described in 10 CFR 50.61.

10) Page 4, Lines 8 and 9

A reference is needed relating the 20% uncertainty to the RT_{PTS}. A discussion of the 20% is also needed which explains whether the 20% includes both the analytic and benchmark uncertainty, and how the measurement uncertainties have been treated with respect to the 20%.

11) Page 4, Lines 26 and 27

The guide states that input data to the calculations should be based on "verified as-build plant-specific dimensions and materials". The guide needs to be much more detailed in describing how to obtain this information and where it is located; specific examples would be useful.

12) Page 5, Section 1.1.2

This section is not at all clear. In order for the licensee to understand the concepts, it should be rewritten. Lines 12 through 21 have been reworded to provide an illustration.

Suggested rewording: (Lines 12 through 21)

The calculational method to estimate vessel fluence, over the energy range from ~0.1 MeV to ~15 MeV, should use cross sections from the latest version of the Evaluated Nuclear Data File once they have been thoroughly reviewed and tested. Cross section sets based on earlier or equivalent nuclear data files, that have been thoroughly verified and benchmarked may also be used to estimate vessel fluences. However, when a licensee changes the cross section data that has been previously used in the calculations, the effects of these changes on the methodology, fluence estimates, and uncertainty must be updated and appropriately reported (Regulatory Position 3).

The other 4 paragraphs on pages 5 and 6 have been outlined as follows and the principal concepts of each paragraph noted.

Pages 5 and 6

Page 5 line 22 to Page 6 line 2 = Paragraph 2

Page 6 line 3 to Page 6 line 12 = Paragraph 3

Page 6 line 13 to Page 6 line 26 = Paragraph 4

Page 6 line 27 to Page 6 line 34 = Paragraph 5

Paragraph 2 Concepts:

1) The fluence is determined with multigroup cross sections that come from an ENDF library.
2) The cross section dependence on E, Ω should be accurate to determine the correct fluence dependence on E, Ω.

Paragraph 3 Concepts:

1) The multigroup library is constructed from an energy-independent multigroup "master" library.
2) This library (? master). . . . (library characteristics)
   This library . . . . (library characteristics)
   This library . . . . (library characteristics)
3) Get the library from RSIC (Oak Ridge).

Paragraph 4 Concepts:

1) Collaspe the "master" library using spatially dependent spectra to a macroscopic multigroup "job" library.
2) Demonstrate the adequacy of the "job" library,
   a) Compare to master,
   b) Benchmark ?

Paragraph 5 Concepts:

1) Get "job" library from RISC (Oak Ridge).
2) Adequacy of RISC library is OK for fluence calculations.

The basic problem is that Paragraphs 2, 3 and 4 are very confusing. First, the term "multigroup library" is used to describe various libraries, but the licensee has no idea which library is being referenced. The term "multigroup library" must <u>always</u> be quantified; master, job, or # of groups are acceptable, but the quantifying term must <u>always</u> be used.

Second, an obvious, or stated ordering is needed.

Such as:	ENDF/B-VI	Bases	Para. 2
	Master	Characteristics...	Para. 3
	Job	Characteristics...	Para. 4

Paragraph 5 is OK if paragraph 4 describes the "job" library: Or, paragraph 5 may be merged into the paragraph 4 library discussion just as paragraph 3 contains information about RISC.

13) Page 5, Line 24 and Page 6, Lines 13 through 34

Line 24 required that the "...ENDF files <u>must be</u> pre-processed into a 'master' multigroup structure." Lines 13 through 26 on page 6 then suggest that the master multigroup structure <u>may be</u> collasped to a job library. The job library <u>may be</u> demonstrated to be adequate by comparing calculations with both the master and job libraries.

This is not consistent and too prescriptive. The "must be" and "may be" all need to be "should be".

Lines 27 through 34 on page 6 indicate that if the job library is prepared by RSIC, by collapsing a master library with an LWR spectra, it may be used for LWR vessel fluence analyses. Somewhere after line 29, the concept that the job library is benchmarked to measured results needs to be introduced.

14) Page 5, Line 28 through Page 6, Line 2

These lines discuss the development of the (master ?, job ?) multigroup library. The last sentence states: "Sufficient details of the energy and angular dependence of the differential cross-sections (e.g., the minima in the iron total cross-section) should be included to preserve the prescribed accuracy in attenuation characteristics.

What prescribed accuracy in attenuation characteristics should the details of energy and angular dependence preserve? We have no idea what this statement means. Please elaborate in detail.

15) Page 7, Line 2

This prescription is too detailed: It is not necessary for the NRC to delineate the source in this sentence at all. We suggest "fixed" be deleted.

16) Page 7, Lines 5 and 6

This statement needs to be expanded. It is not consistent with the qualification requirements for the fluence calculational methodology. The core-follow calculations have no defined uncertainty and no requirement for a qualified methodology. Likewise, the measured data from in-core instrumentation has no defined uncertainty. Furthermore, the low powered periphery typically has no requirement for qualification. Without addressing these issues it is possible for source distributions from unqualified calculations and measurements to form the bases for qualified vessel fluence calculations.

17) Page 7, Lines 7 to 9

Why is the NRC prescribing that core-follow calculations "should" be performed with a 3-D coarse mesh simulator code. Suppose an analyst wanted to use a fine mesh, multigroup, transport theory code. The NRC's concern <u>must</u> be that the core-follow methodology and results are qualified; this is neither stated, nor has it been the case in the past.

Suggested rewording:
with a three-dimensional (3-D) qualified model which provides relative fission source or power distributions. The spatial detail should be sufficient to determine the source leakage rate. Plant process computers provide

18) Page 7, Lines 9 and 10

While plant process computers provide power distribution data, this data is <u>not</u> qualified and does not have a defendable uncertainty. Only after the power distribution prediction from a qualified design calculation is compared to the process computer prediction can the core-follow methodology verify that the incore instrumentation is functioning and the calculations are within the required uncertainty. Even with the qualified core-follow methodology, the peripheral power is <u>not</u> verified, only the limiting power distribution is verified. Futhermore, many of the older plants do not have peripheral instrumentation coverage.

The NRC should consider upgrading this procedure in the future as recommended in the "overview comments". For this guide, the concept of a qualified source distribution should be stressed along with a sufficient analytic calculational uncertainty evaluation to ensure source uncertainties are included in the vessel fluence uncertainty.

19) Page 7, Lines 11 and 12

The statement that: "The core neutron source <u>should</u> be determined by the power distribution, which varies significantly with fuel burnup, power level, and the fuel management scheme", is too prescriptive and too approximate. The power distribution has been used in the past to determine the neutron source distribution, but it would be better if the product of the neutron yield and fission rate distribution were used in the future.

In a low-leakage fuel management scheme the power distribution does <u>not</u> vary significantly with fuel burnup. In a PWR, the power distribution does not vary significantly with the power level.

Suggested rewording:

The core neutron source should be determined as a spatial function of the neutron production rate which varies significantly with the fuel management scheme.

20) Page 7, Line 24

Suggested rewording:

distribution. However, the "generic" power distribution must be compared to qualified measured distributions obtained during reactor operation and the "generic" distribution must have higher power levels for

21) Page 8, Lines 14 through 25

Line 14 begins by suggesting that the radial plane <u>may</u> be represented by an r,θ coordinate system. Line 19 and 20 then state that "...a θ-mesh of 40-80 angular intervals <u>must</u> be applied".

This is not consistent and too prescriptive. If an r,θ coordinate system <u>may</u> be used, the θ-mesh <u>may</u> require 40-80 angular intervals. The concept that the mesh be quantitatively verified needs to be introduced for both the r and θ mesh. The verification should be emphasized, not the prescription.

Line 24 completes a sentence discussing the r,θ mesh by noting references 19 and 20. The sentence beginning on line 24 again notes "Reference 20 ...". This is redundant and should be deleted.

22) Page 8, Lines 29 through 32

"Determination of the 3-D fluence at the vessel using (r,z) and (r) geometry calculations may also be appropriate, (see Regulatory Position 1.3.2). If these calculations are used to provide an axial correction factor, the source specification may be less stringent if consistent sources are used."

We have absolutely no idea what the last sentence means.

23) Page 9, Lines 3 through 6

Suggested rewording:

The transport of neutrons, from the core to locations of interest, such as the pressure vessel, et cetera, should be determined with a discrete ordinates[5] transport program (Refs. 22-24). The (r,θ) geometry option should be employed in the radial plane[6]. When appropriate, the (r,z) and (r) geometry options may be applied[6]. When calculating a horizontal (radial) plane of the core/

24) Page 10, Lines 29 and 30

These lines state; "...the adequacy of the capsule representation and mesh must be demonstrated using sensitivity calculation."

How must the adequacy be demonstrated; what is the criteria? Change must to should if these questions cannot be answered.

25) Page 10, Line 34 through Page 11 Line 2

The concept of extrapolating the fluence from the surveillance capsule or the inside surface of the pressure vessel to the T/4 and 3T/4 vessel locations appears to directly contradict the statement on page 3, lines 20 to 22. "The prediction of the vessel fluence must be made by an absolute fluence calculation rather than a simple spatial extrapolation of the fluence measurements." In addition, the concept of the neutron spectrum dependence of ΔRT_{NDT} is very confusing terminology. The lines on page 10, 34 through page 11, line 2 need to be deleted. If they are not deleted, much much more detail is needed to understand what the licensee needs to do to calculate the T/4 and 3T/4 vessel fluences.

26) Page 11, Lines 3 through 14

This paragraph appears to be totally inconsistent with Subsection 1.2. In this paragraph, assembly importance factors and sources are discussed as a means of determining the vessel or capsule fluence. In Subsection 1.2 it is noted that peripheral assemblies have strong source gradients that should not be neglected. The pin-wise distribution should be obtained from fine mesh calculations explicitly representing each fuel-pin cell. The r,θ mesh must have 40-80 angular intervals and should reproduce pin-wise source gradients.

How can assembly importance factors and sources be adequate on page 11, Subsection 1.3 when pin-wise data should be used on pages 7 and 8, Subsection 1.2.

Delete this paragraph (page 11, lines 3 through 14), or modify it for pin-wise importance factors and sources. If the paragraph is modified, specify sensitivity evaluations that should be performed and verification assessments that should be analyzed.

27) Page 11, Lines 21 to 23

This discussion is the beginning of a very detailed prescription. While the industry uses approximations like Equation 1 to separate the spatial variables, other approximations are also used. If the phrase at the end of line 22, "...using the expression", were changed to, "...using expressions like", the prescription would be more generally applicable.

28) Page 12, Lines 6 through 8

Suggested rewording:

The source per unit height of the core planar area should be consistent for both the (r,θ) and (r) models. The source per plane in the (r,z) model should have an axial distribution consistent with qualified measurements and the total source per model volume should be identical to the (r) model.

29) Page 12, Lines 12 through 17

The concept that the axial fluence distribution flattens as a function of radial distance from the core is not valid in general.

If the fluence did flatten, the relative maxima would decrease and the relative minima would increase. Thus, the approximation would not tend to overpredict the maxima and underpredict the minima.

In a PWR there tends to be two axial peaks. One is approximately 18 inches from the top of the fuel and the other is approximately 18 inches from the bottom. The fluence (power) distribution between the peaks is 5% to 10% lower than the peaks. The axial distribution of the fluence at various radial locations between the core and reactor cavity is a combination of a symmetric cosine function and the core axial distribution. At the radial location of the pressure vessel, the symmetric axial cosine function has become more obvious. Therefore, the relative axial distribution has become more peaked in the center and less peaked 18 inches from the top and bottom of the fuel. This gives the axial distribution the appearance of having become flatter. However, neither the above discussion nor that in lines 12 through 17 is of primary importance to the guide.

Lines 12 through 17 should be deleted and replaced with the concept that all synthesis approximations should be qualified.

30) Page 12, Line 25

The phrase, "It will result", should be replaced with, "It may result", for the reasons noted in comment 29.

31) Page 13, Lines 17 through 23

The concept that ENDF/B-VI cross section data must be used is inconsistent with Subsection 1.1.2 which states that benchmarked cross section sets other than the ENDF/B-VI set are acceptable. There is no need for ENDF/B-VI cross sections if another set has been benchmarked satisfactorily. Furthermore, this statement presumes that the ENDF/B-VI cross sections are the most accurate without qualification. The word "must" needs to be changed or the discussion modified.

Lines 17 to 23 are also too prescriptive and neglect the basic concept that the guide should focus on qualified methods rather than prescribed methods.

Suggested rewording:

this increased sensitivity to the iron cross-sections, the most accurate (ENDF) cross-section data should be used for cavity fluence calculations[3]. For most cavities, an S_8 angular quadrature is acceptable. However, for specific locations in various cavities, the S_8 approximation will have larger deviations than in other locations. Therefore, the adequacy of the S_8 quadrature must be demonstrated with higher-order S_n calculations for all locations were fluence results are used for benchmarks or to predict radiation effects. In addition, since the radial mesh

32) Page 14, Lines 1 to 3

The concept of determining the vessel inner-wall fluence from the extrapolation of the two measurements is confusing. This concept is in direct contradiction with the concept that vessel fluences are calculated. The measurements only serve to verify the calculational methodology.

Suggested rewording:

available, an additional verification of the calculations may be made by comparing in-vessel and cavity ratios of calculations to measurements. The comparison should show if either biases or increased random deviations are occurring in the calculations due to the vessel or other material regions between the in-vessel and cavity dosimetry measurements. Measurements performed in reactor cavities

33) Page 16, Lines 5 and 6

Validating the licensee's calculations with the calculational benchmarks described in Subsection 1.4.2.3 provides no useful results unless the calculational benchmarks have all biases and uncertainties defined.

Suggested rewording:

Calculational methods must be validated by benchmarks to measurements. Calculational benchmarks may also be used in addition to the measurement benchmarks, if the calculations have previously been validated with measurement benchmarks. The fluence calculational methods should be

34) Page 16, Line 13

The key to the validation of the calculational predictions is the benchmark to measurements. The basic measured results are activities and productions. Thus, the basic comparisons of calculations to measurements must be activity and production results.

Suggested rewording:

(com-)parisons of activities or productions, and may include comparisons of reaction rates, group fluences and total fluences ($E \geq 1$ MeV) for the locations of

35) Page 16, Line 14

It would provide a greater degree of safety if adjustments to the calculational methods or results had to be justified and reported. We suggest "should" be changed to "must".

36) Page 16, Line 17

The technical concept that surveillance capsules provide fluence measurement data is misleading. In the past, measurements provided the means of predicting the fluence. The guide has stated that calculations will predict the fluence in the future. The measurements will provide a means of validating the calculations in the future. To ensure the concepts are correct, the word "fluence" should be deleted from line 17.

37) Page 17, Lines 7 and 8

The subject of Subsection 1.4.2.3, Calculational Benchmarks, ended on line 7. The discussion in lines 8 through 25 refer to Subsection 1.4.2, Comparison with Benchmark and Plant-Specific Data. It is suggested that between lines 7 and 8 a heading be inserted.

Suggested wording:

1.4.2 (Continued)

38) Page 17, Lines 14 and 15

This sentence is confusing. The subsection is "Comparisons with Benchmark and Plant-Specific Data". The general concept is validating the calculations by determining the uncertainty in the calculated fluence with comparisons to measurements. What does it mean that "Differences...should be consistent with the combined uncertainty..."? This statement needs explaining.

39) Page 17, Line 16

The phrase, "The calculated and measured reaction rates ...", does not fit with the remainder of the sentence.

The phrase should be changed to, "The calculations ...".

40) Page 17, Lines 18 through 21

The concept described in these lines is that calculational results typically agree with measurements to within 20% for capsules and 30% for cavity dosimetry. Then it is stated that deviations outside these limits must be investigated and the calculations or measurements modified.

The concept that the 20% and 30% uncertainty values are limits is not warranted nor required. Further, the concept of modifying the calculations or measurements is not warranted nor is it a good prescription.

Suggested rewording:
(End of line 18 - remove the period.) (Beginning line 19 -) (Refs. 35-42). Deviations outside these uncertainty values must be investigated and reported (see Regulatory Position 3).

Specific Comments on Section C,2

Beginning with the title, "NEUTRON FLUENCE MEASUREMENT METHODS", this entire section appears to be slightly out of focus. The basic concept of the guide appears to be that (page 3, lines 6 and 7) "...the fluence prediction is made with a calculation and the 'dosimetry' measurements are used to qualify the calculational methodology." Section C,1 prescribes acceptable "NEUTRON FLUENCE CALCULATIONAL METHODS" for predicting the fluence. Section C,2 begins with the same message as Section C,1; acceptable "NEUTRON FLUENCE MEASUREMENT METHODS" for predicting the fluence. This section should be describing acceptable methods for performing dosimetry measurements whose results qualify the calculational results. It should not be describing "fluence" measurements.

The following comments are suggestions for rewording parts of the Section to better convey the concepts that; (1) Measurements are used to qualify the calculational methodology: (2) The qualification involves a comparison of calculated results to measured results: (3) The measurement methodology must also be qualified to determine biases and uncertainties in the measured results.

The documentation prescribed in Section C,2 appears to suggest that the NRC will be the Q.A.'er of the dosimetry evaluation. If this is not the intent, a general reference to a qualified Q.A. Plan with respect to the analyses in both Sections C,1 and C,2 would be appropriate. In addition, the wording (noted in specific comment #43) that the prescribed documentation procedures are for the licensee's own records is needed.

41) Page 18, Line 7

The main topic of discussion in Section 2 is dosimetry measurements. The title, NEUTRON FLUENCE MEASUREMENT METHODS is misleading. The title of the section should be DOSIMETRY MEASUREMENT METHODS.

42) Page 18, Lines 8 and 9

Dosimetry does not provide an independent estimate of neutron fluence. Dosimetry measurements provide independent values of activity, et cetera, that must be used to benchmark calculations.

Suggested rewording:

Dosimetry measurements provide independent predictions of activities, et cetera, that should be used to benchmark calculations. The dosimetry measurements may also be used with calculated spectrum-averaged cross-sections to estimate the "measured" neutron fluence. The measurement predictions are obtained

43) Page 18, Lines 12 through 16

The sentence states that: "Procedures for performing these measurements to obtain a complete analysis ... are described ... ." It is difficult to understand what a "complete analysis" refers to; a complete fluence analysis, or a complete dosimetry analysis, or a complete benchmark analysis, or what?

In addition, the proper documentation described throughout Section C,2 is only appropriate if the NRC is going to use it for Q.A. or something similar. If the NRC does not intend to Q.A. the measurements, then it should be clearly noted that the documentation procedures are for the licensee's own records.

Suggested rewording:

these measurements to obtain a complete uncertainty assessment are described in this section. Proper documentation procedures for the licensee's own records are also described. In addition, sites for placing updated dosimetry are described.

The dosimetry measurement provisions of the section are summarized in

44) Page 18, Lines 30 and 31

The sentence states that: "The selected dosimeter set must provide adequate spectrum coverage." As noted on page 3, lines 11 and 12, "... calculation-to-measurement comparisons are used to identify biases in the calculations and to provide reliable estimates of the 'calculational' fluence uncertainties." This basic concept should not be confused with other terminology.

Suggested rewording:

reactor construction. The selected dosimeter set must provide thresholds for separately benchmarking calculations above 1.0 MeV. and above .10 MeV. A common set of neutron integrated detectors that may

45) Page 18, Line 32 and Page 19 Lines 1 to 3

Measurements for benchmarking the calculations of the greater than 1 MeV and .1 MeV fluences do not require thermal neutron fluence dosimeters to determine the uncertainty. Therefore the sentence which begins on page 18 line 32, "Taken together..." and continues through line 3 on page 19 should be deleted.

46) Page 19, Lines 4 and 5

The sentence which begins on page 19 line 4 and ends on line 5 should be deleted. The message was just conveyed on page 18 line 30 beginning with the sentence "The selected dosimeter set must...". In addition the sentence on page 19 line 4 confuses the issue of "must provide" versus "should provide".

47) Page 20, Lines 15 through 18

When comparing calculated dosimeter responses to the measurements, the appropriate measured response parameter is the activity or isotopic production. These are the standard parameters used in the industry. This same terminology should be used in the guide.

Suggested rewording:

In order to provide a means of comparing calculated dosimeter responses with measurements, an appropriate measured response parameter must be documented; such as, the measured activity (for example, micro-Curies per gram of the target isotope), the measured productions (for example, helium atoms per initial atom of material), or the measured reactions (for example, fissions per initial atom of the material).

48) Page 20, Line 25

The statement refers to the ASTM as the standard for fission yields. This standard is not the principle one, the ENDF library is better. Furthermore, the analysis should be as consistent as possible. If an ENDF/B-II job library is used, then an ENDF/B-II fission yield should be used.

Suggested rewording:

should be those specified in the relevant ASTM standards, the ENDF library, or the validated job library. In situ neutron

49) Page 20, Line 29

The word "reporting" is assumed to refer to Section C,3 in the guide. In this sentence the word "reporting" should be changed to "documenting" to convey the concept that the licensee's files should contain the reference measurements and corrections.

50) Page 21, Lines 6 through 13

There are several different methods that are acceptable for estimating the measured biases and uncertainties. The details provided in the draft guide are too prescriptive and ask for information that is not necessary for the NRC to qualify the licensee's methods. The basic requirement should be that the licensee's uncertainty methodology be provided in a topical report with the biases and uncertainties in the measurements noted.

Suggested rewording:

Regulatory Position 1.4.2 states that the calculations must be validated by comparison with measured benchmarks. In order to validate the calculations with comparisons to measurement benchmarks, evaluations must be performed to estimate the bias and uncertainty associated with the measured response for each dosimeter type. The bias and uncertainty must be included in the documentation of the measured results.

There are several different methods that are acceptable for estimating the measured biases and uncertainties. Whatever method is used, the specific components used to determine the systematic deviations (biases) and standard deviations (uncertainties) for each dosimeter type should be separately identified. The bias and uncertainty values should be noted as upper, lower, or best estimates that are either added to the measurements, or multiplied by the measurements. Each component of the bias and uncertainty methodology should be described as part of the documentation explaining how the component values are combined to obtain the bias and uncertainty for each dosimeter type. This evaluation of the measurement biases and uncertainties for each dosimeter provides a means of ensuring a reliable benchmark of the calculations.

51) Page 21, Lines 14, and 15 through 18

Section 2.2 weakens the draft guide as it is written. The basic concept of validating the dosimeter measurements is excellent. However, this excellent concept is weakened by being highly prescriptive: It appears that the only validation techniques that are acceptable are benchmarks to either a standard neutron source, or a reference neutron field. There are various means of validating the measurement biases and uncertainties: Validation with a reference neutron field is far from the best one.

Either Section 2.2 should be deleted, or it should be rewritten to be less prescriptive and to provide more general guidance. If the section is not deleted, the following are suggestions for rewording the title and lines 15 through 18. In addition, comments 52 and 53 provide suggestions for rewording other parts of the section if it is not deleted.

Suggested rewording:

2.2 <u>Validation of Dosimeter Measurements</u>

The dosimeter measurements used to benchmark the calculations must meet the requirements of a quality assurance program (mandated for surveillance measurements by 10 CFR 50). This program must ensure long term measurement consistency and confirm that the measurements are reliable. (Inter-laboratory comparisons, such as those carried out under the Surveillance

Dosimetry Improvement Program, have been useful in validating the quality assurance programs of various laboratories. Validating laboratory quality assurance programs with standard neutron sources and reference neutron fields would also be useful.) Regulatory Position 2.1.3 indicates that it is important that both (a) the random deviations, or the standard deviation in the measurements (uncertainties), and (b) the systematic deviations (biases) be evaluated to ensure reliable measurements.

The Material Dosimetry Reference Facility (MDRF) may be used for validating the quality assurance programs of various laboratories

52) Page 21, Lines 21 thorough 33 and Page 22 Lines 1 and 2

If the validation of the measurements is to be accomplished by exposing each type of dosimeter to a standard or reference neutron field, then the field itself must have been validated to have a neutron fluence whose spatial and spectral magnitude is certified to have (1) no biases, and (2) a standard deviation with no functional or correlative dependencies.

This part of the guide is too prescriptive in its explanation of the treatment of the differences between the reference field results and the licensee's measured results. The primary point of the guide should be to inform the licensee that the methodology for obtaining any biases or uncertainties in the dosimeter measurements should be part of a topical report.

Suggested rewording:

If the validation of the measurements is to be accomplished by exposing each type of dosimeter to a standard neutron source or reference neutron field, then the following procedures should be considered. The reference field itself must have been validated to have a neutron fluence whose spatial and spectral magnitude is certified to have no biases and a standard deviation with no functional or correlative dependencies. The magnitude and degree of normality of the fluence standard deviation must be certified and documented. The reference measured activity is determined by (1) the product of the energy dependent fluence from the reference field, and (2) the appropriate dosimeter cross sections and parameters, integrated over the appropriate energy range for the reaction.

Enough dosimeters, to have a statistically significant sample from each dosimeter type, must be irradiated in the reference field. The irradiated dosimeters are measured and the responses statistically compared to the reference responses. Any bias in the dosimeter measurements is determined by the statistical evaluation of the mean difference. The uncertainty in the dosimeter measurements is determined by the statistical evaluation of the root mean square difference and is a function of the reference fluence normality and standard deviation.

If there is a bias in the measured response, the dosimeter measurement methods and parameters must be examined in order to determine the functional cause. If the cause of the bias can be identified, the bias must be used to correct the measured responses of any future dosimeter which has a bias due to the same functional cause. However, if the specific cause of the bias cannot be identified, the bias must be applied to future measurements using one of the following two methods.

(1) Correct the measured response for (a) the specific dosimeter type, and (b) the specific instrumentation and procedures that were used when the bias was identified. <u>Note:</u> Any changes to the instrumentation, procedures, or dosimeters must be revalidated before the bias can

continue to be used to correct the measured response.

(2) If the magnitude of the bias is .707 ($1/\sqrt{2}$) of the standard deviation in the measured response: Combine the bias with the standard deviation to increase the uncertainty in the measured response.

53) Page 22, Lines 3 through 8

Again, we agree that the licensee should document the methods used to validate the uncertainties in the measurements. However, there are other ways to do this rather than using a standard neutron source or reference neutron field. The guide should be less prescriptive.

Suggested rewording:

The procedures used to validate the measured dosimeter responses (such as comparing measured responses to responses obtained from another laboratory, reference neutron field, et cetera) must be documented. The documentation must include the results of the comparison in terms of biases and uncertainties for (1) each dosimeter type, and (2) the instrumentation and procedures.

If the uncertainties associated with the validation of the measured responses (such as a comparison of measured responses to reference responses) are used as the value of the measured uncertainty, then the component uncertainties associated with the dosimeters, instrumentation and measurement procedures must be identified and documented. When measured responses are obtained from dosimeters which were not part of the validated set, the uncertainty in the unvalidated measurements may only be assumed to be the same as that for the validated measurements if the uncertainty in each component associated with the dosimeters, instrumentation, and measurement procedures, is equal, or less than the respective value in the validated set.

For instance, if the validated dosimeter counts were 5000, then an unvalidated dosimeter of the same type would require 5000 counts or more if the uncertainty from the validated set was used for the unvalidated set. Likewise, if the validated dosimeter has an uncertainty of 50 milligrams in the detector material, then an unvalidated dosimeter of the same type would require a detector material uncertainty of 50 milligrams or less.

54) Page 22, Lines 32 to 34

If Section 2.2 is deleted or written as suggested above, then this note is not needed.

55) Page 22, Lines 14 thorough 29

The title of Section 2.3 is misleading and should be reworded as noted below to reflect the information in lines 15 through 31.

In addition to the misleading title, the section begins with the concept that fluences should be determined from measurements. "A fast neutron fluence (E > 1 MeV) <u>should</u> be obtained for each detector ...." "These measured fluences and a suitably weighted average fluence <u>must</u> be reported ...." This concept contradicts the basic objective of the measurements as noted on page 3, lines 11 and 12, "... calculation-to-measurement comparisons are used to identify biases in the calculations and to provide reliable estimates of the 'calculational' fluence uncertainties."

Lines 15 through 24 are too prescriptive; there are better ways to benchmark the calculational methodology than those described. A more general discussion is suggested.

Suggested rewording:

2.3 <u>Calculational Uncertainty Determination from Dosimeter Measurements</u>

Regulatory Position 1.4.2 states that the calculational methods must be validated by comparison with measurement benchmarks. The benchmarks validate the calculational methodology by providing a means of determining the bias and uncertainty in the calculated fluences (E > 1 MeV). The bias and uncertainty in the calculated fluences must be estimated from the benchmark comparison.

The benchmark comparison may be performed in several different ways. Two of these are presented below.

(1) The calculated unsaturated activities, isotopic productions, et cetera, may be directly compared with the respective measured responses from a sufficient dosimeter set (see Regulatory Position 2.1.1). The bias and uncertainty determined by the statistical comparison for each dosimeter set must be weighted to determine the bias and uncertainty in the fluence (E > 1 MeV).

(2) The calculated fluences (E > 1 MeV) may be compared with measured fluences. The measured fluence is obtained for each dosimeter from the quotient of the measured activity, isotopic production, et cetera, and the respective calculated average response function. The measured fluence from each dosimeter and dosimeter set must be weighted to obtain measured fluences with E > 1 MeV. The statistical comparison of the calculated and measured fluences (E > 1 MeV) determines the bias and uncertainty in the calculated values.

Whatever approach is used to determine the bias and uncertainty in the calculated fluences from the benchmark comparisons, the calculated biases and uncertainties must be documented along with the measurement biases and uncertainties. If the calculated uncertainty from the benchmark is less than the measured uncertainty, the calculated uncertainty may be assumed to be within the measured uncertainty. If, after appropriately treating any biases, the calculated uncertainty from the benchmark comparison is more than ~20% for in-vessel dosimetry or ~30% for cavity

56) Page 23, Line 23

To ensure a sufficient degree of safety, we believe that at least two of these benchmarks <u>must be</u> performed, and any others may be performed at the discretion of the licensee.

Suggested rewording:
well-known and documented uncertainties. Two of these benchmarks must be performed. Other benchmarks may be used to

Specific Comments on Section C,3

57) Page 24, Lines 23 through 29

This discussion should end with the statement that a topical report presenting the details of the fluence methodology should be satisfactory for compliance with the guide. Subsequent analyses by the licensee to update the vessel fluence biases and uncertainties may be 50.59 reports, "for information only".

58) Page 25, Lines 1 through 5

Reporting the calculated multigroup fluences is not necessary, unless the NRC intends to Q.A. the values themselves. These fluence values are internal to the computer code and are available to the NRC during an audit. BWNT integrates the fluences and intends to report the integral values as noted in Subsection 3.1.3.

Therefore, lines 2 through 4 and the sentence ending on line 5 should be deleted. The title of the section should be changed as follows.

Suggested rewording:

3.1.2 <u>Calculational Adjustments</u>

59) Page 25, Line 7

If an adjustment is made to the calculational results, either internally in the computer code, or externally in the output, the concept that the value and basis <u>should</u> be reported does not appear sufficient to ensure safety. BWNT believes that the value and basis <u>must</u> be reported in the topical.

60) Page 25, Lines 11 and 12

Measured fluences are not required to benchmark the calculations. Therefore, there should be no requirement to report them.

Suggested rewording:

(loca-)tions, should be reported. The uncertainties for each measurement location should also be reported. The