Resolution to Public Comments for
Interim Staff Guidance Document No. 23 (ISG-23),
"Application of ASTM Standard Practice C1671-07 when performing technical reviews of spent fuel storage and transportation packaging licensing actions"

Issue	Comment # Line #	Comment	NRC Resolution of Comment	Changes to ISG
1	Comment 1	Nuclear Energy Institute The ISG contains several clarifications and additional guidance that do not pertain to content, or applicants' use of the ASTM standard. These clarification and additional guidance should already be in the revision to NUREG-1536. Alternatively, the scope of the ISG could be broadened beyond applicability to just the ASTM standard in order to include these items. Specific examples are cited in the comments below.	Some of the comments from the Nuclear Energy Institute (NEI) were generic in nature and/or applied to areas involving the regulation of spent fuel not directly related to this standard. The Nuclear Regulatory Commission plans to review the requirements related to spent fuel storage and transportation as part of the response to SRM COMDEK 09-001. The industry and the public will be engaged in this activity which could lead to the incorporation of additional NEI comments.	No changes.
2	Comment 1 Line 31	Dr. Turner This "clarification" seems to be internally inconsistent by requiring that requalification should not be necessary if re-qualification has already been performed on the principle parameters. Perhaps the NRC means to exclude requalification tests of radiation	The staff's intent was to explain that some requalification tests (such as corrosion testing) do not need to be performed, provided that certain properties of the neutron absorber are not changed, e.g., alloy composition, open porosity, etc.	No changes.

		resistance, corrosion tests, and high temperature response, for example.	The staff does not see the need to make editorial changes for clarity.	
3	Comment 2 Lines 35-38 Comment 1 Lines 31, 35– 37	<u>Nuclear Energy Institute</u> It is not clear why an SFST ISG would address long-term use of neutron absorbers (e.g., a year or more) in spent fuel pools. The standard is not intended for wet storage. <u>NAC International</u> Clarification regarding use of Section 5.2.1.3 of ASTM C1671-07 … This clarification does not extend to long-term use …… in spent fuel pools, … ASTM C1671 -07 is titled "Qualification and Acceptance of Boron Based Metallic Neutron Absorbers for Nuclear Criticality Control for Dry Cask Storage Systems and Transportation Packaging". The standard is not applicable to in-pool neutron absorbers – adding the clarification to the ISG does not appear appropriate because both the ISG and the ASTM standard are not applicable to pool storage.	The same materials which are used in dry cask storage are also used in spent fuel pools. The staff wanted to clarify that minor changes to the surface finish of neutron absorber materials which have a minimal affect on the performance of neutron absorbers in dry cask storage may significantly affect the corrosion resistance of these materials in spent fuel pools. Therefore this ISG cannot be used to fully describe the qualification and testing of neutron absorbers for spent fuel storage. To reduce ambiguity, however, the references to spent fuel storage will be removed from the ISG.	References to spent fuel storage in lines 35-38 will be removed from the ISG. Removed: This clarification *does not* extend to long-term use (e.g., a year or more) of neutron absorbing materials in spent fuel pools, where minor contaminants accrued during fabrication can significantly influence the corrosion behavior of such materials.
4	Comment 3 Lines 40-48	<u>Nuclear Energy Institute</u> A neutron absorber supplier change may be simply the result of a company sale to a new entity. This	The staff agrees that the ISG needs to be clarified. A limited degree of requalification should be necessary if a new supplier	The staff will change lines 40-48 to reflect the staff's response. Removed:

		change may result in no change in the location, equipment, process, and personnel involved in the manufacture of the material. Similarly, a manufacturing facility may be relocated but continue applying identical processes, process control and equipment. There should not be an automatic assumption that anything beyond the control of key processes should be examined. The purpose of the key process specification is to outline the steps required to produce a consistent material compatible with that produced for the qualification program. Please clarify.	manufactures the neutron absorbing material. A limited requalification is unnecessary, if the same fabrication equipment and procedures are used.	The staff considers a review of key processes and process controls alone insufficient to ensure that qualified neutron absorbers produced by a new supplier will meet the same specifications as those produced by the previous supplier. Added: "Following a change of supplier (excluding the use of the same fabrication equipment and procedures), the supplier should do a review of key process and controls and perform qualification testing demonstrating that the neutron absorbing material has the specified mechanical properties, required density, limits on porosity, and (if applicable) resistance to blistering."
	Comment 4 Lines 46	<u>Nuclear Energy Institute</u> If NRC staff considers the guidance "insufficient" it would be helpful if the staff provided guidance on what is considered sufficient with respect to this part of the ASTM standard.		
	Comment 2 Lines 40-48	<u>NAC International</u> Neutron absorber supplier change may be the result of a company sale to a new entity. This change may result in no change in the location, equipment, process, and personnel involved in the manufacture of the material. Similarly, a manufacturing facility may be relocated but continue		

		applying identical processes, process control and equipment. There should not be an automatic assumption that anything beyond key processes control should be examined. The purpose of the key process specification is to outline the steps required to produce a consistent material compatible with that produced for the qualification program. The implication of the NRC's statement is that qualification testing may have to be redone if review of the key processes is deemed insufficient by NRC.		
5	Comment 5 Lines 58	<u>Nuclear Energy Institute</u> Specifying that the accelerated testing should be "longer" than the anticipated service life is vague and should be clarified.	The staff agrees that the clarification is ambiguous. Given the neutron flux of spent nuclear fuel (10^7 – 10^8 n/cm.s) in the dry cask storage environment is not expected to affect aluminum / boron carbide composites for well beyond the licensing period for dry cask storage.	The staff will remove Lines 51-8 to reflect the staff's response. Removed: Section 5.2.5.1 of C1671-07 requires that the neutron absorber material be exposed to "service conditions or equivalent accelerated conditions" as part of the qualifying tests. The staff should ensure that the service life adequately represents the term of the license or Certificate of Compliance, e.g., 5 or 20 years, or longer if subsequent renewals will be requested. The staff is cautioned that the effects of accelerated testing may not exactly match the actual effects

				encountered under operating conditions over the entire service life. Hence, for accelerated tests, the computed test period should represent a period longer than the anticipated service life.
6	Comment 6 Lines 59-61	Nuclear Energy Institute Including the service life of the neutron absorbing materials in the CoC and/or Technical Specifications (TS) is not appropriate. Including this information in the SAR, subject to initial NRC review and approval and 72.48 review after that for future changes is sufficient.	Aluminum / boron carbide composites are not expected to be altered by the dry cask storage environment over time periods well beyond the licensing period for cask storage. Therefore the staff sees no need to include the service life of the neutron absorbers in the CoC and/or Technical Specifications.	The staff will remove lines 59-61 to reflect the staff's response. Removed: The staff should confirm that the service life for the neutron absorbing materials is specified in the Safety Analysis Report and Certificate of Compliance, or the Technical Specifications of the application.
7	Comment 7 Line 68	Nuclear Energy Institute Please confirm the statement that clad neutron absorbers with porosity between 1 and 3% have experienced blistering, or withdraw these numbers. EPRI report 1009696, Boral Behavior Under Simulated Cask Vacuum Drying found that Boral with porosity between 1-3% exhibited blisters. However, the porosity for these test coupons was determined by the difference in weight of the coupons before and after wetting, indication that this is interconnected (open) porosity at the edge of the sheets rather than total	The staff finds that the nature of the porosity discussed in the ISG should be clarified. Open pores, which permit water intrusion is of specific concern.	Line 68 will be clarified to specify 1 – 3% open porosity.

		porosity. NRC Generic Safety Issue 196 addressed Boral degradation and concluded that no new guidance or requirements for licensees were necessary. It is recommended that the ISG be modified to discuss Generic Safety Issue 196 and its resolution.		
8	Comment 8 Lines 70	<u>Nuclear Energy Institute</u> Please clarify how blistering can have an effect on retrievability. There are numerous casks already loaded and in-service with clad-type neutron absorbers (e.g., Boral).	Electric Power Research Institute Report TR1013721, "Handbook of Neutron Absorber Materials for Spent Fuel Transportation and Storage Applications," 2006, states: "Similarly, in-pool blistering of Boral has, to date, proved to be primarily an aesthetic effect; however, the potential effects on fuel assembly clearance and the reactivity state of region 1 racks have been noted. In addition, it has been noted that, in a few instances, *rack cell wall deformation has occurred making it difficult to remove fuel*." *(emphasis added)* In a similar manner, the Staff finds that dimensional changes (blistering of Boral) could lead to problems with fuel retrievability from dry casks.	The references to blistering in lines 68-72 will remain in the ISG, but clarifying changes will be made to lines 68-72. Removed: and (during loading in the spent fuel pool) on the effective neutron multiplication factor, keff. Added: Unclad aluminum / boron carbide neutron absorbing materials with open porosities less than 0.5-volume percent may not be required to undergo simulated submersion and drying tests.

9	Comment 9 Lines 74	Nuclear Energy Institute The ultimate demonstration of Boron-10 presence and uniformity per specification is acceptance testing with the associated statistical treatment. The qualification testing merely demonstrates that there will be sufficient uniformity (or enough excess Boron-10) to minimize the risk of failing acceptance testing. For acceptance testing, the certificate holder must develop an adequate sampling rate, and must sample production at this rate in either a systematic or probabilistic fashion. Removing coupons "contiguous to each plate" is irrelevant because plate sizes can vary significantly from one basket design to another, thus resulting in large variation in the sampling rate per unit surface area.	Applicants should provide specific criteria in the qualification and acceptance programs indicating the percentage of neutron poison plates which are tested, or the minimum number of samples taken per surface area of poison plate material. Examples of acceptance testing criteria that the staff has accepted will be listed in the ISG.	After Line 78, examples of previously approved acceptance criteria will be added. Added: In the past the staff has accepted: 1) (For a neutron absorbing material with a significant qualification program and non-statistically derived minimum guaranteed properties), wet chemistry analysis of mixed powder batches followed by additional neutron attenuation testing of a minimum of 10% of the neutron poison plates. 2) Sampling plans where at least one neutron transmission measurement is taken for 2000 square inches of neutron poison plate material in each lot. 3) A sampling plan which requires: that each of the first 50 sheets of neutron absorber material from a lot, or a coupon taken there from, be tested (by neutron attenuation). Thereafter, coupons shall be taken from 10 randomly selected sheets from each set of 50 sheets. This 1 in 5

				sampling plan shall continue until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder or aluminum powder) or a process change. A measured value less than the required minimum areal density of boron-10 during the reduced inspection is defined as nonconforming, along with other contiguous sheets, and mandates a return to 100% inspection for the next 50 sheets.
10	Comment 10 Lines 80-90	Nuclear Energy Institute The amount of "credit" taken for boron-10 in the application is not addressed in the ASTM standard. Thus, this clarification is not germane to the purpose of the ISG and should be deleted. This topic appears to be adequately addressed in the recent proposed revision to NUREG-1536.	The staff finds that "Clarification regarding use of Section 5.2.6.2 and 5.3.4.1 of ASTM C1671-07 " would be more accurately described as "Additional guidance regarding use of Section 5.2.6.2 and 5.3.4.1 of ASTM C1671-07". Overall, the staff disagrees with the comment. Discussion of credit given for the boron-10 content in the neutron absorber material should be incorporated into the ISG, as it is directly influenced by the methods (e.g., neutron attenuation and wet chemical testing) used to determine the boron-10 content of the materials during acceptance testing.	The staff will only make editorial changes to lines 80-104. Additional information will be added after line 105. Added: Applicants should be encouraged to provide statistically significant data showing the correspondence between neutron attenuation testing and wet chemistry data and the precision of both methods. Such data may permit the partial substitution of neutron attenuation measurements with chemical methods for materials receiving 90% credit.

11	Comment 2 Line 86	Dr. Stanley Turner Relating to 75% or 10% credit for Boron-10 in the neutron absorber is not supported by any credible evidence. The limits are erroneously derived from the following reference: Allen H. Wells et al "Criticality Effect of Neutron Streaming between Boron Carbide Granules in Boral for Shipping Cask", Transactions of the American Nuclear Society, Vol. 54, Page 205-206,1987 The error arose from ignoring the natural properties of neutron scattering in the water moderator in spent fuel storage cells. In discussion with Allen, he acknowledged that at the time of his paper, he did not have the computer capability to validate his basic assumption, that neutron behavior was the same in neutron attenuation as in criticality calculations. This limitation in computer capability no longer exists and with improved computers, it is easy to show that there is a great difference between neutron attenuation and criticality calculations. Because of isotropic scattering in criticality calculations that does not exist in neutron attenuation measurements, Allen's basic assumption has been found to	The percentage credit given to neutron absorbing materials is determined principally by the robustness of a materials' qualification and/or acceptance program, which should include neutron attenuation measurements. Materials with large particle sizes of absorber may receive 90% credit for boron-10 content if the qualification and/or acceptance programs demonstrate statistical significance (typically the "95/95" criteria described in the ASTM standard), and make sufficient use of neutron attenuation in the qualification and acceptance testing. A 10% deduction is taken from the measured areal density of boron-10 because benchmarks used in the criticality analysis typically are not closely representative of configurations in a spent fuel cask. The 75% credit is given to materials which use principally wet chemical testing for acceptance testing. The staff agrees that neutrons from fissile materials in casks will not exclusively be directed perpendicular to the faces of	The staff will only make editorial changes to lines 80-104.

		be in error. In criticality calculations, the neutron path length is greater by somewhat less than 40% than the corresponding path length in neutron attenuation. Neutron attenuation tests use lengthy collimation tubes to generate a mono-directional beam of neutrons. In criticality calculations there is no collimation tube and the neutrons are scattered isotropic ally by the water moderator. Neutron streaming effects are discussed more fully in Reference 1 and in the attached document (Section 5.0) and analytical data is presented to show that neutron streaming has a virtually negligible effect in criticality analysis. Also presented in section 5 is a qualitative discussion of the different path lengths for neutron attenuation and for criticality analyses. In neutron attenuation the neutron beam is collimated but collimation does not exist in criticality analyses. This is the principal evidence for the absence of neutron streaming effects in criticality calculations. Modern computers are readily able to calculate the k-effective in criticality calculations with specific definition of particle sizes.	neutron absorbing materials. The staff finds however, that the most conservative approach for determining the areal density of a material is from attenuation experiments where the beam is directed perpendicular to plates of neutron absorbing material. Hence, no credit will be given to the additional thickness of material that neutrons may see in actual service.	

12	Comment 11 Lines 84	Nuclear Energy Institute If the boron-10 credit discussion remains in this ISG, including the amount of boron-10 credit used in the criticality analysis in the TS is not appropriate. Including this information in the SAR is sufficient.	See response to Comment 1.	The staff will only make editorial changes to lines 80-104.
13	Comment 12 Lines 95-96	Nuclear Energy Institute The statement that alternate means of Boron-10 areal density inspection must be calibrated against neutron attenuation requires a technical basis. There is a practical limitation, because there are few neutron attenuation facilities available to perform this work, and if they were to become unavailable, production of neutron absorbers would come to a stop unless there was an alternative available. The purpose of benchmarking as conceived by the ASTM working group was not to "calibrate" the alternate method, but to see if there was a bias that needs to be factored in when using the alternate method. It is interesting to note that one regulatory authority (BAM) uses chemical and spectrometric analysis to verify the neutron attenuation results.	The actual performance of a neutron absorbing material is dependent on the quantity of the actual neutron absorber (e.g., boron-10) in the material and the distribution and particle size of that neutron absorber in the material. The influences (or biases) caused by distribution and particle size cannot be determined by wet-chemistry testing, but can be observed through neutron attenuation measurements. For neutron absorbing materials which receive 90-percent credit, more extensive testing such as neutron attenuation needs to be part of the acceptance program.	The staff will only make editorial changes to lines 80-104.
14	Comment 13 Lines 93-99	Nuclear Energy Institute No guidance is provided as to the application of the terms "partial	Depending on the *qualification and acceptance* testing plans, the staff may accept as few as	The staff will only make editorial changes to lines 80-104.

		substitution," "periodic sampling," and "proper sample size." This may be interpreted in varying degrees by individual reviewers/applicants and result in individual negotiations with NRC from application to application. Please clarify or refer to an acceptable standard for these terms.	10% of the coupons to undergo neutron attenuation for acceptance testing. Examples of acceptance testing plans that the staff has found acceptable in the past will be stated in the ISG. Continued testing at some level needs to assure consistency in the fabrication process.	
	Comment 14 Lines 94	<u>Nuclear Energy Institute</u> The text discusses partial substitution for attenuation testing with other methods, presumably wet chemistry testing. Does this mean that a CoC holder can use wet chemistry testing as the primary acceptance test and neutron attenuation testing as a verification test with a smaller sample size? An example of a partial substitution for attenuation tests should be provided for clarity.		
	Comment 3 Lines 93-99	<u>NAC International</u> No guidance is provided as to the application of the terms "partial substitution," "periodic sampling," and "proper sample size." This may be interpreted differently by individual reviewers/applicants and result in negotiations with the NRC on different packaging applications. For a qualified material and an alternate test process that has been		

		benchmarked to neutron attenuation, what is the basis for requiring re-testing? As the material has been qualified and produced under a QA program requiring key process controls and material input constraints, is there an NRC expectation of significant variation in product?		
15	Comment 15 Lines 99-100	Nuclear Energy Institute Editorial: Insert a blank line between these two lines.	The staff agrees with the comment.	A blank line will be inserted between lines 89 and 100.
16	Comment 16 Lines 100-104	Nuclear Energy Institute A requirement for neutron attenuation testing on 75%-credit Boron-10 material represents a double penalty on the material. In the case of Boral, the reduced (75% credit) historically has been traced to streaming within the neutron absorber core material due to a larger particulate boron carbide (compared to metal matrix composites with a finer particulate of boron carbide). Neutron attenuation testing with a collimated thermal neutron beam (standard test procedure for neutron attenuation testing) directly measures the streaming phenomena, resulting in lower measured Boron-10 content than an equivalent homogenous absorber (e.g. ZrB_2). Applying the	The staff understands the concern regarding a double penalty, but wet-chemistry measurements should be benchmarked against a direct measurement of the performance of the neutron absorbing material during qualification testing.	The staff will only make editorial changes to lines 80-104.

	Comment 4 Lines 100-104	75% credit on top of this reduces the credited absorber content a second time, therefore accounting for neutron streaming twice. <u>NAC International</u> A requirement for neutron attenuation testing on 75%-credited material represents a double penalty on the material. In the case of BORAL the reduced (75% credit) historically has been traced to streaming within the neutron absorber core material due to a larger particulate B_4C (compared to MMC with a finer particulate B_4C content). Neutron attenuation testing with a collimated thermal neutron beam (standard test procedure for neutron attenuation testing) will directly measure the streaming phenomena resulting in lower measured B-10 content than an equivalent homogenous absorber (e.g. ZrB_2). Then applying the 75% credit reduces the credited absorber content a second time, resulting in accounting for neutron streaming twice. Therefore, material tested using a collimated neutron beam should permit 90% credit as applicable to other materials qualified and accepted using neutron attenuation testing.		

17	Comment 3 Line 106 Comment 17 Lines 112-117	<u>Dr. Turner</u> The NRC statements raise more questions than are resolved. First, There is no supporting evidence that zirconium diboride is homogeneous or a suitable standard for neutron attenuation measurements. Unless the ZrB_2 is present at near l00% theoretical density, it would exist in particles subject to neutron streaming. Uniformity in ^{10}B distribution is not an adequate measure of density. Furthermore, there is a concern whether the zirconium adequately represents *the* scattering equivalent of the carbon when B_4C is used (Scattering in the matrix material is generally not very important.) Secondly, B_4C standards are manufactured with very finely divided B_4C particles pressed and sintered to nearly full density (99.5 ± 0.5 %TD) leaving no room for neutron streaming and are effectively homogeneous. Furthermore, the carbon provides a more reasonable representation of the B_4C scattering. <u>Nuclear Energy Institute</u> The statement regarding neutron absorber standards requires a technical basis. Whether homogeneous absorbers or heterogeneous absorbers are used,	The staff understands the difference between physical density (porosity) and the density or boron-10 in a material. The staff always assumed that the chemical homogenous standards referenced by the applicants were near full density, prepared by hot-pressing. The staff finds that heterogeneous calibration standards may be used, given certain qualifying factors. These factors will prohibit the use of non-pedigreed calibration standards or materials which are not homogenous, e.g., silicon rubber embedded with large boron carbide particles.	The staff will revise the ISG to permit heterogeneous calibration standards. Removed: The staff does not accept the following language in Section 5.2.6.2(1): "If materials with discrete absorber particles or phases are used for calibration standards, then the size of the particles containing the neutron absorber should be small enough so that neutron streaming and self-shielding is insignificant." Only homogenous neutron absorbing materials such as zirconium diboride (ZrB2) with uniform absorption properties should be considered for neutron attenuation testing standards, as homogenous materials preclude, or at least minimize, any neutron streaming effects which may occur in heterogeneous materials. This exception to ASTM C1671-07 precludes the use of materials such as boron carbide reinforced aluminum matrix composites as calibration standards for neutron absorption. Added: Homogenous neutron absorbing

		there is always an approximation of the condition that is modeled in the criticality calculations. If a chemically homogenous sheet of ZrB_2, TiB_2, B_4C, etc., is used, the standard is generally paired with a sheet of aluminum to account for the scattering effect of the matrix alloy. But this separation of the absorber and the scatterer into two separate sheets is artificial. Heterogeneous absorbers do not represent the homogenous mixture in a computer model for criticality analysis, but they better represent the overall material distribution, and with a sufficiently fine dispersion of the boron-containing particles, the behavior with respect to a neutron beam is indistinguishable from a homogeneous material. This is precisely what the ASTM standard requires. Calibration traceable to a national standard or to a physical constant (e.g., a monoenergetic neutron cross section) would in any event be required by any certificate holder's QA program. <u>Nuclear Energy Institute</u>		materials with uniform absorption properties such as zirconium diboride (ZrB_2) or hot-pressed boron carbide (B_4C), (typically paired with aluminum shims) or heterogeneous alumimum / B_4C calibration standards with pedigrees traceable to widely recognized institutions (e.g., national laboratories) are acceptable as neutron attenuation calibration standards.
	Comment 18 Lines 112-117	The text precludes the use of "boron carbide reinforced aluminum matrix composites" as the calibration standard for neutron absorption. It is		

		suggested that the ISG recommend that if heterogeneous neutron absorbing particles are used, then the applicant should justify the necessary controls (e.g., particle sizes, and calibration controls are in place to effectively eliminate the possibility of self-shielding and neutron streaming.) These controls should be defined in the Safety Analysis Report, but not part of the technical specifications. Additionally, the staff's independent and extremely conservative criticality study shows "no significant difference in keff" with exaggerated heterogeneities properties for the neutron absorbing material of a transport cask. Thus, the staff's own study supports that boron carbide is acceptable for use in neutron attenuation standards.		
18	Comment 19 Lines 119-125	Nuclear Energy Institute This additional guidance is unnecessary for clarifying the use of an ASTM standard by a CoC holder and should be deleted or clarified. The NRC's input on, and acceptance of the use of alternative testing methods occurs either via the review of license applications or by inspection.	The staff agrees with the comment, there is no need to specifically mention a regulatory agency in the ASTM standard.	Lines 124 – 125 will be deleted. Removed: The applicant should confirm that use of a uniformity testing method other than neutron attenuation is acceptable to the NRC, not just the designer.
19	Comment 1	Holtec	The staff recognizes the	Editorial changes will be made to

	Lines 127-162, specifically the Figure 1 (lines 148 to 151)	We welcome the discussion, and the conclusion that neutron beams between 1 and 2.54 cm are acceptable for testing. However, there are concerns about the information presented in the Figure: • The data in the figure shows a very large variation in the results, with the smallest value about 0.9105 (at 0.25 cm) up to 0.9180 (at 2 cm), i.e., a maximum difference of about 0.0075 delta-k. Even in the range of the heterogeneity between 1 and 2.5 cm, the maximum difference is about 0.0050 delta-k. • The differences appear random, and not the result of any clear trend. • Cases with constant and non-constant density show no clear correlation, i.e. in some cases they result in almost identical values, while in other they are significantly different (more than 2 or 4 standard deviations, depending on whether the error bars indicate 1 or 2 standard deviations). There are no apparent trends between the two curves. The concern is that an uninformed reader could come to the erroneous	limitations of its own analysis, but the objective was to create an extreme (bounding) case to demonstrate that beam sizes 1-inch in diameter were acceptable for neutron attenuation measurements. The staff is encouraged by the results of the criticality analysis presented by the commentor, and hopes that the conservatisms the applicants have demonstrated in their own analysis increase public confidence in the safety of spent fuel storage and transportation.	the introduction to the second paragraph of Section 5.2.6.2(2) for clarity.

		conclusion that minor variations in the neutron absorber could lead to quite substantial changes in reactivity, and could question the conclusion of “no significant differences” as stated in the text. However, a closer look at the observations listed above indicates insufficient convergence of the calculations, rather than problematic behavior of the neutron absorber, as the reason for the differences. In other words, the plot may potentially only show statistical noise, rather than the behavior of the absorber panels; and that the effect of changes in the absorber panels, or in the beam size is far less. This is supported by similar calculations performed by Holtec a few years ago. The difference between our calculations and the calculations in the ISG is that they were performed at 80/120% boron loading (ISG 50/150%), and that a stripe pattern along the panel length was used (ISG: checkerboard). The results are shown in the figure at the end of this discussion. The main observation is that the maximum difference is only about 0.0015 delta-		

		k, which is much less than that shown in the ISG figure. The standard deviation of the calculations is about 0.0007 deltak, so even those differences could conceivable be purely statistical in nature. However, since they are much smaller, they would not raise any concerns regarding the absorber panels. We recommend that the calculations for the ISG be re-performed with parameters that reduce those statistical effects as far as practical.		
	Comment 4 Line 127	<u>Dr. Stanley Turner</u> This section is very confusing and seems to place emphasis backwards. Line 132 states that "A neutron beam 1-cm diameter is often used .....". So also a 1" (2.54 cm) beam diameter is often and has been used for more than 25 years on many projects. Section 3 of the attached document presents a detailed evaluation, analytically and experimentally of the effect of beam size on attenuation measurements and sensitivity to defects. These tests support a conclusion that there is no difference		

		a 3/8 inch (0.95 cm) and a 1" (2.54 cm) beam sizes. The NRC document seems to emphasize an upper limit of 2.54 cm when, in fact, the lower limit is the more important limit. The smaller beam size has much greater probability of missing a defect than the larger 2.54 cm beam diameter. The 1-inch beam size does not represent an upper limit and larger beam sizes could be readily qualified if necessary. A beam diameter if 1-inch (2.54 cm) has been confirmed as acceptable from a practical standpoint and has been in use longer than the 3/8-inch (0.95 cm) beam size which has also.		
	Comment 5 Line 133	<u>Dr. Stanley Turner</u> Line 133 and subsequent report of criticality analyses yielded the expected results since it is the average ^{10}B content over a large area that defines the k-effective. Sections 3.2, 3.3, and 4.0 in the attached document presents criticality evaluations of very conservative postulated defects in the absorber panels of a representative storage cell. For example, postulated holes (zero ^{10}B) showed that 0.5-inch diameter every		

		6-inches in all panels yielded only a 0.0005 increase in k-effective. This extremely conservative example illustrates that significant defects can be safely accommodated for spent fuel in storage or transport.		
20	Comment 20 Lines 164-182	Nuclear Energy Institute Industry agrees that visual inspections are generally required, that they will generally look for more than just surface finish as cited in the ASTM standard, and that the visual inspections must be suitable for the specific materials and application. However, industry disagrees with the significance that the review guidance is placing on edge cracking. The ISG clarification fails to explain the consequences of cracks based on their magnitude. A small tight crack would not have sufficient surface area to affect criticality safety and if the absorber is used without structural credit; the notch effect is unimportant.	The staff agrees in-part with the comment, and will remove the overemphasis on cracking. Edge and surface cracking, however, will remain as examples of defects to be addressed in the application. The applicant should establish definitive limits on permissible physical defects on the neutron poison plates.	Lines 170-174 will be deleted. Removed: Special consideration should be given to visual inspection of plate materials containing more than 30 volume percent boron carbide. Plate materials with high loadings of boron carbide (> 30 volume percent) are subject to edge cracking during rolling operations, and the procedures used for inspection of these edge effects need to be closely reviewed to determine the adequacy of the specified procedures.
21	Comment 21 164-182	Nuclear Energy Institute The cited section of the ASTM standard refers to “properties” to be verified, not the techniques to be used to perform the verifications, which is the subject of the clarification. The suggested additional guidance does not pertain	The staff disagrees with the comment; the ASTM standard directly mentions surface finish. Visual inspection is the only practical method for determining surface finish. This ISG is being used to supply additional guidance to the reviewer.	No changes.

		to the information in this section of the standard and should be deleted.		
22	Comment 22 Lines 184-187	Nuclear Energy Institute "Actions to be taken if thickness is outside the permissible limits" is beyond the scope of the ASTM standard. These actions are handled case-specifically in the applicant's corrective action program. This additional guidance should be deleted.	The staff disagrees with this comment. Applications should include an unambiguous statement that significant dimensional defects in the neutron absorbing materials will be taken into consideration by the manufacturer and what the results of such defects will be in regards to their acceptance (reject, rework, etc.). This guidance is included for use by the reviewer.	No changes.
23	Comment 23 Lines 191-192	Nuclear Energy Institute Including "discussion" of deviations in the physical dimensions of the neutron absorber in the CoC or TS is not appropriate. Including this information on the drawings is sufficient without incorporating the drawings by reference into the CoC or TS.	See Comment 1.	No changes.
24	Comment 24 Lines 200-209	Nuclear Energy Institute Industry does not agree that Part 72 Technical Specifications are an appropriate place for the acceptance testing and key process control details. At the most, only the neutron absorber characteristic essential to criticality safety, i.e., the minimum 10B areal density, and major	See Comment 1.	No changes.

		material characteristics such as limits of composition should be included in the TS. That is, the TS should state what must be achieved, not how to achieve it.		
25	Comment 25 Lines 215-218	Nuclear Energy Institute This additional guidance is beyond the scope of the ASTM standard and should be deleted. Safety classification of components such as neutron absorbing materials is governed by the applicant's QA program.	See Comment 1.	No changes.
26	Comment 6 No Line	Dr. Stanley Turner Additional comment (not directly related to ISG-23): Sometimes the Areal Densities are used in parametric studies. This is NOT valid because areal density is a derived value. To be correct, the analyses must be based upon the measured parameter, namely the observed neutron counting rates that are the basis for deriving values of areal density. Furthermore, areal density values vary inversely with transmitted neutron counting rates.	See Comment 1.	No changes.