Comment Resolution on Spent Fuel Project Office Draft Interim Staff Guidance 22, *"Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel,"* November 15, 2005

<u>Commentor 1</u>

Comment 1

At the February 8, 2005, SFPO Licensing Process Conference, NRC agreed to make the ISGs available in draft for comment. While this process is informal, it implies that NRC will follow the general procedure for review and comment. Therefore, input and comments on draft guidance should be given due consideration, including discussion in public meetings, if needed, prior to issuance of final guidance, if any.

Response:

The SFPO agreed to consider audience comments from the 2/8/05 meeting. As a result, the SFPO issued an internal policy to send all ISGs out for public comment. ISG-22 was posted for public comments that will be addressed prior to final issuance.

Comment 2

In addition, NRC should not implement guidance until it is final.

As a general matter, we encourage SFPO to limit use of ISGs to clarifications of regulatory review guidance that do not involve new technical issues and/or compel new licensee or certificates-of-compliance (CoC) holder actions. Other, more appropriate regulatory tools, such as rulemaking, that receive broader NRC regulatory and technical review are available to address such matters.

Response:

The NRC SFPO issues ISGs when the staff has developed a position on a regulatory technical issue. The position espoused in an ISG is one the staff feels has sufficient technical merit. The applicants are free to accept the staff's position or develop a position of their own on the matter. Should the applicant choose the later route, it is incumbent upon the applicant to provide sufficient technical information to support that position. The staff will accept supportable positions other than those in the ISG.

Comment 3

The ISG process does not have the same rigor as regulatory processes that are designed to promulgate new requirements, and hence, has the potential for creating unintended and problematic consequences if used in this manner.

Response:

An applicant or utility is not required to follow the guidance espoused in an ISG, especially if they think it creates unintended and problematic consequences if used. The applicant or utility need only meet the regulatory requirements in 10 CFR 72 or 71. Alternative, supportable positions to those in the ISG are acceptable.

Comment 4

The proposed guidance presents NRC's expectations for changes to licensee spent fuel cask operating procedures or, alternatively, additional inspections and/or analyses to address the potential for rod splitting in 10 CFR Part 72 site-specific licenses and 10 CFR Parts 71 and 72 CoCs. Industry is concerned that, in setting forth these expectations, the ISG describes a new generic technical issue and the actions suggested in the document represent new NRC requirements that should receive a formal backfit analysis in accordance with 10 CFR 72.62. Given this concern, we recommend that this ISG, in its current form, be withdrawn and the issue evaluated in accordance with NRC Management Directive 6.4, "Generic Issues Program.

Response:

This ISG addresses no new technical issue, only the time frame during which the issue might arise. As stated in 10 CFR Part 72.122 (h)(1), the spent fuel cladding must be protected from degradation that leads to gross rupture. Oxidation of the fuel can lead to degradation of the cladding. The commentor should note that no backfit is required by this ISG.

Comment 5

NRC has not communicated a thorough understanding of the conditions under which the fuel rod splitting phenomenon described in the draft ISG may occur.

Response:

Under the section "Issue", the following phrase has been added to the last sentence '. . . if the time-at-elevated-temperature after water removal is excessive (see appendix to this ISG).' With the addition of this phrase the NRC staff feels this section clearly states the conditions under which the problem can occur.

The time-to-start cladding splitting due to the oxidation of the fuel in a fuel rod with pinhole breaches that is exposed to an oxidizing atmosphere depends on the temperature of the fuel, grain size of the fuel, burnup, maybe the fuel cladding type, and moisture in the atmosphere. In general, the longer the fuel is expected to be exposed to the oxidizing atmosphere, the lower that the temperature needs to be maintained to prevent splitting of the cladding. The time-at-temperature (TT) curves developed to date (RE Einziger and RV Strain "Oxidation of Spent Fuel at Between 250 and 360°C" EPRI Report NP-4524, 1986 for example) are based on oxidation data obtained from LWR or CANDU oxide fuel with Zircaloy cladding and burnups below 48 GWd/MTU. Most of the fuel was in the 30 GWd/MTU or lower range. These TT plots can be used for fuel having a burnup below ~45 GWd/MTU and Zircaloy cladding to easily determine the allowable exposure duration to an oxidizing atmosphere if the fuel temperature is known, or conversely the maximum allowable temperature if the exposure time is known. For example, using Fig 3-9 of the above reference, at 360°C one would expect to incur splitting between 2 and 10 hours. On the other hand if one expected to stay at temperature for 100 hours then the fuel temperature must be kept below 290°C.

Should the fuel being stored have higher burnup, or different cladding, then adjustments to the plots must to be made. For example, at higher burnups, adjustments for diffusion into the smaller grains of the rim region, lack of a fuel-to-cladding gap, along with the slower rate of oxidation in the bulk of the fuel having high burnup and large grains at the higher burnup will have to be made as the data becomes available (see Commentor 4, Comment 5).

Comment 6

Furthermore, as discussed in the enclosure, the industry has seen no evidence of this phenomenon during more than 20 years of dry spent fuel storage operations. Therefore, the safety and risk significance of the issue are not clear.

Response:

Since there is no access to the fuel after the cask is sealed, it is not clear whether this effect has or has not occurred to date. In addition, much of the fuel loaded to date has been very cool, or has had no breaches in the upper end of the fuel, or has not been uncovered because a limited drain/blowdown was used. In none of these events would the effect be experienced. There may be operational risk to the operator that opens a cask that he believes contains intact fuel and finds it contains powdered fuel.

Comment 7

Industry would very much like to discuss with NRC its perspectives on the temperature and time boundaries that would limit the occurrence of this phenomenon, as well as on other relevant issues, prior to NRC taking any further action in this area.

Response:

As indicated in the appendix to the ISG, the oxidation rate is a function of both the time and temperature. The extent of the allowable fuel oxidation allowable prior to the onset of cladding splitting and the development of a gross breach is dependent of a number of fuel specific variables. The effect of these variables on the allowable time at temperature is not clearly defined. A brief discussion of the issue with industry was conducted in March 2006. The staff are willing to discuss further industry perspectives on any aspect of this issue. The issue of the exact nature of the oxidation phenomena has been under discussion in the technical community for many years and the uncertainties in the rate calculations have not been resolved. We see no need to delay implementation of the ISG.

Comment 8

Until a thorough consideration of the risk significance of this issue has been completed, industry believes that it is inappropriate for NRC to compel licensees and CoC holders to modify their operating procedures and/or perform additional inspections and analyses in support of dry spent fuel storage operations. However, NRC is already implementing this ISG (despite its draft status) through the Request for Additional Information (RAI) process on several ongoing licensing actions. We strongly object to this practice, and we believe this action is premature and not consistent with NRC’s internal policy for handling generic technical issues. The implementation of requirements should not precede completion of the applicable regulatory process necessary to ensure that they are the correct requirements.

Response:

The NRC staff has not asked any applicant to comply with ISG-22. The NRC staff has pointed out to applicants that 10 CFR 72.122(h)(1) requires that no gross degradation occur. We think that a drain down with air has the potential for gross degradation and needs to be addressed. We suggested a number of alternatives that could be used to approach the issue. Should an applicant want to take a risk based approach, there is nothing in this ISG preventing it. The NRC staff will ask RAIs on issues that need to be addressed to meet the appropriate regulation.

Comment 9

Draft Interim Staff Guidance (ISG) 22 effectively requires 10 CFR Part 72 licensees to take actions that would be a significant additional burden to the licensees.

Industry recommends that this issue be evaluated as a generic issue in accordance with NRC Management Directive 6.4 and draft ISG-22 be withdrawn.

Response:

See Response 8. Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 10

Three options are suggested in draft ISG-22. Draft ISG-22 offers three options to address the fuel-in-air issue (lines 80-95). However, the ISG proceeds to discourage licensees from pursuing Options 2 or 3 and clearly attempts to persuade licensees or CoC holders to change their operating procedures to require a non-oxidizing gas environment surrounding the fuel at all times when the fuel cladding is not covered by water (lines 97-103).

Response:

As stated on line 101, of the draft ISG, the applicant can use any methodology they choose to address the issue. The ISG only contains three options with pros and cons of each.

Comment 10a

It is not clear that the ISG identifies a significant safety issue or that the suggested changes to operating procedures are risk-informed or would significantly improve safety commensurate with the cost of the actions.

Response:

If the applicant chooses to approach the issue using a risk-informed methodology, the staff will evaluate the methodology. See response to Comment 6.

Comment 11

Option 1 - Maintain the Fuel Rods in an Appropriate Environment to Prevent Oxidation. The current operating procedures for several cask designs (both bare-fuel designs and canister-based designs) permit air to be in contact with the fuel cladding for short periods of time during the loading operations. Users of two bare fuel cask designs drain the spent fuel pool water from the cask while it is suspended over the spent fuel pool after fuel loading. As the water drains out of the cask, air backfills in the space vacated by the water. Requiring a source of non-oxidizing gas to be connected to the cask while it is suspended over the spent fuel pool would be a significant operational change and would be a less safe evolution from an industrial safety perspective. Other licensees drain the water from the cask or canister prior to welding operations to minimize the potential for generation of hydrogen gas. Again, requiring a change in this operation would have a significant operational impact and must be supported by a clear safety benefit.

Response:

If this option is not suitable for the applicant or particular utilities, they are free to choose one of the other suggested options or propose and support one of their own.

Comment 12

Option 2 - Assure No Fuel Cladding Breaches. Draft ISG-22 suggests, as an alternative to requiring a non-oxidizing gas in the fuel cavity, assuring that there are no fuel cladding breaches by a "review of records (for example, sipping records) or 100% eddy current inspection of the assemblies." This alternative is not consistent with present industry practice or the guidance in ANSI N14.33 for classifying damaged fuel. Reactor operating records, alone, may be used to classify a fuel assembly as intact (or undamaged). That is, if a fuel assembly is documented to have been discharged from a cycle in which reactor coolant chemistry records confirm there were no leaking fuel assemblies, that assembly is considered undamaged and no additional inspections or tests are performed. A fuel assembly documented to have been discharged from the reactor when reactor coolant chemistry records indicate fuel leakage occurred may either be considered damaged or may be inspected or tested to confirm whether it is damaged or not. Acceptable techniques include fuel sipping, ultrasonic (UT) examination, and eddy current examination, and can vary plant-to-plant. This option in the ISG needs to be modified to include UT inspections and otherwise to be consistent with current industry practice and the guidance in ANSI N14.33.

Response:

The NRC staff is in the process of reviewing the recently issued ANSI standard to determine if they will recommend adoption of all or parts of it. The NRC staff agrees that if the in-reactor gas analysis indicates no failures in core, then all the assemblies in the core can be considered intact for that cycle. If the gas analysis indicates that a rod failure has occurred, then these records will not indicate the assembly containing the breached rod and all assemblies must be considered suspect until further tests are run. Without control rod insertions, sipping has a very short effective lifetime, eddy current requires removal of the rods from the assembly to identify the leaker, and visual only scans a limited surface of the rods. Once again the applicant is free to propose any method of leaker identification as long as it is supportable.

Comment 13

Option 3 - Determine a Time-at-Temperature Profile. This option has the potential for establishing a new, separate fuel cladding temperature limit for oxidizing gas atmosphere conditions in addition to the current limit of 400°C established in ISG-11 for non-oxidizing gas conditions. This could require CoC holders to re-perform the licensing basis storage system thermal analyses. This option would be best pursued generically rather than by individual licensees or CoC holders. This effort would enable industry to determine the specific technical boundaries where fuel rod splitting may be a concern during loading operations. When these parameters are defined, the risk and safety significance of the issue can be determined and appropriate changes to operating procedures may be made, as required.

Response:

The 400°C limit was never intended for use in an oxidizing atmosphere even for a short duration. The current oxidation rate equations were developed for low burnup fuel. Unless new data indicates a significant reduction in the oxidation rate for high burnup fuel, the applicant will need to show that the current rate equations are applicable to their fuel. This is probably a very fuel specific task comparing the characteristic of the fuel in the application with the fuel used to establish the data base used to develop the rate equations. It is obvious that some generic upper temperature can be established for these operations, but that temperature may be significantly lower than that required based on a fuel specific calculation. Additional operational concerns may arise at the lower temperature. If the industry would like to pursue the establishment of a generic temperature limit during loading, we would encourage such a project. Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 14

The ISG fails to describe when and where the fuel rod splitting phenomenon has actually occurred during a spent fuel cask loading campaign and under what conditions. Industry has loaded over 700 dry spent fuel storage systems in the past 20 years, including both bare fuel casks and canister-based systems, exposing the fuel to air during water removal in many cases. If fuel cladding was damaged due to fuel oxidation caused by exposure to air, the released radioactivity would likely that has detected any unexpected radioactive material in the exhaust stream during vacuum drying operations, meaning there is absolutely no indication of this phenomenon occurring.

Response:

The oxidation effect has not been observed to date. Concern was raised when the NRC was made aware that at least one utility was draining almost half the water from a cask before welding the lid and this utility thought the temperature of the rods may rise into the 350°C range. Without further details on past loading history, it is not possible to determine if any or all of the previous experience is relative. Loading of fuel that is very cold due to either low burnup or long pool residence, unbreached fuel, or cask that have had only limited water drained so no rods were uncovered, will not experience the oxidation phenomena. The NRC appreciates and applauds the industry for a fine safety record to date.

Comment 15

Industry believes the ISG requires actions to be taken that have not been considered in a risk-informed manner. The likelihood and safety significance of potential fuel rod splitting due to oxidation of fuel pellets must be evaluated for safety significance and weighed against the industrial safety implications of the proposed operating procedure changes to ensure the net change is a significant increase in safety to the public and plant operating personnel. Industry is willing to work in parallel with NRC to develop the appropriate technical boundaries of the issue in a timely manner, commensurate with its safety significance. Failure to fully evaluate the risk versus the consequences on the proposed actions could result in actions being taken that are, on the whole, less safe.

Response:

The NRC would not take or encourage actions that lead to a less safe operation. If the industry can demonstrate, either by action or analysis that the risk associated with the action does not warrant protecting the fuel from oxidation during cask loading operations, the NRC staff will assess such analysis as a possible solution to the problem.

Comment 16

Line 12: The phrase “(also known as blow-down)” should be deleted. Some storage systems simply drain the water from the cask.

Response:

Removed.

Comment 17

Lines 44-48: The sentence beginning with “As required. . .” is not clear. 10 CFR 72.122(h)(1) refers to gross rupture of the fuel cladding, not the fuel, and confinement of fuel, not fuel cladding. This sentence needs to be re-worded to more accurately reflect the regulations.

Response:

The 2nd and 3rd “fuel” in the sentence were changed to “fuel rod”.

Comment 18

Lines 55-57: The statement that the chemical form of oxidized fuel is different from the CoC implies that material of such a form violates the CoC. Such a statement fails to take into account that such material changes would occur in very small quantities. No definition of “significant” oxidation is provided. The statement also fails to recognize that other trace materials not specifically authorized by the CoC are routinely included (e.g., “crud”, boric acid residue, etc.) in the cask contents. This paragraph should be deleted.

Response:

Ref [EIN84] indicates that a length along the rod equal to several pellet diameters is oxidized to U_3O_8 prior to the time that the initial defects splits enough to be considered a gross breach. The sentence in question was modified to state ". . . If oxidation of the UO_2 fuel pellets is sufficient to develop a gross breach, then sufficient U_3O_8 is formed to change the chemical form from that . . ."

Comment 19

Lines 72-74: The terms "reasonable assurance" and "encouraged" don't appear consistent with the regulatory requirement to provide reasonable assurance that gross rupture of the fuel cladding will not occur. We suggest replacing "is encouraged" with "must be demonstrated."

Response:

Agree. The ISG will be revised to be consistent with the regulation.

Comment 20

Lines 84-86: No fuel inspection technique currently employed will "assure" there are no cladding breaches. As discussed above, industry believes that reactor operating records alone are sufficient to classify certain fuel assemblies as intact (or undamaged).

Response:

See response to Comment 12.

Comment 21

Line 88: This line refers to an air atmosphere. Elsewhere in the document care is taken to use a broader term, such as "oxidizing gaseous atmosphere." Consistent terminology should be used.

Response:

"Air" changed to "oxidizing."

Comment 22

Line 91: "Any" should be "Such an."

Response:

Changed.

Comment 23

Lines 93-94: This sentence is not clear and pre-supposes analysis work is required. We suggest re-wording this sentence, "Alternatively, fuel rod splitting in an oxidizing gas atmosphere might be precluded by imposing a maximum fuel cladding temperature while the fuel is in this environment."

Response:

If the applicant wants to use option 3, and prevent oxidation by limiting the maximum temperature, they will have to show that no oxidation occurs at that temperature. The maximum temperature will depend on the fuel in question, and the time the fuel will be at the maximum temperature. Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 24

Line 97: This line refers to visual inspection yet visual inspection is not included in Option 2. The acceptable types of inspections should be consistent.

Response:

The statements are consistent as written. Option 2 indicates the inspection techniques that are acceptable. Line 97 discusses the pitfalls of both the recommended and other, such as visual techniques.

Comment 25

Line 98: The term “pinhole cracks” is unclear. We suggest using “pinholes or hairline cracks.”

Response:

Changed.

Comment 26

Line 102: The term “inert atmosphere” appears to be inappropriate here. “Inert” may be construed to mean only a noble gas. However, as noted on Line 80, nitrogen (not a noble gas) is considered to be acceptable. A better term would be “nonoxidizing atmosphere.” We suggest that the sentence read: “The use of a nonoxidizing atmosphere in the fuel cavity to prevent fuel oxidation is one method accepted by the staff to address the issue.”

Response:

Changed.

Comment 27

Lines 105-117: The statement referring to “supportable analysis” implies that CoC holders and/or licensees are expected to perform additional analyses. This is also supported by recent licensing case work where NRC staff has requested an applicant to address this issue. This appears to be a request that should receive a formal backfit evaluation by NRC pursuant to 10 CFR 72.62.

Response:

The paragraph has been modified to indicate it is only applicable if the applicant chooses Option 3. Addressing the issue of potential oxidation of the fuel and providing analysis for Option 3 are two different things. A recent applicant has been asked to address the issue of fuel oxidation because 10 CFR 72 .122 (h)(1) clearly indicates that “no degradation leading to gross ruptures or otherwise be confined so the degradation will not pose operational safety problems with respect to its removal from storage.” This is within the purview of the technical review whether this ISG existed or not.

Any effect of oxidation in casks already loaded has already occurred. Until such time as the cask is to be unloaded, this is a non-issue for those casks; ergo any backfit and consequential action might require unnecessary fuel movement and its associated risks. Evaluation of the potential existence of this problem and subsequent actions can be determined at the time the cask is to be opened or transported.

Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 28

Lines 157 and 178: The lines appear to give inconsistent chemical formulas for the intermediate oxide (U_4O_9 and $UO_{2.4}$).

Response:

U_4O_9 should have an O/M ratio = 2.25. What researchers found was the structure of the phase formed, via x-ray diffraction is U_4O_9, but the weight plateau occurs at an O/M of 2.4. The phase is commonly referred to in the oxidation literature at U_4O_9 but the time to the plateau is measured at O/M = 2.4.

Comment 29

Line 166: This discussion appears to assume that an unlimited amount of oxidizing gas would be available to interact with the fuel, irrespective of the size of the cladding flaw. For small defects (pinhole leaks or hairline cracks) the amount of oxidizing gas entering the fuel cladding would be limited by the nature of the defect and would be considered in evaluating this issue.

Response:

The rate of oxidation may be limited by the oxygen content of the atmosphere, but there is no conclusive, even anecdotal, evidence that the size of the defect is limiting the access of oxidizing gas to the fuel.

Comment 30

Line 206: The comparison “1 micron vs. 10 micron” is ambiguous. It is not clear what dimensions are being compared or whether the “vs.” should be “to” in reference to a size range of the grains.

Response:

“vs 10 microns removed” to remove ambiguity.

Comment 31

Line 219: “CUN03" is cited as a reference but is not included in the reference section of the ISG.

Response:

This reference was inadvertently left in, and has been removed.

Comment 32

Line 221: It is not clear in this discussion or in the discussion of Option 3 whether the time period during vacuum drying before the cask is considered dry (i.e., a few torr of pressure) is included or excluded from concern with regard to this phenomenon.

Response:

This section is only intended for background information on oxidation. In this option, the applicant needs to account for all the time when the fuel is in an oxidizing atmosphere at an elevated temperature. This section indicates that data would support the applicants claim to be in a non-oxidizing atmosphere if the oxygen partial pressure is sufficiently low. Exactly how low is an uncertainty of the data base.

Comment 33

Line 224: “All oxidation” should be “Oxidation” to be consistent with the “few exceptions” caveat.

Response:

Correction made.

Comment 34

Line 264: “Spent Fuel” should be “Spent Nuclear Fuel.”

Response:

Correction made.

Comment 35

Lines 283-284: Delete “TIC: 238459.”

Response:

There is no reason to remove the notation. It is another method that a reader can obtain the reference through the Technical Information Center in Oak Ridge.

<u>Commentor 2</u>

Comment 1

From 10 CFR 72.122(h)(1), it is unclear whether the SNF oxidation needs to be prevented. The rule is implying that (a) SNF cladding must be protected against gross ruptures or (b) the SNF must be confined such that the oxidation should not pose operational safety. The risk assessment for (b) may allow the oxidation to some extent.

Response:

If the fuel is confined and is declared in the SAR as “damaged” then the comment is correct. If the fuel with pinholes or hairline cracks is considered “intact” per ISG-1, then oxidation to a gross breach must be prevented.

Comment 2

In that regard of the system performance, **Technical Review Guidance** seems to be very prescriptive. The stated inerting or lower temperature operation are design options to **prevent** the oxidation.

Response:

Agree.

Comment 3

In the 2nd line of **Fuel Oxidation and Cladding Splitting**, should read “temperature and burnup.”

Response:

Changed.

Comment 4

In the 3rd paragraph of **Fuel Oxidation and Cladding Splitting** - if cladding becomes more embrittled with H as burnup goes up, this strain criteria may be lowered.

Response:

The comment is true. This section is just a general background to the splitting phenomenon. The effects of hydrogen embrittlement are discussed on lines 237 and 238.

Comment 5

In the 9 and 10th lines of **Fuel Oxidation and Cladding Splitting**, if rims are mixed with Zr (from cladding), the oxidation will be slowed.

Response:

Rim effects are discussed in the section on the limitations of the data base.

Comment 6

In the 2nd paragraph of **Fuel Oxidation and Cladding Splitting**, under high humid conditions, schoepite or dehydrated schoepite would form. They will become more or less particulates under any applied stress.

Response:

Agree.

<u>Commentor 3</u>

Comment 1

In Appendix A to the draft ISG-22, NRC cited various reports on fuel oxidation and resulting cladding impacts. The data are predominantly from the 1980s, and do not necessary relate to the situation of concern cited by the NRC, i.e., fuel rods with minor cladding defects (pinhole leaks and hairline cracks) exposed to air for short periods during dry storage loading operations. Draft ISG-22 Appendix A refers to no new data pertinent to this issue, and the Commentor is unaware of any new and relevant data, other than the apparent absence of problems in actual dry storage operations. Appendix A does refer to recent Bechtel SAIC Company (BSC) study of handling spent fuel in air (Reference 2). That BSC study did not provide any new data and did not relate directly to dry storage loading operations at reactor sites. Also, NRC did not cite the Bechtel study as the basis for the new requirements related to fuel pellet oxidation. It is not clear why fuel oxidation in air during dry storage loading operations is now a risk-significant issue. Prior to issuance of the draft ISG, NRC should explain fully the rationale for imposing new requirements at this time in the absence of new adverse data.

Response:

The Commentor is correct that little new data on fuel oxidation has been obtained in recent years. Fuel oxidation is not a problem when the cask drainage or blow down is such that the fuel remains covered. It has recently come to the attention of the NRC that at least one licensee drains a substantial amount of water out of the cask and uncovers the fuel. The NRC has a concern that this might be occurring at other utilities thus the ISG was prepared. If a licensee does not drain or blow down the cask below the level of the fuel, this ISG does not affect that licensee.

Comment 2

In the draft guidance, NRC provides three possible alternatives for compliance: (1) maintaining fuel rods in a non-oxidizing environment (e.g., argon, nitrogen, or helium), (2) assuring that there are no cladding breaches, or (3) ensuring that time/temperature profile of loading operations precludes oxidation that would lead to a cladding breach. It is clear, however, from the draft guidance that NRC's strong preference is to preclude oxidation through the environment (Option 1). If adopted, this approach would impact some dry storage system loading operations. While it may appear to the NRC to be a "simple fix," this restriction would further complicate and constrain loading operations, with potential adverse impacts on drying times, industrial safety, and dose.

Response:

The NRC staff has presented three acceptable options. If these are not practicable for a utility, the NRC staff is amenable to the use of supportable options proposed by an applicant.

Comment 3

The Commentor understands that NRC is already requiring dry storage vendors to comply with draft ISG-22 in order to get approval for new applications and for applications to revise existing Certificates of Compliance (see Reference 3). This would appear to be premature, because there is no new information indicating a safety concern, and the guidance has just recently been provided to industry and to the public for comment. The Commentor recommends that NRC complete the development of its regulatory guidance, including consideration of public and industry input, prior to imposing new requirements.

Response:

The NRC staff has not asked any applicant to comply with ISG-22. The NRC staff has pointed out to applicants that 10 CFR 72.122(h)(1) requires that no gross degradation occur. We think that a drain down with air has the potential for gross degradation and needs to be addressed in any SAR. We suggested a number of alternatives that could be used to approach the issue. The NRC staff will ask RAIs on issues that need to be addressed to meet the appropriate regulation.

Comment 4

It appears that NRC has recently developed concerns relating to the potential for oxidation of fuel pellets during dry storage loading operations, and that those concerns are based on data that are at least ten years old. There appears to be no new relevant data, and NRC has presented no basis to conclude that it is now a risk-significant issue. The commentor believes that at this time the issue would most appropriately be addressed through further investigation. Rather than rushing to a regulatory quick fix for something that does not appear to be a problem, the commentor would prefer to work with the NRC and the industry to evaluate jointly the concern and identify actions, if any that are needed to address it. However, if NRC chooses to issue the ISG in final form, NRC should present the basis and justification for imposing additional requirements at this time. NRC should also clarify what it intends to do with respect to operations with already-certified systems, to which the ISG will not apply.

Response:

See the response to Commentor 3 Comment 1 and Commentor 1 Comment 27.

<u>Commentor 4</u>

Comment 1

Our primary recommendation concerns the citation in Appendix A of ISG-22 of “[BEC05]” the *Commercial Spent Nuclear Fuel Handling in Air Study* (Study). The commentor recommends that the NRC state that the Study is not directly applicable to the context of fuel handling situations presented in ISG-22, since the Study considers handling fuel at much higher temperatures and for extended durations than those expected for normal handling operations under 10 CFR Parts 71 or 72.

Response:

The NRC staff does not agree fully with the commentor. We agree that the model development was only a small part of the study, therefore we modified the statement to read “The DOE developed a model for fuel oxidation and cladding splitting, for use during long durations at the Yucca Mountain handling facility, that tries to account for the . . .” The temperatures of concern in the DOE study are above 300°C. This may involve the same temperature range of concern during a cask blow down. We do agree that the time span of interest is shorter during the cask drain down, but this in itself should not invalidate the use of the model.

Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 2

Technical Review Guidance, lines 88 through 95. The commentor recommends that the NRC expand the discussion for Approach 3. Equation 3 of “Oxidation of Spent Fuel in Air at 175° to 195°C” (Einziger, et al. 1992) shows that the time to reach the plateau (prior to U_3O_8 formation) is more than 24 hours and the temperatures less than 300°C. If the duration of blowdown is less than 24 hours and the temperature is limited to 300°C, oxidation to U_3O_8 should not be an issue. The NRC staff should include this information in the ISG as additional justification for Approach 3.

Response:

If this information was included into ISG-22, this guidance would be applicable for only low burnup fuel. Until the oxidation behavior of the rim in high burnup fuel is determined, the NRC staff is not sure that this guidance would also hold for higher burnup fuel.

Comment 3

Appendix A, lines 161 through 164. The commentor recommends that the NRC clarify the specific reference for these lines. Lines 161 through 164 assert that the mechanism of oxidation in unirradiated fuel differs from irradiated fuel and the mechanistic change occurs at or below 10 GWd/MTU. The Canadian data (Boase, D.G. and Vandergraaf, T.T., 1977, “The Canadian Spent Fuel Storage Canister: Some Materials Aspects”) relate to fuel below the 10 GWd/MTU level, while data contained in *Oxidation of Spent Fuel in Air* at 175° to 195°C (Einziger et al. 1992) has burnups approaching 30 GWd/MTU, so the transition point is not clear. The basis for citing “~10 GWd/MTU” should be provided.

Response:

Change will be made to read “This mechanistic change occurs between ~ 10 and 30 GWT/MTU.”

Comment 4

Appendix A, line 180. The commentor recommends that the NRC consider including a reference to “Oxidation of Fuel Rod under Dry Storage Condition” (Nakamura et al. 1995). This reference discusses the effects of both 1% air-Ar and 5% air-Ar test on whole rods and shows that the oxidation rates at these reduced air atmospheres are lower than in air alone.

Response:

Agree, reference added.

Comment 5

Appendix A, lines 201 through 202. The commentor recommends the NRC note that the DOE has performed limited bare fuel oxidation of ATM-109 fuel, including from the rim, with burnups greater than 60 GWd/MTU. The data are unpublished, but there was no U_3O_8 formation in 4000 hours at 305°C. Desgranges 2005 shows that the oxidation of very high burnup fuel is not faster because of the rim effect. This work was presented at the Materials Research Society (MRS) 2005, 29th International Symposium on the Scientific Basis for Nuclear Waste Management by Fournet et al. 2005. The NRC staff should consider this information when finalizing ISG-22.

Response:

The NRC staff thanks the commentor for bringing this work to our attention. Until the document is publicly available, we are not able to take a position on the work. When it is made publicly available applicants may be able to use the data to extend current models, developed for lower burnup fuels, to evaluate the oxidation rates of higher burnup fuel.

Also see last two paragraphs of response to Comment 5 of Commentor 1.

Comment 6

Appendix A, line 219. A reference should be provided for CUN03.

Response:

Reference was removed as it was no longer relevant.

Comment 7

Appendix A, lines 220 through 221. In addition to a reference to Nakamura et al. 1995 in Appendix A, line 180, the work described in Kohli et al. 1985 shows that in a limited oxygen environment (when oxygen is depleted by the oxidation process), the oxidation is localized, and the oxidation front propagates at a rate one order of magnitude slower than with unlimited oxygen. The commentor recommends the NRC include Kohi et al. 1985 as a reference in ISG-22 as support for the statements made in lines 220 through 221.

Response:

The Nakamura reference has been added. However, the Kohli work has limited applicability for the effects of depleted oxygen on the oxidation and splitting rate. The effects seen by Kohli could also be attributed to the complete deprivation of oxygen to the fuel for a substantial amount of time between changes of capsule atmospheres.

Comment 8

Appendix A, line 231. The text states that the tests were on PWR cladding, but the reference "[JOH84]" refers to BWR cladding in the title. The Staff should consider correcting this discrepancy.

Response:

PWR changed to LWR to make statement correct.

<u>Commentor 5</u>

Comment 1

Paragraph starting on line 83 under heading "Technical Review Guidance" on page 2, with respect to second approach. The reactor operating records should also be included in the review of records. Such a review could obviate additional inspections, such as sipping, if the fuel remained in operation during cycles where no fuel leak was identified.

Response:

Sipping records were only given as an example. Any combination of records that can support the claim of no breaches is acceptable.