UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC (Independent Spent Fuel Storage Installation)	)	ASLBP No. 97-732-02-ISFSI
	)	August 20, 1999

STATE OF UTAH'S REQUEST FOR ADMISSION OF LATE-FILED SECOND AMENDED UTAH CONTENTION Q[1]

Introduction

Pursuant to 10 C.F.R. § 2.714, the State of Utah hereby seeks the admission of late-filed Second Amended Contention Q. Second Amended Contention Q challenges the adequacy of the Applicant's analysis of potential accidents that may damage the integrity of spent fuel cladding.[2] In particular, the Applicant relies for satisfaction of

[1] This amended contention is supported by the Declaration of Marvin Resnikoff in Support of State of Utah's Second Amended Contention Q (August 20, 1999), which is attached hereto as Exhibit 1.

[2] On July 22, 1999, the State filed a request for admission of late-filed Amended Contention Q, which asserted that the Applicant must perform a revised cask stability analysis in conformance with newly issued NRC Staff guidance raising questions about the ability of stored spent fuel to withstand impacts. In responding to the contention, the Applicant pointed out that Holtec International, the manufacturer of the cask it intends to use, had performed such an analysis in June of 1999. It also appeared from the Applicant's Response that the Applicant intended to adopt the Holtec analysis in satisfaction of applicable NRC regulations. Therefore, the State withdrew Amended Contention Q on August 18, 1999. State of Utah's Reply to Applicant's and Staff's Responses to Amended Contention Q and Notice of Withdrawal of Amended

10 C.F.R. § 72.74(d) on a cask stability analysis by Holtec International, Inc. ("Holtec"), which is inadequate to show that the storage casks used at the proposed Private Fuel Storage Facility ("PFSF") will maintain their integrity under design accident conditions.

As discussed below, the amended contention satisfies the Commission's standards for late-filing.

Background

The Applicant's analysis of a hypothetical cask drop/tip-over accident is addressed in Section 8.2.6 of the PFS Safety Analysis Report ("SAR"). With respect to accidents involving the HI-STORM cask, the Applicant relies on the analysis presented in section 3.5 of the Holtec Topical Safety Analysis Report ("TSAR") that asserts that the most vulnerable fuel can withstand 63g's in the most adverse orientation. PFS SAR, Rev. 0, at 8.2-31.

Based on these statements in the PFS application, the State's original contention Q charged that: "The Applicant has failed to adequately identify and assess potential accidents, and therefore, the Applicant is unable to determine the adequacy [of] the ISFSI design to prevent accidents and mitigate the consequences of accidents as required by 10 CFR 72.24(d)(2)." State of Utah's Contentions on the Construction and Operating License Application by Private Fuel Storage LLC for An Independent

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Contention Q. Second Amended Contention Q addresses the State's concern that the Holtec analysis is inadequate to satisfy the NRC's regulations.

Spent Fuel Storage Facility (November 23, 1997) ("State's Contentions") at 114-115. Bases 1 and 3 related to the failure to take into account stresses on fuel cladding that would increase its vulnerability to impacts:

> The Applicant states that "the most vulnerable fuel" can withstand 63 g in the most adverse orientation. SAR at 8.2-32. However, the Applicant does not provide the basis for its statement. The Applicant does not specify whether this includes fuel with leaks and cladding failures which has been stored underwater for many years and dry for many more years. Furthermore the Applicant has not provided the g loading that would cause such fuel to fail.
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> * * *
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> The cask maximum lift heights of 10 and 18 inches imply that vertical drops greater than these amounts would result in damage to the canister or interior contents. SAR at 10.2-9. The Applicant must not only address lifting accidents while onsite at the ISFSI, but at the intermodal transfer site or during transport on either rail or highway, where significant damage could occur during an accident with potential resulting release of nuclear material. Cladding of spent fuel elements is likely to be very brittle through extensive radiation embrittlement, so cladding failure is likely during such accidents.

State's Contentions at 114-115.

In opposing the admission of Contention Q, the Applicant stated that the analysis described in the PFS SAR relied on report UCID-21246, by the Lawrence Livermore National Laboratories)(October 20, 1987) ("LLNL Report"), which identifies the 17 x 17 Westinghouse fuel assembly as the "most vulnerable fuel." Applicant's Answer to Petitioner's Contentions at 208 (December 24, 1997) ("Applicant's Answer to Contentions"). According to the Applicant, the LLNL Report states that despite having "the worst combination of the longest unsupported

length and the thinnest cladding wall thickness," the Westinghouse fuel can "sustain a load in bending equivalent to 63 g's at 380 degrees Celsius without exceeding the yield strength of the cladding at that temperature." Id., *citing* LLNL Report at § 4.0, page 4.

Both the Applicant and the Staff challenged the State's failure to provide a basis for its concern that the cladding was more vulnerable to rupture than supposed by the Applicant. Applicant's Answer to Contentions at 209; NRC Staff's Response to Contentions Filed by (1) the State of Utah, (2) the Skull Valley Band of Goshute Indians, (3) Ohngo Gaudadeh Devia, (4) Castle Rock Land and Livestock L.C., et al., and (5) the Confederated Tribes of the Goshute Reservation and David Pete (December 24, 1997) at 39-40. At the Prehearing Conference, the State argued that although the Applicant had provided more information about what it characterizes as the most vulnerable fuel, it still had not specified whether the fuel analyzed "includes fuel with leaks and cladding failures that has been stored under water for many years and stored dry for many more years," making the fuel "especially vulnerable." Statement by Diane Curran, Tr. at 390-91 (January 28, 1998). In addition, the State argued, the Applicant had not "described the G-loading that would cause such fuel to fail." Id.

Contention Q and its bases were denied admission in their entirety by the Licensing Board in LBP-98-7, 47 NRC 142, 195, aff'd on other grounds, CLI-98-13, 48 NRC 26 (1998). Without explaining its application of the law to the facts, the Board

summarily ruled that the contention and its bases:

> fail to establish with specificity any genuine material dispute; impermissibly challenge the Commission's regulations or rulemaking-associated generic determinations; lack materiality; lack adequate factual or expert opinion support, and/or fail properly to challenge the PFS application.

LBP-98-7, 47 NRC at 195.

On May 21, 1999, the NRC Staff issued NRC Interim Staff Guidance document ISG-12 - Buckling of Irradiated Fuel Under Drop Conditions, which is attached hereto as Exhibit 2. ISG-12 recommends that any analyses which rely on the LLNL Report should be re-done, using either the new information about the effects of irradiation, or an alternative method which demonstrates that cladding stress remains below yield.

On June 8, 1999, ten days before ISG-12 became available to the public, Holtec submitted Revision 7 to its TSAR for the HI-STORM storage cask. Section 3.5 of the revised TSAR contains a new cask stability analysis, which responds to the information provided in ISG-12.

PFS has not issued any license application amendment adopting the revisions to Section 3.5 of the Holtec TSAR into its own license application. However, statements in the Applicant's and NRC Staff's responses to the State's July 22, 1999 request for admission of Amended Contention Q, indicate that the Applicant intends to adopt Holtec's revised cask stability analysis in satisfaction of 10 C.F.R. § 72.24(d)(2). Applicant's Response to State of Utah's Request for Admission of Late-filed Amended Utah Contention Q at 8 (August 6, 1999) ("Applicant's August 6 Response"); NRC

Staff's Response to State of Utah's Request for Admission of Late-filed Amended Utah Contention Q at 11, note 12 (August 5, 1999) ("NRC Staff's August 5 Response").

AMENDED CONTENTION Q: The Applicant has failed to adequately identify and assess potential accidents involving impacts to fuel cladding. In particular, the Applicant has failed to take into consideration (a) compounded embrittlement and thinning of the zircalloy cladding, and (b) the dynamic effects of a cask drop accident. Therefore, the Applicant is unable to determine the adequacy of the ISFSI design to prevent accidents and mitigate the consequences of accidents as required by 10 CFR 72.24(d)(2).

BASIS: In its SAR, the Applicant represents that the most vulnerable fuel cladding in the storage casks at the PFS facility can withstand an impact of 63 g's. SAR at 8.2-32. The Applicant relies for this calculation on Holtec's accident analysis, which in turn relies on the LLNL Report. *Id.*, *citing* Holtec TSAR and Reference 21 (the LLNL Report).

The Applicant now appears to rely on a new analysis, submitted by Holtec in Rev. 7 to its HI-STORM TSAR. The revised analysis constitutes an improvement, but does not fully satisfy the directives of ISG-12 or other applicable NRC guidance. Holtec now uses the assumptions in ISG-12 that led the Staff to calculate a likely force of 13g's at which cladding would be damaged, rather than 63g's. However, Holtec imposes a constraint on the system, namely that the cladding cannot bow greater than

the dimensions of the lattice in which it is placed. This is a valid assumption. When it is assumed that the cladding cannot bow greater than the dimensions of the lattice, Holtec calculates that the maximum force the cladding can withstand rises from 13g's to approximately 64g's. SAR at 3.5-15. This is greater than the 63g's previously calculated by Holtec and asserted in Rev. 0 of the PFS SAR.

However, two significant issues still have not been addressed by Holtec, which could have a significant effect on the g force that the cladding can tolerate. Therefore, the Holtec analysis constitutes an inadequate basis for determining the Applicant's compliance with 10 C.F.R. § 72.24(d)(2).

a) One of the deficiencies in the LLNL Report that is criticized in ISG-12 is that the analysis assumes material properties applicable to unirradiated fuel. ISG-12 at 1. ISG-12 recommends that the characteristics of irradiated fuel should be included, in either of the two alternative methodologies proposed. *Id.* at 2. Although ISG-12 characterizes this as a recommendation, it is clear that consideration of these characteristics is essential to performing an adequate cask stability analysis. This is illustrated by the fact that when the Staff re-did the LLNL analysis, taking irradiation effects into account, the g force that could be withstood by the cladding dropped dramatically from 63 g's to 13 g's, which is far below the design basis (45 g) for the HI-STORM cask. *See* PFS SAR at 8.5-31.

Contrary to the guidance of ISG-12, there is no indication in the HI-STORM

TSAR that Holtec took into account the effects of the irradiation and consequent embrittlement of the zirconium alloy used in the cladding. The effect of continual bombardment by neutrons over time is to make the cladding more brittle and easily shattered. This embrittlement effect is likely to be compounded by thinning of the zircalloy cladding in high-burnup fuel, a phenomenon recognized by the NRC Staff in NRC Information Notice 98-29, Predicted Increase in Fuel Rod Cladding Oxidation (August 3, 1998) (attached hereto as Exhibit 3). As noted in IN 98-29, higher burnup fuel has a wall thinning effect (up to 17% according to Westinghouse). The State's expert has calculated that this would lead to a 25% reduction in g force to cause cladding failure. *See* Table entitled "Effects of Changing Variables," attached hereto as Exhibit 4. As demonstrated by comparing columns A and C of the table, the force of 63.54 g's drops to 50.81 (a reduction of 25%) when a 17% decrease in fuel cladding thickness is assumed.

The combined increased embrittlement and increased thinning of the cladding is likely to have a significant effect on the size of the g force that is necessary to rupture the cladding, and therefore it must be considered in the analysis.

b) As instructed by ISG-12, Holtec's revised cask drop analysis takes into account the weight of fuel by assuming the cladding weight is due to the zirconium alloy plus weight of fuel. However, Holtec applies an oversimplistic static analytical model, using fixed moments, forces, and accelerations. TSAR at 3.5-7 and following.

In fact, the forces at work within the cask are more complex, requiring a dynamic analysis that takes into account the physical structure of the fuel pellets and their relationship to the cladding.

For instance, the Holtec analysis simply replaces the fuel pellets inside a fuel rod with effectively heavier cladding. This is incorrect. Within each fuel rod, the fuel pellets are stacked on their sides, inside the cladding. As Holtec acknowledges, during an horizontal drop, the cladding bows. When the cask drops, the individual pellets will break from their initial rigid constraint and strike the thin cladding. This has a dynamic effect similar to that of a "water hammer" that occurs in nuclear power plant piping. This would add an additional impulsive force on the cladding. Thus, the g force on the cladding may well be greater than the 45 g force to which the cladding is ostensibly designed. Holtec has not taken this significant dynamic effect into consideration.

The Applicant has previously argued that the Commission has determined that the cladding need not be maintained if additional confinement is provided, and that the "canister could act as a replacement for the cladding." Applicant's Answer to State's Contentions at 209-210, *citing* 51 Fed. Reg. 19,106, 19,108 (1986); 53 Fed. Reg. 31,651 (1988); 10 C.F.R. § 72.122(h)(1). Section 72.122(h) provides that:

> The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning

of consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

The Applicant appears to believe that this regulation allows it to disregard a cladding failure and to fall back on the canister as the sole means of confining radioactivity in the cask. This is a misinterpretation of the regulation that would eviscerate the defense-in-depth, multiple barrier approach on which the Applicant has relied in its license application.[3] The regulation merely provides that if the cladding fails, then the licensee may substitute another, *additional* protective barrier, such as an additional canister.[4] Reg. Guide 3.48, Standard Format and Content for the Safety

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[3] The SAR for the PFS facility refers to Chapter 7 of the Holtec HI-STORM TSAR for a description of the "confinement design" for the HI-STORM storage system. PFSF SAR § 4.2.1.5.5. As explained in the TSAR, the HI-STORM cask relies on "multiple confinement barriers provided by the fuel cladding and the MPC enclosure vessel [*i.e.*, the canister] to assure that there is no release of radioactive material to the environment." Holtec Report HI-951312, Revision 5, at 7.2-1 (February 1999).

[4] In its August 6 Response to Amended Contention Q, the Applicant argued that the State's discussion of the concept of multiple confinement "does not refute the authority cited at pages 209-210 in Applicant's December 24, 1997 Answer to Petitioners' Contentions, in particular the quotation from the proposed rule) 51 Fed Reg. 19,106, 19,108 (1986) which explicitly provides that the 'canister could act as a replacement for the cladding.'" Applicant's Response at 9, note 12. The Applicant misunderstands the rule, and completely ignores the defense in depth concept underlying the Commission's general requirement that spent fuel be protected by both cladding and canister. The Commission's requirement that spent fuel must be containerized when the cladding fails does not amount to the abandonment of the general requirement that spent fuel cladding must perform its function. Indeed, all NRC regulatory guidance, as addressed by PFS in the SAR and Holtec in the HI-STORM TSAR, assumes that under ordinary circumstances, both the cladding and the canister are available to protect the public from potential escapes of radioactivity from a storage cask.

Nor does the fact that PFS's accident dose calculation assumes a 100% fuel cladding failure lend any support to the Applicant's argument. Applicant's Response

Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage) (1989) also contemplates that license applications will address "protection by multiple confinement barriers and systems." Reg. Guide 3.48 § 3.3.2. It would utterly defeat the concept of multiple confinement, as well as the representations in the license application regarding the assurance of safety through defense-in-depth, if one of the confinement barriers could be completely disregarded when it failed.

The cask maximum lift heights of 10 and 18 inches imply that vertical drops greater than these amounts would result in damage to the canister or interior contents. SAR at 10.2-9. The Applicant must not only address lifting accidents while onsite at the ISFSI, but at the intermodal transfer site or during transport on either rail or highway, where significant damage could occur during an accident with potential resulting release of nuclear material.[5] Cladding of spent fuel elements is likely to be very brittle through extensive radiation embrittlement; so cladding failure is likely during such accidents.

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at 9 note 12. As with any other type of accident analysis, the analysis simply assesses whether, when the principal safety system fails, the backup system can perform the required safety function. This is entirely consistent with the NRC's defense-in-depth approach to safety regulation.

[5] The Applicant has argued that this requirement would not apply to the intermodal transfer facility ("ITF"), because it is a transportation facility. Applicant's August 6 Response at 9. As discussed in Utah Contention B, however, the State contends that the ITF does constitute a storage facility.

Satisfaction of Late Filed Factors:

The State meets the 10 CFR § 2.714(a) late filed factors for amending its contention.

Good Cause: First, the State has good cause for the late filing. The State first became aware that the Applicant intends to amend its license to rely on the revised Holtec cask stability analysis when the Applicant filed its August 6 Response to Amended Contention Q. (Because of an e-mail transmission problem, the State did not receive the Applicant's Response until August 10, 1999). Although Holtec had submitted the revised analysis to the NRC on June 8, 1999, the Applicant did not not mention any change in Chapter 8 of the PFS SAR, which addresses the accident analysis required for compliance with 10 C.F.R. § 72.24(d)(2), when it amended its SAR on August 10, 1999. Letter from John D. Parkyn, PFS, to NRC, enclosing Amendment 4 to PFS License Application. In particular, there were no change pages to Chapter 8, no discussion of the revised Holtec analysis, and no change to either the SAR's reliance on the 1997 Revision 1 to the Holtec HI-STORM TSAR (listed as Reference 1 in the SAR at page 8.4-1), or the SAR's reliance on the 1987 LLNL Report, which is listed as Reference 21 in the SAR at page 8.4-2. As the State has discussed in previous pleadings before this Board, the NRC's regulations unequivocally require intervenors to identify disputes with the license application. *See* State of Utah's Request for Admission of Late-Filed Amended Utah Contention C at 15-17 (June 23,

1999). If anything, by raising this issue based on representations in the Applicant's pleadings before they have been adopted in the license application, the State is raising this issue early.[6]

The State also has good cause because it has diligently pursued the issue of the inadequacy of the Applicant's cask stability analysis since this proceeding began. The State first attempted to raise the issue in Contention Q in 1997, but the contention was rejected. Then, because the State had no recourse through this licensing proceeding, the State and Dr. Resnikoff pursued the issue through comments on the Safety

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[6] The State also notes that it has made a reasonable effort to keep up with the amendments to the Holtec TSAR for the HI-STORM storage cask. To this end, the State has had an ongoing informal arrangement with Holtec, by which Holtec sends the State revisions to the TSAR. *See* letter from Denise Chancellor, State of Utah Attorney General's office, to Gary Tjerland, Holtec International (June 9, 1999), attached hereto as Exhibit 5. In general, Holtec sends the revisions as they are issued. The Holtec TSAR has been in a flurry of revisions over the last several months, as the application is in the last stages of being finalized. Thus, Holtec did not send either Revision 7 or Revision 8 to the State when they were issued in June of 1999. Instead, at the end of July, Holtec sent the State a copy of Revision 9, which incorporates all of the changes that were made in Revisions 7, 8, and 9. *See* letter from Brian Gutherman, Holtec International, to Denise Chancellor, State of Utah Attorney General's Office (July 27, 1999) (attached hereto as Exhibit 6), enclosing Revision 9 to HI-STORM TSAR. This amended contention is being filed within 30 days of the State's receipt of Rev. 9.

Nevertheless, it is important to bear in mind that the PFS SAR, and not the Holtec TSAR, is the focus of this licensing proceeding. It is reasonable for the State to assume that, if some revision to the TSAR is to be relied on by the Applicant, the Applicant will provide notice of its changed reliance in an amendment to the PFS SAR. The State has made a much more diligent attempt to keep up with relevant amendments to the TSAR than the Applicant's effort to meet its obligation to incorporate relevant TSAR changes into its license application. The State should not be penalized for the Applicant's lax approach to revising the PFS SAR, or the Staff's endorsement of its lax approach. *See* Staff's August 5 Response at 11 note 12.

Evaluation Report for the HI-STAR transportation cask, and through correspondence with the NRC Staff. Although the Applicant and the Staff cite these efforts as showing a lack of good cause, precisely the opposite is true: the State has continued to try to raise the issue in every way possible, despite the Board's rejection of the issue.

Moreover, the validity of the State's concerns have been vindicated by the Staff's issuance of ISG-12, which effectively implements the concerns raised in Amended Contention Q and Dr. Resnikoff's correspondence with the Staff. Now that Holtec and the Applicant have responded to ISG-12 by providing the analysis that the State has sought since 1997, it is appropriate that the State be given an opportunity to address whether the analysis is sufficient to demonstrate the integrity of PFS's casks under accident conditions.

Development of a Sound Record: The State's participation will assist in developing a sound record. Dr. Resnikoff, who has considerable expertise in technical issues regarding the storage and degradation of spent nuclear power plant fuel, will testify regarding Amended Contention Q. As stated in his attached Declaration, the amended contention constitutes a summary of the testimony that he will provide. He expects that his testimony will be augmented and refined after he has had a chance to review the calculations underlying the information provided in the Holtec TSAR.

Availability of Other Means for Protecting The State's Interests: The State has no alternative means, other than this proceeding, for protecting its interest in

ensuring that the accident analysis for safety components used at the PFS facility is adequate to ensure the protection of its citizens from excessive radiation doses. Although the Applicant argues that the adequacy of the cask design to protect against accidents is a generic issue related only to the approval of the HI-STORM storage cask, this position is belied by the regulations, which explicitly require the applicant for an ISFSI to provide an analysis of the adequacy of structures and components to protect against accidents. 10 C.F.R. § 72.24(d)(2). There is no other forum in which the State can challenge the adequacy of the PFS license application to provide this required information. Moreover, to the extent that the generic rulemaking for the HI-STORM casks will address the issue, it is a very different kind of proceeding, which affords the State much less of an opportunity to vindicate its views. In the rulemaking for the approval of the HI-STORM cask, the State may submit written comments. However, it may not conduct discovery to probe the basis for the assertions in the HI-STORM TSAR, nor may it cross-examine the applicant's experts in a hearing. Thus, whatever opportunity may exist to criticize the HI-STORM cask design falls far short of the formal hearing provided for the proposed PFSF.

Representation by Another Party: The State's position will not be represented by any other party, as there is no other party with a similar contention admitted to this proceeding.

Broadening of Issues or Delay of the Proceeding: The admission of Second

Amended Contention Q will not unduly broaden or delay the proceeding. Litigation of the contention would require the opportunity for some discovery into the basis for the new Holtec analysis, which could be accomplished in Phase II of the hearing. The addition of one more issue, which is clearly defined and limited in its scope, would not delay the completion of Phase II or place any unreasonable burdens on the parties. To the extent that the litigation does broaden or delay the proceeding, it is nevertheless important and worthwhile, because it raises a fundamental safety issue regarding the integrity of spent fuel storage casks under accident conditions.

Conclusion

For the foregoing reasons, Second Amended Contention Q is both admissible and meets the Commission's standard for late filed contentions. Accordingly, it should be admitted.

DATED this 20th day of August, 1999.

Respectfully submitted,

Denise Chancellor, Assistant Attorney General
Fred G Nelson, Assistant Attorney General
Laura Lockhart, Assistant Attorney General
Diane Curran, Special Assistant Attorney General
Connie Nakahara, Special Assistant Attorney General
Attorneys for State of Utah
Utah Attorney General's Office
160 East 300 South, 5th Floor, P.O. Box 140873
Salt Lake City, UT 84114-0873
Telephone: (801) 366-0286, Fax: (801) 366-0292

CERTIFICATE OF SERVICE

I hereby certify that a copy of STATE OF UTAH'S REQUEST FOR ADMISSION OF LATE-FILED SECOND AMENDED UTAH CONTENTION Q was served on the persons listed below by electronic mail (unless otherwise noted) with conforming copies by United States mail first class, this 20th day of August, 1999:

Rulemaking & Adjudication Staff
Secretary of the Commission
U. S. Nuclear Regulatory Commission
Washington D.C. 20555
E-mail: hearingdocket@nrc.gov
(original and two copies)

G. Paul Bollwerk, III, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: gpb@nrc.gov

Dr. Jerry R. Kline
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: jrk2@nrc.gov
E-Mail: kjerry@erols.com

Dr. Peter S. Lam
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: psl@nrc.gov

Sherwin E. Turk, Esq.
Catherine L. Marco, Esq.
Office of the General Counsel
Mail Stop - 0-15 B18
U.S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: set@nrc.gov
E-Mail: clm@nrc.gov
E-Mail: pfscase@nrc.gov

Jay E. Silberg, Esq.
Ernest L. Blake, Jr.
Shaw, Pittman, Potts & Trowbridge
2300 N Street, N. W.
Washington, DC 20037-8007
E-Mail: Jay_Silberg@shawpittman.com
E-Mail: ernest_blake@shawpittman.com
E-Mail: paul_gaukler@shawpittman.com

John Paul Kennedy, Sr., Esq.
1385 Yale Avenue
Salt Lake City, Utah 84105
E-Mail: john@kennedys.org

Richard E. Condit, Esq.
Land and Water Fund of the Rockies
2260 Baseline Road, Suite 200
Boulder, Colorado 80302
E-Mail: rcondit@lawfund.org

Joro Walker, Esq.
Land and Water Fund of the Rockies
2056 East 3300 South Street, Suite 1
Salt Lake City, Utah 84109
E-Mail: joro61@inconnect.com

Danny Quintana, Esq.
Danny Quintana & Associates, P.C.
68 South Main Street, Suite 600
Salt Lake City, Utah 84101
E-Mail: quintana@xmission.com

James M. Cutchin
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
E-Mail: jmc3@nrc.gov
(*electronic copy only*)

Office of the Commission Appellate Adjudication
Mail Stop: 16-G-15 OWFN
U. S. Nuclear Regulatory Commission
Washington, DC 20555
(*United States mail only*)

Laura Lockhart
Assistant Attorney General
State of Utah

EXHIBIT 1

UNITED STATES OF AMERICA

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	
PRIVATE FUEL STORAGE, L.L.C. (Independent Spent Fuel Storage Installation)	Docket No. 72-22-ISFSI

August 20, 1999

DECLARATION OF DR. MARVIN RESNIKOFF IN SUPPORT OF STATE OF UTAH'S SECOND AMENDED CONTENTION Q

1, Dr. Marvin Resnikoff, declare under penalty of perjury that:

1. I am the Senior Associate at Radioactive Waste Management Associates, a private consulting firm based in New York City. On November 20, 1997 and January 16, 1998, I prepared declarations which were submitted to the Licensing Board by the State of Utah in support of its contentions regarding Private Fuel Storage, L.L.C.'s proposed Independent Spent Fuel Storage Installation. I assisted in the preparation of State of Utah's original Contention Q, which was submitted on November 23, 1997. A statement of my qualifications was attached to the November 1997 declaration. I also prepared a declaration in support of the State of Utah's Amended Contention Q (July 22, 1999), which was subsequently withdrawn.

2. I am familiar with Private Fuel Storage's ("PFS's") license application and Safety Analysis Report in this proceeding, as well as the applications for the storage and transportation casks PFS plans to use. I am also familiar with NRC regulations, guidance documents, and environmental studies relating to the transportation, storage, and disposal of spent nuclear power plant fuel, and with NRC decommissioning requirements.

3. I assisted in the preparation of the State of Utah's Second Amended Contention Q. The technical facts presented in the Second Amended Contention Q are true and correct to the best of my knowledge, and the conclusions drawn from those facts are based on my best professional judgment.

4. If Second Amended Contention Q is admitted for litigation, I would testify regarding my

opinion of the inadequacy of the cask stability provided in the Holtec HI-STORM Topical Safety Analysis Report ("TSAR"), Rev.9, provided to the State by Holtec under cover letter dated July 27, 1999. Second Amended Contention Q provides a summary of the testimony I would give, based on the information that has been provided to date. I would expect to be able to expand upon and refine my testimony, after having an opportunity to review the calculations that underlie the information provided in the TSAR.

Dr. Marvin Resnikoff

July 22, 1999

EXHIBIT 2

ISG-12 - Buckling of Irradiated Fuel Under Drop Conditions

Dry Cask Storage | News and Information | NRC Home Page | E-mail

Spent Fuel Project Office

Interim Staff Guidance - 12

Issue: Buckling of Irradiated Fuel Under Bottom End Drop Conditions

Discussion:

Fuel rod buckling analyses under bottom end drop conditions have traditionally been performed to demonstrate integrity of the fuel following a cask drop accident. The methodology described by Lawrence Livermore National Laboratory (LLNL) to analyze the buckling of irradiated spent fuel assembly under a bottom end drop in their report UCID-21246 is a simplified approach. It assumed that buckling occurred when the fuel rod segment between the bottom two spacer grids reached the Euler buckling limit. The weight of fuel pellets was neglected in the analysis; only the weight of the cladding was considered. Material properties for unirradiated cladding were used. The buckling analysis also neglected the stiffness of the pellets which could have been fused or locked to the cladding. It assumed the total weight of the cladding to be on top of the fuel rod segment between the bottom two spacer grids. In addition, it also assumed that the fuel rod segment between the bottom two spacer grids was pin-connected. The restraint and lateral support of the fuel basket structure to the fuel assemblies were ignored in the analysis.

The weight of pellets and irradiated material properties should be included in any end drop analysis. With these changes, the simplistic method of UCID-21246 may not yield acceptable results. For example, the staff conducted calculations using the same methodology as LLNL report UCID-21246 except irradiated material properties for the clad, and the weight of fuel pellets are included in the calculations. The most vulnerable fuel assembly in the LLNL report, a 17x17 Westinghouse fuel assembly, was chosen for this exercise. Euler buckling loads for the clad were calculated using the following formula:

$P_{cr} = {}^2EI/L^2$

where

$E_{clad} = 10.47 \times 10^6$ psi

$I_{clad} = 1/4 \times (r_o^4 - r_i^4) = 1/4 \times (0.187^4 - 0.1645^4) = 3.85 \times 10^{-4}$ in^4

L = 24 inches

The results indicate that

P_{cr} = 69 lb

Since the weight of cladding and pellets for the 144 inch-long fuel rod is about 4.98 lb, the buckling load in terms of gravitational acceleration (g) is

$P_{cr}/W = 69/4.98 = 13.86$ g

This is considerably smaller than the 82 g reported in the LLNL report UCID-21246. However, there are several bounding assumptions in this approach which make the results unrealistically low for predicting cladding failure.

Conclusion:

Analyses of fuel rod buckling performed to demonstrate fuel integrity following a cask drop accident yield results which contain a large margin to actual failure. The calculated onset of buckling does not imply fuel or cladding failure. Where such analyses yield unacceptable results, more realistic analyses of dynamic fuel behavior are appropriate and acceptable. If the cladding stress remains below yield strength, the fuel integrity is assured.

Recommendation:

If the analytical approach described in the LLNL report UCID-21246 for axial buckling is used to assess fuel integrity for the cask drop accident, the analysis should use the irradiated material properties and should include the weight of fuel pellets.

Alternately, an analysis of fuel integrity which considers the dynamic nature of the drop accident and any restraints on fuel movement resulting from cask design is acceptable if it demonstrates that the cladding stress remains below yield. If a finite element analysis is performed, the analysis model may consider the entire fuel rod length with intermediate supports at each grid support (spacer). Irradiated material properties and weight of fuel pellets should be included in the analysis.

The appropriate section of Standard Review Plan, NUREG-1536, should be revised to clearly Reflect analytical approach for fuel rod bucking analyses.

Approved

E. William Brach

Date

301.415.6500

EXHIBIT 3

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

August 3, 1998

NRC INFORMATION NOTICE 98-29: PREDICTED INCREASE IN FUEL ROD CLADDING OXIDATION

Addressees:

All holders of operating licenses for nuclear power reactors, except those licensees who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

Purpose:

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees of recent Westinghouse experience with one of its reactor fuel designs which has exhibited higher than expected rates of oxidation of zircalloy cladding at high burnups . It is expected that recipients will review the information for applicability to their facilities and consider action as appropriate, to avoid similar problems. The material and discussion contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On October 28, 1997, Westinghouse notified NRC that modification of its fuel cladding corrosion model in its fuel rod design code, PAD, to reflect new data on Zircaloy-4 oxidation at high burnup may create compliance issues for its Integral Fuel Burnable Absorber (IFBA) fuel with Zircaloy-4 cladding. The modified code may predict higher fuel temperatures and internal pressures at high burnup conditions. This, in turn, may lead to code results that do not meet the Westinghouse criterion prohibiting gap reopening and that do not meet the loss-of-coolant accident (LOCA) criterion in 10 CFR 50.46(b)(2).

The Westinghouse criterion prohibiting gap reopening was approved by the NRC staff for steady-state operation when internal pressure in the rod exceeds reactor coolant system pressure. The staff approved this criterion in lieu of a criterion requiring that the internal pressure of the fuel rod not exceed reactor coolant system pressure. Both criteria have the same purpose, which is to not allow separation between the fuel pellet and the cladding late in life; this limits temperature difference between fuel and clad and therefore minimizes maximum fuel temperature.

The acceptance criterion in 10 CFR 50.46(b)(2) requires that the calculated maximum total oxidation of the cladding not exceed 0.17 times the total thickness of the cladding before oxidation. Total oxidation includes both pre-accident oxidation and oxidation occurring during a LOCA. If this total oxidation limit were to be exceeded during an accident, the cladding could become embrittled. The cladding could then fracture and fragment during the reflood period and lose structural integrity. This in turn could compromise the structural soundness and coolable geometry of the core and ultimately the ability to keep the core cooled.

Historically, the focus of compliance with 10 CFR 50.46 has been on 10 CFR 50.46(b)(1), "Peak Cladding Temperature," which usually is most limiting at the beginning of fuel life. Because the oxidation rate is known to be dependent on temperature, total oxidation was also deemed most severe

at the beginning of life (BOL). The contribution of preaccident oxidation to the calculated total oxidation had not previously been thought to be significant, but as measured cladding oxidation thickness in the later stages of assembly service life increased faster than had been predicted, it became so.

On November 6, 1997, the NRC staff, Westinghouse, and the Westinghouse Owners Group (WOG) met in a public meeting to discuss this matter. At that meeting, the WOG stated that it would provide a list of affected plants, the projected dates when each might become vulnerable to potential non-compliance, and details of its plans to address the issue. The WOG also stated that each affected plant would take appropriate individual actions in terms of reporting pursuant to 10 CFR 50.46(a)(3)ii before the plant reached its projected date of vulnerability.

Westinghouse stated that it planned to perform more detailed assessments for individual plants and to make timely recommendations to each licensee for compensatory actions with regard to the compliance issue. In the longer term, Westinghouse will correct its model in PAD to better account for recent higher burnup oxidation data and will begin using the revised model by August 1998.

The NRC staff found that this approach was adequate to address in the near term the specific problems reported by Westinghouse and that plants with Westinghouse IFBA fuel could continue to operate in compliance with 10 CFR 50.46. The staff noted that the burnup related phenomena, which could result in noncompliance with the oxidation requirements of 10 CFR 50.46, may not be limited to Westinghouse IFBA fuel but might affect any Zircaloy fuel used in high burnup applications. The staff also notes that the oxidation-related phenomena discussed in this information notice may affect licensees' compliance with the reporting requirements of 10 CFR 50.46(a)(3), as well as the performance criteria of 10 CFR 50.46(b).

Discussion:

Westinghouse employs the NRC-approved PAD computer code to evaluate fuel performance. In 1996, Westinghouse found that two cladding-related models in PAD were nonconservative in analyses of fuels at high burnup. It has recently been shown that the effects of these non-conservatisms in the models could lead to nonconservative calculation of post-LOCA cladding oxidation. These analyses are used to show compliance with 10 CFR 50.46 (b), criterion (2).

The first deficient model deals with fuel rod gap pressure. For the last several years, Westinghouse plants have used high-duty fuel rods, with IFBA and Zircaloy-4 cladding in their core designs. The IFBA rods have a boron coating on the UO2 pellet surface. Westinghouse discovered that for higher burn up IFBA fuel, the rod internal pressure buildup attributed to helium released from IFBA was higher than the buildup previously modeled by the PAD code. Westinghouse revised the PAD model to account for increased helium release from IFBA rods and the increased rod pressure buildup resulting from this helium release.

The second deficient model is the Zircaloy-4 cladding oxidation calculation in the PAD code. Westinghouse corrected the corrosion model for Zircaloy-4 cladding material to address the accelerated levels of corrosion actually being measured for high burnup fuel rods. The measured corrosion levels were higher than had been calculated using the previous oxidation model. Using the corrected corrosion model, Westinghouse interpreted the PAD results to indicate that the degraded thermal conductivity of the cladding due to the higher oxidation levels produced an increase in fuel cladding temperatures and consequent higher clad creep rates. These higher creep rates could, in turn, lead to gap reopening, which would be contrary to a Westinghouse design criterion. In addition, Westinghouse concluded that with potential gap re-opening, degraded thermal conductivity of the fuel pellets due to high burnup further elevated the local fuel temperature.

The accompanying higher stored energy level and the high pre-LOCA oxidation level could, as early as the second half of the second duty cycle, make this higher burnup fuel more limiting with respect

to the LOCA criterion of 10 CFR 50.46(b)(2) than the analysis of record for BOL fuel. Westinghouse further indicated that the gap reopening is a concern not only for IFBA rods, but also for gadolinia rods which contain gadolinia powder mixed homogeneously with UO2 pellets. The gadolinia degrades the thermal conductivity of the fuel pellets, resulting in a higher operating temperature of the fuel.

Westinghouse stated that exceeding the criterion prohibiting gap reopening did not directly lead to clad failures. However, fuel rods with gap reopening could be more vulnerable to swelling and rupture during LOCAs and could challenge the 17 percent oxidation limit. Therefore, high burnup or high duty-fuel rods with a tendency toward gap reopening would be more vulnerable under LOCA conditions. Licensees and fuel vendors with other types of Zircaloy clad fuels may wish to consider the relevance of this information to the oxidation models in use for their specific fuels in light of this new experience, which suggests that oxidation levels at high burnup may be more severe than previously expected.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

orig /s/'d by
David B. Matthews FOR

Jack W. Roe, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Kulin Desai, NRR
301-415-2835
E-Mail: kdd@nrc.gov

Frank Orr, NRR
301-415-1815
E-Mail: fro@nrc.gov

Edward Goodwin, NRR
301-415-1154
E-Mail: efg@nrc.gov

(NUDOCS Accession Number 9807290129)

EXHIBIT 4

Effects of Changing Variables

Table 4 in *Dynamic Impact Effects on Spent Fuel Assemblies*

	A	B	C	D	E	F	G
Rod array	17x17	17x17	17x17	17x17	17x17	17x17	17x17
Assembly weight (lb)	1450.00	1450.00	1450.00	1450.00	1450.00	1450.00	1450.00
# of rods	264.00	264.00	264.00	264.00	264.00	264.00	264.00
Fueled length (in)	144.00	144.00	144.00	144.00	144.00	144.00	144.00
# of spacers (N)	7.00	7.00	7.00	7.00	7.00	7.00	7.00
L = (fueled length/N-1)	24.00	24.00	24.00	24.00	24.00	24.00	24.00
E (psi)	1.04E+07	1.04E+07	1.04E+07	1.30E+07	1.04E+07	1.04E+07	1.04E+07
oy (psi)	8.05E+04	8.05E+04	8.05E+04	8.05E+04	4.50E+04	4.50E+04	8.05E+04
t (in)	0.02	0.02	0.02	0.02	0.02	0.02	0.05
ro (in)	0.19	0.19	0.18	0.19	0.19	0.19	0.21
ri (in)	0.16	0.16	0.16	0.16	0.16	0.16	0.16
A (in2)	0.02	0.02	0.02	0.02	0.02	0.02	0.05
I = (1/4*3.14(ro^4-ri^4)	3.85E-04	3.85E-04	3.09E-04	3.85E-04	3.85E-04	3.85E-04	9.37E-04
W (lb)	0.84	0.84	0.69	0.84	0.84	0.84	1.78
w (lb/in)	0.04	0.04	0.04	0.04	0.04	0.04	0.04
r (in)	0.18	0.18	0.17	0.18	0.18	0.18	0.19
pressure (lb)	2250.00	1187.80	2250.00	2250.00	2250.00	1187.80	2250.00
oa (psi)	8787.50	4639.02	10472.14	8787.50	8787.50	4639.02	4675.00
M (lb-in)	2.32	2.32	2.32	2.32	2.32	2.32	2.32
ob (psi)	1128.70	1128.70	1378.17	1128.70	1128.70	1128.70	519.50
P (lb)	68.56	68.56	55.00	85.69	68.56	68.56	166.87
ga	81.93	81.93	80.06	102.41	81.93	81.93	93.71
gy	63.54	67.21	50.81	63.54	32.08	35.76	145.96

A: Values from Westinghouse specimen (Dynamic Impact Effects...Table 4)
B: Pressure changed to a lower value (value in An Assessment of the Risk...)
C: Thickness of fuel cladding decreased due to oxidation by 17%. Column A's thickness is reduced by 17%.
D: E Modulus changed to higher value (value in An Assessment of the Risk...)
E: Yield stress lowered to half the original value
F: Yield stress lowered and pressure lowered (E and B)
G: Doubling the thickness

Note:
DIE = Dynamic Impact Effects...
AAR = An Assessment of the Risk...
AAR's E modulus was expected to be lower, as they took irradiated zircaloy into account. However, it was not, after conversion

	AAR	DIE	
E modulus	1.30E+07	1.04E+07	psi
Pressure	1187.80	2250.00	psi

EXHIBIT 5

STATE OF UTAH
OFFICE OF THE ATTORNEY GENERAL

JAN GRAHAM
ATTORNEY GENERAL

CAROL CLAWSON
Solicitor General

REED RICHARDS
Chief Deputy Attorney General

PALMER DEPAULIS
Chief of Staff

June 9, 1998

VIA FAX: (609) 797-0909 and FIRST CLASS MAIL

Mr. Gary Tjerland
Holtec International
555 Lincoln Drive
Marlton, NJ 08053

re: Revisions to HI-STORM and HI-STAR Cask Licensing Applications

Dear Mr. Tjerland:

As you recall, the State of Utah and Holtec International entered into a Confidentiality Agreement on November 7, 1997, to enable certain employees of the Utah Department of Environmental Quality and its contractors to have access to and review proprietary information submitted by Holtec to the U.S. Nuclear Regulatory Commission. The State has now been admitted as a party to the Private Fuel Storage, LLC (PFS) ISFSI licensing proceedings (Docket No. 72-22), and as PFS is proposing to use Holtec as a cask vendor, the status of the HI-STAR and HI-STORM cask license applications are inextricably linked to the PFS licensing proceeding.

In a meeting (open to the public) between Holtec and the NRC Staff on May 28, 1998, it became apparent that Holtec must submit revisions to its HI-STORM and HI-STAR cask license applications. It is our understanding that Holtec will submit the first revision to the HI-STORM application to the NRC by June 15, 1998.

The purpose of this letter is two fold. First, the State requests that any revised cask license applications or amendments, and other relevant information, such as responses to the Staff's Requests for Additional Information, that Holtec or its representatives submit to the NRC also be sent to the State of Utah. Please use my name as the contact person. Second, the State would like to establish a procedure for using the existing Confidentiality Agreement to allow the State to access proprietary information that Holtec submits to the NRC. Currently the definition of Confidential Information is limited to the proprietary information

160 East 300 South, 5th Floor, P.O. Box 140873, Salt Lake City, Utah 84114-0873
Telephone: (801) 366-0290 Facsimile: (801) 366-0292

the State now has in its possession. One method would be to add an addendum to the existing agreement each time Holtec sends additional proprietary information to the State. If you feel that adding addenda to the existing Agreement is an unworkable approach, the State is willing to enter into a separate agreement that would allow the State to timely receive proprietary information that Holtec submits to the NRC.

Please do not hesitate to contact me at (801) 366-0286 to discuss the most expeditious way by which the State may be kept appraised of ongoing developments in the Holtec cask licensing proceedings.

Sincerely,

Denise Chancellor
Assistant Attorney General

cc: Docket No. 72-22 Service List

EXHIBIT 6

HOLTEC INTERNATIONAL

Holtec Center, 555 Lincoln Drive West, Marlton, NJ 08053
Telephone (609) 797-0900
Fax (609) 797-0909

BY OVERNIGHT MAIL

July 27, 1999

Ms. Denise Chancellor
Assistant Attorney General
State of Utah
160 East 300 South, 5th Floor
P.O. Box 140873
Salt Lake City, UT 84114-0873

Subject: Revision 9 to HI-STORM 100 Topical Safety Analysis Report

References: Private Fuel Storage, LLC; Holtec Project No. 70651

Dear Ms. Chancellor:

Enclosed please find one uncontrolled copy of Revision 9 to the HI-STORM 100 Topical Safety Analysis Report (TSAR). Revision 9 also includes changes made in Revisions 7 and 8 during the final licensing interactions between Holtec and the NRC over the past couple of months. A summary of changes for Revisions 7, 8, and 9 is included behind the cover letter in the front of Volume 1. Revision 9 completely replaces Revision 6, currently in your possession. Therefore, your copy of Revision 6 should be destroyed or returned to Holtec at your earliest convenience.

Please note that TSAR Revision 9 is non-proprietary, therefore, a revision to the Confidentiality Agreement between Holtec and the State of Utah is not necessary.

In accordance with our previous agreement, Holtec will invoice the State of Utah $1,500 for this two-volume TSAR document under separate correspondence to cover costs associated with the copying and shipment of these large documents.

If you have any questions, please contact me at (609) 797-0900, extension 668.

Sincerely,

Brian Gutherman
Project Manager

Enclosure: One uncontrolled copy of Revision 9 to HI-STORM 100 TSAR

HOLTEC INTERNATIONAL

Holtec Center, 555 Lincoln Drive West, Marlton, NJ 08053
Telephone (609) 797-0900
Fax (609) 797-0909

Document ID: PFS018

cc: Max DeLong, PFS (w/o encl.)
Jay Silberg, Shaw, Pittman, Potts, and Trowbridge (w/o encl.)