UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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Nils J. Diaz, Chairman
Jeffrey S. Merrifield
Gregory B. Jaczko
Peter B. Lyons

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

CLI-05-19

MEMORANDUM AND ORDER

The State of Utah has petitioned for review of a series of Licensing Board orders concerning the hazard from a potential aircraft crash into Private Fuel Storage, L.L.C.'s (PFS's) proposed Independent Spent Fuel Storage Installation (ISFSI). The Board found, ultimately, that the probability of a release of radiation from an aircraft crash into the facility was less than one in a million, and therefore the facility complied with applicable NRC safety standards.[1] For the reasons set forth below, we deny the petition for review and we also authorize the NRC staff to issue a license to construct and operate the PFS facility.[2]

[1] *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), Memorandum (Public (Non-Safeguards) Version (Regarding F-16 Aircraft Accident Consequences)), ADAMS ML050620391 (Feb. 24, 2005) and *Private Fuel Storage, L.L.C*. (Independent Spent Fuel Storage Installation), LBP-05-12, 61 NRC 319 (2005) (Memorandum and Order (Ruling on Reconsideration)). *See also Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-03-04, 57 NRC 69, 122 (2002).

[2] *See* 10 C.F.R. § 2.764(c)(2004). Throughout today's decision we cite the NRC's former adjudicatory rules, which appear in the 2004 volume of the *Code of Federal Regulations.* In early 2004, the Commission issued new adjudicatory rules, but they do not apply to this case, which began before their promulgation. *See Final Rule: Changes to Adjudicatory Process*, 69 Fed. Reg. 2182 (Jan. 14, 2004).

I. BACKGROUND[3]

Because the proposed PFS facility would lie in Skull Valley, Utah – underneath the flight path of military aircraft – the possibility of an aircraft crash into the site raised concerns to which this agency has devoted much attention, including lengthy adjudicatory hearings before our Licensing Board. Air Force jets travel between Hill Air Force Base and the Utah Testing and Training Range over Skull Valley, including the proposed PFS site, at the rate of about 7000 flights per year.

NRC regulations require that ISFSIs be able to withstand "credible" accidents.[4] In this case, a significant question faced by the Board was how likely an aircraft crash had to be before it was considered "credible" – in other words, at what point does an accident become so unlikely that the Commission does not require that it be considered in the facility's design? The Board determined that any event having a less than one-in-a-million annual probability could be disregarded in the facility's design.[5] The Board referred its ruling to the Commission. A Commission decision agreeing with the Board was issued in November, 2001.[6]

After extensive hearings in 2002, the Board, applying its "credible" accident criteria, ruled that an F-16 crash into the facility was within the design basis for the facility. The Board drew this conclusion after finding that the probability of an aircraft crashing into the proposed

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[3] The public version of the Board's partial initial decision explains the background of this complicated proceeding in detail, so we will summarize only briefly here. The Board also issued a non-public, "safeguards" version of its order. *See generally* 42 U.S.C. § 2167; 10 C.F.R. § 73.21. That version discusses evidence and findings that cannot be made public because of security concerns. Our decision today discusses only publicly available information, but our ruling also relies on discussions and findings in the Board's Safeguards order.

[4] *See, e.g.*, 10 C.F.R. § 72.24(d)(2).

[5] LBP-01-19, 53 NRC 416 (2001).

[6] CLI-01-22, 54 NRC 255, 265 (2001).

PFS site was more than one in a million – 4.29 in a million, to be precise.[7] The Board rejected PFS's theory that the likelihood of a crash into the facility would be measurably reduced by an "R" factor, representing the likelihood that the pilot of a crashing F-16 would deliberately steer the aircraft away from the PFS facility before ejecting. Consequently, the Board ruled, before the PFS facility could be licensed, PFS would have to show that such a crash would not release unacceptable levels of radiation. Accordingly, the Board called for a second hearing on the air crash issue, this one to consider the consequences of an F-16 crashing into the site.

PFS and the NRC staff sought Commission review of the Board's decision. Among other things, PFS claimed the Board erred in rejecting the "R" factor,[8] while the NRC staff argued that the Board's "4.29 in a million" finding came close enough to the NRC's "one in a million" standard to deem the aircraft crash threat acceptably low.[9] The Commission held those petitions in abeyance until after the Board-ordered "consequences" hearing on the basis that probability and consequences are "intimately linked" and the Board's initial "probability ruling may be rendered moot or unimportant by subsequent Board findings."[10]

The Board's effort to analyze radiological consequences of an aircraft crash into a facility has no adjudicatory precedent at the NRC.[11] Because the various possible crash scenarios are nearly limitless, the Board and the parties were plowing new ground in calculating the consequences of a "credible" aircraft accident. After much analysis, PFS proposed to carve out from all credible accidents a subset of accidents that it could prove, based on the speed and

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[7] *See* LBP-03-04, 57 NRC 69, 122 (2003).

[8] See Applicant's Petition for Review of LBP-03-04 (Mar. 31, 2003), at 8-9.

[9] *See* NRC Staff's Petition for Commission Review of the Licensing Board's Partial Initial Decision in LBP-03-04 (Mar. 31, 2003), at 6-7.

[10] CLI-03-5, 57 NRC 279, 283 (2003).

[11] Public Partial Initial Decision (PID) at A-10.

angles of impact, would *not* rupture the interior multi-purpose canister, which is the last barrier to release of the fission products in stored spent nuclear fuel.[12] PFS argued that if the percentage of accidents that would *not* breach the canister was 80% or more, then the percentage of accidents that *could possibly* breach it must be 20% or less. In that case, PFS reasoned, the overall probability (20% of 4.29 in a million) that an accident could release radiation would be less than the one-in-a-million threshold.[13]

The parties performed complex computer simulations attempting to establish the dividing line between crashes the canister could survive without leaking and those it might not. Determining the breach probability had three basic steps. The first was to determine the maximum strain that the canister theoretically could survive without rupture. (The parties diverge at this point because Utah calculated that maximum strain before failure to be much lower than PFS and the NRC staff did.)

PFS then selected a hypothetical "bounding event" accident that it said would not exceed the maximum strain and therefore would not breach a canister. Of necessity, any accident at a *lower* speed or *greater* angle than the "bounding event" would have a lesser impact.[14] PFS did not fully analyze accidents exceeding the bounding event because the probability of those accidents was, by PFS's calculus, less than one in a million.[15] The probability of crashes exceeding the bounding event is referred to as the "unanalyzed event

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[12] *Id.* at B-3.

[13] *Id.* at B-3.

[14] The particular speeds and angle discussed as the "bounding event" is considered safeguards material. The assumed angle of impact for the bounding event is near to the horizontal, because blunter angle impact at the same speed would have a less forceful impact on the cask.

[15] PFS submitted some analysis showing that some higher speed accidents would also not breach a cask. *See* Public PID at B-9.

probability."

The last step for PFS was to demonstrate, based on statistical analyses of historic crashes, that 80% or more of the expected crashes at the site would indeed be within the bounding event.

Utah countered PFS's approach by challenging PFS's premise that its canisters would withstand the force of the so-called "bounding event." Utah also maintained that a larger percentage of the predicted accidents would exceed the "bounding event" than PFS claimed.[16] The NRC staff supported PFS's approach.

The Board found 2-1 in PFS's (and the NRC staff's) favor, holding that the annual probability of a radiation-releasing air crash was less than one in a million.[17] The Board majority credited PFS's evidence on the performance of the multi-purpose canisters in an air crash scenario, on the strains imposed by the bounding event crash, and on the relative probability of crashes below or exceeding the bounding event. The majority also emphasized that PFS's crash analysis included "materially conservative assumptions ..., leading to the logical conclusion that the probability computed by the Applicant (and agreed [to] by the Staff) is likely to materially overestimate the probability (perhaps by an order of magnitude)."[18]

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[16] Utah also analyzed accidents with a slightly different speed and angle than PFS's hypothetical "bounding event," but the force of impact of the "bounding event" accident is not in dispute in Utah's petition for review.

[17] *See* Public PID at B-8, C-1.

[18] The "conservatisms" include the following: (1) PFS's analyses assumed direct hits that would "maximize" damage, whereas in reality "a large fraction of such incidents would be expected to be other than direct hits;" (2) it was assumed that an aircraft hitting the "skid zone" around the facility would continue undamaged to hit a canister, even though the aircraft would be unlikely "to rebound off the desert without damage and without loss of part of its energy to the ground;" (3) because of the so-called "R" factor, there is some likelihood that a pilot would steer the aircraft away from the PFS site prior to ejection; and (4) PFS presented analyses indicating that the casks could withstand some higher speed impacts than the "bounding speed impact." *See* Public PID at B-8 to B-9. *See also* LBP-03-04, 57 NRC at 92-98 (explaining the "R factor").

In dissent, Judge Lam objected to the findings in favor of PFS for various reasons, some of which Utah reiterates in its petition for review. Judge Lam stated, for example, that there were insufficient data relating to historical crashes to reliably predict future crash probabilities. He also cited various uncertainties in the methods used to translate historical crash rates into a predicted rate.[19] In addition, Judge Lam stated that PFS should use a DOE-prescribed ductility ratio as the standard for predicting "failure," at least of the canister's overpack.[20] He concluded that PFS had not met its burden to satisfy the 10^{-6} safety standard.

II. Discussion

A. Motion for Reconsideration: 1 x 10^{-6} Probability Standard

As an initial matter, Utah asks the Commission to reconsider its 2001 decision setting a "one-in-a-million" (1 x 10^{-6}) threshold probability standard for a design basis air crash at the PFS facility.[21] Utah argues that the 2001 Commission ruling wrongly presupposed that the threshold standard had to be either one in a million or one in ten million, without considering the possibility of an intermediate number, for example (as Utah now suggests) one in five million.[22] Utah also disputes the Commission's finding that the consequences of an accident at an ISFSI would be more like an accident at a so-called geologic repository operations area ("GROA") than at a nuclear power reactor.

The Commission's ruling compared the one-in-a-million threshold standard established for a GROA – a temporary storage area to be used in conjunction with a permanent repository for disposing of spent nuclear fuel – to the one-in-ten-million threshold standard established for

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[19] *See* Public PID, at D-2 to -3.

[20] *See id.* at D-4.

[21] CLI-01-22, 54 NRC 255.

[22] *See* State of Utah's Petition for Review of Contention Utah K (Aircraft Crashes), at 4.

a nuclear power reactor. The decision noted that in terms of both everyday operation and potential accident consequences, PFS's proposed ISFSI resembles a GROA more than a nuclear power reactor.[23] In addition, it pointed out that in previous rulemakings the NRC had announced its intent to "harmonize" regulations pertaining to ISFSIs and GROAs.[24]

Utah's new challenge to the one-in-a-million threshold probability standard amounts to an untimely motion for reconsideration.[25] Lateness alone is sufficient to reject Utah's reconsideration request.[26] Moreover, Utah's new argument fails to meet our reconsideration criteria. Reconsideration motions must be based on "elaboration or refinement of an argument already made, an overlooked decision or principle of law, or a factual clarification."[27] Utah's reconsideration request is none of these. Utah's argument for an intermediate accident probability standard, such as one in five million, was not raised in its 2001 appellate brief before the Commission.[28] Nor did the 2001 decision "overlook" legal principles or require "factual clarification." As the Commission held in 2001, in rulemakings prior to this adjudication it was made clear that GROAs and ISFSIs are similar facilities and should have the same design

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[23] *See* CLI-01-22, 54 NRC at 264-65.

[24] *See id.* at 264, citing 61 Fed. Reg. 64,257, 64,262 (Dec. 4, 1996).

[25] *See* 10 C.F.R. §2.786(e) (2004) (setting forth a 10-day deadline for filing a petition for reconsideration of a Commission decision).

[26] *See, e.g, Private Fuel Storage , L.L.C.* (Independent Spent Fuel Storage Installation), LBP-00-14, 51 NRC 301, 310-11 (2000) (late-filed motion for reconsideration requires good cause, as well as new information or changed circumstances).

[27] *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Units 2 and 3), CLI-02-1, 55 NRC 1, 2 (2002).

[28] *See* "State of Utah's Brief on the Question Certified in LBP-01-19: The Regulatory Standard for Aircraft Crash Hazards at the PFS Site - Contention Utah K (Credible Accidents)," (July 13, 2001).

bases.[29] The Commission stated that there is "little basis" for using a reactor-like probability standard at an ISFSI (or a GROA); an accident at a reactor poses a greater risk than the accidental release of stored spent fuel because the contents of the reactor are under pressure that presents a "driving force behind dispersion" of radioactive materials.[30] For these reasons, Utah's request does not make the requisite showing.

In any event, the Board found that even a small breach of a single storage cask was not credible in the event of a direct hit by the single-engine F-16. A single F-16 crash could not significantly damage more than one cask, so the total number of casks on site – in other words, the total radioactive source term contained in the entire facility – is irrelevant. The number of casks increases the probability of a hit, but does not increase the potential consequences of a hit.[31] The Board's recent decision bolsters our 2001 ruling.

B. The Licensing Board's Rulings

The Commission will grant plenary appellate review of Licensing Board decisions – a discretionary step – in limited circumstances only. Among other things, we inquire whether there is reason to believe that (1) a Board "finding of fact is clearly erroneous," (2) a Board "legal conclusion is without governing precedent or is a departure from or is contrary to established law," or (3) the Board committed a "prejudicial procedural error."[32] Here, because of the complexity of this proceeding, we granted the parties an increase in page limits and extra time to file a petition for review and responses. After considering Utah's petition carefully we

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[29] CLI-01-22, 54 NRC at 264.

[30] *Id.* at 264-65.

[31] Similarly, Utah's argument the proposed PFS facility is unlike the planned geologic repository in that PFS cannot control military overflight of the facility, goes to probability of a crash, not the similarity of the consequences.

[32] *See* 10 C.F.R. §2.786(b)(4)(2004).

see no factual, legal or procedural basis for disturbing the Licensing Board's carefully-rendered decision in this case. Below, we set forth the reasons why we find Utah's petition unpersuasive.

1. Standard of Review

Utah's petition for review focuses largely on the Licensing Board's fact-driven evaluation of the evidence on air crash risks at the PFS facility. As we have held previously in this proceeding, our "standard of 'clear error' for overturning a Board factual finding is quite high."[33] "A 'clearly erroneous' finding is one that is not even plausible in light of the record viewed in its entirety."[34] The short of the matter is that we expect our Licensing Boards to review testimony, exhibits, and other evidence carefully and to resolve factual disputes. That is the Boards' chief function in our adjudicatory system. Thus, unless there is strong reason to believe that in a particular case a Board has overlooked or misunderstood important evidence, we will defer to its findings of fact.

This very proceeding illustrates why it is sensible to defer to the Board acting in its factfinding capacity. At the hearing leading to the ruling before us today, the Board heard from 20 witnesses, who presented 225 exhibits, over the course of 16 days. The hearing transcript spans over 4,500 pages. In making its findings, the Board was required to sift through this evidence, to review studies and documents, and to make countless judgments on the credence to give each expert witness. We are not inclined to engage in any kind of *de novo* factual inquiry, particularly in a proceeding of this complexity, involving numerous experts and voluminous exhibits. As the United States Supreme Court has pointed out, the likelihood that a reviewing body will rely on the presumption of correctness of a trial court's factual

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[33] CLI-03-8, 58 NRC 11, 25-26 (2003).

[34] *Tennessee Valley Authority* (Watts Bar Nuclear Plant, Unit 1; Sequoyah Nuclear Plant, Units 1 and 2; Browns Ferry Nuclear Plant, Units 1, 2, and 3), CLI-04-24, 60 NRC 160, 189 (2004) (internal citations and quotations omitted).

determinations "tends to increase when trial judges have lived with the controversy for weeks or months instead of just a few hours."[35]

2. Cruise Missile Testing.

Utah challenges the Board's 2001 summary disposition ruling that impacts from errant cruise missiles need not be considered in the design basis of the facility.[36] In that decision, the Board granted a PFS motion for summary disposition and found that a cruise missile accident at PFS is not a credible event. Utah argues that its air crash contention – "Utah Contention K" – is whether the cumulative probability of a crash from military activities, including cruise missile testing, constitutes a credible event. It was error, Utah says, for the Board to look at the probability of a cruise missile impact separately to determine that the probability of that event is too small for consideration.

But the Board's ruling, as we read it, was not based on the probability of a cruise missile impact falling below the 1×10^{-6} threshold probability for a credible event. Rather, the Board cited PFS's undisputed evidence that the flight path for cruise missiles tested at the Utah Test and Training Range would not be within ten nautical miles of the facility.[37] The Board also relied on PFS's undisputed evidence that, according to Air Force officials, no cruise missile has crashed more than one mile off its flight path.[38] Given these two pieces of evidence, it was reasonable for the Board to conclude, as it did, that there was no material factual dispute suggesting that cruise missiles present any statistically significant threat to the facility. It is

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[35] *Bose Corporation v. Consumers Union of the United States, Inc.*, 466 U.S. 485, 500 (1984).

[36] *See* LBP-01-19, 53 NRC 416, 424-29 (2001). As this ruling granted only a partial summary disposition, it was interlocutory and not appealable by the parties until the final disposition of this portion of the case.

[37] *Id.* at 427.

[38] *Id*.

therefore not necessary to determine whether a cruise missile crash is sufficiently like an F-16 crash to necessitate adding the probabilities together to reach a total probability for threats from the air.

3. Loss of Shielding

Utah claims the Board committed a prejudicial procedural error in ruling on reconsideration that "loss of shielding" was not preserved as a issue in the second hearing.[39] Utah argued in its motion for reconsideration that even if the multi-purpose canister was not penetrated in a crash, its concrete overpack could be stripped away, leading to excessive offsite radiation doses. Utah says the Board was wrong to end its analysis once it found that the canister would not rupture in a credible accident.

Utah argues that it never had the opportunity to present evidence on the loss of shielding claim because of the Board's ruling that the second hearing, rather than considering the "consequences" of a radiation release as originally envisioned, instead would focus on the probability of rupturing the canister. Excessive radiation doses due to damage to the overpack would go to the "consequences" of the crash, Utah says, an issue specifically precluded by the Board's pre-hearing ruling.[40]

In our view, the Board reasonably found that Utah had waived the right to argue about shielding loss by not bringing it up earlier. Our understanding of the procedural history of the air crash issue supports the Board's decision.

The first hearing on aircraft crash hazards examined the likelihood that an F-16 would crash anywhere on the site of the PFS facility.[41] After that hearing, the Board ruled against

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[39] *See* LBP-05-12, 61 NRC 319 (2005).

[40] *See Memorandum Concerning Scheduling* (April 15, 2004), at 2.

[41] The Board limited the scope of the first aircraft crash hearing in response to a PFS motion *in limine*. *See* Tr. at 3008; LBP-03-4, 57 NRC at 136-41.

PFS, finding the likelihood of an F-16 crash onto the PFS site unacceptably high (an annual chance of 4.29 in a million). The Board found that the license could not be issued at that juncture unless PFS addressed the "consequences" issue, either by demonstrating that an F-16 would not penetrate a cask, or that, if it did, there would be no significant radiation doses to the public.[42]

Over the next year, the parties worked steadily to gather experts and statistics and perform the calculations necessary to determine what the "consequences" of an aircraft crash would be. It soon became clear that delineating between the "probability" of an aircraft crash and its "consequences" is not simple. To illustrate, if there is a 4.29 in one million chance that an F-16 would crash somewhere on the PFS site, a certain percentage of those crashes would not even hit a spent fuel storage cask, because portions of the facility site would be vacant or not used for spent fuel storage. A percentage of those crashes that did hit a spent fuel container would strike a only glancing blow. Some would be at high speed, and some would be at a speed too slow to inflict damage. Therefore, only a portion of the estimated 4.29 in one million crashes would actually result in damage to a cask.

After performing its calculations, PFS argued that even if the annual probability of a crash on the site was greater than one in a million, the probability of *significant damage* to a cask was below one in a million. It then asked the Board to limit the scope of the second hearing to the probability of a crash severe enough to penetrate the storage canister and to release contaminants. The Board agreed to limit the scope of the hearing to the probability of canister breach, which, as it pointed out, could be seen as either a part of the probability or the consequences factors of risk.[43]

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[42] LBP-03-4, 57 NRC 69, 135 (2003).

[43] Memorandum Concerning Scheduling (April 15, 2004) (committing to writing the Board's April 8, 2004 oral decision), n.1.

Utah now argues that the Board's decision limiting the scope of the second hearing to the probability of a canister breach precluded it from making its argument that the "loss of shielding" from a damaged overpack would have unacceptable dose consequences even in the event that the canister was not penetrated. Utah argues that damage to the overpack should have been at issue in the second hearing because the parties repeatedly referred to "cask breach" and "cask damage" when discussing the results of an accident. Utah points out that the parties in this proceeding have regularly used the term "cask" when referring to the concrete overpack (which provides shielding), and "canister" when referring to the multi-purpose canister inside (which confines the radioactive byproducts).

We conclude that the Board acted reasonably in deciding that Utah had not timely raised the overpack-shielding issue. It is evident from the record that the entire phase two hearing was aimed at determining the likelihood that the multi-purpose canister would be breached, based on the assumption that only the release of radioactive materials from inside the spent fuel canister would raise concerns. Utah did not raise arguments or concerns about the shielding, either at the hearing itself or in the lengthy lead-up to the hearing. The NRC staff pointed out in its argument on Utah's reconsideration motion[44] – and the Board emphasized in its reconsideration decision[45] – that Utah never even mentioned the phrase "loss of shielding" in any of the 15 pre-hearing conferences leading up to the second hearing.

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[44] *See* Tr. at 19,771 (Staff searched the transcripts for the phrase). The Board also searched the transcript for the word "shielding" and it never appeared. *See* Tr. at 19,717. Although Utah could not point to any time when it specifically made this argument, Utah now claims that its position was evident from the whole of its presentation. But the Board found otherwise. On this point, we do not find a basis to second guess the Board, which is much more familiar with the record and with the parties' statements and expectations than we are.

[45] LBP-05-12, 61 NRC at 327 ("*During the entire time the matter was under discussion the question of diminished shielding never arose."* (emphasis in original)).

Utah, in short, never complained, until its reconsideration motion, that the Board hearing had focused on too narrow an issue – canister breach. It was Utah's burden to "structure its participation so that it is meaningful, so that it alerts the agency to [its] position and contentions"[46] As the Board indicated,[47] had Utah presented its loss of shielding argument sooner, the phase two hearing might have been restructured to include the probability of an accident stripping the overpack in addition to (or rather than) the probability of perforating the canister. It is too late to take that tack now. We see no obvious abuse of discretion, or procedural error, in the Board's refusal to restart its phase two hearing in response to Utah's untimely loss of shielding claim.

Indeed, accepting Utah's late claim would, in effect, return the complex probability-consequences inquiry to the starting line. The Board would first have to determine the probability that a crash would strip away a portion of the overpack before it went on to examine the offsite dose consequences of a partially or totally exposed canister.[48] In short, the parties would then be subject to another three-week hearing and the months of investigation preceding it. Such a result would be patently unfair to PFS, the NRC staff, and the Board, which have already focused extraordinary resources on the probability issues as originally framed.

Utah argues that potential violations of NRC dose limits cannot be waived by procedural default.[49] Utah's failure to raise its loss of shielding claim in timely fashion does not, however, waive NRC safety standards or excuse PFS from meeting them. It means only that Utah cannot

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[46] *Vermont Yankee Nuclear Power Corp. v. NRDC*, 435 U.S. 519, 553 (1978)

[47] LBP-05-12, 61 NRC at 328.

[48] The Board might also have to determine the likelihood of other factors, for example, the probability that a crashing aircraft would strike a cask on the outside boundary of the formation (because radiation from a cask situated in the interior of the cask formation would be blocked from the boundary by the surrounding casks).

[49] *See* Utah's Petition at 12.

litigate the loss of shielding issue at an NRC hearing. Absent a statutory "mandatory hearing" requirement, NRC licensing boards sit to resolve discrete (and timely raised) *contested* issues only.[50] We depend on the NRC's expert technical staff to ensure that our licensees meet all other agency requirements.

4. Rejection of DOE Standard for Failure Strains of Steel Components.

Utah claims that the Board "arbitrarily rejected" a DOE standard for analyzing the performance of hazardous facilities in aircraft crashes.[51] At the phase two hearing, Utah urged the Board to use the DOE's Standard, *Accident Analysis for Aircraft Crash into Hazardous Facilities,*[52] to predict what strains PFS's multi-purpose canister could tolerate before failing in an aircraft crash. In particular, Utah argued that the Board should follow the DOE Standard's prescription of a "ductility ratio" of 20 as a criterion by which to gauge when the steels at issue would fail in tension. Rather than relying on the DOE approach, the Board relied on tests, placed in the record by PFS, showing the performance of stainless steel under tension.

The Board gave two reasons for not applying the portions of the DOE Standard Utah cites.[53] First, DOE's prescribed "ductility" ratios were apparently intended for a different type of structure, primarily buildings. Second, the type of failure the DOE Standard addressed was failure by collapse or deformation, not perforation. The Board's view was carefully considered and does not strike us as "clearly erroneous" or unreasonable. The parties argued the point during the phase two hearing and again at length at the oral argument on Utah's motion for reconsideration. The Board listened to a great deal of argument and testimony and considered

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[50] *See generally Exelon Generation Co., LLC* (Early Site Permit for Clinton Site), *et al.,* CLI-05-17, 62 NRC __ (July 28, 2005).

[51] *See* Utah's Petition at 17.

[52] U.S. Department of Energy, DOE Standard DOE-STD-3014-96, October, 1996.

[53] *See* Public PID at B-3 to -4, B-10; LBP-05-12, 61 NRC at 332-33.

numerous exhibits in making its decision.

The DOE Standard provisions that Utah cites prescribe a permissible "ductility ratio" to determine when a structure will fail by "excessive structural deformation and collapse."[54] If the strain of the crash exceeds the prescribed ratios, then the DOE Standard says that the steel structure is assumed to fail.

> 6.3.3.3 Structural Evaluation Criteria. Deformation responses computed for various target structural components ... are then used to compute the ductility ratio (the ratio of computed displacement to elastic displacement) Computed ductility ratios are then compared to the permissible ductility ratios specified below to determine if the component would *deform excessively or collapse* under impact loads. ...
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> b. for steel structural components, the permissible ductility ratios shall be as specified in Section Q1.5.8 of AISC Nuclear Specification, ANSI-N690 (Reference 11). For plate structures, the permissible ductility ratio is 10 is recommended.[55]

In calculating how much strain PFS's multi-purpose canister could withstand, both PFS and the NRC staff looked at experimental data that showed the canister's stainless steel make-up could tolerate 90 percent true strain in tension before it failed by rupture.[56] By comparison, the DOE Standard-prescribed ductility ratios would result in much more frequent assumed failures – 1/40th the strain of the experimentally determined failures.[57] PFS and the NRC staff advocated deriving an assumed canister failure rate by reducing – in accordance with customary engineering practice – the experimentally determined strain to allow a safety factor of two or three.[58] Their approach won the approval of the majority of the Board.

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[54] *See* DOE Standard at 35, §4.3c. A ductility ratio is the ratio of computed displacement to elastic displacement or the yield strain. The yield strain is the point at which the material is changes from elastic to plastic, in other words, when it will be permanently deformed.

[55] *See* DOE Standard at 76, § 6.3.3.3. (Emphasis added.) *See also* n. 61 below.

[56] *See* Public PID at B-4.

[57] *See id.*

[58] *See id.*

a. The DOE Standard is Intended for a Different Type of Structure than the Multipurpose Canister

The Board observed that the DOE Standard addressed collapse of buildings, which are typically constructed of carbon steel, not stainless steel like a multi-purpose canister.[59] Stainless steel is considerably more ductile than carbon steel – that is, it will bend farther without breaking. Vessels such as the multi-purpose canister tend to be constructed of stainless steel.[60] The portions of the DOE Standard that Utah seeks to apply refer to an ANSI/AISC Standard that explicitly excludes pressure vessels.[61]

Utah now argues only that (1) the DOE Standard never explicitly says it does *not* apply to stainless steel pressure vessels and (2) an appendix to the DOE Standard describes how to evaluate potential exposure patterns in case a pressure vessel containing hazardous materials ruptures in an airplane crash. But neither argument persuades us that the Board's decision--to look at actual stainless steel performance instead of attempting to "fit" the problem to some pre-existing code–was wrong. Utah apparently does not dispute the proposition that stainless steel would perform differently from carbon steel in a crash. Utah does not offer any evidence that the two types of steel would perform similarly. Nor do we see any reason why the Board should have applied the DOE Standard to pressure vessels when that standard relies on an ANSI standard that explicitly excludes pressure vessels. Finally, the appendix that Utah cites is used to determine various exposure scenarios when a hazardous material container is breached; it is not used for determining whether a breach has occurred.

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[59] *See id.* at B-10, (discussed in more detail in Safeguards PID at B-12 to -13); LBP-05-12, 61 NRC at 332-33.

[60] Soler/McMahon Reb., Post Tr. 15,228 at 15. Utah does not dispute this, but rather cites this testimony in its brief.

[61] ANSI/AISC Standard N690, *Specifications for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* (1994), at 23.

b. The DOE Standard Addresses a Different Failure From That at Issue Below

It is apparent, as the Board found, that the portions of the DOE Standard that Utah advocates were not intended to address the type of failure that lies at the heart of the matter here. The majority of the Board determined that the ductility ratios in that standard were developed to determine the ability of structural components to carry loads: "[T]here was no justification for us to adopt a standard ductility ratio, developed for other situations, when that standard ratio was not shown to be relevant to, or derived from experiments about, the particular type of failures at issue here."[62] Judge Lam, in his dissent, thought the DOE Standard applicable to the concrete and carbon steel overpack, but his dissent takes no position on whether the "ductility ratios" should be used to determine perforation of the multi-purpose canister.[63]

The Board found that the DOE's ductility ratio did not answer the specific question at issue in the hearing – when the multi-purpose canister would rupture and allow its contents to escape. The portions of the DOE Standard invoked by Utah may help determine whether a steel component may fail by buckling or deformation. Other provisions of that standard address failure by penetration (the failure of concern here), but Utah does not advocate using those

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[62] LBP-05-12, 61 NRC at 333.

[63] Judge Lam argued:

> A singularly important but unresolved dispute with respect to the Applicant's structural analysis is the Applicant's declination to adopt the DOE ductility ratio standard as the failure criterion for the spent fuel storage cask. The DOE ductility ratio standard was developed by a group of experts, assembled by the Department of Energy, to protect facilities containing radioactive or chemical materials from the hazards of an accidental aircraft crash.

Public PID, at D-4 (citations omitted).

provisions.[64] At the hearing below, the Board did not need to inquire whether the canister might be deformed or even weakened by the impact – rather, the Board considered the narrower question of whether the canister would *leak*. The Board held that Utah's preferred DOE Standard was not helpful in resolving that question.

The Board explained that other kinds of damage were not at issue in the proceeding because only a release of fission products would have offsite effects:

> [A]n incident which does not release radiation, but nonetheless causes the overpack and the [multipurpose canister] to be so damaged that the fuel contained within the [multipurpose canister] is no longer intact, may well be significantly more likely than one which is so damaging that radiation is released. *But such incidents are not at issue here.* Under the regulatory system, such incidents–because they are not radiation releasing–are to be dealt with by a licensee if and when they occur. Under that circumstance, the agency will become heavily involved (as it does in the aftermath of any accidents) to assure that possible effects of radiation arising out of the recovery operations are safely handled. Such incidents may present a serious problem in terms of what it takes of a licensee to clean up, but with no radiation "consequences," they do not have to be designed against.[65]

In sum, we find no clear error of fact in the Board's decision to use experimental data rather than the DOE Standard. The Board explained in detail its reasoning in rejecting the DOE Standard, both in its original ruling and on reconsideration, and its reasoning rested on the evidence before it.

We should also observe that all three parties, NRC staff, PFS and Utah performed extensive computer simulations, using sophisticated computer codes, and found as a common result that "*the maximum strain computed to occur in the [multipurpose canister] was well below (by at least a factor of eight or nine) the experimentally determined failure strain.*[66] Thus, there

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[64] *See* DOE Standard at 35, §4.3b. "Local damage to steel targets: 1. penetration - to prevent perforation of a steel target, the minimum wall thickness required is at least 125 percent of the predicted penetration depth." *See also* DOE Standard, at 69-70, §6.3.2.2 Local Response Evaluation – Evaluation of Steel Targets.

[65] Public PID at B-2 (emphasis in original).

[66] *See id.* At B-3 (emphasis in original).

is a wide margin of safety.

There is no basis for further Commission review.

5. Claimed Errors in Calculating Probability[67]

Utah next argues that the Board used skewed accident data when estimating the probabilities of air crash accidents at various speeds.[68] Utah claims that the Board should have eliminated seven historical accidents that Utah says were dissimilar to possible Skull Valley accidents, and which had the effect of shifting the probability distribution toward slower speeds. In addition, Utah also argues that the Board arbitrarily eliminated from consideration certain hypothetical "top impact" crashes that should be considered "unanalyzed events."

As discussed above, the Board found acceptable PFS's "bounding aircraft impact" representing the top speed for the majority of accidents.[69] The "bounding speed" the Board used rested on PFS's structural analysis showing that its canister would not rupture at that or any lower speed. The bounding event is not necessarily a precise "cut-off" between crashes that would breach the canister and those that would not. The actual "cut-off" might well be at higher speeds than the bounding event. But because PFS's calculations showed that crashes

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[67]As noted above, in countering Judge Lam's dissenting view that too many uncertainties infected PFS probability analysis, the Board majority pointed to "large conservatisms ... built into the analyses." *See* Public PID at B-12; *see also id.* at B-8 to B-9. Utah's petition for review says that the Board's "conservatism" finding rests on "subjective judgement, speculation and lack of evidentiary support." *See* Utah's Pet. at 26 *et seq*. But, as set out in detail in PFS's response to the petition for review, ample record evidence supports the Board's finding. *See* Applicant's Response to State of Utah's Petition for Review of Contention Utah K, at 25-29. In any case, the Board did not reduce the calculated probability at all to account for the conservatisms. Utah does not come close to suggesting there was "clear error."

[68]*See* Utah's Petition at 21-26.

[69] The Board accepted PFS's bounding speed and angle over Utah's (which involved a slower speed and slightly different angle) because it found that *neither* impact would have sufficient strain to breach a cask. Since either bounding speed was within the bounds of safety, it was appropriate to use the larger set (higher bounding speed) when calculating the relative probabilities of crashes within or outside the bounding speed. *See* Public PID at B-5 (explained more fully in safeguards version).

at higher speeds, while not impossible, were too improbable to be credible, the effects of those impacts were not analyzed. Thus, higher speed accidents are unanalyzed events and the probability of their occurrence is called the "unanalyzed event probability."

Utah argues that PFS (and the Board) set the unanalyzed event probability too low. In other words, according to Utah, certain higher speed crashes are more likely than the Board figured and therefore should have been considered credible. Utah claims that the Board "ignore[d] critical evidence" that the unanalyzed event probability exceeds one in a million.[70]

a. Seven Disputed Crashes

Utah would eliminate from consideration seven historical crashes that occurred at low speeds when the pilot delayed ejection in an attempt to land following engine failure. Including these accidents, which Utah says could not take place in Skull Valley, made the probability of a crash at lower speeds seem more likely.

Because there are limited available data of actual F-16 crashes, determining the probability of crashes at particular speeds and angles within Skull Valley proved a challenge for the parties and the Board. Of 121 accidents worldwide for which data were available, PFS identified 61 that it thought were of a type possible in Skull Valley. Further analysis eliminated four of those that were runway accidents, and therefore not possible in the air over Skull Valley, leaving 57 for the Board's analysis.

The Board considered the historical data issue at hearing and again in response to Utah's motion for reconsideration.[71] At the hearing, Utah sought to eliminate 13 additional crashes,[72] but on reconsideration focused its argument on the seven crashes on which it bases

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[70] *See* Utah's Petition at 21.

[71] Public PID at B-7 to-8; LBP-05-12, 61 NRC at 334-36.

[72] Safeguards PID at B-20.

its petition for review. [73] As with the Board's other factual findings, the Board's decision on which historical air crashes to include and exclude from its probability calculation is not "clearly erroneous."

It is apparently undisputed that an F-16 could not take off or land in Skull Valley.[74] But the Board did not find this sufficient reason to eliminate the seven crashes now in dispute, even though they involve accidents where the pilots were looking to land, because the crashes were all initiated by the type of engine failure that *could* occur in Skull Valley. The Board found that these accidents were "fairly representative of one end of the range of crash scenarios."[75]

We find no clear error in the Board's ruling. Even assuming that Utah is correct in its view that eliminating these crashes from the data set would shift the probability distribution toward higher speeds, it is not clear that the result would be a more accurate prediction of future Skull Valley accidents. The Board found that the significant feature of the seven disputed crashes is that they resulted from engine failure. The Board explained that in case of engine failure, pilots are trained to trade forward speed for higher altitude, thus giving the pilot more time to attempt to restart the engine prior to ejecting.[76] Of the 57 accidents the Board agreed were relevant, 91% involved loss of engine power. In 63% of the loss of engine power loss accidents, it appeared that the pilot followed proper procedures.[77] And when the pilot follows procedures, the Board found, the aircraft crashes at a speed that "at any angle, is well below

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[73] LBP-05-12, 61 NRC at 335

[74] *See* LBP-05-12, 61 NRC at 319.

[75] *See id.*

[76] *See* Public PID at A-6.

[77] *Id.* at B-6.

the speed of the Bounding Aircraft Impact."[78]

For these reasons, pilot experiencing engine failure over Skull Valley would probably not attempt to land; he would be expected to follow the above procedures to attempt to restart the engine. Utah has not given us reason to believe that most engine failure crashes would actually occur at higher speeds than in the seven disputed incidents.

It is also clear that there is more than one way to consider the data. For example, PFS suggested that if the Board were to eliminate the seven disputed incidents, then it should also "weight" the remaining crashes to reflect their likelihood of occurrence in Skull Valley. PFS argued that because the vast majority of flights in Skull Valley are at the 3000-4000 foot altitude range, the Board could "weight" historical accidents occurring at that initial altitude more than accidents that initiated at higher altitudes, which tend to result in higher speed impacts.[79] Weighting the probabilities would skew the data back toward slower speeds. The Board considered still other approaches to evaluating the available data, but concluded that using the entire set of 57 Skull Valley-type events would maximize the use of available data.[80]

The Board's inclusion of the seven disputed engine failure accidents does not appear to us "clearly erroneous" – that is, not even "plausible" on the record.[81] The Board, in any event, found no reason to believe that a re-analysis, leaving out the seven disputed accidents, would raise the unanalyzed event probability above acceptable bounds.[82]

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[78] *Id.* Another 10 percent of relevant historical accidents were "deep stall" incidents where the aircraft falls vertically to the ground "like a leaf." A deep stall accident would not strike a cask with a force exceeding the bounding impact. *Id.*

[79] *See* LBP-05-12, 61 NRC at 335.

[80] *See* Safeguards PID at B-23.

[81] *See Tennessee Valley Authority,* CLI-04-24, 60 NRC at 189.

[82] *See* LBP-05-12, 61 NRC at 336.

b. Side Impacts Following Top Impacts.

Utah claims that the Board erroneously eliminated from consideration side impacts to a second cask after an F-16 first strikes the top of another cask. Utah argues that after a shallow impact to the top of a cask, an aircraft could continue without a significant loss of speed to crash into the side of another cask.

Again, we see no basis for declaring the Board's decision "clearly erroneous." The Board accepted PFS's expert's testimony that in the case of impacts to the top of the cask, the critical concern is the *vertical* speed at which the aircraft is traveling. An F-16 coming in at a shallow angle (close to the horizontal) would have a vertical speed much slower than the aircraft's overall speed. Therefore if the vertical speed were within the bounding event speed, then the crash would be within the bounding event.

Utah argues that any top impact with a *horizontal* speed greater than the bounding impact speed should be considered an unanalyzed side impact to neighboring casks. Therefore, Utah argues, the unanalyzed event probability is higher than the Board found.

The Board considered this argument on reconsideration, and rejected it. The Board explained why it would not expect such grazing, or "topping," incidents to contribute materially to the unanalyzed event probability.[83] Due to the arrangement of casks in the storage area, initial top impacts are more likely, because the sides of most casks are somewhat shielded by neighboring casks. Therefore, all potential crashes were divided into "top impact" or "side impact" for analysis, with the parties calculating the effective area for all tops or sides of casks that could be exposed to accident.

PFS introduced the testimony of Dr. Alan I. Soler[84] at the hearing. He testified that an F-

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[83] *See* LBP-05-12, 61 NRC at 336-41.

[84] Ph.D. (Mechanical Engineering); Executive Vice President for Engineering, Holtec International (lead structural expert for design of the HI-STORM 100 cask system).

16 hitting the top of one cask at a high speed and shallow angle would not drop more than a few inches before hitting the next cask, and the tops of the casks have protuberances that would snag on the F-16's underside, preventing it from simply skipping to the next cask without loss of momentum.[85] The Board addressed this point in its reconsideration ruling. Where a major portion of the F-16 strikes the top of a cask, the Board said, it will "suffer material deformation" and "lose substantial momentum." [86]

Because of these factors, the Board found, the only way a craft hitting the top of a cask could continue unimpeded to strike the side of the next cask would be if it struck a glancing blow to the far side of the cask (that is, if only a small portion of the F-16's fuselage hit the cask top).[87] The Board reasoned that accounting for these side impacts would simply reallocate some impacts from "top" to "side" and "*effectively enlarge[], from a computational perspective, the cross-sectional area of the sides of the casks being impacted.*"[88]

Relying on an estimate provided by the NRC staff's expert, Dr. Dennis R. Damon,[89] the Board found that although this reallocation would increase the unanalyzed event probability, it would not be by enough to raise it to one in a million or more.[90] Reallocating some top impacts to side impacts would increase the unanalyzed event probability because the top impact was measured by vertical speed and the side impact would be measured by the greater horizontal speed.

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[85] LBP-05-12, 61 NRC at 337; Testimony of Dr. Soler, Tr. 19,555-567.

[86] LBP-05-12, 61 NRC at 339.

[87] *Id.*

[88] *Id.* (emphasis in original).

[89] Ph.D, (Nuclear Engineering), Senior Level Advisor for Risk Assessment, Office of Nuclear Material Safety and Safeguards.

[90] LBP-05-12, 61 NRC at 341 (total unanalyzed event probability would be 7.8×10^{-7}).

Utah claims that simply reallocating a small fraction of "grazing" top impacts is not enough. It argues that every top impact with a horizontal speed exceeding the bounding speed should be considered to be an above-bounding impact to neighboring casks without regard to where on the cask lid the aircraft hits. It complains that the Board's analysis "allows countless high impact crashes to escape any contribution towards the probability of breach because the F-16 first strikes a cask top and the fact that it could continue on at speeds sufficient to breach is disregarded."[91]

Utah's petition has two problems: first, Utah does not specify the number of crashes with which it is concerned, and, second, its overarching theory of unimpeded secondary impacts seems to us unproven, if not far-fetched. The Board already has determined that the majority of crashes would not occur at speeds sufficient to breach a canister regardless of whether the impact was to the top or sides. Utah says the probability of a sufficiently high speed top impact is 1.94×10^{-7}, based on a calculation performed by PFS's expert Dr. Allin Cornell. According to PFS, however, that calculation was performed merely to determine the effect Utah's "unrealistic" scenario would have on the unanalyzed event probability.[92] The second difficulty we have with Utah's argument is understanding the mechanics of such a crash. An expert's opinion does not seem necessary to conclude that an F-16 cannot simply pass unimpeded through several feet of steel and concrete. Conceivably, we suppose, there could be a crash where an F-16 would hit the top of the cask at an angle and push it over, allowing the aircraft to continue on its trajectory. If so, however, Utah has given us no record evidence to support it or to perform probability calculations. The only relevant expert evidence called to our attention is that of Dr. Solar – who said that an F-16 hitting squarely on the top of a cask lid would itself bear the brunt

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[91] Utah's Petition for Review, at 22.

[92] PFS Brief at 23, n. 53.

of the impact.

Therefore, Utah has not demonstrated that the Board committed any error, much less "clear error," in deciding this issue.

III. License Issuance

Our decision today concludes this protracted adjudication – which has generated more than 40 published Board decisions and more than 30 published Commission decisions. The adjudicatory effort, plus our staff's separate safety and environmental reviews, gives us reasonable assurance that PFS's proposed ISFSI can be constructed and operated safely. We express our appreciation for the diligent efforts of all involved in the adjudication – the intervenors (particularly the State of Utah), the NRC staff, and PFS itself.

There are no remaining adjudicatory issues to resolve. Accordingly, once it has made the requisite findings pursuant to 10 C.F.R. § 72.40, the Staff is authorized to issue PFS a license to construct and operate its proposed ISFSI.[93]

CONCLUSION

For the foregoing reasons, Utah's petition for review is *denied*, and the NRC staff is *authorized* to issue to PFS a license to construct and operate its proposed ISFSI.[94]

IT IS SO ORDERED.

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[93] Under 10 C.F.R. § 2.764(c)(2004) the NRC staff cannot issue a license to construct and operate an away-from-reactor ISFSI without express Commission authorization. In this case we might have authorized license issuance earlier this year, once the Board issued its last partial initial decision, and notwithstanding Utah's subsequent reconsideration motion and petition for review. *See, e.g., Massachusetts v. NRC*, 924 F.2d 311, 322 (D.C. Cir. 1991), *cert. denied*, 502 U.S. 899 (1991). We decided, however, to hold off on license issuance until (in consultation with our technical and legal staff) we could complete our consideration of Utah's concerns.

[94] In view of today's decision, we need not consider the petitions for review still before us (held in abeyance) that challenge the Licensing Board's original probability ruling. *See* notes 8-10, *supra*, and accompanying text. Those petitions are, in effect, moot.

For the Commission

/RA/

Annette L. Vietti-Cook
Secretary of the Commission

Dated at Rockville, Maryland,
this 9th day of September, 2005

Commissioner Gregory B. Jaczko respectfully dissents, in part:

I appreciate the efforts of all parties involved in this long and detailed adjudication. I join in the Commission's decision to the extent the decision addresses the issues raised in the State of Utah's brief to the Commission seeking review of the final licensing board actions. I, too, am unconvinced by the arguments raised by the State of Utah in its brief and would defer to the Board's findings of fact regarding these issues.

I dissent in part because I believe the decision involves an important interpretation of the Commission's regulations and associated guidance related to aircraft hazard analyses that has not been adequately addressed – that of when an actual consequence analysis should be performed. Because I believe the final figures reached by the Board's calculation (which I do not disagree with) render an accident credible, I believe an additional analysis of the consequences of the F-16 aircraft hazard should be assessed prior to the issuance of the license.

As the NRC staff described in earlier briefs, the probability of a credible aircraft crash at the PFS site is calculated to be right at the established threshold at which additional analysis of the consequences of a crash is required. There is detailed analysis in the record of the exhaustive efforts to determine whether the actual probability is a fraction above that threshold or a fraction below. This analysis unfortunately missed the point and resulted in lengthy and unnecessary delays in this adjudication. An objective review of the inherent uncertainties

associated with a calculation of this magnitude makes it clear that the probability of an accident is "about" at the threshold which makes it credible. The precedent setting question then is, if the probability falls right at the established standard, what is the appropriate action for the Commission to take to ensure the adequate protection of the public?

I believe that in such situations fraught with uncertainty, it is the Commission's responsibility to approach these issues cautiously. The standard for establishing whether or not an accident is credible must be respected and if it is reached, the Commission should require the additional analysis necessary to determine any potentially harmful consequences. If those consequences could result in radiation exposures to the public that are above the exposure limits as defined by NRC regulations, then applicants are required to design against those possibilities.

These hearings were originally proceeding along this very path, but unfortunately never reached this logical conclusion. In an extensive opinion, the Licensing Board found that the Applicant, Private Fuel Storage, failed to show that the probability of an aircraft hazard was less than approximately 10^{-6}. The Board stated 'there is enough likelihood of an F-16 crash into the proposed facility that such an accident must be deemed "credible"', requiring an additional analysis of the design of the facility to show that such credible accidents would not result in a radiation exposure that exceeds the limits of 10 C.F.R part 100.[95] Specifically, the Board found that the probability of an accident was 4.29×10^{-6} per year, which exceeded the approximate 10^{-6} threshold for credibility.[96] The Board's finding on this issue was based on an understanding that the calculation for this probability was determined using the "classic four-factor NUREG-0800 formula".[97] Following a challenge of this decision to the Commission by the applicant, the

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[95] *See* LBP-03-04, 57 NRC 69, 77 (2003).

[96] *Id.* at 88.

[97] The applicant argued that this formula should be modified to account for pilot actions in the event of a crash, but the Board rejected this argument in LBP-03-04, leaving the

Board's decision was upheld. [98] As a result, the applicant was forced to further evaluate the aircraft hazard.

The decision now before the Commission depends exclusively on a refinement of the calculation by the Board and I have concerns about the Board's application of this refined calculation. In arriving at the new probability for an aircraft hazard the Board adopted a new calculation that involved a consideration not only of the probability of an accident, but also the probability that an F-16 which crashed at the facility would breach one of the casks, leading to radiation exposure. After a contentious and complicated hearing, the Board found that the new probability was 0.74×10^{-6} and, more important, found that this number was <u>below</u> the threshold of 10^{-6}, eliminating aircraft hazard as a credible accident scenario.

As I indicated above, I do not dispute the Board's determination that this new probability calculation was 0.74×10^{-6}, but I do dispute the conclusion of the Board that this meets the established screening criteria to eliminate the aircraft hazard as a credible scenario. The staff's brief to the Commission appealing LBP-03-04, also supports this argument. There, the staff indicated that, "Dr. Campe testified that the criterion [for determining credibility of aircraft hazard] is expressed as an order of magnitude criterion – *i.e.*, an approximate value. He further testified that typically, order of magnitude thresholds are viewed as midpoints, such that 5×10^{-6} would be the dividing point between 10^{-6} and 10^{-5}.[99] Although the staff was arguing in that instance that, since the initial probability of an aircraft crash of 4.29×10^{-6} per year was consistent with 10^{-6} per year, the aircraft hazard should not be considered credible, I agree that the staff's description of the *interpretation* of the probability calculation is correct. In other words, the staff is correct that

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traditional four-factor formula.

[98] *See* CLI-03-05, 57 NRC 279.
[99] Staff's Petition for Commission Review, March 31, 2003, at 6.

$4.29x10^{-6}$ is *of the same order of magnitude* as 10^{-6}. Similarly $0.74x10^{-6}$ is *of the same order of magnitude as* 10^{-6}. The important content of the calculated number is just the order of magnitude.

I believe this is an important issue, because the Board has now effectively overturned Commission precedent in having flexibility to deal with the approximate probabilities in NUREG-0800. As NUREG-0800 clearly states, "This requirement is met if the probability of aircraft accidents resulting in radiological consequences greater than 10 CFR Part 100 exposure guidelines is less than *about* 10^{-7} per year (see SRP Section 2.2.3)."[100] Probability calculations of this kind are extremely difficult and fraught with uncertainty and can be rendered meaningless if the numerical results are given greater specificity than they actually inherently contain. For that reason, the staff correctly drafted and interpreted NUREG-0800 to reflect on order of magnitude estimate, not an absolute number. As the staff brief indicates, citing several cases, "[f]or events the estimated probability of which is of the order of 10^{-7} per year, there is virtually no hope that there will ever be sufficient data available to obtain a precise measured value."[101]

The Board majority and minority acknowledged the practical realities of this staff position in the difficulties of making its decision. Judge Farrar stated, "[i]n contrast, even those of us in the majority recognize that the F-16 accident crash challenge presents a close case, in which the demonstrated margins are, by our lights, narrow (and not persuasive to our dissenting colleague)."[102]

As a result, I believe the Board erred by establishing a new interpretation for the NUREG-0800 approximate probability, essentially replacing the credibility standard of "about 10^{-7}" with

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[100] *See* NUREG-0800, §. 3.5.1.6., (emphasis added). Although NUREG-0800 references 10^{-7}, the Commission determined in CLI-01-22 that the appropriate numerical standard in this case is 10^{-6}.

[101] *Id.*

[102] See Board's Public Memorandum and Order, p. B-13 (Feb. 24, 2005).

"exactly 10^{-7}". Using the staff's reasoning, the Board should merely have looked at the *second* probability calculation as providing an order of magnitude estimate, which would be 10^{-6}. Thus, the *second* probability calculation failed to show conclusively that the aircraft accident was not credible, that is *less than* 10^{-6}.

Thus the Commission needs to consider alternative criterion to determine whether the aircraft hazard is high or low risk. The probability analysis simply failed to provide information useful in ruling out aircraft hazard as a credible threat. That leaves the applicant with only one option – complete a full consequence analysis of the design of the facility to show that the consequences of a credible aircraft crash will not lead to exposures above the 10 C.F.R. Part 100 limits. Such an approach would assure the adequate protection of public health and safety.

Although I have expressed my views in a slightly different manner, my concerns draw upon the dissent of Judge Lam. I agree fully with his conclusions that, "[more needs to be done. The Applicant should demonstrate that a breached spent fuel storage cask would not result in a site-boundary radioactive dose exceeding regulatory limits, or should implement other remedies such as the installation of physical barriers. Such a decisive demonstration, or the implementation of genuine remedies, would ensure the adequate protection of public health and safety."[103]

Therefore, I dissent in the decision of the Commission to authorize the staff to issue to Private Fuel Storage a license to construct and operate its proposed storage facility at this time. The misinterpretation of our regulations should be remedied by performing the necessary consequence analysis to ensure the adequate protection of the public health and safety from the issuance of this license.

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[103] *Id.* at D-7.