II. CLARIFICATION REGARDING IMPACT OF CANISTER BUILDING DESIGN CHANGES ON AIR CRASH HAZARD[36]

Question: PFS has changed the design of the PFSF canister transfer building (CTB) roof to improve constructabilty and reduce the overturning moment potentially resulting from a seismic event. Specifically, the minimum thickness of the roof is now 8 inches, supported by steel roof girders, rather than an all-concrete design with a 12-inch thick roof. What effect does the design change have on PFS's general aviation hazard calculation, given that PFS had excluded some general aviation aircraft from its impact probability calculation because their impacts were bounded by the design basis tornado missile for the building?

Response

In the Addendum to its aircraft crash impact hazard report, PFS estimated the general aviation traffic through Skull Valley and calculated a crash impact probability for general aviation aircraft at the PFS site.[37] PFS's approach was to calculate the number of general aircraft that would have to transit Skull Valley per year to result in a crash impact hazard of 1 E-7, 1 E-8, and 1 E-9. Addendum at 14. PFS then considered the calculated numbers of aircraft per year for each probability in light of the fact that F-16 pilots who flew through Skull Valley from Hill Air Force Base had observed no general aviation or only minimal general aviation in Skull Valley. Id.[38] Accordingly, PFS determined that the level of general aviation traffic through Skull Valley corresponded to the level of traffic that would result in a general aviation crash impact hazard at the PFSF of less than 1 E-8. Id. at 14-15.

In relating the general aviation crash impact hazard to the number of general aviation aircraft that transit Skull Valley per year, PFS accounted for the fact that 55 percent of the general aviation aircraft that transit Skull Valley would pose no crash impact hazard to the PFSF because their impact characteristics were bounded by the impact characteristics of the design basis tornado missile for the PFSF, including the CTB. Id. at 15. Therefore, design changes to the CTB are relevant to PFS's general aviation crash impact assessment only to the extent that potential impacts involving those 55 percent would no longer be bounded by the design basis tornado missile.

The design change to the CTB reduced the minimum thickness of the building roof to 8 inches.[39] This thickness is not sufficient to withstand the design basis tornado missile impact

[36] This question was raised by the NRC Staff in an April 18, 2001 teleconference with PFS.

[37] Addendum § III.A.

[38] Clover Control, at Hill AFB, also reported having no records of general aviation traffic in Skull Valley. Report at 67 n.63.

[39] The design change to the CTB also increased the exterior dimensions slightly. See, e.g., PFSF SAR Fig. 4.7-8. The effect of this change was to increase the effective area of the PFSF site as a whole, see Report § III.A.3, by less than one percent for all aircraft hazards other than general aviation and by less than two percent for general aviation. Since the crash impact probability is directly proportional to the site effective area, id. at 6, the increase in CTB dimensions increased the aircraft hazard to the PFSF proportionately. PFS notes this effect here but, because of its negligible magnitude, has not incorporated it into the calculations performed elsewhere in this submittal.

A/6

(the Spectrum II automobile impact, see PFSF SAR at 3.2-8).[40] The remainder of the building, however, including the building walls up to the roof, is strong enough to withstand an impact by the Spectrum II automobile. Therefore, the only effect of the design change relevant to PFS's analysis is to make the roof of the CTB potentially susceptible to impacts involving those 55 percent of general aviation aircraft that are bounded by the design basis tornado missile.[41] Thus, the impact of the design change is to increase the general aviation crash impact hazard by the probability that one (or more) of the 55 percent of general aviation aircraft that are bounded by the design basis tornado missile would impact the CTB roof directly in an orientation conducive to maximum penetration.

PFS had assessed the probability of a general aviation aircraft impact causing a release of radioactive material at the PFSF to be less than 1 E-8. Addendum at 14-15. PFS accounts for potential impacts on the roof of the CTB by aircraft formerly bounded by the tornado missile as follows. The impact probability, P, for aircraft flying along an airway, as PFS modeled Skull Valley, is given by $P = N \times C \times A / w$, where N is the number of aircraft per year, C is the crash rate per mile, A is the site effective area, and w is the airway width. Addendum at 13. The number of general aviation aircraft, N, may separated into two groups, 1) those 55 percent of the aircraft bounded by the tornado missile, and 2) those 45 percent not bounded. Thus, the impact probability becomes:

$$P = 0.55\, N \times A / w + 0.45 \times N \times A / w$$

In the former case, in which all of the aircraft that were bounded by the tornado missile (the 55 percent) posed no hazard to the PFSF, the effective area of the site, A, for the bounded aircraft, was effectively zero, in that there was no area in which an impact of those aircraft could have resulted in a release of radioactive material. Thus, the probability was defined by:

$$P = 0.55\, N \times 0 / w + 0.45 \times N \times A / w, \text{ or}$$

$$P = 0.45 \times N \times A / w.$$

In the former case, P = 1 E-8, thus:

[40] The CTB roof, however, is designed to withstand other tornado-driven missiles in Spectrum II as necessary to meet NRC requirements. PFSF SAR at 3.2-8.

[41] As PFS noted in its Report at 71a n.74, spent fuel inside the CTB will be contained within and protected by a spent fuel shipping cask or a spent fuel storage cask 92 percent of the time that spent fuel is present in the building. Only while transfer operations are taking place and while the canister is inside the transfer cask will the canister not be protected by a shipping or storage cask. Nevertheless, PFS does not take credit for the protection provided by the shipping or storage casks here. This analysis assumes that any general aviation impact on the roof of the CTB might result in the breach of a spent fuel canister and the release of radioactive material. PFS also does not take into account the fact that an aircraft impact into the roof of the building might not affect a spent fuel canister inside at all. First, the roof is supported by an extensive network of steel beams and girders through which the aircraft would have to penetrate to affect a cask. Second, the building is much larger than a spent fuel canister. Third, there are small general aviation aircraft that still would not penetrate the roof because of their light weight and low speed. Furthermore, a glancing blow by a light aircraft might not penetrate the roof. Hence, not all of the 55 percent of general aviation aircraft bounded by the design basis tornado missile should necessarily be included in this calculation.

$1\ E\text{-}8 = 0.45 \times N \times A / w$

Under the present CTB design, however, the effective area for the 55 percent of general aviation aircraft that had been bounded by the tornado missile is not equal to zero, but rather is equal to the area of the roof of the CTB, A_r. This is because, for the purpose of this analysis, we assume that an impact of one of those aircraft on the roof of the building might cause a release of radioactive material. Therefore, the new general aviation crash impact probability, accounting for the new design of the CTB, is defined by:

$P = 0.45 \times N \times A / w + 0.55\ N \times A_r / w$

Taking $0.45 \times N \times A / w = 1\ E\text{-}8$ from above, $N / w = 1\ E\text{-}8 / (0.45 \times A)$. Thus,

$P = 1\ E\text{-}8 + 0.55/0.45 \times 1\ E\text{-}8 \times A_r / A$, or

$P = 1\ E\text{-}8\ (1 + 1.222 \times A_r / A)$.

The area of the CTB roof, A_r, is equal to 26,488 sq. ft., or 9.50 E-4 sq. mi. See PFSF SAR Fig. 4.7-8.[42] The effective area of the site, A, is equal to 0.1193 sq. mi. for general aviation aircraft.[43] Therefore, the new general aviation crash impact probability is equal to:

$P = 1\ E\text{-}8\ (1 + 1.222 \times 9.50\ E\text{-}4 / 0.1193)$, or,

since P defined the upper bound of the probability,

$P < 1.01\ E\text{-}8$.[44]

[42] The effective area of the roof is the actual area of the roof of that part of the CTB that is protected by the building's tornado missile barrier (as noted above, the roof itself forms part of the barrier for certain Spectrum II missiles). The remainder of the roof, covering offices, store rooms, and the cask transporter aisle, on either side of the building, does not protect areas where spent fuel casks will be located; thus, it is not relevant to the general aviation hazard to the building. See PFSF SAR Fig. 4.7-8. In its assessment of crash impact hazards for other aircraft, PFS included a "skid area" and a "shadow area" in its site effective area calculation for the CTB to account for the possibilities that 1) an aircraft could impact the ground in front of the site and skid into it and 2) a crashing aircraft that would otherwise hit the ground behind the site could hit an elevated part of the site. Report § III.A.3. Here, because the only impact of concern is an impact directly on to the roof of the CTB, PFS does not need to include a "skid area" or "shadow area" in the effective area calculation for the roof. In fact, impacts that would occur in the hypothetical "skid area" and "shadow area" of the roof, if the same areas used for the CTB as a whole were used for the roof, would impact the side of the CTB.

[43] This is the newly calculated CTB effective area, reflecting the small changes to the building's dimensions that PFS recently made. The original effective area of the site for general aviation aircraft was 0.1173 sq. mi. Report at 69.

[44] The effect of the change in the dimensions of the CTB, see note 39 above, was to increase the site effective area for general aviation from 0.1173 to 0.1193, an increase of 1.7 percent. If that increase is combined with the effect of the change in the CTB roof thickness, the total effect of CTB design changes on the general aviation hazard to the PFSF is equal to 1.01 x 1.017 = 1.027 or an increase of 2.7 percent. Thus, PFS estimates the general aviation hazard to the PFSF to be less than 1.027 E-8, or, as a practical matter, still less than 1 E-8.

Therefore, the design change to the CTB has a negligible effect on the general aviation hazard to the PFSF.[45]

[45] As an aside, if the entire CTB were susceptible to impacts of light general aviation aircraft, then A_r would be replaced by the effective area of the entire CTB, 0.109 sq. mi. (this includes the CTB "skid area" and "shadow area," see note 42, above) and the general aviation impact hazard to the PFSF would increase from 1 E-8 to 1.1 E-8. Thus, the general aviation hazard assessment for the PFSF is not sensitive to design changes to the CTB.