National Nuclear Security Administration

Department of Energy
National Nuclear Security Administration
Washington, DC 20585

January 30, 2012

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Dear Mr. Chairman:

Safety is a core value of the Department of Energy (Department), and infuses all that we do. Following recent discussions you and I had about the safety of National Nuclear Security Administration (NNSA) activities at the Los Alamos National Laboratory's Plutonium Facility (PF-4) nuclear facility, I wanted to take a moment to explain the Department's conclusion that operations at PF-4 have continued to adequately protect public safety.

The Department works aggressively to ensure that the risk from our nuclear activities does not appreciably add to the overall risks the public faces from everyday activities. We design new nuclear facilities so that the radiological consequence of design-basis accidents would be so low that they could not affect the adequate protection of the public, regardless of how long the facility operates or how unlikely the accidents. We evaluate our existing facilities to this same standard and take appropriate actions when we conclude that it is not met.

Our evaluation of the existing PF-4 facility in 2008 established a Documented Safety Analysis (DSA) for the facility that was compliant with the Department's Nuclear Safety Rule. The DSA concluded that safety measures at PF-4 were reasonable and adequately protected the public under current standards for existing facilities. However, the evaluation highlighted that the facility was not as resilient and its safety systems were not as effective as we would require of a new facility constructed today. Therefore, taking the most conservative approach, we concluded that additional analysis and modifications to PF-4 were warranted to minimize the potential for a radiological release following an accident triggered by a rare earthquake and subsequent main-floor fire. Upon analysis, the actual risk to the public was so small, given the rarity of the posited earthquake and fire event, that NNSA concluded that it was prudent to allow continued operations while we took measures to modernize the facility.

Following up on that 2008 evaluation, between 2008 and 2011, we conducted a more detailed analysis of the possible responses of the PF-4 facility to earthquakes. The facility had been designed to the best available earthquake information when it was constructed in the 1970s. However, our commitment to continuous improvement requires reevaluation of our facilities — and data and assumptions regarding the risks they face — periodically. When we evaluated new seismic information that had not earlier been available, we learned that the PF-4 facility could undergo a partial collapse in a severe earthquake. We concluded that the possible structural damage increased the potential for a radiological release from the facility.

Our immediate assessment of the situation concluded that the additional risk from the continued operation of PF-4 remained small compared to other risks faced by the public, so no emergency actions were warranted to reduce public risk or ensure adequate public protection. Subsequent analysis confirmed these initial conclusions. Nevertheless, the margin by which we ensure adequate protection was less than is generally the case with our new or existing facilities.

Consequently, as the responsible Secretarial Officer, I directed that the facility be upgraded in a timely manner. We immediately restricted activities in the most vulnerable parts of the facility and initiated repairs. The most significant repair was the completion of upgrades to the roof to ensure its structural stability. A significant portion of the upgrades is now complete. Considering the small incremental risk to the public and the fact that we were implementing prudent actions to mitigate and resolve the issues we had identified, I concluded that facility operations continued to adequately protect the public while further upgrades and analyses are made.

For your reference, I am providing more detailed, supporting information as enclosures to this letter. Enclosure 1 provides a technical basis for concluding that PF-4 operations pose a very small increase in risk to the public. Enclosure 2 describes the actions taken since 2008 to improve safety at PF-4. Enclosure 3 is a comprehensive description of the path forward as well as current plans for analyses and safety improvements. Finally, Enclosure 4 provides a concise explanation of the term 'adequate protection' as applied to PF-4.

In a September 29, 2011, letter to you, NNSA committed to provide a revised project execution plan (PEP) for seismically-related upgrades by January 31, 2012. However, per Enclosure 3, since ongoing seismic upgrades will be completed in April 2012, and additional seismic analyses will be completed in June 2012, NNSA will now send the revised PEP in August 2012.

I look forward to continuing to work with the Board and its staff to ensure any potential remaining technical issues regarding PF-4, and our plans for improvements, are promptly identified, accurately communicated, and effectively resolved. If you have any questions, please feel free to contact me.

Sincerely,

DONALD L. COOK
Deputy Administrator
for Defense Programs

Enclosures

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Enclosure 1

Los Alamos National Laboratory – Public Health Risk Posed by the Plutonium Facility During a Post-Seismic Fire Event

Summary

The Plutonium Facility (PF-4) accident analysis in the June 2011 Justification for Continued Operation (JCO) evaluated the effect of a combined earthquake, fire, and partial building collapse. The calculated radiation dose to the hypothetical maximally exposed off-site individual (MEOI) was conservatively estimated to be 2,100 rem Total Effective Dose Equivalent[1] (TEDE) for a postulated once-in-5,000-year accident (Case 1). By October 2011, PF-4 was structurally upgraded, reducing the calculated MEOI dose to 143 rem once-in-2,000 years (mitigated, Case 2). By April 2012, additional repairs will be completed that protect PF-4 safety basis assumptions and reduce the calculated MEOI dose to less than 25 rem TEDE.

Risk is commonly defined as the product of consequence and probability. This paper provides perspectives on the public risk from PF-4's temporary condition. The first part discusses general plutonium health risks. The next part evaluates the effects of progressively less conservative assumptions in the accident analysis that cumulatively reduce the calculated MEOI doses to 17 rem and 2 rem for Cases 1 and 2, respectively. If the accident occurred, these results could be exceeded half the time since they are based on median assumptions.

The final part evaluates the June 2011 "worst-case" post-seismic fire scenario (i.e., 2,100 rem MEOI dose at 5,000 year return period). It is estimated that:

- The average increased risk of latent cancer fatality (LCF) for the public within 10 miles was about 0.02 percent – equivalent to about twice the national average lifetime risk of dying in a cataclysmic storm.

- Assuming that the once-in-5,000 year accident occurred, the average dose to a public individual within 10 miles would have been 4 rem. This is comparable to about one-tenth of the lifetime dose this person will receive from background radiation. It corresponds to a 1 percent increase in lifetime risk of dying from cancer – comparable to half the national average risk of dying in a fall.

- Under the currently understood conditions (i.e., Case 2: 143 rem MEOI dose at 2,000 year return period), the public health risks are an order of magnitude lower than for Case 1.

While the risks should be further reduced, they are also very low. An earthquake large enough to significantly damage PF-4 and cause these increases in long-term cancer risk will also cause significant damage and acute injuries and fatalities in the surrounding communities. The latter would likely be the dominant public health concern if the postulated major earthquake occurred.

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[1] Footnote information is provided at the end.

Plutonium Health Effects

Radiation is part of the natural environment. The average background radiation levels in Los Alamos range from about 0.3 to 0.6 rem per year from natural sources and average about 0.8 rem per year including man-made sources, such as consumer products and medical procedures.[1, 2] A person who lives 70 years in the local area will gradually accumulate a dose throughout their lifetime equivalent to a "committed dose" of roughly 50 rem.

Los Alamos National Laboratory (LANL) has been working with plutonium for nearly seven decades, and the risks are well known. Plutonium is a dense, man-made, radioactive metal that emits alpha radiation that is readily shielded by a sheet of paper or the outer skin; therefore, external exposure to plutonium incurs little health risk. Its dominant health hazards are nuclear criticality (which is not the subject here) and the potential for development of latent cancers, primarily from inhalation. If plutonium dust is inhaled, most of it will be exhaled; the remainder will concentrate mainly in the lungs, the bone surface, and the liver. Since plutonium is slowly expelled from the body over decades, the risk is measured in terms of a committed effective dose that accumulates over a 50 year period for workers and 70 years for the public (References (1) - (5)).

> *Perspective:* Because plutonium emits alpha radiation that is readily shielded, it does not pose the same acute health risks as deep-penetrating radiation from gamma or neutron sources that cause immediate, whole-body exposures. Many references cite an acute dose of 350 to 500 rem of deep-penetrating radiation as fatal to about half an exposed population within 30 days (e.g., Reference (6), total effective dose equivalent).[1]
>
> In contrast, there is no record of acute human effects from large plutonium uptakes by inhalation or ingestion, although uptakes of up to about 13 μCi have been reported, equivalent to 800 rem (i.e., Mayak worker studies).[3,4] Animal testing indicates that about 20 mg inhaled, equivalent to 80,000 rem, would be fatal within 30 days.[5] Since most calculated MEOI doses are much lower, the most significant health effect would be an increased risk of cancer as dose accumulates during a person's lifetime.

The national average lifetime risk of dying from cancer is about one in five (21 percent).[6] To evaluate the increased LCF risk from radiation exposure, recent LANL environmental impact statements (EISs) have used 6.0×10^{-4} LCF/rem as the probability of a latent cancer fatality for doses less than 20 rem and 1.2×10^{-3} LCF/rem for greater doses.[7]

Margins Analysis

Before estimating the increased risk to the public, it is worthwhile to understand the conservatisms in the June 2011 PF-4 accident analysis. DOE safety basis analyses are primarily developed using the DOE-STD-3009 methodology, which includes use of specified conservatisms, including but not limited to: worst-case accident excursions, bounding inventories, bounding airborne release fractions, and wind and atmospheric conditions that occur 5 percent of the time or less (i.e., 95 percent meteorology). This leads to uniform and consistent decision-making in the selection of hazard controls relied upon to protect the public.[8]

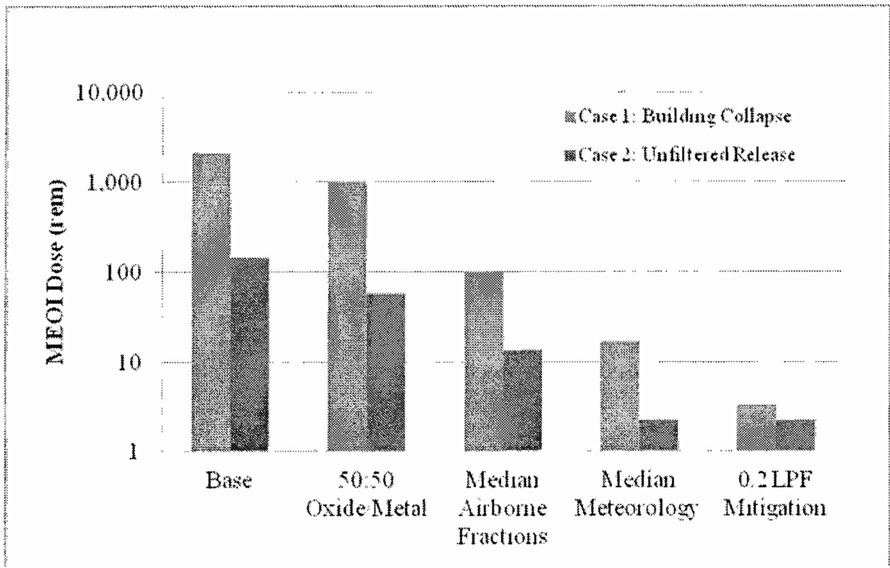

Figure 1: Effect of Changing Safety Basis Assumptions

Figure 1 is a semi-logarithmic plot of the calculated MEOI doses while progressively changing a few key assumptions.[9] The base cases correspond to June 2011 results. Case 1 (2,100 rem MEOI) assumed, sequentially, the plutonium is spilt and impacted as oxide and then exposed to a 500°C fire as metal; while oxide physically cannot spontaneously transform to metal, the entire accident sequence is bounding for any expected worst-case excursion. Case 2 (143 rem MEOI) essentially considered a smaller inventory that experiences just the spill and fire; the release is mitigated by limiting the airborne particulate leakage from the building to 20 percent.

The next column shows about a factor of two reduction from assuming two material forms – a 50:50 ratio of metal and oxide. This is not surprising because the oxide powder is significantly more dispersible during the spill and impact than the metal, while the opposite holds true during the fire; this would likely still qualify as a bounding analysis. The third column shows an order of magnitude reduction from assuming median instead of bounding airborne release fractions.[10] The fourth column shows a factor of six reduction from using median instead of 95 percent meteorology.[11] The last column shows the effect of restricting building leakage.

> *Perspective:* The cumulative effect of making median instead of bounding assumptions reduced the calculated MEOI dose by two orders of magnitude to 17 rem and 2 rem for the June 2011 (Case 1) and October 2011 (Case 2) conditions, respectively; considering constrained building leakage, the calculated doses are 3 and 2 rem. If all the calculation parameters were median values, these results would be expected to be exceeded about half the time if the accident occurred.
>
> There is also margin in the assumed accident frequencies (e.g., once in 5,000 years); these were based on the structural failure probabilities and did not consider other

conditional probabilities, such as the conditional probability of a large fire starting and growing within the facility and progressively effecting and engaging all of the assumed material at risk; this refinement would reduce the frequency of the event from once in thousands of years to once in hundreds of thousands of years.

Increased Public Risk of Latent Cancer Fatalities

Although DOE has not established a standardized methodology for determining whether or not the quantitative safety objectives of the Safety Goal from DOE Policy 420.1, *DOE Nuclear Safety Policy,* are met, this section provides perspective on the increased public risks from the partial building collapse scenario (Case 1) and the unfiltered release scenario (Case 2) by comparing them to:

- normal lifetime dose from background radiation (estimated: 50 rem)
- lifetime risk of cancer fatality (i.e., 21 percent LCF/lifetime)
- lifetime fatality risks due to commonly understood hazards, such as falls, vehicle accidents, and cataclysmic storms.

The table below summarizes the results. Column A data assume the accident occurred. Column B considers that the estimated likelihoods for the partial building collapse (Case 1) and the unfiltered release (Case 2) are once in 5,000 years and 2,000 years, respectively. The consequences and risks associated with currently understood conditions (Case 2) are approximately an order of magnitude less than for the June 2011 conditions (Case 1).

	Case 1 (Jun 2011)		Case 2 (Oct 2011)	
A: assumes accident occurred; B: considers accident frequencies	A	B	A	B
Increased risk to average public individual				
Dose received during next 50 years (rem)	4 rem		0.3 rem	
Percent increase above lifetime background radiation dose	8 %	0.1%	0.6 %	0.02 %
Percent increase above lifetime LCF risk	1 %	0.02%	0.1 %	0.003 %
Increased risk to the MEOI (50 percent meteorology)				
Dose received during next 50 years (rem)	350 rem		24 rem	
Percent increase above lifetime LCF risk	300%	3 %	14 %	0.5 %

Columns A and B are related as follows. Given an assumed 70-year lifetime, an accident that occurs once in 5,000 years has a likelihood of about 1 in 70 of occurring during a lifetime. Similarly, an accident that occurs once in 2,000 years has a likelihood of about 1 in 30 of lifetime occurrence.

Insight on the increased public risk posed by the June 2011 accident scenarios can be gained from using previously reported data in LANL environmental impact statements (EIS), References (8) - (10). The EISs retain conservatisms typical of DOE safety basis analyses (e.g., bounding inventories and airborne release fractions), except they assume median atmospheric conditions while safety basis analyses assume 95 percent meteorology.

To estimate the effect on the public-at-large, 27 unique scenarios from References (8) – (10) were evaluated. EISs calculate MEOI accident doses, population doses, and population LCFs within 50 miles. Instead of 50 miles, this evaluation more conservatively assumes the entire exposure and LCF risk are incurred by the approximately 20,000 people living within 10 miles of LANL.

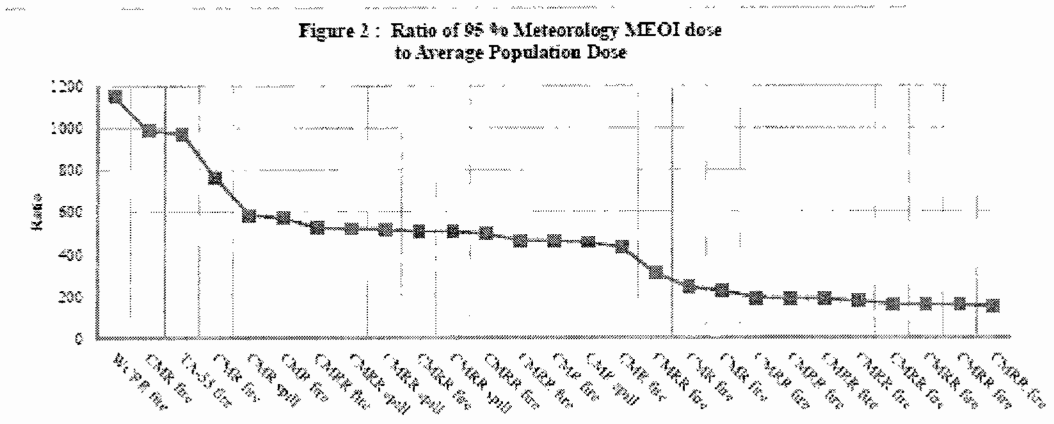

Figure 2: Ratio of 95% Meteorology MEOI dose to Average Population Dose

As shown in Figure 2, the calculated radiation dose (95 percent meteorology) to the MEOI is 150 to 1,200 times higher than to the average public individual within 10 miles (50 percent meteorology); the median is about a factor of 500, with a variability of about a factor of three.

> *Perspective:* Assuming the accident occurred, the calculated MEOI dose of 2,100 rem for Case 1 translates to an average individual dose to the public of 4 rem, which is 8 percent of their estimated lifetime dose from background radiation (50 rem).[2] At this dose, the increased lifetime risk of dying from cancer is 1 % (i.e., 21 percent LCF/lifetime risk increased to 21.25 percent LCF/lifetime); the increase is roughly comparable to half the national average lifetime risk of dying in a fall. [12, 13]
>
> Considering that Case 1 has a likelihood of about once in 70 lifetimes (i.e., 1 in 5,000 years), the average public individual's increased lifetime risk of dying from cancer is 0.02 percent and is roughly comparable to a third of the national average lifetime risk of dying in an air transport accident; it is roughly twice the national average lifetime risk of dying in a cataclysmic storm.[13]
>
> For Case 2 and assuming the accident occurred, the average public individual's increased lifetime risk of dying from cancer is 0.1 percent and is roughly comparable to the national average lifetime risk of dying from a firearm discharge. Considering that Case 2 has a likelihood of about once in 30 lifetimes (i.e., 2,000 years), the increased lifetime risk of dying from cancer is 0.003 percent and is roughly comparable to the national average lifetime risks of dying in an earthquake or from a dog bite. [13]

The calculated MEOI doses for Cases 1 and 2, assuming the accident occurred, would significantly increase lifetime cancer risk (300 percent and 14 percent, respectively); however, there are conservatisms in this analysis. Major structural upgrades have already been completed, and further upgrades and analysis are expected to be complete during the next 6 months that will significantly reduce these values. Considering the likelihoods of these accidents, the increased lifetime risk to the MEOI at these doses are roughly comparable to the national average lifetime risk of dying in a fall for Case 1 and to accidental drowning for Case 2.

Conclusion

The primary human health hazard associated with plutonium is an increased risk of cancer. The accident conditions evaluated by the PF-4 seismic JCO in June 2011 posed a very small increase in risk to the public, on the order of a fraction of percent. Even if the accident were to occur, the average increase in radiation exposure to the public would have been equivalent to about one-tenth of what they receive from background radiation. Actions taken between June 2011 and October 2011 further reduced the public's risk by an order of magnitude; additional risk reduction actions will be completed by spring 2012.

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Footnotes:

1. A rem is a measure of radiation dose that considers relative biological effectiveness. Dose can be received from both external sources and internal sources. The dose from internal sources is measured in terms of a committed effective dose equivalent (CEDE), which is the weight sum of the dose received by specific body organs and tissues over 50 years. The total effective dose equivalent (TEDE) is the sum of the deep-dose equivalent, for external exposures, and the CEDE for internal exposures. See Reference (5). Unless specified otherwise, all doses in this paper are expressed in TEDE units.

2. The local background radiation levels are from the CMRR draft SEIS, Ref (9), Table 3-14.

3. Doses cited in this paper are based on the dose conversion factors of ICRP-72 and plutonium oxide (S-Class); PF-4 data is increased by a factor of 1.78 over ICRP-72 Pu-239 values to account for PF-4 Pu isotopics and aging. Older data in the literature is based on ICRP-30 and will indicate inhalation doses a factor of 5 higher than those from ICRP-72.

4. Reference (7), pg 10-11, pg 138, discusses Mayak worker studies and the absence of data on acute human health effects; individual exposures up to 470 kBq are cited, which is 13

uCi; 800 rem CEDE is inferred using ICRP-72 conversion factors, although a comparable PF-4 number would be 1,400 rem, adjusting for PF-4 plutonium aging and isotopics.

5. References (1) and (2) report that 20 mg of optimally-sized Pu dust would cause death within roughly a month from pulmonary fibrosis or edema.

6. Reference (13), pg 7, Table 1.17, indicates the total lifetime cancer risk is 0.21 LCF/person. The CMRR draft EIS, Reference (9), Table 3-17, gives the LCF rate statistics.

7. Reference (8), pg D-15, and Reference (9), pg C-2, cite these probabilities for calculating latent cancer fatalities (LCFs) per rem received. The 6 $x10^{-4}$ LCF/rem value cited is near that used by the EPA in Reference (14), pg 2, 5 $x10^{-4}$ LCF/rem, for all cancer types combined. Reference (14) cites ICRP 60 (1991).

8. DOE STD-3009, Reference (16), describes the most commonly used and accepted methodology for preparing safety basis analyses. One step of the process involves accident analyses that bound "the envelope of accident conditions to which the operation could be subjected" to quantify consequences and estimate probabilities.

9. The Fig. 1, MEOI doses in rem are as follows (cumulative factor reduction in parenthesis):

	Case 1 Building Collapse	Case 2 Unfiltered Release	Average Cumulative Factor Reduction
Base	2150 (1)	143 (1)	1
50:50 Oxide/Metal	969 (2.2)	56 (2.6)	2
Median Airborne Fractions	99 (22)	13 (11)	16
Median Meteorology	17 (130)	2 (64)	97
0.2 LPF Mitigation	3 (649)	2 (64)	356

10. DOE HDBK-3010, Reference (17), contains airborne release and respirable fractions (ARF*RF) appropriate for use in DOE safety basis analyses. For this evaluation, the following values are used:

Material	Insult	Bounding	Median	Ratio	Data (Ref 17)
Oxide	Spill	6 e-4	1.5 e-4	4	pg 4-9
	Impact	2 e-3	8 e-5	25	pg 4-87
	Fire	6 e-5	6 e-5	1	pg 4-7
Metal	Spill	1 e-6	1 e-6	1	pg 4-4 / judgment
	Impact	1 e-6	1 e-6	1	pg 4-4 / judgment
	Fire	2.5e-4	7 e-6	36	pg 4-25

11. The factor of six for 95 percent meteorology, compared to median meteorology, is from the ratio of doses calculated for a CMRR seismically induced fire in Reference 11, Table 4, Case 1A, and Reference 12, Table C-1.

12. Calculation: Assume the once in 5,000 year accident has occurred:
    National average lifetime risk of cancer fatality is 0.21 LCF/person.

The risk of LCF per rem is 6e-4 LCF/rem for doses below 20 rem.

The ratio of average public dose to MEOI dose is 500 (Figure 2 median).
Then:
(2,100 rem) / (500) * (6e-4 LCF/rem) / (0.21 LCF/person) = 0.012; 1.2 percent increased risk.

13. The increased LCF risk for the average public individual for Cases 1 and 2, assuming the accidents occurred (A) and considering the frequencies of the accidents (B) are as follows (LCF/person):

	Assuming the accident occurred (A)	Considering accident frequency (B)
Case 1	2.5e-3 (1 in 400)	3.5e-5 (1 in 28,000)
Case 2	1.7e-4 (1 in 5,800)	6.0e-6 (1 in 170,000)

National Safety Council (Reference (15)) indicates that the lifetime odds of dying from the following causes are as follows:

- a motor vehicle accident: 1 in 88;
- a fall: 1 in 171;
- a car occupant: 1 in 303;
- accidental drowning and submersion: 1 in 1,123;
- firearm discharge: 1 in 6,309;
- air and space transport accidents: 1 in 7,032;
- a cataclysmic storm: 1 in 46,044;
- being bitten or struck by a dog: 1 in 120,864;
- an earthquake or other earth movement: 1 in 148,756.

Enclosure 2
History of PF-4 Safety Basis Development

December 2008 Documented Safety Analysis (DSA)

Unmitigated/mitigated radiation doses were 7,250 rem / 2,900 rem, based on an accident scenario involving 5MT of one plutonium material form, an unconstrained full-floor fire, and an assumed 40 percent leak path factor.

Key actions taken were described in the enclosure to the Secretary's letter of February 2, 2010 (http://www.hss.doe.gov/deprep/2010/TB10F02A.pdf). Updates to these actions are below:

- Installed an automatic seismic shutdown capability for non-vital laboratory room electrical loads to reduce room ignition sources.
- Installed and began using a new safety-class nuclear material storage system using fire-rated safes and containers.
- Addressed NFPA and fire hazard analysis deficiencies.
- Achieved safety-class fire suppression for operational (non-seismic) accidents
- Developed conceptual designs for potential seismic upgrades to key active confinement ventilation subsystems and to the safety-class fire suppression system; pursuing latter using operating funds (to be completed in FY-13).
- Completed implementing combustible control program procedure, and the removal of more than 11 tons of combustible material from the facility, primarily from first floor laboratory rooms (estimate ~20 tons were removed).
- Implemented a fire wall surveillance and maintenance program.
- Implemented ignition source control program.
- Assessed and repaired the facility's main fire wall.
- Assessed and developed conceptual designs to achieve two-hour fire rated separation between the facility's four primary operating areas (planned to be completed in FY-15).
- Initiated procurement of new, more robust special nuclear material containers; these containers are designed to provide increased assurance of confinement in a seismically-initiated fire when stored in environments not susceptible to direct flame impingement.
- Robustly packaged nearly 0.7 MT of plutonium equivalent in FY-10.
- Submitted several DSA iterations, leading to an approved update in October 2011.
- Repackaged 60 Russian Product Containers of heat-source plutonium that had pressure safety concerns into new safety class containers.
- Retrieved and safely vented 40 legacy non-safety class heat-source plutonium containers.
- Replaced 195 HEPA filters with higher temperature rated filters.

- Upgraded portions of the Facility Control System that ensures proper ventilation flow and differential pressure between ventilation zones.
- Developed fire department pre-plans that contain emergency response guidelines for the fire department and other first responders.
- Developed a model of the existing ventilation system that can be used to evaluate system modifications for migrating to a safety class active confinement strategy.
- Developed a hydraulic model of the fire suppression system that identified weaknesses that were subsequently addressed; also developed informed decision making for migrating this system to safety class.
- Relocated the forklift charging station (an ignition source) away from safety-related equipment.
- Replaced vault sprinkler heads with lower-actuation-temperature heads that will respond sooner and limit the development of a vault fire.
- Improved ground attenuation model for seismic ground motion, which reduced seismic loads.

December 2009 DSA Submittal

This DSA submittal was not approved, but the analysis provided perspective. Unmitigated/mitigated doses were 473 rem / 189 rem, based on an accident scenario involving 3 MT of plutonium in 6 material groups, an unconstrained full-floor fire, and an assumed 40 percent leak path factor.

June 2010 DSA Submittal

This DSA submittal also was not approved. Unmitigated/mitigated doses were 275 rem / 110 rem, based on an accident scenario involving 2.6 MT of plutonium in 9 material groups, an unconstrained full-floor fire, only one casting furnace in operation, and an assumed 40 percent leak path factor.

June 2011 Seismic Justification for Continued Operation (JCO)

June 2011: Unmitigated and mitigated drag strut failure mode: 2,100 rem (for a once-in-5,000 years event)

Oct 2011: Unmitigated/mitigated dose after drag strut repair: 278 rem / 143 rem (for a once-in-2,000 years event)

JCO: Key actions completed include:

- Strengthened the roof, thereby addressing the most significant known weakness – a building collapse failure mode.

- Braced ventilation room columns, addressing the next most significant known weakness.
- Braced ventilation fan pads, addressing another major weakness.
- Imposed restrictive material-at-risk limits to reduce the amount of plutonium that could be released in an accident.
- Removed plutonium from vulnerable glove-boxes underneath five mezzanines that could fail.
- Repaired two of the five mezzanines, including the weakest one.
- Installed a seismic shut-off switch to isolate non-vital electrical loads in a seismic event.
- Upgraded the necessary equipment and established a process to completely isolate ventilation, if required.
- Packaged 1.2 kg of heat-source plutonium in robust containers to prevent release, equivalent to 170 kg of weapons-grade plutonium.
- Braced four shield walls.
- Remediated captured ventilation room columns.

By April 2012, the following actions will be complete:

- Repair the three remaining mezzanines.
- Reinforce lab room ceiling supporting steel, to prevent buckling.
- Complete confirmatory analysis for roof cold joints.
- Establish evaluation criteria and completed initial non-linear analysis for corridor columns.

By May 2012, the following actions will be complete:

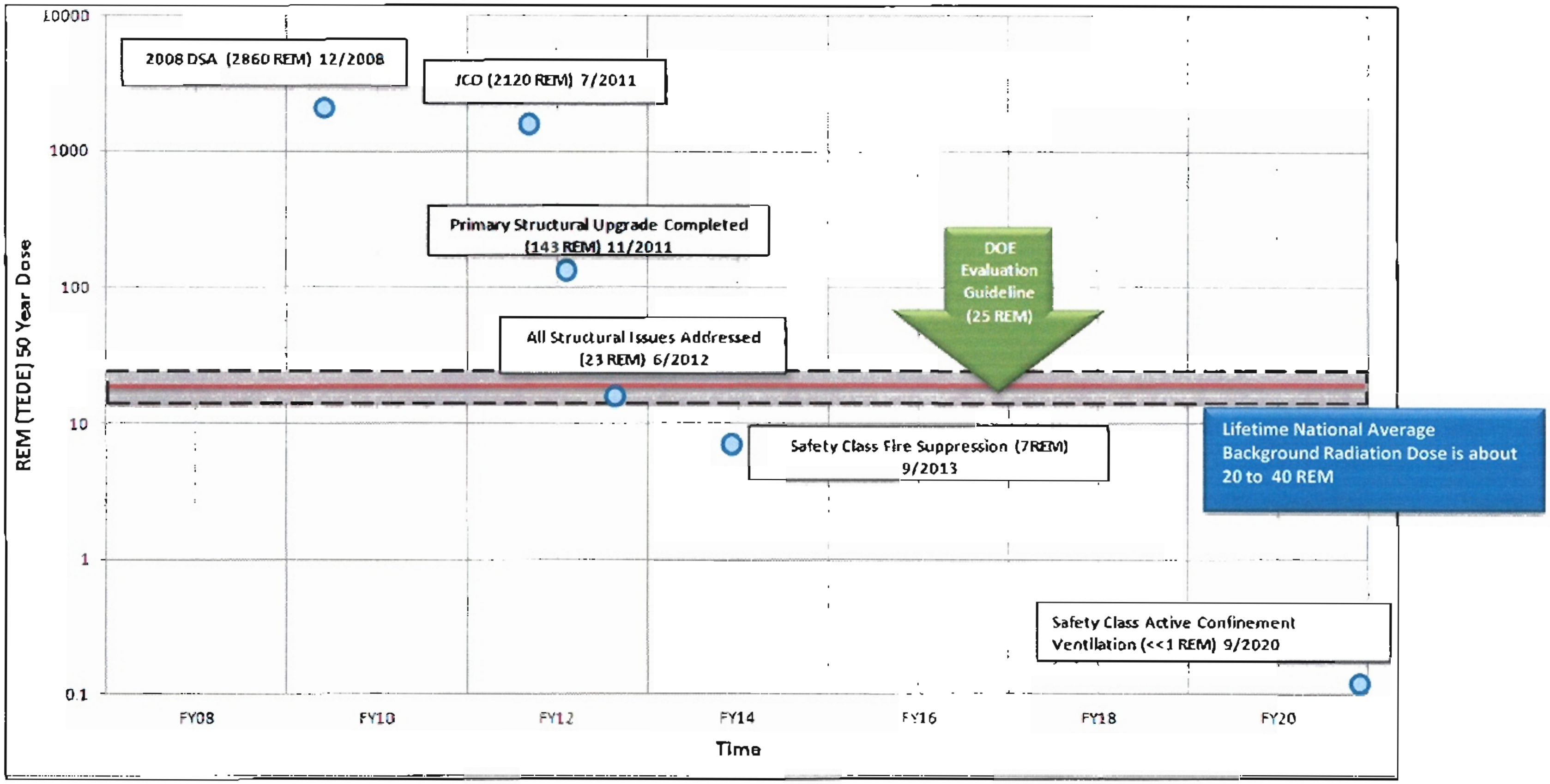
- Assumptions in the 2011 DSA will be protected and the JCO will no longer be necessary.
- Mitigated radiation dose will be less than 25 rem.
- The 2011 DSA estimates the probability of the post-seismic fire event at 3×10^{-6} /yr.

By June 2012, non-linear analysis for corridor columns will be complete.

See Figure 1 at the end of this enclosure for a summary of the results of efforts to reduce mitigated consequences from a post seismic fire at LANL PF-4.

<u>October 2011 DSA Analysis</u>

This DSA was approved and is scheduled to be implemented by May 2012. It requires the seismic JCO to be satisfactorily closed to protect the 2011 DSA analysis assumptions.



Notes: (1) The hypothetical PF-4 dose values are conservatively estimated doses to the maximally exposed off-site individual for the purpose of classifying safety controls. (2) The frequency of the hypothetical PF-4 dose values from a seismic induced fire are on the order of once every several thousand years, i.e., a very low frequency event. However, the average annual exposure that the U.S. population is currently receiving is 300-600 mREM per year. (3) The lifetime national average background radiation dose is based on 0.3 REM/year to 0.6 REM/year and a 70 year lifetime.

Figure 1: Results to Reduce Mitigated Consequences from Post Seismic Fire at LANL PF-4

Enclosure 3
Path Forward to Reduce the Potential Consequences of a Seismically-Induced Fire at Los Alamos National Laboratory's Plutonium Facility

Current Status

The Los Alamos National Laboratory (LANL) Plutonium Facility (PF-4) structure was recently re-evaluated in accordance with national consensus standards using the newly understood ground motion that would occur on the order of once in 2,500 years. In general, the results showed that the structure met industry codes and standards with a few exceptions.

The elements that were the exceptions, if not strengthened, limit the structure's ability to confine hazardous materials and could lead to partial collapse of the facility. These elements included:

- Roof drag strut (a member at the roof that transfers horizontal loads in the roof deck to the interior north-south shear wall);
- Reinforced concrete columns with limited strength to resist shear loads;
- Steel beam to concrete column connections in the basement; and
- Mezzanines located above the laboratory floor.

When the structural issues were first identified, corrective action was taken to fix the problems as quickly as possible without compromising quality, including creating seven upgrade projects. Currently, five of the seven projects have been completed. The remaining two projects will be complete in early 2012. The projects generally involve reinforcing the roof, installing additional steel columns to support beams, providing additional anchorage to walls and concrete pads, reinforcing ceiling beams, and detaching support columns from adjacent structures. Some of the key structural actions completed include:

- Strengthened the roof, thereby addressing the most significant known weakness -- a building collapse failure mode;
- Braced ventilation room columns, addressing the next most significant known weakness;
- Braced ventilation fan pads, addressing another major weakness;
- Repaired the weakest of the five mezzanines and one additional mezzanine;
- Braced four shield walls; and
- Remediated captured ventilation room columns.

As a result of the external expert peer review comments, Los Alamos National Security, LLC (LANS), recommended a nonlinear analysis to examine the structure's ability to respond to beyond design basis ground motion and ultimate capacity. In addition, the Defense Nuclear Facilities Safety Board (Board) technical staff questioned the modeling accuracy used at the roof level of the structure in the area of the service chases, as well the capacity of the main floor of the structure.

Modeling sensitivity studies to determine the effects of the construction joints in the roof slab over the service chase walls are underway. The final calculation will be available in January 2012. Static nonlinear pushover and push up/down analyses to understand the ultimate performance of the structure (including addressing Board staff questions on the floor capacity) will be completed by June 2012.

The analyses supporting responses to Board staff questions will provide insight as to the performance of the structure to beyond design basis ground motion. The results will be used either to confirm what has already been produced or to guide further modifications to the structure depending upon the outcome of the analyses.

Near-Term Path Forward

The near-term path forward to complete the remaining two (of seven) upgrade projects and complete the remaining seismic/structural analyses is as follows:

By April 2012, LANS will have:

- Repaired all five mezzanines;
- Reinforced laboratory room ceiling supporting steel to prevent buckling;
- Completed analysis for roof cold joints; and
- Established evaluation criteria and completed initial non-linear analysis for corridor columns.

By June 2012, LANS will have completed the non-linear analysis for the corridor columns.

After June 2012, all seven upgrade projects and the remaining seismic/structural analyses will have been completed. At that time the conservatively estimated mitigated consequences to a hypothetical maximally exposed individual at the site boundary (MEOI) from a seismically-induced fire event are expected to be in the range of the Department's Evaluation Guideline of 25 rem. This assumes that no additional structural upgrades are needed following completion of the seismic/structural analyses and that the National Nuclear Security Administration (NNSA)-approved 2011 PF-4 Documented Safety Analysis (DSA) and Technical Safety Requirements (TSR) have been implemented, currently planned for completion by the end of May 2012.

To incentivize LANS to complete the above Fiscal Year 2012 actions, NNSA and LANS have developed two award term measures in the FY12 Performance Evaluation Plan for the LANL contract. These two measures include completion of structural upgrades and analyses, and implementation of the 2011 DSA and TSR, in Fiscal Year 2012.

Longer-Term Path Forward

NNSA and LANS currently have a robust safety strategy for PF-4 for beyond 2011, which was provided to the Board on September 30, 2011. This strategy addresses the upgrades that are most important. The intent is to update this strategy and provide it to the Board in July 2012 and then annually thereafter until it is completed.

The current schedule described in the strategy includes:

- In FY13, complete seismic upgrades to the fire suppression system, resulting in conservatively estimated mitigated consequences of 7 rem to a hypothetical MEOI from a seismically-induced fire;
- In FY14, complete glove-box stand upgrades and install glove-box fire suppression;
- In FY15, improve fire barriers; and
- In FY20, complete seismic upgrades related to active confinement ventilation, resulting in conservatively estimated mitigated MEOI consequence of less than 1 rem from a seismically-induced fire.

In parallel, NNSA and LANS will reevaluate the need for additional modifications and improvements annually as part of the annual safety basis update process, as required by DOE regulations.

Enclosure 4
Adequate Protection of Workers, the Public, and the Environment
Los Alamos National Laboratory Plutonium Facility Operations

Summary

This enclosure discusses how the National Nuclear Security Administration (NNSA) applies the concept of adequate protection of workers, the public, and the environment to nuclear facilities that are not fully consistent with the Department of Energy's (DOE) nuclear safety guidance. To illustrate, it applies the concept qualitatively to public protection at an existing nuclear facility in Los Alamos, New Mexico. Additional technical and quantitative details for that facility are provided in separate enclosures.

Conceptual Discussion

Ensuring the safety of workers, the public, and the environment is a core value and a fundamental principle for nuclear operations, often expressed in terms of ensuring their adequate protection. NNSA ensures adequate protection through commitments established in Department of Energy (DOE) Policy 420.1, *Department of Energy Nuclear Safety Policy.*

Consistent with this policy, the conclusion that a facility is safe to operate considers all factors associated with facility operations, and all of the measures that the Department has established to ensure their safety. These measures include compliance with our nuclear safety requirements and standards, effective implementation of our safety management programs, and the actions taken to eliminate or mitigate hazards. NNSA also considers the magnitude of the hazards, the rigor and quality of the hazard analysis, the necessity of the work to be done, the nature and potential impacts of accidents, the physical and administrative measures put in place to prevent or mitigate these impacts, and the availability of other measures that could be reasonably implemented.

Based on those considerations, NNSA concludes that adequate protection is provided when the safety measures and resulting operations are 1) consistent with safe operation of a nuclear facility and 2) involve no undue risk. This determination is made by the responsible federal approval authority. It is an educated and informed judgment, made within the bounds established by requirements; guided by policies, standards and guidance; and supported by contractor and federal technical analyses. It can be a complicated and nuanced decision that is also supported by consultation with senior-level decision makers and multiple subject matter experts.

The determination relies in large part on the hazard controls established and evaluated in Documented Safety Analyses, Justifications for Continued Operations, and corresponding Safety Evaluation Reports. However, these documents are not designed to capture every nuance of the final decision. Instead, they focus on the adequacy of the analysis, the significant hazards and controls, conditions of approval, and other considerations that are amenable to regulatory enforcement and change control.

Considerations that may or may not be captured explicitly in these documents and that affect a final judgment on adequate protection include, but are not limited to: the necessity of the work; planned operational improvements and anticipated schedules; past performance of the operating contractor; the effectiveness of existing safety management programs; maturity of oversight programs; the degree to which safety-related requirements have been implemented; and the degree to which guidance and non-mandatory standards have been followed.

Such considerations affect the judgment of the decision maker and are expressed in the selection of additional safety measures that must be in place before operating, in the selection of measures to be implemented while operating, and in the pace at which safety upgrades are scheduled and achieved. Judgments regarding adequate protection can be dynamic, depending not just on achieving a pre-determined level of consequence or risk, but also on the availability of additional measures to reduce risk, the availability of resources to implement those measures, and the pace at which those measures may be or are being taken. New information or changes in the situation can lead to reassessment of whether the existing plans continue to adequately protect the public, workers, and the environment, and additional measures may be required as needed.

Application to PF-4

Between 2009 and 2011, the PF-4 nuclear facility at Los Alamos operated under a safety analysis that had been approved late in 2008. While compliant with Departmental requirements, the 2008 analysis did not demonstrate consistency with Departmental safety guidance for a design basis seismic event followed by a full facility fire. NNSA approved the analysis based on a holistic consideration of factors described above, including commitments to make timely corrective actions to achieve consistency with Departmental guidance. These commitments were documented in a Safety Evaluation Report, although the report was not as thorough as it could have been in capturing the full rationale for approving the analysis.

In 2011, new information was developed indicating that seismic events and their civil/structural impacts could be more severe than had been previously analyzed. Additional changes to the facility, and significantly more time and effort, would be needed to enable the facility to be consistent with Departmental guidance.

The principal guidance not met at PF-4 affects the implementation of safety measures that minimize the off-site consequences of a seismic event. The Department expects that, if an accident occurs which a facility should be designed to address, existing safety measures should reduce off-site radiological consequences to an insignificant level. Safety measures are warranted to protect the public when calculated offsite consequences of individual accidents challenge DOE's Evaluation Guideline (EG) of 25 rem Total Effective Dose Equivalent (TEDE). This value is comparable to the average natural background radiation in the United States (about 20 to 40 rem TEDE). Typically, especially for new facilities, defense in depth safety measures reduce maximum off site accident doses to around a rem TEDE or less (well below background levels), without regard for how unlikely a design basis accident may be.

These expectations are established as guidance and reflect a preferred approach to ensuring public safety that addresses a single element—driving the consequences of an accident to an insignificant level—which greatly simplifies the decision on adequate protection of the public. When this guidance cannot be followed, many other considerations have to be taken into account and the decision becomes more complicated.

At PF-4, these expectations were not met, which triggered the need to look at other factors. Although the public health consequences and risk were estimated to be relatively small[1], the calculated radiation doses at the site boundary were many times the evaluation guideline used to select safety measures, with associated accident likelihoods of once in a few hundred to once in a few thousand years. An evaluation of available options identified additional measures that could be reasonably taken to bring the facility into compliance with Departmental guidance in a timely manner.

Consequently, the Deputy Administrator for Defense Programs directed the application of all available resources that could be effectively used to address the situation, and NNSA launched an immediate campaign to upgrade the facility, initiating all measures that could be reasonably taken to meet Departmental guidance on an expedited basis.

In parallel, the contractor developed and submitted a Justification for Continued Operations (JCO) that captured the new information and the response planned to address the situation. The JCO evaluated the PF-4 structural deficiencies and provided appropriate actions to be taken. It included compensatory measures that eliminate hazards, reduce radioactive material at risk, and provide additional defense-in-depth during the few months it would take to upgrade PF-4 to address the structural deficiencies. The most significant of these compensatory measures included: (1) isolating the PF-4 ventilation exhaust stacks following a seismic event to isolate potentially unfiltered releases; (2) limiting material at risk on the first floor and in the basement of PF-4; and (3) removing gloveboxes beneath seismically vulnerable mezzanines from service and removing the associated material at risk. The JCO noted that even the most likely structural failures due to a seismic event had a very low probability of occurrence when compared with the timeframe for resolution of these issues. Within a few months, a significant portion of the corrective actions were completed; foremost among them is the installation of a roof modification to ensure confinement capability.

When reviewing the JCO and the situation in general, the NNSA approval authority and his staff evaluated the options available and the actions being taken to ensure public safety. Their analysis considered the totality of the situation, and they documented their overall conclusion in the Safety Evaluation Report. At that time, the issue of how adequate protection was determined had been raised. So, the report included a brief discussion of the commitments the Department had made toward ensuring adequate protection in the DOE Nuclear Safety Policy, and their relevance to the JCO.

No single element dominated the determination of adequate protection. Rather, the determination reflected an overall conclusion that all that could be reasonably done to reduce public risk was being done, and the risk itself was not undue – that is, the public was not being exposed to an unnecessary risk or to risk that could be further minimized by following any other

[1] A discussion of the health risk associated with the seismic accident at PF-4 is presented in a separate enclosure.

reasonably available course of action, and its absolute magnitude was shown to be small based on bounding estimates.

After methodically considering all of these factors, the NNSA Los Alamos Site Office Manager (the Federal approval authority for PF-4) determined that operations were being performed in a manner and under constraints that, together with the planned facility and operational upgrades and considering the time needed to implement those upgrades, continued to provide adequate protection for the public, the workers, and the environment. The Deputy Administrator fully supported his determination.