

# Department of Energy Review of the Materials and Fuels Complex Documented Safety Analysis

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## Abstract

In January 2005, the Idaho Operations Office (DOE-ID) finalized a vulnerability assessment of Nuclear Safety Management practices at the Materials and Fuels Complex (MFC) (previously the Argonne National Laboratory – West). MFCs merger with the laboratory elements of the former Idaho National Engineering and Environmental Laboratory was in support of formation of the Idaho National Laboratory (INL). During the same period, Battelle Energy Alliance (BEA) performed as part of the contract transition, due diligence reviews which included the topical area of nuclear facility safety bases.

The DOE vulnerability assessment and the BEA Transition Review noted that MFC Documented Safety Analysis (DSA) reports for fixed nuclear facilities did not meet the safe harbor provisions of 10 CFR 830 Subpart B, Nuclear Safety Management Rule. As a result of these reviews, DOE in coordination with BEA created an MFC DSA upgrade plan which built a risk based schedule to bring the affected nuclear safety basis documents into conformance with the provision of the safe harbor methodology and in full compliance with the nuclear safety rule.

Reduction in anticipated budget prompted the DOE Idaho Operations Office to conduct an additional focused review of MFC nuclear safety basis documentation and controls. Specifically, the review team was chartered to take a “hard look” at the existing safety bases for MFC facilities with significant worker consequences and develop a priority listing of items to be addressed, including an analysis of the adequacy of the existing controls to determine the timing of upgrades to the existing documents based on program needs and vulnerability to the Department.

The review team concluded that were no near-term vulnerabilities or imminent nuclear safety risks identified in the DSAs. However, since the MFC DSAs do not fully comply with the safe harbor provisions of 10 CFR 830 Subpart B, failure to upgrade these DSAs represents a significant vulnerability for the Department because of the difficulty in accurately conducting the Unreviewed Safety Question (USQ) process. Application of the USQ process to safety basis documents which do not comply with safe harbor provisions of the rule could lead to inadequate decisions by DOE on facility operations. Further, imprecise use of the USQ process can result in weakening the linkage between the DSA and the Technical Safety Requirements. DOE management is ultimately responsible for safe operation of the Department’s facilities, and must base decisions on facility operations on sound and reliable information.

## Introduction

**Note:** In assessing this situation, the Department of Energy determined that there were no immediate risks to workers, the public or the environment. Safety is always the Department's No. 1 concern, and because of that, it was felt that it was important to make sure that safety documentation at Materials and Fuels Complex meets the highest standards. DOE is currently working toward that goal.

The Department of Energy, Chicago Office (DOE-CH) Argonne Site Office transitioned to the DOE, Idaho Operations Office (DOE-ID) for management in October 2004. In February 2005, Battelle Energy Alliance (BEA) took over Management and Operations of the former Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory – West to become the Idaho National Laboratory. Argonne National Laboratory – West became the new Materials and Fuels Complex (MFC) campus. As part of contract transition, all of the former Argonne National Laboratory – West nuclear safety documents were reviewed by both an independent group of nuclear safety professionals associated with BEA and DOE-ID (DOE-ID 2005). The results of these reviews indicated that the state of ANL-W nuclear safety documentation was not in concert with the expectations of DOE-ID for approved nuclear safety documentation and did not fully satisfy the requirements of 10 CFR 830, Subpart B. Of specific concern in these reviews were the use of mitigated accident analysis, derivation of controls from the accident analysis and identification of design features and controls.

BEA submitted an action plan to upgrade the deficient DSA reports to DOE-ID in May 2005. The total estimated cost for these upgrades, including necessary design basis development was approximately \$11.8M, over a four-year period. This estimate did not include the cost for implementation of the nuclear safety document upgrades. The additional resources needed to upgrade the DSAs was not fully addressed by current year and planning year budgets. There was concern expressed by DOE regarding the validity of the estimate, the scope of the upgrades, and the extent of the vulnerabilities given the amount of available resources.

As the Federal oversight for the safety of Idaho National Laboratory (INL) nuclear facilities, DOE-ID had an obligation to ensure that DSAs provide the appropriate level of protection to facility workers, the public and the environment. This obligation to safety must be risk informed so that overly conservative limits are not placed on facility operations. Currently, the INL is on a path to holistically upgrade the MFC DSAs, however, the current funding is such that only a focused upgrade on those issues of greatest safety significance and risk mitigation can realistically be pursued in the short term.

In the summer of 2006, after discussions with NE-32, DOE-ID, BEA and DOE-EH a Potentially Inadequate Safety Analysis (PISA) was declared on the MFC Nuclear Safety Basis documents. This PISA determined that from the previous reviews three main issues were prominent in the MFC DSA: mitigated accident analyses, evaluation of co-located worker dose consequence and facility hazard categorization/material-at-risk evaluation. A follow-on Evaluation of the Safety of the Situation and Justification of Continued Operations were soon developed by BEA.

In December 2006, the DOE-ID Assistant Manager for Infrastructure Support directed that a focused DOE-ID review of the current MFC safety basis documentation and controls be conducted. Specifically, the review team was chartered to take a “hard look” at the existing safety bases for MFC hazard category 2 nuclear facilities and develop a priority listing of items that needed immediate attention. The review was to include an analysis of the adequacy of the existing controls to determine the timing of upgrades to the existing documents based on program needs and vulnerability to the Department. Such vulnerabilities may have included current programmatic risk and gaps in the controls set that could have near term impacts to workers, public, or the environment.

### **Condition of the MFC Documented Safety Analysis**

Legacy conditions of the MFC facilities and supporting DSAs resulted in some challenges in the update/upgrade process.

- The Transient Reactor Test (TREAT) was in a shutdown condition with no current plans for restart. Current TREAT activities were not described in the facility DSA.
- As BEA began the upgrade of one of the first DSAs, it was found that a number of supporting references were not easily retrieved.
- BEA found that documentation supporting the quality level of some facility safety systems, structures, and components (SSCs) and their supporting systems could not easily be retrieved.
- Facility documentation was not up to date in regards to current standards in all cases. Specifically, the Natural Phenomena Hazards standards for seismic and flooding vulnerabilities had not been updated.

### **Documented Safety Analysis Review Methodology**

A review team was formed that consisted of eight DOE-ID and Office of Nuclear Facility Management (NE-32) personnel. Most of these persons were either Nuclear Safety System or Technical Safety Manager certified under the DOE Technical Qualification Program. Three BEA persons assisted the team as advisors. For each of the facilities reviewed, additional BEA personnel were called upon to provide facility-specific expertise. The following methodology was established for the MFC DSA review:

- Determine the prioritization for each facility DSA upgrade.
- Determine the accuracy and extent of the nuclear source term as described in the DSA.
- Evaluate the hazards list for completeness.
- Evaluate the hazards and accident analysis to ensure the major categories of design basis accidents have been adequately addressed.
- Determine the appropriate safety SSCs.

- Determine if there are adequate supporting Technical Safety Requirements (TSRs).

With the exception of the facility prioritization, the techniques discussed in DOE-STD-3009-94<sup>1</sup> were applied for this review.

## **Prioritization of Safety Basis Upgrades**

During Phase I of the review the prioritization and risk ranking and the first two facilities were evaluated for the adequacy of hazards analysis and the associated TSR controls. During Phase II of the review, the balance of the facilities were evaluated for the adequacy of the hazards analysis and the associated TSR controls. After that analysis was completed, the results were analyzed to arrive at an overall recommendation for the priority of the safety basis upgrades. This analysis was combined with the Prioritization and Risk Ranking analysis that was performed by BEA in Idaho National Laboratory Plan NS-18308<sup>2</sup> to arrive at an overall DSA prioritization.

### **Prioritization and Risk Ranking**

The review team evaluated hazard category 2 Documented Safety Analyses to determine the priority based on relative risk. A risk determination was accomplished by using the sum-of-ratios of the nuclides method in DOE STD 1027-92<sup>3</sup>. This sum of ratios multiplied by the dose consequence of one REM at 100 meters multiplied by the number of workers located at each facility provided the facility risk baseline in person-REM (NRC, 2004). This baseline number was multiplied by the Nuclear Regulatory Commission (NRC 1995) mitigation value of \$3000/person REM to define the base facility rank. Each facility design basis accident consequence was evaluated in the same manner and compared to the baseline. The higher of the dose consequence due to the DOE-STD-1027 methodology or the design basis accident dose consequence values (\$/person-REM) was used. The direct program funding consumed by each facility was added to this basis as an indicator of mission and activity. Professional judgment was used as necessary to refine the ranking. For example, if a facility had a significant source term, but was only currently used for storage, and had no significant programmatic activity, and then this facility ranking was adjusted in comparison to a facility with high programmatic activity and lesser source term. Planned activities and future facility uses were not considered for this ranking. The final ranking values in dollars consisted of mitigation costs per REM based on the higher number comparing source term to design basis accidents plus the facility current program activity in direct funding. The results of this analysis are displayed in Table 2.

**Table 2. Facility Prioritization and Risk Ranking**

Facility	1 Hazard categorization sum-of-ratios	2 No. of in-facility and co-located workers	3 Column 1 * column 2	4 Column 3 * \$3000	5 Highest design basis accident consequence (from the SAR)	6 Column 2 * column 5 * \$3000	7 Higher value of columns 4 and 6	8 Current program/mission need (note 1)	9 Professional judgment (note 1)	10 Ranking value (add column 7 & 8)	11 Comparative rank Number
	(rem)	(#)	(person-rem)	(rem)	(rem)	(rem)	(rem)	(rem)	(rem)	(rem)	(#)
NRAD	0.983	10	9.83	0.024	2.95e4	Note 1	2.95e4	805K	Note 4	8.4e5	7
HFEF	1.530	10	153	7.09	4.6e5	Note 1	4.6e5	9339K	Note 3	9.8e6	3
SSPSF	30	10	300	1.8e-4	9e5	Note 1	9e5	8200K	Note 4	8.7e6	4
ZPPR	1316	7	9122	10	2.8e7	Note 1	2.8e7	580K	Note 2	2.85e7	2
TREAT	1.65	20	33	18	9.9e4	Note 1	1.1e6	718K	Note 4	1.8e6	6
RSWF	163	7	1.14e3	0.37	3.4e6	Note 1	3.4e6	1820K	Note 4	5.2e6	5
FCF	398	14	5572	0.11	1.7e7	Note 1	1.7e7	9060K	Note 2	2.6e7	1

Note 1 – The resultant design basis accident value (\$) was clearly less than the hazard categorization value so not calculated.

Note 2 – Ranking based on highest radiological inventory.

Note 3 – Ranking based on high radiological inventory and significant programmatic funding.

Note 4 – Ranking based on current and/or anticipated programmatic input plus overall radiological inventory.

NRAD-Neutron Radiography Reactor

HFEF-Hot Fuel Examination Facility

SSPSF-Space and Security Power Systems Facility

ZPPR-Zero Power Physics Reactor

TREAT-Transient Reactor Test Facility

RSWF-Radioactive Scrap and Waste Facility

FCF-Fuel Conditioning Facility

## Results

The team found that the qualitative risk associated with operation of the facilities to be acceptable to the Department during this period of upgrade. The Space and Security Power System Facility (SSPSF) was found to have a very minimal risk due to the form and design of the material-at-risk (MAR).

The existing analysis for the co-located worker and the off-site dose consequences remains valid, given the following caveats. The current approved DSAs analyze co-located worker dose using mitigated analysis and a distance in excess of DOE guidance. However, more conservative worker evaluation guidelines were applied and re-analysis of the co-located worker dose may not change the level of risk accepted by DOE. If re-analysis of the co-located worker dose is not performed on the current MFC DSAs, the assumptions must be protected and approved by DOE. In-facility worker dose was not calculated for any of the MFC nuclear facility safety basis documents.

The Review Team qualitatively determined that there were no near term vulnerabilities to the in-facility worker. Existing systems, structures, and components (SSCs) and institutional safety programs were qualitatively evaluated as mitigation of, or prevention for the various accident conditions. These were determined to be adequate for in-facility worker protection.

In certain cases, there were differences that were identified between the Teams suggested safety SSCs and the SSCs listed in the DSAs and the MFC Vital Safety Systems list. There are several systems designated as Primary Confinement. The regulatory basis for this designation was not defined.

The current method for preventing criticality at MFC facilities is not in accordance with DOE-ID guidance. Fissile material controls are documented in Criticality Hazard Control Statements (CHCS). An appropriate subset of CHCS controls are not carried forward into the TSRs. The team recommends that an appropriate subset of criticality controls be elevated to the TSR level so the acceptance of risk by DOE is fully understood.

Overall, the team found that the conclusions of an all encompassing Potentially Inadequate Safety Analysis for MFC Nuclear Facilities<sup>4</sup> to be valid, specifically:

- The hazard categorization is valid for all Phase I & II facilities.
- The MAR is valid for Phase II facilities. The MAR for FCF did not include actinides or transuranics; and the MAR addressed in the ZPPR DSA is less than the actual inventory.
- The PISA related issue on the lack of analysis for facility worker consequences remains valid for all DSAs.

## Recommendations

The Review Team recommended the following:

1. In-facility worker dose consequences should be evaluated for all nuclear facilities and analysis should evaluate the adequacy of existing protective measures.
2. A limited subset of the criticality controls should be elevated to the TSRs so that DOE approval (DOE risk acceptance) is obtained. It is expected that extensive re-analyses of criticality hazards should not be required.
3. Active and passive safety SSCs should be identified, and appropriately incorporated into the DSA/TSRs in accordance with DOE guidance.
4. DOE-ID should review TREAT activities to ensure they are supported by the current DOE approved safety basis.
5. The MFC DSA upgrades should be separated as follows:
  - a. DSAs should be upgraded to include evaluations of in-facility worker dose and the subsequent TSR level controls (if any) that result from these evaluations. Where DSA references exist, it should be assumed by BEA and DOE that they are adequate.
  - b. When DSA references can not be found to support the accident analysis and the ability of SSCs to carry out their function, these situations should be addressed as a focused design basis reconstitution (DBR). No assumption should be made that there exists a PISA due to lack of reference documentation.
  - c. If a question arises regarding the current facility activities or a new activity that is to be performed in the facility and DSA reference(s) do not exist to support the activity, a justification for continued operation or a change to the DSA should be submitted to DOE.
6. There appears to be vulnerabilities in the current DSAs regarding the ability of safety SSCs to carryout their function (specifically in regards to seismic qualifications and quality level). Where questions arise in this area, a graded approach should be used to qualify safety SSCs. Seismic qualification due to application of new standards should be treated as a DSA update.
7. BEA should develop a plan to include the implementation of new standards (i.e. Natural Phenomenon Hazards [NPH]).
8. INL must maintain rigorous conduct of operations, integrated safety management, training, and self-assessment programs.
9. DOE-ID must maintain rigorous assessment and oversight of nuclear operations and programs.
10. The results of the Phase I and Phase II should be considered to re-evaluate the cost, scope, and schedule for the MFC upgrade plan NS-18308.

## Conclusion

The review team concluded that no near-term vulnerabilities or imminent nuclear safety risks were identified in the MFC DSAs/TSRs. However, these documents did not comply with the safe harbor provisions of 10CFR830 Subpart B. Failure to upgrade these DSAs represents a significant vulnerability for the Department because of the difficulty in accurately conducting the USQ process. Application of the USQ process to safety basis documents which do not comply with safe harbor provisions of the rule could lead to inadequate decisions by DOE on facility operations.

As the Federal oversight for the safety of INL nuclear facilities, DOE-ID has an obligation to ensure that DSAs provide the appropriate level of protection to facility workers, the public and the environment. This obligation to safety must be risk informed so that overly conservative limits are not placed on facility operations.

Implementation of the recommendations contained within the Phase I and II reports can occur in a cost effective manner. BEA should evaluate a revision to INL Plan NS-18308 to show the cost, scope, and schedule for achieving conformance with DOE-STD-3009 utilizing the recommendations from the Phase I and II.

## References

1. Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports DOE-STD-3009-94, U.S. Department of Energy, March 2006
2. MFC Work Plan for Safety Basis Upgrade Plan NS-18308, Idaho National Laboratory, May 2006
3. Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Reports DOE STD 1027-92, U.S. Department of Energy, September 1997
4. Pre-existing Potentially Inadequate Safety Analysis for MFC Nuclear Facilities/Activities, MFC-USQ-2006-558, Idaho National Laboratory, August 2006