Department of Energy
Washington, DC 20585

March 6, 2014

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

Dear Mr. Chairman:

The purpose of this letter is to provide a copy of the Department of Energy's Nuclear Safety Research and Development (NSR&D) Status Report, which describes actions taken to complete Commitments 7 and 8 in the Department's Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2004-1, *Oversight of Complex, High-Hazard Nuclear Operations.*

We recognize that a robust NSR&D Program is an important part of the Department's efforts to continue to improve our understanding of hazards associated with our nuclear operations, and ensure that appropriate controls are in place to address those hazards. We expect that our NSR&D Program will evolve as we gain experience in identifying and addressing NSR&D needs across the Department and welcome continued dialogue with the Board staff as we implement this program.

If you have any questions or need further information, please contact me at (202) 287-6071, or Dr. James O'Brien, Director, Office of Nuclear Safety, at (301) 903-1408.

Sincerely,

Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

Enclosure

Report to the Deputy Secretary

Nuclear Safety Research and Development Status Report

February 2014

Office of Health, Safety and Security
U.S. Department of Energy

Executive Summary

This report provides an overview of the Department of Energy (DOE) Nuclear Safety Research and Development (NSR&D) Program and discusses how DOE and the National Nuclear Security Administration (NNSA) currently identify and prioritize NSR&D needs, and evaluate and fund NSR&D projects.

The NSR&D Program has been established to provide an enduring Departmental capability to perform research to strengthen the technical bases of DOE's regulatory infrastructure, enhance technical knowledge and understanding with regard to nuclear facility safety, and support continuous improvement in the safe operation of DOE, including NNSA, nuclear facilities. The NSR&D Program is managed by the Office of Health, Safety and Security (HSS); but involves and is supported by DOE, including NNSA, program offices.

DOE's NSR&D Program implements Commitments 7 and 8 made to the Defense Nuclear Facilities Safety Board (DNFSB) in its Implementation Plan for DNFSB Recommendation 2004-1, *Oversight of Complex, High-Hazard Nuclear Operations,* to:

- *Develop processes to identify needed safety research and development needs across the DOE, including NNSA, and to determine if and to what extent those research needs are being addressed through current plans and budgets*; and

- *Develop a method to ensure that nuclear safety research and development needs are identified and integrated into DOE, including NNSA, programming, planning, budgeting, and execution processes including methods to share the results of completed research and development.*

NSR&D projects can be managed and funded via the corporate NSR&D Program or by DOE, including NNSA, program offices depending upon whether it is focused on addressing a site-specific, program office-specific, or a corporate issue. In either case, the NSR&D Program serves to share the NSR&D results DOE-wide to facilitate gaining corporate benefit from the research effort.

DOE's NSR&D Program has grown to the state where it has established processes to identify NSR&D needs, to evaluate and fund NSR&D projects, and to share NSR&D information. DOE, including NNSA, program office projects, along with HSS projects, appropriately address current higher priority NSR&D needs.

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1.0 INTRODUCTION

This report provides an overview of the Department of Energy (DOE) Nuclear Safety Research and Development (NSR&D) Program and discusses how DOE and the National Nuclear Security Administration (NNSA) currently identify and prioritize NSR&D needs, and evaluate and fund NSR&D projects.

DOE committed to establishing and implementing an NSR&D Program for defense nuclear related facilities and activities in the Department's Implementation Plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2004-1, *Oversight of Complex, High-Hazard Nuclear Operations.* This report addresses specific commitments made in that regard. However, DOE's NSR&D may apply to and serve all DOE nuclear facilities and operations, including those that are not defense nuclear facilities.

2.0 BACKGROUND

On May 21, 2004, the DNFSB issued Recommendation 2004-1 which stated that DOE and NNSA should take steps to "ensure continued integration and support of research, analysis, and testing in nuclear safety technologies." DOE accepted this Recommendation and in its Implementation Plan (*Implementation Plan to Improve Oversight of Nuclear Operations*, October 12, 2006) committed to the following related to NSR&D:

> *Commitment 7: Develop processes to identify needed safety research and development needs across the DOE, including NNSA, and to determine if and to what extent those research needs are being addressed through current plans and budgets*; and
>
> *Commitment 8: Develop a method to ensure that nuclear safety research and development needs are identified and integrated into DOE, including NNSA, programming, planning, budgeting, and execution processes including methods to share the results of completed research and development.*

DOE's Office of Environment, Safety, and Health led the Department's initial NSR&D efforts. A reorganization resulted in the transfer of the NSR&D responsibility to the NNSA in 2006 and then to the Office of Health, Safety and Security (HSS) in 2011. The transfer to HSS was made in recognition that it served as a more centralized approach to lead the complex-wide NSR&D effort.

3.0 DOE NSR&D PROGRAM

3.1 Overview and Mission

DOE's NSR&D Program provides a corporate-wide structure and process to coordinate and integrate the Department's NSR&D activities among DOE, including NNSA, program offices. DOE's NSR&D involves a systematic search for knowledge to advance the fundamental understanding of nuclear safety science and technology through scientific study, analysis, modeling, and experiments. The overall purpose of NSR&D is to support DOE, including

NNSA, in standards development, validation of analytical models and methods, development of improved or enhanced technology, and improvements in operating practices. NSR&D also supports DOE, including NNSA, in making technically justified and well-informed nuclear safety decisions, and helps to develop and maintain the technical expertise and the analytical tools and techniques necessary to sustain a robust nuclear safety infrastructure.

The NSR&D Program's mission is to:

- Establish an enduring Departmental commitment and capability to utilize NSR&D in preventing and/or reducing high hazards and risks posed by DOE, including NNSA, nuclear facilities, operations, nuclear explosives, and environmental restoration activities.
- Foster a Departmental culture that embraces NSR&D as a standard business practice for effecting continuous improvement in nuclear facility safety, consistent with integrated safety management principles; and
- Optimize NSR&D resources to resolve existing and emerging nuclear facility safety concerns.

DOE's NSR&D Program provides a mechanism to effectively share information addressing NSR&D activities and results, and to seek cost-effective means to conduct NSR&D that may have DOE-wide benefit. The NSR&D Program solicits input from the Department's Nuclear Safety Council, whose membership consists of senior managers representing each of the program offices that operate and manage nuclear facilities.

The NSR&D Program is implemented under a NSR&D Program Operating Plan, which is periodically reviewed and updated as needed. Major elements of the plan include:

- NSR&D Committee
- Program Office and HSS Roles and Responsibilities
- NSR&D Needs Identification and Proposal Evaluation Processes
- Sharing of NSR&D Results
- Integration of NSR&D efforts into DOE, including NNSA, Budgeting Processes

These elements are discussed further below.

3.2 NSR&D Committee

The objectives of the NSR&D Committee are to: (1) promote communication and coordination among DOE, including NNSA, program offices to enhance synergy on NSR&D efforts that can benefit the Department; (2) identify nuclear safety research needs and opportunities within the DOE, including NNSA, and their program offices; (3) coordinate the review and prioritization of NSR&D Program needs and proposals in order to identify overlaps, gaps, and opportunities where joint funding may mutually benefit multiple DOE, including NNSA, program offices; and (4) foster and facilitate networking and information exchange on NSR&D needs and activities across DOE, including NNSA, programs and with external national and international organizations.

The NSR&D Program solicits proposals for projects that have corporate application (i.e., across multiple DOE, including NNSA, program offices). The NSR&D Committee reviews and prioritizes those proposals for support by available corporate funding, via HSS, or, if appropriate, by joint program office and HSS funding. The Committee also supports development of an NSR&D Annual Report, and dissemination of the report to the DOE complex.

The NSR&D Committee was established, and operates under the NSR&D Committee Charter and NSR&D Program Operating Plan. The Committee consists of the following program and staff offices:

- NNSA
- The Office of Environmental Management (EM)
- The Office of Science (SC)
- The Office of Nuclear Energy (NE)
- The Chief of Defense Nuclear Safety
- The Chiefs of Nuclear Safety for EM, NE, and SC
- HSS, Chair

3.3 NSR&D Program Roles and Responsibilities

3.3.1 DOE, including NNSA, Program Office Roles and Responsibilities

DOE, including NNSA, program offices are responsible for the safety, design and operation of its nuclear facilities and activities. The DOE complex is engaged in a wide variety of nuclear operations, including nuclear explosives operations conducted at NNSA facilities, and nuclear waste operations conducted under the responsibility of the Office of Environmental Management. DOE also sponsors fundamental scientific research at some of its nuclear facilities operated by the Office of Science and the Office of Nuclear Energy. Many of these operations and facilities have unique designs/processes and pose different engineering and technological challenges. Thus, NSR&D needs may be specific to the individual nuclear operations and facilities and the specific program offices that manage them.

It is appropriate that DOE, including NNSA, program offices manage their respective NSR&D efforts to support safe nuclear operations and facility safety. Nonetheless, there are cross-cutting and synergistic elements of nuclear facility and process design and operational safety that may affect virtually all nuclear facilities. Consequently, DOE, including NNSA, recognize the benefit of communicating and coordinating their NSR&D activities to avoid potential gaps or duplication of effort, to identify cross-cutting NSR&D needs, and to build on each other's NSR&D efforts to the extent practicable. Thus, in addition to the program office NSR&D efforts, the Office of Nuclear Safety, within HSS, provides a DOE-wide coordinating and information sharing function as well as limited funding for cross-cutting NSR&D projects. Appendix A provides an overview of the DOE, including NNSA, program office efforts related to NSR&D.

3.3.2 HSS Roles and Responsibilities

HSS has primary responsibility for coordinating the Department-wide NSR&D process and sharing of NSR&D results, as well as for providing initial funding for NSR&D proposals selected under the NSR&D proposal review process. HSS also chairs the NSR&D Committee. HSS sponsors and manages a range of NSR&D projects addressing cross-cutting nuclear safety issues across the DOE complex. This includes, but is not limited to, NSR&D in support of HSS's role in ensuring that DOE's nuclear safety regulatory infrastructure is technically sound and reflects best practices. In this regard, HSS's Office of Nuclear Safety evaluates the results of NSR&D projects for insights relevant to the technical bases supporting DOE nuclear safety policy, requirements, and guidance. The Office also supports NSR&D projects to provide technical information necessary for the development of new, and enhancement of existing, policy, requirements, and guidance.

3.4 NSR&D Needs Identification and Proposal Process

Identification of specific NSR&D needs is accomplished using a variety of approaches, including: (1) workshops of subject matter experts; (2) calls for proposals; (3) analyses of operational events; (4) review of emerging problems; and (5) review by the NSR&D Committee to validate and prioritize Department NSR&D needs.

Research needs can be met either by individual program offices (for those research needs specific to a facility or project) and/or by selection for corporate (HSS) funding via the NSR&D Program proposal solicitation and selection process. The identification of NSR&D needs by the individual program offices by means of the processes listed above is taken into consideration in selecting projects for corporate funding. Section 3.7 discusses the projects selected in the first annual proposal solicitation process. The second annual solicitation was issued in January 2014, with final project selection planned for June 2014.

The NSR&D Committee has developed a process that identifies, prioritizes, and funds NSR&D proposals based on Departmental needs, which includes initial screening, review, and ranking, as well as input from the Nuclear Safety Council. To initiate the proposal solicitation process, the NSR&D Committee has developed instructions outlining the key information required for proposal submission. Selection and funding of NSR&D proposals considers the expected Department-wide benefits and costs.

3.5 Methods for Sharing of NSR&D Results

The NSR&D Program and NSR&D Committee have been working with the Office of Scientific and Technical Information (OSTI) within SC to evaluate and use an existing Departmental database that collects research and development from across the DOE complex. OSTI and its predecessors have collected research and development results that date back to the Manhattan Project and information on projects conducted internationally. The database includes a single-point-of-access interface to provide R&D results once access is granted. The NSR&D Program utilizes the OSTI database to search and collect information on previous research and to verify that research proposals are unique. Furthermore, NSR&D Program funded research will be submitted to OSTI to capture and share the results complex-wide, in accordance with DOE Order 241.1B, *Scientific and Technical Information Management.*

3.6 Integration of NSR&D efforts into DOE, including NNSA, Budgeting Processes

NSR&D activities are integrated into DOE, including NNSA, planning, programming, budgeting, and execution processes through a variety of methods. For the past two years, the HSS budget, submitted to the Office of Management and Budget, has included a request for funding to "*maintain a DOE-wide nuclear safety research and development program to provide corporate-level leadership supporting the coordination and integration of nuclear safety science and technology...and coordinate the conduct of nuclear safety research and development activities.*" The HSS budget for NSR&D includes two main areas of funding (1) the NSR&D proposal process and (2) Office of Nuclear Safety research projects, in addition to NSR&D Program support. The NNSA-wide "special funding" for NSR&D activities is supported through funding for (1) Readiness in Technical Base and Facilities and (2) Directed Stockpile Work. This NNSA "special funding" for cross-cutting NSR&D needs is evenly split between nuclear explosive safety and nuclear facility safety needs. NNSA, EM, NE, and SC may also integrate NSR&D-related activities into their annual facility and project budgets.

3.7 Current Corporate NSR&D Projects

The NSR&D proposal solicitation process was initiated in January 2013 and proposal selection concluded in May 2013. A total of 23 NSR&D proposals were submitted and reviewed. Appendix B provides a description of the top six proposals that were prioritized by the NSR&D Committee in 2013. The following three proposals were selected for funding:

- Development and Manufacture of an Ergonomically Sound Glovebox Glove;
- In-Place Filter Testing Instrument for Nuclear Material Containers; and
- Ceramic HEPA Filters.

Initially, HSS is providing funding for projects selected in the prioritization process, with additional funding being solicited from program offices or other sources depending upon where the NSR&D provide the greatest Departmental benefit.

Other NSR&D projects currently underway and managed by HSS are described in Appendix C. NNSA "specially funded" projects are described in Appendix D.

3.8 NSR&D Annual Report

HSS, through the NSR&D Program, will issue an annual report that will list ongoing and completed NSR&D activities throughout the DOE complex. Collecting these NSR&D activities annually will allow the NSR&D Program and NSR&D Committee to keep the Department informed regarding the needs and gaps associated with ongoing and completed activities. Compilation of information for the first annual report is currently in progress.

4.0 STATUS OF ACTIONS COMMITTED TO IN DOE'S IMPLEMENTATION PLAN FOR DNFSB RECOMMENDATION 2004-1

DOE committed to the following related to NSR&D in its Implementation Plan for DNFSB Recommendation 2004-1:

> Commitment 7: Develop processes to identify needed safety research and development needs across the DOE, including NNSA, and to determine if and to what extent those research needs are being addressed through current plans and budgets.

DOE stated that it would provide a report to the Secretary that declares that "adequate processes are in place and agreed upon" and provides the basis for this declaration. In a memorandum dated July 3, 2012, HSS modified the commitment deliverables to be sent to the Deputy Secretary.

This document serves as the report identified in Commitment 7 and provides the basis for DOE's conclusion that it has adequate processes in place to support a robust and sustainable NSR&D Program as described in sections 3.1 through 3.4.

DOE also committed to:

> Commitment 8: Develop a method to ensure that nuclear safety research and development needs are identified and integrated into DOE, including NNSA, planning, programming, budgeting, and execution processes including methods to share the results of completed research and development.

Similar to Commitment 7, this commitment provides additional actions to ensure that (1) the NSR&D needs are integrated into DOE, including NNSA, planning, programming, budgeting, and execution processes and (2) methods are in place to share the results of completed research and development.

DOE has completed these actions as described in sections 3.5 through 3.7 of this report.

5.0 FUTURE PLANS

As experience is gained with the various elements of the NSR&D Program, DOE and the NNSA, through the NSR&D Committee, will continue to work to improve and strengthen the means by which nuclear safety issues are identified and NSR&D activities are developed to address those issues. One particular area of emphasis will be on cross-cutting issues that could affect and/or benefit multiple program offices and their nuclear facilities. In this regard, HSS is developing a process for identifying such generic safety issues on an ongoing basis, prioritizing them using a risk-informed methodology, and, as appropriate, addressing high-priority issues through NSR&D projects. To assist in developing this process, HSS has consulted with the U.S. Nuclear Regulatory Commission, which has operated a program to identify and address unresolved generic safety issues since 1977.

6.0 CONCLUSION

DOE's NSR&D Program provides a corporate-wide structure and process to improve coordination, integration, and support of the Department's research, analysis, and testing of nuclear safety technologies, consistent with its Implementation Plan for DNFSB Recommendation 2004-1. DOE's NSR&D Program has grown to the state where it has established processes in place to identify NSR&D needs, evaluate NSR&D projects, and share NSR&D information. DOE, including NNSA, program office projects, along with HSS projects, appropriately address current high-priority NSR&D needs.

Based on the NSR&D efforts, actions, and processes described in this report, the Department has fully addressed Commitments 7 and 8 of its Implementation Plan. Commitments 7 and 8 are considered to be completed with the issuance of this report. Furthermore, DOE will annually issue a report to document the Department's NSR&D Program and activities; and will continue to improve from ongoing experiences and lessons learned.

Appendix A

Overview of DOE, Including NNSA, Program Offices NSR&D Efforts

1. National Nuclear Security Administration

The NNSA has safety basis approval authority for 70 nuclear facilities at eight sites. The NNSA is an active participant on the NSR&D Committee; and has a well-developed process for identifying NSR&D projects for its own support. That process was initiated in 2002 for R&D in support of operations at the Pantex Plant, and has been expanded to include other NNSA sites. Following the issuance of DNFSB Recommendation 2004-1, NNSA established the NNSA NSR&D Working Group (WG) to better manage the development of the annual NSR&D programs at NNSA's design and production agencies.

WG membership includes representatives from NNSA Headquarters, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratories, Pantex Plant, Savannah River National Laboratory, the Nevada National Security Site, and the Y-12 National Security Site. The NNSA design and production agencies submit to the WG prioritized lists of NSR&D projects for which special funding is requested. The WG meets periodically to review and coordinate NSR&D work, identify NSR&D needs, prioritize and integrate NSR&D projects, and develop the WG's annual report. HSS also attends the WG meetings for awareness and to discuss areas where NNSA proposals may have corporate benefit. One of the WG Chairs is a member of and participates on the DOE NSR&D Committee.

The NSR&D WG develops an annual report that lists and briefly discusses the program-funded NSR&D projects for each NNSA design and production agency. The report also provides an NNSA-wide integrated and prioritized list of NSR&D projects for which special funding is requested. The report is forwarded by the WG Chair to the NSR&D Committee. The WG report also includes a reference to and a summary of planned criticality safety related NSR&D projects, which are developed and funded by the Nuclear Criticality Safety Program.

2. Office of Environmental Management

EM has safety basis approval authority for more than 80 nuclear facilities at 10 different sites. EM supports the operation of the NSR&D Committee; it has also supported a robust technology development and demonstration (TDD) effort for many years. EM's overarching strategy for TDD was described in its 2008 Engineering & Technology Roadmap, which received approval from the National Research Council. Consistent with the objectives of DOE's NSR&D Program, EM's TDD mission focuses on environmental remediation, modeling, and risk assessment; deactivation and decommissioning; and the safe characterization, retrieval, treatment, monitoring, and disposition of wastes and nuclear materials associated with EM operations across the country.

Three EM "Mission Units" are currently responsible for technology development: Site Restoration, Tank Waste and Nuclear Material, and Waste Management. The three Mission Units receive support from four other offices focused on safety, security, quality assurance, contracts, project management, budget, and human resources. EM's TDD activities are enhanced by its active engagement with partners in government, the national laboratories, the military, academia, and industry. Such collaborative efforts allow sharing and leveraging of resources, identification of mutual or cross-cutting technology needs, elimination of duplicative efforts, and open discussion and development of policies.

3. Office of Science

SC has safety basis approval authority for 16 nuclear facilities at four laboratories. At this time, relatively little of SC's work is related to NSR&D. However, SC representatives serve as members of the NSR&D Committee, and SC has committed to support the NSR&D Program and the Committee from the perspective of overall programmatic integration and awareness. In this way, SC may bring potentially significant NSR&D issues to the attention of the NSR&D Committee, and be prepared to deal with nuclear safety issues that arise at its facilities.

4. Office of Nuclear Energy

NE has safety basis approval authority for 17 nuclear facilities/activities, all of which are located at the Idaho National Laboratory. NE actively supports the NSR&D Committee's efforts in assessing cross-cutting research needs, and is also responsible for its own nuclear safety research portfolio, which is developed by assessing the capabilities and technical needs required to support current and future NE and national needs. NE research program management engages key staff, including strategic planners, subject matter experts, and program managers, as needed to establish the areas or topics where new research and development is needed.

Appendix B

Description of the Top Six NSR&D Proposals for 2013

1. Development and Manufacture of an Ergonomically Sound Glovebox Glove

This project supports the development of a safer and more ergonomically-designed glovebox glove that will potentially reduce glovebox worker injuries and glove breaches, and improve worker comfort. The ultimate objective of the project is to partner with a manufacturer for large-scale production of the improved glove, so that it can be integrated into gloveboxes throughout the DOE complex.

2. Technical Review for Application of Seismic Isolation in DOE Nuclear Facilities

This project supports development of a method for evaluating the nuclear safety benefits of seismic isolation (SI) for DOE nuclear facilities using the provisions of national consensus codes and standards (such as American Society of Civil Engineers (ASCE) 4, *Seismic Analysis of Safety-Related Nuclear Structures*). Some potential benefits of SI are: 1) decoupling the facility from the earthquake hazard thus decreasing risk of material release during large earthquake events; 2) cost savings for the facility and/or equipment; and 3) applicability to both nuclear and high hazard non-nuclear facilities. The proposed case study of a SI nuclear facility would provide important information on its viability for reducing earthquake risk at DOE nuclear and high hazard non-nuclear facilities.

3. In-Place Filter Testing Instrument for Nuclear Material Containers

The technical objective of this project is to develop a hand-held instrument to assess filter functionality on nuclear material storage containers that are loaded with nuclear material and to develop a corresponding methodology for qualifying the filter test instrumentation. The instrument will measure the air flow through and pressure drop across a container filter, without requiring removal of the container lid.

4. Evaluation of the Service Life of American Society of Mechanical Engineers (ASME) AG-1, *Code on Nuclear Air and Gas Treatment*, Fibrous Glass High-Efficiency Particulate Air (HEPA) filters as a Function of Filter Age, Design, and Exposure to Temperature/Relative Humidity

This project supports development of a model to predict aging effects on the range of filters employed by DOE, as a function of temperature, relative humidity, and time. An environmental exposure chamber would be developed for HEPA filters and protocols established for correlating laboratory-based exposures with aged filters received from facilities. Data generated by this study will provide DOE and ASME guidance on service life of fibrous glass HEPA filters. This research would identify, more clearly, filters that can be credited, and provide a basis for adequately protecting credited filters.

5. Evaluation of the Effectiveness of Current ASME AG-1 Qualification Testing to Ensure HEPA Filter Performance Under Anticipated Design Basis Event Conditions

This objective of this project is to identify the effective operating envelope of AG-1 axial flow HEPA filters with respect to pleating geometry/separator type and varying flow rates under design basis event temperature-relative humidity conditions, as a function of scenario filter loading. Recent testing at Mississippi State University has identified instances when qualified AG-1 axial flow filters that have been loaded to four inches of differential water pressure fail rapidly (less than 10 minutes) when subjected to elevated temperature and relative humidity (RH) conditions (130 °F and 60% RH). These are significantly below expected safe operating conditions and much less than AG-1 qualification conditions for clean filters. Results will be incorporated into filter service life portions of AG-1 fibrous glass HEPA filter sections and into the Nuclear Air Cleaning Handbook by reference. Findings will be provided to DOE in the form of a final report for distribution among groups responsible for related DOE standards, orders, and handbooks.

6. Ceramic HEPA Filters

This project supports development of ceramic HEPA filter technology to benefit DOE nuclear facilities by testing new and innovative materials for HEPA filter components (e.g., media, sealants, gaskets). The satisfactory performance of ceramic filters in a fire could significantly reduce safety basis costs of support systems associated with mitigating a release, such as fire suppression, fire detection and alarm, and internal building structure. Advanced ceramic HEPA filters provide an excellent barrier against downwind transport of radioactive material in a nuclear facility. This is essential for the development of the American Society of Mechanical Engineers (ASME) AG-1, *Code on Nuclear Air and Gas,* Subsection FO, *Ceramic Filters* and may eventually be reflected in the relevant DOE standard, DOE-STD-3020, *Specification for HEPA Filters Used by DOE Contractors.*

Appendix C

Nuclear Safety Research Projects Underway in HSS's Office of Nuclear Safety

In addition to the three projects described in Section 3.7, HSS's NSR&D Program is currently funding two projects selected by the Office of Nuclear Safety and has been working with the DOE, including NNSA, program offices on two additional projects that have potential for expansion to address nuclear safety regulatory issues. The four projects are as follows.

1. Atmospheric Dispersion (HSS)

This project comprises the development of a technical basis document for the default atmospheric dispersion value used for analyses of unmitigated accident impacts on collocated workers, and assessment of the appropriate use of the default value for both radiological and chemical releases. The default atmospheric dispersion value is cited in DOE Technical Standard (STD) 1189, *Integration of Safety into the Design Process.*

2. Relationship Between DOE Nuclear Safety Goals and Evaluation Guideline (HSS)

This project involves exploratory research on the relationship between DOE's Safety Goal, contained in DOE Policy 420.1, *Nuclear Safety Policy*, and the Evaluation Guideline in DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Documented Analyses,* which is used for identification of safety class controls. The Safety Goal provides quantitative safety objectives for the risk of prompt fatalities and latent cancer fatalities, while the Evaluation Guideline is used for calculation of the maximum dose to a hypothetical off-site individual and classification of safety controls to prevent or mitigate off-site radiological releases. The Nuclear Safety Policy states that the quantitative safety objectives for public protection are to be used as aiming points in support of the Safety Goal that guides the development of DOE's nuclear safety requirements and standards. This assessment examines whether use of DOE's Evaluation Guideline in identification of safety-class controls achieves the objectives of the Nuclear Safety Policy.

3. Airborne Release Fraction and Respirable Fraction Values (NNSA)

HSS continues to support NSR&D efforts that are important to establishing the technical bases for DOE nuclear safety requirements. For example, HSS's Office of Nuclear Safety is working with NNSA's NSR&D WG and the Y-12 field office on research related to airborne release fraction and respirable fraction values from burning of uranium metals. Although NNSA has funded the research, HSS is the organization responsible for incorporating the results in an update to the Department's handbook on airborne release fractions and respirable fractions (DOE Handbook 3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*), thus making the results readily available to the DOE complex.

4. Spray Release (EM)

HSS is currently working with the Office of River Protection (ORP) and Pacific Northwest National Laboratory on research related to spray release accidents due to pipe failure. Testing associated with the project was funded through ORP to support design of the Waste Treatment and Immobilization Plant. Testing is complete; however, HSS monitored the testing and is evaluating the results to determine the extent to which the results are applicable Department-wide, including potential updating of the Department's handbook on airborne release fractions and respirable fractions.

Appendix D

National Nuclear Security Administration's 2013 NSR&D Working Group Special Funds Projects

In fiscal year 2013, there were a total of 42 proposals submitted to NNSA's NSR&D Working Group. The following are the 18 projects selected for special funding.

1. A Common Approach to QMU Explosive Safety Analysis

This project focuses on establishing the logical relationships between factors important to explosive safety analysis. A Quantification of Margins and Uncertainties (QMU)-based approach is typically used to estimate the "risk" associated with operating and fielding complex technical systems. Estimations of risk in the QMU framework are defined by certain parameters. The most significant parameters of importance include: (a) Uncertainty; (b) Upper and Lower Operating Boundaries (Thresholds); and (c) Designed Operating Margin. Values for these parameters are determined from different factors of empirical knowledge or subjective belief about the characteristics of the risk distribution. The newly-devised factorial structure will be validated for fit and suitability to electrostatic discharge (ESD) threats that would typically be encountered in the production environment.

2. Current Flow Across Broken Bridge Wire in Detonators

This project investigates the initiability of detonators with broken or gapped bridge wires. This is an area that needs additional research and testing. Damaged detonator scenarios include a mechanically broken or gapped bridge wire. Understanding the bounding conditions for energy, power and voltage is important for assessing the probability of initiation and output energy for damaged detonators in a variety of weapon configurations. Previous work scoped the problem to better understand and focus on gap sizes that pose a safety threat and to identify threshold sized gaps. This effort is focused on more testing in the range of the threshold gap size. This allows a better understanding of the statistical nature of threshold breakdown due to gap widths. Two different scenarios are being addressed: (1) discharge due to increasing voltage across a given gap width; and (2) sudden application and discharge of a charged object in excess of the normal gap breakdown voltage. These different scenarios may turn out to have the same or different reaction thresholds.

3. Effect of Adhesive – HE Incompatibility of Thermal Initiation

The goal of this project is to evaluate the safety envelope of PBX 9501 when Barco Bond or Wilethane adhesives are cured in contact with the explosive. Recent differential scanning calorimetry (DSC) data shows that both of these adhesives are incompatible with PBX 9501 – resulting in a decrease in the temperature of peak exothermic decomposition of the explosive. The decomposition peak rise of these mixtures is also more rapid than that of the explosive alone, indicating that significant energy is generated. The implication is that the mixture is less thermally stable, is possibly more energetic, and may be more susceptible to heating induced by mechanical insult. This work will evaluate the significance of these implications.

4. Ceramic Filters for Nuclear Facility Ventilation

This project supports development of a ceramic HEPA filter technology to benefit DOE nuclear facilities by providing lower life-cycle costs associated with safety class and safety significant systems in nuclear facilities. The satisfactory performance of ceramic filters in a fire could significantly reduce safety basis costs of support systems associated with mitigating a release, such as fire suppression, fire detection and alarm, and internal building structure. Advanced ceramic HEPA-filters provide an excellent barrier between radioactive material in a nuclear facility and everything downwind. The technical objective is to develop improved filtration materials for ceramic filters using Lawrence Livermore National Laboratory (LLNL)/DOE developed innovations. This continuing task will build on the ceramic filter medium fabrication techniques developed previously. A commercial filter membrane approach has been developed along with an advanced nanofiber filtration medium in development.

5. Flash X-ray and Streak Imaging of Deflagration-to-Detonation Transition (DDT) Phenomena in HMX-based Explosives

This project uses flash x-ray radiography to perform the first direct measurements of density in an HMX-based deflagration-to detonation transition (DDT) experiment, time-resolved and coordinated with simultaneous spatially-resolved measurements of luminosity. DDT presents a clear danger for many weapons systems because it can develop under a broad range of conditions and have potentially severe consequences, but key phenomena, such as convective burning and plug formation processes, are difficult to model and predict. New quantitative measurements of these processes, which will be performed as part of this project, will enable a greatly-improved predictive capability for violence in HMX explosives.

6. Development of Cookoff-Induced DDT Modeling Capabilities

The objective of this project is to develop a model for cookoff-induced deflagration-to-detonation-transition (DDT) in conventional high explosives (CHEs). DDT models integrated in to ASC codes can be used to assess the probability and outcome of thermal hazard scenarios. Predictive DDT models guide the development of preventative and mitigative measures to avoid and reduce collateral damage. DDT development will be accomplished using the convective-burn model in conjunction with the ignition and growth model. While modeling capabilities for DDT in porous bed HMX, and separately for cookoff violence, have been successfully demonstrated, modeling of cookoff-induced DDT in CHEs has not yet been developed. The project will develop and benchmark the model with recent and newly proposed DDT experiments. Special attention will be given to quantifying model parameter uncertainties and their influence on overall DDT response in order to better understand margins.

7. Triboelectric Charging of Foams

This project will characterize triboelectric processes occurring in nuclear weapons foams, including the charge bound in nuclear weapons foams and the resultant energy deposition for those foams. The triboelectric effect occurs when materials become electrically charged after they come into contact with a different material and are then separated. This occurs during the assembly/disassembly process of nuclear weapons, when pockets of charge can be generated and trapped in foams. Triboelectric processes are dependent on materials used, surface finishes, and perhaps even temperature and are not well characterized. The foam characterization study will help support weapon hazard analyses and development of mitigation techniques for assembly/disassembly processes, along with the development of foams with reduced triboelectric properties.

8. Visual Inspection Reliability

The goals of this project are to increase performance effectiveness, efficiency, and safety by identifying potential methods for optimizing visual inspection performance in nuclear safety operations. Visual inspection is commonly used throughout industry to identify defects in manufactured materials and components. However, humans are imperfect inspectors who sometimes miss flaws, potentially jeopardizing safety if the defective part becomes part of the inventory. At other times, inspectors label a part defective when it actually does not have any flaws. This can result in increased costs and inefficiencies in the process. Potential benefits of this project include reduced errors during visual inspection, a more efficient process, and enhanced safety in the long term if defective parts are more reliably identified.

9. LMA Lightning Detection Investigation

This project will investigate the effectiveness of a Lightning Mapping Array (LMA), which can detect the electrical activity in an area surrounding the plant. This array would use the high frequency characteristics of cloud-to-ground, cloud-to-cloud and inter-cloud lightning discharges. It is known that, in the majority of cases, cloud-to-cloud and inter-cloud electrical activity *precedes* cloud–to–ground lightning by up to an hour depending on atmospheric conditions. The current Lightning Location and Protection System (LLPS) only detects cloud-to-ground strikes. This newer technology may provide more advanced warnings of lightning strikes to the plant by sensing precursor events. Analysis of the data from the LMA sensors may demonstrate that LMA can be effective as an early warning system, as well as serving as a redundant system to reinforce the current LLPS.

10. Experimental Measurement of Brush Discharge Characteristics

The purpose of this project is to characterize the maximum potential current pulse capable of flowing from a dielectric material to a conductive material, with emphasis on materials present in Pantex bays and cells. Based on preliminary results from the LLNL brush discharge model, a selection of dielectric materials with model-specified geometries will be uniformly charged to a high charge density. Preference will be given to materials that are readily available in Pantex bays and cells. A conductive material will then be brought into close proximity with the dielectric to determine how easily a conductor can pull charge from the dielectric and the characteristics of that current pulse, including amplitude and temporal characteristics, and deposited energy. Variables such as geometry, humidity (0-15%), temperature, material cleanliness, and porosity are also considered. A better understanding of dielectric discharge parameters for Pantex-specific materials would aid with ESD calculation/modeling protocols, improve weapons response assumptions and eliminate unnecessarily conservative controls.

11. Continuous Wave Electromagnetic Field Effects on EED's

This project is a continuation of earlier NSR&D special-funded work to determine the effects of continuous wave electromagnetic sources (transmitters) on electrically-initiated electroexplosive devices (EEDs). The objective is to complete the computer modeling and physical validation of the models in order to relax standoff requirements between transmitters and EEDs. At issue are the actual effects to electrically initiated EED from the electromagnetic fields associated with radio frequency transmitters. The current approach to determining separation distances between EED's and transmitters uses highly conservative assumptions about the initiation energy of the device and the antenna configuration of the cabling attached to the device. This results in onerous controls that are purely administrative. It is possible that controls only need to be implemented for a limited number of components in a limited number of configurations, and may not be necessary at all.

12. Ceramic Ventilation Filters Deployed at Device Assembly Facility

This project supports deployment of a ceramic HEPA filter technology to benefit DOE nuclear facilities by reducing or eliminating certain safety basis costs associated with safety class and safety significant systems in nuclear facilities. This project involves field testing in a DOE nuclear facility and development of ventilation system designs and technologies that take advantage of the benefits offered by ceramic filters (e.g., a variety of on-line and off-line filter cleaning technologies). The technical objective of this project is to develop a template for deployment of ceramic HEPA filters in the DOE complex, to modify the design of an existing nuclear facility safety-significant HEPA-filtered ventilation system, then deploy, and in-situ test ceramic HEPA filters in a DOE/NNSA nuclear facility.

13. Determination of ARF/RF for Use in Safety Basis Documents

The objective of this project is to determine the bounding (i.e., 95th percentile cumulative distribution) Airborne Release Fractions (ARF) / Respirable Fractions (RF) for thermal oxidation of uranium metal and uranium metal alloys resulting from a two-hour design basis facility fire event where bare uranium metal is subject to direct flame impingement. The project supports Y-12 Safety Basis Documents by repeating portions of experiments in DOE Handbook 3010 simulating uranium metal response under catastrophic fire scenarios that led to the bounding values presented in the handbook. The uranium samples used in testing exhibit characteristics representative of the bulk of the Y-12 inventory on a mass basis that could potentially be involved in the event (e.g., metallurgical phase, surface area to mass ratio, composition of alloys, etc.); the primary focus is on materials anticipated for use in meeting the Uranium Processing Facility design basis mission requirements. Long-term benefit to DOE includes facilitating revision of the uranium section of DOE Handbook 3010 for use in developing safety bases complex wide.

14. Development of New Holdup Measurement System with Medium Resolution Detectors

This project supports development of a new Holdup Measurement System, using medium resolution gamma-ray detectors. The current Holdup Measurement System is based on sodium iodide detectors, which are low-resolution gamma detectors that only analyze the U-235 region in the gamma spectrum. Because of its low resolution, this system cannot distinguish the multiple gamma rays emitted by U-235. This forces the analyst to treat the entire U-235 region as a single peak. Moreover, the presence of U-238 and other isotopes is ignored, which means that the current system cannot measure the enrichment of in-situ material, and provides a limited capability to identify other isotopes. The new system will be able to confirm the enrichment of *in situ* material and provide an enhanced capability to identify isotopes other than uranium. Consequently, it will improve the ability of nondestructive assay personnel to quantify, in the field, deposits of uranium and other radioactive materials, including those deposits that are dense or inhomogeneous.

15. In Situ NCS Holdup Monitoring System Upgrade

The objective of this project is to develop a modern, long-term sustainable Holdup Measurement System (HMS) for supporting *in situ* nondestructive assay (NDA) measurements of fissionable materials for nuclear criticality safety. HMS Version 4 (HMS-4) is the current "state-of-the-art" NDA system deployed in the field. Further, HMS-4 is a portable measurement system that has been used for years in DOE facilities to conduct passive NDA measurements for quantifying nuclear material residues held up *in situ* in processes and equipment; however, HMS-4 is plagued with software/hardware compatibility issues that are not tenable for long-term NDA measurement system sustainability. The proposed work will result in the development of the next generation NDA measurement system (i.e., HMS-5).

16. Validation of Hydrogen Exchange Methodology on Molecular Sieves for Tritium Removal from Contaminated Water

The technical objective of this R&D effort is to evaluate various platinum (Pt)-catalyzed molecular sieve materials to determine their hydrogen isotope exchange efficiency, with the eventual goal of using these materials to effectively remove tritium from contaminated water in various facilities in the DOE complex and commercial entities. In addition, this technology could be used to successfully remove tritium from contaminated groundwater. The Pt-catalyzed molecular sieve material will be evaluated using protium (H_2), deuterium (D_2), and tritium. In addition, the project will determine the optimum catalyst level needed to maximize the hydrogen exchange efficiency with a minimal amount of Pt. Previous studies were only able to detect about 1% D_2 in the effluent. In order for this process to be applicable for the removal of tritium from contaminated water, it is necessary to determine the amount of exchange gas needed to reduce the amount of heavy isotope to parts per million levels on the molecular sieve bed. The successful demonstration of this technology could eliminate the use of magnesium beds in facilities that process tritiated water (especially the Savannah River Site (SRS) Tritium Facilities). This would result in a significant reduction in the amount of radioactive waste generated.

17. Development of a Safe Disposition Path for Tritiated Hydride Storage Material

The technical objective of this NSR&D effort is to develop an experimentally based oxidation strategy for end-of-life hydrogen storage bed material. This technology will be used to provide a safe disposal path for hydride beds retired from service at the SRS Tritium Plant. The activity consists of performing recovery of a tritium ages sample and thermogravimetric analysis (TGA) with mass spectrometry (MS). Recovery of a tritium aged sample will be accomplished by performing a series of isotopic dilutions with deuterium to reduce the tritium concentration in the sample to acceptable levels. Tritium concentration will be tracked via high resolution mass spectrometry. Oxidation testing will consist of heating the sample at a prescribed temperature ramp in the presence of an oxygen containing gas. Changes in mass will be detected by the TGA while the composition of the TGA effluent will be monitored by the MS. The successful demonstration of this technology will allow the SRS Tritium Plant to simultaneously eliminate concerns related to pressure buildup and potentially pyrophoric materials to safely dispose of the beds in a timely manner.

18. Non-Linear Seismic Soil Structure Interaction Analysis of Nuclear Facilities

The focus of this research is to develop and document a method for performing time domain, non-linear seismic soil structure interaction (SSI) analysis. Non-linear SSI analysis will provide a more accurate representation of the seismic demands on nuclear facilities and their systems and components, and, for intense ground motions, lower in-structure response spectral ordinates. This method will accommodate both geometric non-linearity (e.g., separation of structure and soil) and material non-linearity in the soil and structure. Developing a robust non-linear method for SSI analysis of DOE-regulated nuclear facilities should typically lower the in-structure response of facilities during design basis shaking and improve the safety basis by providing a better understanding of its response during earthquake shaking.