



Department of Energy

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SEP 03 2003



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Mr. Frank Marcinowski, Acting Director
Office of Radiation and Indoor Air
U.S. Environmental Protection Agency
401 M. Street, S. W.
Washington, DC 20460

Dear Mr. Marcinowski:

The purpose of this letter is to provide additional information requested in your March 06, 2003 response to our request for Environmental Protection Agency (EPA) approval of Phase 1 of the Enriched Xenon Observatory (EXO) experiment. Enclosure 1 provides background material and the additional information that you requested. Enclosure 2 is a block diagram that depicts the review process for all experiments conducted at the Waste Isolation Pilot Plant (WIPP). Enclosure 3 is a revised unreviewed safety question (USQ) documentation checklist that addresses:

- staging of the experiment components on the surface and in the underground,
- transportation of the equipment and supplies to the underground,
- assembly of the experiment,
- operation of the experiment, and
- removal of the experiment from the underground.

Finally, Enclosure 4 is a revised Job Hazard Analysis with updated worksheet documentation containing additional detail related to industrial hazards.

The Department of Energy (DOE) carefully considers potential accidents associated with all proposed activities, including physics experiments, at the WIPP. In particular, the EXO experiment was rigorously examined, as documented in the attached documents, and postulated accidents were considered in detail for both potential long-term and short-term impacts to the WIPP facility. This letter provides updated information regarding potential events that were evaluated prior to our first submission, but not documented to your satisfaction in that submission.

New excavation work will not be required for installation of the double beta decay experiment in the former Core Storage Alcove. In addition, all materials and equipment will be removed from the WIPP underground at the end of the experiment. Therefore, the DOE is convinced that this experiment will neither change the long-term performance of the repository nor affect our ability to collect effluent samples to demonstrate continued compliance with 40 CFR 191, Subpart A.



Enclosure 1

Additional Information Requested by the EPA In Support of Enriched Xenon Observatory Experiment

Response to EPA Questions

The additional information requested in the March 6, 2003 EPA response to our November 25, 2002 letter regarding the EXO experiment is provided below. Specifically, this information documents our consideration of the short- and long-term impacts on the Waste Isolation Pilot Plant (WIPP) facility from potential accidents related to the EXO experiment. As a point of clarification, any experiment proposed to be conducted in the WIPP underground is subjected to this same level of scrutiny before the DOE makes a decision to seek EPA approval.

In its response, the EPA stated that sufficient information had not been provided to support the DOE's contention that the EXO experiment does not potentially impact the accidents evaluated in the WIPP Safety Analysis Report (SAR). Specifically, the EPA response noted that "The increasing number, complexity, and physical extent of experiments at the WIPP warrant a more in-depth exploration of the potential effects of accidents on the operations and performance of the WIPP than included in your project description. Specifically an expansion of the SAR, or a substantially equivalent analysis should be performed to examine the potential effects of such accidents."

Attachment 3 of this document includes a revision of our original Unreviewed Safety Question (USQ) evaluation (Attachment 6 of the November submission). This USQ evaluation provides our analysis of potential hazards in more detail than in our original submission, and demonstrates that the potential impact of the EXO experiment was considered with respect to each of the accidents evaluated in Chapter 5 of the WIPP SAR. Similarly, a revised EXO Job Hazard Analysis (JHA) (Attachment 4 of this document) is provided to replace Attachment 1 of the first submission. The revised JHA has additional detail regarding the potential industrial type accidents that were evaluated for the EXO experiment. In addition, the DOE believes that the segregation of the EXO experiment from all aspects of the waste handling process ensures that short-term impacts on waste handling from the experiment are precluded.

The WIPP is classified by the DOE as a nonreactor nuclear facility and certain waste handling and disposal areas of the WIPP are designated as Hazard Category 2. As such, the WIPP SAR must comply with the requirements of 10 CFR 830 Subpart B, Safety Basis Requirements and DOE-STD-3009, Preparation Guide for US Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses.

DOE-STD3009-94 provides guidance with respect to how hazards should be treated in a Documented Safety Analysis (DSA). DSAs specifically examine those hazards inherent in processes and related operations that can result in uncontrolled release of hazardous radiological material. The WIPP CH SAR (DOE/WIPP-95-2065 REV. 6) is the DSA in effect for CH waste disposal operations. The SAR documents the analyses used to develop and evaluate the adequacy of the WIPP CH TRU safety basis. The safety basis defines the controls that ensure the safety of workers, the public, and the environment from the hazards posed by WIPP waste handling and emplacement operations during the disposal phase.

Standard industrial hazards such as burns from hot objects, electrocution, falling objects, etc., are considered in the SAR only to the degree that they can contribute to a significant release of hazardous material (e.g., 115-volt wiring as initiator of a fire) or that they constitute major energy sources, e.g., explosive materials. These hazards are considered in the USQ evaluation.

The USQ process identifies the hazards associated with a proposed activity, e.g., the EXO experiments, and assesses the impact of the activity's installation and operation against the documented safety basis in the SAR. This process can result in either a positive or negative USQ determination. If the result is positive, then either the activity is not performed or controls are established such that the DOE can approve the proposed activity. If the result of the USQ evaluation is a negative USQ determination, then additional controls are not needed with respect to the existing safety basis and the activity is not restricted (from a safety basis perspective).

The underground physics experiments proposed for WIPP thus far, including the EXO experiments, have been evaluated and determined to have no impact on the accidents already analyzed in the SAR and to not create the potential for a new accident that is not already bounded by the existing SAR and programmatic controls. The experiments proposed for WIPP would be conducted in a portion of the underground that is in a different ventilation circuit than the ventilation for waste disposal operations. Also, materials (other than small portable tools or instruments) associated with the experiment are not transported along routes associated with the transfer of waste or personnel to the underground. These measures ensure that off-normal conditions will not result in a hazardous materials release that could either compromise worker safety or impact disposal operations. As such, it is neither necessary or appropriate to explicitly consider the postulated accidents associated with the proposed experiments in the SAR.

The WIPP project requires the development of a job hazard analysis (JHA) to implement the requirements of the U.S. Department of Labor, Mine Safety and Health Administration Safety Manual Number 5, *Job Safety Analysis*. Specifically, WP 12-IS.01, the Industrial Safety Manual, requirements ensure that proposed experiments are also evaluated to identify potential industrial hazards such that the appropriate preventive or mitigative measures are included in the work instructions and procedures for installing and operating the experiment.

The USQ and the JHA processes cover the radiological and the industrial hazards, respectively. However, in view of the EPA response to the proposed EXO experiment, the USQ safety evaluation process will be revised to more thoroughly address aspects of proposed experiments and better explain the existing programmatic controls that ensure activities are within the current safety basis. In Revision 7 to the CH SAR, a discussion regarding experiments has been added to Chapter 5 to ensure that experiments are explicitly addressed through the USQ process. The language is provided below.

External organizations are allowed by the DOE to perform particle astro-physics experiments in the WIPP underground. The experiments are conducted in areas that are isolated from the underground waste handling process and waste disposal area by distance and ventilation and, therefore, should have no impact on the hazard and accident analysis developed in this SAR. All new tests or experiments, and changes to those tests or experiments, shall be evaluated through the Unreviewed Safety Question process. The evaluations typically address not only the potential for the tests or experiments to affect waste handling and disposal, but also the impacts that the staging and transport of required

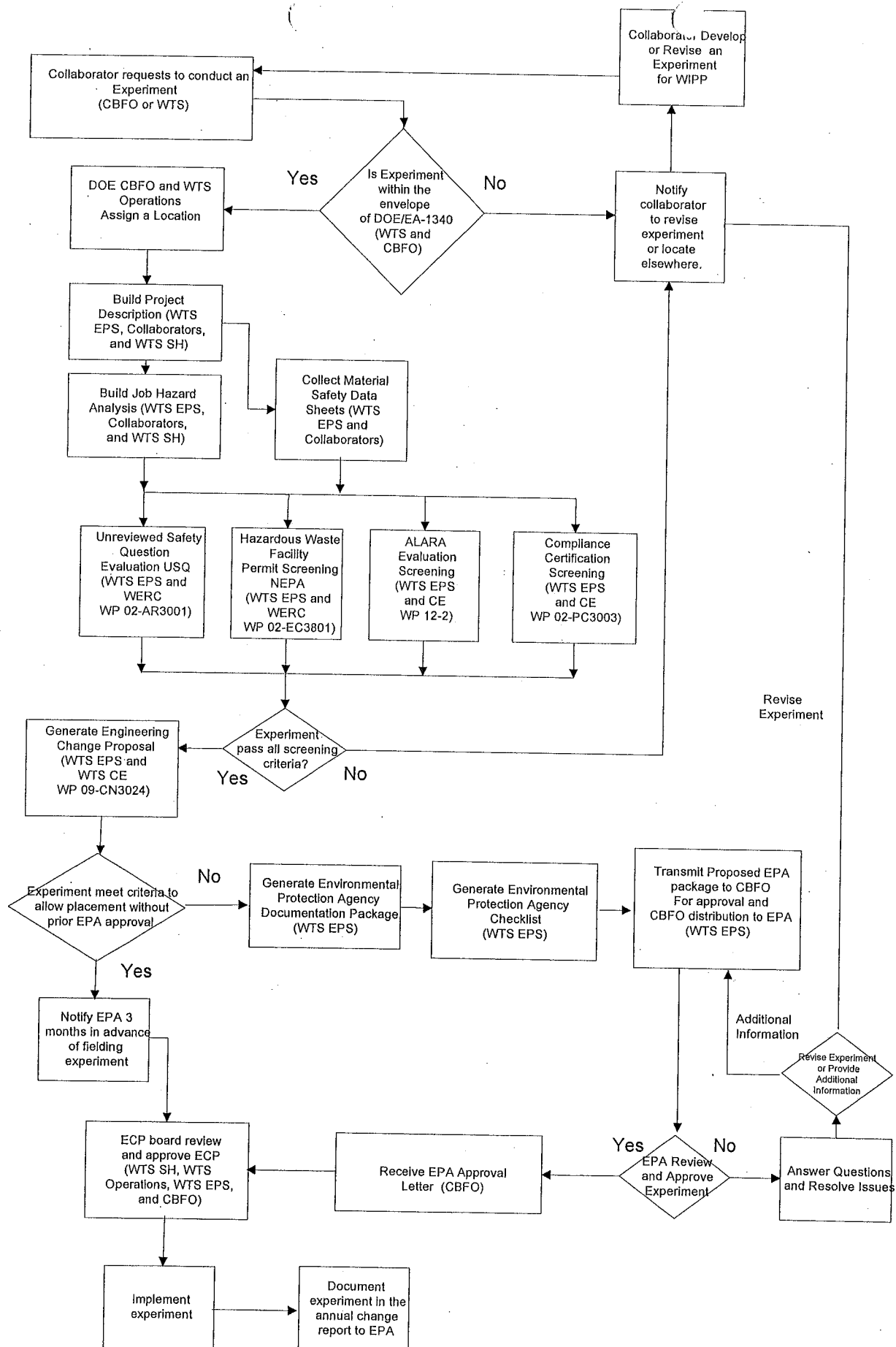
materials and assembly of the test or experiment may have on the hoists and the waste disposal ventilation circuit. Materials to support tests or experiments should not be transported on the same hoist trip as CH waste and should not be stored, even temporarily, at the Waste Shaft Station.

Any experiment hosted by WIPP will follow strict safety guidelines and will not jeopardize the main waste disposal mission. Attachment 2 of this document (General WIPP Astrophysics Review Process Block Diagram) describes the review process for each experiment before it can be approved for implementation at the WIPP. Many organizations have input into the siting decision and safety controls that are required of each experiment. The following criteria for experiments demonstrate that the principles of "defense-in-depth" are employed to ensure that the safety envelope for WIPP is not violated:

- experiments are located in ventilation circuits segregated from the waste disposal ventilation circuits,
- the priority for use of WIPP resources is such that an experiment can not interfere with waste disposal operations, and
- each experiment is subject to the established Engineering Change Proposal process.

Enclosure 2

General WIPP Astrophysics Review Process Block Diagram



Enclosure 3

Revised Unreviewed Safety Question Documentation for the Enriched Xenon Observatory Experiment

Attachment 4 - USQ Safety Evaluation Worksheet

1. IDENTIFICATIONUSQ Evaluation Log Number: **02-015 Revision 1**

Proposed Activity Number and Title (e.g., procedure number/title, ECP number/title, etc.)

Enriched Xenon Observatory (EXO) Experiment

Proposed Activity or Issue Description:

See attached evaluation

Entry Condition: (More than one may be checked)

- ☐ Facility Modification
- ☐ Procedure Change
- ☒ New Operation (Test or Experiment)
- ☐ Potential Inadequate Safety Analyses (Discovery)
- ☐ As-found Discrepancy Between Physical Configuration and TSRs (Discovery)
- ☐ Other (Specify) _____

2. REFERENCE INFORMATION

(Provide detailed answers to the following and attach to this completed worksheet.)

- A. Identify Systems, Structures, and Components (SSC) or process involved.
- B. Identify the SAR and revision number used for the evaluation.
- C. Where is the process or SSC described in the SAR?
- D. Reference location of other information used for the USQ Determination (Drawing, ECOs, TSR references, procedures, etc).

USQ SAFETY EVALUATION**3. IMPACT ON THE ACCIDENTS EVALUATED IN THE SAFETY ANALYSIS REPORT**

(Provide detailed answers to the following and attach to this completed worksheet.)

- A. Identify the applicable SAR accidents reviewed for potential impact by the change. (SAR Chapter 5 accidents)
- B. Identify the applicable SAR event trees in Appendix D, "Determination of Frequency for Selected Accidents" corresponding to the identified accidents.
- C. Discuss the impact of the change on the probability of occurrence of these accidents. (Change to basic event logic, initiating event logic, fault tree probability, life cycle estimates, etc.)
- D. Identify the applicable SAR tables in Appendix E, "Source Term/Dose Calculations," corresponding to the identified accidents
- E. Discuss how the parameters and SSC affected by the change impact the consequences of these accidents (change the waste volume, magnitude of accident, material at risk, damage ratio, different release point, etc.).

Attachment 4 - USQ Safety Evaluation Worksheet

Safety Evaluation Log Number **02-015 Rev. 1****4. IMPACT ON EQUIPMENT IMPORTANT TO SAFETY**

(Provide detailed answers to the following and attach to this completed worksheet.)

- A. Determine if the proposed change or issue impacts the Waste Hoist Brake System (If this answer is no question 4B is not applicable).
- B. Determine if the proposed change or issue creates a failure mode not previously evaluated in the SAR (SAR Appendix C and DOE/WID-96-2178).

5. POTENTIAL FOR CREATION OF A NEW TYPE OF UNANALYZED ACCIDENT

(Provide detailed answers to the following and attach to this completed worksheet.)

- A. Identify potential initiating events resulting from the change which could result in the release of radioactive material. (Will the change or activity be in the proximity of the waste container? Does it affect the waste handling process? Consider changes which may indirectly affect the waste (e.g. placing compressed gas cylinders in waste handling areas which could become missiles).
- B. Determine if the impact of this change could result in a new type of initiating event not previously identified (review the "hazard analyses" - SAR Chapter 5, SAR Appendix C, and FHA).
- C. Determine whether the hazards resulting from the impact of the change could be considered a new type of accident. (What would the hazard rank of the event be? Could the new event be bound by the existing accidents? What is the probability of the event occurrence?)

SUMMARY QUESTIONS

(Indicate yes, no, or n/a for each)

YES	<u>NO</u>	Based on 3C above, does the change increase the probability of a SAR accident?
YES	<u>NO</u>	Based on 3E above, does the change increase the consequences of a SAR accident?
YES	NO	<u>N/A</u> Based on 4B above, does the change create the possibility for a different type malfunction of equipment important to safety than previously in the SAR?
YES	<u>NO</u>	Based on 5C above, does the change create the possibility for a new type of accident not previously evaluated in the SAR?
YES	<u>NO</u>	Does the change require a TSR Change?

EVALUATION RESULTS

YES	<u>NO</u>	Does the proposed activity/issue result in a USQ or TSR change? (If the answer to any of the above summary questions is "yes," the change requires DOE approval)
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WP 02-AR3001

Rev. 3

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Attachment 4 - USQ Safety Evaluation Worksheet

Safety Evaluation Log Number 02-015 Rev. 1

COMPLETION		
Evaluator: Mike Carter	<i>Mike Carter</i>	4/24/03
Printed Name	Signature	Date
Safety Analysis Independent Review: Concurrence Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		
Justification:		
<i>JAMES MC CORMICK</i>	<i>James McCormick</i>	4-28-03
Printed Name	Signature	Date
Safety Analysis Manager: Approval <input checked="" type="checkbox"/> Disapproval <input type="checkbox"/>		
Anne E. Strait	<i>A E Strait</i>	4-28-03
Printed Name	Signature	Date
NRB: Concur <input type="checkbox"/> Nonconcur <input type="checkbox"/>		
Describe Action Required:		
Printed Name	Signature	Date

1. PROPOSED ACTIVITY OF ISSUE DESCRIPTION

The Enriched Xenon Observatory Experiment (EXO) is a multi-faceted experiment whose purpose is to investigate neutrino-less double beta decay, an extremely rare type of nuclear process that will allow for the measurement of the mass of neutrinos. The experiment will be conducted in two phases operating in harsh conditions in the WIPP underground and will evolve into a highly technical experiment. This USQ Safety Evaluation addresses the affect of the following on the Contact Handled (CH) Transuranic (TRU) waste handling receipt, transfer to the underground, and emplacement:

1. Staging of the EXO equipment and supplies on the surface
2. Transport of the EXO equipment and supplies to the underground
3. Assembly of the EXO experiment in the underground
4. Operation of the EXO experiment
5. Removal of the EXO experiment

Standard industrial hazards are to be addressed in a Job Hazard Analysis.

2. REFERENCE INFORMATION

- A. Identify Systems, Structures, and Components (SSC) or process involved .

Waste Handling Building, Waste Hoist, Salt Hoist, and Underground Disposal Ventilation Circuit. The process is for the installation and operation of the EXO experiment. The installation will take place in the underground core storage room located in South 400, West 170, which is isolated from the waste disposal ventilation circuit. The experiment and cryogenic materials are located in the construction ventilation circuit exhaust path.

- B. Identify the SAR and revision number used for the evaluation.

WIPP CH SAR, DOE/WIPP-95-2065, Revision 6

- C. Where is the process or SSC described in the SAR?

The SSCs in 2.A above are described in Section 4.2 of the CH SAR. The EXO experiment as described in Reference D.1 is not described in the CH SAR. The EXO experiment is a new one-of-a-kind experiment in an extremely specialized technical area.

- D. Reference location of other information used for the USQ Determination (Drawing, ECOs, TSR references, procedures, etc.

1. Project Description for the Enriched Xenon Observatory (EXO) Experiment (attached).
2. WP 04-HO1002, Salt Handling Shaft Hoist Operation, Rev. 6.
3. WP 04-WH1003, Waste Handling Hoist Operation, Rev. 7.
4. WP 12-IS.01, Industrial Safety Program, Rev. 7.

Attachment to USQ Safety Evaluation #02-015 Rev. 1

5. WP 04-WH1011, CH Waste Processing, Rev. 19.

3. IMPACT ON THE ACCIDENTS EVALUATED IN THE SAFETY ANALYSIS REPORT

A. Identify the applicable SAR accidents reviewed for potential impact by the change. (SAR Chapter 5 accidents).

CH1 Spontaneous Ignition (Drum) in the WHB
CH2 Crane Failure in the WHB
CH3 Puncture of Waste Containers by Forklift in the WHB
CH4 Drop of Waste Containers by Forklift in the WHB
CH5 Waste Hoist Failure
CH7 Spontaneous Ignition (Drum) in the Underground
CH9 Drop of Waste Containers by Forklift in the Underground
CH11 Underground Roof Fall

B. Identify the applicable SAR event trees in Appendix D, "Determination of Frequency for Selected Accidents" corresponding to the identified accidents.

Figure D-1, CH1 Spontaneous Ignition (Drum) in the Waste Handling Building
Figure D-2, CH2 Crane Drop of Waste Containers in the WHB
Figure D-3, CH3 Puncture of Waste Containers by Forklift in the WHB
Figure D-4, CH4 Drop of Waste Containers by Forklift in the WHB
Figure D-5, CH5 Waste Hoist Failure
Figure D-6, CH7 Spontaneous Ignition (Drum) in the Actively Ventilated Underground
Figure D-7, CH9 Drop of Waste Containers by Forklift in the Underground
Figure D-8, CH11 Underground Roof Fall

C. Discuss the impact of the change on the probability of occurrence of these accidents. (Change to basic event logic, initiating event logic, fault tree probability, life cycle estimates, etc.).

The preparation for, conduct of, or removal of the EXO experiment do not affect the process method for handling the containers or the storage/disposal arrays. Prior to downloading CH waste, Reference 2.D.5 requires inspection of the underground transport route and emplacement area and a waste transport notification system is in place to ensure that the transport route is clear. Therefore, there is no affect on the probability of occurrence for the CH SAR accidents listed in 3.A above.

D. Identify the applicable SAR tables in Appendix E, "Source Term/Dose Calculations," corresponding to the identified accidents.

Table E-1, Source Term Analysis for CH1 Drum Fire in the WHB
Table E-5, Source Term Analysis for CH2 Crane Drop in the WHB
Table E-15, Source Term Analysis for CH3 Puncture and Drop by Forklift in the WHB
Table E-25, Source Term Analysis for CH4 Drop of Waste Containers from Forklift in the WHB
Table E-31, Source Term Analysis for CH5 Waste Hoist Drop
Table E-34, Source Term Analysis for CH7 Internal Drum Fire in the Underground
Table E-38, Source Term Analysis for CH9 Drop of Waste Containers in the Underground
Table E-45, Source Term Analysis for CH11 Roof Fall in the Underground

Attachment to USQ Safety Evaluation #02-015 Rev. 1

- E. Discuss how the parameters and SSC affected by the change impact the consequences of these accidents (change the waste volume, magnitude of accident, material at risk, damage ratio, different release point, etc.).

Accidents CH1 and CH7 - Since preparation for, conduct of, or removal of the EXO experiment do not affect the contents of the waste containers, the analyzed consequences of CH1 and CH7 are not affected.

Accidents CH2, CH3, CH4, CH9, and CH11 - The preparation for, conduct of, or removal of the EXO experiment is not part of the waste handling process and is not allowed in the waste handling areas, therefore, the analyzed consequences of these accidents are not affected.

Accident CH5 - Since during waste downloading to the underground disposal rooms, the Waste Hoist is dedicated to the transport of waste, the analyzed consequences of CH5 are not affected.

4. IMPACT ON EQUIPMENT IMPORTANT TO SAFETY

The preparation for, conduct of, or removal of the EXO experiment has no impact on the Waste Hoist Brake System.

5. POTENTIAL FOR CREATION OF A NEW TYPE OF UNANALYZED ACCIDENT

- A. Identify potential initiating events resulting from the change which could result in the release of radioactive material. (Will the change or activity be in the proximity of the waste container? Does it affect the waste handling process? Consider changes which may indirectly affect the waste (e.g, placing compressed gas cylinders in waste handling areas which could become missiles).

References 2.D.2 and 2.D.3 require that materials and supplies to be transported be secured in the conveyance using an approved method. Reference 2.D.4 specifies the requirements for the transportation, storage, and handling of compressed gas cylinders. Compressed gas cylinders are moved from the hoist station to their storage or operating location in a timely manner. These transport and storage requirements will prevent any damage to compressed gas cylinders.

During normal underground ventilation conditions, there is approximately 65 KCFM of flow down the waste shaft directly to the exhaust shaft and approximately 60 KCFM of flow down the salt shaft joining approximately 220 KCFM supply flow in the West 30 drift which also supplies the waste disposal ventilation circuit. The construction ventilation circuit exhaust flow past the core storage room is approximately 124 KCFM. These air flows should provide sufficient dilution to any possible gas leaks during transport to prevent any affect on underground waste handling operations.

All other EXO experiment operations will take place in areas isolated from the waste handling process and the only associated radioactive materials less than 10 micro-curie sealed sources. Therefore, there are no potential initiating events for the creation of a new type of CH SAR unanalyzed accident.

Attachment to USQ Safety Evaluation #02-015 Rev. 1

- B. Determine if the impact of this change could result in a new type of initiating event not previously identified (review the "hazard analyses" - SAR Chapter 5, SAR Appendix C, and FHA).

Based on 5.A above, there are no new type of initiating events resulting from the change which could result in the release of radioactive material.

- C. Determine whether the hazards resulting from the impact of the change could be considered a new type of accident. (What would the hazard rank of the event be? Could the new event be bound by the existing accidents? What is the probability of the event occurrence?).

Since there is no change in the process, there are no new type of accidents resulting from the change which could result in the release of radioactive material.

Based on the above evaluation; preparation for, conduct of, or removal of the EXO experiment at the WIPP does NOT result in an Unreviewed Safety Question.

Enclosure 4

Revised Job Hazard Analysis Documentation for the Enriched Xenon Observatory Experiment

Job Hazard Analysis-Enriched Xenon Observatory Project

Contents:

1. Introduction
2. Location
3. Configuration of EXO
4. Hazards
5. Plans for Response to an Accident or an Occurrence
6. EXO Job Hazard Assessment Worksheet

1. Introduction

The Enriched Xenon double-beta decay Project (EXO) is a multi-faceted experiment to investigate neutrino-less double-beta decay, an extremely rare type of nuclear process that would allow the measurement of the mass of neutrinos. EXO involves the use of several potentially hazardous materials, as well as several potentially hazardous activities associated with its construction and operation. This Job Hazard Analysis (JHA) covers those activities associated with the Phase 1 of EXO (see Section 6). The JHA identifies those areas that require special attention, and provides a detailed plan of the measures that will be used to minimize the hazards involved. Furthermore, it describes countermeasures that will be used in the unlikely event of an accident or spill of a potentially hazardous material. This document should be read in conjunction with the EXO Project Description. The JHA also describes the specific ground control inspections that the experimental team must conduct during normal operations of the EXO project.

2. Location

This project will be located in the WIPP underground in the W170 drift at approximately S400 in the former Core Storage Alcove. The currently unoccupied eastern half of the alcove will be allocated to EXO. A proposed floor plan of the experiment is shown in Figure 1, Module Arrangement.

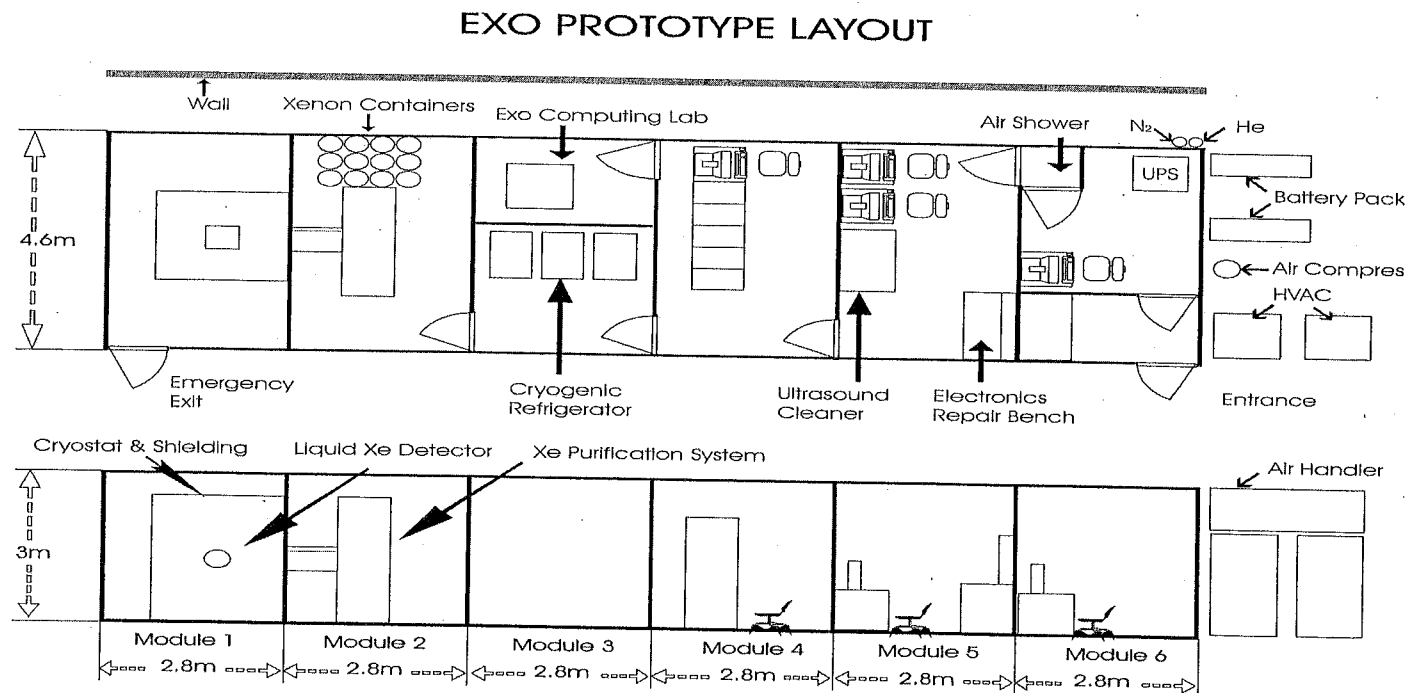


Figure 1 Module Arrangement

3. Configuration of EXO

The experimental array will consist of six modules. They will be assembled at Stanford University, shipped to the WIPP, taken underground, and connected to each other. The experiment will require extremely low radioactive background conditions (along with shielding from cosmic radiation). For this reason, the modules will be configured as clean rooms and will travel from California to WIPP sealed to avoid contamination from outside dust (Figure 1).

4. Hazards

(a) Lead Bricks

While lead will not be used as primary shielding, it is possible that up to 20 tons of lead may be used as the outermost shielding layer. The lead to be used as shielding comes in the form of bricks that measure 2" x 4" x 8" and weigh about 25 pounds each. The lead bricks have several hazards associated with them.

- i) Their intrinsic weight means that during the construction of EXO several precautions must be followed.
 - a. Steel-toed shoes will be worn at all times.
 - b. NIOSH lifting procedures will be followed. The Occupational Health and Safety department at Pacific Northwestern Laboratory will train the designated Safety Officer in the correct lifting techniques, such that he will be able to train any others involved in the construction phase. The revised NIOSH lifting equation (DHHS, NIOSH Publication 94-110 1994) applied to EXO results in a lifting index of about 1.1, which while indicating no major issues, does recommend that only physically fit people should be involved. Mechanical aids will be used wherever possible; specifically, a cart will be used to move the bricks over any significant distances, such as from where a forklift deposits the bricks to where they are needed.
 - c. Before transportation, the lead bricks will be placed onto wooden pallets, approximately 55 bricks per pallet. A plywood sheet will be placed over the top of the bricks, and banded to the pallet. Additionally, shrink-wrap material will secure the bricks to the pallet. This will provide ample protection against bricks falling off.
- ii) Lead dust is recognized as toxic with a federal eight-hour human exposure limit of $50\mu\text{g}/\text{m}^3$, and a WIPP action level of $30\mu\text{g}/\text{m}^3$. Therefore several measures will be taken to protect against exposure to airborne particles.
 - a. Before entering the WIPP, each package of bricks will be inspected for gross oxidation. Lead with gross, friable oxidation will not be allowed on site. Should minor cleaning be necessary, it will be done in accordance with the project description and all waste will be handled in accordance with the EXO Waste Management Plan. Each pallet will be covered with plastic wrap or each package of bricks will be inside an enclosed container to contain any lead dust that might be generated during transportation into the WIPP underground.
 - b. Upon arrival in the former Core Storage Alcove, the pallets will only be placed on surfaces, such as a layer of heavy-duty plastic, which protect the salt floor from becoming contaminated with dust. The dust covers and bands

will then be removed. Care must be taken and leather and nitrile gloves and safety glasses must be worn when removing the bands to protect against potential cutting and falling hazards.

Bricks will be installed in the experiment using established administrative controls. Personnel will wear leather and nitrile work gloves, disposable Tyvec coveralls, and approved respirators if exposure sampling indicates they are necessary. Whenever bricks are moved, they will be lifted, not dragged. A dust cover will be installed consisting of heavy-duty plastic sheeting. No eating, drinking, or smoking will be allowed in the area of the experiment and signs will be posted at the modules to indicate this. After leaving the area, simple practices of good hygiene will be required, such as prompt changing and cleaning of clothes and washing of hands. Upon any changes to the lead structure, the plastic will be carefully removed and the structure vacuumed with a HEPA filtered vacuum to remove any dust deposits. If the lead dust measurements indicate that there is a potential for exposure, administrative controls will be introduced to ensure that no personnel could be exposed to a lead dust concentration above the WIPP action level.

(b) LN₂

Use of LN₂ presents several potential hazards such as cryogenic surfaces (frostbite burns from contact), pressurized cylinders (high energy source), and possible oxygen displacement (asphyxiation).

- i) LN₂ is extremely cold (-196°C = -320°F at atmospheric pressure) and can cause severe frostbite. Standard safety procedures, which include wearing insulated cryo-gloves and a face shield, will be used when transferring the liquid nitrogen from the tank to the Dewars. Also, insulated gloves will be worn by personnel when touching any object cooled by LN₂. The gloves will be loose fitting so that they can be thrown off if liquid is accidentally poured inside them.
- ii) The pressurized LN₂ cylinders are a high-energy source that can propel the cylinder valve or parts of the cylinder if a catastrophic rupture of the cylinder separates the valve or parts due to a violent mechanical shock. To prevent mechanical shock during transportation or storage, the cylinders shall be properly secured at all times. LN₂ container caps shall be secured over the valve when the cylinder is not in use. Overhead protection will be required when cylinders are in use (unless inside a building).
- iii) Steps will be taken (e.g., proper air exchange, oxygen monitoring, etc.) to ensure that the proper ventilation necessary to maintain oxygen levels above 19.5 percent (minimum for breathing air) exists during normal operation of the project. All xenon modules will be equipped with an oxygen monitoring system that will alarm within the clean room, external to the modules in the former Core Storage Alcove area, and in the WIPP Central Monitoring System.

(c) Wooden Pallets

The number of wooden pallets will be minimized since they add to the overall level of combustibles in the WIPP underground.

- i) Pallets will be taken to the former Core Storage Alcove by forklift, and placed on a tarp to avoid possible contamination of the underlying salt with lead dust.
- ii) Once emptied, a minimum number of pallets will be stored in the underground (available in case the lead needs to be moved). The remaining pallets will be removed from the underground for storage at the surface. The total number of pallets in the underground is expected to be about ten.
- iii) It would be preferable for high-density polyethylene (HDPE) or steel pallets to be used. Wooden pallets will be replaced as needed.

(d) Electrical

- (i) **110 V supply.** The EXO will use many electronic modules for the data acquisition system, all of which are powered through 110V lines hooked up to Electrical Substation No. 4. Ground fault circuit breakers will be used. Extension cords will not be used except as a temporary measure. All extension cords will be ground fault circuit interrupter (GFCI) protected.
- (ii) **High Voltage.** The exact configuration of the electronics in Module 3 is still under discussion. In general, a multi-channel high voltage power supply (HVPS) intended for photomultiplier tubes, such as the CAEN model SY527, and a single channel higher voltage unit providing up to 100 kV (DC) at less than 100 microamperes to the detector. There will be several low voltage bench top power supplies and five to ten VME crates. About five NIM instrumentation crates will be used. The VME crates will house TDC and ADC units, controllers and readout modules/memories. There will also be up to 100 channels of 2kV, 2mA to supply photomultipliers. Standard high voltage, safety procedures will be applied in the appropriate areas.

(e) Liquid Xenon

Loss of cooling resulting in the evaporation of the xenon will produce a xenon-venting event. The maximum amount of xenon vented (full inventory of xenon) will be about 1000 cubic feet in gas phase. This would be about 2.5 percent of the volume of air in the former Core Storage Alcove. This release would occur in a time exceeding one hour. Pressure burst disks will be installed on all critical components of the system. All modules will be equipped with an oxygen monitoring system that will alarm within the clean room, external to the modules in the former Core Storage Alcove area, and in the WIPP Central Monitoring System so adequate warning will be provided. Worst case calculations, assuming complete and immediate release of the Xenon, could drop the oxygen level in the immediate area of the modules to 18.5 percent; however, if the release takes about one hour the oxygen level will not drop below the 19.5 percent limit. While the burst disks are designed to safeguard the system against the possibility of explosion, the value of the enriched xenon-136 contained in the system (up to \$1.5M), suggests the use of a redundant refrigeration system so that venting of xenon is considered to be an extremely unlikely scenario.

(f) Ground Control

No ground control problems are expected, because the WIPP has an excellent ground control program, and work areas are inspected daily. Title 30 CFR 57 requires that persons experienced in ground control examination evaluate ground conditions and designate areas to be tested for loose ground. WIPP personnel are qualified for this task after completing a 40-hour miner-training course. Each person is required to examine, and as applicable test, ground conditions in areas where work is to be performed, prior to commencing work. Specific requirements for ground control are provided in the Annual Ground Control Operating Plan (see Attachment 5: DOE/WIPP 02-3212 revision 0).

5. Plans for response to an accident or an occurrence

(a) Response to an Ethanol or Acetone leak

Ethanol or acetone may be used for surface treatment of equipment. If a spill occurs during the fluid transfer process, work will be stopped, the Central Monitoring Room (CMR) shall be notified, and the fluid will be contained, absorbed, and managed in accordance with approved spill response and reporting procedures. Waste products will be characterized and properly managed and disposed of, using approved WIPP site generated waste management procedures.

(b) Response in the event of an underground fire

Response to fire in the underground will be in accordance with approved WIPP procedures. Personnel discovering a fire will notify the CMR by regular phone (8111) or the mine pager phone. Personnel may attempt to extinguish the fire using a portable fire extinguisher only if they have been trained and feel capable and safe in doing so. If unable to extinguish the fire, they will evacuate to an egress hoist station. Personnel encountering smoke will don their self-rescuer immediately. NOTE: Self-rescuers are for emergency egress only and ARE NOT to be used for fire fighting purposes.

(c) Response to lead dust exposure

WIPP is taking proactive measures to anticipate and prevent significant worker exposure to lead, particularly airborne lead. Administrative controls on duration of lead handling operations will be in place until sampling data indicates that work with lead can be safely conducted on an extended basis. Should personal air sample results indicate significant lead exposure, handling times will be limited and/or respiratory protection shall be required.

(d) Response to an injury (e.g., from dropping a brick)

A first aid kit will be in the EXO modules for immediate response; the CMR will be notified on the mine pager phone. Assistance will be provided by trained WIPP emergency response personnel.

(e) Response to a leak of LN₂

If a major leak or spill occurs during the fluid transfer process to fill the LN₂ Dewars, work will be stopped, the CMR will be notified, and proper first aid will be administered if any LN₂ comes in contact with skin. Closing the main LN₂ supply valve will halt the release. The incident will be managed in accordance with approved response and reporting procedures. During transportation the LN₂ canisters are protected from hazards by the attachment of a protective cap. All canisters will be inspected when received from the distributor and prior to any transportation at the WIPP. The cap must be in place protecting the valve. If the valve is missing, the LN₂ canister will not be transported underground or used but will immediately be returned to the distributor.

(f) Response to a leak of Liquid Xenon

All modules will be equipped with an oxygen monitoring system that will alarm within the clean room, external to the modules in the former Core Storage Alcove area, and in the WIPP Central Monitoring System in the event of a loss of liquid xenon so adequate warning will be provided. As stated in section 4(e), worst case calculations, assuming complete and immediate release of the Xenon, the oxygen level in the immediate area of the modules could drop to 18.5 percent; however, if the release takes about one hour the oxygen level will not drop below the 19.5 percent limit. If a low oxygen monitor alarms, work will be stopped, the immediate area will be evacuated, and the Central Monitoring Room Operator and Underground Services will be notified. No one will enter the experiment modules if the external low oxygen monitor is alarming. The Central Monitoring Room Operator and Underground Services will be notified, and they will investigate the alarm using proper protective equipment.

(g) Emergency evacuation routes

Primary route:

Exit the former Core Storage Alcove to the east and turn left in the W170 drift. Proceed to S90 and turn right at S90 and proceed east to the E0 drift. Turn left (north) at E0 and assemble/exit at Salt Handling Shaft.

Secondary route

Exit the former Core Storage Alcove to the east and proceed to the W170 drift, turn to the left (north). Proceed along W170 to N150. Turn right at N150 and proceed east to the E0 drift. Turn right (south) at E0 and proceed to the assembly area /exit at the Salt Handling Shaft.

6. EXO Job Hazard Assessment Worksheet

Below are Job Hazard Assessment worksheets associated with expected activities related to the installation and operation of the EXO experiment.

EXO
JOB HAZARD ASSESSMENT WORKSHEET

Movement of Bricks to Underground and on to the former Core Storage Alcove
(Type of Work Performed)

Author: _____ Date: _____ WIPP Safety Engineer Concurrence _____ Date: _____

STEP	HAZARD	MITIGATING ACTIONS
1) Truck deliver to staging area	a) Shifting of load, bricks fall, damage equipment, injure personnel. b) Failure of pallet, bricks fall, damage equipment, injure personnel. c) Airborne lead dust inhalation.	a) Load secured. b) Pallets inspected prior to being received at site. Defective pallets replaced. c) Bricks cleaned and wrapped in plastic prior to receipt.
2) Forklift stage bricks on surface	a) Pallet failure, bricks fall, damage equipment, injure personnel. b) Misaligned forks, bricks fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne lead dust inhalation. d) Plastic comes loose, lead dust inhalation.	a) Qualified forklift operator. Pallets inspected. Faulty pallets replaced. b) Qualified forklift operator and spotter. Bricks secured with plastic and straps. c) Qualified forklift operator and spotter. d) Plastic secured off site. Inspect before handling. Repair with duct tape if necessary.
3) Forklift load bricks on cage	a) Pallet failure, bricks fall, damage equipment, injure personnel. b) Misaligned forks, bricks fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne lead dust inhalation. d) Plastic comes loose, lead dust inhalation.	a) Qualified forklift operator. Pallets inspected. Faulty pallets replaced. b) Qualified forklift operator and spotter. Bricks secured with plastic and straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary.
4) Forklift remove bricks from cage	a) Pallet failure, bricks fall, damage equipment, injure personnel. b) Misaligned forks, bricks fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne lead dust inhalation. d) Plastic comes loose, lead dust inhalation.	a) Qualified forklift operator. Pallets inspected. Faulty pallets replaced. b) Qualified forklift operator and spotter. Bricks secured with plastic and straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary.
5) Forklift unload bricks at the former Core Storage Alcove	a) Pallet failure, bricks fall, damage equipment, injure personnel. b) Misaligned forks, bricks fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne lead dust inhalation. d) Plastic comes loose, lead dust inhalation. e) Mine traffic causing accident.	a) Qualified forklift operator. Pallets inspected. Faulty pallets replaced. b) Qualified forklift operator and spotter. Bricks secured with plastic and straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary. e) Qualified operators.

- ◆ **Equipment:** (list any tools that may represent a hazard and all chemicals)
- ◆ **PPE:** (list all PPE required)
- ◆ Can pushing, pulling, lifting, bending or twisting cause strain?
- ◆ Is there a danger of striking against, being struck by, or otherwise making a harmful contact with an object?
- ◆ Is fall protection equipment required?
- ◆ Have MSDS been reviewed for chemicals used?
- ◆ Are there any environmental issues: heat, cold, lighting?

☐ **Comments:**

EXO
JOB HAZARD ASSESSMENT WORKSHEET

Movement of Liquid Nitrogen to Underground and on to the former Core Storage Alcove
(Type of Work Performed)

Author: _____ Date: _____ WIPP Safety Engineer Concurrence _____ Date: _____

STEP	HAZARD	MITIGATING ACTIONS
1) Truck deliver to staging area	a) Shifting of load, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced.
2) Forklift stage canisters on surface	a) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. Qualified forklift operator and spotter.
3) Forklift load canisters on cage	a) Shifting of load, canisters fall, damage equipment, injure personnel. b) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. b) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. Carriers secured with containment chains. Qualified forklift operator and spotter.
4) Forklift remove canisters from cage	a) Shifting of load, canisters fall, damage equipment, injure personnel. b) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. b) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. Carriers secured with containment chains. Qualified forklift operator and spotter.
5) Forklift unload canisters at the former Core Storage Alcove	a) Shifting of load, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced.

- ◆ **Equipment:** (list any tools that may represent a hazard and all chemicals)
- ◆ **PPE:** (list all PPE required)
- ◆ Can pushing, pulling, lifting, bending or twisting cause strain?
- ◆ Is there a danger of striking against, being struck by, or otherwise making a harmful contact with an object?
- ◆ Is fall protection equipment required?
- ◆ Have MSDS been reviewed for chemicals used?
- ◆ Are there any environmental issues: heat, cold, lighting?
- ◆ **Comments:**

EXO

JOB HAZARD ASSESSMENT WORKSHEET

Movement of Liquid Xenon to Underground and on to the former Core Storage Alcove (Type of Work Performed)

Author: _____ Date: _____ WIPP Safety Engineer Concurrence _____ Date: _____

STEP	HAZARD	MITIGATING ACTIONS
1) Truck deliver to staging area	a) Shifting of load, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced.
2) Forklift stage canisters on surface	a) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier boxes. Caps placed over valves for fall protection. Defective caps replaced. Qualified forklift operator and spotter.
3) Forklift load canisters on cage	a) Shifting of load, canisters fall, damage equipment, injure personnel. b) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier boxes. Caps placed over valves for fall protection. Defective caps replaced. b) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. Carriers secured with containment chains. Qualified forklift operator and spotter.
4) Forklift remove canisters from cage	a) Shifting of load, canisters fall, damage equipment, injure personnel. b) Misaligned forks, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier boxes. Caps placed over valves for fall protection. Defective caps replaced. b) Canisters secured to carrier racks. Caps placed over valves for fall protection. Defective caps replaced. Carriers secured with containment chains. Qualified forklift operator and spotter.
5) Forklift unload canisters at the former Core Storage Alcove	a) Shifting of load, canisters fall, damage equipment, injure personnel.	a) Canisters secured to carrier boxes. Caps placed over valves for fall protection. Defective caps replaced.

- ◆ **Equipment:** (list any tools that may represent a hazard and all chemicals)
- ◆ **PPE:** (list all PPE required)
- ◆ Can pushing, pulling, lifting, bending or twisting cause strain?
- ◆ Is there a danger of striking against, being struck by, or otherwise making a harmful contact with an object?
- ◆ Is fall protection equipment required?
- ◆ Have MSDS been reviewed for chemicals used?
- ◆ Are there any environmental issues: heat, cold, lighting?

☐ **Comments:**

EXO
JOB HAZARD ASSESSMENT WORKSHEET
Assembly of Modules and Detector
(Type of Work Performed)

Author: _____ Date: _____ WIPP Safety Engineer Concurrence _____ Date: _____

STEP	HAZARD	MITIGATING ACTIONS
1) Placement of lead bricks	a) Lifting. b) Lead dust – inhalation. c) Lead dust – ingestion. d) Tripping on equipment. e) Dropping brick.	a) Training in proper lifting. Using mechanic means where possible. Apply NIOSH lifting equation. b) DO NOT SLIDE BRICKS. Bricks will be cleaned before arrival at site. Remove plastic cover slowly. Perform initial air monitoring under limited work duration administrative controls. HEPA vacuum loose dust. Establish administrative controls based on monitoring results. c) Use impervious gloves and coveralls while moving brick. Remove PPE using contamination methods. Wash hands before eating, drinking, or other hand to mouth activity. d) Training. Use caution bi-folds. e) Steel toed shoes required.
2) Assembly of Modules	a) Lifting. b) Pinch Fingers.	a) Training in proper lifting. b) Careful use of hand tools. Wear leather gloves.
3) Assembly of XSRP System	a) Pinch Fingers. b) Burn from baking of XSRP system. c) Fire from use of Acetone or Ethanol. d) Respiratory issues from use of Acetone or Ethanol.	a) Careful use of hand tools. b) Use of gloves allows proper time for system to cool. c) Ensure adequate ventilation. Fire extinguisher close to area. No smoking/eating/drinking signs will be posted at experimental area. d) Ensure adequate ventilation.
4) Assembly of N ₂ Dewar system	a) Lifting	a) Training in proper lifting.
5) Filling of LN ₂ system	a) Eye contact with LN ₂ . b) Skin contact with fluid or cold metal. c) Leak of LN ₂ .	a) Chemical goggles or a face shield will be used during transfer of the fluid. b) Use of impervious cryo-gloves. Inspect supply tubes prior to use. c) Ensure proper ventilation prior to fluid transfer. Isolate LN ₂ by closing valve. Inspect Swagelock fittings.
6) Xenon system.	a) Filling, Leak of Xenon. b) Operating, Leak of Xenon.	a) Ensure proper ventilation prior to fluid transfer. Oxygen monitoring system in operation. Trained personnel. b) Oxygen monitoring system in operation. Pressure relief disks in system design.
7) Assembling detector	a) Electrical.	a) Qualified experimenters will perform work following site procedures. Work on de-energized equipment. GFCIs are required. Extension cords may not be used on a permanent basis.

- ◆ **Equipment:** (list any tools that may represent a hazard and all chemicals)
- ◆ **PPE:** (list all PPE required)
- ◆ Can pushing, pulling, lifting, bending or twisting cause strain?
- ◆ Is there a danger of striking against, being struck by, or otherwise making a harmful contact with an object?
- ◆ Is fall protection equipment required?

- ◆ Have MSDS been reviewed for chemicals used?
- ◆ Are there any environmental issues: heat, cold, lighting?

☐ Comments:

EXO

JOB HAZARD ASSESSMENT WORKSHEET

Movement of Modules to Underground and on to the former Core Storage Alcove (Type of Work Performed)

Author: _____ Date: _____ WIPP Safety Engineer Concurrence _____ Date: _____

STEP	HAZARD	MITIGATING ACTIONS
1) Truck deliver to staging area	a) Shifting of load, damage equipment, injure personnel.	a) Load secured
2) Forklift stage modules on surface	a) Pallet failure, modules fall, damage equipment, injure personnel. b) Misaligned forks, damage equipment, injure personnel. c) Misaligned forks, plastic rips, module contamination. d) Plastic comes loose, module contamination.	a) Qualified forklift operator. Modules inspected. Faulty modules repaired. b) Qualified forklift operator and spotter. Modules secured with straps. c) Qualified forklift operator and spotter. d) Plastic secured off site. Inspect before handling. Repair with duct tape if necessary.
3) Forklift load modules on cage	a) Pallet failure, module's fall, damage equipment, injure personnel. b) Misaligned forks, modules fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne salt dust contamination. d) Plastic comes loose, dust contamination.	a) Qualified forklift operator. Modules inspected. Faulty modules repaired. b) Qualified forklift operator and spotter. Modules secured with straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary.
4) Forklift remove modules from cage	a) Pallet failure, modules fall, damage equipment, injure personnel. b) Misaligned forks, modules fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne salt dust contamination. d) Plastic comes loose, dust contamination.	a) Qualified forklift operator. Modules inspected. Faulty modules repaired. b) Qualified forklift operator and spotter. Modules secured with straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary.
5) Forklift unload modules at the former Core Storage Alcove	a) Pallet failure, modules fall, damage equipment, injure personnel. b) Misaligned forks, modules fall, damage equipment, injure personnel. c) Misaligned forks, plastic rips, airborne salt dust contamination. d) Plastic comes loose, dust contamination. e) Mine traffic causing accident.	a) Qualified forklift operator. Modules inspected. Faulty modules repaired. b) Qualified forklift operator and spotter. Modules secured with straps. c) Qualified forklift operator and spotter. d) Inspect. Repair with duct tape if necessary. e) Qualified operators.

- ◆ **Equipment:** (list any tools that may represent a hazard and all chemicals)
- ◆ **PPE:** (list all PPE required)
- ◆ Can pushing, pulling, lifting, bending or twisting cause strain?
- ◆ Is there a danger of striking against, being struck by, or otherwise making a harmful contact with an object?
- ◆ Is fall protection equipment required?
- ◆ Have MSDS been reviewed for chemicals used?
- ◆ Are there any environmental issues: heat, cold, lighting?

☐ **Comments:**