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Hazards Analysis For The Plutonium Finishing Plant Polycube Stabilization Process

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Hazards Analysis For The Plutonium Finishing Plant Polycube Stabilization Process

Key Words: Hazards analysis, stabilization, polycube, 2736-Z building

Abstract: A hazards analysis was performed to identify and evaluate hazards associated with the stabilization of plutonium-bearing polystyrene cubes and fragments ("polycubes"). This document describes the methodology and presents the results of the hazard analysis performed. The Hazards and Operability Study (HazOp) technique was used to identify the hazards associated with the polycube stabilization process.

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Abbreviations, Acronyms, and Initials

AIChE	American Institute of Chemical Engineers
ALARA	as low as reasonably achievable
CAM	continuous air monitor
CSER	Criticality Safety Evaluation Report
DOE	United States Department of Energy
FSAR	Final Safety Analysis Report
HazOp	Hazards and Operability study
NRC	Nuclear Regulatory Commission
PFP	Plutonium Finishing Plant
P&ID	Piping and Instrumentation Diagram
PSAR	Preliminary Safety Analysis Report
Pu	plutonium
SC	Safety Class
SS	Safety Significant

1.0 INTRODUCTION

A hazards analysis was performed to identify and evaluate hazards associated with the stabilization of plutonium-bearing polystyrene cubes and fragments ("polycubes"). This document describes the methodology and presents the results of the hazard analysis performed. The Hazards and Operability Study (HazOp) technique was used to identify the hazards associated with the polycube stabilization process.

The scope of the HazOp included activities starting with the retrieval of the polycube storage containers from the vaults in the 2736-Z Building. The final process is either transfer of the stabilized materials to the Room 235B Glovebox HA-53BTS Bagless Transfer System (BTS) for welding into a Bagless Transfer Can (BTC) or, transfer of Stabilized materials to Glovebox HC-18M for placement into slip-lid cans to be sealed out and canned in two clean cans, the last one being a 7-in. Food Pack Can (FPC). The Seal-out process is performed from either glovebox HC-18M or HC-13MD.

The BTS system does not use a seal-out process. The material is inserted into a can that is open to the glovebox through a sphincter port, with most of the can outside the glovebox. A hollow can lid is inserted into the can and welded in place. The welded can is released by cutting the can through the welded closure, the hollow lid forming a seal for both the BTC and the remnant.

2.0 HAZARD ANALYSIS

The methodology and results of the PFP polycube stabilization process hazard analysis and evaluation are presented in this section. A hazard analysis is a structured, systematic examination of a system, process, or procedure during which hazards, causes, effects, and corrective and/or preventative measures are identified. The resulting identified hazards are then evaluated and placed into Accident Groups, based on the initiating event and the resulting consequences of the hazard.

2.1 Polycube stabilization Process Hazard Identification Methodology

A Hazards and Operability study (HazOp) was selected as the method by which to identify the hazardous conditions associated with the polycube stabilization process. A HazOp study is a discovery technique in which a group of experts is guided systematically through an examination of the basic elements of a system, process, or procedure. During this process, hazardous conditions of interest are identified, potential causes and consequences of the hazards are evaluated, and possible corrective and/or preventive measures are proposed. Engineered and Administrative Safety Features are not credited in assignment of consequence rankings during the study sessions. This allows for determination of Safety Class *(SC)* and Safety Significant **(SS)** equipment or controls, if warranted by the consequences.

The team of experts for the polycube stabilization process HazOp Study consisted of process and plant engineers who are designing the system, plant operators who are familiar with the process and the facility, and hazard and accident analysts, plant engineering management, and consultants familiar with both the process being analyzed and the hazards analysis process. Short resumes of HazOp team members are presented in section ***2.3.***

A HazOp Study form is used to record the findings of the team. The form used for the polycube stabilization process HazOp is shown as Table 1. The HazOp Study Form is used to record the following data:

Column 1, Node ID #: **A** unique alphanumeric identifier assigned to each hazardous condition which permits cross-referencing information contained from the HazOp with the accident tables that are generated later in the hazard evaluation process.

Column 2, Node Description: Defines the parameter being evaluated in any particular study node.

Column 3, Deviation: Defines and describes the condition applied to the parameter being evaluated, using both guide word and specific parameters. The examination of deviations is structured through the use of standard guide words, which can be adapted as needed to match any particular process variable The deviation guide words (and their generic meanings as used during the HazOp) are:

No, Not, None	Negation of the design intent; "No" is almost always the worst case of "Less".
Less, Low, Short	Quantitative decrease in the process variable. Generally taken to mean a large enough decrease to cause a consequence of interest.
More, High, Long	Quantitative increase in the process variable. Generally taken to mean a large enough increase to cause a consequence of interest.
Part of	Qualitative decrease in the process variable. Can mean the introduction of another substance to a mix, or a change in a standard pre-existing mixture ratio, etc.
As Well **As, Also**	Qualitative increase in the process variable. Can mean addition of another substance to a mix without a change in the pre-existing constituents.
Other Than	Complete substitution in the process variable
Reverse	Logical opposite of the process variable.

Other guide words were introduced as needed to fit specific situations, such as Leak, Rupture, Loss of Containment, Reaction, Ignition Source, Sampling, Startup, Shutdown, and Maintenance/Testing. These determinations were made during the meeting, when the need for use of these extra guide words during the HazOp session was reasonably obvious. Note that not all guide words made sense or were able to be used with all process variables.

Column 4, Possible Causes: Lists the possible causes of the parameter deviation being evaluated.

Column 5, Hazardous Event/Failure Mode: Describes the hazard or accident resulting from the parameter deviation.
Column 6, Consequences: Describes the consequences of the hazard or accident.

Column 7, Cons Rank: Consequence Rank contains a qualitative estimate of the result of the event, assuming that no controls, engineered or administrative, are present. However, naturally occurring phenomena that limit the consequences of an event are assumed to take place ("rules of the universe"). This consequence ranking is a "first cut," qualitative, consensus estimate of the safety severity of the consequences. These rankings (as taken from HNF-SD-CP-SAR-021, *Plutonium Finishing Plant Final Safety Analysis Report* (PFP FSAR (FDH 1999)) are as follows (in increasing order of severity):

- S0 No effect outside the glovebox confinement systems; negligible safety concerns for the facility worker.

- S1 Potential industrial injury, low radiological or chemical exposure dose consequences to the facility worker.

- S1* Potential severe harm or potential death from industrial injury, radiological dose or chemical exposure to the facility worker. Hazardous conditions sufficient to cause severe harm or death to facility workers are typically associated with events which may result in significant pressurization of or damage to the glovebox structure with potential release of radiological material. Therefore, events with sufficient energy to impact the glovebox in a manner which may cause a significant release of radiological material from a glovebox are assigned an S1* consequence rank. This is a conservative approach since such events will not necessarily result in harm or death to facility workers.

- S2 Potential significant radiological dose consequences or chemical exposure to onsite workers located outside the facility.

- S3 Potential significant radiological dose consequences or chemical exposure to the offsite population.

Engineered safety features and controls specific to the processing of polycubes are not credited in assigning the above consequence rankings. The consequence ranking assigned to the hazardous event aids in determining whether controls should be designated Safety Significant (SS) or Safety Class (SC).

The effects of energetic events on the glovebox structure are assessed to determine if the hazardous event can compromise the SS confinement function provided by the glovebox structure and ventilation system. Similarly, the 2736-Z and 234-5Z Building structures are credited with protecting onsite workers and the offsite public outside PFP from accidents that breach glovebox confinement.

Column 5, Freq Rank: Frequency Rank is a "first cut," qualitative, consensus estimate of the frequency of the hazardous condition (also referred to as "event"), assuming that no engineered or administrative safety features are present. These rankings (as taken from the PFP FSAR (FDH 1999)) are as follows (in increasing order of likelihood):

F0 Events categorized as "beyond extremely unlikely," with a frequency of less than 1×10^{-6}/yr. Events in this category (such as a meteor strike) are so unlikely they generally do not require special controls.

F1 Events categorized as "extremely unlikely," with a frequency range of 1×10^{-6}/yr to 1×10^{-4}/yr. Events in this category are not expected to occur during the lifetime of the facility.

F2 Events categorized as "unlikely," with a frequency range of 1×10^{-4}/yr to 1×10^{-2}/yr. Events in this category could occur during the lifetime of the facility but with a low probability.

F3 Events categorized as "anticipated," with a frequency range of 1×10^{-2}/yr to 0.1/yr. Events in this category could occur one or more times during the lifetime of the facility.

Column 9, Engineered Safety Features: Lists existing hardware design features that could mitigate or prevent the event being considered.

Column 10, Administrative Safety Features: Lists administrative controls that could mitigate or prevent the event being considered.

Column 11, Remarks: The remarks column is used to record information that the team judges to require documentation. This can include, but is not limited to, assumptions about facility operation or recommendations for changes in the planned design or operation.

2.2 Hazard Analysis Results

A HazOp study was performed on October 25 and 26,2000, to identify the hazards associated with the polycube stabilization process. The process was broken down into eighteen nodes for this HazOp study. Each node is either a portion of the system or an action occurring within a portion of the system. The nodes are:

1. Remove Polycube Containers from Storage
2. Transport Polycube Containers to Room 230-B
3. Sphincter Polycube Containers into Glovebox HC-21A
4. Open polycube Containers in Glovebox HC-21A
5. Remove polycubes from Containers and Place in Furnace Boats
6. Transport Polycube in Furnace Boat to Furnaces in Glovebox HC-21C via Glovebox Conveyor HC-2
7. Stabilize Polycube in Furnace in Glovebox HC-21C
8. Remove Furnace Boat and Transport to Glovebox HC-I8M or HA-20MB
9. Sieve/Sample Stabilized Polycube Materials
10. Store Polycube Materials in Gloveboxes 18BS or ISM during Sample Analysis
11. Bag-Out Samples from Glovebox 18M or 13MD
12. Transport Samples to Analytical Lab
13. Transport Samples to SFE Glovebox via Conveyors HC-2, -3, -4, and -28
14. Transport Confirmed Stabilized Material to Rm. 235 BTS for Seal-out
15. Place Confirmed Stabilized Material into FPC and Seal-out from Glovebox 18M or 13MD
16. Natural Phenomena Hazards
17. Startup, Shutdown, Maintenance, and Construction Hazards
18. "Hot Boxing"

The results of binning by accident groups and sorting by the consequence rankings from the HazOp table are presented in section 2.4.3. For each group, all S1* and S2 events are sorted out and collected into a subgroup for evaluation as accidents. All S1 events in each group are collected into a second subgroup for evaluation as abnormal operations. Finally, all SO events in each group are collected into a third subgroup identifying events with negligible consequences. Categorizing hazardous events as either "abnormal operations" or "accidents" is consistent with the NRC Regulatory Guide 3.39 format of the PFP FSAR (FDH 1999). In this way, every hazard was binned into one of the accident groups and sorted **by** its consequence ranking.

2.3 Polycube Stabilization Process HazOp Participant Biographies

This section contains the professional biographies of the participants of the PFP Polycube stabilization Process HazOps conducted October 25 and 26,2000.

David M. Carson - Process/Specialty Engineer II, SAR Engineering Services

Mr. Carson is currently employed in the SAR Engineering Services section of the Safety Analysis and Nuclear Engineering group of Fluor Federal Services, and acted as leader/facilitator of the session. He has eight years of Nuclear Reactor Operator experience, having been a certified Operator at N Reactor, followed by nine years of Technical, Procedure, and Manual writing and editing experience from Tank Farms, Effluent Treatment, the Spent Nuclear Fuel Canister Storage Building, and Specialty Engineering. Mr. Carson has received training in process hazard analysis using the HazOp and What If techniques, has led process hazard analysis sessions using these techniques, and has participated in development of these process hazard analysis techniques as used in Specialty Engineering.

Martin Prisc - B&W Hanford Company. Engineer

Mr. Prisc has 30 years experience working at the Mound Facility in the process development and analytical sections. For over 15 years his experience includes involvement with Safety Analysis and Risk Assessments, USQ and FSAR documentation, and as a member of the Safety Overview Committee. Mr. Prisc has a Master of Science degree in Inorganic Chemistry from the University of Cincinnati located in Cincinnati, Ohio.

David A. Himes – B.S., Engineering Physics, M.S. (Nuc. E.), Ph.D.(Nuc. E.. minors E.E. & M.E.)

A total of 25 years experience in nuclear reactor and radioactive waste facility operations and analysis including health physics and safety. Includes *6* years experience in nuclear reactor operations (with 3 years as a nuclear submarine officer in the U.S. Navy), and over 22 years experience in the fields of reactor fuel testing and evaluation, analytical modeling, and radiological and toxicological safety analysis. Former licensed nuclear research reactor operator. Sixteen publications on gamma spectroscopy, thermophysical properties of nuclear reactor fuel, nuclear waste disposal, and radiological and toxicological accident analysis.

Robert M. Marusich, Fluor Federal Services, Inc. – Engineer, Safety Analysis and Risk Assessment

Mr. Marusich has over 28 years experience in safety analysis. Mr. Marusich's experience includes both commercial reactors and DOE nuclear and non-nuclear facilities. He was also contributor and later manager of the Probabilistic Risk Assessment (PRA) Group at Consumers Power Co. in charge of the Palisades and Big Rock Point PRAs. Mr. Marusichs area of expertise is consequence analysis. He has performed consequence analyses for many of the processes performed within each of the Hanford facilities. Mr. Marusich has been performing consequence analysis for PFP for 11 years and has worked on numerous processes within PFP. Mr. Marusich has a B.S. and M.S. in Nuclear Engineering from the University of Wisconsin.

Scott W Harder, Fluor Hanford. Inc. - Nuclear Chemical Operator (Lead Worker)

Scott Harder is a NCO assigned to PFP since January 93. Scott was assigned to Thermal Stabilization when it first began in the fall of 94. He has been a working lead in Thermal Stabilization since June of 97.

Errol P. Bonadie - Engineer II, Vault Operations and Product Handling Cognizant Engineer

Mr. Bonadie holds a Bachelor of Science in Chemical Engineering from Pratt Institute; Brooklyn, New York and has worked at the Plutonium Finishing Plant since coming to Hanford on May 23, 1983, as a Senior Engineer. Mr. Bonadie has been concerned with Process Engineering and worker safety during the Operations of the Plutonium Reclamation Facility and Remote Mechanical C-Line, as well as, shipments of metal product from Hanford. Errol has been Cognizant Engineer for Vault Storage, Product Handling and Shipping since 1990. As Product Handling Cognizant Engineer, Mr. Bonadie has authored and/or maintained operating procedures for handling and moving Special Nuclear Material (SNM). Mr. Bonadie's previous experience was ten (10) years as a chemical engineer for Diamond-Shamrock Corporation Research Center in Painesville, Ohio; chlorine and caustic production in Muscle Shoals, Alabama; the International Division in Morristown, New Jersey, and special sulfonates production in Carlstadt, New Jersey.

Charles R. Zook. Fluor Federal Services, Inc. - Lead Mechanical Engineer, Transition Proiects & Site Engineering & Construction Services

Mr. Zook has 35 years experience in mechanical engineering, project management, and program management in both private industry and government. He is currently the Lead of the Mechanical Engineering for Fluor Federal Services in the Transition Projects & Site Engineering & Construction Services division. He has been responsible for the design of a number of environmental, process, and remote handling projects, performing as the Principal Lead Engineer on many of these projects. Mr. Zook has extensive experience in the field of remote handling, including robotics, electromechanical cranes, and manipulators. He also has significant experience in the administration of engineering costs and schedules, and has established a successful record of completing projects within cost and schedule.

Paul Rittman, Fluor Federal Services. Inc. - Dose Rate Estimator, Safety Analysis and Nuclear Engineering

Paul Rittmann is currently employed in the Safety Analysis and Nuclear Engineering Group of Fluor Federal Services. He is currently assigned the ALARA evaluation for polycube processing, and participated in the initial portion of the session to learn more about the proposed handling of polycubes. Paul has been employed as an analyst at Hanford for the last 20 years. He has experience with radiological engineering, low-level waste performance assessment, emergency planning, and safety analysis. Paul has a doctorate in theoretical physics and is a member of the American Academy of Health Physics.

Robin Scott, Fluor Hanford, Inc. - NCO. WAVS

Mr. Scott is an experienced Nuclear Chemical Operator at the Plutonium Finishing Plant.

Pam Miller. Fluor Hanford, Inc. - NCO. Thermal Stabilization Support Team

Ms Miller has been a Nuclear Chemical Operator at the Plutonium Finishing Plant for nearly 12 years. She spent 7 of those years in the PFP Solid Waste Operations Group and the past 2 years have in Thermal Stabilization. She participated in the ORR for Thermal Stabilization restart, and the Readiness assessment for the Bagless Transfer System startup. She has also recently been certified in the Bagless Transfer System.

Dwayne Speer, Fluor Hanford, Inc. - Project Manager, Metals, Oxides. and Polycubes Stabilization, PFP

Mr. Speer has been at the Plutonium Finishing Plant for the past two years where he participated in the restart of materials stabilization at the facility and has provided leadership and management of oxides and metals stabilization. Prior to coming to PFP he was the Manager of the B Plant/WESF Baseline Control group during the deactivation of that facility. He has also been the Project Manager for the Hanford Liquids Effluents characterization and remediation efforts in compliance with Consent Order DE 91NM-177 with the Washington State Department of Ecology. Mr. Speer spent six years as Decommissioning Engineering Manager and three years as Decommissioning Activity Manager with Westinghouse. Mr. Speer's formal education is as a Health Physicist and he spend the first ten years of his career performing formal Health Physics assessments.

Jeffry P. King, Fluor Hanford, Inc. - Operations Specialist, PFP Technical Support Authorization Basis Team

Mr. King is the PFP Operational Safety Requirements representative with the Nuclear Materials Stabilization Project Authorization Basis Technical Support Team. He is also an Unreviewed Safety Question Core Evaluator and participated in reviews and USQ development for initial polycube oxidation demonstration test plans. Mr. King has extensive experience in PFP Operations including five years as a Senior Health Physics Technician during start up of the 2736-ZB Building, Plutonium Reclamation Facility and Remote Mechanical "C" Line operations in the 1980's. His PRF processing experience included the previously used Miscellaneous Treatment Glovebox # 4 polycube plutonium recovery process. Mr., King's training background includes the Nuclear Technology program at Columbia Basin College, Root Cause Analysis, Risk Evaluation, Surveillance Methodology, Auditing Methods for Auditors, and Hazardous Waste Shippers Certification. He has been involved with PFP Authorization Basis document development since 1993, H.R. "Rees" Risenmay, Fluor Hanford. Inc. - Cognizant Engineer, Thermal Stabilization Support Team

Mr. Risenmay has 16 years experience at the Hanford site. His experience has been in the Chemical Engineering Laboratory, the PUREX plant, the U03 plant, and the PFP plant. His experience is mostly in process engineering with detailed knowledge of the processes and safety aspects for each plant. Mr. Risenmay has a Bachelor of Science Degree in Chemistry from Brigham Young University and a Bachelor of Science Degree in Engineering with chemical engineering emphasis from the University of Washington.

Thurman D. Cooper, Fluor Hanford, Inc. - Chemist, PFP Plutonium Process Support Laboratories

Mr. Cooper is currently employed in the Plutonium Process Development Laboratory of the PFP Plant of Fluor Hanford Co., and is a plutonium chemist. He has eight years of experience as a radiochemist at Oregon State University, 4 years experience as a radiation control group manager, and 24 years of experience as a plutonium development chemist. Mr. Cooper received a BS degree in general chemistry and an MS degree in Radiochemistry from Oregon State University. His practical experience and "on the job" training at PFP in plutonium chemistry has made him an expert in that field.

2.4 Accident Group Selection

The hazardous events identified by the HazOp process are segregated into accident groups in a process known as "binning". This process of grouping the hazards is the starting point for the quantitative accident analysis process. The results of that type of analysis are compared to applicable regulations and requirements for systems, structures, and components to determine the necessary Safety Class and Safety Significant components. Accident selection methodology is provided in section 2.4.1. Generalized summaries of the accident groups assigned for the polycube stabilization process are presented in section 2.4.2. The resulting accident binning for the polycube stabilization process is provided in Section 2.4.3. Representative Accidents for the polycube stabilization process are described in section 2.4.4.

2.4.1 Accident Selection Methodology

The selection of accidents for quantitative analysis was performed using a binning process, as recommended by *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94 (DOE 1994) and *Hazard and Accident Process,* HNF-PRO-704 (HNF 1999). All accidents are binned according to the potential accidents identified in the HazOp table (Appendix A). The binning is based on grouping similar hazardous conditions that challenge similar barriers. The potential accidents were grouped into eight bins, summarized below; a listing of all accident groups considered during binning is shown in Table 2. Matching characteristics for the specific hazards to these respective bins was completed using the same ID as in the HazOp tables. The results of the binning are presented in section 2.4.3. From each accident bin, existing hazardous conditions with consequence rankings of S1* or greater are grouped as "accidents", and from these a "Representative Accident" is chosen to undergo further analysis. The chosen Representative Accident is usually that accident with the highest combination of consequence and frequency, though more than one Representative Accident may be chosen for each accident group, if grouped accidents with similar consequences result from very different causes. Any accidents that are unique to the process being evaluated are always analyzed, Selection of Representative Accidents for the cementation process are presented in section 2.4.4. A general flowsheet schematic for the accident selection process is shown in Figure 1.

2.4.2 Accident Group Summaries

A generalized summary of the accident groups assigned to hazardous events for the polycube stabilization process includes:

Group A1 – Process Upset – No Worker Impacts. The four S0 events identified by the HazOp in this group are production upset events which do not result in the release of radiological material or in a significant increase in worker exposure, but the occurrence of the events degrades the normal operation of the polycube stabilization process and possibly decreases product output.

Group A2 – Process Upset – Worker ALARA concerns. The HazOp identified eight S1 Abnormal Occurrences and one S0 process upset. These events are of a somewhat more serious nature than those of Group A1, and are characterized by an increase in worker exposure due to increased time spent near or handling the polycubes which, on average, have a high doserate. Dealing with the upset often results in additional dose to facility workers, especially in the cleanup or repair process where additional worker doses are incurred.

Group B – Radiological Release Inside Glovebox. The HazOps identified five S1 Abnormal Occurrences in this group. Events considered in this group take credit for the mitigative containment of the glovebox. The principal control is the maintenance of a negative pressure differential between the glovebox and the surrounding room. Release of radiological material to the glovebox , while not a danger by worker inhalation, does increase sources of direct radiation and, in a similar manner as Group A2, results in additional worker exposure as a result of recovery operations.

Group C – Radiological Release From Glovebox. The HazOps identified three Abnormal Occurrences (S1) in this group. The Abnormal Occurrences relate to a ruptured glovebox glove which produces a radiological release to the room.

Group D1 – Deflagration in Glovebox. The HazOp identified two S1* accidents resulting in a deflagration inside the glovebox. The accident involves a loss of power (thus a complete loss of ventilation and vacuum) while polycubes are being heated in the furnace, at the time that temperatures are in the range of maximum flammable gas production. This flammable gas could flow out of the furnace door into the stagnant glovebox, where it may attain a concentration above the Lower flammability Limit (LFL), creating conditions for a possible deflagration within the glovebox.

Group E – Criticality. Three SO negligible safety concerns criticality concerns were identified in this group, all related to material spacing.

Group F1 – Fire in Glovebox. The HazOp identified seven SO negligible safety concerns, involving ignition of flammable gases or the polycubes themselves during heating in the furnace.

Group G – Industrial Hazards. The hazards in this group are the same ones faced by workers in standard industrial activities, such as falls, burns, shocks, and including to some degree, exposure to chemical hazards. Four S1 Abnormal Occurrence were identified in this accident group, all involving hand injuries.

Group J – Radiological Release Inside Facility. Nineteen S1 Abnormal Occurrences were identified in this group. All events relate to drops of or leaks from the vented polycube storage cans in the vaults during retrieval.

Group NPH – Natural Phenomena Initiator. The HazOp identified one S2 accident and one S1 Abnormal Occurrence in this accident group. The NPH group includes events resulting from natural forces such as earthquakes, rain, snow, flooding, high winds, and fires.

2.4.3 Accident Binning Results

The polycube stabilization process HazOps identified **83** hazardous conditions, of which 1 was identified as S2, 2 as S1*, 40 as S1, 15 as SO, and 25 as N/A (which indicates either no hazard, or no such condition, but were included in the HazOp for completeness).

Results of the accident binning are presented in tabular form as Table **3.** Representative Accidents (See section 2.4.4, below) are indicated with **bold** type. The Abnormal Occurrence selected for evaluation is presented in Section 2.4.5.

2.4.4 Representative Accident Selection and Basis

The following accidents have been selected as Representative Accidents, requiring further analysis. They are:

PCS - 7.7.1 A total loss of plant power results in the loss of all ventilation in the glovebox (from loss of the E4 system) and furnace (from loss of the 26-in Hg vacuum system) at a time that the furnace is in the temperature range corresponding to maximum flammable gas production from the polycubes being stabilized. This flammable gas could flow out of the furnace into the stagnant glovebox, where it may attain a concentration above the LFL, creating conditions for a possible deflagration within the glovebox.

This accident was selected as a Representative Accident for accident group D1, "Deflagration in Glovebox" because it has potentially the largest energy release of all accidents.

PCS - 16.1.2 A seismic event causes Glovebox HC-21C to topple or fail, causing operator injury and a release of radioactive materials to the environment.

This accident was selected as the Representative Accident for accident group NPH "Natural Phenomena Hazards" because it has the largest potential consequence of any identified accident.

2.4.5 Abnormal Occurrence Selection and Basis

One Abnormal Occurrence (PCS - 16.1.3)has been selected for further evaluation. This Abnormal Occurrence involves a seismically-induced fire in the furnace glovebox. This Abnormal Occurrence will be evaluated to determine if any significant addition to the seismic release occurs due to the fire.

2.5 Effect of Polycube Stabilization Process on Existing PFP Accidents

The previous sections discussed the new accidents and abnormal occurrences identified through the HazOp process associated with polycube stabilization process operations. In addition, an evaluation is required to determine if the initiation of polycube stabilization process operations has any impacts on the accidents and abnormal events analyzed previously in the PFP FSAR (FDH 1999). In order to examine the incremental doses that may accrue from operation of the polycube stabilization process to the existing abnormal operations and accidents analyzed in the PFP FSAR, each abnormal operation and accident analyzed in the FSAR has been evaluated for impacts assuming operation of the polycube stabilization process. This evaluation is documented in Table 4 for abnormal operations and Table 5 for accidents. As can be seen from the tables, effects on abnormal operations and accidents currently analyzed in the FSAR are not expected from operation of the polycube stabilization process, except for the seismic event. For the seismic event, polycube stabilization process operations will result in an addition to the plant release; the exact amount of the addition is currently undergoing analysis, which will be documented in *Accident Analysis for the Plutonium Finishing Plant Polycuhe Stabilization Process*, HNF-7288 (FH 2000).

3.0 REFERENCES

AIChE 1992, *Guidelines For Hazard Evaluation*, Second Edition, American Institute of Chemical Engineers, Center for Chemical Process Safety of the American Institute of Chemical Engineers, New York, New York.

DOE 1994, *Preparation Guidefor U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94, U.S. Department of Energy, Washington. D.C.

FDH 1999, *Plutonium Finishing Plant Final Safety Analysis Report*, HNF-SD-CP-SAR-021, Fluor Hanford, Richland, Washington.

FH, 2000, *Accident Analysis for the Plutonium Finishing Plant Polycuhe Stabilization Process*, HNF-7288, Fluor Hanford, Richland, Washington

HNF 1999, *Hazard and Accident Analysis Process*, HNF-PRO-704, Rev. 1, Fluor Daniel Hanford, Richland, Washington.

Figure I: Accident Selection Process Flowsheet

Process Step	Description
Hazards and Operability Study	A HazOp was used to identifying hazards of polycube stabilization process operations and related PFP activities
↓	
List of Accidents or abnormal occurrences classified by consequence and frequency	Consequence and frequency are qualitatively evaluated.
↓	
Sort Accidents by "TYPE" and "CATEGORY"	"TYPE relates to the atitiident phenomena - (fire, explosion,
↓	
Perform conservative and simplified calculation of consequences for determination of LEVEL OF SIGNIFICANCE	LEVEL OF SIGNIFICANCE implies a potential consequence that approaches risk evaluation guidelines. Selection criteria are established for the purpose of identifying and evaluating Safety Class structures, systems, and components.
↓	
Develop "REPRESENTATIVE" (bounding) accident or accidents for each "TYPE"	"REPRESENTATIVE" accidents are those that bound the consequences for a grouping of similar accidents. "SIMILAR" means accidents of the same type challenging the same or analogous barriers. "ANALOGOUS" barriers reflect the same preventionimitigationidesign philosophy but may be located in a different part of the facility or project.
↓	
Review list of remaining accidents and identify "UNIQUE accidents	"UNIQUE" accidents have potential consequences that may approach the "Risk Evaluation Guidelines" and challenge different barriers from the "REPRESENTATIVE for that accident type.

Table 1: Hazard and Operability Study Form

Node ID #	Node Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks

Table 2: Accident Groupings

No.	Accident Group Title
AI	Process Upset - no worker impacts
A2	Process Upset - worker ALARA concern
B	Radiological Release Inside Glovebox
C	Radiological Release from Glovebox
D1	Deflagration in Glovebox
D2	Deflagration Outside of Glovebox
E	Criticality
F1	Fire Inside of Glovebox
F2	Fire Outside of Glovebox
G	Industrial Hazards - not resulting in severe worker injury
H	Release to Vacuum System
I	Toxic Chemical Release Inside Facility
J	Radiological Release Inside Facility
K	Storage Canister Rupture
NPH	Natural Phenomena Initiator (Seismic Event)

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (XX sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
A1	**PROCESS UPSET - NO WORKER IMPACTS**				
	Accidents There are no accidents (S2 or S1* events) identified for Group A1.				
	There are no abnormal occurrences (S1 events) identified for Group A1.				
A1	PCS - 1.8.1	Not placing polycube container in overpack container when retrieving from vault.	Procedural violation	S0	Events in this group are production upset events and do not result in release of radiological material or significant increase in worker exposure. Because they result in negligible safety concerns to facility workers, hazards with S0 consequences are not evaluated further.
	PCS - 3.3.1	Failure to perform verification of accountability information when retrieving polycube containers from vaults.	Procedural violation		
	PC3 7.7.2	Heat double or triple batch of polycubes (4 - 6 cubes) in one furnace boat.	Narrows safety margin		
	PCS - 7.10.1	Loss of glovebox ventilation and vacuum during heating of char to 1,000 °C	Process upset		

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
A2	**PROCESS UPSET - WORKER ALARA CONCERN**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group A2.				
		Abnormal Occurrences			
A2	PCS - 1.2.2	Remove wrong polycube can from CMU in vault	Extra exposure to replace it and get right can	S1	
	PCS - 1.7.1	Failure to perform accountability actions when removing polycube container from vault	Extra exposure to correct possible mis-batching		
	PCS - 1.9.1	Hand-carry overpack container rather than use transport cart	Excess operator exposure		
	PCS - 2.1.1 PCS - 2.2.1	Transport wagon tipped over during transport - either between 2736-Z and 234-5Z or inside 234-5Z	Overpack containers roll out of wagon - Contamination of inside of overpack container - process upset in later steps, when overpack opened.		
	PCS - 3.1.3	Overpack container lid will not open when trying to unpack the container	Increased dose from extended time working on overpack lid		
	PCS - 4.2.1	Can opener malfunctions while attempting to open polycube container	Increased dose from extended time to open polycube can		
	PCS - 5.1.1	Spill polycubes outside of furnace boat when emptying polycube container	Increased dose from cleanup inside glovebox		

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (xx sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
		Negligible Safety Concern			
A2	PCS - 1.9.2	Drop overpack container containing polycube storage container into transportation cart	Contamination of inside of overpack container - process upset in later steps, when overpack opened.	≤0	Events in this group are production upset events and do not result in release of radiological material or significant increase in worker exposure. Because they result in negligible safety concerns to facility workers, hazards with S0 consequences are not evaluated further.
B	**RADIOLOGICAL RELEASE INSIDE GLOVEBOX**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group B.				
		Abnormal Occurrences			
B	PCS 5.3.1	Spill furnace boat during weighing of polycube materials	Increased dose from cleanup inside glovebox	S1	
B	PCS - 5.4.1	Failure to place boat cover on boat before placing on conveyor - material blown from boat during movement on conveyor	Increased dose from cleanup of conveyor	S1	
B	PCS - 7.1.1	Furnace boat falls from table in front of furnace before insertion into furnace	Increased dose from cleanup inside glovebox	S1	
B	PCS - 7.3.1	Spill furnace boat contents (outside of furnace) while inserting boat into furnace	Increased dose from cleanup inside glovebox	S1	
B	PCS - 7.9.1	Spill furnace boat contents while adding new polycubes on top of char	Increased dose from cleanup inside glovebox	S1	
	Negligible Safety Concerns				
	There are no Negligible Safety Concerns (S0 events) identified for Group B.				

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (xx sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
C	**RADIOLOGICAL RELEASE FROM GLOVEBOX**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group C				
		Abnormal Occurrences			
C	PCS - 4.1.1	Failure to place leather gloves over glovebox gloves	Ruptured glove - release to room	S1	
	PCS - 4.1.3	Leather overgloves are degraded	Ruptured glove - release to room		
	PCS - 4.2.2	Leather glove pinched in can opener while opening polycube container	Ruptured glove - release to room		
	Negligible Safety Concerns				
	There are no Negligible Safety Concerns (S0 events) identified for Group C				
D1	**DEFLAGRATION INSIDE GLOVEBOX**				
		Accidents			
	PCS - 7.7.1	**Lose both offgas vacuum and glovebox ventilation, due to a total loss of power, while heating polycubes with furnace temperature between 350 °C - 500 °C**	**Flammable gas mixture in glovebox - possible deflagration**	**S1**	**Selected as Rep. Acc. because it has potentially the largest energy release of all identified accidents.**
D1	PCS - 16.1.1	Seismic event causes total loss of power while heating polycubes with furnace temperature between 350 °C - 500 °C	Flammable gas mixture in glovebox - possible deflagration	S1 *	
	Abnormal Occurrences				
	There are no abnormal occurrences (S1 events) identified for Group D1				
	Negligible Safety Concerns				
	There are no negligible safety concerns				

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
E	**CRITICALITY**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group E				
	Abnormal Occurrences				
	There are no abnormal occurrences (S1 events) identified for Group E				
		Negligible Concerns			
	PCS - 2.2.2	Transport wagon passes too close to other fissile material	Criticality infraction - violation of criticality contingency (spacing)	S0	Events in this group are production upset events and do not result in release of radiological material or significant increase in worker exposure. Because they result in negligible safety concerns to facility workers, hazards with S0 consequences are not evaluated further.
	PCS - 3.4.3	Polycube container dropped from sphincter port inside glovebox onto another polycube container	Criticality infraction - violation of criticality contingency (spacing)		
	PCS - 7.3.2	Load furnace boat into furnace #5 before loading one into furnace #4	Criticality infraction - violation of criticality contingency (spacing)		
F1	**FIRE INSIDE OF GLOVEBOX**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group F1				
	Abnormal Occurrences				
	There are no abnormal occurrences (S1 events) identified for Group F1				
F1		**Negligible Safety Concerns**			
	PCS - 7.6.1 PCS - 7.6.2	Wrong heating program selected or furnace controller fails, leading to excess heating ramp rate	Polycubes could catch fire in furnace and plug offgas filter, leading to flammable gas buildup in furnace and burning of gases around furnace door ("halo")	S0	A "halo" burn like this would not raise the glovebox temperature above 50 °C (one furnace) or 100 °C (two furnaces). Halon dumps at 92 °C.

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (xx sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
F1	PCS - 7.7.3	Offgas system has no flow from time of furnace startup (not on or plugged filter)	Flammable gases ignite	S0	Gas begins evolving at 350 °C, ignition temperature is 475 °C. Inside of furnace is likely to be above the Upper Flammability Limit, therefore gases will burn in halo around door or just above furnace, and as long as there is glovebox airflow, GB temperature won't go above 50 deg. C (one furnace - see above).
	PCS 7.7.4	Offgas system goes to no flow during heating	Flammable gases ignite		Differs from 7.7.3 in that you may be above ignition temperature inside furnace when flow is lost - gases would ignite in the furnace and shut heating down on furnace high temperature deviation interlock.
	PCS - 7.7.5	Offgas system has low flow from time of furnace startup (wrong setting or plugged filter)	Flammable gases ignite		Flammable gases will reach LFL only if offgas flow is ≤ 25% of normal flow.
	PCS - 7.7.6	Offgas system goes to low flow during heating (gradual loss of vacuum system, plugging filter, or another vacuum system user placing a high demand on system)	Flammable gases ignite		
	PCS - 7.10.2	Partial loss of offgas vacuum flow during heating of char	Potential CO fire in furnace if flammable gas concentration rises above LFL		
G	**INDUSTRIAL HAZARDS - NOT RESULTING IN SEVERE WORKER INJURY**				
G	**Accidents**				
	There are no accidents (S2 or S1* events) identified for Group G				
		Abnormal Occurrences			
	PCS - 3 3.1.4	Overpack container opened without proper PPE	Hand injury; potentially contaminated wound	S1	

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (xx sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
G	S - 4.1.2	Failure to place leather gloves over glovebox gloves while opening polycube container with can opener	Hand injury; potentially contaminated wound	S1	
	PCS - 4.1.4	Degraded leather gloves placed over glovebox gloves while opening polycube container with can opener	Hand injury; potentially contaminated wound		
	PCS - 4.2.3	Glove pinched in can opener while opening polycube container with can opener	Hand injury; potentially contaminated wound		
	Negligible Safety Concerns				
	There are no Negligible Safety Concerns (S0 events) identified for Group G				
J	**TOXIC CHEMICAL RELEASE INSIDE FACILITY**				
	Accidents				
	There are no accidents (S2 or S1* events) identified for Group G				
		Abnormal Occurrences			
J	PCS 1.1.1	Contamination found on polycube container in vault due to deterioration of filter	Contamination spread/inhalation dose - internal deposition of Pu	S1	
	PCS 1.1.2	Survey smear of top of polycube can dislodges filter	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS 1.2.1	Drop polycube can while removing from CMU in vault	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS 1.2.3	Remove an incorrect (unsurveyed/ contaminated) polycube can from vault	Contamination spread/inhalation dose - internal deposition of Pu		
	1.3.1	Filter falls off polycube can when removed from vault	Contamination spread/inhalation dose - internal deposition of Pu		

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (**xx** sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID #	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
	PCS - 1.4.1	Particulate from inside or top of can suspended in air when polycube can moved to low-dose work area in vault	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 1.4.2	Drop polycube can when moving can to low-dose work area in vault	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 1.5.1 PCS - 1.5.2	Fail to place occlusive seal over top of polycube can, or seal is not complete	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 1.6.1	Fail to survey polycube can coming from vault	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 1.6.2	Drop or knock over polycube can while surveying can out of vault	Contamination spread/inhalation dose - internal deposition of Pu		
J	PCS 1.7.2	[illegible] performing accountability actions at vault	[illegible] spread/inhalation dose - internal deposition of Pu	S1	
	PCS - 1.7.3	Damage polycube can while removing CMU label at vault	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 1.8.2	Drop or knock over polycube can while placing can into overpack container	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 3.1.1	Open overpack container containing breached polycube can	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 3.1.2	Open overpack container without prior survey	Contamination spread/inhalation dose - internal deposition of Pu		
	PCS - 3.2.1	Drop or knock over polycube can while removing can from overpack container	Contamination spread/inhalation dose - internal deposition of Pu		

Table 3: Accident Binning for the Magnesium Hydroxide Precipitation Process (xx sheets)

Table 3: Accident Binning for the Polycube stabilization Process (13 Sheets)

Accident Group	Event ID	Hazards Description	Consequence Description	Consequence Category	Comments and Justification for Selection of Representative Accidents and Abnormal Occurrences
J	PCS - 3.4.1	Drop polycube can while sphinctering can into glovebox	Contamination spread/inhalation dose - internal deposition of Pu	S1	
	PCS - 3.4.2	Polycube can filter breaches when can is turned on its side prior to sphinctering in to glovebox	Contamination spread/inhalation dose - internal deposition of Pu		
	Negligible Safety Concerns				
	There are no negligible safety concerns (S0 events) identified for Group I				
NPH	**NATURAL PHENOMENA INITIATOR (SEISMIC EVENT)**				
NPH		**Accidents**			
	PCS - 16.1.2	**Seismic event causes glovebox to collapse and fail**	**Contamination spread, operator injury**	**S2**	**Selected as Rep. Acc. due to having the largest potential consequence of any identified accident.**
		Abnormal Occurrence			
	PCS - 16.1.3	Seismically-induced fire	Contamination spread	≤1	
	Negligible Safety Concerns				
	There are no negligible safety concerns (S0 events) identified for Group NPH				

Table 4: Effects of Polycube Stabilization Process Operations On Existing PFP Abnormal Operations
(2 sheets)

PFP FSAR Section	PFP Abnormal Occurrence	Effect Posed by Pu Stabilization and Packaging Equipment and Subsequent Processing Operations
9.1.1	Radioisotope-Bearing Liquid Spills	**No Effect.** No liquids are used in the Polycube Stabilization Process.
9.1.2	Radioisotope-Bearing Pressurized Liquid Container	**No Effect.** No liquid containers are involved in the Polycube Stabilization process.
9.1.3	Radioisotope-Bearing Powder Spills	**No Effect.** Operation of the Polycube Stabilization Process will have no effect on radioisotope-bearing material handling procedures, and therefore no effect on this abnormal occurrence.
9.1.4	Radioisotope-Bearing Pressurized Powder Container	**No Effect.** There are no containers involved in the Polycube Stabilization Process that can pressurize
9.1.5	Stack Release Resulting from Filter Changes	**No Effect.** Operation of the polycube stabilization process will– have no effect on filter changes, therefore will have no effect on this abnormal occurrence.
9.1.6	Overpressure of Remote Mechanical C Line Pressure Vessel	**No Effect.** The RMC Line pressure vessel is no longer used, therefore this accident is no longer relevant.
9.1.7A	Excessive Building Pressurization-234-5Z	**No Effect.** Operation of the polycube stabilization process will have no effect on building ventilation, or on the analyzed accident.
9.1.7B	Excessive Pressurization of 236-Z Building	**No Effect.** The polycube stabilization process equipment and operations are in the 234-52 Building.
9.1.7C	Excessive Building Pressurization 2736-ZB Building	**No Effect.** The polycube stabilization process equipment and operations are not in the 2736-ZB Building.
9.1.7D	Excessive Building Pressurization 2736-Z Building	**No Effect.** Polycube stabilization process operations in the 2736-Z Building will not affect ventilation.
9.1.7E	Excessive Building Pressurization, 241-Z Building	**No Effect.** The polycube stabilization process does not use the chemicals involved in the analyzed accident, therefore operation of the polycube stabilization process will have no effect on this accident.

Table 4: Effects of Polycube Stabilization Process Operations On Existing PFP Abnormal

PFP FSAR Section	PFP Abnormal Occurrence	
9.1.7F	Building Depressurization—All Plutonium Finishing Plant Operations	**No Effect.** The analysis in Section 9.1.7F of the FSAR concludes that depressurization of Building 234-52 will not result in structural failures. Based on the conclusions of the
9.1.8	Loss of Ventilation	
9.1.9	Glovebox Glove Breach	

Table 5: Effects of Polycube stabilization Process Operations On Existing PFP Accidents (2 sheets)

PFP FSAR Section	PFP Abnormal Occurrence	Effect Posed by Pu Stabilization and Packaging Equipment and Subsequent Processing Operations
9.2.1A	Product Concentrator	**No Effect.** The Product Concentrator is not currently in use at PFP.
9.2.1B	Filtrate Evaporator	**No Effect.** The Filtrate Evaporator is not currently in use at PFP.
9.2.1C	Deflagration in Glove-boxes MT-5/HC-21C	**No Effect.** This accident is no longer used in the PFP FSAR.
9.2.1D	Laboratory Waste Concentrator	**No Effect.** The Laboratory Waste Concentrator is not currently in use at PFP.
9.2.1E	Explosion, Hydrogen in Fluorinator	**No Effect.** The Fluorinator is not currently in use at PFP.
9.2.1F	Flammable Gas Explosion	**No Effect.** Operation of the polycube stabilization process does not require the use of flammable gases as analyzed in the FSAR, therefore will have no effect on the accident as analyzed. However, a new accident does involve a possible flammable gas explosion, from gases evolved during heating of polycubes in the furnaces.
9.2.1G	Explosion, Slag and Crucible System Deentrainer	**No Effect.** The slag and crucible process is not currently in use at PFP.
9.2.2A	Remote Mechanical C Line Fire	**No Effect.** Operation of the polycube stabilization process equipment does not affect the likelihood or consequences of the RMC Line Fire at PFP.
9.2.2B	Roof Fire, 234-5Z	**No Effect.** Operation of the polycube stabilization process equipment does not affect the likelihood or consequences of a roof fire at PFP.
9.2.2C	Glovebox MT-5 / HC-21C Fire	**No Effect.** This accident is no longer used in the PFP FSAR.
9.2.2D	Waste Drum Events	**No Effect.** Operation of the polycube stabilization process is not relevant to waste drum accidents.
9.2.3	Criticality	Operation of the polycube stabilization process is not expected to have any effect on the FSAR criticality accident. However, criticality analyses are in early stages, and a final determination on effects awaits completion of those analyses.
9.2.4	Seismic Event	The polycube stabilization process will have an addition to release quantities for this accident.

Table 5: Effects of Polycube stabilization Process Operations On Existing PFP Accidents
(2 sheets)

PFP FSAR Section	PFP Abnormal Occurrence	Effect Posed by Pu Stabilization and Packaging Equipment and Subsequent Processing Operations
9.2.5	Strong Wind	**No Effect.** The 234-5Z Building is shown in the analysis to survive the design basis wind. No releases from the polycube stabilization process glovebox are anticipated due to high winds. Operation of the polycube stabilization process equipment does not affect the Strong Wind accident analysis.
9.2.6	Hydrogen Fluoride Induced Plutonium Release	**No Effect.** The Fluorinator is not currently in use at PFP.
9.2.7	Aircraft Accident	**No Effect.** Aircraft impacts into the PFP facility are shown in the analysis to be incredible given flight restrictions prohibiting helicopter operation in proximity to the PFP.
9.2.8	Toxic Chemical Release	**No Effect.** The polycube stabilization process accident is bounded by the analyzed accident.

APPENDIX A: Polycube Stabilization Process HazOp Table

Polycube Stabilization HazOp										DATE: 25 – 26 October, 2000
Node ID #	**Description**	**Deviation**	**Possible Causes**	**Hazardous Event/ Failure Mode**	**Consequences**	**Cons Rank**	**Freq Rank**	**Engineered Safety Features**	**Administrative Safety Features**	**Remarks**
PCS-1.0	**Remove Polycube Containers from Vault Storage**									
PCS-1.1.1	Survey cubicle/can	contamination found on can	deterioration of filter on polycube can	inhalation dose	internal deposition of Pu	S1	F3	filter on polycube can E3 airflow Vault CAM	RWP (Vault is CA) Training and Procedures (T&P)	Initial survey should not include a wipe of the top of the can – to protect the label/filter.
PCS-1.1.2	Survey cubicle/can	survey smear dislodges filter	filter adhesive deterioration	contamination spread inhalation dose	internal deposition of Pu	S1	F3	None	T&P	should survey the sides of the can on the CMU – then move it to the RBA to deal with the top of the can.
PCS-1.2.1	Remove can from CMU	drop can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking other cans off is not credible. May want to investigate use of extension tools for this step. (Then freq becomes F3)
PCS-1.2.2	Remove can from CMU	wrong can – wrong material	human error	Extra work	Extra exposure	S1	F2	Labeling – cubicle & pedestal cubicle design – limited # of possible mistaken cans	T&P	N/A
PCS-1.2.3	Remove can from CMU	wrong can – unsurveyed/ contaminated	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	Labeling – cubicle & pedestal cubicle design – limited # of possible mistaken cans	T&P	N/A

Polycube Stabilization HazOp | 25 – 26 October, 2000

Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-1.3	Remove can from CMU	filter fails – falls off	label adhesive deterioration (label holds filter on)	contamination spread inhalation dose	internal deposition of Pu	S1	F3	None	T&P	Should include a visual inspection step in procedure – mitigation of filter opening to come later.
PCS-1.4.1	Move/place can in low-dose work area in vault	suspension of particulate from inside or top of can	filter failure – suspension due to airflow	contamination spread inhalation dose	internal deposition of Pu	S1	F3	None	T&P	Strongly suggest putting seal on top of can as early as possible – maybe while still on CMU
PCS-1.4.2	Move/place can in low-dose work area in vault	drop can (includes inversion)	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	If a device is used to move the can, the frequency ranking for dropping will go up.
PCS-1.5.1	Seal top of can – over filter	didn't seal can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Seal doesn't necessarily have to be tape – some kind of occlusive seal is what's necessary
PCS-1.5.2	Seal top of can – over filter	didn't seal can	seal not well-formed	contamination spread inhalation dose	internal deposition of Pu	S1	F2	Seal design	T&P	Gas pressure buildup in can not a concern before 1 week after application of seal.
PCS-1.6.1	Survey can out of vault	no survey	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F1	None	T&P	Instrument failure could cause a lack of survey, but human error would cause that not to be corrected – stays the same.
PCS-1.6.2	Survey can out of vault	drop or knock over can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking over sealed can would be unlikely to cause a contamination spread – F rank is for knocking over, not contamination spread.
PCS-1.7.1	Perform accountability actions	didn't perform actions	human error	mis-batching	rework	S1	F1	None	T&P	Includes, removal of CMU label, weighing, verification of serial numbers

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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-1.7.2	Perform accountability actions	drop or knock over can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking over sealed can would be unlikely to cause a contamination spread – F rank is for knocking over, not contamination spread.
PCS-1.7.3	Perform accountability actions	damage can while removing CMU label	tool punctures can OR can otherwise damaged	contamination spread inhalation dose	internal deposition of Pu	S1	F1	Design of CMU label removal tool can design	T&P	Cans are approximately 15 years old and not expected to be very degraded; material inside is fairly benign and is not expected to severely degrade cans (PVC tape could create some HCl)
PCS-1.8.1	Place can in overpack container	don't place can in overpack container	human error	none	procedural violation	S0	F1	None	T&P	Need to analyze trade-offs between increased exposure & glovebox waste using plastic bags vs. contaminating NMC-8 interiors.
PCS-1.8.2	Place can in overpack container	drop or knock over can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking over sealed can would be unlikely to cause a contamination spread – F rank is for knocking over, not contamination spread.
PCS-1.9.1	Place overpacked can in transportation cart	don't place in cart – hand-carry overpack	human error	High dose to operator	overexposure	S1	F1	None	T&P	Likely to be the "Lard Can" wagon.
PCS-1.9.2	Place overpacked can in transportation cart	drop overpack	human error	contamination of interior of overpack container	process upset in later process steps	S0	F3	None.	T&P	Consequences wouldn't be until later, when overpack is opened inside destination

Polycube Stabilization HazOp

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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-2.0	**Transport Polycube Containers to Room 230-B**									
PCS-2.1.1	Pull cart out of 2736-Z and into 234-5Z	tip wagon over	mechanical malfunction	rolling overpack containers out of wagon - potential internal contamination of overpack container	operator exposure to recover	S1	F2	None	T&P	N/A
PCS-2.2.1	Pull cart to Room 230B	tip wagon over	mechanical malfunction	rolling overpack containers out of wagon - potential internal contamination of overpack container	operator exposure to recover	S1	F2	None	T&P	N/A
PCS-2.2.2	Pull cart to Room 230B	pass wagon too close to other fissile material	human error	violation of criticality contingency - interaction	criticality infraction	S0	F2	None	T&P Criticality Specifications	Before a transfer is made, the route is inspected & verified, to determine where any areas of interaction could occur. BED is in charge of approving all fissile material movements to assure no interactions occur.

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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-3.0	**Unpack and Sphincter Polycube Containers into Glovebox HC-21A**									
PCS-3.1.1	Open overpack container	breached polycube container inside overpack	dropping overpack container faulty polycube container seal	contamination spread inhalation dose	internal deposition of Pu	S1	F1	none.	T&P	If the overpack has been dropped, recommend making Room 230B an ARA to open the overpack container. If a container inside an overpack is found to be contaminated, the overpack container is sealed back up and a recovery plan is formulated.
PCS-3.1.2	Open overpack container	open overpack container without survey	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F1	none.	T&P	N/A
PCS-3.1.3	Open overpack container	Overpack container lid will not open	mechanical failure	increased time spend opening overpack container	increased dose	S1	F2	Design of the overpack container	T&P	Screw-on overpack lids have a mark that indicates the proper torque required to seat the O-ring. Recommend buying some strap wrenches if screw-on overpack lids are used.
PCS-3.1.4	Open overpack container	container opened without using proper PPE (leather gloves)	human error	hand injury	potentially contaminated wound	S1	F1	None	T&P	N/A
PCS-3.2.1	Remove polycube container from overpack container	drop or knock over can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking over sealed can would be unlikely to cause a contamination spread – F rank is for knocking over, not contamination spread.
PCS-3.3.1	Verify accountability information	don't perform verification	human error	none	procedural violation	S0	F2	None	T&P	

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Node ID #	**Description**	**Deviation**	**Possible Causes**	**Hazardous Event/ Failure Mode**	**Consequences**	**Cons Rank**	**Freq Rank**	**Engineered Safety Features**	**Administrative Safety Features**	**Remarks**
PCS-3.4.1	Sphincter polycube container into glovebox	drop can	human error	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	Knocking over sealed can would be unlikely to cause a contamination spread – F rank is for knocking over, not contamination spread.
PCS-3.4.2	Sphincter polycube container into glovebox	polycube container seal breaches when turned on side for sphinctering	mechanical failure	contamination spread inhalation dose	internal deposition of Pu	S1	F2	None	T&P	
PCS-3.4.3	Sphincter polycube container into glovebox	Polycube container dropped from sphincter port inside glovebox	human error	dropped container falls onto other polycube container	Criticality spacing infraction	S0	F2	None	T&P Criticality Specifications	CSER adequacy form in preparation.
PCS-4.0	**Open Polycube Containers in Glovebox HC-21A**									
PCS-4.1.1	Place leather gloves over glovebox gloves	don't place leather gloves	human error	ruptured glove	contamination spread to room	S1	F3	None	T&P	Glovebox gloves are leaded.
PCS-4.1.2	Place leather gloves over glovebox gloves	don't place leather gloves	human error	cut hand	contaminated wound	S1	F3	None	T&P	N/A
PCS-4.1.3	Place leather gloves over glovebox gloves	leather gloves are degraded	mechanical failure	ruptured glove	contamination spread to room	S1	F3	None	T&P	N/A
PCS-4.1.4	Place leather gloves over glovebox gloves	leather gloves are degraded	mechanical failure	cut hand	contaminated wound	S1	F3	None	T&P	N/A
PCS-4.2.1	Open can with can *opener*	Can opener doesn't *operate correctly*	mechanical failure	Extended operation *time*	increased dose	S1	F3	Can Opener design	T&P	Note – manual can openers seem to work better than existing electric can openers
PCS-4.2.2	Open can with can opener	glove pinched in can opener	mechanical failure	ruptured glove	contamination spread to room	S1	F3	None	T&P	N/A
PCS-4.2.3	Open can with can opener	glove pinched in can opener	mechanical failure	cut hand	contaminated wound	S1	F3	None	T&P	N/A

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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-5.0	**Remove Polycubes from Containers and Place in Furnace Boats**									
PCS-5.1.1	Dump all polycubes from can into boat	spill outside boat	human error	none	cleanup	S1	F3	None	T&P	N/A
PCS-5.2.1	Tong excess polycubes (more than 360 g) from first boat into transport boat(s)	drop polycubes	human error	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCS-5.2.2	Tong excess polycubes (more than 360 g) from first boat into transport boat(s)	Leave whole can in boat (triple-batch)	human error	None in GB	None	N/A	N/A	N/A	N/A	Safety consequences take place in furnace – double batch will violate administrative limit of 25% of LFL in furnace during heating; triple-batch may reach 50% of LFL.
PCS-5.3.1	Weigh boat	Spill boat	human error	none	cleanup	S1	F3	None	T&P	N/A
PCS-5.4.1	Place boat cover on boat	don't place cover on boat	human error	blow dust from boat during transport	additional dose from cleanup of conveyor	S1	F3	None	T&P	N/A
PCS-6.0	**Transport Polycube in Furnace Boat to Furnaces in Glovebox HC-21C via Glovebox Conveyor HC-2**									
PCS-6.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No hazards unique to polycubes.
PCS-7.0	**Stabilize Polycube in Furnace in Glovebox HC-21C**									
PCS-7.1.1	Stage boat in front of furnace	boat falls off table	human error	spill inside glovebox	additional dose from cleanup	S1	F3	None	T&P	N/A
PCS-7.2.1	Take boat cover off	don't take boat cover off			N/A					Boat won't fit in furnace with cover on.
PCS-7.3.1	Load boat into furnace	spill boat outside furnace	human error	spill inside GB but outside furnace	additional dose from cleanup	S1	F3	None	T&P	N/A
PCS-7.3.2	Load boat into furnace	Load furnace 5 before furnace 4	human error	criticality spacing violation	criticality infraction	S0	F2	None	T&P Criticality Specifications	CSER adequacy form in preparation.

Polycube Stabilization HazOp

Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-7.4.1	Start offgas system	don't start offgas system	human error	None at this point	None	N/A	N/A	N/A	N/A	Safety consequences take place once furnace is heated – flammable gas buildup.
PCS-7.4.2	Start offgas system	don't start offgas system	failure of system	None at this point	None	N/A	N/A	N/A	N/A	Safety consequences take place once furnace is heated – flammable gas buildup.
PCS-7.4.3	Start offgas system	Set wrong flowrate (LOW)	human error	None at this point	None	N/A	N/A	N/A	N/A	Safety consequences take place once furnace is heated – flammable gas buildup.
PCS-7.4.4	Start offgas system	Set wrong flowrate (LOW)	Instrument failure	None at this point	None	N/A	N/A	N/A	N/A	Safety consequences take place once furnace is heated – flammable gas buildup.
PCS-7.4.5	Start offgas system	Set wrong flowrate (HIGH)	human error/instrument failure	None.	N/A	N/A	N/A	N/A	N/A	Higher flowrate through the furnace is better.
PCS-7.5.1	Check dP on offgas filters	don't check filters – filters plugged – no flow	human error	None at this point	None	N/A	N/A	N/A	N/A	Safety consequences take place once furnace is heated – flammable gas buildup.
PCS-7.6.1	Select program and start furnace heating	select wrong program	human error	Excess heating ramp rate	Polycubes could catch fire in furnace and plug offgas filter (lose furnace airflow) – flammable gas buildup in glovebox – burn in halo around furnace door with continuing glovebox airflow	S0	F3	None.	T&P	Control of combustibles in furnace glovebox lowers consequence ranking. Burn with continued airflow should not raise GB temperature to greater than 50 deg C (for one furnace operating – with two, temp could go to 100 deg. C – Halon dumps at 92 deg. C).

Polycube Stabilization HazOp — 25 – 26 October, 2000

Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-7.6.2	Select program and start furnace heating	controller failure	equipment failure	Excess heating ramp rate	Polycubes could catch fire in furnace and plug offgas filter (lose furnace airflow) – flammable gas buildup in glovebox – burn in halo around furnace door with continuing glovebox airflow	S0	F3	None.	T&P	Control of combustibles in furnace glovebox lowers consequence ranking. Burn with continued airflow should not raise GB temperature to greater than 50 deg C.

Polycube Stabilization HazOp

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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-7.7.1	Heat boats	lose both offgas and glovebox ventilation with temperature between 350 & 500 deg. C	loss of power	material would continue to generate flammable gas in the glovebox while still hot	Flammable gas mixture in glovebox – possible deflagration	S1*	F3	2 independent power supplies to plant	Power delivery MOUs with BPA & Dyncorp	Casualty response procedures should include taking boats from furnaces to stop generation of flammable gas, and ventilating glovebox for a period of time before relighting furnaces to remove remaining gases from glovebox. Casualty response procedures should also provide for emergency entry/protective equipment availability of responders (e.g., console operators need to have fitted masks with them). May be up to 30 min. before flammable gases build to LFL in glovebox; however, opening furnace may lead to ignition of evolving gases (if furnace temperature is greater than 475 deg. C – ignition temp for flammable gases). Safety analysis considered 800 g of polycubes in one furnace – operation will have ~400 g in each of two furnaces.
PCS-7.7.2	Heat boats	double or triple batch in boat (4 or 6 cubes)	human error	flammable gas above 25% of LFL (administrative limit = 25% LFL)	None by itself – narrows safety margin.	S0	F2	None.	T&P	Triple batch would reach ~60% of LFL).

Polycube Stabilization HazOp

DATE
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Node ID #	Description	Deviation	Possible Causes	Hazardous Event/ Failure Mode	Consequences	Cons Rank	Freq Rank	Engineered Safety Features	Administrative Safety Features	Remarks
PCS-7.7.3	Heat boats	Offgas system NO flow (not on or plugged filter – from furnace startup)	human error	Flammable gas > LFL	flammable gas ignition	S0	F2	None.	T&P	Gas begins evolving at 350 deg C; ignition temperature 475 deg C. At that time: inside furnace likely above UFL – gases will ignite as they come out into glovebox. Exterior burning of gases won't shut down the furnace on high temp deviation – gases will burn in halo around door or just above furnace, and as long as there is glovebox airflow, GB temperature won't go above 50 deg. C. Consider adding alarming dP gauges on offgas system – possibly as an interlock to furnace program.
PCS-7.7.4	Heat boats	Offgas system NO flow (loss of vacuum system or plugged filter - lose during heating)	failure of system	Flammable gas > LFL	flammable gas ignition	S0	F3	None.	T&P	Differs from above because you may be above the ignition temperature when flow lost – it would ignite in the furnace and shut down on temperature deviation. Most dangerous situation would be this loss at the same time as a GB ventilation failure.
PCS-7.7.5	Heat boats	Off gas system LOW flow (wrong setting on valve or plugged filter)	human error	flammable gas > LFL	flammable gas ignition	S0	F2	None.	T&P	Low flow of < 25% could lead to flammable gas > LFL.

Polycube Stabilization HazOp										DATE: 23 – 26 October, 2000
Node ID #	**Description**	**Deviation**	**Possible Causes**	**Hazardous Event/ Failure Mode**	**Consequences**	**Cons Rank**	**Freq Rank**	**Engineered Safety Features**	**Administrative Safety Features**	**Remarks**
PCS-7.7.6	Heat boats	Off gas system LOW flow	failure of system	Flammable gas > LFL	flammable gas ignition	S0	F3	None.	T&P	Causes of low flow could include a different vacuum system user placing a heavy load on vacuum system, or filter beginning to plug, or gradual loss of vacuum system.
PCS-7.8.1	Cool boat for addition of more polycubes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PCS-7.9.1	Add new polycubes on top of char	spill boat or polycubes	human error/equipment failure (table)	contamination spread in glovebox	excess dose related to cleanup	S1	F2	None.	T&P	N/A
PCS-7.10.1	Heat full batch of char to 1000 deg C	lose both offgas and glovebox ventilation (NO flow)	loss of power	None.	Process upset	S0	F3	None	None	N/A
PCS-7.10.2	Heat full batch of char to 1000 deg C	partial loss of offgas flow (LOW flow)	system failure	Flammable gases > LFL	Potential CO fire in furnace	S0	F3	None	None	CO fire exhaust may damage furnace exhaust ducting – need to evaluate temperatures for that case. CO production and fire can occur only in specialized circumstances. Recommend evaluation of reactive ash OSD for continued utility.
PCS-8.0	**Remove Furnace Boat and Transport to Glovebox HC-18M or HA-20MB**									
PCS-8.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-9.0	**Sieve/Sample Stabilized Oxide from Polycubes**									
PCS-9.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-10.0	**Store Oxide from Polycubes in Gloveboxes 18BS or 18M During Sample Analysis**									
PCS-10.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-11.0	**Bag Out Samples from Glovebox 18M or 13MD**									

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Node ID #	**Description**	**Deviation**	**Possible Causes**	**Hazardous Event/ Failure Mode**	**Consequences**	**Cons Rank**	**Freq Rank**	**Engineered Safety Features**	**Administrative Safety Features**	**Remarks**
PCS-11.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-12.0	**Transport Samples to Analytical Lab**									
PCS-12.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes. NOTE: An LOI must be performed to verify that all carbon has been removed. (SFE checks only for water). If U is present – LOI will be ineffective, due to weight gain.
PCS-13.0	**Transport Samples to SFE Glovebox Via Conveyors HC-2, -3, -4, and -28**									
PCS-13.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-14.0	**Transport Confirmed Stabilized Material to Rm. 235 BTS for Seal-Out**									
PCS-14.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes.
PCS-15.0	**Place Confirmed Stabilized Material into FPC and Seal-Out from Glovebox 18M or 13MD**									
PCS-15.1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique to polycubes. Food pack cans will be used if the Rm. 235 BTS has not been approved to process Pu

PCS-16.1.1	Seismic event	0.2 g earthquake	Seismic Event	Loss of power	Flammable gas mixture in glovebox - possible deflagration	S1*	F2	2 independent power supplies to plant	Power delivery MOUs with BPA and Dyncorp	Same as 7.7.1
PCS-16.1.2	Seismic event	0.2 g earthquake	Seismic Event	glovebox collapse/fail	contamination spread, operator injury	S2	F2	None	None	Unfiltered release possible if ventilation remains on.
PCS-16.1.3	Seismic event	0.2 g earthquake	Seismic Event	seismically-induced fire	contamination spread	S1	F2	None	None	Trash not normally stored in furnace GB – only flammables are windows & gloves

Polycube Stabilization HazOp										DATE: 25 – 26 October, 2000
Node ID #	**Description**	**Deviation**	**Possible Causes**	**Hazardous Event/ Failure Mode**	**Consequences**	**Cons Rank**	**Freq Rank**	**Engineered Safety Features**	**Administrative Safety Features**	**Remarks**
PCS-16.2.1	Fire	fire in process rooms	Fire in Process Rooms	N/A	N/A	N/A	N/A	N/A	N/A	Nothing unique about polycube process.
PCS-17.0	**Startup, Shutdown, Maintenance, and Construction Hazards**									
PCS-17.1.1	Startup	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Nothing not previously covered.
PCS-17.2.1	Shutdown	Evacuation (criticality/CAM) without emergency shutdown of furnaces	emergency shutdown button not pushed on evacuation	None	None	N/A	N/A	N/A	N/A	No hazard without simultaneous loss of airflow.
PCS-17.3.1	Maintenance	support system taken out without notification	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No unique hazards related to polycube process.
PCS-17.4.1	Construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Alarming dP gauges may be installed – installation covered by existing work [illegible]
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Doors must be assured to not seal – must not be air tight. Criticality evaluation must be performed (viz. 3 boats, side-by-side).

APPENDIX B: HazOp Recommendations

Introduction

During the conduct of the HazOp sessions for the polycube stabilization process, numerous recommendations were formulated and recorded in the HazOp table (see Appendix A). Those reconimendations involving consequences greater than SO are presented below, along with the concerns that prompted the recommendations to be made.

Node ID#	Consequence Ranking / Recommendation	Concern raised
PCS - 1.1.1	S1: Initial survey of polycube can in vault while still on CMU should not include a wipe of the top of the can.	The filter over the polycube can vent may be dislodged, with spread of contamination and possibility of inhalation.
PCS - 1.1.2	S1: Survey of polycube can in vault while still on CMU should involve only the sides of the can, then a move of the can to the RBA to deal with the top of the can.	The filter over the aolycube can vent may be dislodged, with spread of contamination and possibility of inhalation.
PCS - 1.3.1	S1: Should include a visual inspection of the polycube can while still on CMU in vault to check state of filter cover on top of the can.	The filter over the polycube can vent may be degraded, which may lead to spread of contamination and possibility of inhalation.
PCS - 1.4.1	S1: Strongly suggest placing occlusive seal on top of polycube can in vault as early as possible - perhaps while still on CMU.	The filter over the polycube can vent may be dislodged, with spread of contamination and possibility of inhalation.
PCS - 1.8.1	SO: Need to analyze trade-offs between increased exposure involved in placing polycube cans in plastic bags before placing in overpack containers vs. contaminating overpack container (NMC-8) interiors.	The filter over the polycube can vent may be dislodged, with spread of contamination and possibility of inhalation.
PCS - 3.1.1	S1: If the overpack container has been dropped during transportation to Room 230B, recommend making room an ARA to open the overpack container.	The filter over the polycube can vent may be dislodged, with spread of contamination and possibility of inhalation.
PCS - 3.1.3	S1: Recommend buying some strap wrenches if screw-on overpack lids are used.	Screw-on overpack lids have a mark that indicates the proper torque required to seat the O-ring; it could be difficult to meet this by hand, and/or difficult to then open the can by hand from this oosition.

Node ID#	Consequence Ranking / Recommendation	Concern raised
PCS - 7.7.1	SI*: Casualty procedures should include steps to remove boats from furnaces (to stop generation of flammable gas) and ventilating the glovebox for a period of titne to remove remaining flammable gases from glovebox before relighting furnaces. Casualty response procedures should also provide for emergency entry/protective equipment availability of responders (e.g., console operators need to have properly-fitted masks with them).	**A** power loss leading to loss of vacuum and ventilation in the furnace and glovebox at a time when polycubes are being heated could result in the buildup of flammable gases to the LFL in the glovebox, potentiating a deflagration.
PCS - 7.10.2	SO: Recommend evaluation of reactive ash OSD for continued utility.	CO production may not be applicable here.

APPENDIX C: Peer Review

PEER REVIEW CHECKLIST

Document Title: Hazards Analysis for the Plutonium Finishing Plant Polycube Stabilization Process, HNF-7278
Document Author: D.M. Carson
Document Date: November, 2000
Scope of Review: Entire Document

Yes	No	NA	
[X]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[X]	Computer codes and data files documented.
[ ]	[ ]	[X]	Data used in calculations explicitly stated in document.
[ ]	[ ]	[X]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[X]	Mathematical derivations checked including dimensional consistency of results.
[ ]	[ ]	[X]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[X]	Hand calculations checked for mors. Spreadsheet results should be treated exactly the same as hand calculations.
[ ]	[ ]	[X]	Software input correct and consistent with document reviewed.
[ ]	[ ]	[X]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]	Limits/criteria/guidelines applied to analysis results am appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[X]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[X]	[ ]	[ ]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]	[ ]	[X]	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

David J. Braun David J. Braun 11/6/00
Reviewer (Printed Name and Signature) Date