

F.4

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

February 8, 1994

MEMORANDUM FOR: Technical Director

COPIES: Board Members

FROM: Richard E. Tontodonato

SUBJECT: Trip to Review Feed Characterization for Rocky Flats Plant
Building 707 Thermal Stabilization Process, January 20, 1994

1. **Purpose:** This memorandum is a report by the DNFSB staff (Richard Tontodonato and Davis Hurt) on a visit to the Rocky Flats Plant on January 20, 1994 to review the characterization of feed materials for the Building 707 thermal stabilization process.
2. **Summary:** EG&G has completed characterization of the brushings and other ordinary plutonium oxide materials currently identified as feed for thermal stabilization, and has characterized some of the duct residues planned to be stabilized. Results from testing oxides indicate, as expected, that these materials will be safe to process in the Building 707 calciners. Plutonium-bearing duct residues, however, undergo large weight losses when heated and may not be adequately stabilized if only heated to 500°C. Reduced batch sizes, slower heat-up rates, and a higher stabilization temperature may be required to safely stabilize them. The Stabilization Technical Review Group, a group of EG&G plutonium experts assigned to evaluate the characterization results, has not yet decided what testing or analysis is needed to determine how to process the duct residues.
3. **Background:** The Department of Energy plans to restart two calcining furnaces in Building 707 for the purpose of converting potentially unstable plutonium materials to stable plutonium dioxide, PuO₂. DOE-Rocky Flats Office (DOE-RFO) and EG&G-Rocky Flats (EG&G) personnel did not originally plan to perform any chemical analysis or other objective characterization of the feed materials. However, the Board believed it would be risky to process some of the materials, particularly the oily duct residues, without understanding more about their compositions. After significant discussion, DOE-Office of Defense Programs (DOE-DP) management agreed that feed characterization was warranted. Subsequently, at the Board's February 1993 public meeting in Boulder, Colorado, DOE representatives stated that they had developed a plan to sample each can of duct residue and perform selected chemical analyses to ensure these materials could be safely stabilized. In March 1993, the DNFSB staff reviewed the characterization program

and concluded that it adequately addressed potential calcination safety issues. (documented in a trip report forwarded by the Board to DOE-DP on March 19, 1993)

4. **Discussion:** EG&G has completed characterization of the brushings and other ordinary plutonium oxide materials currently identified as feed for thermal stabilization, and has characterized some of the duct residues planned to be stabilized. Twelve containers of duct residues have been sampled and analyzed, and another 16 containers are scheduled to be sampled once thermal stabilization begins. EG&G does not plan to sample the remaining 59 containers of duct residues in FY 1994 because they are not scheduled to be stabilized in FY 1994. Test methods and results to date are described below:

- a. **Test Methods:** EG&G uses thermogravimetric analysis (TGA) and infrared spectroscopy (IR) to characterize two samples from each can of feed material. In TGA, a 15-30 milligram sample is heated in air to about 900°C, and weight changes are monitored as a function of temperature. Weight losses can be caused by evaporation of absorbed water or other volatile materials or by chemical reactions evolving gaseous products. Weight gains are typically due to oxidation of plutonium metal. This test can be used to estimate how much plutonium metal is in a sample, and whether significant chemical reactions occur when it is heated.

In IR, a two milligram sample is mixed with 300 milligrams of an infrared-inert material, formed into a one millimeter thick pellet, and illuminated with an infrared source. Absorption is measured as a function of infrared wavelength. Organic species and some inorganic materials can often be identified using this process.

- b. **Test Results:**

- (1) **Oxides:** Oxide materials showed a small (1-2%) change in weight in TGA, and contained essentially no IR-active constituents. These materials should be safe to calcine. EG&G is also using the TGA results to estimate the plutonium metal fines content of the samples. EG&G is considering removing containers with sufficiently low plutonium metal fines content from heat detectors, to make room for storing uncharacterized scrapings that will be generated in the upcoming plutonium metal repackaging effort.
- (2) **Duct residues:** Duct residues experienced up to 80 percent weight loss in TGA, indicating they are vastly different from the oxide materials. Most of the weight loss occurs below 500°C, but some samples showed noticeable weight losses up to about 800°C. EG&G plutonium experts consider it likely that the weight loss is due to organic material in the residues burning in the test, but suspect that inorganic

coatings used in molds may also be involved. IR revealed little about the nature of the duct residues, the only conclusion being that some of the samples may contain hydrocarbon oils.

Discussions with members of the Stabilization Technical Review Group revealed that they have not yet decided what additional testing, if any, will be done to define how to safely stabilize the duct residues. Their opinion was that the duct materials could probably be safely stabilized either by limiting the batch size or by heating to a relatively low temperature (perhaps 200°C), holding there to allow gases to evolve at a manageable rate, then heating up to the stabilization temperature, possibly above 500°C. Additional TGA testing, using reduced heating rates and hold times at different temperatures, will be needed to define this modified process. The members of the Stabilization Technical Review Group did not envision performing other laboratory analyses to more precisely determine the constituents of the residues. From a safety perspective, this is acceptable, but it does not address the potential for RCRA-regulated constituents in the residues.

5. Conclusions:

- a. As expected, characterization of plutonium oxide feed materials indicates that they can be safely stabilized in the Building 707 calciners.
- b. Characterization results for the plutonium-bearing duct residues indicate that procedural or process changes will be needed before they can be safely stabilized in the Building 707 calciners. Continued DNFSB staff attention is warranted to ensure DOE-RFO and EG&G adequately resolve this problem.

April 14, 1998

5.7

Mr. Robert Card
[]
Kaiser-Hill Company, L.L.C.
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

EA 98-03

Subject: Consent Order Incorporating Agreement between U.S. Department of Energy
and Kaiser-Hill Company, L.L.C.

This letter refers to the Department of Energy's (DOE) evaluation of the facts and circumstances presented to DOE by Kaiser-Hill Company, L.L.C.'s (Kaiser-Hill) internal investigation reports of three events that occurred at the Rocky Flats Environmental Technology Site between January 1996 and January 1998.

These events involved (1) an unplanned [radioactive material] uptake by two workers during a CERCLA Tank Remediation Project conducted by Rocky Mountain Remediation Service (RMRS), a sub-contractor to Kaiser-Hill; (2) seventeen workers receiving small radiation exposures as a result of inadequate assessment of area dosimetry data for several offices adjacent to rooms containing radioactive material and; (3) an RMRS sealed source custodian receiving unnecessary exposure while performing a radioactive source inventory and leak test.

While the actual safety significance of these events was low and none of these incidents resulted in radiation exposures at or near the limits specified in the Occupational Radiation Protection Rule (10 CFR 835), DOE is concerned because these events collectively indicate significant weaknesses in the controls necessary to perform work safely.

DOE has evaluated the results of the internal investigations of these events conducted by the Kaiser-Hill team and has concluded that the findings and conclusions with respect to these events have been comprehensive. DOE has concluded that these investigations disclose all relevant facts and objectively assess the actual, potential, or programmatic safety significance of these events. DOE's approval of the Kaiser-Hill team's aggressive investigation of these events, coupled with similar results in a number of prior cases, leads DOE to conclude that any further investigation into these matters by DOE is unnecessary and unwarranted.

DOE has also evaluated and agrees with the adequacy of the corrective actions completed and scheduled for implementation to correct work control deficiencies and to prevent recurrence of these or similar events in the future. As a result of the Kaiser-Hill team's aggressive response to these three events and during previous events, and to encourage similar responsiveness in the future, DOE has elected to issue the enclosed Consent Order in accordance with 10 CFR 820.23 in lieu of possible enforcement proceedings, Notice of Violation, or civil penalties. With this Consent Order, Kaiser-Hill has agreed to remit a \$100,000 monetary remedy in recognition of the programmatic work planning and control problems identified as a result of their internal investigations.

No written response to this letter is required. As provided by Section VI of the enclosed Consent Order, the Kaiser-Hill team is to remit the \$100,000 monetary remedy to the Treasurer of the United States.

In accordance with the terms and conditions of the enclosed Consent Order, any required changes to corrective action completion dates regarding these three events must receive prior written approval from the Manager, DOE Rocky Flats Field Office. The original of the Consent Order signed by the parties has been filed with the Office of the Docket Clerk.

Sincerely,



Peter N. Brush
Acting Assistant Secretary
Environment, Safety and Health



U.S. Department of Energy

Office of Enforcement and Investigation

In the matter of) Report No. NTS-RFO-KHLL-ENVOPS-1997-0001
Kaiser-Hill Company, L.L.C.) NTS-RFO-KHLL-SITEWIDE-1997-0009
Rocky Flats Environmental) NTS-RFO-KHLL-371OPS-1998-0001
Technology Site) Enforcement Action 98-03

CONSENT ORDER INCORPORATING AGREEMENT BETWEEN U.S. DEPARTMENT OF ENERGY AND KAISER-HILL COMPANY, L.L.C.

I

Kaiser-Hill Company, L.L.C. (Kaiser-Hill), is the integrating management contractor for the Department of Energy (DOE) at the Rocky Flats Environmental Technology Site (RFETS), Golden, Colorado. Kaiser-Hill is responsible for all activities related to the environmental restoration of contaminated areas and facilities, and maintaining [radioactive materials] at RFETS.

II

The following incidents were reported voluntarily by Kaiser-Hill to the DOE Noncompliance Tracking System (NTS) for evaluation:

CERCLA Tank Remediation Project
NTS-RFO-KHLL-ENVOPS-1997-0001

Internal intakes of [radioactive material] occurred in two workers participating in Rocky Mountain Remediation Services' underground tank remediation activities on August 12, 1996. Doses of [specified amounts] committed effective dose equivalent were assigned. Although radiological hazards associated with the work had escalated over a period of several months, compensatory radiological planning and controls were not adequately reviewed and implemented. Radiological work control

program weaknesses identified by the Kaiser-Hill root cause analysis included inadequate monitoring to document radiological conditions in the work place and to

detect changes in radiological conditions of the workplace; inadequate As Low As Reasonably Achievable (ALARA) measures including both the use of ventilation and confinement; failure to follow procedures to maintain exposures ALARA; failure to generate and maintain radiological records; and less than adequate area monitoring for airborne radioactive materials.

The uptakes were discovered through routine bioassay for one worker and by special request for bioassay by the second worker; i.e., the intake event was unrecognized. The investigation report points out that a significant amount of time lapsed between the submittal of excreta and notification of the workers of their bioassay results--more than one year. The report states that confirmation that an intake occurred requires the recount of the original positive sample, and acquisition of two additional follow-up urine samples. In this case, the confirmatory process was lengthy: For one worker, recount of the original positive urine sample required seven weeks, acquisition of the first follow-up urine sample was not initiated for an additional ten weeks, and acquisition of the second follow-up sample occurred 25 weeks after that. Consequently, the internal dose evaluation program was not adequate to demonstrate timely compliance with 1996 occupational exposure limits.

[Buildings] Area Monitoring
NTS-RFO-KHLL-SITEWIDE-1997-0009

Forty-one individuals in 1996 and 39 in 1997 (including one declared pregnant worker) were evaluated for unmonitored radiation exposures as a result of inadequate assessment of area monitoring data for several offices adjacent to rooms containing radioactive materials. Six individuals for 1996 and 11 for 1997 were assigned doses greater than [a specified amount] effective dose equivalent (EDE) (maximum doses were [specified amounts] EDE, respectively). Safe Sites of Colorado (SSOC) was assigned responsibility for the RFETS radiological control program in late February 1997. The area monitoring report for the first quarter of 1997 was issued on July 30, 1997, and described high dosimeter measurements for several office areas in Buildings []. On September 15, 1997, the second quarter area monitoring report was issued and conveyed similar results. SSOC initiated an investigation and utilized a combination of area postings, personnel relocations, and interim administrative controls to reduce occupational exposures within the affected office areas. Dose reconstructions began in mid-September 1997. The reconstructions revealed two pregnant workers who were within the office areas; one was working in an affected area for a short period of time and was assigned [a specified amount] EDE, and the second employee, a declared pregnant worker, received an estimated [specified amount] EDE. SSOC's root cause analysis identified the following radiological control programmatic deficiencies: monitoring of individuals and areas, monitoring of declared pregnant workers, administrative controls, and work processes.

Exceedance of RWP Suspension Limits
NTS-RFO-KHLL-3710PS-1998-0001

On January 14, 1998, a sealed source custodian conducted a semi-annual inventory and leak test of several [radioactive material] sealed sources, and was supported by a radiological control technician (RCT) who had no prior source inventory experience. The general radiological work permit for the job required a pre-job briefing and established a 100 mrem/hour beta/gamma dose rate limiting condition of operation. No pre-job briefing was conducted. Prior to the inventory and leak testing, the RCT measured exposure rates in excess of 100 mrem/hour yet failed to halt any further work. The custodian proceeded to verify each source's labeling by physically handling each source and then swabbing it for leak testing purposes. One source had an exposure rate of [a specified amount] at 30 centimeters. Afterwards, the RCT discussed the event with another RCT to verify proper procedures. Dose estimates for the custodian were [a specified amount] EDE to the hand, [a specified amount] EDE to the wrist, and [a specified amount] EDE to the lens-of-eye. The following radiological control deficiencies were identified: area monitoring of the workplace, radiation safety training, administrative controls, and work processes.

III

DOE has evaluated the results of the investigations conducted by Kaiser-Hill and has concluded that the findings and conclusions with respect to these incidents are comprehensive. DOE has concluded that these investigations fully and accurately disclose all relevant facts, including the identification of potential violations of nuclear safety requirements in the areas of radiation protection and quality assurance, and objectively assess the actual, potential, or programmatic safety significance of these potential violations. DOE's approval of Kaiser-Hill's aggressive investigation of these events, coupled with similar results in a number of prior cases, leads DOE to conclude that a full independent investigation by DOE into these matters is unnecessary and unwarranted.

IV

DOE acknowledges Kaiser-Hill's aggressive and comprehensive investigation to determine the causes of these incidents, and open and objective assessment of the operational shortcomings involved. DOE has also evaluated and agrees with the adequacy of the corrective actions completed and the schedule for implementation of those corrective actions that remain yet to be completed as described in the above referenced NTS reports. In consideration of the foregoing, DOE and Kaiser-Hill have reached agreement on this matter under which both have agreed to issuance of this Consent Order to avoid potentially protracted and otherwise unnecessary additional investigation by DOE; and potential challenges on the part of Kaiser-Hill to findings by DOE, possible enforcement proceedings, Notice of Violation, and any imposed civil penalties. DOE and Kaiser-Hill agree and recognize that in recognition of the response

by Kaiser-Hill to these matters, the payment included by Kaiser-Hill has been significantly reduced from what could have been proposed through the formal enforcement process.

V

DOE acknowledges that Kaiser-Hill's execution of and payment in accordance with this Consent Order does not constitute or imply admission by Kaiser-Hill of potential regulatory violations. Both DOE and Kaiser-Hill agree that the sum paid by Kaiser-Hill to resolve this matter shall not be considered a reimbursable cost.

VI

This Consent Order is issued under DOE's authority in Section 234A of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2282a), and 10 CFR Part 820.23. Kaiser-Hill agrees to pay to the Treasurer of the United States (Account Number 891099), mailed to the Director, Office of Enforcement and Investigation, U.S. Department of Energy, an amount of \$100,000 reflecting an agreed amount in lieu of any subsequent investigation, Notice of Violation, and imposition of civil penalty.

This Consent Order does not preclude DOE from investigating or pursuing enforcement action against Kaiser-Hill for cases other than those described in the above referenced NTS reports, or if Kaiser-Hill fails to proceed with corrective actions as outlined in their plans as described in the above referenced NTS reports.

DOE agrees that it will not pursue an enforcement action or civil penalty for any potential violations pertaining to the above referenced matters. DOE may subsequently consider enforcement action if it later becomes known that any of the facts or information provided regarding the described events were knowingly false or inaccurate in any material way.

ACCORDINGLY, it is hereby Ordered as follows:

1. In accordance with its authority under the Price-Anderson Amendments Act (42 U.S.C. 2282a) and 10 CFR 820.23, DOE issues this Consent Order. In accordance herewith, Kaiser-Hill will proceed with the corrective actions detailed in NTS reports NTS-RFO-KH-ENVOPS-1997-0001, NTS-RFO-KHLL-SITewIDE-1997-0009, and NTS-RFO-KHLL-371OPS-1998-0001. Any required changes to

completion dates established in the subject NTS reports shall receive the prior approval of the Manager, Rocky Flats Field Office. The subsequent failure to timely complete such corrective actions may, in the sole discretion of DOE, constitute a sufficient basis to reopen the investigation with respect to the subject potential violations.

- 2. Kaiser-Hill agrees to pay \$100,000 to the Treasurer of the United States within 15 days of the issuance of this Order. It shall be mailed to the Director, Office of Enforcement and Investigation, Office of the Assistant Secretary for Environment, Safety and Health, U.S. Department of Energy, P.O. Box 2225, Germantown, MD 20874-2225, Attention: Office of the Docketing Clerk.
- 3. Upon completion of all corrective actions to the satisfaction of DOE, the payment made to DOE under this Consent Order shall completely resolve and serve as a full and final settlement of any and all enforcement actions taken under 10 CFR 820 arising from the referenced NTS reports.
- 4. This Consent Order shall become a Final Order upon receipt of said amount referenced in Item 2.
- 5. Kaiser-Hill hereby waives any and all rights to appeal or otherwise seek judicial review of this Consent Order. However, both DOE and Kaiser-Hill retain the right to judicially enforce the provisions hereof by all legal means.

On behalf of my respective organization, I hereby agree to and accept the terms of the foregoing Consent Order.

FOR DOE-EH

FOR Rocky Flats Field Office

_____/ /98
 R. Keith Christopher
 Director, Office of Enforcement
 and Investigation
 U.S. Department of Energy

_____/ /98
 Jessie M. Roberson
 Manager, Rocky Flats Field Office
 U.S. Department of Energy

FOR Kaiser-Hill

_____/ /98
 Robert G. Card
 []
 Kaiser-Hill Company, L.L.C.
 Rocky Flats Environmental Technology Site

F. 4



Department of Energy

Washington, DC 20858

July 17, 2001

Mr. Alan Parker

[]

Kaiser-Hill Company, L.L.C.

Rocky Flats Environmental Technology Site

10808 Highway 93, Unit B

Golden, CO 80403-8200

EA-2001-04

Subject: Preliminary Notice of Violation and Proposed Imposition of Civil Penalty,
\$385,000

Dear Mr. Parker:

This letter refers to the Department of Energy's (DOE, Department) evaluation of the facts and circumstances concerning a number of events and programmatic failures affecting nuclear safety at the Department's Rocky Flats Environmental Technology Site. The DOE Office of Price-Anderson Enforcement, in coordination with the DOE Rocky Flats Field Office (RFFO), conducted an on-site investigation during April 3-5, 2001. The results of this investigation were provided to you on May 14, 2001; and an enforcement conference was held with you and members of your staff on June 5-6, 2001, to discuss these findings. The conference's summary report is enclosed.

Based on the Department's investigation and information you provided during the enforcement conference and thereafter, the DOE has concluded that violations of 10 CFR 830, "Nuclear Safety Management," and 10 CFR 835, "Occupational Radiation Protection," likely occurred. These violations are described in the enclosed Preliminary Notice of Violation (PNOV).

Sections I and II of the PNOV describe deficiencies related to the implementation of [Nuclear] Safety and Waste Facility work control requirements. These deficiencies were associated with a series of recent events involving transuranic material size reduction, container loading, and assay activities. Although the safety significance of the individual events was relatively low, the recurring nature and supervisory involvement associated with several of the events reflects more fundamental concerns requiring management attention.

Section III of the PNOV describes violations associated with the breakdown of work and

procurement processes occurring during the August 2000 procurement of 500 55-gallon replacement drum lids. The drum lids were intended for use in nuclear waste interim storage and eventual shipment of the waste to the Waste Isolation Pilot Program (WIPP). During the procurement action, Kaiser-Hill Company (KH) ordered the drum lids despite the fact that two mandatory quality assurance reviews of the drum lid requisition had not been completed. Furthermore, the drum lids were ordered to a specification that was not designed for drum lid replacement parts and KH did not formally establish receipt inspection criteria. All 500 drum lids were ultimately rejected for use due to design and fabrication defects, and transportation damage.

Section IV of the PNOV describes procedural implementation and As Low As Reasonably Achievable (ALARA) deficiencies associated with the implementation of the Building 771 Radiation Safety Program. These deficiencies were identified in association with specific events occurring in August and September 2000 involving inadequately controlled work activities associated with contaminated air-mover preparation and airline removal. Your investigation into an October 2000 event involving an out-of-calibration air sampler identified additional concerns related to radiological procedural compliance, adequacy and compliance with work controls, and effectiveness of management oversight.

Section V of the PNOV describes violations of the quality improvement provisions of 10 CFR 830. The breakdowns cited in this section demonstrate a failure by KH to correct previously identified and long-standing quality problems in the areas of Procurement, [Nuclear] Safety, and Authorization Basis implementation. Effective correction of these problems upon their initial identification would have prevented the majority of the events and deficiencies cited in the PNOV. An associated underlying weakness is the ineffective implementation of your assessment programs. This concern was recognized by several of the KH root cause determinations performed in conjunction with the subject events.

In accordance with 10 CFR 820, Appendix A, "General Statement of Enforcement Policy," the violations described in the enclosed PNOV have been classified as eight Severity Level II problems with an aggregate civil penalty of \$385,000. In determining these Severity Levels, DOE considered the actual and potential safety significance associated with each event under consideration, the programmatic and recurring nature of the violations, and other factors.

With respect to the [Nuclear] Safety and Waste Facility Work Control violations, 25 percent mitigation of civil penalties was awarded as several of the events were self-identified by the contractor. Full mitigation for self-identification was not warranted because some of the events were self-disclosing. No mitigation was awarded for corrective actions, since the deficiencies were largely long-standing and recurrent in nature.

No mitigation for identification or for corrective actions was awarded for the cited Procurement violations. KH did not initially recognize the 55-gallon drum lid

procurement as a recurring issue. Further, deficiencies in the Procurement program have been long-standing and the subject of repeated DOE Enforcement Actions and penalties, including the issuance of civil penalties in calendar years 1999 and 2000, and an Enforcement Letter in 2000. This demonstrates the general ineffectiveness of corrective actions taken to date. As a further specific example, subsequent to the June enforcement conference KH identified an additional procurement-related noncompliance associated with the inadequate control of suspect/counterfeit electrical circuit breakers. Although not specifically cited as part of this PNOV, this later event emphasizes the recurrent nature of deficiencies in this area. Therefore, the DOE believes it is appropriate to escalate the procurement-related civil penalties by 50 percent to emphasize the need for management to achieve effective and long-term resolution in this area.

With respect to the Building 771 Radiation Safety deficiencies, no mitigation for identification was awarded due to the self-disclosing nature of the events. Fifty percent mitigation for corrective actions, however, was awarded in recognition of the depth of the contractor's investigation into the air sampler calibration event and the scope of the corrective actions.

No mitigation for either identification or effectiveness of corrective actions was deemed appropriate for the Quality Improvement violation. In keeping with the subject of this violation, the DOE intends to closely monitor the effectiveness of corrective actions undertaken in response to this PNOV, as well as your progress in improving the timeliness and adequacy of your assessment programs.

You are required to respond to this letter and follow the instructions specified in the enclosed PNOV when preparing your response. Your response should document any additional specific actions taken to date. Corrective actions will be tracked in the Noncompliance Tracking System (NTS). You should enter into the NTS (1) any actions that have been or will be taken to prevent recurrence and (2) the target and completion dates of such actions. After reviewing your response to the PNOV, including your corrective actions entered into the NTS as well as the results of any other assessment or inspection, DOE will determine whether further enforcement action is necessary to ensure compliance with DOE nuclear safety requirements.

You are further required to provide a summary briefing to the RFFO on the status of corrective actions completed and planned concerning the Procurement program's programmatic deficiencies within 60 days of your receipt of this letter.

Sincerely,

R. Keith Christopher

R. Keith Christopher
Director

Office of Price-Anderson Enforcement

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Enclosures:

Preliminary Notice of Violation
Enforcement Conference Summary
List of Attendees

cc: B. Mazurowski, DOE-RFFO
S. Cary, EH-1
M. Zacchero, EH-1
S. Hurley, OE
P. Rodrik, OE
A. Weadock, OE
S. Zobel, OE
D. Stadler, EH-2
F. Russo, EH-3
R. Jones, EH-5
C. Huntoon, EM-1
H. Himpler, EM PAAA Coordinator
L. Bressler, DOE-RFFO PAAA Coordinator
R. Farrell, DOE-WIPP PAAA Coordinator
F. Casella, KH PAAA Coordinator
R. Azzaro, DNFSB
Docket Clerk, OE

PRELIMINARY NOTICE OF VIOLATION
and
PROPOSED IMPOSITION OF CIVIL PENALTY

Kaiser-Hill Company, L.L.C.
Rocky Flats Environmental Technology Site

EA-2001-04

During a Department of Energy (DOE) investigation conducted on April 3-5, 2001, violations of DOE nuclear safety requirements were identified. In accordance with the "General Statement of Enforcement Policy," 10 CFR 820, Appendix A, DOE proposes to impose civil penalties pursuant to section 234a of the Atomic Energy Act of 1954, as amended, 42 USC 2282a, and 10 CFR 820. The particular violations and associated civil penalties are set forth below.

I. [Nuclear] Safety

10 CFR 830.120(c)(2)(i) requires that "[w]ork shall be performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate methods."

Contrary to the above, work was not performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate methods in that work activities associated with the size reduction of [radioactive material] items, the loading of nuclear materials into transuranic (TRU) waste containers, and the handling and storage of TRU waste containers, were not performed in accordance with approved procedures and [nuclear] safety operating limits. Specifically:

- A. [Radioactive Material] Size Reduction Activities: The [radioactive material] sizing procedure, PRO-556-FO-1025, and the corresponding [nuclear] safety evaluation, JCG-21, required operators to (1) re-secure sized [radioactive material] pieces in part carriers prior to initiating can-loading activities, and (2) empty, and verify empty, any partially filled can used for packaging newly-sized [radioactive material] pieces. However, on June 22, 2000, Kaiser-Hill Company (KH) identified that operators were placing a partially filled [radioactive material] can in the work area and loading the can as [radioactive material] pieces were re-

sized without (1) re-securing all of the newly sized [radioactive material] pieces, and (2) emptying and verifying empty the partially filled can.

- B. TRU Waste Container Loading Activities: [Nuclear] Safety Operating Limit ([]SOL) RMS-19, revision 12, requires the [radioactive material] content of each package be limited to [specified quantity] when two packages are placed in a single 10-gallon drum. However, on December 21, 2000, KH identified in Building 707 that workers loaded three 10-gallon drums with TRU waste that exceeded this [limit] per package [] SOL limit.

[] MVM-015-3 requires the [radioactive material] content of certain 55-gallon drums not to exceed [specified quantity]. However, on December 29, 2000, KH identified in Building 707 that workers loaded a 55-gallon drum with several packages having assay values, when totaled that exceeded the [] limit. The worker and a second verifier signed a data form listing the assay values of the individual packages but failed to ensure the loaded drum complied with the limit. Subsequent to the event, a re-assay of the loaded drum established a new assay value below the [] limit.

- C. TRU Waste Storage and Handling Activities: [Nuclear Safety] Analyses for Building 440 (JP-410) and for Building 991 (BSM-583) require that only certain nuclear material assay methods be used to verify [radioactive] material content of containers prior to their storage in Buildings 440 and 991, respectively. However, on August 28, 2000, KH identified that 40 containers in Building 440 and eight containers in Building 991 were being stored without having the [radioactive] material content verified, using one of the required methods.

Subsequent to the above problems, KH issued Standing Order-71 and Operations Order OO-MSWO-001 prohibiting the further shipment and receipt, respectively, of drums without the required assay method. However, KH identified on January 24, 2001, Building 569 shipped a noncompliant drum to Building 664 which accepted it for storage.

This violation constitutes a Severity Level II problem.
Civil Penalty - \$41,250

II. TRU Waste Facility Work Controls

10 CFR 830.120(c)(2)(i) requires that "[w]ork shall be performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate methods."

Contrary to the above, work was not performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate methods in that facility operations in Buildings 440 and 664 were not performed in accordance with approved authorization basis (AB) documents and

technical specification requirements (TSRs). Specifically:

- A. Building 440 Specific AB Issues: The Building 440 Basis for Operation (BFO), Revision 7, required the following controls:

1. Ridged Liners for Drums stacked higher than the second tier.
2. AB Surveillances within specified time frequencies.
3. Minimum aisle spacing limits.
4. Protection of electrical panels with concrete barriers.

However, KH identified in July and August 2000 that Building 440 routine waste handling and storage operations were not being conducted in accordance with the above AB requirements for an undetermined period of time.

- B. Building 664 Specific AB Issues: The Building 664 AB contains a TSR limit and corresponding Limiting Condition for Operation (LCO) action statements on the amount of nuclear material in radioactive waste containers.

However, KH identified in February 2000 that the facility was storing 19 waste drums that exceeded the TSR limits. A second AB violation occurred upon discovery of the drums when the facility management failed to curtail all facility operations in accordance with the above LCO action statements. These drums were stored in Building 664 since August 1997 when the new AB for the facility established requirements prohibiting storage of these drums. Laboratory analysis of assay information, although available, was not used to determine compliance during a 1997 AB implementation inventory.

- C. Container Re-assay Work Control Issues: KH did not develop an effective work control process for timely notification to facility management of changes in waste container assay values. The container assay value affects the facility compliance with the AB TSRs. TSR LCO actions require the facility operations to be terminated and the facility returned to a compliant state within [specified] days. Specifically:

1. In Building 440, the re-assay of two drums in January 2001 identified higher nuclear material contents in excess of the TSR limits. However, the facility continued to store the drums until February 22, 2001, when the LCO action statements were entered.
2. In Building 664, one drum was re-assayed in January 2001 with new material values in excess of the TSR limit. LCO action statements were not entered until February 22, 2001.
3. In Building 991, the re-assay of three drums in December 2000 identified nuclear material contents in excess of the TSR limits. LCO action statements were not entered until February 26, 2001.

This violation constitutes a Severity Level II problem.

Civil Penalty - \$41,250

III. Procurement

- A. 10 CFR 830.120(c)(2)(i) requires, in part, that "[w]ork shall be performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate means."

Contrary to the above, work was not performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate means in that:

1. The Rocky Flats Environmental Technology Site Acquisition Procedure for Requisitioning Commodities and Services, Revision 1, 1-W36-APR-111, requires that requisitions for "closure commodity" procurements be reviewed and signed by the Requisitioning Manager or Material Acquisition Member, the WADLET Manager and the Customer Service Organization. Waste Isolation Pilot Plant (WIPP) related procurements must also be reviewed and signed by the TRU Waste Project Quality Assurance Officer.

However, on August 23, 2000, KH placed a telephone order with Myers Container Corporation for 500 55-gallon replacement waste drum lids without first obtaining all required quality assurance reviews and approvals of the related requisition. Specifically, KH ordered the drum lids after the TRU Waste Project Quality Assurance Officer and the Customer Service Organization withdrew their approvals of the requisition for the waste drum lids. The drum lids are designated as "closure commodity" and WIPP-related items and were intended for use in the storage and movement of transuranic radioactive waste and eventual shipment of the waste to WIPP.

2. The KH Procurement System Manual establishes procurement procedures for the acquisition of items for the Rocky Flats Environmental Technology Site. Revision 1 of Volume 1, Part 2, section 1.201-2, requires that the buyer of items shall assure that no subcontract shall be entered into, modified, or terminated unless all required reviews, clearances, or approvals have been obtained.

However, on August 23, 2000, KH failed to obtain all required approvals before procuring 500 55-gallon replacement waste drum lids.

This violation constitutes a Severity Level II problem.

Civil Penalty - \$82,500

- B. 10 CFR 830.120(c)(2)(iii) requires, in part, that "[p]rocured items and services shall meet established requirements and perform as specified."

Contrary to the above, procured items and services did not meet established requirements and perform as specified in that:

1. On August 23, 2000, KH procured 500 55-gallon replacement waste drum lids to a specification that was not designed for drum lid replacement parts and did not establish requirements for drum lid replacement parts.
2. On or about August 28, 2000, KH received 500 55-gallon replacement waste drum lids that did not meet requirements to Subject Matter Expert criteria. Specifically, 83 percent of the lids failed for nonconformance to convexity, for dents/bends, or for gasket adhesion nonconformance. The remaining lids failed due to markings, paint thickness, and paint coverage.

This violation constitutes a Severity Level II problem.
Civil Penalty - \$82,500

IV. Building 771 Radiation Safety Program

- A. 10 CFR 835.104 states that "[w]ritten procedures shall be developed and implemented as necessary to ensure compliance with this part, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards."

Contrary to the above, written procedures were not developed and implemented as necessary to ensure compliance with 10 CFR 835 in that:

1. Manual MAN-102-SCRM, "Rocky Flats Environmental Technology Site Radiological Control Manual," version 1, dated October 15, 2000, requires in section 551.2 that "[m]onitoring shall be performed only by trained and qualified individuals using instruments that are properly calibrated and routinely tested for operability."

However, equipment used for process monitoring or data collection was not calibrated and maintained in that on October 16, 2000, a DOE Facility Representative observed a low-volume air sampler (low-vol) in the Building 771, [], tent that was in use beyond its calibration expiration date. KH's broader investigation of this finding in Building 771 resulted in the identification of several survey meters and other low-vols in this same situation, and discovery of an alpha radiation detector in use despite that instrument having failed a performance check.

2. Procedure RSP-01.01, section 4.1.2[1] requires a RCT to "[p]erform and properly document surveys." Section 7.6 of this procedure requires that worker DAC-hr tracking be performed when powered air purifying respirators are used. Such respirators were used from the September 7 through October 17, 2000.

However, records were not specified, prepared, reviewed, approved, and maintained in that during September 7 through October 17, 2000, documentation of Radiological Work Permit (RWP)-required airborne radioactivity measurements and worker DAC-hr tracking was not performed

for work evolutions occurring in the Building 771, [], containment tent. Furthermore, radiological contamination surveys within the room [] tent were required by RWPs 00-771-5216, -5218, and -5250 before, during, and after the completion of a work activity. KH was unable to locate contamination survey records for the period of September 15 through October 15, 2000, though radiological work activities were occurring in the room [] tent during that time.

3. Manual MAN-102-SCRM, "Rocky Flats Environmental Technology Site Radiological Control Manual," version 1, dated October 15, 2000, requires in section 322.7 that "[w]orkers shall acknowledge by signature or through electronic means...that they have read, understand and will comply with the RWP prior to initial entry to the area and after any revisions to the RWP." However, multiple instances were identified where several RCTs entered Building 771 controlled areas during calendar year 2000 without acknowledging (by signature or electronic means) that they had read, understood, and would comply with the applicable RWP.

This violation constitutes a Severity Level II problem.
Civil Penalty - \$27,500

- B. 10 CFR 830(c)(2)(i) states that "[w]ork shall be performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate means."

Contrary to the above, work was not performed to established technical standards and administrative controls using approved instructions, procedures, or other appropriate means in that:

1. Manual MAN-071-IWCP, "Integrated Work Control Program," revision 2, dated March 30, 2000, states in section 4.3.6.3 that "Pen and Ink changes SHALL be reviewed and concurred with by the affected organization(s)..."

However, the original Building 771 berm removal work package, Work Control Number #T0102407, was approved on February 25, 2000, and was intended for the removal of 12 uncontaminated berms. The work package was later modified by "pen and ink" changes, on May 17, 2000, to add additional berms including those for room [], and on August 21, 2000, to permit the use of an electric saw and jackhammer for berm removal. These changes were not submitted to all affected organizations for review and concurrence.

2. ALARA Job Review (AJR) 00-771-012 states the only acceptable concrete demolition method for the removal of berms in Building 771 are "...hammer, chisel, hammer drill or any combination of the three."

However, an electric jackhammer was used to facilitate concrete berm

removal in Building 771 but its use was not authorized on the controlling AJR. No revisions were made to the AJR to allow its use, and no approvals from Radiological Engineering were obtained to resolve this conflict with the AJR.

3. Procedure 3-PRO-229-RSP-01.01, "Radiological Work Permit," revision 0, dated March 10, 1998, states in section 3 that "[s]pecific RWPs are written to control work in a radiologically controlled area." Section 2.1 of this procedure requires that it is a RCT's responsibility to terminate work activities if work "...is performed beyond the original scope of work stated on..." the RWP.

However, radiological work within the Building 771, [], containment tent was not always controlled by a specific or applicable RWP or AJR. For example, drum repackaging activities were conducted for several weeks using the RWP originally developed for glovebox removal until the drum repackaging RWP was finally approved on June 14, 2000. Pre-evolution briefing records indicate piping was size-reduced in the room [] tent on September 27, 2000, though the RWP and AJR for that activity was not approved until October 18, 2000. Work activities were not terminated despite the lack of a work scope-specific RWP.

4. Procedure PRO-405-RSP-01.03, "Soft Sided Containment (Plastic House)," revision 2, dated January 20, 2000, states in section 3 that Radiological Engineering will design the containment, and the Job Supervisor will ensure that all prerequisites, assessments, and inspections have been performed.

However, during removal of one of the Building 771, [], berms, the use of an electric saw generated sufficient quantities of contaminated dust such that a nearby continuous air monitor (CAM) would occasionally alarm. The work crew then independently constructed a half-tent to aid in dust control. No pertinent reviews and approvals were performed, and a Radiological Engineer was not involved in the half-tent's design until after the half-tent had been in use and CAM alarms continued to occur.

This violation constitutes a Severity Level II problem.
Civil Penalty - \$27,500

- C. 10 CFR 835.1001(a) states that "[m]easures shall be taken to maintain radiation exposure in controlled areas ALARA through physical design features and administrative control."

Contrary to the above, measures were not taken to maintain radiation exposure in controlled areas ALARA through physical design features and administrative control in that:

1. On September 11, 2000, construction workers breached a contaminated instrument airline as part of a wall removal conducted under a minor

maintenance work package in room []. Hazards associated with the airline removal were not recognized during the work activity and no physical design or administrative radiological controls specific to the breach were utilized (workers were wearing respiratory protection due to other work activities in the room). The line breach resulted in an airborne release of [radioactive material] and the spread of [radioactive material] contamination to the immediate work area.

2. On August 21, 2000, personnel were swapping contaminated hoses between two radiological air movers in preparation for using one of the air movers. The work was conducted in an informal fashion; no procedure was in place to control the activity, and the work had not been formally reviewed nor approved. No formally established and effective physical design or administrative controls appropriate to the work activity were utilized. The activity resulted in an airborne release of [radioactive material], the spread of minor [radioactive material] to the immediate work area, and detectable uptakes of [radioactive material] by four individuals (two resulting in significant doses). None of the individuals received a dose in excess of DOE regulatory limits.

This violation constitutes a Severity Level II problem.

Civil Penalty - \$27,500

V. Quality Improvement

10 CFR 830.120(c)(1)(iii) requires that "[p]rocesses to detect and prevent quality problems shall be established and implemented. Items, services and processes that do not meet established requirements shall be identified, controlled, and corrected according to the importance of the problem and the work affected. Correction shall include identifying the causes of problems and working to prevent recurrence."

Contrary to the above, correction [of items, services and processes] did not include identifying the causes of problems and working to prevent recurrence in that

A. [Nuclear] Safety

KH corrective actions have been ineffective in preventing the recurrence of long-standing and repetitive noncompliances in the area of [nuclear] safety. Specifically, those [nuclear] safety procedural noncompliances described in section I of this PNOV are similar to [nuclear] safety infractions previously reported to DOE in 1996, 1997, and 1998. DOE elected not to pursue enforcement action based on KH's commitment to implement corrective actions. In the 1998 report (NTS-RFO-KHLL-SITELWIDE-1998-0003), KH acknowledged that corrective actions were not adequately comprehensive to prevent the current problems. During 2000 and 2001, numerous additional incidents of [nuclear] safety problems have been identified and reported, thereby demonstrating that prior corrective actions have been ineffective in correcting problems and preventing recurrence. For example, corrective actions taken in response to the

Building 707 [radioactive material] sizing event were limited in scope and did not prevent the occurrence of similar deficiencies during the later TRU waste container loading event.

B. TRU Waste Facility Work Controls

KH corrective actions have been ineffective in preventing the recurrence of work control deficiencies similar to those described in section II of this PNOV. Specifically, Building 440 deficiencies described in section II are similar to those identified during the original 1997 Basis for Operation Operational Readiness Review (ORR). The KH Cause Analysis, dated September 28, 2000, indicates that line management's corrective action process did not adequately address ORR concerns.

C. Procurement

KH corrective actions have been ineffective in preventing the recurrence of long-standing and repetitive noncompliances in the area of Procurement. Specifically, those noncompliances described in section III of this PNOV have been previously identified to KH by DOE through multiple Enforcement Actions (EA-1999-06; EA-2000-01) and an Enforcement Letter (September 11, 2000).

This violation constitutes a Severity Level II problem.
Civil Penalty - \$55,000

Pursuant to the provisions of 10 CFR 820.24, KH is hereby required within 30 days of the date of this Preliminary Notice of Violation and Proposed Imposition of Civil Penalty to submit a written statement or explanation to the Director, Office of Price-Anderson Enforcement, Attention: Office of the Docketing Clerk, P.O. Box 2225, Germantown, MD 20875-2225. Copies should also be sent to the Manager, DOE Rocky Flats Field Office, and to the Cognizant Secretarial Offices at Headquarters for the facilities that are subjects of this notice. This reply should be clearly marked as a "Reply to a Preliminary Notice of Violation" and should include the following for each violation: (1) admission or denial of the alleged violation, (2) any facts set forth that are not correct; and (3) the reasons for the violation if admitted, or the basis for denial if denied. Corrective actions that have been or will be taken to avoid any future violation will be delineated with target and completion dates in DOE's Noncompliance Tracking System. In the event the violations set forth in the Preliminary Notice of Violation are admitted, this Notice will constitute a Final Notice of Violation in compliance with the requirements of 10 CFR 820.25.

Any request for remission or mitigation of civil penalty must be accompanied by a substantive justification demonstrating extenuating circumstances or other reasons why the assessed penalty should not be paid in full. Within the 30 days after the issuance of this Notice, unless the violations are denied, or remission or mitigation is requested, KH shall pay the civil penalty of \$385,000 imposed under section 234a of the Atomic Energy Act of 1954, as amended, by check, draft, or money order payable to the Treasurer of the United States (Account 891099) and mailed to the Director, Office of

Price-Anderson Enforcement, Attention: Office of the Docketing Clerk, at the above address. Should KH fail to answer within the time specified, KH will be issued an Order imposing the civil penalty. In requesting additional mitigation of the proposed civil penalty, KH should address the adjustment factors described in 10 CFR 820, Appendix A, section IX.

R. Keith Christopher

R. Keith Christopher
Director
Office of Price-Anderson Enforcement

Dated at Washington, DC,
this 17th day of July 2001

Enforcement Conference Summary

The Department of Energy's (DOE) Office of Price-Anderson Enforcement (OE) held an Enforcement Conference with Kaiser-Hill Company, L.L.C. (KH), personnel on June 5-6, 2001, in Germantown, Maryland, to discuss the circumstances of the events described in the OE Investigation Summary Report in addition to KH's proposed and implemented corrective actions pertaining to the various events. Mr. Keith Christopher, OE Director, began the conference by explaining this meeting would be an opportunity for KH to make its case for enforcement mitigation. Mr. Christopher further stated that material provided by KH would be incorporated into the docket file.

Mr. Alan Parker, [], in his opening statement said that through schedule pressures personnel had lost focus of the details associated with various work activities. Mr. Parker, though, emphasized that KH's employees can follow procedures. Mr. Parker then gave an overview of the timeline for the various events and corrective actions.

Mr. Kelly Trice, [], spoke about the Building 771 radiation safety program deficiencies. He acknowledged that the continued use of the room [] containment enclosure was allowed by management, but also stated that the necessary approvals were not obtained. Mr. Trice then described the revision of the self-assessment program for Building 771; this program is simpler to use, is now done on a scheduled basis, and assessments will go beyond determining what procedures are in place by also assessing procedure implementation.

Mr. Paul Kreitz, [], provided an overview of the current procurement process at the site and spoke of the previous enforcement actions concerning procurement deficiencies. A discussion ensued between Mr. Kreitz and OE staff regarding procedural noncompliances associated with the expedited purchase of drum lids. Due to time constraints, Mr. Christopher directed this discussion to be continued outside of the conference. Mr. Christopher then adjourned the conference for the day.

The conference resumed the following morning (June 6) with Mr. Marvin Brailsford, [], discussing the [nuclear] safety and authorization basis deficiencies described in the DOE's investigation summary report. Mr. Brailsford then followed this discussion with an overview of the corrective actions taken to date. Mr. David Del Vecchio, [], provided a similar overview and discussion regarding [nuclear] safety and authorization basis deficiencies in Building 707 activities.

Mr. Ken Powers, [], addressed the management assessment deficiencies.

Mr. Lincoln Hall, [], provided his perspective of the events and described the corrective

actions to date as a basis for enforcement mitigation. Mr. Hall further indicated the procurement deficiencies were not as troublesome to KH as they appeared to be to the DOE. Mr. Parker then gave the closing remarks for the KH presentation.

Mr. Christopher stated that KH's presentation and other information would be taken into consideration for the DOE's enforcement deliberations. Mr. Christopher also asked that the procurement issues discussed the day before be concluded within ten days. The conference was then adjourned.

Referenced NTS Numbers

NTS-RFO-KHLL-771OPS-2000-0002,
NTS-RFO-KHLL-771OPS-2000-0003,
NTS-RFO-KHLL-D&DOPS-2000-0001,
NTS-RFO-KHLL-KHILL-2000-0001,
NTS-RFO-KHLL-KHILL-2000-0002,
NTS-RFO-KHLL-PUFAB-2000-0002
NTS-RFO-KHLL-PUFAB-2001-0001,
NTS-RFO-KHLL-REGWSTOPS-2000-0001
NTS-RFO-KHLL-SITEWIDE-2000-0008, and
NTS-RFO-KHLL-SITEWIDE-2001-0002

June 5-6, 2001

Kaiser-Hill Company, L.L.C.

[Nuclear] Safety, Authorization Basis, Procurement,
Building 771 Radiation Safety Program, and Quality Improvement Deficiencies

Enforcement Conference List of Attendees

Office of Price-Anderson Enforcement

R. Keith Christopher, Director
Sharon Hurley, Enforcement Officer
Peter Rodrik, Enforcement Officer
Anthony Weadock, Enforcement Officer
Steven Zobel, Enforcement Officer
Steven Hosford, Technical Consultant

Rocky Flats Field Office

Barbara Mazurowski, Manager
Paul Hartmann, Assistant Manager
Lisa Bressler, PAAA Coordinator

Office of Environmental Management

Henry Himpler, PAAA Coordinator
M. Ellen Chitwood, EM-5
Maria Gavrilas-Guinn, EM-5
Marc Jones, EM-33
W. Alexander Williams, EM-33

Office of Environment, Safety and Health

Bill Weaver, EH-3

Kaiser-Hill Company

Alan Parker, []
Lincoln Hall, []
Frank Casella, []
Steve Crowe, []
Kelly Trice, []
Ken Powers, []
Marvin Brailsford, []
David Del Vecchio, []



Environmental Health Programs Hanford Health Information Network

You are here: [DOH Home](#) » [EH Home](#) » [HHIN](#) » Potential Health Problems from Exposure to Selected Radionuclides

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All [HHIN publications](#) are available.

A PUBLICATION OF THE
Hanford Health
Information Network

Potential Health Problems from Exposure to Selected Radionuclides

Plutonium, Strontium, Cerium and Ruthenium

For more than 40 years, the U. S. government produced plutonium for nuclear weapons at the Hanford Site in south central Washington State. In 1986, responding to citizen pressure, the U.S. Department of Energy made public hundreds of previously restricted documents. Since then, much attention has focused on the very large releases of iodine-131 as a possible cause of thyroid disease. However, Hanford also released other forms of radiation into the air and the Columbia River.

This report examines the releases of four radionuclides to the air and the potential health effects which might result from people being exposed to these materials. The four radionuclides are: plutonium, strontium, cerium and ruthenium. Other radionuclides were released to the Columbia River. A separate HHIN publication addresses the possible health effects of these radionuclides.

According to the Technical Steering Panel of the Hanford Environmental Dose Reconstruction Project, the largest contributors to dose from the air pathway were first, iodine-131, then cerium-144, plutonium-239, ruthenium-103, ruthenium-106, and strontium-90. Dose is the amount of radiation absorbed by a person's body. There were many other radioactive materials released into the air, as well, but these contributed less to dose,

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according to the Technical Steering Panel.

The Hanford Environmental Dose Reconstruction (HEDR) Project was established to estimate what radiation dose people living near Hanford some time between 1944 and 1992 might have received from releases of radioactive materials. The Technical Steering Panel, which directed the study, completed its role in 1995. The federal Centers for Disease Control and Prevention (CDC) is now working with the HEDR Task Completion Working Group to continue public participation and to assure completion of the remaining HEDR activities. When using information from this and other studies, readers should keep in mind that research results depend on a number of factors, such as the information available, and the methods and type of analysis used.

What are the possible health problems from exposure to plutonium, strontium, cerium and ruthenium? Most of the information on health effects from these materials has come from studies of plutonium workers and research involving animals. None of these studies contains information that relates to the specific situation of those people who lived downwind from Hanford. While comparisons to the Hanford situation are uncertain, the information in this report may help identify potential health problems which may have been caused or could be caused by exposure to these radionuclides.

Radiation health scientists generally believe that any dose of radiation, however small, carries with it an increased risk of some adverse health effect, such as cancer. This does not mean that everyone who receives an exposure will suffer an effect. It means the risk of a radiation-induced health problem is increased. Even if a particular effect does occur in an individual, it is not possible to determine, with current scientific methods, that it was caused by radiation exposure.

History of Hanford's Hot Particles

Unlike iodine-131 - which was released as a gas - plutonium, strontium, cerium and ruthenium became attached to particles of rust or dust and were then released. There were two time periods in Hanford's operation when there were major releases of radioactive particles:

- From late 1944 through at least 1951, there were large releases of particles containing plutonium, strontium and cerium.

From 1952 to 1954, there were large releases of particles containing ruthenium.

Plutonium, Cerium and Strontium

Starting in 1944, Hanford produced plutonium for use in nuclear weapons. Uranium fuel was partially transformed into plutonium inside the nuclear reactors along the Columbia River. The irradiation of uranium not only created plutonium but also created numerous other radioactive elements, including the radionuclides of cerium, strontium and ruthenium, which are the subject of this report. After irradiation, the uranium fuel (now containing plutonium and the other radionuclides) was transported several miles to the separations plants at the center of the Hanford Site. It was here that the fuel was dissolved in nitric acid. After numerous chemical steps, the plutonium was separated from the fuel and purified for use in nuclear weapons.

The process of separating the plutonium released pollution to the air and the ground. This report focuses on the potential health effects from exposure to those radionuclides that were released to the air on particles. These particles are called "hot" because they were radioactive.

Plutonium, cerium and strontium were released to the air from the original plutonium separations plants from late 1944 through at least 1951. In the fall of 1947, monitoring equipment revealed radioactive particles on the ground surrounding the stacks of the plutonium plants. The ventilation system in the radioactive processing area was the source of the problem. The interior of the plants' ventilation system had started to rust in places. Plutonium and the other radioactive materials attached to the rust. Later, parts of the contaminated rust broke off and went up and out the stacks. The sections inside the plants in which the operators worked had a separate ventilation system that was not affected by the particle problem.

The particles contained plutonium, cerium and strontium. Other radioactive materials were also present in at least some samples of the particles but in lower concentrations. Most of the particle was rust or other non-radioactive material.

In January 1948, Hanford replaced the ventilation system. The number of relatively large particles decreased, but smaller particles continued to escape. Hanford scientists believed that the smaller particles had been released from the start of plutonium separations in December 1944. In March 1948, Hanford documents reported the release of as many as 100 million particles per month.

Because of their size and weight, many of the particles landed on the ground within the Hanford Site boundaries. However, Hanford technicians detected some particles as far away as Mullan Pass (now known as Lookout Pass) in Idaho; and Spokane and Mt. Rainier in Washington. The concentrations of the particles at these locations were "comparable" to those in Richland (Richland is located about 25 miles southeast of the separations plants).¹

Hanford officials were concerned about possible health effects on workers from hot particles. They considered lung cancer (from the inhalation of particles) to be the most serious health threat.

Hanford radiation protection officials imposed several work restrictions and ordered that some workers be given filter masks. However, most workers, including construction workers and security guards, were not issued filter masks. Hanford officials considered the plutonium particle problem so serious in October 1948 that they stopped separating plutonium for at least three days.²

It is uncertain how long the problem with the plutonium particles continued. According to a U.S. Senate report, the last reference to the problem was at a meeting in 1951. Herbert M. Parker, Hanford's chief health physicist, said at the meeting: "The particle problem still remains, in my opinion, a very serious health problem."³

Ruthenium

After World War II, a new type of chemical process was developed to recover plutonium for use in nuclear weapons. An unintended effect of this process was that flakes of material, including ruthenium, accumulated on the inside lining of the stack at Hanford's Redox plant. "Redox" stood for "reduction-oxidation" and described the kind of chemistry used to separate the plutonium. As in the case of plutonium particles, the ruthenium built up within the process ventilation system, which was separate from the building ventilation system.

The Redox plant began operations in 1952. Shortly afterward, technicians discovered the ruthenium particle problem. Material containing ruthenium had deposited on the inside of the stack. As the material built up on the stack lining, some of it broke off in the form of flakes and was carried up and out the stack. Radiation surveys found very large flakes, some several inches across, on the ground

around the base of the stack.

The largest reported release was in January 1954 when about 200 curies of ruthenium were released. Hanford radiation technicians tracked the particles as far as Spokane, Washington, about 150 miles to the northeast. In April 1954, airborne radiation equipment tracked the particles as far as northeastern Montana.

Inhaling ruthenium particles posed a health danger. In addition, the ruthenium particles posed a hazard if any of the large particles had fallen onto a person's exposed skin.

Hanford Assessment Not Yet Completed

Since the release of the first 19,000 pages of Hanford historical documents in 1986, much has been learned. However, it is not enough to form a complete assessment of the impact of the Hanford releases. This is especially true in the matter of Hanford's particle problems. For example, the HEDR Project has not yet estimated doses from the hot particle releases.

Possible Health Problems of Plutonium, Strontium, Cerium and Ruthenium

Keep the following points in mind when reading the sections on the possible health problems of the selected radionuclides:

- Researchers have done a few studies involving human exposure to plutonium, as well as several animal studies. For cerium, ruthenium and strontium, the only data available are from animal studies.
- Comparing the health effects on animals and on people exposed to radiation from Hanford is problematic for three main reasons:
 1. The life span of human beings is much longer than that of the animals used in studies.
 2. It is uncertain if humans are affected in the same way as animals.
 3. Most of the animal studies involved exposure to very high levels of radiation (equivalent to a human exposure of thousands of rem). Hanford exposed people to generally lower levels of radiation but over a long time.

This report provides information about each of the four radionuclides. The same categories of information are presented for each:

- the possible health effects
- a general description of the radionuclide
- the estimated amount released from Hanford from 1944 to 1972

The dose estimates are cumulative for 1944-1992, whole body in rem EDE (effective dose equivalent). The release estimates are cumulative for 1944-1972. These numbers are taken from the Hanford Environmental Dose Reconstruction draft reports released in April 1994. Both the release and dose estimates for the four radionuclides are not complete because: (1) the Hanford Environmental Dose

Reconstruction Project has not yet reconstructed the amount of the four radionuclides released on particles; (2) the computer model used in the study did not simulate the behavior of particles; and (3) the Dose Reconstruction Project has not yet estimated doses from the hot particle releases. This work is now underway. The federal Centers for Disease Control and Prevention (CDC) is now working with the HEDR Task Completion Working Group to continue public participation and to assure completion of the remaining HEDR activities.

its chemical form as released from Hanford's weapons plants

The chemical form of the radionuclide is very important in assessing how the body might handle the material. The chemical form may significantly affect the dose a person receives from incorporating the material into the body. One aspect of the chemical form is whether it is soluble or insoluble. The Hanford Environmental Dose Reconstruction Project assumed that plutonium and cerium were released in soluble forms.

the range of representative doses

The dose estimates are cumulative for 1944-1992, whole body in rem EDE (effective dose equivalent).

a summary of health studies

Plutonium

Possible Health Effects: Bone, liver and lung cancer; leukemia; chromosome aberrations

Description: The isotope of plutonium for which the Dose Reconstruction Project is calculating dose estimates is plutonium-239.

Estimated Amount Released from Hanford: 1.78 curies

Chemical Form of Release: Assumed to be soluble⁴

Range of Representative Dose Estimates: 0.03 mrem EDE to 3.6 mrem EDE

Summary of Scientific Studies

PLUTONIUM:

Cancer

Studies of plutonium workers and many animal studies have focused on exposure to insoluble forms of plutonium. The Hanford Environmental Dose Reconstruction Project assumed that the plutonium released to the air was in a soluble form. The potential health problems of soluble and insoluble plutonium are described below.

When plutonium is inhaled in an insoluble form, most of it that is retained in the body remains in the respiratory tract. In this kind of exposure, cancers of the lung are possible. Plutonium workers are usually exposed to the insoluble forms of plutonium. Studies of these workers have not found an increased risk for lung cancer that is related specifically to plutonium exposure.⁵ In animal studies, nearly all animals that were exposed to high doses of insoluble plutonium died either of extensive lung damage or lung cancer.

Most insoluble plutonium particles that are inhaled are removed from the body within a few days. Some particles are removed via the lymph nodes. Some of these particles may remain in the lymph nodes for years. In animal studies, high exposure caused the lymph nodes to stop functioning properly. Dr. H. Metivier with the Experimental Toxicology Laboratory in Montrouge, France, has suggested that plutonium could weaken the immune system in humans and lead to the development of cancers outside of the lymph nodes.⁶

In 1987, a study of Rocky Flats workers by Dr. Gregg S. Wilkinson (then at the Los Alamos National Laboratory) and others concluded that workers who had plutonium inside their bodies had an increased risk of lymphopoietic neoplasms (tumors affecting a kind of white blood cells).⁷ A report by the Committee on the Biological Effects of Ionizing Radiations of the National Research Council (BEIR IV) was skeptical about this finding because the Rocky Flats study did not show any increases in lung, bone or liver cancers.⁸

Plutonium in a soluble form acts differently in the body than the insoluble form. Instead of remaining in the lungs and the lymph nodes, as the insoluble form does, soluble plutonium enters the blood relatively quickly and deposits on bone surfaces and in the liver. About 40 percent of the plutonium that enters the blood goes to bone surfaces, 40 percent to the liver and the remaining 20 percent to muscle.⁹ If a person is exposed to soluble plutonium, cancers of the bone and liver are possible, with the likelihood dependent on the dose.

Some scientists stress the need for additional studies on humans because of the long time lapse between exposure and when cancers are diagnosed. This period is called the latency period. For plutonium, the latency period is estimated to be more than 30 years, but may vary depending on the dose received.¹⁰

PLUTONIUM:

Leukemia

There are conflicting opinions in two studies regarding plutonium exposure and the risk of leukemia. Leukemia is a cancer of the blood and begins in the blood cells formed within the bone. Metivier stated at a symposium presented by the French Society of Biophysics and Nuclear Medicine in 1982 that there is a possibility of leukemia if the bone marrow is exposed to plutonium.¹¹ However, the 1988 BEIR IV report stated there is no evidence that plutonium can cause leukemia.¹² In humans, relatively little plutonium is found in the bone marrow, and the dose to this tissue is quite small compared to the dose to the bone surfaces. The risk of leukemia from exposure to plutonium is likely to be far less than the risk of bone cancer.

PLUTONIUM:

Chromosome Aberrations

E. Janet Tawn and her colleagues in the Medical Department at British Nuclear Fuels, Sellafield,

Handwritten notes:
-> differences in metabolism
- differences in transport
- stored in form
- 2 differences in susceptibility
- to ionizing radiation
- compare with other exposure
- with other studies
- minimum dose

England, did a study of the chromosomes of 54 plutonium workers who were exposed to plutonium mainly by inhalation. Each plutonium worker had a higher number of chromosome aberrations compared with workers not exposed to plutonium. The scientists concluded that the exposure to plutonium increased the number of aberrations.¹³

Strontium

Possible Health Effects: Leukemia, bone cancer, weakened immune system

Description: The isotope of strontium for which the Dose Reconstruction Project is calculating dose estimates is strontium-90. In the body, strontium is chemically similar to calcium. Therefore, the body is likely to use strontium in the same way it would use calcium.

Estimated Amount Released from Hanford: 64.3 curies

Chemical Form of Release: unknown

Range of Representative Dose Estimates: 0.0007 mrem EDE to 0.07 mrem EDE

Summary of Scientific Studies

STRONTIUM

Leukemia

Strontium may cause leukemia.¹⁴ More than 90 percent of the strontium that remains in the body is in the bones.¹⁵

According to M. Thomasset, MD, Director of Research at the National Center of Scientific Research, National Institute for Health and Medical Research, Le Vesinet, France, "continuous low doses" of strontium cause relatively more cases of leukemia than high, one-time doses.¹⁶

STRONTIUM

Cancer

Because strontium deposits in the bones, bone cancer is also a possible health effect. Animal studies have shown that high doses of strontium produce a relatively large number of bone cancers. At lower levels of exposure, there are very few cases or none. A Utah study conducted on beagles did not find bone cancers at low doses.¹⁷

STRONTIUM

Immune System

Thomasset reported that continuous low doses of strontium weakened the immune system for up to one year after the exposure.¹⁸

Cerium

Possible Health Effects: Leukemia; and bone, liver, and nasal cavity cancers

Description: The isotope of cerium for which the Dose Reconstruction Project is calculating dose estimates is cerium-144.

Estimated Amount Released from Hanford: 3,770 curies

Chemical Form of Release: Assumed to be soluble¹⁹

Range of Representative Dose Estimates: 0.05 mrem EDE to 5.4 mrem EDE

Summary of Scientific Studies

CERIUM

Cancer

All of the information on cerium's health effects comes from animal studies. Cerium concentrates in the bone marrow. Because of this, the risk of leukemia is the predominant potential health problem.

When insoluble cerium is inhaled, it remains in the lung. When soluble forms are inhaled, cerium moves into the bones and liver. Bone and liver cancers, as well as liver damage, are possible. The National Council on Radiation Protection has stated that cancers of the nasal cavity are also possible.²⁰

Ruthenium

Possible Health Effects: Cancer, skin burns

Description: There are two isotopes of ruthenium for which the Dose Reconstruction Project is calculating dose estimates: ruthenium-103 and ruthenium-106.

Estimated Amount Released from Hanford:

ruthenium-103: 1,160 curies

ruthenium-106: 388 curies

Chemical Form of Release: unknown

Range of Representative Dose Estimates: 0.009 mrem EDE to 0.89 mrem EDE

Summary of Scientific Studies

RUTHENIUM

Cancer

Very little information is available on the potential for ruthenium to induce cancers. One study that considered the possible health effects from ruthenium did not distinguish between ruthenium-103 and ruthenium-106. In animals exposed to ruthenium, cancers did develop. However, a report on the study by R. Masse, a veterinarian and Chief of the Experimental Toxicology Laboratory in Montrouge, France, did not specify where in the body the cancers developed.²¹

RUTHENIUM

Skin Burns

Ruthenium particles released from Hanford posed a hazard if any of the particles had fallen onto a person's exposed skin. This could have caused skin burns.

downwinder perspective

Many callers to the Hanford Health Information Lines have questions and concerns about the release of plutonium and other radioactive materials from Hanford. Some downwinders have health problems and believe that they are, or might be, related to Hanford. The following personal perspective is offered to help readers understand these experiences and concerns.

"My father worked at Hanford as an ironworker/rigger, heavy equipment operator and supervisor from 1947 until his death from lung cancer in 1985. He was 60 years old when he died. Thirty-four of his years at Hanford were spent in the 200 Areas (where the plutonium was processed and separated). He and his crew buried contaminated dry waste such as lab equipment or, in some cases, even trucks and cranes in the ground. He helped to construct the tank farms and was involved in the transfer of liquid wastes to the underground tanks.

"Dad was aware of the problems with the stacks and release of plutonium particles onto the ground and he worried because his crew was there.

"Years later, in 1974, dad discovered that the Hanford doctors had for four years withheld evidence that he had scarring in his lungs. During his annual medical checkup, a new doctor mentioned that the scarring in his lungs was getting worse. He asked the doctor, 'What scarring?' Being concerned about getting proper medical care, dad went to Seattle for another exam. After a thorough work-up at the Virginia Mason Clinic, he was diagnosed with 'silicosis, caused by particles in the lungs.' His condition continued to deteriorate, eventually becoming lung cancer.

"I can't help but wonder, what were those particles? Were they 'hot particles' released from the stacks at Hanford decades earlier? Were they just sand? And why did the Hanford doctors, year after year for four years, withhold my dad's medical condition from him?"

This perspective was contributed by a woman whose father worked at Hanford. She was born in 1948 in Richland and lived there until 1966. She recalls that much of her family's milk and vegetables came from her uncle's farm in Kennewick. Name withheld by request.

Unresolved Issues Concerning Hanford's Hot Particles

During the preparation of this report, the technical reviewers raised several important points that should be included.

Karl Z. Morgan, Ph.D., expressed great skepticism with the estimate for the amount of plutonium released from Hanford. The current estimate from the Hanford Environmental Dose Reconstruction Project is 1.78 curies of plutonium released to the air. Based upon his experience at the Oak Ridge (Tennessee) nuclear weapons facility and his knowledge of Hanford processes, Morgan believes that the current estimate is "a gross underestimate." Morgan is regarded by many as the father of health physics and was chief of radiation protection at Oak Ridge. He was chairman of the Internal Dose Committees of both the International Commission on Radiological Protection (ICRP) and the National Committee for Radiation Protection (NCRP) from 1949 to 1971. These committees set the maximum permissible radiation exposure limits on the international and national level, respectively.

Professor **Ronald L. Kathren** felt it was important to state that, given the current low radiation dose estimates from the selected radionuclides, it is "extremely unlikely" that there will be any measurable health problems among those exposed to Hanford's radiation releases. "Measurable health problem" means an effect that could be determined by an epidemiological study as being related to exposure from Hanford's radiation. Kathren is the director of the United States Transuranium and Uranium Registries and a professor at Washington State University.

Tim Connor stated that the assumption by the Hanford Environmental Dose Reconstruction Project that all of the plutonium released by Hanford to the air was in a soluble form is tenuous at best. Connor is concerned that even if the plutonium separated at Hanford was initially dissolved by nitric acid, further steps in the separation process would have resulted in transforming at least some of the soluble plutonium to an insoluble form. Thus, a considerable fraction of plutonium escaping to the atmosphere may have been in an insoluble form. Connor is a researcher with the Energy Research Foundation in South Carolina and was a staff member of the Hanford Education Action League (HEAL) for several years.

Summary

While comparisons to specific individuals are often uncertain, the information in this report may help identify potential health problems from exposure to Hanford's releases of plutonium, cerium, strontium and ruthenium. An important point to recall is that the estimates of the amounts released and the doses received are not yet complete.

The Technical Steering Panel completed its role in 1995. The federal Centers for Disease Control and Prevention (CDC) is now working with the HEDR Task Completion Working Group to continue public participation and to assure completion of the remaining HEDR activities.

References for the History of Hanford's Hot Particles

Stohr, Joe. Memo to the Technical Steering Panel and the Centers for Disease Control: "Preliminary Review of Documents Describing Hanford Particulate Releases, 1944-1954." December 26, 1990.

Thomas, Jim. Hanford Education Action League (HEAL) Memo to the Technical Steering Panel:

"Request for Independent Calculations on the Active Particle Problem." April 20, 1992.

Till, John, Ph.D., and Charles Miller, Ph.D. Memo to the Technical Steering Panel: "Active Particle Problem at Hanford." Undated.

U.S. Senate, Majority Staff of the Committee on Governmental Affairs. "Early Health Problems of the U.S. Nuclear Weapons Industry and Their Implications for Today." December 1989.

NOTES

1 - HW-11348. "Action Taken with Respect to Apparent Enhanced Active Particle Hazard." H.M. Parker. October 25, 1948; p.2.

2 - HW-11348, p.2.

3 - "Early Health Problems of the U.S. Nuclear Weapons Industry and Their Implications for Today." Report of the Majority Staff of the Committee on Governmental Affairs, U.S. Senate, December 1989; p. 9 - Referring to meeting notes from the Advisory Committee for Biology and Medicine, Jan. 12, 1951.

4 - Telephone conversation with Bruce Napier, June 13, 1994. Napier is a scientist with Battelle Pacific Northwest Laboratory and worked extensively on the Hanford Environmental Dose Reconstruction Project.

5 - There have been human plutonium studies by several groups of researchers. Three of these are: George L. Voelz, Occupational Medicine Group, Los Alamos National Laboratory, et al. who studied 26 Manhattan Project workers at Los Alamos with 37-year follow-up after exposure (Voelz 1985); J. F. Acquavella et al. who also considered Los Alamos workers (Acquavella 1983); and Gregg S. Wilkinson et al. who studied Rocky Flats workers (Wilkinson 1987).

6 - H. Metivier in *Radionuclide Metabolism and Toxicity*; Galle, P. and R. Masse (eds.); Paris: Masson, 1982; p. 184. The book is a compilation of papers presented at a 1982 symposium that was organized by the French Society of Biophysics and Nuclear Medicine and the University of Paris.

7 - Gregg Wilkinson, Ph.D. "Mortality Among Plutonium and Other Radiation Workers at a Plutonium Weapons Facility." *American Journal of Epidemiology*. 1987; p. 231-250.

8 - Committee on the Biological Effects of Ionizing Radiations (BEIR IV); *Health Risks of Radon and Other Internally Deposited Alpha-Emitters*; Washington, DC: National Academy Press, 1988; p. 328.

9 - Telephone conversation with Prof. Ronald Kathren, U.S. Uranium and Transuranium Registries, July 22, 1994.

10 - George L. Voelz, MD. "Health Considerations for Workers Exposed to Plutonium." *Occupational Medicine: State of the Art Reviews*. Oct-Dec 1991; p. 694.

11 - H. Metivier in Galle and Masse, p. 193.

12 - BEIR IV, p. 325.

13 - Tawn, E.J. et al. "Chromosome Studies in Plutonium Workers." *International Journal on Radiation Biology and Related Studies in Physics, Chemistry and Medicine*, May 1985; p. 599-610.

14 - M.C. Thorne and J. Vennart; "The Toxicity of Sr-90, Ra-226 and Pu-239." *Nature*; October 14, 1976; p. 555-8. Thorne is with the Radiobiology Unit in Hardwell, England.

15 - M. Thomasset. "Strontium: Metabolism and Toxicity of Strontium" in Galle and Masse, p. 104.

16 - M. Thomasset in Galle and Masse, p. 111.

17 - National Committee on Radiation Protection (NCRP) No. 110; *Some Aspects of Strontium Radiobiology*; 1991; p. 32.

18 - M. Thomasset. "Strontium: Metabolism and Toxicity of Strontium" in Galle and Masse, p. 110.

19 - Telephone conversation with Bruce Napier, June 13, 1994.

20 - National Committee on Radiation Protection (NCRP) No. 60; *Physical, Chemical, and Biological Properties of Radiocerium Relevant to Radiation Protection Guidelines*; 1978; p. 55.

21 - R. Masse, "Ruthenium and Activated Metals" in Galle and Masse, p. 131-142.

References for Selected Radionuclides

Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Plutonium*, TP-90-21. December 1990.

Galle, P. and R. Masse, eds. *Radionuclide, Metabolism and Toxicity*. Paris: Masson, 1982.

NCRP Report No. 60. *Physical, Chemical, and Biological Properties of Radiocerium Relevant to Radiation Protection Guidelines*. Washington, DC: National Council on Radiation Protection and Measurements, 1978.

NCRP Report No. 110. *Some Aspects of Strontium Radiobiology*. Bethesda, MD: National Council on Radiation Protection and Measurements, 1991.

Published Fall 1994

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BUILDING 771 HISTORICAL WORKPLACE
SURVEY

DOCUMENT 1
MTS-193-94
Page 1 of 1

Name: _____ Date: _____

Org: _____ Director: _____

Bldg: _____ Job Title: _____

Plant Extension/Digital Page: _____

Supervisor/Manager: _____ Supervisor/Manager
Ext/DP: _____

1. Were you hired at Rocky Flats prior to 1968? If not, when?
2. Did you have a routine work assignment in Building 771 prior to 1968? If so, what was your specific work assignment in Building 771 and where in Building 771 was your work routinely performed? (be as specific as you can)
3. Were you a chemical process operator or assigned to chemical processing jobs in Building 771 prior to 1968? If so, what lines, rooms, or processes were you assigned to?
4. Were there other buildings in which you worked prior to 1968 where you were also exposed to neutrons?
5. Have you worked at another nuclear facility where you may have been exposed to neutrons?
6. Please list any additional questions or concerns which you would like answered (use back of page if necessary).

Signature

Date

We appreciate your assistance in completing this questionnaire. The questionnaire will be used for completion of a dose reconstruction and to update your radiation exposure records.

PLEASE RETURN COMPLETED FORM TO M. R. PROCHOWNIK, BLDG 123

SYNOPSIS OF NEUTRON DOSE ISSUE

In August of 1992, the Health Effects Department of EG&G Rocky Flats, Inc., received funding from the Department of Energy to medically monitor the health of former radiation workers and to re-evaluate doses to workers from plutonium and other ionizing radiation exposures at the Rocky Flats Plant primarily in building 771. The re-evaluation of doses in former workers is presently underway and a status report on this project was given on May 18, 1994. The status report included the following preliminary conclusions:

- The radiation workers most exposed to neutrons in the early 1950's (until July 1958) were not monitored for neutron doses.
- Neutron doses were poorly evaluated from neutron film until 1967.

These conclusions also indicate that the accuracy and completeness of historical neutron data prior to 1968 is in question. This could have the effect of underestimating the neutron doses reported for workers during this time period. Several neutron film from the late 1950s to the early 1960s have been re-read and many doses reported as zero (0) actually should have been reported higher than zero. Other film which were evaluated that had indicated a non zero exposure actually read zero.

Since only a small portion of the film was reviewed there is little indication of the magnitude of the problem until the previous personnel neutron dose for these individuals can be re-evaluated. However, it must be noted that the risk received by these employees from this radiation exposure has already been incurred by these employees and through administrative controls, further occupational radiation risk can be limited.

An initial personnel record search was performed to identify present active employees who had worked at Rocky Flats prior to 1968. The search indicated that there are approximately 138 individuals who meet this criteria. A preliminary review of the individual work locations and exposure history was also performed. Of the 138 employees 80 have been identified as workers who had worked in building 771 prior to 1968.

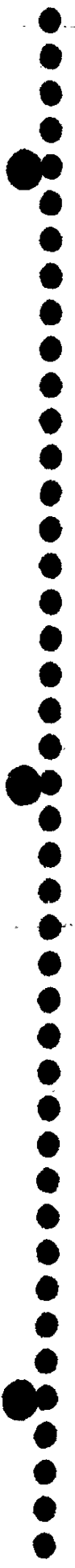
For the 138 individuals identified who worked at Rocky Flats prior to 1968 a neutron dose was estimated using a neutron to gamma ratio. A neutron to gamma ratio was determined by reviewing the neutron and gamma doses for the different processes in building 771. From the neutron and gamma doses a 2 to 1 neutron to gamma ratio was determined. Using the neutron to gamma ratio, neutron doses were estimated using each individuals gamma dose for each year of employment prior to 1968. The estimated neutron doses were then added to the individuals lifetime dose and an estimated total lifetime dose was created. Until dose reconstructions can be completed, this estimated lifetime dose will be used to determine N rem work limitations.

Prior to the DOE Order N5480.6, Radiological Control Manual, no legal or regulatory requirement existed to control an employee's total lifetime occupational radiation dose. Section 212 of the Radiological Control Manual requires administrative control of a worker's lifetime occupation dose to a total exposure equal to that worker's age in years (N rem). In addition, Section 216 requires that special control levels be established for those personnel who have doses exceeding their age in years. These requirements are scheduled for implementation by January 1996, pursuant to the EG&G Radiological Control Manual Implementation Plan.

However, due to this recently identified neutron dose concern, early implementation of the lifetime control level and the special control level requirements as outlined in the Radiological Control Manual will be implemented soon. This will control future exposures to all effected individuals until the re-evaluation of the film and/or a dose reconstruction can be completed for each individual. This action would also include approximately 60 additional active employees due to current internal dose exceeding the Radiological Control Manual lifetime control level. Special control levels will be established in accordance with the Radiological Control Manual based upon the appropriate controls determined from these evaluations.

The special control level will be applied to all employees whose dose is above the N rem control level. These employees will have an administrative control level of 100 mrem per year additional exposure (internal + external). This control level will stay in effect until the employee falls below their N rem level at which time the employee will be limited to the current plant Administrative Dose Guideline.

Sources of Information
Acronyms



SOURCES OF INFORMATION

Defense Nuclear Facilities Safety Board, *Report on Radiation Protection Review at the Rocky Flats Plant*, December 1, 1993.

Foster, P.P. 1991. "Study of plutonium oxide fuel inhalation case." *Radiation Protection Dosimetry* 38 (1-3): 141-146.

Investigation Team Report: Investigating the source of potential internal radiological exposures involving eleven personnel in Building 771, Rocky Flats Environmental Technology Site, March 15, 2001.

Newman, Lee; Mroz, Margaret; Ruttenber, James, *Lung Fibrosis in Plutonium Workers*, May 31, 2002.

Office of Enforcement and Investigation, U.S. DOE, Consent Order, April 14, 1998.

PNNL-MA-860, Chapter 8.0: 8.13, Jan. 31, 2003.

Potential Health Problems from Exposure to Selected Radionuclides, Hanford Health Information Network, May 2000.

Preliminary Notice of Violation and Proposed Imposition of Civil Penalty, Office of Price Anderson Enforcement, July 17, 2001.

Roth, Herrick S. 1989. *Local 8031: Its Struggles and Its Victories*. A.B Hirschfield Press, Denver, CO.

Sullivan, M.T. *Lifetime Dose Limitation and Neutron Dose Reconstruction*, Letter, July 26, 1994.

Tontodonato, R.E., *Trip to Review Feed Characterization for RFP Building 707 Thermal Stabilization Process*, Jan. 20, 1994, Letter, February 8, 1994.

Toxicological Profile for Plutonium, Agency for Toxic Substances and Disease Registry, TP-90-21, December 1990.

Voelz, George, "Health Considerations for Workers Exposed to Plutonium," *Occupational Medicine: State of the Art Reviews*. October-December 1991, pp. 694.

Wilkinson, Gregg, "Mortality Among Plutonium and Other Radiation Workers at a Plutonium Weapons Facility," *American Journal of Epidemiology*, 1987, pp. 231-250.

Worker Testimony included as additional response to SEC Section F: Cindy Schubert, Leonard Homan, Gary Burbach, William Jordan, Don Williams, Howard Long, Harry Charles Wolf, Robert Carlson.

ACRONYMS AND ABBREVIATIONS

AMAD - Activity Median Aerodynamic Diameter

CEDE - Cumulative Effective Dose Equivalent

DAC - Derived Air Concentration

D&D - Deactivation and Decommissioning

DNFSB - Defense Nuclear Facility Safety Board

DOE - Department of Energy

EEOICPA - Energy Employees Occupational Illnesses Compensation Program Act

Ge - Germanium

ICRP - International Commission on Radiological Protection

NIOSH - National Institute of Occupational Safety and Health

NDT - Nondestructive Testing

NTA - Nuclear Track Emulsion Type A films

Pu - Plutonium

FUSPS - Plutonium Stabilization and Packaging System

RadCon - Radiation Control Manual

RFETS - Rocky Flats Environmental Technology Site

RV - Reaction vessel

SAAM - Selective Alpha Air Monitor

SEC - Special Exposure Cohort

SS&C - Sand, slag and crucible

TLD - Thermoluminescent dosimeter

TBD - Technical Basis Document

USWA - United Steelworkers of America

The USWA, Local 8031 reserves the right to provide additional information beyond that which is included in this petition and in support of our ability to obtain Special Exposure Cohort designation for the Rocky Flats class of workers.



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RIR No.: 99-485
Originator:
Project: RMRS
Date Entered: 11/2/1999 12:00:00 AM
Event Date: 10/28/1999 12:00:00 AM
Status: CLOSED
Date Closed: 11/18/1999 12:00:00 AM
Building: 771
Location: 146B
Description: Upon completing of the containment construction for HV-1916 a RCT performed a whole body frisk and discovered a liquid spot on the right forearm. Contamination was detected at 40K dpm/100cm². The coveralls were removed and the same liquid and contamination was found on the skin. The employee was immediately taken to the decontamination room for a fifteen minute flush and then transported to the on-site medical facility. Surveys of the affected area were 6K after the fifteen minute rinse. Decontamination was completed at the medical facility.
RS Supervisor: J. Harris
Immediate Corrective Action: Fifteen minute flush and transported the employee to medical for further decontamination.
Primary Event Code: B4
Secondary Event Codes: B5, B15
Apparent Cause: EQUIPMENT
Facility Mgr: J. O'Brien
DOE Categorization: Completed
Occurrence Rpt. No.: 99-0756
Responsible Mgr.: D. Burks
Responsible Dir.: C. Crawford
Target Date: 11/27/1999 12:00:00 AM
Corrective Actions: Employee successfully deconned. A nearby valve was found to be contaminated. It was deconned and contained.
PATS No.:
Comments: RMRS PA Screen No. RMRS-99-997. CEDE <100 mrem confirmed, B15 event code added 2/16/00. (das)

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RIR No.: 99-490
Originator:
Project: RMRS
Date Entered: 11/4/1999 12:00:00 AM
Event Date: 11/2/1999 12:00:00 AM
Status: CLOSED
Date Closed: 11/18/1999 12:00:00 AM
Building: 771
Location: 187
Description: Employee was reaching into B-Box187E and contaminated his left glove and elbow of coveralls. Contamination levels were at 100,000 dpm on glove and coveralls.
RS Supervisor: M. Fitzpatrick
Immediate Corrective Action: Contained and removed contaminated clothing and escorted employee to west SOP. No other contamination was found after full body frisk and survey of area in room 187.
Primary Event Code: B13
Secondary Event Codes:
Apparent Cause: PROCEDURE/TRAINING
Facility Mgr: K. D. Stoval
DOE Categorization: Completed
Occurrence Rpt. No.: 99-0766
Responsible Mgr.: L. Rosenbrock
Responsible Dir.: A Crawford
Target Date: 12/1/1999 12:00:00 AM
Corrective Actions: Nasal smears taken. Fecal samples submitted. Body count. Fact finding meeting determined B-Box was incorrectly posted. RIR 99-493 generated to address B-Box posting.
PATS No.:
Comments: RMRS PA Screen No. RMRS-99-1000

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RIR No.:	99-534
Originator:	
Project:	RMRS
Date Entered:	12/6/1999 12:00:00 AM
Event Date:	12/2/1999 12:00:00 AM
Status:	CLOSED
Date Closed:	1/4/2000 12:00:00 AM
Building:	771
Location:	158
Description:	During routine glove box work, an employee self monitored and discovered 10,000 on his left hand. Contamination surveys of the glove found 10,000 on the thumb area of the anti-cs. Surrounding area surveys were <500 dpm/100cm2 and no other contamination was detected on the employee. PIF calculations were 6.25 and nasal and mouth samples were taken.
RS Supervisor	J. Harris
Immediate Corrective Action:	Removed the employees glove and surveyed the inner liner. Contained the glove box glove.
Primary Event Code:	B13
Secondary Event Codes:	B5
Apparent Cause:	EQUIPMENT
Facility Mgr:	J. J. O'Brien
DOE Categorization:	Not Applicable
Occurrence Rpt. No.:	
Responsible Mgr.:	R. Caulfield
Responsible Dir.:	A. Crawford
Target Date:	1/1/2000 12:00:00 AM
Corrective Actions:	Changed GB glove. Crew continues to inspect and survey GB gloves and continue to wear leather gloves over GB gloves.
PATS No.:	
Comments:	RMRS PA Screen No. RMRS-99-1055

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RIR No.:	99-539
Originator:	
Project:	RMRS
Date Entered:	12/9/1999 12:00:00 AM
Event Date:	12/7/1999 12:00:00 AM
Status:	CLOSED
Date Closed:	1/4/2000 12:00:00 AM
Building:	771
Location:	
Description:	Employee entered CA without TLD and failed to sign in under a RWP. Employee was in the work area for approximately one hour.
RS Supervisor	J. Harris
Immediate Corrective Action:	Locked out the employee from the HIS 20 system. Performed a micro rem survey to support a dose reconstruction.
Primary Event Code:	B3
Secondary Event Codes:	C2
Apparent Cause:	PERSONNEL
Facility Mgr:	K. D. Blake
DOE Categorization:	Completed
Occurrence Rpt. No.:	99-0838
Responsible Mgr.:	R. Caulfield
Responsible Dir.:	A. Crawford
Target Date:	1/6/2000 12:00:00 AM
Corrective Actions:	Although this incident was an individual personal error. The 771 project has instituted a check point Charlie which consists of project personnel just outside the SOP checking to ensure personnel have TLDs.
PATS No.:	
Comments:	RMRS PA Screen No. RMRS-99-1059

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Radiological Improvement Report Details

RIR No.:	00-250
Originator:	
Project:	771
Date Entered:	6/27/2000 12:00:00 AM
Event Date:	6/21/2000 12:00:00 AM
Status:	CLOSED
Date Closed:	8/25/2000 12:00:00 AM
Building:	771
Location:	114
Description:	While doing glove box clean out of line 2 room 114, operator pulled out of the gloves. Surveyed his hand and found 20,000 dpm on the right palm of the anti-c glove. Contained the glove on the operator. Surveyed glovebox side and on the floor < MDA of 12-1A. PIF completed, level II
RS Supervisor	D. Sinner
Immediate Corrective Action:	Contain anti-c glove . Remove operator from the area, completed survey of the area. Glove port contained. Notified RCTTS, CCA, Internal Dosimetry.
Primary Event Code:	B13
Secondary Event Codes:	
Apparent Cause:	EQUIPMENT
Facility Mgr:	A. B. Adams
DOE Categorization:	Not Applicable
Occurrence Rpt. No.:	
Responsible Mgr.:	M. Brown
Responsible Dir.:	K. Trice
Target Date:	7/21/2000 12:00:00 AM
Corrective Actions:	All immedaite actions were appropriate and complete. Changing the glove removed the source of contamination. No further actions required.
PATS No.:	
Comments:	No intake

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Radiological Improvement Report Details

RIR No.:	00-251
Originator:	
Project:	771
Date Entered:	6/27/2000 12:00:00 AM
Event Date:	6/22/2000 12:00:00 AM
Status:	CLOSED
Date Closed:	7/11/2000 12:00:00 AM
Building:	771
Location:	SOP
Description:	After the employee removed anti-cs and proceeded to self monitor hand carried items, identified elevated reading on bump cap. Employee contacted RCT and the RCT confirmed 4,200 dpm/100cm2 alpha on the rear portion of the cap. No other contamination was detected on the employee or other items. In an attempt to locate a source of the contamination, RCT discovered 2,000 dpm on a phone that the employee had used. No other contamination could be found in any other areas that the employee worked.
RS Supervisor	J.Harris
Immediate Corrective Action:	Calculated the PIF @ 2.6 and requested nasal and mouth samples. The telephone was immediately decontaminated. A survey of ear muffs employee had worn earlier and the employee's locker that stores the bump cap in, no contamination found. The activity was confirmed to be PU 239 using Alpha Spectrometry.
Primary Event Code:	B6
Secondary Event Codes:	B15
Apparent Cause:	PERSONNEL
Facility Mgr:	T. R. Hergert
DOE Categorization:	Completed
Occurrence Rpt. No.:	2000-0356
Responsible Mgr.:	M. Brown
Responsible Dir.:	K. Trice
Target Date:	7/22/2000 12:00:00 AM
Corrective Actions:	Area was deconned and all crews were briefed on proper rad practices covering touching areas on their bodies in the CA. This briefing was conducted during Pre Evs.
PATS No.:	
Comments:	CEDE-5 mrem

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Radiological Improvement Report Details

RIR No.: 99-540

Originator:

Project: 771

Date Entered: 12/14/1999 12:00:00 AM

Event Date: 12/13/1999 12:00:00 AM

Status: CLOSED

Date Closed: 11/6/2000 12:00:00 AM

Building: 771

Location: 179

Description: After placing several packages into an approved waste container, the employee self monitored using a combo. The combo identified the possibility of contamination, the RCT confirmed 10k dpm total activity on the anti-c gloves. Nasal and mouth samples were taken because the PIF was calculated at 6.25. The waste packages were resurveyed along with Anti-c gloves worn from the previous day and all surveys were <500 dpm. The source of the initial 10k dpm could not be located.

RS Supervisor: J. Harris

Immediate Corrective Action: Stopped work and verified all boundaries. Contacted Internal Dosimetry.

Primary Event Code: B13

Secondary Event Codes:

Apparent Cause: OTHER/Packaging

Facility Mgr: J. J. O'Brien

DOE Categorization: Not Applicable

Occurrence Rpt. No.:

Responsible Mgr.: G. Bracken

Responsible Dir.: A. Parker

Target Date: 1/12/2000 12:00:00 AM

Corrective Actions: All actions were taken in accordance with approved procedures. Work was stopped pending a complete investigation. No further actions are required.

PATS No.: 2000-000124

Comments: RMRS PA Screen No. RMRS-99-1060 Letter ARL-007-00 sent to Gary Bracken requesting copy of PIF and surveys for closure on 5/26/2000. Copy of PIF submitted, but no survey copies can be produced. Closed without surveys-bjs 11/6/00.

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Radiological Improvement Report Details

RIR No.: 00-031
Originator:
Project: RMRS
Date Entered: 1/24/2000 12:00:00 AM
Event Date: 9/23/1999 12:00:00 AM
Status: CLOSED
Date Closed: 2/2/2000 12:00:00 AM
Building: 771
Location:
Description: Following an entry into a plastic house on 9/23/99, RCT submitted routine nasal swabs. On e swab was slightly above decision level so fecal samples were requested. Initial fecal samples showed an intake did occur but were not supported by other workplace indicators so additional samples were requested. Analysis of all data indicates that an intake of 270 mrem did occur. This brings employee's CY99 exposure to 369 mrem.

RS Supervisor K. Harrawood
Immediate Corrective Action: Employee was restricted from work in radiological area while determining exposure up until Jan 1, 2000 when his allowable exposure was reset. Investigation is complete.
Primary Event Code: A1
Secondary Event Codes:
Apparent Cause: OTHER/ No identified cause
Facility Mgr: A. B. Adams
DOE Categorization: Completed
Occurrence Rpt. No.: 2000-0005
Responsible Mgr.: K. Harrawood
Responsible Dir.: A. C. Crawford
Target Date: 2/23/2000 12:00:00 AM
Corrective Actions: There are no apparent indicators of how this occurred. The entry into the ten and the doffing were iaw all procedures and no abnormal conditions were identified. Corrective actions were completed in the form of a bioassay program for employee. This RIR was filed for training purposes only. RIR 00-031 closed out by referencing Occurrence Report RFO-KHLL-771OPS-0005 per HSP 3.02

PATS No.: 2000-000115
Comments: PA Screen # RMRS-0-1135

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Radiological Improvement Report Details

RIR No.: 00-332

Originator:

Project: 771

Date Entered: 8/23/2000 12:00:00 AM

Event Date: 8/21/2000 12:00:00 AM

Status: CLOSED

Date Closed: 10/12/2000 12:00:00 AM

Building: 771

Location: 180K

Description: While moving a 4" hose from the one INOEX airmover to another one, a CAM alarmed. RCT found 100,000 dpm removable on top of the airmover 1 square foot. Also 3,000 dpm removable on flat surfaces in the room 100 square feet. 1 RCT had 1,500 dpm on left shoulder and back area of the anti-cs. They also found 2,520 dpm under chin 16 square inches. 600 dpm on the chest on the skin 20 square inches. Also 2,160 dpm on the back of his head and 1,800 dpm left side of his head by the ear in his hair. CAM had 4,516 dpm on the filter paper.

RS Supervisor D. Sinner

Immediate Corrective Action: All personnel left the area responding RCT surveyed personnel. Contained the contamination on the one person and exited to the decon room with employee. No contamination on another personnel. Contacted CCA and RCTTS. RCT deconned in the Bldg with mild soap and water. PIF completed on all personnel. Level I nasals were taken.

Primary Event Code: B4

Secondary Event Codes: B5, B7, B11, B13

Apparent Cause:

Facility Mgr: T. R. Hergert

DOE Categorization: Not Applicable

Occurrence Rpt. No.: 2002-0002

Responsible Mgr.: T. Dieter

Responsible Dir.: K. Trice

Target Date: 9/20/2000 12:00:00 AM

Corrective Actions: Completed immediate actions, performed bioassay analysis and conducted project wide training on "scope creep" seminars. Price Anderson materials completed for investigation.

PATS No.: 2000-001269

Comments: Cross reference RIR# 00-412.-bjs

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Radiological Improvement Report Details

RIR No.: 00-397
Originator:
Project: 771
Date Entered: 10/19/2000 12:00:00 AM
Event Date: 10/16/2000 12:00:00 AM
Status: CLOSED
Date Closed: 12/18/2000 12:00:00 AM
Building: 771
Location: 186
Description: During a tour/walkdown, a DOE representative found an out of calibration low volume air sampler connected to an SSC tent in room 186. Air sampler in question is low vol. # HO6027, with a cal due of 9/2/00. Therefore, inadequate air sampling was performed during this time.
RS Supervisor: A. C. Vigil
Immediate Corrective Action: Sampler was tagged out and removed from service, and replaced with a valid in cal sampler. 771 rad manager and CCA notified. An investigation as to what work, when it was done, how long, and who was in the 186 tent at those times was initiated.
Primary Event Code: B1
Secondary Event Codes:
Apparent Cause: PERSONNEL
Facility Mgr: H. Lerum
DOE Categorization: Completed
Occurrence Rpt. No.: 2000-0613
Responsible Mgr.: D. Boone
Responsible Dir.: K. Trice
Target Date: 11/15/2000 12:00:00 AM
Corrective Actions: Interviewed monitors, issued personnel corrective actions, calibration of air samples required, no adjustments, sample results were verified for the time in question.
PATS No.: 2000-001496
Comments:

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Radiological Improvement Report Details

RIR No.:	00-408
Originator:	
Project:	771
Date Entered:	10/26/2000 12:00:00 AM
Event Date:	10/25/2000 12:00:00 AM
Status:	CLOSED
DateClosed:	3/8/2001 12:00:00 AM
Building:	771
Location:	114
Description:	While performing cut out operations of lines 8 & 9, worker became tired and was exiting the tent. While the RCT was doing whole body check out of the D&D worker, it was discovered that the PAPR filter was low and employee had contamination of 2,000 dpm on the face piece of the respirator and 67 dpm on filter.
RS Supervisor	D. Sinner
Immediate Corrective Action:	Stopped job, checked all PAPR filters, PIF completed, notifications made. RIR written. PIF level 1.
Primary Event Code:	B13
Secondary Event Codes:	C4
Apparent Cause:	EQUIPMENT
Facility Mgr:	T. R. Hergert
DOE Categorization:	Completed
Occurrence Rpt. No.:	2000-0636
Responsible Mgr.:	D. Boone
Responsible Dir.:	K. Trice
Target Date:	11/24/2000 12:00:00 AM
Corrective Actions:	PAPR use was investigated across the site. Bioassay sampling was performed. PAPR unit contamination is not unusual in the given work conditions.
PATS No.:	2000-001569
Comments:	

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RIR No.:	00-412
Originator:	
Project:	771
Date Entered:	10/31/2000 12:00:00 AM
Event Date:	10/30/2000 12:00:00 AM
Status:	CLOSED
Date Closed:	12/18/2000 12:00:00 AM
Building:	771
Location:	180K
Description:	Upon receiving sample results from Internal Dosimetry lab, it has been determined that the employee has exceeded the ACL for annual exposure.
RS Supervisor	M. Fitzpatrick
Immediate Corrective Action:	Informed employee of the lab results and started the extension process.
Primary Event Code:	B2
Secondary Event Codes:	
Apparent Cause:	PERSONNEL
Facility Mgr:	H. Lerum
DOE Categorization:	Completed
Occurrence Rpt. No.:	2000-0484
Responsible Mgr.:	D. Boone
Responsible Dir.:	K. Trice
Target Date:	11/30/2000 12:00:00 AM
Corrective Actions:	The uptake is documented on a previous RIR. The extension has been granted. TLD re-instated. There will be no actions of this occurrence.
PATS No.:	
Comments:	Cross reference RIR# 00-332 -bjs

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RIR No.: 00-464
Originator:
Project: 771
Date Entered: 12/1/2000 12:00:00 AM
Event Date: 12/1/2000 12:00:00 AM
Status: CLOSED
Date Closed: 3/8/2001 12:00:00 AM
Building: 771
Location: 149
Description: Employee was supporting removal of electrical items in the overhead in room 149 of building 771 by line #40. Employee's lapel air sample read 7.6 DAC and employee was without respirator protection.
RS Supervisor M. Welling
Immediate Corrective Action: PIF calculated, nasal smears taken, contamination surveys performed in the affected area, air samples taken throughout room 149.
Primary Event Code: B16
Secondary Event Codes:
Apparent Cause: OTHER/No source located
Facility Mgr: T. R. Hergert
DOE Categorization: Not Applicable
Occurrence Rpt. No.:
Responsible Mgr.: D. Boone
Responsible Dir.: K. Trice
Target Date: 12/31/2000 12:00:00 AM
Corrective Actions: PI performed, bioassay submitted for internal disposition. There were no CAM/SAAM alarms. Ongoing investigation to locate source.
PATS No.:
Comments:

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