Accuracy and completeness of historical neutron doses affects:

- Legal Defensibility
- Epidemiological and Health Effects Studies (CDH Cancer Incidence Study, CEDR)
- Radiation Protection based on lifetime doses/Radiation Record Credibility

Approach:

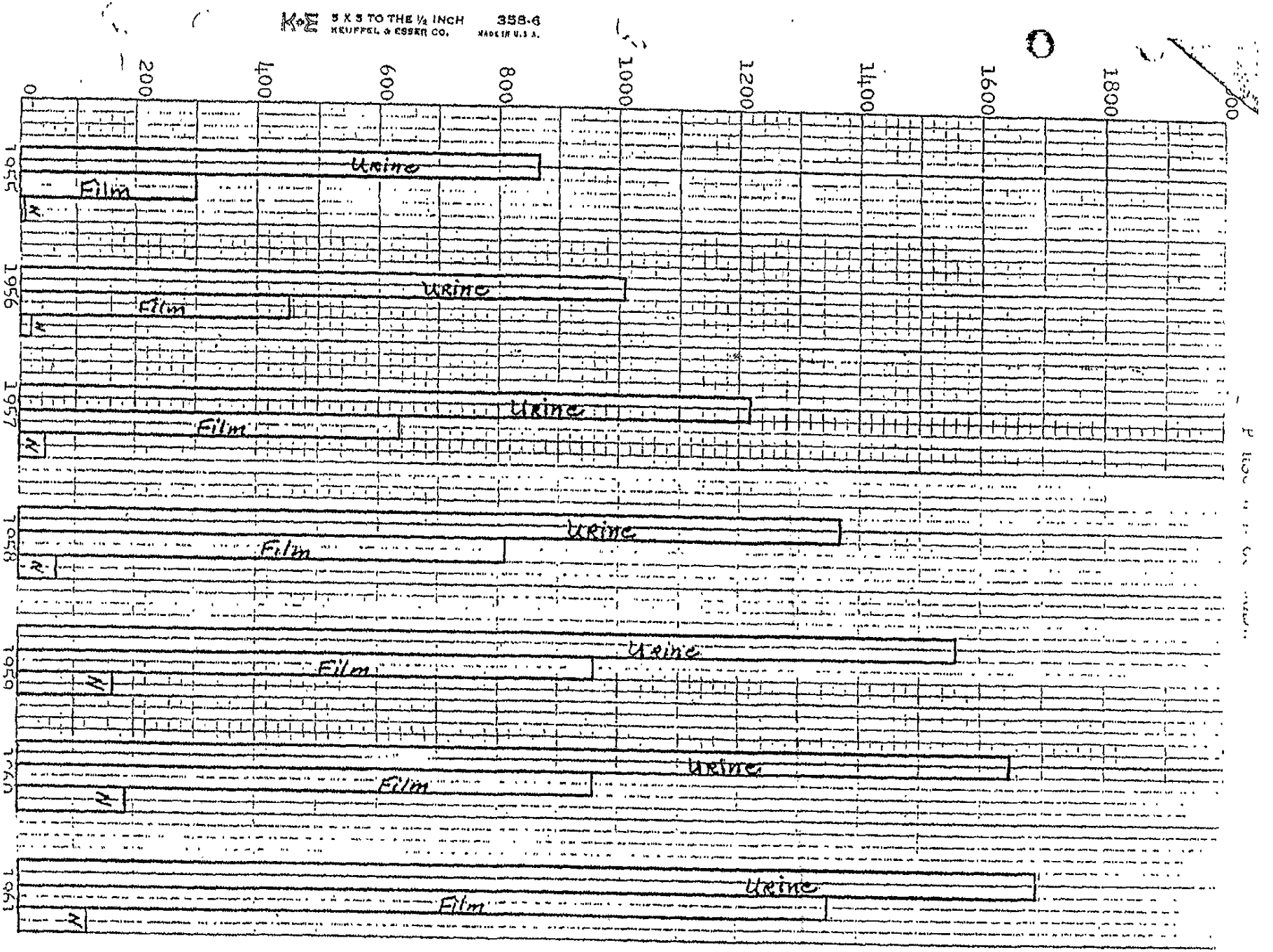
1. Reevaluate neutron doses from old film, 1959 to 1966.

   Retrieve film and worksheets from storage.

   Read selected film microscopically.

   Compare new evaluation with initial evaluation.

2. Review old records to reconstruct the early history of neutron dosimetry at Rocky Flats.


K+E 5 X 5 TO THE ½ INCH 358-6
KEUFFEL & ESSER CO. MADE IN U.S.A.
0
200
400
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1600
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1956
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N
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1961
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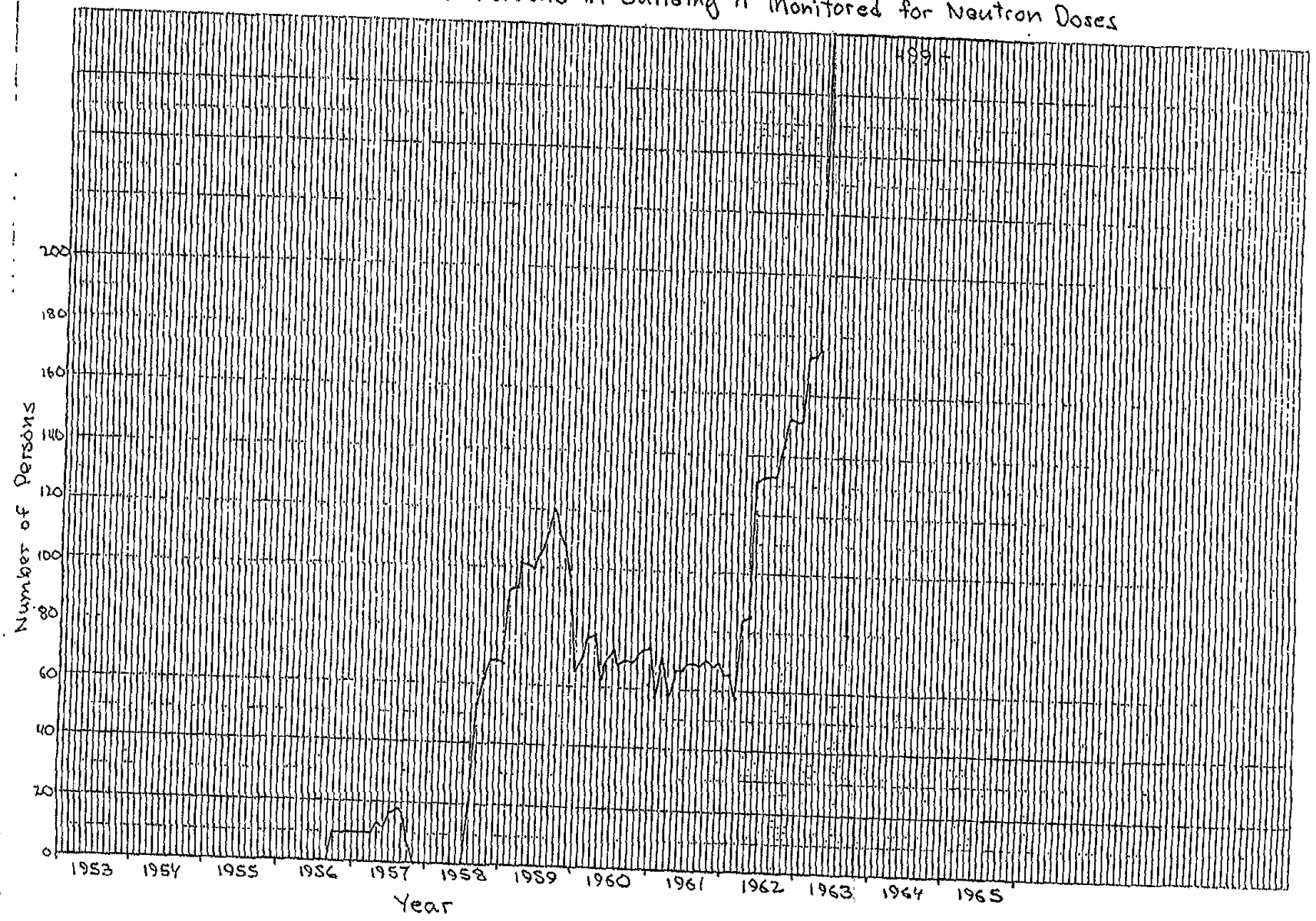
Film
N

Number of Persons in Building 71 Monitored for Neutron Doses



Excerpt from: July Monthly Progress Report, Chemistry Lab. and Personnel Meters

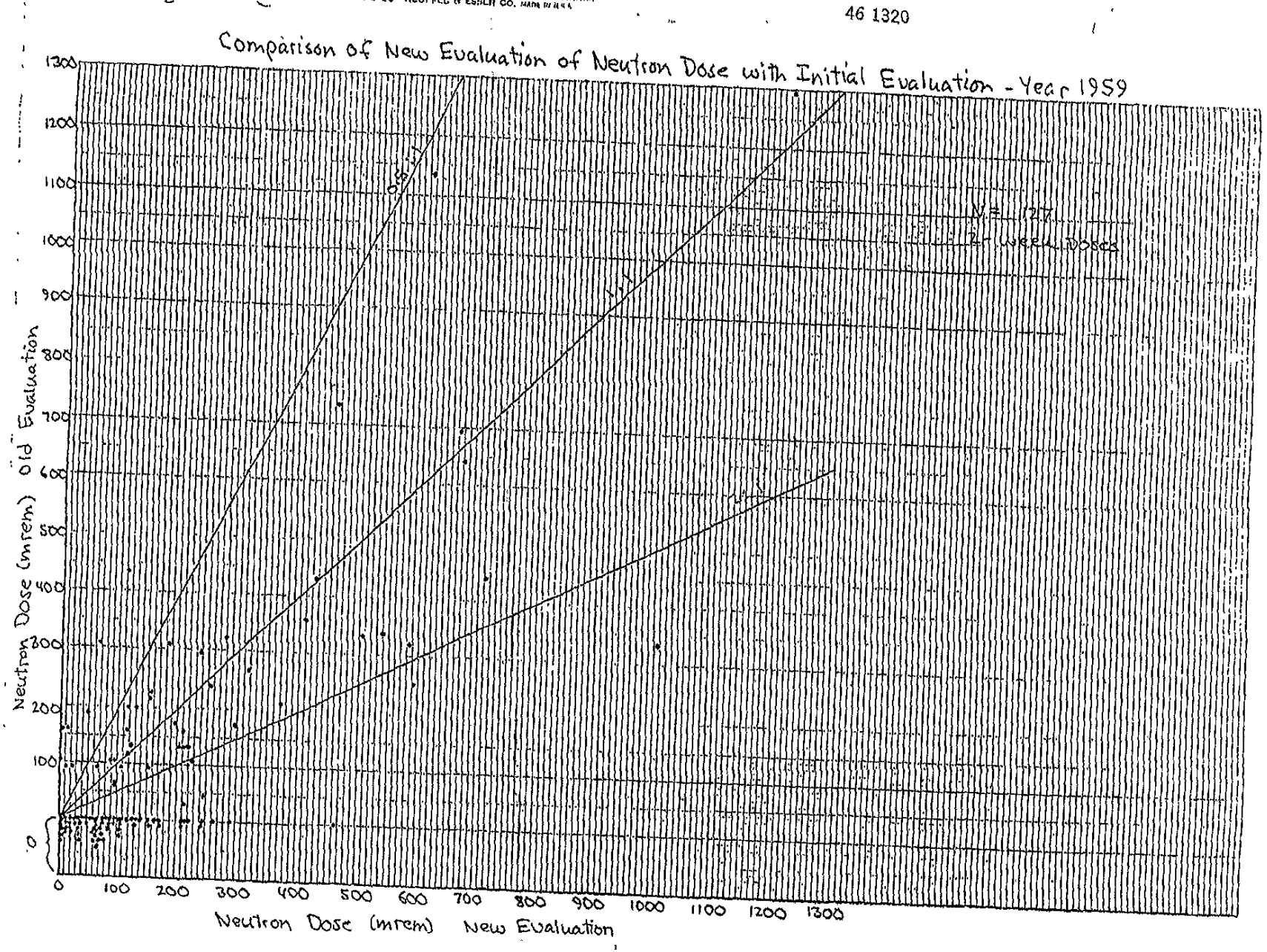
August 4, 1958

from S. E. Hammond to C. W. Piltingsrud

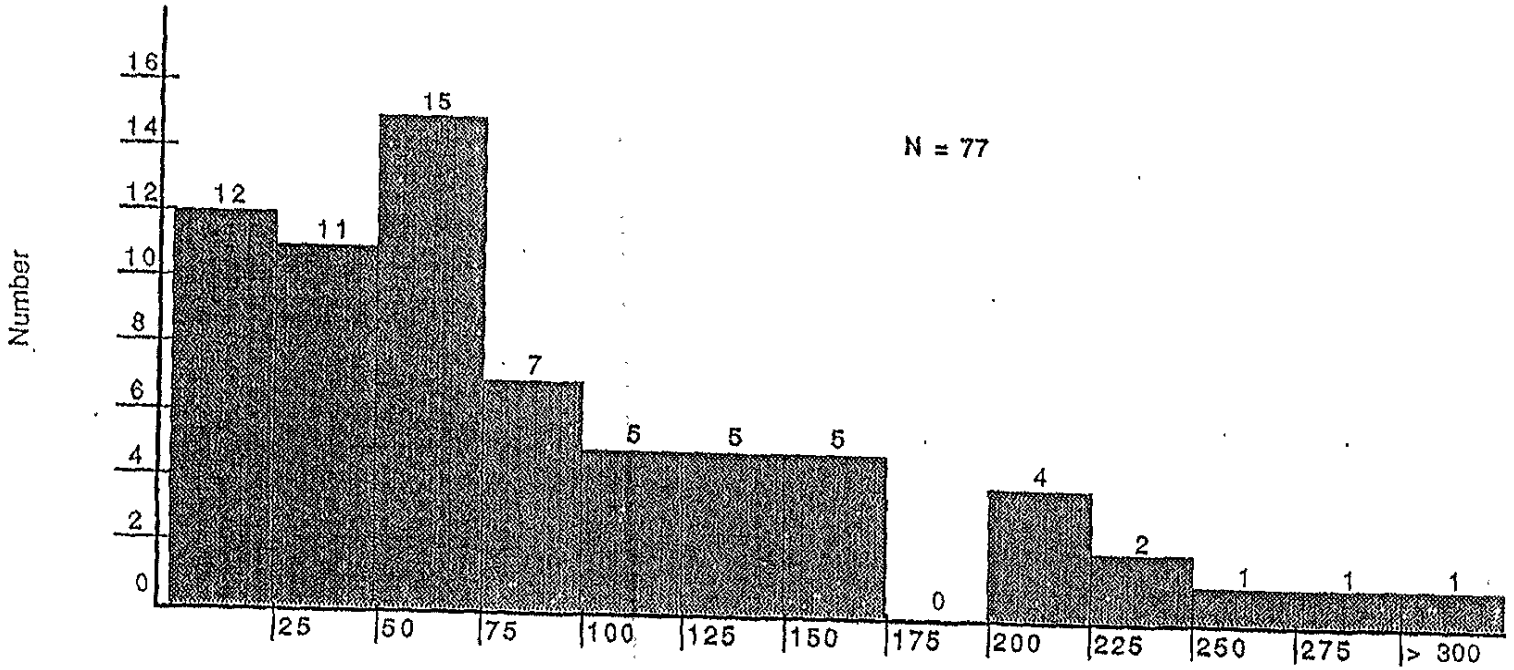
" Neutron film has been furnished 71-bldg., to start personnel dosimetry there this month. An estimated twenty persons will be covered. Following extensive studies by Ray, Gronquist, and Owen on neutron dosimetry at 71-bldg., we changed our method of interpreting neutron film as reported by memo earlier this month. It is interesting to note that if we had used this method during the previous coverage at 71-bldg., fortnightly neutron doses as high as 4 rem would have been reported. "

Percent of Neutron Film for Which the Initial Evaluation was Zero for Workers in Building 71

Year	Percent Zero
1959	88.9
1960	96.6
1961	95.6
1962	54.4



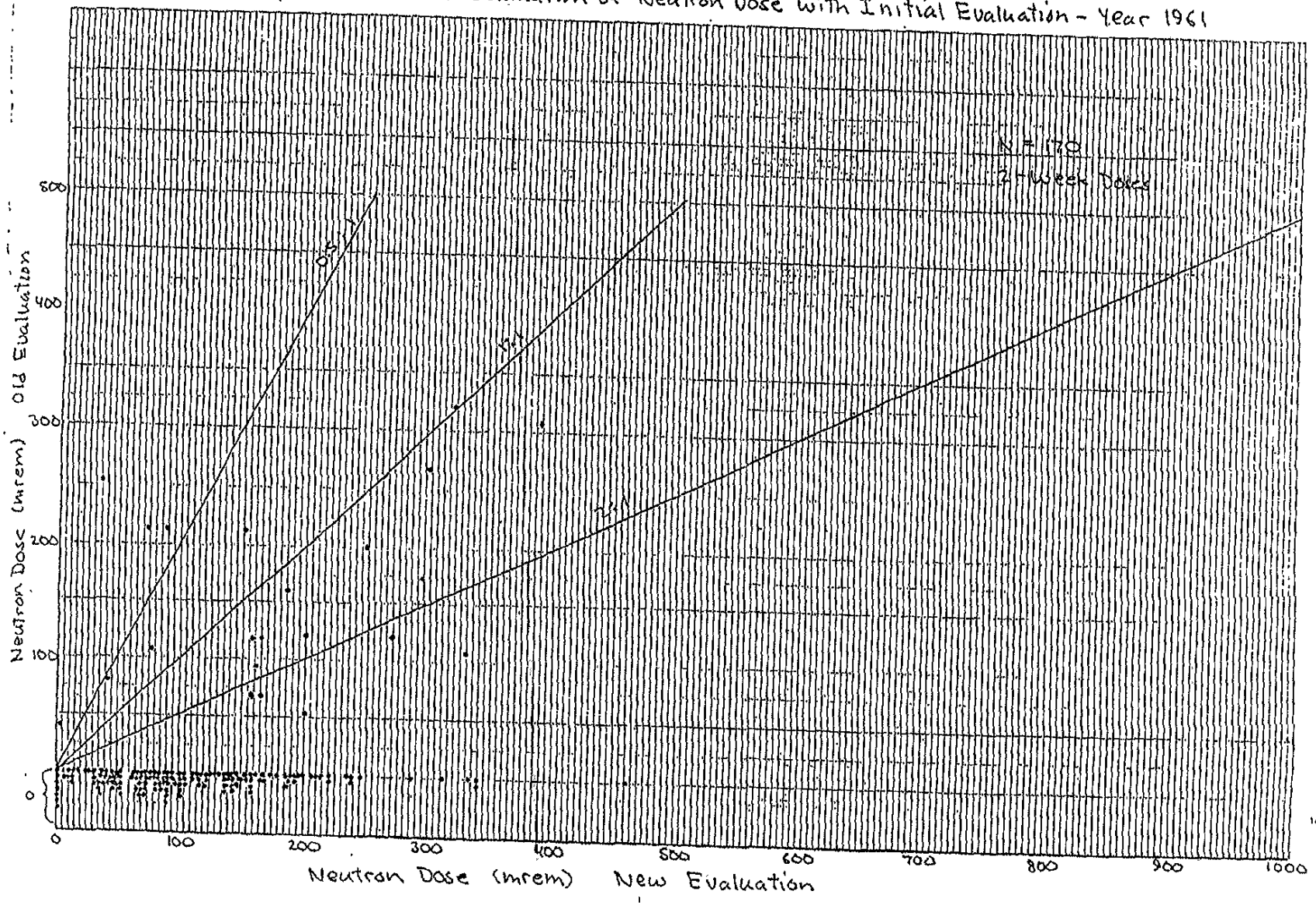
Year 1959. Reevaluated Neutron Doses for Which Initial Evaluation Was Zero, 2-week Period



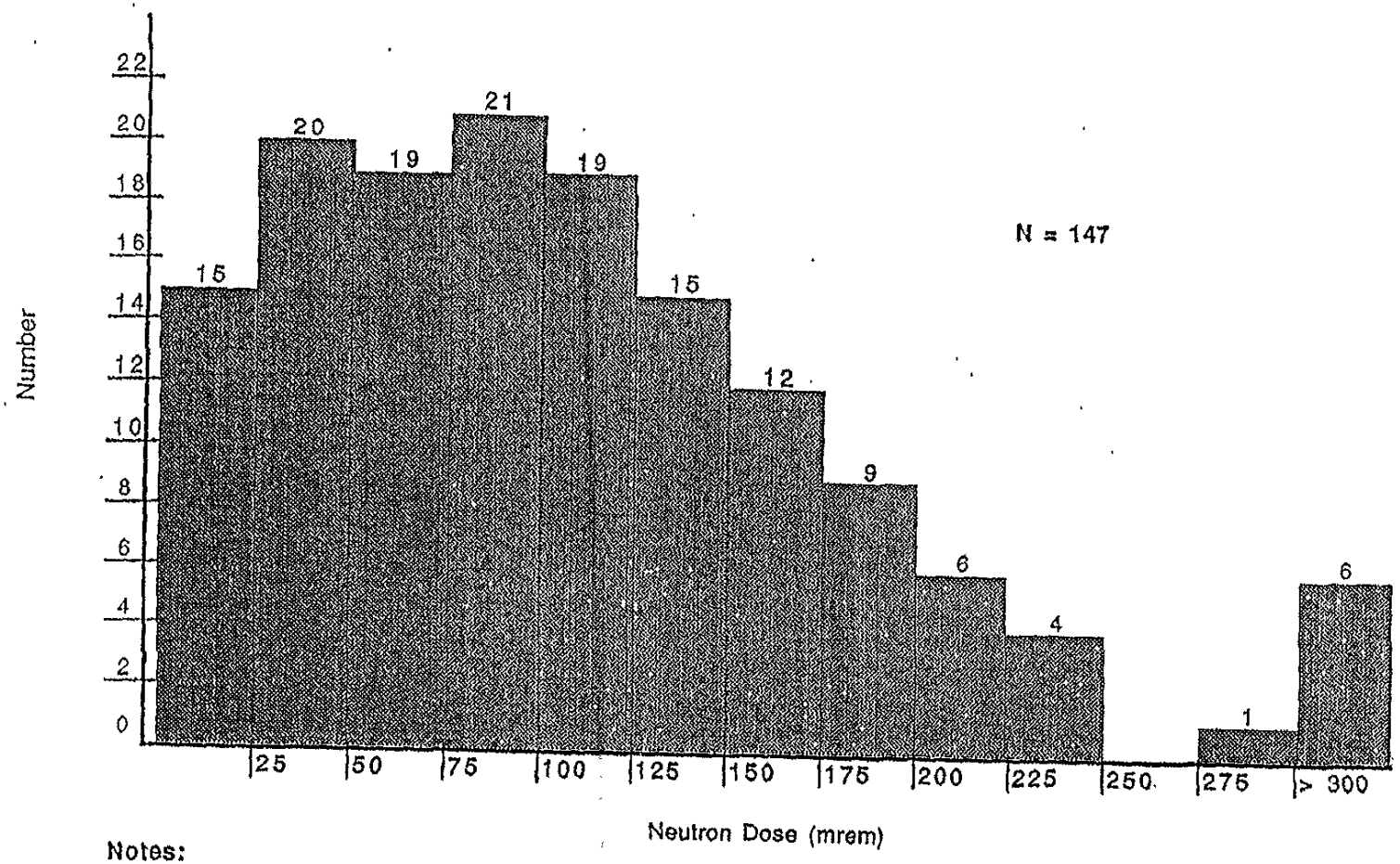
Notes:

1. Highest Neutron Dose = 466 mrem
2. 31% > 100 mrem
3. 12% > 200 mrem

Comparison of New Evaluation of Neutron Dose with Initial Evaluation - Year 1961



Year 1961. Reevaluated Neutron Doses for Which Initial Evaluation Was Zero, 2-week Period

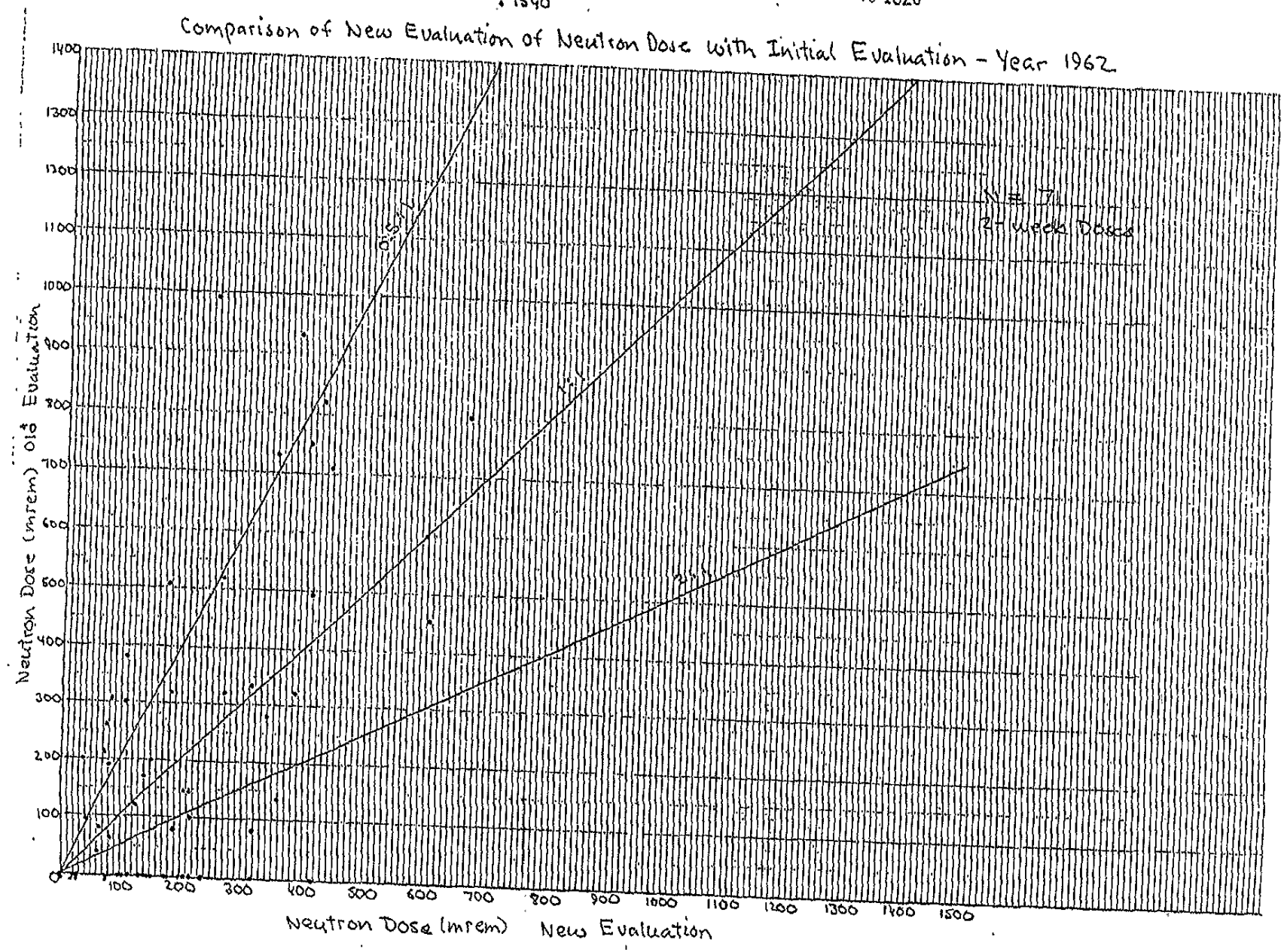


Notes:

1. Highest Neutron Dose = 1,085 mrem
2. 49% > 100 mrem
3. 12% > 200 mrem

1540

46 1320

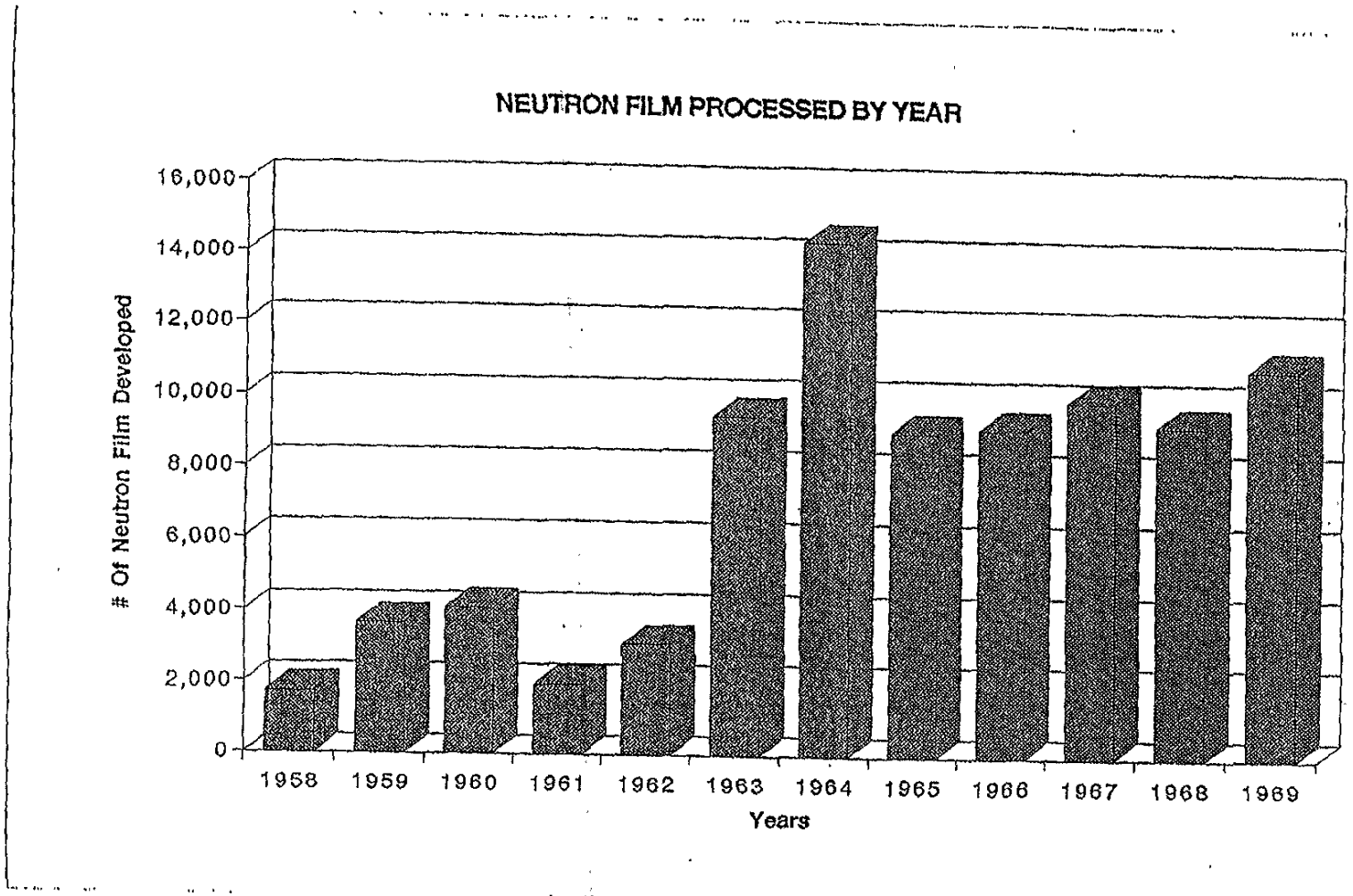


Excerpt from: Status Report - Dosimetry - February 1967

March 8, 1967

from John Mann to C. W. Piltingsrud

" January neutron dosimetry film were evaluated using the new track reading procedure. About half of the total film developed were read out, thus allowing twice as much time for reading each film. The average neutron dose assigned to those personnel that worked in the highest neutron exposure areas in Building 71 increased by a factor of 5 over the average for 1966. "


NEUTRON FILM PROCESSED BY YEAR
Of Neutron Film Developed
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
Years

Recommendations (Preliminary)

1. Establish a program to reevaluate a substantial number of neutron films.

   Investigate/fund development of an automated film reader system.

   Establish in-house program and/or offsite contract.

2. Establish a program to reconstruct neutron doses for persons not monitored in 1950's.

3. Review and reconstruct the lifetime dose status of active workers who may have been exposed to neutrons at Rocky Flats prior to 1967.

4. Reconstruct the lifetime dose status of former workers who records indicate were exposed to neutrons prior to 1967.

5. After identification of exposed individuals, notify each one of dosimetry gaps in their record and offer to include them in medical monitoring recall program for former radiation workers.

F.4 Records and Information are Inadequate for Individual Dose: Technical Reports from Government Entities or Journals

Attached is a copy of the March 15, 2001, Investigation Report for the Building 771 worker exposures that shows that D&D activities have created unmonitored exposures over time that go undetected by workplace indicators and have resulted in undetected worker exposures. Attached are copies of technical reports from the Defense Nuclear Facilities Safety Board (DNFSB) supporting our basis for petition that unmonitored exposures and deficiencies have created a situation in which accurate dose reconstruction cannot be performed. Also attached are DNFSB documents that support the contention that processes involving high fired oxides were conducted as recently as the 1990s-2000s with oxide stabilization processes in both Building 707 and 371. Also attached are Price Anderson Enforcement documents that provide evidence of issues surrounding unmonitored exposures and chronic exposures over time that are not detected by work place monitors. Other relevant supporting documentation is also attached. All of the attached documents support our basis for petition.

Investigation Team Report

Investigation of the source of potential internal radiological exposures involving eleven personnel in Building 771

March 15, 2001

March 15, 2001

On December 13, 2000, I established a team to investigate the source of internal radiological exposures involving personnel from Building 771. The purpose of this investigation was to determine the cause or potential cause of the Building 771 worker exposures and to make recommendations to mitigate recurrence in keeping with the Site's commitment to As Low As Reasonably Achievable goals.

As of today, March 15, 2001, I accept the findings and recommendations of this team and the team's responsibilities are completed.

Kaiser-Hill takes any worker exposure very seriously and we remain fully committed to the safe, accelerated closure of Rocky Flats.

MS Spears

Mark Spears
Kaiser-Hill Vice President
Engineering, Environmental, Safety and Quality Programs

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1.0 EXECUTIVE SUMMARY

Introduction

On October 16, 2000, a Department of Energy Rocky Flats Field Office (DOE-RFFO) representative performing a routine surveillance in Building 771 found that an air sampler being used for monitoring airborne radioactivity levels inside the containment tent in Room 186 was past due for calibration. Upon further investigation, building management determined that routine measurements from the air sampler were not properly documented from September 7 through October 17, 2000. Subsequent testing on the air sampler demonstrated that it was within calibration tolerances and functioning properly.

Bioassay monitoring of individuals associated with D&D operations in the Room 186 tent was initiated. A total of 11 workers who worked in the containment tent between September 7 and October 17 submitted fecal samples for bioassay. All of the workers had been wearing the required level of personal protective equipment while working in the tent. This equipment included full-face powered air purifying respirators and anti-contamination clothing.

Preliminary bioassay results, issued in late November 2000, showed unexpected levels of internal exposure in 10 of the 11 workers. To further quantify the results, 3 workers with the highest results were assayed using a lung counter. Results indicated exposures of less than the minimum sensitivity of the lung count analysis.

Rocky Flats site managers requested reanalysis of the initial bioassay samples, offered the opportunity for volunteers to provide fecal samples, suspended work in Building 771, and began a review to identify the source of the radioactivity that caused the positive fecal results. The management review identified numerous contamination control weaknesses for which compensatory measures were applied. However, a clear source for the internal depositions was not identified. As the investigation progressed, additional waste workers and several individuals who provided voluntary fecal samples also showed positive fecal bioassay results. As of the time of this report, some samples continue to be analyzed. Results for nine of the original 11 workers are in the range of 6 millirem to 60 millirem, which is a 50-year committed effective dose equivalent. This equates to 0.12 to 1.2 millirem per year over a 50-year period. Results are pending on two of the original 11 workers. One of these two is expected to also be in a similar range. The last worker's dose is expected to be somewhat higher than this range, and the Site continues to review the possibility that this worker was involved in a separate event. A discussion of these two workers is included as Appendix 2.

An Investigation Team was chartered December 13, 2000, to investigate the source of internal exposures involving personnel in Building 771.

Investigation Methodology

The Investigation Team reviewed work histories of the personnel and reconstructed a timeline of their activities. Records and documents pertinent to Building 771 radiological safety, work controls and the site radiological safety program were reviewed. Personnel pertinent to the incident, building managers, and other support personnel, were interviewed.

Results of Investigation

From the review of the timeline of possible inhalation events studied during the course of this investigation, there is no event in which all 11 workers were present and no series of events in which various groups of the workers could have received a single, large intake. An analysis was conducted of internal dosimetry results for the past six years. These results demonstrated that during airborne contamination incidents for which the workers were not contaminated and not wearing respirators, the individuals did not receive an intake resulting in a dose greater than a few millirem. Thus, it is extremely unlikely that the positive fecal results under investigation were due to an acute inhalation because an acute airborne contamination incident high enough to cause a detectable intake would have resulted in a Continuous Air Monitor (CAM) alarm. With one exception, all of the individuals stated that they were not in rooms in which a CAM alarmed when they were not wearing respirators.

In addition, the Investigation Team conducted an analysis to determine the average, steady-state level of airborne contamination throughout Building 771 from January 28, 2000 to January 19, 2001. Breathing the average air within Building 771 for 25 hours per week would result in an annual internal dose of 4 millirem. Since the dose range identified was between 6 millirem and 60 millirem, it is therefore extremely unlikely that intakes occurred due to slightly elevated, ambient airborne radioactivity in Building 771.

The Investigation Team reviewed studies from the Hanford and Savannah River sites that revealed that internal plutonium exposures could be detected in scheduled fecal examination in the absence of workplace indicators such as personnel contamination or airborne radioactivity alarms. The rates of positive (above background) fecal results in the two studies were comparable to the overall results seen in Building 771. Air samples at Hanford were consistent with those at Rocky Flats.

The Hanford study indicated that the fecal bioassay results changed with time depending on the work being performed (e.g., maintenance and repair versus routine processing operations). Since the weekly air sample results in Building 771 appear to fluctuate with the number of radiological work hours logged, it can be expected that the Rocky Flats intakes will follow a similar pattern. Therefore, the fecal values seen at Building 771 are most likely to be the result of a series of small, acute events and/or a series of small, chronic exposure periods, interrupted by weekends, holidays, training, etc. These intakes have been modeled as "effective" chronic intakes.

The fecal sampling in Building 771 revealed that workers were incurring very low-level intakes below the threshold of workplace monitoring systems.

Conclusion and Judgement of Need

Decontamination and decommissioning activities such as those currently under way at Building 771 are vastly different from many other radiological activities normally encountered in the DOE complex. The destructive nature of D&D activities can produce localized contamination and airborne radioactivity. When D&D activities take place in facilities contaminated with plutonium, the challenges to a radiation safety program are especially great. Workplace indicators are not capable of detecting low levels of plutonium contamination in equipment and materials or as airborne radioactivity.

In addition, urinalysis and lung counting do not have the sensitivity necessary to detect intakes of plutonium at the DOE investigation level of 100 millirem. While the analysis of fecal samples does offer the necessary sensitivity, fecal sampling is not used routinely at Rocky Flats because compliance of the workforce is difficult to maintain and interpretation of results without a known intake event is very difficult. Fecal examination is required when workplace indicators signal the possibility of internal deposition of radionuclides.

In summary, the Investigation Team concluded that the most likely cause of the positive bioassay results was exposure to low levels of airborne plutonium radioactivity from radiological work operations exacerbated by D&D operations. These low levels of airborne radioactivity are below the threshold of workplace indicators.

While the exposure to individuals from these intakes are well within regulatory limits, the critical nature of the investigation into positive fecal results from workers from Building 771 identified several areas for improvement that could contribute to maintaining exposures to the Site's As Low As Reasonably Achievable goals. These include requirements for respiratory protection in situations involving direct waste handling, improved containment of items staged for size reduction, improved building ventilation, and improved engineered controls. Corrective actions are detailed in a corrective action plan that will be submitted as a result of this report, and also as part of a March 14, 2001 Root Cause Analysis on Building 771 Radiological Safety Program Concerns.

However, with the most robust controls for contamination in place and highest attainable compliance with protective processes and procedures, some level of internal exposure to radionuclides will most likely occur in individuals who are directly involved in high-risk activities associated with the decontamination and decommissioning of Rocky Flats former plutonium processing facilities.

2.0 METHODOLOGY

The Phoenix methodology of incident investigation was followed for this investigation in compliance with MAN-062-CAUSEANALYSIS, Revision 2, *Cause Analysis Requirements Manual*. Records and documents pertinent to Building 771 Radiological Safety, Building 771 work controls, and the Site Radiological Safety program were reviewed. A complete listing of documents reviewed is included in the bibliography following this report. Personnel pertinent to the incident, Building Managers and staff support were interviewed and information was verified and corroborated to the extent practicable. Analytical tools such as the Comparative Timeline were used to reconstruct activities and events related to the personnel involved and are retained in the analysis records. The analysis team meets the requirements specified in MAN-062-CAUSEANALYSIS, Revision 2.

3.0 BACKGROUND

On October 16, 2000, a DOE-RFFO facility representative performing a routine surveillance in Building 771 found that an air sampler being used for monitoring airborne radioactivity levels inside the containment tent in Room 186 was past due for calibration. Upon further investigation, building management determined that routine measurements from the air sampler were not properly documented from September 7 through October 16, 2000.

The air sampler was checked and was found to be within tolerances and did not require readjustment. This indicated that even though the calibration time period had expired, the monitor had been working properly. The 11 workers determined to have worked in the containment tent between September 7 and October 17 submitted fecal samples for bioassay. This testing was precautionary since all of the workers working in the Room 186 tent had been wearing the required level of Personal Protective Equipment (full-face powered air purifying respirators and anti-contamination clothing). The purpose of the testing was to determine if there had been any exposure incidents in the tent during the time period in question. Eight of these workers were waste handlers, three were Radiological Control Technician (RCTs).

It was anticipated that small non-event-related intakes could be occurring (possibly from the tent or other activities performed) which would be detected by a fecal bioassay. When workers' samples showed radioactivity, additional fecal samples were requested in an attempt to identify the source of the intakes. In addition, management made an offer to the other workers in the building to perform fecal bioassay sampling. Workers accepting this offer were asked to submit three fecal bioassay samples in order to establish the time dependence of the results.

The preliminary bioassay results, issued in late November 2000, were unexpectedly above the decision level. Three of the workers with the highest results were given lung counts that indicated the internal exposures were less than the approximate minimum sensitivity of the analysis.

Building 771 management assessed the adequacy of the facility's Radiological Safety Program and found numerous weaknesses, which were reported under the Price-Anderson Amendments Act (PAAA) on November 30, 2000 as NTS-RFO—KHLL-771OPS-2000-0003, *B771 Radiological Safety Program*. The report was amended to

incorporate the unexpected positive fecal results and additional information, and an event investigation/root cause analysis was requested to identify the cause of the exposures.

The Building 771 assessment negates the conclusion that the work done in the Room 186 tent would result in the intakes identified from the eleven workers. Work histories and workplace indicators for the employees were then reviewed. One employee had been involved in a positive CAM alarm on Oct. 20, 2000, that was determined to contribute to a positive bioassay. This alarm stemmed from a separate work activity and was not related to the tent work in Room 186. The other workers had nothing in their work histories that would indicate an event that could have caused positive fecal results.

Facility Background

The Building 771/774 Complex was primarily used to recover plutonium, using numerous hazardous chemicals in the recovery, separation, and purification processes. During its operational lifetime, Building 771 has had several significant fires and releases of radiological contamination within the building, leaving a unique challenge to Decontamination and Decommissioning (D&D) activities.

The D&D work is essentially the deconstruction of the facility. The building has miles of contaminated pipes running throughout the building connecting tanks, glove boxes, and plutonium process systems. Some of the pipes and tanks once contained hazardous chemicals such as kathene, hydrochloric acid, or nitric acid. Some of the tanks that once held plutonium solutions are large, weighing at least 1500 pounds empty. Gloveboxes in which plutonium was once processed are highly contaminated. Every tank that once contained gas, chemicals, or solutions must be emptied, the contents safely disposed of, and sent out as waste. Every liquid solution must be analyzed for contamination and to verify its identity before it can be safely disposed of. The building has been in place since 1953, and can contain hidden hazards. For instance, chemical and contamination spills can leave a lasting effect when the flooring is removed or when a tank is moved revealing contamination underneath the feet of the tank. Work must proceed cautiously, requiring planning, anticipation of possible hazards, and with proper worker protection.

Compared to other Site plutonium buildings, Building 771 is currently involved in much more complex, intrusive D&D work creating a higher potential for resuspension of contamination. This is evidenced by the number of positive, event-triggered bioassay samples. Building 771 received the majority of Rocky Flats internal dose during 2000, approximately 70% of all the Site dose. Building 779 was in D&D activities in 1999. During that year, the building workers received the majority of the Site's internal dose, approximately 64%.

Workplace Monitoring and Controls

All Rocky Flats personnel who work in the contamination areas wear several items of required protective clothing designed to protect the worker from skin contamination. When working in airborne radioactivity areas, workers are required to wear respiratory protection. During the time period in which the air sampler was past calibration in Building 771 and airborne radioactivity measurements were not being documented, workers in the Room 186 tent were wearing PAPRs, which provide a protection factor of 1000 in airborne radioactivity areas.

A system of workplace indicators has been implemented at Rocky Flats to provide early detection of intakes and to trigger special bioassay monitoring. These indicators are summarized below, and the technical justification is documented in the Internal Dosimetry Technical Basis Documentation. These workplace indicators are implemented site-wide through procedure 3-PRO-210-RSP-14.01, Bioassay Monitoring, Criteria and Actions for Potential Intakes. The workplace indicators are used to trigger special bioassay sampling protocols using the guidance in the established Internal Dosimetry procedures (RDI-5106, Response to Potential Intakes) and the Internal Dosimetry Technical Basis Documentation.

The workplace indicators implemented by the Rocky Flats Site are equivalent to or exceed the guidance contained in DOE-STD-1128-98. A summary of the workplace indicators used to trigger Internal Dosimetry evaluation and their comparison to the levels in DOE-STD-1128-98 are listed below.

	Workplace Indicator	RFETS Lower Limit	DOE-STD-1128-98
1	Nasal/Mouth Swabs	Detectable activity	Detectable activity
2	Facial Contamination (area normally inside respirator seal)	60 dpm	200 dpm
3	Contamination inside respirator	60 dpm	Detectable activity
4	Head/neck contamination (area normally outside respirator seal)	300 dpm	2000 dpm
5	Airborne contamination.	40 DAC-hours	40 DAC-hours
6	Verified CAM/SAAM alarm	600 dpm on filter (~40 DAC-hours)	40 DAC-hours
7	Hand/forearm/clothing contamination	1600 dpm	10,000 dpm
8	Wounds	Any wound occurring in a CA, HCA, or ARA (follow-up for wounds occurring in an RBA is optional).	Any skin break while handling material other than sealed sources.

Appropriate respiratory protection factors are applied to indicators 4 through 7. All contamination levels are based on total alpha activity and not activity per unit area. The minimum detectable activity for the most sensitive field survey instrumentation in use at the Rocky Flats Site (NE Electra) for alpha contamination surveys is approximately 60

dpm. In addition, the building radiological safety organization or the individual worker can request bioassay sampling even if the workplace indicator lower limits are not exceeded.

The workplace indicators were designed to define potential intake events, which require follow-up bioassay sampling and which may result in dose of 100 mrem or more. In actual practice, the doses assigned are much lower than predicted by the workplace indicators due to the conservative assumptions used in their development.

The workplace indicator program has three vulnerabilities. First, it relies on the proper field measurements being taken in the proper way and at the proper time. For example, the need to take nasal/mouth swabs must be recognized, the swabs must be taken promptly, and they must be prepared and sent to the laboratory. Second, the program must rely on the professional judgement of the field radiation safety personnel to identify additional intakes since not all situations can be anticipated. Third, the workplace indicator program was not designed to detect low-level intakes protracted over long periods of time, nor can it be reasonably redesigned to do so.

The follow-up sampling initiated following a potential acute inhalation incident typically includes one or more fecal samples. The individual involved is required to refrain from work with radiological materials until after all requested samples are collected. Fecal sampling is a more sensitive method for detecting intakes; however, it is also highly dependent on the time interval between the intake and the collection of the sample and the particle size of the inhaled material. The minimum detectable dose for a single fecal sample can range from less than one mrem to more than 200 mrem CEDE, for samples collected less than five days and more than 14 days after an acute inhalation. Interpretation of fecal bioassay results can also be confounded by small ingestion intakes.

The interpretation of fecal bioassay sample results is more complicated for the case of a chronic intake scenario. To accurately determine the intake rate and corresponding internal dose, it is necessary to know the relation between the start and end of the intake as well as the sample collection date. Following the start of a chronic inhalation of International Commission on Radiological Protection (ICRP) Class-Y material with a particle size of 1 μm Average Median Aerodynamic Diameter (AMAD), the fecal excretion increases to an equilibrium state within approximately 10 days. When the inhalation has ended, the fecal excretion decreases by approximately a factor of seven within the first five days. If the chronic inhalation is interrupted by time off from work with radioactive materials or by the use of protective equipment, then the fecal excretion will decrease during the interruption and then increase when the intake resumes. Also, interpretation of the fecal results is likely to be confounded by ingestion or small acute inhalations near the end of the exposure period. Since these events are unlikely to be identified by other workplace indicators, their resulting contribution to the fecal results would be interpreted as being due to the chronic inhalation and therefore result in an overestimate in the chronic intake rate.

Due to the event date-dependant nature of fecal samples, as well as confounding factors of otherwise undetected small ingestion or acute inhalation events, it is not recommended that the accumulation of any set number of DAC-hours over an extended period of time be used to trigger follow-up bioassay sampling. It would be reasonable to trigger bioassay sampling if the DAC-hour tracking indicates an unusual accumulation

over a short uninterrupted period of time such as one work week. The sampling should be conducted before work with radioactive materials is allowed to continue. The internal dose from any accumulated exposure, that was otherwise unevaluated, should be assigned based on the DAC-hour tracking logs.

RFETS Bioassay Monitoring Program

Workers who are likely to receive 100 mrem in a year from all internal exposures are placed in a routine bioassay program. They are required to provide annual urine samples and have periodic lung counts. In a plutonium facility, neither of these two methods has the sensitivity to detect small intakes (less than 100 mrem). They do, however, have the ability to detect intakes at less than the federal limit of 5 rem for occupationally exposed workers. The inability of the routine bioassay program to detect small intakes is termed the "technology shortfall" for plutonium bioassay.

As described above, a system of workplace indicators, following DOE guidance, has been implemented to provide early detection of personnel intakes and to trigger follow-up or "special" bioassay monitoring. The workplace indicators include such things as personnel contamination, airborne radioactivity, and CAM alarms. For each indicator, a value is calculated based on a workplace measurement, which indicates the level of potential internal exposure. The building radiological safety organization or the individual worker can request sampling even if the workplace indicators are not triggered.

Because of its sensitivity to small intakes, fecal bioassay sampling is included in the special bioassay monitoring protocols. Fecal sampling is not included as a part of the routine bioassay program because the analysis is complex for the bioassay laboratory, it is harder to gain worker compliance, and the interpretation of the results is difficult. The last point will be detailed below, during the discussion of the interpretation of bioassay results from personnel in Building 771.

Accuracy of Bioassay Results

The Internal Dosimetry Program (IDP) at RFETS is defined by a set of documents designed to meet or exceed the requirements of 10 CFR 835 and 10 CFR 830.120. These include the Internal Dosimetry Technical Basis Documentation, procedures manual, Quality Assurance Plan, and Bioassay Statement of Work (SOW). Since 1997 Rocky Flats has used contract laboratories exclusively for indirect bioassay analyses. An independent consultant to the Investigation Team reviewed the bioassay quality assurance protocols and found them to be adequate.

The Bioassay SOW contains detailed customer requirements and includes a general analytical laboratory module and a specific module for bioassay analyses. These SOW modules detail the requirements with which the laboratories must comply to be awarded and maintain a contract for the analysis of RFETS bioassay samples. Analytical Services Division provides an indirect bioassay subject matter expert (e.g., a radiochemist) to guide development and maintenance of the SOW and evaluation of laboratory performance. Each data package is reviewed independently before being forwarded to Internal Dosimetry. A blind audit program is used to verify that the analytical laboratory's performance is in accordance with the Bioassay SOW. This

program includes pre-award and annual performance verification samples as well as shipping. In addition to testing by RFETS, the laboratory used during the Building 771 investigation has participated in a number of laboratory inter-comparison studies. In every case, the laboratory exceeded the requirements.

During the investigation, some sample analyses failed the quality control requirements. An investigation by Internal Dosimetry and Analytical Services determined that these problems were primarily due to shipping an extremely large number of samples (equivalent to approximately 6 months' workload) to the laboratory in the month of December. The contract specifies turnaround times based on a given workload. The samples that were sent during the Building 771 event far exceeded that workload. There is currently only one laboratory which has met the SOW requirements to process bioassay samples. Analytical Services has been trying to qualify additional laboratories for at least two years without success.

The quality control program worked as designed because the laboratory self-identified problems, operations were paused until corrective actions could be implemented, and then resumed operations with minimal loss of data. Performance testing results have consistently demonstrated the laboratory's ability to perform quality work. There is no evidence that the results seen in the Building 771 bioassay samples should not be accepted. These results are also consistent with the fecal sample results from plutonium facilities at Hanford and the Savannah River Site (see Appendix 4).

4.0 ANALYSIS

Intake Pathways

The possible intake routes for internal radiation exposure is ingestion, injection, absorption through the skin, and inhalation. Each of these routes are evaluated below. The investigative team ruled out ingestion by direct contact with the mouth, injection, and absorption as pathways and focused on inhalation as the primary pathway for these exposures.

a. Ingestion. This pathway includes two sources: (1) Inhalation of airborne particles through the nose or mouth, trapped by the mucous membranes, and subsequently swallowed. This pathway accounts for a large portion of the intake during inhalation. (2) Ingestion by direct contact with the mouth. It is not likely that all 11 workers ingested plutonium by contaminating their faces. There are data to show that none of them received any skin contamination. These results were confirmed through interviews.

b. Injection. There are no data to support injection, such as a puncture wound, as a route of intake by any worker.

c. Absorption. No skin contamination was reported by any of the eleven workers during the time period in question.

d. Inhalation. There are three possible general scenarios for inhalation intakes: a single large event, breathing a slightly elevated, airborne radioactivity level and numerous small intakes by inhalation.

Because ingestion by direct oral contact, injection, and absorption are considered extremely unlikely to be the cause of the intakes, the only possible route is inhalation. The three inhalation scenarios of a single, large event, a slightly elevated steady state airborne radioactivity level, and numerous small intakes, were analyzed using the available data to determine the most likely cause of the internal doses. Each of these scenarios is addressed below. A backup analysis was conducted to further confirm that a single inhalation event did not cause the internal doses.

Single Large Inhalation Event

From review of the possible inhalation events timeline generated during the course of this investigation, there is no event in which all 11 workers were present and no series of events in which various groups of the workers received a single, large intake.

Timeline Development

The Investigation Team evaluated over 200 events, culled from all available documentation, that could have reasonably caused a release of contamination. This data was put into a timeline format, and each incident was examined to determine if any of the 11 workers were present, and whether the release could then have been the source of the intakes of the 11 workers. Twenty of the most likely events to cause an intake were then exhaustively studied. After many hundreds of hours of analysis, it was determined that there were no events where all 11 workers were present, and no series of events where various groups of the workers could have received a single, large intake.

Internal Dosimetry Backup Analysis

To test the hypothesis that a worker without a respirator would not receive an intake in a room with a CAM alarm (assuming, of course, that the worker exits the area promptly), the past six years of internal dosimetry data was analyzed. All intakes that were due to inhalation events were reviewed; a total of 156 cases that fit the hypothesis were evaluated; these are listed in the accompanying **Figure 1** *(all figures are in the back of this report)*. These results show that during airborne contamination incidents, with no concurrent personnel contamination (where personnel are not in respiratory protection), the individuals will not receive an intake resulting in a dose greater than a few millirem. Thus, the Building 771 intake is extremely unlikely to have been due to an acute inhalation, because an acute airborne contamination incident high enough to cause a detectable intake would have resulted in a CAM alarm, assuming proper placement of the CAM.

Slightly Elevated Airborne Radioactivity in the Atmosphere in Building 771
An analysis of the fixed air head data in Building 771 indicates that workers breathing the average air within the building would receive an internal dose of 4 mrem in one year. Since the 11 workers received intakes greater than 4 mrem, it is considered unlikely that their doses were due to slightly elevated airborne radioactivity in the building.

Hypothesis

One hypothesis for the source of the intakes to the eleven workers was that the steady state concentration of airborne radioactivity in Building 771 was causing the intakes. For this hypothesis to be true, the radioactivity level, measured in units of Derived Air Concentration (DAC), would have to be high enough to account for the intakes seen. Also, all workers who spent the same amount of time in the Contaminated Area would have the same intake.

Analysis of the Fixed Air Head Data for All of Building 771

The fixed air head data for Building 771, from January 28, 2000 through January 19, 2001, was obtained and analyzed. A plot of all data, for each room as well as for the building, was prepared (see **Figure 2**). It was clear that several known airborne radioactivity releases were skewing the average airborne concentration erroneously high. To attempt to see just the steady state average DAC value of the building, these event-related periods of radioactivity were removed in several stages. This resulted in removing 1.7% of the data (64 data points were removed out of a data set of 3,735 data points). See **Figure 3** for a count of the data points in the data set.

An analysis of the fixed air head data in Building 771 demonstrates that when the event-related periods of airborne contamination greater than 6% DAC are removed, the average steady state level of airborne contamination throughout Building 771 from September 1, 2000 to January 19, 2001, is essentially at the minimum detectable activity (MDA) of 0.21% DAC. The calendar year 2000 average is about 0.3% DAC. See **Figure 4** for graphs depicting the average DAC by room and by week. It is believed that the data analysis approach is sound and the results are an accurate indication of the steady state atmosphere within Building 771. Breathing the "average air" within Building 771 for 25 hours per week would result in an intake with an annual internal dose of about 4 mrem. It is therefore unlikely that intakes occurred due to slightly elevated airborne activity in the atmosphere of the building.

Evaluation of Intakes of Workers in Building 771

Internal dosimetry data was grouped into three sets: the Waste Packaging Crew and the RCTs, the D&D workers, and others in the building. The Waste Packaging Crew and the RCTs have statistically significant higher intakes than the other populations. This further supports the contention that the intakes were not a result of a high steady state radioactivity level in the building.

Numerous Small Inhalation Intakes

Numerous small releases of plutonium causing elevated airborne radioactivity below the air monitoring equipment alarm capabilities was determined to be the most likely cause of the low-level uptakes. From interviews, it was learned that the waste workers considered the waste they were handling either "cold" (uncontaminated) or "hot" (contaminated) [their words]. They typically handled waste and packed waste boxes and drums without respiratory protection when they were told by the RCT that the waste was "cold." The RCTs used a Ludlum 12-1A portable instrument to perform the survey.

Due to the history of Building 771 there are small amounts of loose surface contamination on pipes, under pipe hangers, and at pipe joints, in addition to being in cracks and crevices of other waste the workers handled. When this material was disturbed in the D&D process (crimped, band-sawed, etc.), and handled, the surface contamination that has been there under years of accumulated dust and grime may become airborne. It follows then that as the waste workers packed the waste crates small releases of contamination could result.

Room 179, the Location of Most of the Low Level Waste Packaging, has a Higher Average DAC than Other Rooms

As shown in **Figure 5**, the average DAC value in Room 179 is one of the highest of any room in Building 771. The waste crew spent significant time in this room.

The DAC Value from the Fixed Airhead in Room 179 Increased As More Waste Was Packaged

Since virtually no D&D work was done in Room 179, the question becomes one of exactly where did the higher level of airborne radioactivity come from? If it indeed were the result of waste packaging, then as more waste was packaged, more radioactive contamination would be released. As shown in **Figure 6**, the average DAC level in Room 179 approximately follows the volume of low level waste packaged.

The More D&D Work Being Done in the Building, the Higher the Average DAC

Most of the work in Building 771 during this timeframe was facility D&D. The D&D work, being intrusive, would raise the average DAC level in the building. As can be seen in **Figure 7**, the average DAC value in the building approximately correlated to the hours worked.

An Exposure Model of the Building 771, Room 179 Atmosphere During Low Level Radioactive Waste Packaging

The average airborne contamination level in room 179 during the Year 2000 was approximately 0.5% DAC, as determined from the fixed air head, when transients caused by known releases were deleted from the data base. A model was developed

that demonstrated the DAC value in Room 179 was reasonable, given the waste packaging that occurred there (see Appendix 3 for the Exposure Model).

Modeling of Bioassay Results

As stated in the previous section, the Investigation Team concluded that it was unlikely that the exposures of the waste team members were due to a single, unknown acute event in which all eleven workers were exposed. Internal Dosimetry used this information to model the bioassay results and determine the intakes and doses.

Sufficient data did not exist to model the series of small acute exposures, which represented the actual conditions in the building. In such cases, a chronic intake represents a reasonable approximation or "effective" model for a series of small acute exposures. The chronic intake was assumed to begin on January 1, 2000 (or the first RWP entry) and end on December 31, 2000 (or the last RWP entry). Generally, the doses determined in this manner resulted in calculated total exposures of 10-20 DAC-hours protracted over the entire year. This agrees with the above analysis since it is feasible that the workplace indicators would not have detected intakes at this level.

Doses for 9 of the 11 original workers ranged from 6 to 60 mrem. Results are pending on two of the original 11 workers. One of those workers' dose is expected to be similar in range. The last worker's dose is expected to be less than 300 mrem, and the Site continues to review the possibility that this individual was involved in a separate event. See Appendix 2 for a discussion of these two workers.

Doses for the nine that have been assigned were verified, and final reports were peer-reviewed by a second Internal Dosimetry health physicist. Internal Dosimetry health physicists briefed those workers on the results of their dose assessments.

Bioassay Results for Workers Submitting Personal Request Samples

Preliminary statistical tests performed on the data indicate that there is a difference in the proportion of greater than decision level results between groups. The proportions of greater than decision level results are not statistically different for the RCTs and waste crew and for the D&D workers and others (non-"hands-on" workers). In addition, there is a statistically significant difference in the magnitude of the results for the different groups. These results are consistent with the observation that the waste crew as a group spends the most time in the contamination area. This additional time provides the opportunity for more exposure to ambient airborne radioactivity and additional opportunities for exposure to small acute events. It is also consistent with the work practices in place at the time. For example, D&D workers wearing respiratory protection brought waste that had been surveyed, and the waste crew accepted it without wearing respiratory protection.

5.0 POTENTIAL CAUSES

Root Cause

The Investigation Team concluded that the most likely cause of the positive bioassay results was exposure to low levels of airborne plutonium radioactivity from radiological work operations exacerbated by D&D operations. These low levels of airborne radioactivity are below the threshold of workplace indicators.

Vulnerabilities and Exacerbating Factors

Vulnerabilities are conditions that existed in the workplace that allowed the exposures to happen. Exacerbating factors potentially contributed to the exposure issue – potentially affecting the amount of internal exposure received. Both are potential contributors and are discussed in the same section for that reason.

Lack of Respiratory Protection When Handling/Packaging Waste

Waste crew members received, handled, packaged, and transported items throughout the contamination area without respiratory protection. These items had been surveyed by wiping and checking with a Ludlum 12-1A, which had a minimum sensitivity of about 500 dpm/wipe. However, the possibility of the undetected low-level removable contamination still existing on these items that could have contributed to potential intakes was not considered.

Use of Inadequate Local Ventilation

The investigation team identified several weaknesses associated with engineered controls, particularly local ventilation. Local ventilation is a key engineered control used during D&D activities when there is inadequate total containment that confines the radioactive material. The Investigation Team identified several incidences where there was insufficient use of localized ventilation controls that could have resulted in spreading removable contamination to the surrounding areas and could have resulted in elevated airborne radioactivity.

Further details and additional examples of these weaknesses are addressed in NTS-RFO—KHLL-771OPS-2000-003, *Building 771 Radiological Safety Program Concerns.*

Facility Airflow Pattern Surveys and Checks

The airflow pattern surveys were reviewed for adequacy to determine if air-monitoring equipment is properly situated to detect an airborne release of radioactivity. The review identified several weaknesses, which appear to be a combination of unclear procedural guidance and insufficient rigor of compliance with existing requirements. For example:

1. Airflow pattern surveys were not routinely conducted following room configuration changes, such as removal of gloveboxes, tanks, and wall penetrations.
2. There were several instances where Radiological Safety chose an insufficient number of release points to evaluate the placement of air-monitoring equipment.
3. A number of airflow pattern surveys demonstrated problems with the placement of the air-monitoring equipment and building ventilation problems that were not analyzed by Radiological Engineering to require further investigation or action.
4. There were several instances of poor survey documentation, such as: maps were not representative of the areas being surveyed; the comments section was lacking in resolving questions regarding airflow patterns on the survey; and the vertical placement of the smoke device was not recorded.

Control and Reuse of Respiratory Protection Equipment Within Contamination Areas

Respiratory protective devices used by personnel in Building 771 were sometimes used for multiple entries into Airborne Radioactivity Area (ARAs) within the contamination areas, increasing the risk of exposure from undetected contamination in the respiratory protection equipment. Some workers have stored respirators in the Contaminated Area (CA), which may increase the risk of intakes.

The practice of reusing respirators provides opportunities for individuals to have an uptake of radioactive material. Normally respirators that are to be reused would be surveyed for contamination upon doffing. Then the respirator would be placed in a bag and sealed, ready for its next use. These respirators would not be surveyed again prior to a second wearing. However, the respirator may have low levels of contamination inside the mask due to the survey techniques used. If the respirator were being stored and/or reused within the contamination area, the individuals would be handling the respirator with gloves that were only frisked with either an Electra or Ludlum-12-1A survey instrument. The preferable method would be to swipe the interior of the respirator and count it on a SAC-4 system to verify the levels of contamination below 20-dpm/100 cm^2.

However, it should be noted that there is no prescriptive guidance on surveying respirators for re-use. Even if procedures were developed to specify the approach to surveying the respirator for reuse, opportunities of cross-contamination due to the wearing of contaminated gloves remain high. Therefore, the practice of reusing respirators provides vulnerabilities in the program in which individuals could receive uptakes of radioactive material.

Lack of Adequate Containment/Surveys

During this period, there was a lack of adequate containment of items staged for size reduction, that surveys of these items were not being conducted and documented, that surveys in overhead areas were not adequate, and that many job coverage surveys were not documented. Interviews revealed that some of these surveys had been conducted but that the results had not been recorded properly.

It was the usual practice to stage gloveboxes, tanks, etc. for size reduction without taking special precautions to contain and/or prevent the spread of contamination while the items were in the staged locations. In addition, these items were not included in routine surveys to ensure that there were no releases of contamination in the area from this equipment.

Surveys of the overhead areas were conducted only when work was planned for a particular area. There were no routine contamination surveys in these areas. When conducting certain activities in the overhead spaces, the contamination situation in the overheads (and the impact on co-located workers) was not completely understood.

Co-located Worker Effects

Planning for use of the hydraulically operated pipe crimper/cutter tool did not fully consider the potential of this activity for spreading contamination. Considerable effort was applied during D&D planning to develop the capability to crimp and cut piping of various sizes using a hydraulically powered crimping/cutting tool. This cutting method was relatively fast compared to the use of roller cutters or saws. However, this cutting method caused considerable shock to piping runs and adjacent support structures that could have extended to adjacent rooms and had the potential for dislodging contamination. It was standard practice to require respiratory protection in rooms where this tool was used to cut radioactive/contaminated piping. However, on some occasions, personnel in the vicinity of non-contaminated piping crimping/cutting were not required to wear respirators. In these instances there was a potential for exposure to contamination from the shock to adjacent piping.

Use of Low-Volume Samplers

Low-volume air samplers used without controlled exhaust (HEPA filtration) could increase the risk to co-located workers. It was observed that a low-volume air sampler was exhausting from the Room 186 tent directly into Room 186 proper. Examination of the configuration revealed that the low-volume air sampler exhaust hose had been disconnected inadvertently from the Room 186 tent. Under normal conditions, this hose was attached and routed the exhaust from the low-volume air sampler back into the Room 186 tent. In addition, this low-volume air sampler was not equipped with a HEPA filtered exhaust. Therefore, this uncontrolled exhaust from a CA/HCA could have created a localized airborne radioactivity area. This contamination could have been inhaled inadvertently by waste management workers.

Fixed Air Head Filter Loading

The filters in the Building 771 fixed air heads are removed weekly and analyzed for alpha contamination. The amount of industrial grit deposited on the filter is unknown. Dust or grit on the filter can mask the alpha radiation emanating from the filter. This would cause a less accurate reading, and depending on the absorption factor used in calculating the airborne radioactivity level, may cause an erroneously low reading.

Building Ventilation

Building ventilation (airflow) is maintained by 3 sets of main plenum supply and exhaust fans. Each set of exhaust fans has 2 fans and 1 flow meter. During normal operation any combination of fans can be used. The flow meters associated with each fan set sense the airflow and send a signal to a "totalizer." The totalizer sums the signals from the 3 fan sets and indicates the total amount of air being exhausted from the building. During the year 2000, airflow in the facility was increased by increasing the speeds of the supply and exhaust fans and accomplished in a manner to maintain the differential pressures within the building more or less constant. The objective of the building exhaust ventilation is to maintain the rooms negative with respect to the hallways.

It was noted that, in Room 186, the differential pressure occasionally would become positive with respect to that of the hallway, possibly due to door openings and closings. This may be an artifact of the slow response of the exhaust ventilation fan-speed control system. However, it also could be an indication that engineering controls in place are not effective in maintaining the appropriate airflow in the building, thus increasing the potential for intakes of radioactive material.

Following glove box removal, HEPA filters are sometimes installed at the new terminus of the exhaust ducts. These HEPA filters are positioned high in the overhead. Although the radiological source term has been removed from the locations where the glove boxes have been dismantled and the differential pressure between the room and the hallway has been maintained as before, the effect of placing the HEPA filters high in the overhead degrades the high-to-low ventilation airflow path normally maintained in nuclear facilities to minimize the potential for worker exposure to airborne radioactive material.

Use of the Ludlum Model 12-1A Survey Instrument

The site-wide use of the Ludlum Model 12-1A survey instrument for general contamination monitoring increases the potential for low-levels of undetected surface contamination. When used under optimum laboratory conditions, the sensitivity of the instrument is approximately 500-dpm/100 cm^2. However, when used by RFETS RCTs for field surveys, the instrument may not be detecting contamination levels of less than 1000 dpm/100 cm^2.

Most low-level waste was not bagged or wrapped prior to packaging into low-level waste crates or drums. After a scan and large area wipe survey, most waste packages were deemed free from contamination and subsequently handled by personnel in Room 179. The affected waste management personnel routinely handled such waste packages

without respiratory protection. Operations included the packaging of waste bags into the appropriate waste containers pending final disposition.

Waste bags were usually surveyed with a Ludlum 12-1A prior to their transfer to Room 179. These surveys typically included a scan and large area wipe of the exterior surface of the bag. The large area wipe also was surveyed in the work location with the Ludlum 12-1A. Normally no swipes were taken and counted on a SAC-4 or equivalent.

Improper Survey Techniques

The RCTs sometimes used the Ludlum 12-1A-survey instrument to monitor wet surfaces for radioactive contamination during the berm removal project(s). Using an alpha detector on a wet surface will not accurately detect low levels of contamination.

The team was provided evidence that during the berm removal project(s), RCTs performed alpha scan surveys of wet/moist concrete surfaces. Water mist was directly applied to the concrete berms as a dust control method. It is assumed that the applied water probably caused a significant attenuation of the potential alpha surface contamination. The surveys typically consisted of a scan and several fixed points relative to the exterior surfaces of the berm. No swipes were taken and counted on a SAC-4. It is expected that the survey results probably underestimated the actual contamination levels due to the wet/moist surfaces. These underestimated alpha contamination levels were especially problematic since it was reported that some of the concrete berm materials dried during handling and transfer operations.

By using the less sensitive Ludlum 12-1A instrument, in addition to performing the alpha surveys on wet/moist surfaces, it is conceivable that a portion of the berm material, designated as "clean," could have actually possessed surface contamination levels slightly less than 500 dpm/100 cm^2. After the berm material dried, a portion of this undetected surface contamination could have subsequently created a localized airborne area and inadvertently be inhaled by co-located workers.

Housekeeping

During a tour of Building 771, it was noted that dusts and debris were collecting in the rooms, hallways and air exhaust pre-filters of the facility. Resuspension of low-levels of contaminated dusts may have contributed to the worker uptakes. Deconstruction dusts, dirt, human hair, and other debris will collect in low airflow areas and can be re-suspended by turbulent work activities, cart movements, etc. It is a nuclear industry good work practice to periodically clean work areas and traffic patterns using "maslin mops" to help minimize the dust build-up and problems associated with its re-suspension. The mop surfaces are usually monitored for contamination collection similar to a large area wipe.

Room 186 Tent Design to Support Size Reduction Activities

The Room 186 tent design was appropriate for its initial use, the in-situ size-reduction of the glove box #865. The design was not optimal for the size reduction and waste packaging activities for which it was later used. The tent design lacked adequate accommodations for incoming material staging.

The radiological engineer smoke tested the downdraft table but did not perform the required ventilation flow rate check. Furthermore, the radiological engineer did not smoke-test the downdraft table with the workers standing in their work locations or with the band saw installed on the worktable. This could result in the reliance on a less than optimum control.

Other Vulnerabilities and Exacerbating Factors

Other potential vulnerabilities and exacerbating factors included:

- Compliance with ALARA Job Reviews,
- Engineering controls during berm removal,
- Radiological Control Supervisor/Management expectations and performance issues,
- Field instrument performance checks, and
- Deficiencies in radiological record-keeping.

A thorough discussion of these topics is included in the document *NTS-RFO—KHLL-771OPS-2000-003, Building 771 Radiological Safety Program Concerns.*

Mitigating Factors

There are several factors that prevented the exposures from being worse. The respiratory protection is very good and often protects workers against contamination levels much higher than that which they are expected to encounter. The workplace indicators such as the FAH monitoring, SAAM/CAM alarms, and personnel monitoring can identify contamination releases independent of the low-volume air samplers. The Building 771 employee concern resolution process and union safety concerns programs have identified actual and/or potential problems and have resolved them before unwarranted risks were taken.

Conclusion

The positive bioassay results for the waste crew workers in Building 771 were most likely the result of a series of low-level exposures. Similar, but somewhat lower, results seen in the workers submitting personal request fecal samples are consistent with the observation that the waste crew typically spent the most time in the contamination area. Waste packaging activities were also likely contributors to the exposures.

Decontamination and decommissioning activities are significantly different from many other radiological activities normally encountered in the complex. The destructive nature of D&D activities may produce high levels of localized contamination and/or airborne radioactivity. When the D&D activities take place in facilities contaminated with plutonium, the challenges to a radiation safety program are especially great. Work place indicators may not be capable of detecting low levels of plutonium contamination on

equipment, materials, etc., or as airborne radioactivity. For example, while acute exposures at high DAC-hour levels should be detected readily, an exposure in the range of 10 to 20 DAC-hours protracted over a working year would not be detected by work place indicators.

In addition, urinalysis and lung counting do not have the sensitivity necessary to detect intakes of plutonium at the DOE investigation level of 100 mrem, while the analysis of fecal samples does offer the necessary sensitivity. Despite the sensitivity offered by fecal sampling, interpretation of the results, without a known intake event, is very difficult.

Although the exposures in question are low – ranging from 6 to 60 mrem, CEDE – the site takes its As Low As Reasonably Achievable goal and responsibility very seriously and will take corrective actions to reduce the chances of long-term low level exposures in the work place. However, even if all corrective actions are 100 percent implemented, it will not completely eliminate the low-level exposures received from performing work in a plutonium facility.

6.0 COMPENSATORY MEASURES

The following compensatory actions were initiated on November 29, 2000 after the Building 771 management became aware of the positive bioassay results for ten of the eleven individuals and suspended work to assess the situation. These actions were complete and/or ongoing when work was authorized to resume on December 12, 2000. The investigation team examined these actions to confirm they were ongoing or complete.

- All removed gloveboxes that have been staged for size reduction were contained in plastic sheeting. Weekly surveys of stored/staged gloveboxes for contamination were required.

- Fixed airhead results, CAM/SAAM alarm logs, air sampling trends, DAC-hour tracking, routine surveys, and key facility logs for the preceding three months were reviewed in an attempt to clearly identify the source of radioactivity in the fecal samples.

- The containments on cut process lines (piping) were re-inspected for proper containment and, if necessary, re-contained.

- Reemphasized the requirement to perform smoke-testing of airflow patterns after room configuration changes.

- Performed continuous low-volume air sampling in each room during D&D work, rather than just when respiratory protection was being worn.

- Radiological contamination surveys of the entire building floors and overhead areas were performed. These surveys identified several areas of contamination but they were in areas generally not worked and were not thought to be not high enough to have directly caused the intakes. A quarterly contamination survey of overhead

areas was added to the list of required surveys. A requirement that respiratory protection be worn for all intrusive work in overhead areas was implemented.

- The number of survey points was increased on routine contamination surveys.
- RCTs were briefed on the need to improve job coverage survey documentation.
- Respiratory protection was required for all waste transportation and packaging activities.
- Lapel air samplers were required for all workers involved in the Room 186 tent. Nasal and mouth smears were required for each worker exiting the Room 186 tent after wearing respiratory protection.
- Temporary lapel air samplers were required for one member of each work crew in Building 771.
- Supervisors, including RCT supervisors, were required to maintain logs.
- Toolbox training was provided to workers and RCTs on proper work practices for containing waste, for having RCTs present, and for wearing respiratory protection when handling, transporting and/or processing waste.
- Stop-work protocols and procedure hold-points were reemphasized to all personnel.
- Personnel were required to monitor anti-contamination clothing prior to doffing to address the possibility that higher than expected residual contamination may be present on the clothing. This requirement was discontinued on January 16, 2001 after results showed no increase in radioactivity levels.
- CAMs were placed at each of the two step-off pads. Building management discontinued this practice on January 16, 2001 after Radiological Engineering analysis of the data.
- An additional CAM was added in Room 186.
- An assessment of respirator cleaning, testing, training, issuance, and use was performed by the Site Industrial Hygiene organization. The results showed no shortcomings that would explain the uptakes.
- Each work crew was briefed on the Integrated Work Control Program and procedure compliance including Job Hazard Analyses, ALARA Job Reviews, and Radiation Work Permits.
- Since the investigation had not been successful in clearly identifying the source of the uptakes, respiratory protection was required to be worn for all D&D work activities until determined that it is no longer needed.

7.0 RECOMMENDATIONS

Training Recommendations Include:

- *Develop a Toolbox briefing for Site RCTs concerning the proper method to detect alpha contamination. This training shall include increased usage of large area wipes, increased use of the SAC-4, and guidance on the handling of wet swipes and surfaces.*
- *Incorporate the lessons learned from this investigation into the various modules of RCT and RCTTS continuing training.*
- *Develop a training package on improvements needed in radiological records and documentation and train RCTs and RCTTS in the modules of RCT Continuing Training.*
- *Develop an ALARA "Tool Box" briefing for D&D workers and First Line Supervisors that is similar to the Learning Objectives for the ALARA Training for Technical Support Personnel and that stresses the lessons learned from this investigation.*
- *Provide examples of key conditions to include during interpretation of smoke-testing data in Radiological Engineer Training. Develop and provide training.*
- *Provide awareness training for Radiological Engineers, Planners, Building Management related to potential radiological hazards that need to be considered and on engineering controls to mitigate the hazards.*
- *Train Radiological Engineers, RCTs, and RCTTSs on proper performance of smoke-testing.*
- *Hold a toolbox on changing hazard recognition to inform workers and first-line supervisors of the need to involve Radiological Engineering when radiological conditions change and/or when existing controls are insufficient to control demolition dusts. This training has been conducted and documented by the project.*

Procedure Recommendations Include:

- *Modify Site procedures to require independent Radiological Engineering review of the use of point sources as an engineering control.*
- *Require mock-up, smoke and velocity testing of any new ventilation designs prior to actual use.*
- *Modify Site procedures to require the optimal design of local ventilation controls. Require mock-up and smoke and velocity testing of any new hood designs prior to actual use.*
- *Modify the RWPs to evaluate the need for respiratory protection when handling laundry, low-level and transuranic wastes, when opening drums and TRUPACTs that contains these items.*
- *Modify RSPs*
  - *to require formal quarterly "During Work ALARA Job Reviews" for work activities covered by AJRs extending for more than 3 months.*
  - *to allow the RCTTS to determine release points on airflow pattern surveys with concurrence from the Radiological Engineer*
  - *to include documentation of vertical references for smoke release on airflow pattern surveys.*
  - *to include examples of configuration changes that require AME placement evaluation.*

- to include acceptable differential pressure range for air movers. Include note not to wet HEPA filters.
- to require that samplers in airborne contamination areas have properly controlled exhaust
- to provide prescriptive guidance of survey map quality regarding current configuration of room including equipment located within the room.
- to clarify requirements for determination, documentation and periodic inspection of face airflow velocity and air mover differential pressures
- to require the selective use lapel air samplers to confirm the results of low-volume job coverage air samplers

- Modify Site procedures to require electrical engineer evaluation of the adequacy of circuits used to support equipment used for radiological control.
- Modify other applicable procedures to clarify responsibility for performance of the Tent Inspection.
- Revise OO-771-197 to clarify responsibility for performance of the Tent Inspection.
- To evaluate the feasibility of modifying the actions for potential intakes

Engineering Controls Recommendations Include:

- Evaluate the use of "drop-down" or temporary ventilation exhaust points at or near to the elevation of the pre-D&D airflow exhaust suction points to maintain the high-to-low ventilation airflow path.
- Discontinue use of and disassemble the Room 186 Tent. Do not use the downdraft table until it has met the requirements in RSP-01.02.
- KH Radiological Engineering independently reviews new construction of D&D tents for design and ventilation considerations.
- Address the uncharacterized facility hazards through the use of improved survey techniques; placing increased emphasis on engineered controls; and institute the conservative use of Personal Protective Equipment (PPE) when conditions are unknown.
- Revise the Airborne Radioactivity Area posting level to 0.1 DAC.
- Increase the total airflow within the facility to the maximum practical. If unable to increase airflow, increase intra-facility air filtration through the use of HEPA filter equipped air-movers.

Programmatic/Administrative Recommendations:

- Site Radiological Protection group to evaluate site-wide return to posting/de-posting ARAs at 10% DAC and revise Technical Bases and procedures as appropriate.
- D&D supervisors should check to ensure that work to be performed is within the work scope of the AJR.
- Radiological Engineers should periodically tour the workplace and review work in progress for adherence to approved AJR work scope and ALARA opportunities.
- Investigate airflow pattern surveys and re-perform as necessary to ensure building ventilation and differential pressure is adequate for radiological controls (i.e., rooms being negative to corridor; airflow between rooms documented; and airflow going from RBA to CA).
- Evaluate requiring DAC hour tracking for all personnel wearing respiratory protection for radiological protection purposes.

- *Evaluate the Site process for DAC hour tracking for purpose of improving implementation and effectiveness and for providing supporting documentation for use on the assignment of dose.*
- *Enhance the DAC-hour tracking program to allow calculation of doses due to low-level protracted exposures.*
- *The contract with the company providing the fixed air head data should be re-evaluated to allow each building to receive the fixed air head data electronically, to allow easier trending of DAC values near the MDA.*
- *Implement requirements to contain staged glove boxes, survey of staged glove boxes and equipment, and perform surveys in the overheard periodically.*
- *Improve job coverage surveys and increase the number of survey points on weekly routine contamination surveys in the CA.*
- *Develop and provide specific guidance on the re-use of respirators.*
- *A scientific study using the current filters and as-built air flow rates should be conducted to empirically determine a self-absorption correction factor that takes into account filter loading from industrial grit associated with D&D activities.*
- *Implement the use of "Maslin Mops" (or equivalent) to maintain a cleaner work environment, minimize the build-up of dusts and debris, and detect low-level contamination.*
- *The central Radiological Engineering group should develop an evaluation process to supplement the internal audit program specified by 10 CFR 835.102.*
- *Assess the current work activities and current building configuration in Building 771 to determine applicability to the Building 779 lessons learned.*
- *Perform particle size and solubility studies to allow for more accurate dose assignments from DAC-hour tracking.*
- *Improve communications and coordination between operations and support personnel through adherence to ISM; defining roles and responsibilities; and increasing Radiation Protection staffing/support.*
- *Develop a Technical Basis addressing protracted low-level intakes.*

8.0 ATTACHMENTS

INVESTIGATION TEAM SIGNATURES

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776 Closure Project

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ACRONYMS

ALARA	As Low As Reasonably Achievable
AJR	ALARA Job Review
AKI	Annular Kinetic Impactor
APR	Air Purifying Respirator
CAM	Continuous Air Monitor
CCA	Configuration Control Authority
CEDE	Committed Effective Dose Equivalent
DAC	Derived Air Concentration
D&D	Decontamination & Decommissioning
DPM	Disintegration Per Minute
ECAQ	Extraneous Condition Affecting Quality
EES&QP	Engineering, Environmental, Safety & Quality Programs
ESH&Q	Environmental, Safety, Health & Quality
FR	Facility Representative
HEPA	High Efficiency Particulate Air
HIS	Health Investigation System
IAW	In Accordance With
IWCP	Integrated Work Control Program
LTA	Less Than Adequate
MDA	Minimum Detectable Activity
OASIS	Oxford Alpha Spectroscopy Integrated System
ORPS	Occurrence Reporting & Processing System
PAAA	Price Anderson Amendments Act
PAPR	Powered Air Purifying Respirator
PCM	Personnel Contamination Monitor
PF	Protection Factor
POD	Plan of the Day
RCT	Radiological Control Technician
RCTTS	Radiological Control Technician Technical Supervisor
RE	Radiological Engineer
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RIR	Radiological Improvement Report
RRPT	Registered Radiation Protection Technologist
RSP	Radiological Safety Procedure
RSSM	Radiological Safety Section Manager
RWP	Radiological Work Permit
SAAM	Selective Alpha Air Monitor
SCO	Surface Contaminated Object
SWB	Standard Waste Box
TEDE	Total Effective Dose Equivalent

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

December 1, 1993

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: J. W. Troan

SUBJECT: Report on the Radiation Protection Review at the Rocky Flats Plant

1. Purpose: This memorandum documents the Defense Nuclear Facilities Safety Board (DNFSB) technical staff and outside expert trip to the Rocky Flats Plant to review the Radiation Protection Program. The review was based on a visit to Rocky Flats on August 16-20, 1993.

2. Summary: The staff reviewed the Radiation Protection Program for consistency with Department of Energy (DOE) Order 5480.11, Radiation Protection for Occupational Workers, DOE Notice 5480.6, Radiological Control, and DOE Order 5400.5, Radiation Protection of the Public and the Environment.

   The Rocky Flats Plant Radiation Protection Program was considered by the staff to be adequate. The following are the significant staff observations:

   a. The staff noted that the Managing and Operating (M&O) contractor (EG&G, Rocky Flats Inc.) was working towards implementing the DOE Radiological Protection requirements of DOE Order 5480.11 and the DOE Notice 5480.6. Full compliance with the Radiological Control Manual (RCM) was originally planned to be achieved by October 1997. However, EG&G personnel indicated a commitment to achieve full compliance with the RCM by 1996. Plans developed to date do not give enough detail to justify the extended length of time it takes to achieve compliance. In particular, a majority of RCM Chapter 6 training requirements will not be completed until the July to September 1995 time frame. The Rocky Flats Plant (RFP) plan to accomplish RCM training is not consistent with the DOE's Implementation Plan for DNFSB Recommendation 91-6 , which committed to having General Employee Radiological Training, Radiation Worker I and II, and Radiological Control Technician training for all affected workers using the standardized core training material completed by December 1994.

   b The staff noted that a potential existed for workers to be exposed to radiation without being monitored in accordance with the Radiological Control Manual (RCM) and DOE Order 5480.11. In discussions with Building 771 personnel, it was noted that the Thermoluminescent Dosimeter (TLD) badge storage rack was being evaluated to determine the amount of radiation the dosimeters were exposed to while hanging on the rack. This evaluation was being accomplished as a result of RFP personnel

noting that two TLDs that hung on the rack for six months had received approximately 300 mrem. The DNFSB staff questioned whether any unmonitored workers had spent a significant amount of the workday in the area. RFP personnel noted that a guard station was adjacent to the area, and that the guards were not required to wear dosimeters on a routine basis. The radiation level in the guard area was not known at the time of the review, and was to be determined. If the radiation level in the guard's post is similar to that at the TLD storage board, exposure of guards to ionizing radiation may exceed the 100 mrem per year limit for those who are not monitored.

c. Subcontractors working at the plant did not appear to be totally integrated into some Radiation Protection Programs. Currently, their contracts do not require compliance with the RCM, but plans are to include this requirement at the next contract modification. The DNFSB staff did not find that the subcontractors were included in the plant's Radiation Protection As Low As Reasonably Achievable (ALARA) Program, and it was not clear that bioassays for subcontractors were thoroughly managed.

d. The plant's Radioactive Source Control Program has identified a number of sources that can- not be accounted for. There are 2,428 sources, and approximately 137 sources cannot be located. A semi-annual inspection was in progress at the time of the review. EG&G stated that many of these sources would have to be licensed under current Nuclear Regulatory Commission (NRC) regulation, if the NRC had jurisdiction.

3. Background: Department of Energy (DOE) Order 5480.11, Radiation Protection for Occupational Workers, DOE Notice 5480.6, Radiological Control, and DOE Order 5400.5, Radiation Protection of the Public and the Environment establishes the requirements for radiation protection for workers, the public and the environment, and provided the basis for the radiation protection review at the Rocky Flats Plant. These standards were used in the assessment of the program, work practices, training and knowledge level. Evaluation of the implementation of the Radiation Protection Program at Rocky Flats was achieved through review of the program at the Plant and Building levels, observations of practices in the field, and interviews with personnel. The following outlines the areas covered in the review:

A. Radiation Protection Standards Implementation,
B. Radiological Health Operations,
C. Radiation Protection Training and Qualification,
D. Personnel Interviews, and
E. Building Tours.

The review was conducted by: Dan Burnfield, Jim Troan, DNFSB Staff members, and Ted Quale, Outside Expert.

4. Discussion/Observations: Observations and discussions are

presented in the five categories relevant to the Radiation Protection Program.

a. Radiation Protection Standards Implementation

The state of the implementation of Radiation Protection Standards at the RFP varies among the buildings. Presently, there is an effort at the RFP to upgrade to the DOE Order 5480.11 standard, in advance of the RCM implementation.

There is one Compliance Schedule Approval (CSA) for relevant DOE Orders. Specifically, DOE Order 5480.11, Radiation Protection for Occupational Workers has one CSA, because EG&G Rocky Flats does not have a program for routine bioassay monitoring in place.

In the case of DOE Order 5400.5, Radiation Protection of the Public and the Environment, EG&G Rocky Flats personnel believe that EG&G Rocky Flats Inc. is in compliance, and Environmental Protection Agency (EPA) concurrence is expected for the compliance assessments that were submitted in December 1992.

Implementation of the requirements of the DOE Radiological Control Manual (DOE-RCM), that was promulgated by DOE Notice 5480.6, Radiological Control is in progress. The EG&G Project Manager responsible for the Radiological Control Manual (RCM) Implementation reported that the RFP was 43% administratively compliant with the DOE RCM, and that EG&G was working towards implementation. Compliance by subcontractors will be contractually invoked with the next modification to their contract.
DNFSB staff review of the RCM Implementation Plan revealed that technical justification was not always given for compensatory actions, or in the case of no compensatory actions when there was a non-compliance. In some cases the Plan states: "No additional compensatory actions beyond continued compliance with DOE 5480.11 and 5400.5 and other appropriate Orders or Directives are warranted." Adequate basis for this argument has not been stated, given that DOE Order 5480.11 has not been fully implemented at the RFP. The Plan was fairly detailed at a macroscopic or programmatic level, but instances of incomplete corrective action plans and schedule inconsistencies were noted. The Plan's implementation schedule does not show full compliance with the RCM until February 1998. However, EG&G personnel indicated a commitment to achieve full compliance with the RCM by 1996. Not enough detail is provided to substantiate this extended length of time to reach compliance. RFP personnel explained that the RCM Implementation Phase(s) during 1994 would result in the development of detailed plans to achieve full compliance. Key issues identified by RFP personnel associated with the RCM Implementation at the RFP are given in Attachment (1). A separate DNFSB Outside Expert review of the RCM Implementation plan identified that of all DOE sites, RFP had the greatest number of Articles in a "not in full compliance" status. Attachment (2) provides RCM Implementation Plan highlights.

b. Radiological Health Operations

1. DOE

The DOE Rocky Flats Office (DOE-RFO) Radiological Protection and Health Physics Branch consists of a staff of five, with a contractor support staff of seven.

2. Contractor

The Radiation Protection organization consists of approximately 500 personnel, of about 8000 personnel who work at the plant.

The RFP Radiation Protection Program implementation lacks consistency across the Plant. The Deputy Plant Manager stated that the Radiological Control Manual (RCM) implementation is the first step towards Radiation Protection standardization at the plant. However, the resource requirements that are currently defined may be underestimated. The Radiation Protection Director stated that although the plant has had funding cuts, none had been made in the area of Radiological Control implementation. Later in the review, EG&G personnel identified that the Radiation Assistance Program (RAP), a national DOE program had been defunded.

3. Performance Indicators

The Radiological Performance Indicators (PIs) showed a continued reduction in skin contaminations for 1991, 1992 and 1993. Examples of other PIs are given in Attachment (3). The performance indicators presented covered a majority of the suggested Radiological Performance Indicators topics that are identified by the RCM.

4. ALARA Implementation

(a) Plant Level

A program exists for maintaining radiation exposure As Low As Reasonably Achievable (ALARA) at the RFP. An ALARA Oversight Committee (AOC) has been established and advises the General Manager (GM) on the effectiveness of the ALARA effort and makes recommendations to strengthen the program. During the briefings by EG&G management, it was stated that the ALARA program had several areas of weaknesses. These include inadequate field implementation, inadequate training for management and radiological engineers and the failure to properly develop and communicate ALARA goals. Several observations made during the review strongly support this characterization. Attachment (4) provides observations concerning the ALARA Program.

A DNFSB Staff review of the RFP ALARA program, performed from March 29 to April 2, 1993, identified similar problems. The review also noted that the DOE-RFO Radiation Protection and Health Physics Branch was in the process of performing a comprehensive review of the ALARA program. Although little progress has been made toward correcting the deficiencies identified in the earlier DNFSB staff review, the DOE-RFO surveillance was completed and identified several fundamental problems with the ALARA program. EG&G is developing corrective action plans to resolve the surveillance findings. These plans have not been finalized and are not assessed here.

(b) RFP Buildings

The DNFSB staff reviewed the ALARA Program at the building level for several buildings through discussion with personnel and observations. In general, the staff found that some building ALARA programs were not effectively implemented. As expected, the shortcomings observed mirrored those noted at the plant level. One particular deficiency is that the ALARA program does not totally integrate subcontractors. (See Attachment 4).

5. Dosimetry

External Dosimetry Program - RFP personnel noted that the Whole Body Dosimeter Program passed the DOE Laboratory Accreditation Program (DOELAP) in 1990, and that the accreditation certificate was received in October 1991. RFP noted that the program's algorithm has been changed since the last accreditation, and that a wrong correction factor may have been applied in the case of the K17 dosimeter chip. In accordance with the DOELAP procedure, accreditation occurs every two years, and is expected to be accomplished this fall.

RFP personnel recognized that DOELAP accreditation does not test the capability of the dosimeter to respond adequately to the plant's various neutron radiation fields. Because of neutron field measurement uncertainties, RFP plans a field characterization study next year. However, RFP personnel feel that the current system is adequate in the interim since it tends to over-estimate the neutron dose.

A comprehensive Technical Basis Document (TBD) for the External Dosimetry Program is currently being developed. The RFP has received no guidance from DOE-HQ on how to prepare that document. RFP personnel stated that they viewed the purpose of the TBD as a means to document the framework of the program, and to state policy. The TBD is expected to be final in January 1994.

Of the 8000 personnel on site, approximately 5000 receive dosimeters. The criteria for requiring dosimeters is defined in Procedure HSP 18.07, with the Radiation Engineering Group making the determination of who to include.

RFP personnel stated that the Extremity (Wrist) Dosimetry Program was designed to meet the Draft DOELAP Extremity Dosimetry Program Standard. When asked who is required to wear extremity dosimeters, RFP personnel stated that the Radiological Building Engineer would be contacted and would make the decision. RFP personnel stated that there were no specific criteria, but that the question is asked during the Integrated Work Control Package (IWCP) process.

The Extremity (Finger) Dosimetry Program is under development. It is designed to meet the Draft Extremity Standard. Field testing is currently underway, and expected to be complete in mid FY 94.

The periodic turn-in of dosimeters for determining dose (dosimetry exchange) was discussed. A graph of dosimeter excharge versus date showed improvements over the last few

months. These improvements were attributed to holding personnel accountable, and to new procedures that have enforcement measures.

Internal Dosimetry Program - The Internal Dosimetry Program was discussed with the manager of the RFP Internal Dosimetry Program. It was noted that there is a TBD for the Internal Dosimetry Program, and that it is a controlled document.

The Internal Dosimetry Program is in transition from a program requiring each person on-site to participate in fecal sampling to a program requiring periodic urine sampling and lung counting, with a fecal sampling required when other conditions indicate an uptake might have occurred. A new procedure is in draft (revised HSP 18.20), and the program change needs FY94 funding. EG&G plans to have the new program in place by the end of 1993. Currently only one lung counter is operational, with a second lung counter to be in operation in the near future. It was stated that the equipment is old, and that a capital equipment project to replace it is funded. In addition two identical wound counters are in use.

Management of the bioassay program did not appear to be fully developed. RFP personnel noted during briefings that the Radiation Work Permits (RWP) do not stipulate the requirements for bioassay. Review by the DNFSB staff revealed that RWPs did provide a checkpoint to identify if pre- or post- exposure bioassay were required. The discussions did not make clear how contractors are included in the bioassay program. For example, when asked about other subcontractors, RFP personnel indicated that contractors may come and go and not be bioassayed. A deliberate delinquency tracking system does not exist, but delinquencies are identified by other means. There are plans to use a computer system to track and schedule bioassays.

Recurring operational problems with the on-site analytical lab affecting the plant's bioassay program were noted by RFP personnel. Problems include resource allocation and Resource Conservation Recovery Act (RCRA) issues. RFP management is currently establishing an off-site bioassay lab contingency, and interfacing with on-site labs to resolve problems and concerns.

6. Radiological Instrumentation and Equipment

Radioactive Source Accountability - DOE sites maintain radiation sources for the calibration of instruments and equipment, and to perform radiography. These sources frequently contain significant amounts of radioactivity. EG&G stated that many of these sources would have to be licensed under current NRC regulation, if the NRC had jurisdiction. RFP personnel reported that three to seven registered sources, and one-hundred-thirty accountable sources cannot be found at the plant. They plan to inventory database records against file records, cross check historical records against current records, archive all file records for sources that have been disposed of and create a mechanism to make contractors and subcontractors accountable for their sources. A semi-annual inspection is in progress. DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information, gives the requirement to report an "Unusual

Occurrence" in the event of loss of accountability of a radioactive source which exceeds the lesser value of exempt quantities as specified in DOE Notice N5400.9 (Sealed Radioactive Source Accountability) or State standards/regulations. The applicability of these reporting requirements were not ascertained at the time of the review.

Instrumentation - The DNFSB staff observed that EG&G had developed and documented a process for defining requirements and acceptance criteria for instruments and using it to establish the technical basis for selection of Health Physics Instrumentation. This program appeared to be well constructed and likely to result in properly defined equipment specifications. This procedure was prepared for EG&G Corporate Government Contracted and Operated Facilities, and its use may extend beyond Rocky Flats (i.e., EG&G Mound, REECo Nevada Operations, Idaho National Engineering Laboratory).

- Workplace Air Monitoring - RFP personnel described the Work Place Air Monitoring Program at the RFP as an integrated program consisting of seven elements ranging from Selected Alpha Air Monitors (SAAM) to bioassay. Air monitoring in the workplace at RFP is not in compliance with the requirements of the RCM. Specifically, the RCM Article 555, Airborne Radioactivity Monitoring, paragraph 5 requires that Continuous Air Monitors should be capable of measuring one (1) Derived Air Concentration (DAC) when averaged over eight (8) hours (8 DAC-hours) under laboratory conditions. SAAMs used at the RFP were stated by RFP personnel to have a sensitivity of approximately 42 DAC-hours. Improvements are planned and are expected to increase the SAAM sensitivity to approximately 8.5 DAC-hours. In support of this improvement effort, a pilot program has been completed in Building 707 Module J and Building 371. In addition to the sensitivity problem, SAAMs are no longer in production and the RFP relies on cannibalizing or replacing units from approximately 150 spare units held at the Plant. A Capital Project Air Monitoring Improvement Program is in place to support the air monitoring requirements for the future Decontamination and Decommissioning (D&D) work at the RFP. DNFSB staff review of the RFP RCM Implementation Plan identified that EG&G has not included the upgrade to meet the requirement in their Implementation Plan, but has taken an exception to RCM Article 555.

7. Radiation Work Permits and Procedures

Work Control and Planning - As RFP described it, the RFP radiological work control and planning process does not include methods to prioritize their work. Currently, there is more work than Radiological Operations can support. The workload is handled by overtime requests in building work packages. A Plant Priority System is scheduled for implementation in FY 94. This problem is expected to be temporarily exacerbated by further reduction in Radiation Protection Technicians (RPT) availability, when increased training requirements reduce RPT availability below 1993 levels.

Contamination Control - Radiological Operations personnel discussed contamination control at the RFP, noting key issues, and indicating improvement. Attachment (5) provides highlights.

8. Respiratory Protection

A briefing on the Respiratory Protection Program at the RFP was given by the Respiratory Protection Program Administrator (RPPA).

Training was discussed, and it was noted by the RPPA that: 1) training was in place for users of respiratory protection devices, 2) training has been developed for issuers of □ respiratory protection there is no training for some of the respiratory protection decision makers (i.e., the Radiological Building Engineers or Radiation Protection Technicians).

Although the RFP has a documented Respiratory Protection Program in place, it did not appear that the program was in complete accord with the RCM Chapter 5, Part 3 Respiratory Protection Program. The RFP RCM Implementation Plan identifies that the program elements within the requirements are not fully implemented, and schedules compliance with the RCM requirements (Articles 531 through 535) in March 1994. This completion date is not coordinated with specific corrective action plans. Specifically, a new Respiratory Protection Program is identified as a corrective action and is projected to take 720 days to complete, and training requirements are projected to take 365 days.
Why so much time is required to achieve compliance is not apparent.

c. Radiation Protection Training and Qualification

The DNFSB staff reviewed the Radiological Training Program for Radiation Workers, Radiological Protection Technicians and their supervisors. The program was in the process of being revised to meet the requirements of the RCM. It was noted that the modified training would require additional manpower.

General Employee Radiological Training (GERT), Radiation Worker Training (RWT) and Radiation Protection Technician (RPT) Training was noted by EG&G personnel as in compliance with DOE Order 5480.11. The Radiation Safety orientation module of the initial General Employee Training (GET) includes the RCM GERT material but tests are not tracked separately. GET Radiation Safety Modules for subcontractors and requalification, and RWT courses do not include the RCM core training materials. The RPT requalification course is being taught by using the Core modules. Radiation Protection Supervisors are required to attend RPT training and the Supervisors Academy. However, they are not required to receive additional technical training or demonstrate knowledge above the RPT level.

DNFSB staff review of the RCM Implementation Plan revealed that a majority of the RCM Chapter 6 training requirements will not be completed until July to September 1995. The RFP plan to accomplish RCM training is not consistent with the DOE's Implementation Plan for DNFSB Recommendation 91-6, which committed DOE to having General Employee Radiological Training, Radiation Worker I and II Training, and Radiological Protection Technician training for all affected workers using the standardized core training material completed by December 1994.

- The following highlights from discussion with EG&G and observations are provided:

  - Forty percent of the Radiological Operations Section Managers and foremen (supervisors) have attended the Supervisors Academy.

  - EG&G is anticipating that approximately 40% of RPTs will fail the RCM Training. Currently, the training work package budget considers 40% remedial training.

  - Building Radiological Engineers do not have position descriptions.

  - The glovebox training course provided to RPTs has not been reviewed or approved by radiological controls personnel. This course was prepared and is presented by personnel from the Job Specific Training Section of the Performance Based Training Organization.

  - RPTs are encouraged to pursue registration by the National Registry of Radiation Protection Technologist (NRRPT).

In light of the fact that RFP Radiological Protection Program training is not meeting the DOE Implementation Plan for Recommendation 91-6, the DNFSB staff considers RFP Radiological Training Program progress unacceptable.

d. Personnel Interviews

Personnel interviews to discuss radiation protection were conducted by DNFSB Staff. Employees interviewed were from the following categories: 1) Radiation Workers, 2) Radiological Control Technicians and 3) Radiological Controls Supervisor.

In general, employees were confident and knowledgeable about radiation protection commensurate with their position. Response to questions indicated that the radiation program discussed in the briefings was in place, or was in the process of being implemented.

e. Building Tours

Buildings 707, 771, and 881 were toured by DNFSB staff with RFP personnel. EG&G line personnel conducted the tour, made observations and compiled notes. Excerpts from the tours are provided in Attachment (6).

5. DNFSB Staff Follow-up

a. Follow progress made towards achieving RCM compliance.

b. Follow implementation of the computerized tracking and scheduling program for bioassay. Verify that it includes subcontractors who work at the plant.

c. Follow the progress made in resolving deficiencies associated with radioactive source accountability.

d. Examine the details and status of the RCM Article 555 exception.

e. Review the progress of the RFP implementation of the SAAM Improvements and the Capital Project Air Monitoring Improvement Program.

f. Review the results of the Building 771 radiation survey taken in the vicinity of the Ladies Locker Room, Guard Post and TLD Storage Rack.

ATTACHMENT (1) ROCKY FLATS PLANT
KEY ISSUES FOR RADIOLOGICAL CONTROL MANUAL IMPLANTATION

Key issues associated with the implementation of the are:

1. Integration of Radiation Worker and RPTs will require a significant development effort, and student training times will increase. For example, RPTs initial training will increase from 8 weeks to 26 weeks, and requalification will increase from 2 weeks to 12 weeks.

2. Physical Facility Modifications will be required because the proximity of dress out and removal facilities to RCA entrance does not exist in most facilities, and step-off-pad arrangements are not readily supported with existing accommodations. In addition, current laundry capacity may not be capable of supporting layered clothing.

3. Capital Equipment funds are extremely limited, and compliance with other requirements (RCRA) has higher priority in allocation of available funds.

4. Conversion of historical exposure data to Committed Effective Dose Equivalent (CEDE) requires a significant effort (10 person-years). The conversion process will be complicated since depositions were originally quantified in terms of activity (% organ or % body burdens), and by the fact that dose information from other sites is not in the system.

5. Change in the Radiological Operations culture will include: 1) conversion to "Safety" over "Production," 2) individual worker and line management acceptance of responsibility for radiological control, 3) confusion and/or complacency in workers because of rapid and extensive change in requirements, and 4) development of credibility of Radiation Protection with external groups and workers.

6. Schedule - Full compliance by 1996 is considered extremely challenging. The down-sizing of the site as part of mission change creates significant competition for resources. Significant additional upgrades are required. Training must incorporate requalification requirement.

7. Staffing - Reduction in force requires maximized utilization of displaced resources to fill staff openings. Existing resources have a limit with respect to being matched

to resource needs, and the schedule does not facilitate retraining.

Attachment (1)□

ATTACHMENT (2) - RCM IMPLEMENTATION PLAN HIGHLIGHTS

The Rocky Flats Plant (RFP) Radiological Control Manual (RCM) Implementation Plan
was reviewed and the following highlights are provided:

A. RCM Compliance Status:

□ In compliance with 45 items (22.4%).
□ Non-compliant with 156 items (77.6%).
□ No items were identified as Not-Applicable.

Note: Items include Articles (with numbers), Text sections which follow a chapter part but precede a numbered article and Tables which contain requirement statements. Requirement statements are specific and implied "shall" and "should" statements.

B. Exceptions:

Article 521, Internal Dosimetry
Article 555, Airborne Radioactivity Monitoring

C. Approval Status:

Implementation Plan noted by EG&G as approved by DOE with comments.

D. Compliance Schedule:

Refer to the following page(s).

Attachment (2)□ ATTAC

Attachment (3)□ ATT

ALARA Program Performance Indicators were presented in the following areas: 1) Personnel Cumulative Radiation Exposure, 2) Confirmed Intakes greater than 100 mrem CEDE, 3) Skin/Clothing and Area Contaminations and 4) Number of Individuals Exceeding Administrative Dose Guidelines (ADG). The following observations were made during the review:

1. The Operations Management for one building was not able to recall either the five categories of ALARA goals or what the specific goals were for their building for 1993.

2. Although the liquid waste treatment facility is operating essentially at capacity, little if any successful effort has been initiated to reduce the generation rate. This situation is not being addressed as one of the ALARA program goals.

3. Despite the fact that subcontractors do a significant amount of radiological work, they are not totally included in the site's ALARA program.

4. During tours of various facilities it was noted that ALARA information posted on bulletin boards was not current, and in some cases, was incomplete.

5. The method used for development of ALARA external exposure is without a strong foundation. Typically, the estimate of the

previous year's external exposure total is simply factored down by 10 %. Allowances are not made for changes in work load or personnel staffing from year to year. Major changes in work assignments can significantly affect a groups external radiation exposure for a year. However, provisions apparently do not exist to adjust a goal during the year to account for these changes. These issues limit the usefulness of the goals as a management tool.

The EG&G collective dose for 1st and 2nd quarter 1993 was equal to 56 and 82 person-rem respectively, and exceeds the EG&G cumulative dose goal of 100.

The EG&G collective dose 1992 total was 231 person-rem, and the 1992 goal was 157. EG&G is working to determine the reasons for the difference. During briefings, EG&G personnel gave four reasons for last quarter CY 92 increase above goal. These were:

1) material moves in Bldg 991;
2) on-line work in Bldg 707;
3) dose reconstruction for 1992; and
4) data base programming problem.

Attachment (4)□ ATTACHMENT

1. Past practice was to shut down buildings without lay-up, but currently a Transition Program has been implemented in Building 865.

2. Implementation of engineering controls was described as "in infancy." Engineering controls, such as glovebags on ventilation plenums, are being used in Building 707.

3. In the past there was a lack of timely closure of Radiological Deficiency Reports (RDRs). Some RDRs have remained opened for up to 2.5 years. Recently, the data entry backlog has been eliminated, the number of outstanding RDRs have been reduced by 10% over previous years, and further improvements are planned.

4. Radiation Work Permit compliance lacks positive control from non-Integrated Work Control Procedure, and lacks control of external dose. RFP personnel plan to move the RWP Issue Point to Radiological Control Area (RCA) step-off pads, revise procedures to minimize redundancy, purchase computerized access control programs (pending funding), and implement the use of direct reading dosimeters.

5. Radiological Building Engineers were noted as needing additional training in the conduct of ALARA Reviews, and action plans have been developed to provide specific training in ALARA Reviews.

Attachment (5)Σ ATTAC

Buildings 707, 771, and 881 were toured by DNFSB staff with RFP personnel. EG&G line personnel conducted the tour, made observations and compiled notes. Excerpts from the tours are provided below:

Building 707

A large number of radiological deficiencies were identified during the tour. This was especially surprising as EG&G personnel had inspected the building in preparation for not only this tour, but for a preceding tour by members of the DOE Office of Nuclear Safety (ONS) Team.

Several of the deficiencies noted in the August 1993 tour were observed again in September 1993 during a return visit by the DNFSB OE.

Examples of deficiencies observed in August 1993 included:

1. Radiation areas were not shown on survey maps posted at the entrance to modules within the building.

2. Contamination areas were not shown on survey maps posted at the entrance to modules within the building.

3. Differences were noted between radiation levels recorded on survey maps posted at the entrance to modules and those posted on radiation area signs within the module.

4. Radiation survey data was not available for the area of a glove port with the shield open.

5. The contamination containment wrapping on one large contaminated item was not completely taped in place and therefore was not sealed.

6. A Radiation Area sign in the J-Module referred to a radiation area in the overhead. It could not be determined from the sign where in the overhead the Radiation Area was. Scaffolding in the area allowed access to the actual Radiation Area without passing the sign, and effectively rendered the Radiation Area un-posted.

7. Not all information required to be provided on a survey map was filled in.

Attachment (6)

Building 771

1. The Building ALARA Program does not include subcontractors (i.e., J. A. Jones).

2. Higher than usual radiation exposure was noted by RFP personnel for people who store their TLDs at the TLD Board near the Ladies Locker Room. Radiation levels were estimated at approximately 300 milli-rem over a 6 month period. During discussions it was noted that Wackenhut Security Guards in an adjacent vestibule were not required to wear TLDs. EG&G personnel stated that they plan to study radiation levels in these areas.

3. A Radiation Protection Technician (RPT) was observed working at an entrance to Airborne Radioactivity Area. No step off pads were used at entry/exit point, as required by RCM Art. 335.4.

4. Storage of chemicals appeared to be uncontrolled. The following are examples: H_2SO_4 was stored apparently for use for a system that was out-of-use, a container (drum) of paint thinner appeared to be waste, and a Chemical Storage Cabinet was in need of an inventory.

5. Vacuum cleaners that were located in the RCA were not outfitted or marked in accordance with the RCM requirements (Art. 464).

6. Fire extinguisher throughout the building were overdue for periodic inspections.

7. Announcements made on the building's Public Address System were sometimes inaudible.

8. Frisking at exit from the RCA was rapid (typically less than 2 minutes), and did not conform to the requirements of the RCM requirements (RCM, Appendix 3D).

9 . Radiological control requirements varied within the RCA. The tour group was required to wear protective gloves, while personnel in a Control Room (without frisking equipment at the entry/exit point) wore no protective gloves.

Building 881

1. The DNFSB staff had no comments.

Attachment (6)