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Uranium Mill Appraisal Program

U.S. Nuclear Regulatory Commission

R. J. Everett, C. L. Cain

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ABSTRACT

This report describes the results of special team appraisals at NRC-licensed uranium mills in the period May to November 1981. Since the Three Mile Island accident, NRC management has instituted a program of special team appraisals of radiation protection programs at certain NRC-licensed facilities. These appraisals were designed to identify weaknesses and strengths in NRC-licensed programs, including those areas not covered by explicit regulatory requirements. The regulatory requirements related to occupational radiation protection and environmental monitoring at uranium mills have been extensively upgraded in the past few years. In addition, there was some NRC staff concern with respect to the effectiveness of NRC licensing and inspection programs. In response to this concern and to changes in mill requirements, the NRC staff recommended that team appraisals be conducted at mills to determine the adequacy of mill programs, the effectiveness of the new requirements, and mill management implementation of programs and requirements. This report describes the appraisal scope and methodology as well as summary findings and conclusions. Significant weaknesses identified during the mill appraisals are discussed as well as recommendations for improvements in uranium mill programs and mill licensing and inspection.

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I. PROGRAM DESCRIPTION AND SUMMARY CONCLUSIONS

A. Purpose

The purpose of the Uranium Mill Appraisal Program was to evaluate the overall adequacy and effectiveness of each NRC-licensed uranium mill program for the radiological protection of workers, the public, and the environment. NRC inspection programs in the past have been more compliance-oriented along discrete subject areas; whereas, the appraisal team approach was directed into broad areas where explicit requirements did not exist. The goal of the appraisal effort was to evaluate programs in terms of capabilities and performance and to identify significant weaknesses within the program. Although the appraisal effort was not compliance-oriented, violations of NRC requirements were identified and a written response from the licensee was required. The appraisal approach does not imply that violations of requirements are unimportant but perhaps indicative of a deeper problem. The appraisal effort also identified some excellent programs within the overall radiation protection function and documented these findings in the appraisal reports or in letters to uranium mill licensees.

In the identification of program weaknesses, there was no intent to force NRC licensees into commitments in excess of legal requirements. However, in order for the benefits of the appraisal to be accrued in terms of real and assured radiation protection to workers and the general public, licensees were asked to respond to the NRC in terms of specific actions that would be taken to strengthen the weaknesses identified. This approach is consistent with the high level of performance and capability expected of the nuclear industry. The ultimate benefits expected of the appraisal effort were to increase assurance that workers and the general public are being adequately protected and to provide information to the NRC that could be used to structure a more effective licensing and inspection program.

B. Appraisal Scope and Implementation

The Mill Appraisal Program involved two appraisal teams each consisting of one NRC inspector as team leader, one health physicist from the NRC's Uranium Recovery Licensing Branch, and two health physicists from the Pacific Northwest Laboratory,* a contractor to the NRC. Team members were selected based upon their experience and training in the uranium milling industry and were assigned subject areas that matched their experience. The appraisal effort included team preparation through study of each mill site prior to the visit, a 1-week appraisal effort at the site, and a 1-2 week report-writing period. Appraisal findings were presented to mill management at the conclusion of each site visit.

The appraisal effort was structured along the following major topics:

1. Organization, Management, and Training

a. Organization Structure
b. ALARA Program
c. Effectiveness of Radiation Safety Function
d. Communications between Radiation Safety and Operations Components
e. Worker Training

2. Internal Exposure Control

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b. Air Sample Analysis
c. Personnel Exposure Determination
d. Respiratory Protection
e. Urine Bioassay
f. In-vivo Bioassay

3. External Exposure and Contamination Control

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d. Product Transport

*PNL is operated for DOE by Battelle Memorial Institute.

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d. Seepage
e. Embankment Inspections

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b. Ambient Air Sampling
c. Meteorology
d. Direct Radiation
e. Groundwater
f. Surface Water, Soil, and Vegetation
g. Laboratory QA

Fine structure was also developed in each of these major areas to ensure that all significant items were covered. Acceptance of a particular program as being acceptable was judged against NRC Regulatory Guides, NRC branch technical position letters, 10 CFR 20, and generally accepted good health physics practices. Although these documents provided criteria for acceptance, many areas required the collective professional judgment of the appraisal team. A conclusion as to adequacy was made for the six major headings above. If the licensee's program was good, the appraisal team found that major subject area acceptable. Only those weaknesses judged to be significant were formally identified to the licensee for his response. Weaknesses of a lesser nature were identified in the body of the report as items that the licensee should consider in strengthening a program.

C. Summary Conclusions

Summary conclusions were based upon appraisal findings at the 10 mills appraised and the collective experience and judgment of the appraisal teams. It would be desirable to be able to state that the correction of a particular program weakness would result in a definite reduction in worker exposure. This is not possible, but the assumption is made that a stronger radiation safety program gives greater assurance that worker and public exposures are As Low As Reasonably Achievable (ALARA) and well within regulatory limits. Another assumption is that present regulatory limits and control levels are adequate to provide reasonable assurance that a worker's health is protected. Consequently, appraisal findings are based upon each licensee's ability to meet these regulatory limits with confidence as judged by the appraisal team.

Uranium mill regulation has undergone a general tightening of requirements and insistence upon more comprehensive radiation safety programs in the past few years similar to those of other nuclear facilities. This has been met with strong-to-moderate resistance from the industry. It is difficult to convince a uranium mill manager that each worker must monitor upon leaving the site, when he recalls past practices at some mills where workers left the site with visible yellowcake on their shoes and clothing. Some mill managers have made considerable progress in modernizing their mill in terms of engineering controls, comprehensive safety programs, and employment of qualified safety professionals. Other mill managers are slow to change. With few exceptions, mill operators have been able to conduct their operations well below worker exposure limits as set forth in 10 CFR Part 20. Calculated exposures in excess of the weekly limit for soluble uranium have occurred on occasion in the past and were generally acute exposure situations arising from some incident. Exposures in excess of the quarterly limit for insoluble radionuclides have been rare. One occurrence in July 1980 should be pointed out so as to alert mill radiation safety officers of this phenomena. The rubber lining of ion exchange cells appear to preferentially collect radium-226. The replacement of these linings without proper respiratory protection could lead to significant worker exposure. The used linings stored at the site also present significant external radiation levels.

The mill appraisal effort revealed weaknesses in programs related to worker and public health radiation safety. Most significant weaknesses were identified in the areas of organization, management, training and internal exposure control with weaknesses identified in 7 out of 10 mills appraised. Weaknesses in contamination control programs were identified in 5 out of 10 mills appraised and 4 out of 10 in environmental programs. Weaknesses in facility and process control were identified in 2 out of 10 mills and no weaknesses were identified in the mill tailings area. With an exception of the last area, recommendations are made for improvements in each of the other major areas in the body of this report. These recommendations are addressed to mill licensees, NRC uranium mill licensing and NRC standards. With respect to NRC inspection activities at uranium mills it is recommended that NRC increase its contact time with licensees either by increasing inspection time for the annual visit or instituting multiple visits to the facility. This is considered necessary due to the increased complexity of licensee programs and the sheer volume of data and other information to be covered. Further, it is recommended that the appraisal team approach be used every 3-4 years in order to accrue the benefits of the appraisal approach. Significant weaknesses should be corrected and recommendations implemented in order to meet the high standards expected of the nuclear industry and to give the NRC and the general public increased confidence that mill workers and the public health are being protected.

Engineering controls applied in varying degrees among mills have been effective in exposure reduction. Additional applications of engineering controls, process changes, and methods of operation could be made. Other changes should be considered as part of an effective ALARA program. Since the major hazard at uranium mills is exposure to soluble yellowcake, efforts to enclose, automate and collect effluents from yellowcake drying and packaging operations appear to be the most significant area for attention.

In reviewing those mill programs considered to be good, three main ingredients were present. A management attitude existed that saw beyond merely meeting regulatory requirements but insisted upon and encouraged the development of a quality program with health and safety consciousness among all employees. Second, the qualifications and training of the radiation safety officer (RSO) are of prime importance. A qualified RSO can often conduct a quality program even with a minimum of manpower, equipment, and full management support. Lastly, most licensees had implemented some portion of an ALARA program, usually not formally documented; and engineering modifications, procedural changes and housekeeping efforts had been used to provide contamination control and reduce personnel exposure. More formalized additional efforts are desirable. The weaknesses identified in ALARA and worker training programs indicate lack of management attention and commitment to these areas. Management attention and improvements in these programs could result in further exposure reduction, improved worker education and attitude, and a positive effect upon other mill programs. Licensee management is responsible for and has a major role in the further development of radiation protection programs. The NRC is obligated to provide timely guidance in the form of Regulatory Guides and technical positions so that quality programs can be developed.

II. DETAILED FINDINGS AND RECOMMENDATIONS

The results of the mill appraisal program indicated that although the overall health and safety programs were adequate at the mills, a number of significant weaknesses did exist at many of the currently operating facilities. Summaries of the most significant and most frequently identified weaknesses are discussed in the following sections, each of which is identified with the six major areas used in the appraisal program. Also identified are specific recommendations for improvement for each section. These recommendations are presented not only for licensee action, but also for NRC standards development and licensing action.

A. Organization, Management, and Training

1. Appraisal Findings

Significant weaknesses in the area of organization, management, and training were identified at 7 of the 10 facilities evaluated. These weaknesses are described below:

a. Organization Structure

Generally, the appraisers found that the mill radiation safety organizational component reported to the site manager independently of other components. Only one mill had an organization structure which was likely to result in conflict of interest between radiation safety and an operational component. This mill had appointed a single individual to assume the responsibilities of both RSO and mill metallurgist, which included responsibility for ore lot and product assay. In this instance metallurgical responsibilities resulted in insufficient devotion of time to radiation safety duties.

There were several mills, however, where the overall responsibility for tailings management, environmental monitoring, respiratory protection, or fire protection was not centralized under a single individual. Several components shared responsibility in each of these areas, but no single individual coordinated the overall effort. Thus some elements were being duplicated by separate components, and more seriously, some elements thought covered by another component were actually not performed at all. Those mills which had no such problems usually placed the responsibility for all licensed activities under the RSO rather than apportioning them among several department heads.

There were also several mills where no authority had been delegated to the RSO to suspend or modify work activity that could be potentially hazardous to workers or that was in violation of the license. Some mills had

indicated in their license application or procedures that such authority existed, but the appraisers found that exercise of that authority had often been inhibited by mill management or had never been tested by the RSO or his subordinates.

b. Formal ALARA Program

The appraisals revealed that most mills had not established a formal program with an aim to reducing radiation exposure to ALARA levels. Some mills had issued ALARA policy statements in their license applications or in written procedures, but few had communicated program commitments to mill workers. Most mills that had an ALARA program had not performed exposure trend analyses to verify program effectiveness. Most of the mills had only briefly reviewed the draft Regulatory Guide entitled "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable" (Task OH 941-4 dated August 1980) and had only implemented those features that had been previously required by license conditions.

Many of the mills had been required by license condition to perform routine audits and inspections in order to identify means of reducing exposure, but generally these were found to be license compliance audits only. There was virtually no evidence of workers communicating ALARA suggestions to management, nor of management including ALARA as an element of the job performance appraisal for line supervision. These factors were indicative of licensee management complacence in regard to the ALARA effort and evidence that an effective ALARA program is directly attributable to a firm management commitment and involvement in this area.

Only a few mills had established written procedures for the radiation safety and environmental monitoring functions. Many of these procedures were of limited detail containing only a duplication of information submitted in the license application. The appraisers expressed concern that failure to fully proceduralize in detail the developed programs would jeopardize continuity of these programs, if key personnel were to leave the organization, or at least cause difficulty for one required to sustain licensed radiation safety or environmental monitoring activity during temporary personnel absences. One licensee site manager stated that he was reluctant to formulate detailed procedures for fear that he would be cited by NRC, if he failed to follow at all times the precise requirements of such procedures. The appraisers explained that current license conditions requiring procedures specify only that they be reviewed and revised as necessary every 1 or 2 years. NRC has never cited a mill licensee for operating contrary to a procedure as a result of changes that occurred during that interval. Most of the procedures that did exist were not subject to formal review, approval, and revision features.

c. Effectiveness of Radiation Safety Function

The appraisers found that many members of the radiation safety staffs were deficient in terms of health physics training, even though none failed to meet the formal education and experience requirements of the aforementioned draft Regulatory Guide. Many of the RSO's were found to be performing the requirements stipulated in the license conditions and regulations without understanding the underlying technical rationale for these requirements. As a result, many parameters had been analyzed in great detail, while other more important concerns had never been addressed.

Communication between the radiation safety component and the operations components was not often well established. As previously noted, many of the radiation safety components did not have written procedures. Similarly, there were few mills that had established operational procedures which contained radiation safety guidance for routine operational tasks such as product barrelling. The radiation safety component was seldom included as a party for review for such procedures prior to issuance. Some RSO's stated that they were not routinely included in planning efforts for mill maintenance or modification. While most mills lacked radiation safety guidance incorporated into operations procedures for routine tasks, a work authorization (radiation work permit) system had been established for nonroutine work such as maintenance. The major weakness in these systems, however, was the failure to provide sufficient guidance to operations components as to when the special assistance of the radiation safety component was necessary and a work authorization should be initiated.

d. Worker Training

The appraisers found that all mills had training programs that included the elements identified in 10 CFR 19.12 and Section 2.5 of the draft Regulatory Guide OH 941-1. However, interviews with workers revealed that most were unfamiliar with even the most basic radiation safety practices. There also seemed to be little difference in basic radiation safety knowledge between the worker who had been employed at the mill for many years and the recently hired, inexperienced worker. This occurrence seemed to be directly related to management lack of attention in stressing the importance of training of all its workers.

The appraisers found that a contributing factor appeared to be the weak refresher training program which existed at many mills. Typically, a single session was presented only annually for approximately 1 hour and consisted of a basic lecture. One of the better programs reviewed required all workers to attend a monthly class where a single topic was presented by the RSO. The total refresher training course was presented

through 12 monthly classes on various topics and was thereby repeated annually. The instructor utilized audiovisual aids, written handouts, and an exam at the end of each session.

Most of the mills were operating on back shifts, when a member of the radiation safety component was not onsite for assistance or to audit work in progress. The mills usually relied upon the shift foreman to assure that radiation safety rules, such as the proper use of respirators, were followed. Generally, these foremen had not been given radiation safety training beyond that of other mill workers.

2. Recommendations

a. Licensee management should provide evidence of its support for the ALARA effort and the training of all workers. This should not be accomplished by directives alone but should include allocation of proper resources as well.

b. Licensees should establish a clear assignment of centralized responsibility at the mill for such areas as training, tailings management, environmental monitoring, respiratory protection, and fire protection.

c. The draft Regulatory Guide entitled "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable" (Task OH 941-4 dated August 1980) should be issued by the NRC as soon as possible to provide needed guidance to licensees. Section 2.1 of the Guide should be revised to state that the RSO or his designate should have both the responsibility and the authority to suspend work activity. Licensees should fully implement the stipulations in the Guide. Since many licensee personnel responsible for licensed activities, particularly the RSO, were lacking in health physics training, Item 4 of Section 2.4.1 of the Guide should be amended to require more specialized training than that indicated.

d. License conditions should require licensees to develop substantive written procedures which do not simply restate commitments in the license application but provide sufficient detail to add continuity to a radiation safety component in the event of staff changes. Licensee deviation from the detailed provisions of these procedures should not be cited as violations by the NRC as long as procedures are revised no less than once every 2 years and provided the changes do not significantly degrade the quality of radiation protection.

e. Each licensee should be required to develop, document, and implement a detailed ALARA program including in-house action levels. This

requirement should be similar to the ones required of medical licensees.*

f. Licensees should be required to facilitate formal advance review and approval by the radiation safety component of all work which could result in significant exposure to radioactive materials. These approvals should be documented by use of Radiation Work Permits for special work or by use of approved Standard Operating Procedures for routine tasks.

g. The licensee's RSO should be required by license to be a part of advance licensee planning meetings relating to plant modification or maintenance in order to better assure that ALARA elements are included in such planning.

h. Licensees should be required to provide additional training to those individuals who are responsible for radiation safety activities on back shifts.

i. Refresher radiation safety training should be presented in a more effective manner in order to assure that workers gain sufficient understanding of the essentials of radiation protection.

B. Internal Exposure Control

Significant weaknesses in the area of internal exposure control were identified at 7 of the 10 facilities evaluated. These weaknesses are described below.

1. In-plant Air Sampling and Exposure Determination

a. Appraisal Findings

All mills were found to have established an air sampling program to evaluate airborne particulates including soluble uranium (yellowcake), insoluble uranium (ore dust), and radon daughters. Most sampling had been performed through the use of low-volume grab samplers or personal lapel samplers. Uranium content of samples had been determined by fluorometric or radiometric analysis, and radon daughter analysis had been performed using a modified Kusnetz method. Most mills had neither determined nor applied the particulate collection efficiency or alpha absorption factor of air sample filters.

Some of the mills were found to be obtaining samples under conditions which were not representative of those concentrations inhaled by the

*Reference letter to all NRC medical licensees from Office of Nuclear Material Safety and Safeguards dated June 16, 1980.

worker. Often, little consideration was given to placing the sampler at a location that would closely approximate the location or breathing zone of the worker. Also, the operational status of the mill was sometimes ignored during the sampling period; that is, routine samples were taken at a set hour each week regardless of whether the subject mill circuit was in operation. Thus, some samples were taken when the circuit was shut down and airborne dust concentrations were minimal. Sample records were often found to be incomplete in that they not only failed to indicate mill status during sampling, but also omitted the sample performer, the equipment used, and the precise location where the sample was obtained.

Some mills performed no area air sampling but depended solely upon personal lapel samplers worn by workers in key mill areas. Generally, this method was found to report higher worker exposures than the area sampling method and was preferable since it was more representative of work zone air concentrations. However, failure to additionally perform area sampling resulted in inability to properly characterize and post each individual area.

In an effort to simplify posting of airborne radioactivity areas (ARA's), many mills had displayed ARA signs at every mill building entry point, even though most areas within the building did not qualify as ARA's as defined in 10 CFR 20.203(d). Therefore, in these cases there were no postings in the proximity of true ARA's such as the yellowcake drying and packaging area and the ore crushing and storage area. Thus the intended purpose of the sign--to warn workers that they were entering areas of high airborne concentrations of radioactive material--was defeated.

All mills were found to have established intricate systems for calculating and reporting worker internal exposure as determined from sample data. Some mills utilized computer programs; others performed the task manually. Normally calculations were performed for each individual to determine his standing in regard to the weekly exposure limit for soluble uranium, the quarterly limit for insoluble uranium and various other radionuclides such as radium-226, and the annual limit for radon-222. Some licensees had been confused by the draft Regulatory Guide entitled "Health Physics Surveys in Uranium Mills" (Task OH 710-4 dated August 1980) which contradicts earlier guidance and current regulations by inferring that ore dust exposure should be included with yellowcake exposure in determining a worker's standing in regard to the weekly exposure limit. A second contradiction also exists relative to exposure determination for radon daughters. Whereas 10 CFR 20.103 stipulates an annual exposure limit for radon, the draft Guide indicates that it should be considered together with insoluble uranium in determining a worker's standing in regard to the quarterly limit. The appraisers found that 10 CFR 20 also did not clearly present regulatory limits in a straightforward manner. For example, limits pertaining to radon daughters and soluble uranium were to be found only in footnotes to Appendix B of Part 20.

The appraisers found no uniformity among licensees in regard to units of measurement and methods for determining worker exposure. Some mills reported exposure in terms of concentration-time, while others used MPC fraction-time, intake activity, concentration, or fraction of regulatory limit. Airborne radioactivity concentrations were reported in mixed combinations of microcuries or micrograms with milliliters, liters, or cubic meters. Appraisers encountered more than a dozen different units of measurement for concentration alone. Time units included hours, days, weeks, months, quarters, and years. Methods of calculating exposure also varied widely.

Trend analysis and comparison of exposure data with bioassay data were seldom performed.

Certain classes of workers at some mills had not been included in the exposure determination program. Mill foremen, laboratory technicians, and radiation safety personnel were commonly omitted. Often these personnel were not included in any of the bioassay programs either, but were engaged in work which could result in exposures in excess of 25% of regulatory limits.

b. Recommendations

(1) The draft Regulatory Guide entitled "Health Physics Surveys in Uranium Mills" (Task OH 710-4) should be revised and issued as soon as possible and should stipulate the format and content of records to be maintained by mill licensees. It should include sample record forms to assist in the standardization of exposure records and units of measurement. The Guide should also clarify exposure limits and reconcile any contradictions with 10 CFR 20.

(2) Licensees should review air sampling methods to assure that measured concentrations are representative of that inhaled by the worker. Consideration should be given to mill operational status at the time of sampling, and samplers should be located at head height at anticipated worker locations and orientations. Data records should report all sample particulars including mill status, surveyor, equipment used, and location and orientation of equipment.

(3) Licensees should post only those areas which truly are airborne radioactivity areas as defined in 10 CFR 20.203. The posted areas should not encompass those areas which do not fall within the regulatory definition on an ARA. Postings should be placed with the goal in mind of warning workers of those areas where airborne radioactivity is a special hazard. Where lapel samplers are the means of determining worker exposure, area sampling should also be performed in order to determine posting applicability.

(4) Licensees should determine and apply correction factors pertaining to sample filter collection efficiency and alpha absorption as applicable.

(5) Licensee's should perform trend analyses of generated data in order to determine effectiveness of ALARA efforts. Trend analyses results should be substantiated through comparison with similar trend data performed for bioassay data.

2. Respiratory Protection

a. Appraisal Findings

The appraisers found the following three levels of respiratory protection usage at uranium mills:

(1) no use of respiratory protection

(2) use of respiratory protection under a qualified program in accordance with Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection"

(3) use of respiratory protection under a program lacking many of the elements required by Regulatory Guide 8.15 while taking no credit for respirator use in exposure calculations.

Most mills had adopted the third mode which permitted them to gain certain advantages, while maintaining their program free of regulatory control. Use of the equipment had afforded licensees some protection from airborne contaminants as evidenced by bioassay data. In some cases licensees had successfully used this bioassay data to refute air sample exposure data indicating worker exposure in excess of the weekly limit for soluble uranium.

Although perhaps affording the worker some radiation protection, use of respirators without compliance with certain stipulations in the Regulatory Guide was identified as hazardous relative to other aspects of worker safety. For example, most of the mills utilizing respiratory protection in the stated manner had not performed determinations on personnel to assure that they were physically able to perform the work while using such equipment. Some mills had also not established a program to assure proper cleaning, disinfection, decontamination, inspection, repair, and storage of equipment. Thus workers were more readily subject to potential hazards such as infection and malfunction of equipment. When supplied-air respirators were used in conjunction with in-plant air compressors, there had been no determination to assure the quality of the breathing air. Although several appraisers theorized that workers might develop a false sense of security, be more inclined to increase work times in ARA's, and

thereby increase exposure through use of respirators in an unapproved program, a review of exposure records did not appear to substantiate this position.

b. Recommendation

Licensees who use respiratory protection equipment in conjunction with a program that does not meet the specifications of Regulatory Guide 8.15 should be required by NRC in all cases to meet the following minimal standards:

(1) A program should be developed to assure the full effectiveness of equipment through cleaning and disinfection, decontamination, inspection, repair, and storage. (Reference Regulatory Guide 8.15, Section C.4.d.)

(2) Prior to assignment of a worker to tasks requiring the use of respirators, a physician should determine whether the worker is physically able to perform the work and use the respiratory protective equipment. The medical status of each respirator user should be reviewed annually. (Reference Regulatory Guide 8.15, Section C.4.h.)

(3) All respiratory equipment should be approved for use by the National Institute for Occupational Safety and Health. (Reference Regulatory Guide 8.15, Section C.5.)

(4) Respirable air of approved quality should be provided when supplied-air respirators are used. (Reference Regulatory Guide 8.15, Section C.8.a.)

3. Bioassay

a. Appraisal Findings

All of the mills were found to have established a bioassay program including urine analysis for soluble uranium and in-vivo lung counting for insoluble uranium. However, the regulatory basis for requiring such programs was not clearly identifiable. Most of the mills that had been in operation for at least 5 years had been subject to a license condition which required a bioassay program. During June 1978 all mill licenses had been amended to require each licensee to either implement a program described in a referenced "Staff Technical Position" document or to submit an alternative to the described program for approval by the NRC. Most mills had submitted an alternative. A draft Regulatory Guide 8.22, "Bioassay at Uranium Mills" was issued for comment during July 1978 and simply restated the requirements of the "Staff Technical Position" document.

At the time of the appraisal both the licensees and the appraisers were uncertain whether the licensees were subject to their approved alternative, the "Staff Technical Position" document (or Regulatory Guide 8.22), or the license condition in place prior to June 1978. The mills were found to have made choices which evenly divided them among the three possibilities.

In any case, the mills were appraised in regard to the Regulatory Guide, and recommendations for program improvement were made at each mill with the Guide as a basis. Generic recommendations have not been included in this report, since the Guide is still under review.

Apart from the aforementioned lack of technical bioassay criteria, the teams found that many mills had not established a mechanism for assuring that all workers who should be subject to lung counting were actually counted when the vendor visited the site each year. Several instances were observed where employees were absent during the visit for several concurrent years.

b. Recommendations

(1) The NRC should issue Regulatory Guide 8.22 as soon as possible, and NRC Licensing should clarify bioassay license requirements.

(2) The licensee should ensure that all appropriate workers are included in the bioassay program. Workers who should be included in the in-vivo assessment program and who are absent during the annual visit by the in-vivo bioassay vendor should not be omitted from this annual assessment. The licensee should provide an alternate means of providing an in-vivo assessment for these workers.

C. External Exposure and Contamination Control

Significant weaknesses in the area of external exposure and contamination control were identified at 5 of the 10 facilities evaluated. These weaknesses are described below.

1. External Exposure Control

a. Appraisal Findings

Due to the small external exposures typical of workers at most uranium mills, the appraisals revealed no serious deficiencies in this area. Normally all mill workers were supplied with commercially available film or thermoluminescent dosimeters exchanged quarterly and registering no more than several hundred millirems penetrating whole-body exposure per quarter. Most mills reserved at least one dosimeter for use in recording background levels or as a control to register any exposure received by a

dosimeter batch during shipment. No other quality assurance methods were normally used by the licensees.

Vendor reports of beta exposure as recorded by the dosimeters varied considerably among the mills but were relatively low. The appraisers estimated that beta exposure was not significant, and that the use of safety glasses and work clothes in those areas with large surface accumulations of uranium provided protection from beta radiations typical of a mill environment.

In addition to personal dosimetry, all mills characterized radiation exposure rates at numerous locations within the mill complex by means of routine instrument surveys or placement of fixed dosimeters. Some mills evaluated beta fields as well as gamma. In some instances, licensee data or appraisal team instrument surveys indicated that certain unposted areas should be posted as "radiation areas" as required by 10 CFR 20.203(b). Usually the only area that justified such posting was the drummed yellowcake storage compound. Several mills had also misapplied the "radiation area" posting by placing signs at all mill entrances or at intervals around project fencing.

One mill had unusually high levels of external exposure caused by selective absorption of radium-226 by rubber linings in ion exchange tanks. Measured exposure rates in the ion exchange circuit areas of this mill ranged as high as 10 millirems per hour, and several discarded ion exchange tanks in the mill scrap yard qualified for posting as "high radiation areas" at hatch openings.

b. Recommendations

No general recommendations for improvement were identified for this special area; however, mills with ion exchange circuits should be wary of radium buildup in process tanks which could result in increasing exposure rates in this process circuit during later years. The appraisers judged that routine beta dose rate surveys were unnecessary.

2. Facility Contamination Control

a. Appraisal Findings

All mills were found to have applied practices to control ore dust and yellowcake contamination in process areas and to have performed contamination surveys to evaluate contamination levels in nonprocess areas. Generally, those mills which had applied the greatest effort in maintaining process areas free of fugitive dust also had the lowest airborne concentrations and personnel exposures. Some mills had futilely established an elaborate survey program, while applying only token efforts toward contamination control. Those licensees with the better

contamination control programs had carefully applied engineering controls in order to reduce dust emissions within the plant and had allocated manpower for the sole purpose of mill housekeeping. The usual methods of process area cleaning were observed to be water spraying or vacuum cleaning which appeared to be effective in reducing airborne contamination concentrations.

The typical contamination survey program consisted of routine wipe surveys in clean areas adjacent to process areas, including such areas as change rooms, eating areas, laboratories, and offices. Most mill licenses required that surveys for fixed contamination also be performed and that investigation and corrective action be undertaken when designated action levels were exceeded. Portable alpha scintillation counters were normally used for fixed contamination surveys, and laboratory alpha counters were most often utilized for wipe analyses.

Most mills had established administrative practices to assure that all material and equipment leaving the project site were first surveyed for fixed and removable contamination. Release limits were in every case the same as the action levels for the clean mill areas. The appraisers noted that although policy statements regarding this requirement had been established, many mills had not established controls to guarantee that all items were indeed being surveyed. Material leaving through a central shipping and receiving terminal at the mill were well controlled, but other materials subject to shipment by private automobile were less likely to be checked.

b. Recommendations

(1) Acknowledging that contamination control plays an important role in maintaining exposures ALARA, licensees should establish formal programs to control the accumulation of ore dust and yellowcake within the mill buildings. Routine water spraying should be fully utilized to control contamination where possible.

(2) Licensees should strengthen administrative controls used to assure that contaminated materials and equipment are identified, decontaminated, and surveyed prior to release to unrestricted areas.

3. Personnel Contamination Control

a. Appraisal Findings

All mills had instituted measures to control personnel contamination on mill workers by use of protective clothing and mandatory showering or instrument surveying. However, only one mill had personnel contamination

control requirements for all individuals--workers, staff personnel, and visitors--who entered the mill buildings. This mill required all personnel to survey prior to exiting the complex. Most of the time this survey was required to be performed in the presence of a security guard to assure proper survey procedure.

The remaining mills had no survey requirements for mill visitors and staff members and even allowed workers to bypass instrument surveying, if they had showered at shift end. The appraisers observed that many of these workers changed into footwear that were subject to being worn in the mill prior to leaving the site. Those workers that opted to survey rather than shower usually did not survey footwear and often did not perform the alpha survey in a proper manner by slowly moving the detector over the subject area of the body. Since appraisal team members at several of these mills found that they had acquired footwear contamination in excess of the 1000 $dpm/100cm^2$ guideline of most mill licenses, there was reasonable evidence that some contamination was being carried offsite by footwear.

Several of the mills had only one instrument available for personnel survey use and thus had no backup when the device was returned to the manufacturer for calibration or repair.

b. Recommendations

(1) Licensees should require all personnel who have entered the mill process buildings to survey hands, head, and clothing, including footwear, prior to leaving the mill site. An alternate approach would be to restrict to the mill site clothing worn in the mill. Personnel should be trained in the proper survey technique and should be frequently audited to assure compliance.

(2) Licensees should assure that an adequate inventory of portable alpha survey equipment is available at all times for personnel survey purposes. Backup equipment should be purchased for use during repair or calibration of primary equipment.

D. Facility Adequacy and Process Controls

1. Appraisal Findings

Significant weaknesses in the area of facilities and equipment were identified at only 2 of the 10 facilities evaluated. These weaknesses were associated with failure to identify and fully implement engineering controls in order to reduce airborne contamination and were not indicative of generic process control problems at all mills. All mills had installed scrubbers on yellowcake dryer stacks in order to reduce effluent releases, and most had fully enclosed product drying and packaging systems in order to control dust emissions to other mill areas. Dust collectors had been installed to control ore dust, whenever extensive dry ore processing was necessary. However, most of the more recently designed mills made use of

semi-autogenous grinding circuits which reduced dry ore handling, resultant airborne ore dust, and the need for elaborate dust collection systems.

The appraisals were performed at a time when few of the mills were operating at design capacity due to reduced market demand for yellowcake. Thus the appraisers were unable to identify any evidence of marked reduction in radiation safety caused by operation at design limits. Although the work force had also been significantly reduced at most mills, the appraisers determined that office and laboratory space, training facilities, and shower and change room provisions were adequate for full staffing.

All of the mills were shipping yellowcake in 55-gallon drums as a dry product rather than as a slurry by tank truck. Few mills were performing wipe surveys on all drum exteriors, including bottoms, in order to verify removable contamination levels within the limits set by the Department of Transportation (DOT). Some of the mills performed spot checks, however, and in these areas contamination levels were always found to be well within DOT limits. Most mills washed drums after they had been filled and sealed. In addition to marking drums as required by 49 CFR 173.392(c)(8) for LSA materials, some mills were also applying DOT radioactive material labels to drums shipped by transport vehicle consigned as exclusive use. These mills were unaware that 49 CFR 173.392(b) exempts them from this requirement. Otherwise, mill transport of yellowcake was generally found to be performed in compliance with DOT regulations.

The appraisal teams also reviewed fire protection at the mills but found no related generic problems. Mills utilizing solvent extraction circuits had installed special equipment to quickly detect and extinguish any fires resulting from use of the flammable liquids used in this process. Due to their remote locations, mills generally had developed some self-sufficiency in regard to fire response and personnel injury.

2. Recommendation

Mills should wash or otherwise clean product barrels to assure that surface contamination levels are below DOT limits. Contamination levels on randomly selected barrels should be surveyed at the same time and frequency of other routine mill contamination surveys.

E. Tailings Management

Significant weaknesses in the area of tailings management were identified in none of the 10 facilities evaluated, and no generic recommendations for improvement are presented in this report. The appraisal teams reviewed licensee efforts in regard to tailings stabilization and routine inspection of embankment systems for dam integrity, erosion, and seepage.

Also reviewed was licensee capability to readily identify, respond, and correct tailings releases caused by failure of distribution or embankment systems. Outside the scope of the appraisal were review of proper dam construction and assessment of dam integrity.

F. Environmental Monitoring

1. Appraisal Findings

All mills had recently been issued license amendments requiring enhanced environmental monitoring programs in order to assess exposures to the general public for the expressed purpose of determining compliance with 40 CFR 190. This standard, set forth by the Environmental Protection Agency, limits the annual exposure (to radionuclides other than radon and daughters) to any member of the public to 25 millirems whole body, 75 millirems to the thyroid, and 25 millirems to any other organ. The amendments required all mills to formulate environmental monitoring programs in accordance with guidelines set forth in Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (April 1980) and Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment" (February 1979).

Although it was not the intent of the appraisal teams to determine compliance status relative to 40 CFR 190, the teams did compare each program with the guidelines in the Regulatory Guides. Many of the mills had only recently begun monitoring programs under these new requirements. In such cases the teams reviewed only current sample methods and procedures.

Significant weaknesses relative to environmental monitoring were identified at 4 of the 10 facilities evaluated. These weaknesses are described below under five subheadings.

a. Stack Sampling

Most of the mills were required by license to perform quarterly sampling of effluent stacks from scrubbers affiliated with the yellowcake dryer and packaging system. Other stacks were required to be sampled semiannually. Some mills failed to determine and record mill operational status at the time of the sampling; thus, there was some doubt as to whether a stack was actually in use at the time of the sample. Other mills failed to use an isokinetic sampling method and omitted sample analysis for radionuclides other than natural uranium. Some mills only determined radionuclide concentrations in the stack and had not performed measurements of stack flow rate; therefore, a determination of material release rate was not possible.

b. Ambient Air Sampling

Typically mills performed ambient air sampling at the site boundary in the predominant downwind direction from the mill stacks. Other sampling was performed at the nearest resident and at background locations. Sampling was continuous for particulates and periodic for radon. Usually the licensee had installed some meteorology equipment in support of this program.

Some sampling techniques were observed to be poor. Several mills had employed particulate samplers with enclosed sample heads for weather protection. Some of these were judged to result in nonrepresentative sampling as a result of impaction and venturi effects. Radon sampling was often questionable as a result of lack of equipment calibration or similar nonrepresentative methodology.

c. Water Sampling

Mill licenses required that monitoring wells be placed near tailings ponds in order to monitor any tailings excursions in groundwater. Nearby streams and ponds were also required to be sampled. Samples were routinely analyzed for various radionuclides including natural uranium, thorium-230, and radium-226.

Sampling deficiencies were observed to be minimal, although some licensees failed to first bail well casing contents prior to sampling. Two mills were found to have tailings excursions in unrestricted areas in excess of concentrations permitted by 10 CFR 20.106(a).

d. Other Sampling

Most mills had utilized vendor-supplied fixed dosimeters to determine gamma exposure rates in unrestricted areas. Some of these were used in conjunction with passive radon monitoring equipment. Some of the dosimeters were intended for personnel dosimetry and were judged to be too insensitive for environmental monitoring purposes. Vendor reports for these devices often neglected readings less than 10 millirems.

Soil, vegetation, food, and animal samples were also collected by licensees as appropriate and were usually analyzed by external laboratories.

e. Sample analysis, reporting, and quality assurance

Some mills performed analyses of some samples in their own laboratories, while others sent all samples to commercial laboratories for analysis. In some cases a commercial laboratory was owned and operated by the same

corporation that controlled the mill. In any case sample results usually lagged the sample date by 3 to 6 months.

The appraisal teams found that most mills did little more than file data records after receipt. Seldom were trend analyses performed or data reduced to units of measurement that could be directly compared to regulatory limits. In some cases various laboratories were used for the same type of sample, and data were reported in different units at different times. Most mills had not completed quality assurance programs to control sample analyses and reporting, although work in this area was underway in order to fulfill the requirements of the recent license amendments.

As a result of the recent license amendment, many mills had allocated more resources in terms of mill manpower, equipment, and consultant services for environmental monitoring than they had for all other NRC-licensed activities. This effort appeared to be disproportionate to the stated benefit of assuring that no member of the public receive an annual dose in excess of 25 millirems. Such resources could be more profitably applied toward efforts to reduce occupational exposure to mill workers.

2. Recommendations

a. NRC should consider reducing environmental monitoring requirements for uranium mill licensees once 40 CFR 190 baseline data are obtained and regulatory compliance is verified. Licensee resources currently applied to environmental monitoring should be more productively applied to radiation protection of mill workers, particularly ALARA efforts.

b. Licensees should fully evaluate the representativeness of sampling techniques by using other sample methods for verification. If alternate sampling methods are not possible, the licensee should assure that the technique complies with published industry standards or is evaluated by a qualified consultant.

c. Licensees should reduce all collected data to units of measurement indicated in Regulatory Guide 4.14. Trend analyses should be performed in order to readily permit recognition of increasing levels and comparison with any applicable regulatory limit.

APPENDIX A

FACILITIES APPRAISED

Name	Docket No.	Appraisal Dates	Report No.
Atlas Minerals	40-3453	May 11-15, 1981	81-01
Bear Creek	40-8452	June 15-19, 1981	81-01
Energy Fuels Nuclear	40-8681	November 2-6, 1981	81-02
Exxon Minerals (Highland)	40-8102	June 15-19, 1981	81-01
Minerals Exploration	40-8584	July 20-24, 1981	81-01
Pathfinder Mines (Lucky Mc)	40-2259	September 28 - October 2, 1981	81-02
Pathfinder Mines (Shirley Basin)	40-6622	August 24-28, 1981	81-01
Petrotomics	40-6659	August 24-28, 1981	81-01
Rio Algom	40-8084	November 2-5, 1981	81-01
Union Carbide (Gas Hills)	40-0299	September 28 - October 2, 1981	81-01

APPENDIX B

REFERENCES

1. U. S. Nuclear Regulatory Commission. Draft Regulatory Guide, Task OH 710-4. "Health Physics Surveys in Uranium Mills."

2. U. S. Nuclear Regulatory Commission. Draft Regulatory Guide, Task OH 941-4. "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable."

3. Title 10, Chapter 1, Code of Federal Regulations - Energy.

4. U. S. Nuclear Regulatory Commission, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Division of Fuel Cycle and Material Safety USNRC, November 1976.

5. U. S. Nuclear Regulatory Commission, "Manual of Respiratory Protection Against Airborne Radioactive Materials," USNRC Report NUREG-0041, October 1976.

6. U. S. Nuclear Regulatory Commission. Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

7. U. S. Nuclear Regulatory Commission. Draft Regulatory Guide 8.22, "Bioassay at Uranium Mills."

8. U. S. Nuclear Regulatory Commission. Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills."

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10. U. S. Nuclear Regulatory Commission. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment."

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12. U. S. Nuclear Regulatory Commission. Regulatory Guide 3.11.1, "Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings."

13. "American National Standard for Radiation Protection in Uranium Mines," ANSI N13.8-1973. Available from American National Standards Institute, 1430 Broadway, New York, NY 10018, Copyrighted.

14. International Commission on Radiological Protection, "Radiation Protection in Uranium and Other Mines," Report No. 24, Pergamon Press, Elmsford, NY, 1976.

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16. ABSTRACT *(200 words or less)*

This report describes the results of special team appraisals at NRC-licensed uranium mills in the period May to November 1981. Since the Three Mile Island accident, NRC management has instituted a program of special team appraisals of radiation protection programs at certain NRC licensed facilities. These appraisals were designed to identify weaknesses and strengths in NRC licensed programs, including those areas not covered by explicit regulatory requirements. The regulatory requirements related to occupational radiation protection and environmental monitoring at uranium mills have been extensively upgraded in the past few years. In addition, there was some NRC staff concern with respect to the effectiveness of NRC licensing and inspection programs. In response to this concern and to changes in mill requirements, the NRC staff recommended that team appraisals be conducted at mills to determine the adequacy of mill programs, the effectiveness of the new requirements, and mill management implementation of programs and requirements. This report describes the appraisal scope and methodology as well as summary findings and conclusions. Significant weaknesses identified during the mill appraisals are discussed as well as recommendations for improvements in uranium mill programs and mill licensing and inspection.

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