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SHIELDALLOY METALLURGICAL CORPORATION

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September 4, 1996

Mr. Gary Comfort
USNRC
Mail Stop TWFN 8-A-33
Washington, DC 20555

RE: Bioassay testing for employees

Dear Mr. Comfort:

Enclosed with this letter is a draft copy of RSP-010 "Exposure Control - Newfield Facility" which describes the procedures that are followed to assess and control radiation exposures at Shieldalloy Metallurgical Corporation's plant in Newfield, NJ. As part of this procedure, you will find a description of the bioassay monitoring program we are proposing to use to monitor internal exposures for affected employees.

SMC requests that this procedure be reviewed by the NRC in an effort to determine if indirect bioassay is an acceptable and appropriate method to use to determine internal exposure levels. Historically, breathing zone samples have been used for this determination but as you are aware, this method has some shortcomings. Primary among these is the high detection limit that is an intrinsic part of this method and the fact that the samples are only marginally indicative, if at all of actual intake. Use of the indirect bioassay method on the other hand, allows for a more consistent and accurate determination of the actual activity in the body that does not rely on assumptions of intake patterns, breathing rate, deposition fractions, and metabolic models.

One item which has been raised by the NRC as a potential area of concern is the fact that the Annual Limit of Intake for thorium is low enough that any bioassay sampling would have to be conducted on a very frequent basis (approximately every two weeks) in order to accurately evaluate exposures. Attachment 5 of the RSP addresses this issue and in addition discusses the procedure of using uranium as a indicator of the presence of thorium for both chronic and acute intake patterns.

Please note that this entire procedure is not being submitted to the NRC for approval. It is being provided in it entirety as a surrounding and supporting document for the indirect bioassay monitoring program referenced on our license renewal application. Furthermore, this procedure has not gone through final approval by the Radiation Safety Committee and so may undergo minor changes prior to being to its being issued. However, as agreed to in our renewal application, the NRC will receive copies of all procedures when they are issued as final.

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Please do not hesitate to contact me if you have any questions or require additional information.

Cordially,

C. Scott Eves
Vice President
Environmental Services

cc: Jim Valenti
Carol Berger

CSE:emb

SMC	EXPOSURE CONTROL - NEWFIELD FACILITY	Procedure No: RSP-010	Page: 1 of 27
		Revision No. 000	Date: August 30, 1996
		Approved by (President):	
		Approved by (RSO):	
		Approved by (Co-Chair, RSC):	

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CONTROLLED COPY NO. : _____

1 PURPOSE

The purpose of this procedure is to describe the method for assessing and controlling radiation exposures at the Shieldalloy Metallurgical Corporation (SMC) plant in Newfield, New Jersey. The objective of the procedure is to assure that the potential for radiation exposure of SMC personnel, visitors, and contractors is minimized by establishing and enforcing dose limits and administrative dose control points.

2 SCOPE

This procedure pertains to all work activities that involve licensable radioactive materials or the potential for internal exposure to radioactive materials. It applies to all SMC employees, visitors and contractors performing work in controlled areas.

3 REFERENCES

3.1 Title 10, Code of Federal Regulations, Part 19, "Notices, Instructions and Reports for Workers; Inspection and Investigations"

3.2 Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation".

3.3 U. S. Nuclear Regulatory Commission Source Material License Number SMB-743.

3.4 International Commission on Radiological Protection, "ICRP Task Group on Reference Man", ICRP Publication 23, 1975.

3.5 International Commission on Radiological Protection, "Limits of Intakes of Radionuclides by Workers", ICRP Publication 30, 1980.

3.6 National Bureau of Standards, "NVLAP Dosimetry LAP Handbook - Operational and Technical Requirements of the Laboratory Accreditation Program for Personnel Dosimetry Processors", NBS 85-3170, May, 1985.

3.7 American National Standards Institute, "Inspection and Test Specifications for Direct and Indirect Reading Quartz Fiber Pocket Dosimeters", ANSI N322, 1977.

3.8 American National Standards Institute, "Personnel Dosimetry Performance - Criteria for Testing", ANSI N13.11, 1983.

3.9 Lessard, E., et al., "Interpretation of Bioassay Measurements", NUREG/CR-4884, U. S. Nuclear Regulatory Commission, September, 1981.

3.10 American National Standards Institute, "Performance Criteria for Radiobioassay", ANSI N13.30, September, 1989.

3.11 Shieldalloy Metallurgical Corporation, Radiation Safety Procedure No. RSP-001, "Radiation Protection Program Plan".

3.12 Shieldalloy Metallurgical Corporation, Radiation Safety Procedure No. RSP-004, "Radiation Protection Records".

3.13 Shieldalloy Metallurgical Corporation, Radiation Safety Procedure No. RSP-005, "ALARA Program".

3.14 Shieldalloy Metallurgical Corporation, Radiation Safety Procedure No. RSP-007, "Training in Radiation Protection".

3.15 Shieldalloy Metallurgical Corporation, Radiation Safety Procedure No. RSP-009, "Contamination Control".

4 DEFINITIONS

The definition of terms used in this RSP that may not be commonly understood are found in RSP-002, "Definitions".

5 PROCEDURE

5.1 Responsibilities

5.1.1 The President shall:

5.1.1.1 Assure that radiation exposures of all employees, visitors and contractors are maintained as low as is reasonably achievable (ALARA) pursuant to RSP-005.

5.1.1.2 Approve all planned exposures in excess of regulatory or administrative limits.

5.1.1.3 Enforce participation in the monitoring program as scheduled by the RSO.

5.1.2 The Radiation Safety Officer (RSO) shall:

5.1.2.1 Develop and administer an industry-standard radiation monitoring program.

5.1.2.2 Disseminate this policy to all applicable personnel.

5.1.2.3 Approve all planned exposures in excess of regulatory or administrative limits.

5.1.2.4 Review the results of the radiation monitoring program.

5.1.3 The Radiation Safety Committee (RSC) shall review unusual exposure incidents.

5.1.4 Monitored Personnel shall

5.1.4.1 Participate in the radiation monitoring program as directed by the RSO.

5.1.4.2 Provide past exposure history for the employee exposure history files.

5.1.4.3 Maintain an awareness of the radiation dose limits if pertinent to a job assignment.

5.1.4.4 Comply with the contents of this procedure as instructed by the RSO.

5.1.4.5 Maintain their own radiation dose ALARA.

5.1.4.6 Notify the RSO if any unusual conditions or circumstances occur or are observed.

Note: Unusual conditions or circumstances may include spills, abnormal equipment operating conditions, suspected radiation exposures, etc.

5.2 Dose Limits

5.2.1 Regulatory Dose Limits

5.2.1.1 Individual doses for occupational workers shall not exceed 5,000 millirem TEDE or 50,000 millirem TDE per calendar year, excluding medical radiation exposures.

5.2.1.2 Individual doses for visitors and members of the general public shall not exceed 100 millirem TEDE per calendar year as a result of SMC activities.

5.2.1.3 The total radiation dose to the unborn child shall not exceed 500 millirem TEDE.

5.2.1.4 Doses to the skin, the eye and the extremities shall not exceed 50,000 millirem H_S, 15,000 millirem H_E, and 50,000 millirem H_D, respectively.

5.2.2 Administrative Dose Limits

5.2.2.1 Individual doses for employees should not exceed 2,500 millirem per calendar year, excluding medical radiation exposures.

5.2.2.2 Individual doses for members of the general public should not exceed 100 millirem per calendar year from SMC operations involving licensed radioactivity.

5.2.2.3 Approval by the President is required for any employee to exceed these limits.

5.2.3 Notifications

5.2.3.1 The RSO shall immediately inform the USNRC of any instance in which an individual receives more than 25,000 millirem in a calendar year.

5.2.3.2 The RSO shall, within 24 hours, inform the USNRC of any instance in which an individual may have exceeded a regulatory dose limit.

5.2.3.3 The RSO shall, within 30 days, inform the USNRC:

5.2.3.3.1 Of any instance in which a member of the general public receives more than 100 millirem in a calendar year.

5.2.3.3.2 Of any instance in which an embryo/fetus of a declared pregnant female receives more than 500 millirem.

5.2.3.4 The RSO shall, within 30 days, submit a written report to the USNRC for:

5.2.3.4.1 Any instance in which an individual receives more than 2,500 millirem in a calendar year.

5.2.3.4.2 Any instance in which a general employee or member of the general public receives more than 100 millirem in a calendar year.

5.2.3.4.3 Any instance in which an embryo/fetus of a declared pregnant female receives more than 500 millirem.

5.2.3.4.4 Any incident for which notification is required in SMB-743.

5.3 Dose Control for Monitored Personnel

5.3.1 An individual shall participate in an internal or external radiation monitoring program if there is a potential to receive greater than 10% of a regulatory dose limit from either internal or external sources of radiation.

5.3.2 Each individual shall be responsible for controlling their own exposure to radiation hazards such that their annual dose remains below the administrative limits.

5.3.3 Work involving radioactive materials shall be planned and performed in a fashion that minimizes the radiation exposures received.

5.4 Declared Pregnant Female Policy

5.4.1 Female employees who work in restricted areas should inform the RSO and/or the Vice President of Human Resources of a declared pregnancy.

5.4.2 All radiation workers and monitored personnel who perform work in a restricted area shall be instructed in the effects of radiation exposure on the unborn child pursuant to RSP-007.

Note: Both male and female personnel are included in this requirement.

5.4.3 Declared pregnant females working in a restricted area may request a transfer to a different job assignment for the duration of pregnancy.

5.5 Previous Exposure History

5.5.1 Monitored personnel shall complete an USNRC Form-4, "Occupational External Radiation Exposure History" (See Attachment 1).

5.5.2 The RSO shall attempt to obtain previous exposure histories from an individual's former employer(s) whenever possible by initiating a "Request for Occupational Exposure History" form (See Attachment 2).

5.5.3 No employee, visitor or contractor should be permitted to exceed 100 millirem TEDE for occupational exposure in a calendar year at SMC without a known or estimated exposure history on file.

5.6 External Exposure Monitoring

5.6.1 The RSO shall provide monitored personnel with a primary dosimetry device capable of measuring the individual's deep dose equivalent, shallow dose equivalent and eye dose equivalent from external sources.

5.6.2 The primary dosimetry device shall be a TLD-based personnel dosimeter.

5.6.3 Other SMC employees or contractors may be issued a personnel dosimeter at the discretion of the RSO.

5.6.4 Secondary Dosimetry Devices

5.6.4.1 The RSO may provide each monitored individual who may enter a restricted area as part of their work a self-indicating, dose integrating device such as a Pocket Ionization Chamber (PIC), which is considered to be a "secondary" dosimetry device.

5.6.4.2 The monitored individual shall place the primary dosimetry device and the PIC within a hand's width of each other on the part of the whole body that is expected to receive the highest exposure.

5.6.4.3 The monitored individual should read their PICs periodically when in radiation areas to ensure doses received are consistent with expectations.

5.6.4.4 The RSO shall identify individuals whose PIC totals indicate they are at or near administrative dose levels, process their primary dosimetry device, and exclude them from further exposure until primary dosimeter results are available and evaluated.

5.6.4.5 Monitored personnel shall <u>not</u> wear a PIC without a primary dosimetry device.

5.6.5 Placement of Monitoring Devices

5.6.5.1 Monitored personnel shall place the primary dosimetry device on the part of the whole body that is likely to receive the highest exposure.

5.6.5.2 If the highest exposure location on the whole body is not known, monitored personnel may wear additional primary dosimetry devices

on those parts of the whole body that might receive the highest exposure.

5.6.5.3 Monitored personnel shall place extremity dosimetry such that they are as close as possible to the radiation source during work operations without restricting the use of the extremity.

5.6.6 Monitoring for Extremity Exposures

5.6.6.1 For work situations in which extremity exposures are expected to be significantly greater than whole body exposures, or if extremity exposures are expected to exceed 1000 millirem per calendar quarter, or if specified by license or permit requirements, the RSO shall specify additional dosimetry devices to be placed on the extremities to measure and control extremity dose.

5.6.6.2 Each extremity shall have a dosimetry device if that extremity is to be placed into a radiation field (including both penetrating and non-penetrating radiation) in which the extremity could receive 1000 millirem or more than twice the expected whole body dose.

5.6.7 Monitoring for Skin Exposure

5.6.7.1 Due to the complexity of assessing skin dose, the RSO shall control skin dose rates by shielding and decontamination as described in RSP-009.

5.6.7.2 Dose to the skin of the extremities shall be considered extremity dose rather than dose to the skin of the whole body.

5.6.7.3 The RSO shall calculate the skin dose if a worker may have received greater than 1000 millirad from skin contamination or if detectable skin contamination cannot be removed by decontamination.

5.6.8 Equipment Specifications

5.6.8.1 Primary dosimetry services for routine use and for area monitoring, including dosimeters and processing equipment, shall be accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) in all applicable categories, except neutron.

5.6.8.2 Supplementary neutron dosimeters, if issued, shall be accredited by NVLAP in the neutron categories.

5.6.8.3 The RSO shall ensure that dosimeter issuance, retrieval, handling, storage, and processing practices; personnel training and qualifications; quality assurance; documentation; calibration; and record keeping practices meet the minimum conditions for accreditation by NVLAP, and the requirements of ANSI N13.11, "Criteria for Testing Personnel Dosimetry Performance".

5.6.9 Calibration of Dosimetry Devices

5.6.9.1 The RSO shall ensure that primary dosimetry devices are calibrated by the vendor to measure dose equivalent directly or indirectly through calibration factors.

5.6.9.2 The RSO shall ensure that primary dosimetry processing systems are calibrated at least quarterly using NIST-traceable standards.

5.6.9.3 Beta and neutron sensitive dosimeters shall be calibrated using sources that represent the energies of the radiations encountered at SMC.

5.6.9.4 The RSO shall use radiation survey results acquired pursuant to RSP-008 to determine the need for monitoring in particular work areas.

5.6.9.5 The RSO shall ensure that secondary dosimetry devices (e.g., PICs) are calibrated at least annually or any time results indicate that a device is potentially defective.

Note: ANSI N322 guidance should be used in performing these checks.

5.6.10 Deployment, Storage, and Retrieval of Primary Dosimeters

5.6.10.1 The RSO shall retrieve and process primary dosimetry devices issued to employees no less frequently than once every six months.

5.6.10.2 If an individual is known or suspected to have reached or exceeded an administrative dose limit, the RSO shall process the primary dosimetry device prior to that individual being allowed to receive additional external radiation exposure.

5.7 Internal Exposure Monitoring

5.7.1 All employees with the potential to exceed 500 millirem CEDE or 5,000 millirem CDE from internal sources shall participate in a routine internal exposure monitoring program.

5.7.2 Monitoring methodologies may include, but are not be limited to:

5.7.2.1 Indirect bioassay

5.7.2.2 Breathing zone sampling

5.7.2.3 A combination of indirect bioassay and breathing zone sampling

5.7.3 Indirect Bioassay Monitoring

5.7.3.1 Indirect bioassay may be used for routine, confirmatory or special monitoring of personnel for intake of radionuclides.

5.7.3.2 Urine samples should be collected and analyzed for indirect bioassay, however other biological samples (e.g., feces, nasal smears, breath, blood, or other body fluids) may also be used at the discretion of the RSO.

5.7.3.3 Analysis of the radionuclide content of the biological samples shall be performed by a contract analytical laboratory that has been pre-approved by the RSO.

5.7.3.3.1 The contractor shall meet the performance specifications recommended in ANSI N13.30.

5.7.3.3.2 The contractor service shall have written procedures that document the laboratory's analytical capabilities and a QA/QC program which assures the validity of the analytical results.

5.7.3.3.3 The RSO shall ensure that the requirements listed herein are included in the purchase order to the contractor.

5.7.3.4 Urine samples shall be collected in the following manner:

5.7.3.4.1 The RSO (or designee) shall issue a collection kit and an instruction sheet (Attachment 3) to the monitored employee.

Note: Friday issue of kits is recommended so that employees may collect the sample over the upcoming weekend.

5.7.3.4.2 The employee should collect the biological sample and return the kit at the time scheduled.

5.7.3.4.3 Upon receipt, the RSO (or designee) shall complete and secure the sample container labels, affix a tamper-evident seal to the container, complete a chain of custody form (see Attachment 4), and forward the sample to the contract analytical laboratory by overnight carrier.

5.7.3.5 Other biological samples shall be collected, analyzed and shipped as directed by the RSO on a case-by-case basis.

5.7.4 Breathing Zone Sampling

5.7.4.1 Breathing zone sampling may be used for routine monitoring of internal exposures.

5.7.4.2 The breathing zone sampling program shall be administered by the RSO.

5.7.4.3 Samples taken in a work location occupied by a worker should be drawn from a point or series of points within the breathing zone of that worker.

5.7.4.3.1 The sampling location shall be selected so as to be as close to the breathing zone as is practical without interfering with the work or the worker.

5.7.4.3.2 The sampling methodology shall not fractionate by particle size or in other ways distort the physical and chemical properties of the airborne radioactive constituents.

5.7.4.4 Sample Collection and analysis shall be performed in accordance with RSP-008.

5.7.5 Monitoring Frequency

5.7.5.1 Baseline bioassays for monitored employees shall be performed upon employment by SMC only for individuals who were not provided with exit bioassays at their previous place of employment, or at the discretion of the RSO.

5.7.5.1.1 The RSO shall attempt to obtain the results of termination bioassays from previous employers.

5.7.5.1.2 If a baseline bioassay is deemed necessary, it should consist of one or more of the following, as determined by the RSO:

5.7.5.1.2.1 Gamma spectral analysis of a twenty-four hour collection of urine.

5.7.5.1.2.2 Isotope-specific analysis of a twenty-four hour collection of urine.

5.7.5.2 Routine monitoring for intakes by inhalation should be performed at the following frequency, depending upon the bioassay methodology used (see Attachment 5 for the technical basis):

5.7.5.2.1 Once within 35 days of the last work experience with licensed material or at least once per calendar quarter if urine bioassay is used.

5.7.5.2.2 Once every 700 days if fecal bioassay is used.

5.7.5.2.3 At any greater frequency deemed appropriate by the RSO.

5.7.5.3 Special or non-routine bioassays may be performed:

5.7.5.3.1 After detection of facial contamination or positive nasal smear results.

5.7.5.3.2 Following acute exposure to airborne radioactivity without respiratory protection in place.

5.7.5.3.3 When it is suspected that an individual may have incurred an intake in excess of 10% of the ALI for the radionuclide in question.

5.7.6 Validation of Monitoring Results

5.7.6.1 The RSO shall determine the validity of bioassay and air monitoring results prior to their inclusion in the internal dose assessment process.

5.7.6.2 The RSO should evaluate the following items to ascertain the validity of monitoring results:

5.7.6.2.1 Sample collection errors;

5.7.6.2.2 Radiation background interference during counting;

5.7.6.2.3 Calibration errors;

5.7.6.2.4 Computer software errors;

5.7.6.2.5 Errors due to counting geometry; and/or

5.7.6.2.6 Statistical errors.

5.7.6.3 Only valid bioassay or air monitoring results, as determined by the RSO shall be used for assessment of internal radiation dose.

5.7.6.4 If the data are not valid:

5.7.6.4.1 The RSO shall document the basis for that conclusion and include the documentation in the individual's dosimetry record.

5.7.6.4.2 The RSO shall also estimate the internal dose to the individual via other means and include the estimate in the individual's exposure history.

5.7.7 Interpretation of Bioassay Results

5.7.7.1 The RSO shall complete the top of the form entitled "Interpretation of Bioassay" (See Attachment 6).

5.7.7.1.1 The RSO shall identify the route of entry (i.e., inhalation, ingestion, etc.), as the most likely route based upon current knowledge of exposure conditions.

Note: This selection can and should be modified as further information becomes available.

5.7.7.1.2 The lung clearance class for intake by inhalation should be selected based upon current knowledge of the chemical form and/or particle size.

Note: For the radioactive materials in use at SMC, the lung clearance class is "Y".

5.7.7.1.3 The Annual Limit on Intake (ALI) for ^{232}Th and ^{238}U shall be $4x10^3$ pCi and $4x10^8$ pCi, respectively.

Note: These values of ALI are based upon a measured particle size of two (2) micrometers (AMAD) in the workplace.

5.7.7.2 Using available bioassay results, the RSO shall complete the remainder of Attachment 6 as follows:

5.7.7.2.1 The number of days between the suspected date of intake and the date of sample collection for indirect bioassay, or the date of measurement for direct bioassay shall be entered as "t" for each bioassay result.

5.7.7.2.2 The values for "Volume" or "Mass" applicable to indirect bioassay measurements only, shall be entered for each bioassay result.

5.7.7.2.3 The "Activity" (the total activity reported from the bioassay measurement) shall be entered for each result (e.g., pCi/sample).

5.7.7.2.4 The values for "O(corrected)" shall be "Activity" values corrected to reflect the appropriate units of activity in the applicable bioassay compartment.

Note: For example, a single 200 ml urine sample is analyzed and found to contain 25 pCi of "Activity". This value must be corrected to reflect the activity in a twenty-four-hour void. Therefore, "O(corrected)" is equal to (25 pCi × 1400 ml) ÷ 200 ml, or 175 pCi.

5.7.7.2.5 Values for "IRF" for each value of "t" shall be selected from those contained in NUREG/CR-4884.

5.7.7.2.6 For a single bioassay result or to obtain the average intake from multiple bioassay results:

5.7.7.2.6.1 The values entered in column (c), labeled "Intake", shall be obtained by multiplying "O(corrected)" by "IRF".

5.7.7.2.6.2 Columns (a) and (b) shall not be completed.

5.7.7.2.6.3 For multiple bioassay results, the average of the column (c) values shall be computed and entered in slot (d), "Intake"

5.7.7.2.7 To obtain a least-squares fit for multiple bioassay data points:

5.7.7.2.7.1 The columns labeled (a) and (b) shall be completed and the sum of each column shall be entered in slots (e) and (f), respectively.

5.7.7.2.7.2 The best estimate of intake shall be obtained by solving for (e) ÷ (f), and entering the result in (g).

5.7.7.2.8 The CEDE or CDE for the employee shall be obtained by one of the following means:

5.7.7.2.8.1 Divide the value entered in either (d) or (g) by the ALI_S, multiply the result by 5, and enter the result in (h).

5.7.7.2.8.2 Divide the value entered in either (d) or (g) by the ALI_{NS}, multiply the result by 50, and enter the result in (h).

5.7.8 Follow-up actions for confirmed positive bioassay results may include the following, at the discretion of the RSO:

5.7.8.0.1 Additional measurements; and/or

5.7.8.0.2 Acquisition of other data necessary to describe the retention of the radionuclide(s) in the body.

5.7.8.0.3 Any other action recommended by the RSO.

5.8 Radiation Dose Assessment

5.8.1 Assessment of External Dose

5.8.1.1 The deep dose equivalent, H_D, of record is the dose recorded from processing of the personnel dosimeter, in units of "millirem".

5.8.1.2 In the event of dosimeter damage or disfunction, external doses may be estimated from the use of stay time information and ambient

exposure rate information determined during routine or job-specific surveillance.

5.8.1.3 Dose assessments shall be reviewed and approved by the RSO and President prior to entering it into the dose of record unless measured by a personnel dosimeter.

5.8.1.4 The results of the dose assessment shall be entered in the individual's radiation dose totals (USNRC Form-5), and a copy of the dose assessment shall be placed in the individual's dosimetry record file.

5.8.2 Assessment of Internal Dose

5.8.2.1 The RSO may solicit the assistance of an internal dosimetrist for performing internal dose assessments.

5.8.2.2 The committed dose equivalent (non-stochastic) incurred by the employee shall be estimated by:

$$CDE_T\ (millirem) = \frac{Intake}{ALI_{NS}} \times 50{,}000$$

Where T = the organ or tissue of interest, Intake = the activity taken into the body as determined from bioassay measurements, and ALI_{NS} = the non-stochastic Annual Limit on Intake for the radionuclide of interest.

Note: ALI_{NS} for ^{232}Th is $4x10^3$ pCi, based upon a measured particle size of two (2) micrometers (AMAD) in the work place.

5.8.2.3 The committed effective dose equivalent (stochastic) incurred by the employee shall be estimated by:

$$CEDE_T\ (millirem) = \frac{Intake}{ALI_S} \times 5{,}000$$

Where T = the organ or tissue of interest, Intake = the activity taken into the body as determined from bioassay measurements, and ALI = the stochastic Annual Limit on Intake for the radionuclide of interest.

Note: ALI_S for ^{238}U is $4x10^4$ pCi, based upon a measured particle size of two (2) micrometers (AMAD) in the work place.

5.9 Calculation of TDE

5.9.1 The TDE is computed from the deep dose equivalent (H_D) as determined from external radiation monitoring, and the committed dose equivalent (CDE) as determined from internal radiation monitoring.

Note: If external radiation monitoring is not performed, $H_D = 0$.

5.9.2 The TDE is estimated by:

$$TDE\ (millirem) = CDE + H_D$$

5.10 Calculation of TEDE

5.10.1 The TEDE is computed from the deep dose equivalent (H_D) as determined from external radiation monitoring, and the committed effective dose equivalent (CEDE) as determined from internal radiation monitoring.

Note: If external radiation monitoring is not performed, $H_D = 0$.

5.10.2 The TEDE is estimated by:

$$TEDE\ (millirem) = CEDE + H_D$$

5.11 Trend Analysis of Dosimetry Results

Trend analysis of personnel dosimetry and dose assessment results should be performed as part of the ALARA program described in RSP-005.

6 EXEMPTION PROVISIONS

Variances and exceptions to the requirements of this Radiation Safety Procedure shall be permitted pursuant to the written authorization of the RSO and the President.

7 DOCUMENTATION

All Records pertinent to this procedure shall be maintained pursuant to RSP-004.

8 ATTACHMENTS

8.1 Attachment 1 - USNRC Form 4

8.2 Attachment 2 - Request for Occupational Exposure History

8.3 Attachment 3 - Instruction Sheet for Urine Bioassay Program

8.4 Attachment 4 - Chain of Custody Form

8.5 Attachment 5 - Technical Basis for the Routine Monitoring Frequency

8.6 Attachment 6 - Interpretation of Bioassay Form

ATTACHMENT 1
USNRC FORM-4

ATTACHMENT 2
REQUEST FOR OCCUPATIONAL EXPOSURE HISTORY

Date:

Name of Former Employer
Address of Former Employer

Re: Request for Occupational Exposure History

Gentlemen:

So that we may compile radiation exposure histories for new employees, we request your cooperation in providing us with the history of exposure to radioactive materials, including both internal and external exposures, for the following individual, who was formerly employed at your facility.

Name:

Social Security No:

Dates of Employment:

Signature Authorizing Release: _____

Your assistance is appreciated. Should you have any questions, please telephone me at (609) 690-4200. Please mail your response to the attention of the Radiation Safety Officer, Shieldalloy Metallurgical Corporation, West Boulevard, Post Office Box 758, Newfield, New Jersey 08344.

Sincerely,

_____
C. Scott Eves
Radiation Safety Officer

ATTACHMENT 3
Instruction Sheet for Urine Bioassay Program

Name: _____

Signature: _____

Social Security No.: _____

You have been given a urine sample collection kit for your use as a participant in a bioassay monitoring program. ***Do not transfer this kit to any other individual.*** This kit contains an orange plastic bottle, a white bottle cap, a Chain of Custody Form, a sample label, and a Custody Seal. The following are the instructions for use of this kit:

1. Wash your hands carefully prior to voiding. Use the disposable collection container when you void. Select the date you wish to begin your collection. (It is frequently more convenient to begin the collection on a Saturday.)

2. On the morning of your first collection date(e.g., Saturday morning), collect your first void of the day (immediately upon arising) in the orange container. Write your collection date and time here:

_____ _____
Date (month/day/year) Time (a.m.)

3. On the evening of your first collection date (e.g., Saturday evening), collect your last void of the day (immediately before going to bed) in the orange container. Write your collection date and time here:

_____ _____
Date (month/day/year) Time (p.m.)

4. On the morning of your second collection date (e.g., Sunday morning), collect your first void of the day in the orange container. Write your collection date and time here:

_____ _____
Date (month/day/year) Time (a.m.)

5. On the evening of your second collection date (e.g., Sunday evening), collect your last void of the day in the orange container. Write your collection date and time here:

_____ _____
Date (month/day/year) Time (p.m.)

6. On the morning of your third collection date (e.g., Monday morning), collect your first void of the day in the orange container. Write your collection date and time here:

_____ _____
Date (month/day/year) Time (a.m.)

(Continued)

ATTACHMENT 3 (Continued)

7. On the evening of your third collection date (e.g., Monday evening), collect your last void of the day in the orange container. Write your collection date and time here:

_____ _____

Date (month/day/year) Time (p.m.)

8 On the day after your third collection date (e.g., Tuesday morning), confirm that the sample container is tightly sealed. Complete the "Custody Seal" as follows and affix it over both the lid and the container:

Person Collecting Sample: Sign your name.
Sample No: Print your name.
Date Collected: Insert the date recorded in Item 2, above.
Time Collected: Leave Blank

9. Complete the sample label as follows and affix it to the plastic bottle:

SAMPLE ID: Insert your name
DATE COLLECTED: Insert the date recorded in Item 2, above.
TIME COLLECTED: Leave Blank
COMPANY: Insert "IEM"
PROJECT No: Insert "94005.01"
TEST REQUIRED: Leave Blank
COMMENTS: Leave Blank

10. Keep the sample in a cool location until you are ready to return to work. At that time, be sure to bring the collection bottle, this sheet, and the chain of custody form with you.

11. Immediately upon your arrival at the Newfield plant, drop the collection bottle, this sheet, and the chain of custody form off at the Guard Office. ***Be sure to "relinquish custody" of the sample by signing the chain of custody form in the presence of the Guard. At that time, the Guard will "accept custody" of the sample by also signing the chain of custody form.***

12. If you have any questions or if there are items missing from your kit, please contact the Shieldalloy Radiation Safety Officer, Mr. Scott Eves.

PLEASE FOLLOW ALL INSTRUCTIONS CAREFULLY!

ATTACHMENT 4
Chain of Custody Record

ATTACHMENT 5
TECHNICAL BASIS FOR THE ROUTINE MONITORING FREQUENCY

The objective of the internal radiation monitoring program at Shieldalloy Metallurgical Corporation (SMC) is to ensure that a committed effective dose equivalent (CEDE) from an intake of radioactive materials equal to 5,000 millirem(or 50,000 millirem CDE) is not exceeded for monitored employees. The methodology used to determine the minimum sampling/monitoring frequency for the bioassay compartments of interest is:

$$I_0 = \frac{A_c(t)}{IRF_c(t)}$$

where I_0 = the intake of the radionuclide in question at t = 0, A_c is the activity that has been detected in the bioassay compartment of interest at time = t after intake, and $IRF_c(t)$ = the fraction of the initial intake that is expected to be observed in the bioassay compartment of interest at time = t after intake.

Monitoring Methodology

At SMC, the radionuclides of interest are ^{232}Th (plus daughters in equilibrium), and ^{238}U (plus daughters in equilibrium). In both cases, the lung clearance class of "Y" is assumed since the uranium and thorium are in oxide form.[1]

Monitoring for the presence of inhaled thorium in workers is difficult, at best. There are always questions about the degree of equilibrium that actually exists between the series parent and its progeny. Also, the solubility and transportability of suspended radioactivity, whose mass may consist primarily of materials that are relatively insoluble in body fluids, is frequently inconsistent with the respiratory tract model that forms the basis for the ICRP 30 dose assessment methodology. Furthermore, the effect of the particle size distribution on solubility is significant. Finally, conventional bioassay methodologies (urine bioassay and whole body or lung counting) do not have a sufficiently low detection sensitivity to permit their use for routine monitoring. Thus, thorium monitoring presents a special problem for assessment of internal occupational doses.

However, the radioactive materials in use at SMC consist of a combination of uranium and thorium in a known ratio.[2] Unlike thorium, uranium can be detected in body fluids at sufficiently low detection sensitivities to permit its use for routine monitoring. Since there is no mechanism whereby the uranium and thorium are separated prior to intake, it is therefore reasonable to assume that any detectable intake of uranium via conventional bioassay methodologies is also indicative of a 4.5 times greater intake of thorium. Therefore, assessment of the minimum monitoring frequency is based upon detection of ^{238}U in a 24-hour collection of urine.

Monitoring Frequency for Urine Bioassay

For this assessment, the intake of interest, I_0, is assumed to be equal to 50,000 millirem CDE, or the Annual Limit on Intake (ALI) for ^{232}Th. For ^{232}Th at SMC, $I_0 = 4 \times 10^3$ pCi is based upon a nominal particle size of 2 micrometers (AMAD).[3] Since the ratio of thorium to uranium in SMC materials is 4.5, $I_0 = 9 \times 10^2$ pCi for ^{238}U.

The activity present in the bioassay compartment of interest, A_u, is equivalent to the minimum detectable activity of the monitoring methodology. For ^{238}U, the detection sensitivity by the methodology of laser fluorometry is a

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[1]International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers", ICRP Publication 30, Pergamon Press, 1979.

[2]A variety of analyses that have been performed on feed material, baghouse dust, and end slag confirm that the Th/U activity ratio is 4.5 $\pm$ 1.4.

[3]Schooley, N., Shieldalloy Metallurgical Corporation, written correspondence to T. T. Martin, U. S. Nuclear Regulatory Commission, May 11, 1995.

nominal 0.1 pCi per sample,[4] which meets the performance criterion contained in ANSI N13.30 of 0.14 pCi per day.[5] For three 24-hour collections of urine, A_u = 0.1/3, or 0.03 pCi.

The intake retention fraction for ^{238}U is calculated as follows:

$$IRF_u(t) = \frac{A_u(t)}{I_0} = \frac{0.03\ pCi}{9\times10^2\ pCi} = 3.33\times10^{-5}$$

Using the tables contained in NUREG/CR-4884,[6] an intake retention fraction (IRF) for ^{238}U in 24-hour urine of 3.33 x 10^{-5} occurs at t = 35 days. Therefore, collection and analysis of three (3) 24-hour voids of urine once every 35 days will insure that the objective of the monitoring program will be met for a single, acute intake.

For chronic intakes, less frequent monitoring is required. Pursuant to ICRP 54, if the intake pattern is assumed to be evenly distributed over a one year period, a daily excretion of 0.1 pCi is readily detectable.[7] Therefore, a sampling frequency of once within 35 days of the last work experience with licensed materials, in light of the presence of other workplace controls on atmospheric emissions, will exceed the objective of the monitoring program.

Monitoring Frequency for Fecal Bioassay

For this assessment, the intake of interest, I_0, is assumed to be equal to 50,000 millirem CDE, or the Annual Limit on Intake (ALI) for ^{232}Th. For ^{232}Th at SMC, I_0 = 4 x10^3 pCi based upon a nominal particle size of 2 micrometers (AMAD).[8] Since the ratio of thorium to uranium in SMC materials is 4.5, I_0 = 9x10^2 pCi for ^{238}U.

The activity present the bioassay compartment of interest, A_f, is equivalent to the minimum detectable activity of the monitoring methodology. For ^{232}Th, the detection sensitivity by the methodology of isotopic thorium analysis is 0.2 pCi per sample,[9] which meets the performance criterion contained in ANSI N13.30 of 0.14 pCi per day.[10] For a 24-hour collections of feces, A_f = 0.2 pCi.

The intake retention fraction for ^{232}Th is calculated as follows:

$$IRF_f(t) = \frac{A_f(t)}{I_0} = \frac{0.2\ pCi}{4\times10^3\ pCi} = 5\times10^{-5}$$

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[4]Eidson, R., Outreach Laboratory, written correspondence to C. D. Berger, Integrated Environmental Management, Inc. November 27, 1995.

[5]American National Standards Institute, "Performance Criteria for Radiobioassay", ANSI N13.30, September, 1989.

[6]Lessard, E. T., et al, "Interpretation of Bioassay Measurements", NUREG/CR-4884, July, 1987.

[7]International Commission on Radiological Protection, "Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation", ICRP Publication 54, Pergamon Press, 1988.

[8]Schooley, N., Shieldalloy Metallurgical Corporation, written correspondence to T. T. Martin, U. S. Nuclear Regulatory Commission, May 11, 1995.

[9]Eidson; R., Outreach Laboratory, written correspondence to C. D. Berger, Integrated Environmental Management, Inc. November 29, 1995.

[10]American National Standards Institute, "Performance Criteria for Radiobioassay", ANSI N13.30, September, 1989.

Using the tables contained in NUREG/CR-4884,[11] an intake retention fraction (IRF) for ^{232}Th in 24-hour feces of 5×10^{-5} occurs at $t = 700$ days. Therefore, collection and analysis of two (2) 24-hour voids of feces once every 700 days will insure that the objective of the monitoring program will be met for a single, acute intake. The objective will be exceeded for chronic intakes.

[11]Lessard, E. T., et al, "Interpretation of Bioassay Measurements", NUREG/CR-4884, July, 1987.

ATTACHMENT 6
INTERPRETATION OF BIOASSAY

Subject:	Route of Intake:
Date of Intake	Annual Limit on Intake:
Radionuclide:	Dose Conversion Factor:
Solubility Class: ☐ D ☐ W ☐ Y	

t (days)	Volume (Mass)	Activity	O (corrected)	(a) IRF	(b) O x IRF (needed only for least squares fit)	(c) IRF^2 (needed only for least squares fit)	(d) Intake
					(e)	(f)	

(g) Intake = Average of (d) =
or:
(g) Intake = (e)/(f) =

(h) H_{50} = (g)/(ALI) x 5 =
or:
(i) H_{50} = (g) x DCF =

Dosimetrist / Date